SPECIAL ISSUE

THE DIGITAL IMAGE

A TRANSDICIPLINARY RESEARCH CLUSTER

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(EDS.)

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Verlag

CONTENT

"THE DIGITAL IMAGE" – A TRANSDISCIPLINARY RESEARCH CLUSTER

FOREWORD

Images have traditionally played a subordinate role in the context of the humanities. This is also true for the so-called Digital Humanities, which have so far focused on text studies using methods and tools from computer science. With the intention of remedying this situation, we applied to the German Research Foundation (DFG) for acceptance to a Priority Program on the topic of "The Digital Image", a funding format in which different disciplines at German universities dedicate themselves to a broader topic from a variety of perspectives. The goal of our program is not to limit ourselves to the development of tools for analyzing data – in this respect we go beyond the Digital Humanities remit from the outset – but to place the subject matter within a broader methodological and cultural horizon.

We want to address the digital image as a phenomenon that is increasingly shaping the present and the future, while at the same time bringing into focus the fact that digital images play a considerable, indeed an increasingly important role both as objects of research and as epistemic tools for that research, not only in the exceedingly diverse fields of the humanities, but also in the life and natural sciences, and that this role needs to be described and analyzed. In undertaking this task, it seemed to us particularly important to bridge possible traditional gaps between different cultures – for example, by using methodologies common in the field of the humanities to reach into the realm of the natural or life sciences, or by relating mathematical and computer-based technologies to the humanities. Out of a total of around 70 project proposals, 12 were ultimately approved by an independent DFG review panel. These proposals come from the fields of computer science, archaeology, architecture, European and Asian art history, media studies and ethnology. This booklet brings together all projects in the form of brief presentations of their goals and research questions.

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JAPANESE HANDSCROLLS AND DIGITAL EXPLORATIONS. THE PROBLEMS AND CHALLENGES OF RE-/PRESENTATION

FENGYU WANG, MELANIE TREDE

ABSTRACT | Japanese illuminated narrative handscrolls (emaki, literally "painting-scroll") are composed of a complex materiality. Consisting of alternating script passages and paintings that are unrolled from right to left, handscrolls are of an oblong, horizontal materiality that might cover up to dozens of meters. Building on previous pivotal reflections on the digital state of affairs that has spurred new perspectives in the history of European art, this project investigates the specific problems and challenges in re-/presenting the specific materiality of Japanese handscrolls. Of concern are not only book publications and museum spaces, but also website interfaces and computer screens. At the center of investigation are both East Asian, here specifically Japanese, materiality and practices of viewing, and hermeneutics. By scrutinizing existing digital projects on Japanese handscrolls, this research focuses on the following two areas of inquiry:
a) critical reflection of the mediating power of the digital image, and
b) the exploration of new modes of digital representation of Japanese handscrolls.
The latter focuses on three fields of inquiry: materiality, practice, and locality.

Introduction: What is an Illuminated Handscroll?

The handscroll (Jp. 巻物 makimono, lit. "thing to roll") is one of the conventional mounting materialities for painting and writing in East Asia (fig. 1). A scroll consists of multiple sheets of "main paper," (*honshi*), rarely silk, that are joined lengthwise and mounted onto layers of backing paper to form a continuous surface for ink and both mineral and plant-derived pigments. Attached to a wooden and mostly lacquered roller with knobs at the top and bottom, the handscroll is rolled up, tied with a wrapping cord, and stored in a wooden box.[1]

To view a handscroll, one unrolls it from right to left, following the East-Asian reading order. The beginning of a scroll features what is the equivalent of a frontispiece in European book formats – oftentimes adorned with carefully painted motifs or gilded paper. On further unrolling the work to the left, the main paper appears. The viewing of a handscroll proceeds in sections of about fifty centimeters, or two times one's arm length. This is the space that provides an easy viewing of the unrolled section, while holding on to both sides of the scroll. To proceed with reading and viewing, one rolls up the beginning right-hand end of the handscroll, and further unrolls the

title paper

head rod

roller

backing paper

main paper

head border

wrapping cord

viewing direction
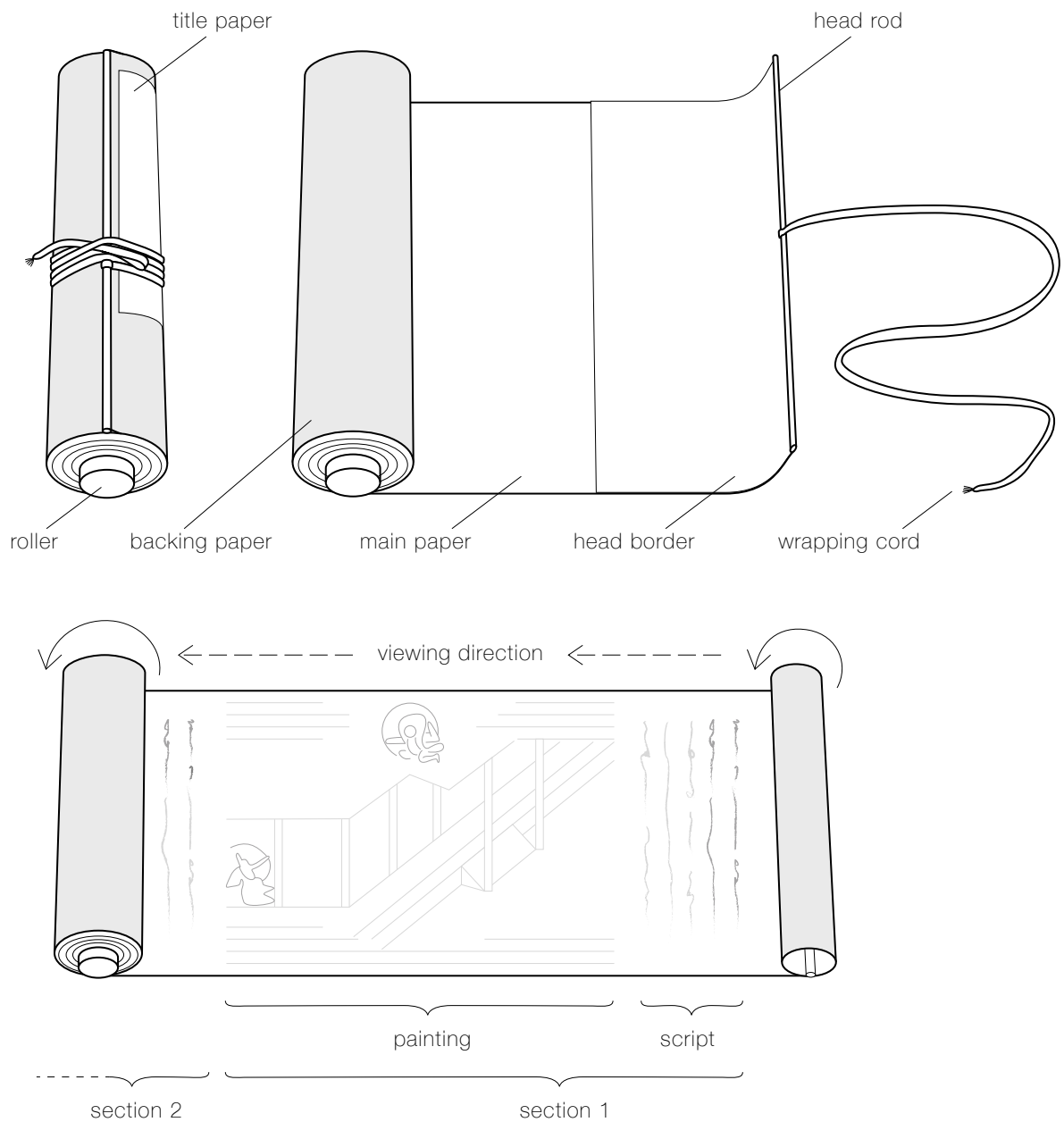
painting

script

section 2

section 1

Figure 1. The material format and handling of a Japanese illuminated narrative handscroll, or emaki; illustration by Fengyu Wang; 2020.

Figure 2. The Illuminated Handscroll of the Karmic Origins of the Deity Dajō Itokuten (Jp. Dajō Ito-kuten engi emaki, Fr. Histoire du sanctuaire Kitano Tenjin); 1538; a set of six handscrolls, ink and color on paper; Guimet National Museum of Asian Arts. Known as the Guimet version of the Illuminated Handscrolls of the Karmic Origins of the Deity Tenjin, or the Guimet version of the Tenjin scrolls; the beginning of the fourth scroll; photo (C) bpk/RMN-Grand Palais (MNAAG, Paris)/Thierry Ollivier.

scroll to the left.[2] This procedure has often been likened to a cinematographic mode by which the rolled up, invisible sections belong to the past while the sections to the left revealed by unrolling the scroll contain the present and future action of the depicted narrative. The consecutively joined paper sections provide a continuous pictorial space, and therefore also a flexibility in the length of the viewing space. A complete unrolling of handscrolls is rarely – and even then seldom – performed in museum settings due to the tension on the paper, the animal-derived glue and the mineral or plant-derived pigments, and concern regarding the scroll's preservation.

Illuminated narrative handscrolls (Jp. 絵巻物 *emakimono* or 絵巻 *emaki*, lit. painting-scroll) constitute a unique type of handscrolls that derived from mainland China but flourished particularly in Japan since the eighth century. These scrolls feature a coherent narrative, presented through alternating sections of brushed script sections and pictorial renderings (fig. 2). They are materialized evidence of an affinity between literature and the pictorial arts that distinguishes itself from its continental predecessors.[3] In many illuminated handscrolls, the paintings prove to be more than just secondary illustrations to the script. Instead, they are creative expressions in their own right, rendering pictorial narratives that are both complementary to, and unconstrained by, textual descriptions. By the fifteenth century so much attention has been paid to the pictorial part of emaki that the painting can be regarded as autonomous from the script.[4] Today, twenty-seven *emaki* are designated as national treasures of Japan in the painting category by the Agency of Cultural Affairs.[5] Therefore, scholars prefer the English word illumination to describe "the hand-painted images in manuscripts" and to manifest the contending yet synthesized relationship between script and painting in *emaki*.[6]

Both, the specific material configuration of Japanese illuminated handscrolls and the script-painting relation discussed above causes confusion and poses challenges when these unique Japanese artefacts are brought to modern museums and libraries. In particular, they represent a different format and require a specific interface in digitized collections.

When European modern art history was introduced to Japan in the late nineteenth-century, the need arose to represent artworks in reproductive media such as periodicals and lantern slides while also presenting them in museum spaces.[7] However, adequate representations of Japanese handscrolls in reproductive media have been a challenge since the very beginning: printed books require the turning of pages and thus interrupt the flow of the narrative or of a painted composition, while lantern slides or PowerPoint presentations tend to focus on single frames. In overseas collections, some of the dislocated illuminated handscrolls are appreciated for their painterly quality in art museums (e.g. the Museum of East Asian Art, Cologne) or as samples of a non-European culture in museums of ethnology (e.g. the Linden Museum, Stuttgart), while yet others are in the collections of libraries such as the State Library, East Asian section in Berlin, and are treated as books or manuscripts. Nowadays, as most of the digitization initiatives are conducted by artefact custodians, the same materiality of Japanese illuminated handscrolls experiences difficulties adapting to the different interfaces of online databases designed by and for

museums, libraries, and universities in Europe, the US, and Japan. In fact, while there are numerous websites both inside and outside Japan representing Japanese prints and paintings in the hanging scroll or folding screen format in a fairly consistent way, despite varying website designs, there are no standards governing the digital representation of handscrolls. Usually, there are a few key images of the multi-meter-long handscrolls, mostly paintings, and either no, or only very few, photographs of the script passages.[8]

Within the framework of the Priority Program (SPP) "The Digital Image" that "addresses the central role played by the image in the complex process of digitizing knowledge in theory and practice,"[9] the present dissertation project investigates the specific problems and challenges in re-/presenting Japanese illuminated narrative handscrolls. Of concern are not only book publications and museum rooms, but also website interfaces and computer screens. The inquiry pays especial attention to how the advancement of reproductive technologies is intertwined with the development of art history as a discipline in which any art historical investigation of an artefact is always facilitated and mediated through its reproductions as means and medium.[10] The project therefore underscores and explores the continuity of the problems and challenges in re-/presenting Japanese handscrolls from a historicizing perspective. Based on both the Japanese materiality and practices of viewing and hermeneutics, and involving the scrutiny of existing digital projects of Japanese handscrolls worldwide, this project critically reflects the mediating power of the digital image and examines new modes of the digital representation of Japanese handscrolls in three areas of inquiry: 1) materiality, 2) practice, and 3) locality.

1. Materiality refers to both the material qualities of the artefact and the handscrolls' oblong format. The aim of this project is to explore the possibilities and limits of digital technologies to convey and inform the user with what is "un-/presentable" in digital form. Despite the drastically inflated amount of visual information that comes with higher resolution, the tactile and material information such as the weight of the artefact, the distinct paper quality, the physical properties of the pigments, etc. will inevitably be omitted in the flattened visual representation of the digital image. The project will discuss potential ways to highlight, convey and translate these "unpresentable" aspects to the viewer.

2. Practice concerns the way in which handscrolls are handled and viewed, and how a digital representation retains, artificially augments, and transforms the ocular experience.

3. Locality includes both the original location of production, and the current residence of an artefact. Locality is also concerned with a) networks between the locations of related objects, b) the socio-political significance of the artefacts at their locations and within these networks, and c) the mobility of the artefact, and the subsequent changes of such significance across time. The PhD thesis will examine various possibilities of mapping such networks with digital tools.

Building on the results of the above inquiries, the project explores the potential and advantages of the digital image, discusses the range of options for future digitization strategies, and presents the results in the form of a PhD dissertation. This path has been chosen in the hope that the flexible, repeatable, and infinitely modifiable nature of the digital image and tools can enhance, augment, and facilitate different ways of viewing and even virtually handling handscrolls.

Case Study of "The Guimet Tenjin": A Cultural Biography

Centering on a 1538 set of six handscrolls entitled *Karmic Origins of the Deity Dajō Itokuten (Deity Tenjin)*, in the collection of the Guimet National Museum of Asian Arts in Paris, this dissertation project investigates a cultural biography of the artefact from three perspectives:

1. creation and original practices within the scrolls' indigenous contexts

2. re-/presentations in museums and conventional paper publications

3. exploration and possibilities of digital representations

The biographical approach affords concentration on one specific artefact. In analyzing comparisons with select related cases, the main focus of the dissertation is on the examination of how layers of the social and cultural significance have accumulated and re-shaped the scrolls through a life of mobility.[11] The cultural biography comprises three foci: the scrolls' creation, their dislocation to a European institution, and eventually their digital "afterlives."

The Guimet set of handscrolls belongs to a larger group of illuminated handscrolls that are dedicated to the Tenjin deity, and related local shrines. The scrolls are therefore referred to as "the Guimet version of Tenjin scrolls." The text of the *Karmic Origins of the Deity Tenjin* narrates the tumultuous life of a high court official, Sugawara no Michizane (845–903), his tragic downfall and eventual apotheosis as the "Heavenly Deity," *Tenjin*.

In 1219, the earliest extant illuminated version of the Tenjin scrolls was created and dedicated to the first shrine devoted to the deity in northern Kyoto, the so-called Tenmangū Shrine. In the following six centuries, as local branches of this increasingly influential shrine were established across the country, the karmic origin stories were transmitted, copied, and re-invented in over sixty known versions, making the group arguably the largest among devotional illuminated handscrolls in premodern Japan.[12] The 1219 set was designated a national painting treasure in the year 1954.[13]

In 1538, the Guimet version was offered to the Tenmangū Shrine in Kaiden village, located in today's Nagaokakyō City, southwest of Kyoto.[14] Among the many other versions, the Guimet scrolls are unique not only in the painting and script styles but also their explicit iconography. A case in point is the depiction of the completely naked Japanese emperor suffering in hell. Although both, the established iconography and the Guimet text version narrate the emperor suffering hell's flames in partial nudity, such an explicit, humiliating rendering of stark nudity is unique among both the many Tenjin scrolls and all other pictorial examples of Japanese art.[15]

In addition, lines of small cursive script in Chinese characters are brushed next to the main depicted figures, specifying their identities, leaving no doubt as to the identity of the emperor. The so-called "script-within-painting" (Jp. gachūshi) is frequently added in devotional emaki to facilitate oral explanations of the painted subjects to lay people (Jp. *etoki*). This didactic activity was widespread by the fifteenth century.[16] Such an outrageous depiction, along with other evidence, suggests that the very production of the 1538 set of Tenjin scrolls had specific social and political significance at the historical point in the geo-political struggles of the local community in and surrounding the Kaiden village.[17] This unique iconography also makes the Guimet version stand out in the larger social network of regional Tenmangū Shrines, and of the productions of Tenjin scrolls in general.

Today, residing in storage and on display in the permanent exhibition of a European museum, the devotional artefact that was once embedded at the social and cultural nexus of a specific shrine has been dislocated and lost its original meaning and significance.[18] Instead, it has turned into "an object of art historical interest,"[19] from a private artefact to a public image.[20] However, the publicity as an overseas artwork also confers new meaning on the Guimet set of Tenjin scrolls. Subject to the "Cooperative Program for the Conservation of Japanese Art Objects Overseas," conducted by the Tokyo National Research Institute for Culture Properties, the Guimet handscrolls went through a thorough restoration from 2004 to 2005, and were completely documented in photographs before and afterwards. The set was first reproduced in its entirety in black and white with a selection of nine painting segments in full color in the journal *Bijutsu Kenkyū* from 2013 to 2014.[21]

The case of the journal *Bijutsu Kenkyū* (Studies in art history) demonstrates a conventional approach to the reproduction of an illuminated handscroll in its entirety in book format (fig. 3). Limited by the size and layout of the pages, the long scroll is cut up into short segments. The opening scene of the fourth scroll is reproduced in three parts in the middle right, lower right, and upper left pictures. Consecutive images were photographed with short overlaps on the two sides to indicate the order of, and connections between, the images. As a result, the same figures in a painting appear twice in different pictures; a line of calligraphy is cut into half at the beginning of the lower right picture. Such a method of reproducing illuminated handscrolls results in the fragmentation of sections of script and painting, and disrupts the continuous flow of viewing. The reader-viewer needs to move her gaze back and forth from right to left in each picture to follow the narrative, and to mentally reconstruct the connection based on the overlapping visual segments. This is the standard and expedient approach to fitting a handscroll in its entirety onto a book page that is vertically oriented and standardized in size, and will later be adapted for website presentations.
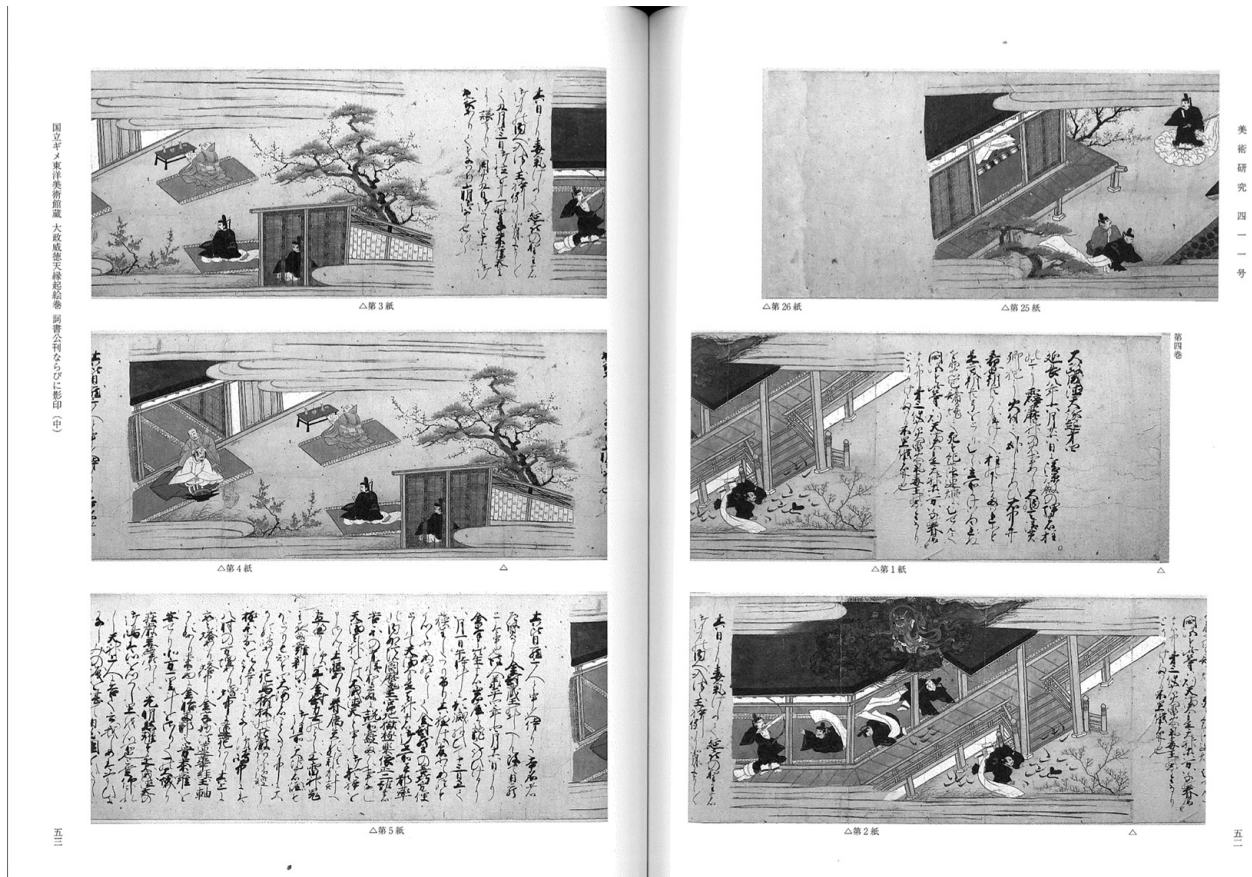
Figure 3. A conventional representation of handscrolls in book form of a Japanese journal for art history; the beginning of the fourth scroll of the the Guimet version of the Tenjin scrolls; Watada, Minoru, Tsuchiya Takahiro, Ōtsuki Chifuyu, and Satō Naoko. "Kenkyū shiryō, kokuritsu Gime tōyō bijutsukan zō Dajō Itokuten Engi Emaki: Kotobagaki kōkan narabi ni eiin (chū)" [Research Materials, Illuminated Handscrolls of the Karmic Origins of the Deity Dajō Itokuten in the Collection of the Guimet National Museum of Asian Arts: The Publication of Script Transcriptions and Reproduction of Paintings (Part 2)]. Bijutsu Kenkyū 411 (February 2014): 353–371.
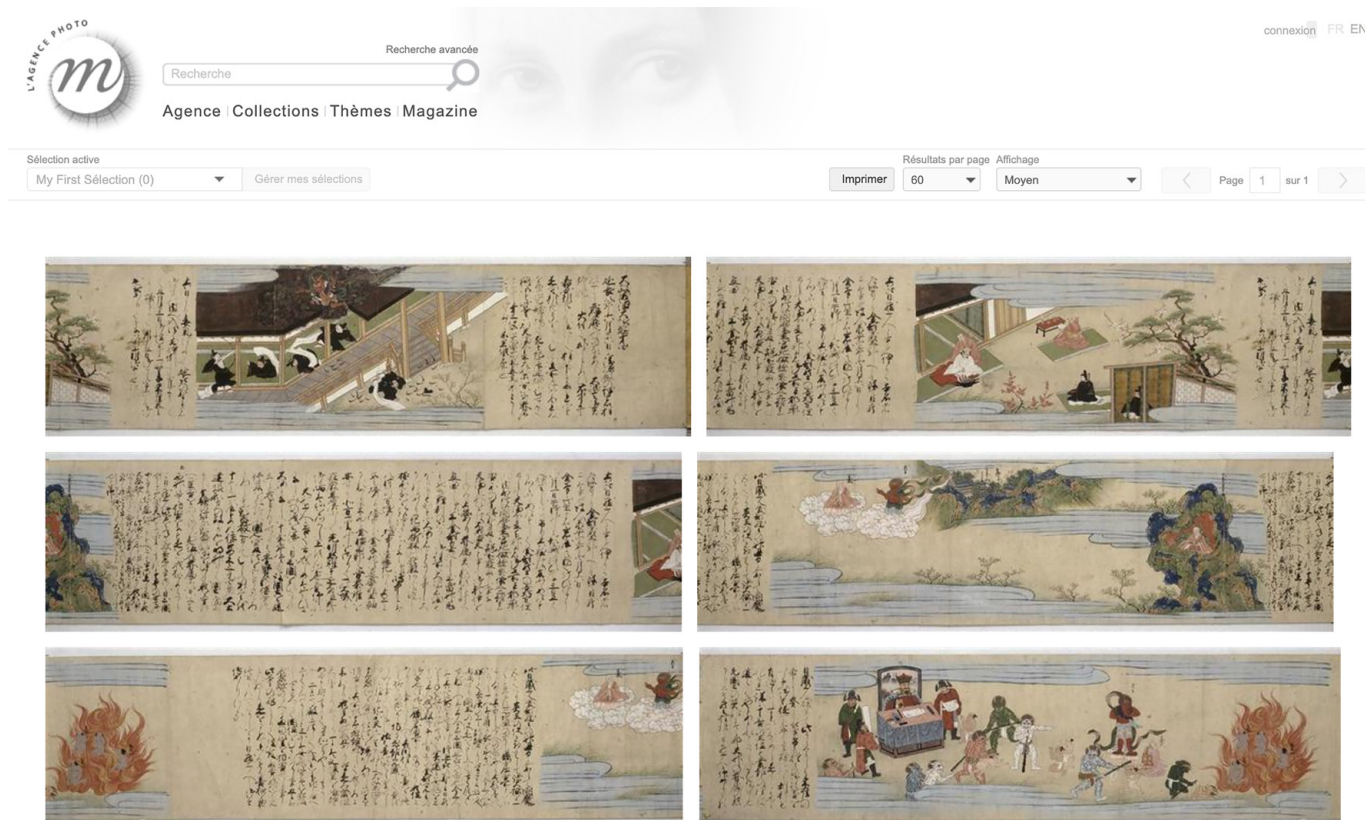
Figure 4. The search interface of the Photo Agency website of Réunion des Musées Nationaux — Grand Palais; the thumbnails of segments from the fourth scroll of the Guimet version of the Tenjin scrolls; RMN-Grand Palais (MNAAG, Paris), photo.rmn.fr; screenshot.

Problems and Challenges

Like a website or a bound book, the format of the handscroll also serves as a specific interface in which pictorial and material contents can be re-/presented, stored, handled, and viewed. Representing handscrolls on either a vertically scrolling website or in a bound book with multiple pages begs the question of how to transform the features of a very specific interface to another medium of representation. A standard way of reproducing handscrolls in book format is to cut them up into small sections of equal or variable lengths, and, according to publication capacities, to make a selection of scenes and sections that are worth reproducing. In the case of illuminated handscrolls, it is the long continuous flow of textual and pictorial narratives that pose challenges. In general, a handscroll can be naturally divided into sections of writing and painting according to the contents. However, because of the continuous quality of a handscroll's surface, the size of each section was generally not standardized until the seventeenth century. Instead, its length may cover a range of measurements. This grants freedom to the painters and scribes of a handscroll to truncate or elaborate certain sections: a lengthy script might precede only a brief illustration while a short passage that is important in iconographic terms might be creatively expanded into a grand visual depiction that unfolds over many sheets of paper. Segmentation, therefore, inevitably disrupts the continuous flow and viewing experience, and oftentimes cuts up individual sections of painting and script.

A part of the collection of a French national museum, the 1538 set of *Karmic Origins of the Deity Dajō Itokuten* has been digitized by the Photo Agency of the "Réunion des Musées Nationaux – Grand Palais" (Rmn-GP), a public cultural institution of the French Ministry of Culture and Communication.[22] The web interface of the photo agency serves as a good example of how the specific materiality of Japanese illuminated handscrolls can pose challenges for its online exhibition (fig. 4). A few thumbnails of one scroll from the Guimet set are shown in the search interface. The entire lengths of the scrolls are, again, cut up into segments to accommodate the format of a website interface that scrolls vertically and is designed to fit the rectangular computer screen. Despite the scroll's orientation that is always read from right to left, the cut-up segments are arranged from left to right, according to the European typographical convention. This arrangement further disturbs the reader's perception of the scroll's original configuration. To access an overview of the scroll within the parameters of such an interface, the reader-viewer starts with the first thumbnail on the upper left, locates the beginning of the scroll on the right end for the image, and inspects its content to the left. To proceed, one moves on to the next image in order, has one's gaze jump all the way to the very right end of the website interface to locate the overlapping segment, and repeats the right-to-left glance. By this point, after finishing viewing the two pictures on the first row of the research interface, the reader-viewer finds oneself back to where one started, the beginning of the first image! As confusing as this written description is, the viewing experience features the repetitive right-to-left viewing movements, according to East Asian reading habits, interrupted by constant jumps between pictures that are arranged in the opposite orientation.

To inspect an individual segment of the scroll, the reader clicks on the thumbnail and opens it in a viewing interface in which the picture is shown on the left, with a "note" that contains the image information displayed in the right panel[23] (fig. 5). Despite the spacious vertical viewing area, the particular oblong shape of the segment limits the size of the image once it has been fitted in. By selecting the "view image only" (*plan cadre*) option below, an enlarged view opens, but the resolution is still not high enough for a close inspection of the image, let alone to allow the script to be read. At the bottom of the "note" section, an option "related images: view all" (*voir toutes les images associées*) sends the viewer back to a search interface where all the segments of one single scroll are presented. In other words, except in the title, *Histoire du sanctuaire Kitano Tenjin* (*série de six makimono*), one reads that the artefact is a set of six handscrolls, and in the "note on the picture" section (*note de l'image: Détail 1*), one fathoms that what is presented is only a segment; there is no information that demonstrates the singularity of the artwork nor an overview of the set of six long handscrolls with forty-two sections of painting and script plus two colophons by which one could clearly position the presented segment in the entire work. If the viewer does not have previous experience with and knowledge of the material configuration of a Japanese illuminated narrative handscroll, not to mention the specificity of the Guimet version of Tenjin scrolls, it will take a lot of confused efforts to figure out the relationship between the thumbnails. In addition, the user experience can be as alien as the way the word *emaki* sounds to an uninitiated ear.
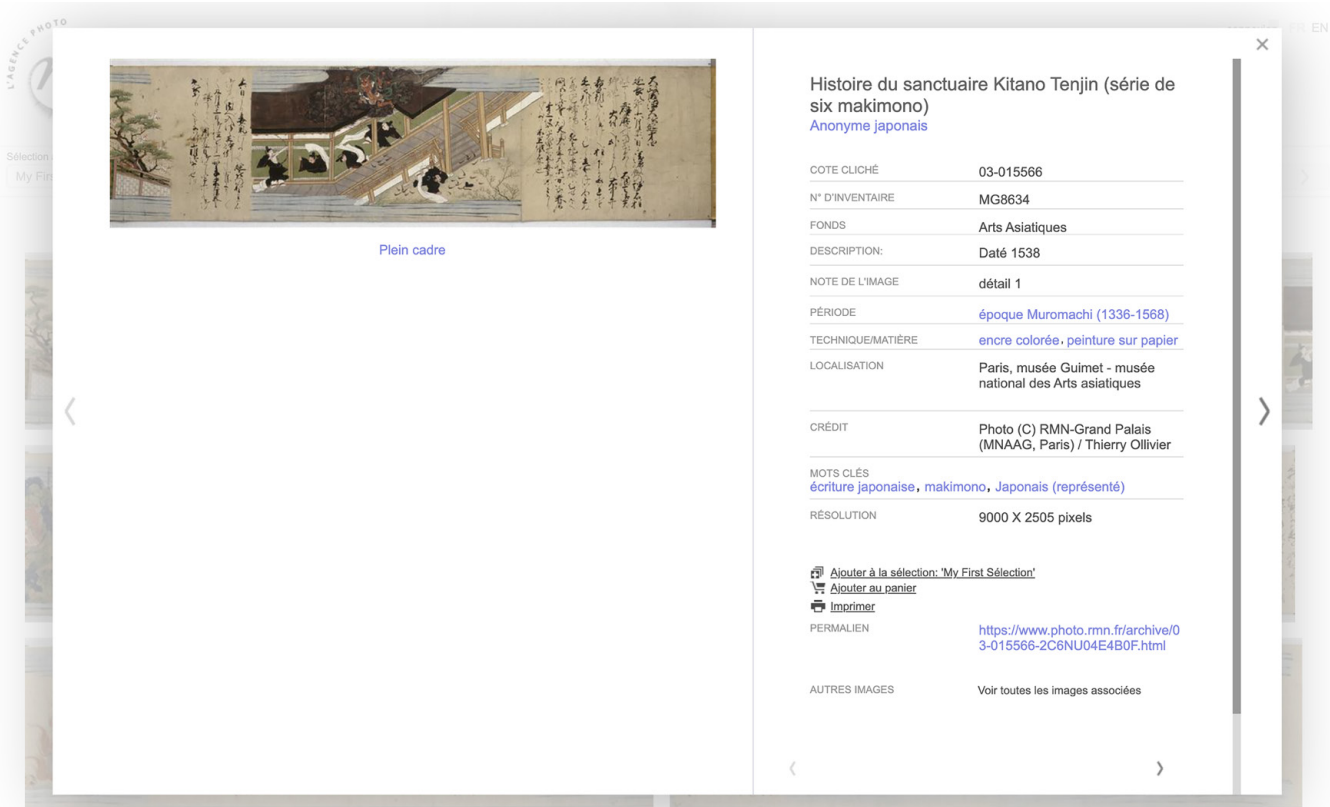
Figure 5. The viewing interface of the Photo Agency website of Réunion des Musées Nationaux — Grand Palais; the first segment from the fourth scroll of the Guimet version of the Tenjin scrolls; RMN-Grand Palais (MNAAG, Paris), photo.rmn.fr; screenshot.

The analysis above is not to intended to accuse the website of the Photo Agency, RMN-Grand Palais of having a flawed design for art digitization projects. Instead, it simply serves to demonstrate how an interface may not cater to the particular materiality and viewing practices of an illuminated handscroll or more generally to a non-European materiality. If one looks at any work by a European painter, say Pablo Picasso's 1954 painting, *Jacqueline aux mains croisées*, one finds not only a single thumbnail of the painting sitting undisturbed in the search interface, but also enlarged views with a resolution high enough to allow a close inspection.[24] Claude Monet's painting *Les Nymphéas: Le Matin aux Saules* also features a large format of 2 meters in height by 12.74 meters in width, and yet finds itself well accommodated on the website. It is not only reproduced in one long overview in its entirety, several square detailed views granting better inspection options, with a few close-ups to highlight remarkable strokes, but also three more photographs in distanced view are provided to demonstrate how the artwork is installed in the exhibition space of the Musée de l'Orangerie.[25]

The case of Japanese handscrolls in library collections is different, as the artefacts consist of both painting and script sections, and are treated as illustrated manuscripts. Such categorization is manifest in the way the objects are handled. Usually, the examination of an illuminated handscroll in a museum collection takes place in a viewing room or in the storage space in the company of a curator and with many protective measures and rules in place, since the issue of preservation is a pertinent concern. Although they vary from institution to institution, the regulations regarding the viewing of an *emaki* in European libraries are relatively loose. For instance, in the Richelieu site of the Bibliothèque nationale de France (BnF), which houses a large collection of Japanese bound books and *emaki*, the reader will be permitted to personally handle a set of handscrolls in the reading room after submitting an online request, providing the scrolls are in good condition. Such an attitude towards handscrolls has also been adopted by the digital website of the BnF's collection, Gallica, designed to represent manuscripts, primarily bound books. Because of the many surfaces in bookbinding, cover, spine, foredge, etc., emaki, too, enjoy

Figure 6. The website of the Metropolitan Museum of Arts, New York, for a thirteenth-century version of the Tenjin scrolls; Illustrated Legends of the Kitano Tenjin Shrine (Jp. Kitano Tenjin engi emaki); late thirteenth century; a set of five handscrolls, ink, color, and cut gold on paper; Metropolitan Museum of Arts; photo (CC) Public Domain; The Metropolitan Museum of Arts, metmuseum.org; screenshot.

especial attention regarding the material condition of the object. A handscroll is presented with many facets of its materiality: front views of the cover in rolled-up state, side views of the roller, backing paper, head border, etc. However, other functions designed for bound books, such as an index with pagination or an optional double-spread view of two images at time, prove to be of no use to the viewing of a handscroll—especially when for premodern East Asian bound books recto (Jp. *omote*) refers not to the right-hand page, but to the left, while verso (Jp. *ura*) refers to the right.

This project aims to show that problems occur when re-/presenting Japanese illuminated handscrolls, especially when the media, formats, or basic layout principles that originate from historical European practices are imagined to be universally applicable and are employed without being adapted for East Asian materials. The Photo Agency's website is designed mainly to accommodate artworks of European genres and formats, and is optimized to present oil paintings. Understandably, the set of Tenjin *emaki* is merely treated as six individual flat images. However, as the case of Monet's long painting hopefully demonstrates, with an especial effort and informed handling, the problems can be solved, sometimes as easily as by changing a few lines of code. A late thirteenth-century set of Tenjin handscrolls is in the collection of, and digitized by, the Metropolitan Museum of Art (MET), New York. When the present project began at the end of 2019, the interface of the Metropolitan Museum of Art in New York City served as one of the examples in which the East Asian reading order of a handscroll is not taken into consideration. The website interface featured a large viewing window accompanied by a row of thumbnails in standardized size to facilitate an overview of the detail in relation to the entire work, but the arrangement of the segments was also initially set in a left-to-right order. Now, after a recent update, the order has been reset, and a very instructive and informative note has been added to assist the viewer without prior knowledge to appreciate the artwork more coherently (fig. 6). "This artwork is meant to be viewed from right to left. Scroll left to view more."[26] What is also remarkable about the MET website is that it also indicates the location of the artefact in the museum, leading the viewer with a click to an

interactive interface that maps the gallery space and highlights of the residence of the Tenjin scrolls. Supplemented with detailed information concerning provenance and exhibition history under "Object Details," it underscores the mobility and the locality of the artefact; despite digital images easily accessible on the internet, the set of emaki has physically travelled from Japan to the American museum, has since made many more trips to diverse exhibition spaces, and currently resides in its own niche in the gallery.

Conclusion: What Does an Emaki Want?

Informed by discourses on materiality imbued with an agency that examines the role of artefacts or simply "things" in the shaping of human experience and social practice,[27] the present project aims to formulate a reflective and normative approach to the extant cases of illuminated handscroll re-/presentations. The project focuses on the idea that the particular materiality of illuminated handscrolls from Japan determines and demands specific handling practices. Once the artefacts are removed from their original locality, they not only acquire a new significance within their different material, social, and cultural contexts, but are also subject to distinct practices. By posing the question "what does an emaki want?" the project does not intend to merely re-establish the practices of the artefact's original context. Instead, the project concentrates on the potential and possible ways of re-/presenting emaki that cater to their materiality and serve specific purposes. This leads to further investigations into the materiality, practice, and locality of digitalization projects themselves, namely not only the means and media of reproduction and the presentation websites and interfaces, but also the corresponding usage and user experience, the data storage and the means of access to those data etc. Such incentive requires us to look beyond natural light photography and website presentation to include all possible media and means such as historical chromoxylography, the X-Ray fluorescent photography that uncovers the layered "grounds" of a painting,[28] or other forms of publication that benefit from digital tools to create new possibilities of re-/presenting illuminated handscrolls. In this regard "we need to engage with the focus, purpose, and success of our efforts to 'send a copy' of cultural and heritage objects to the user community via digital technologies,"[29] or in other words, to ask what an emaki wants from its digitization is ultimately to ask what a viewer or an art historian wants.

NOTES

[1] See Japanese Painting (Conservation), Graduate School of Fine Arts, and Tokyo University of the Arts, eds, An *Illustrated Dictionary of Japanese-Style Painting Terminology* (Tokyo: Tokyo University of the Arts, 2010), 136.

[2] Ibid., 140–141.

[3] Namiki Seishi, *Nihon kaiga no tenkanten, Shuhanron Emaki: "emaki" no jidai kara "fūzokuga" no jidai e* [A Turning Point in Japanese Painting, Illuminated Handscrolls of Debate over Sake and Rice: From the Age of "Illuminated Handscroll" to the Age of "Genre Painting"] (Kyoto: Shōwadō, 2017), 17–8.

[4] Namiki, *Nihon kaiga no tenkanten*, 68–9. Melanie Trede, *Image, Text and Audience: The Taishokan Narrative in Visual Representations of the Early Modern Period of Japan* (Hamburg, Germany and New York: Peter Lang, 1999), 14.

[5] The number here also includes the cases where two or three designated items belong to, or are considered to belong to, the same set of artwork, but are in different collections. Kokushitei bunkazai nado dētabēsu [Database of National Designated Cultural Properties of Japan], accessed July 2, 2020, https://kunishitei.bunka.go.jp/bsys/index.

[6] Trede, *Image, Text and Audience*, 81–82. Ya Decoopman, *The Art of Revealing History: The Kasuga gongen genki e and Its Re-creations in Seventeenth to Twentieth-century Japan* (Zürich: LIT Verlag, 2019), 14–15.

[7] On the introduction of the very concept of "fine art" along with art history as a discipline and its institutions to Japan in the later nineteenth century, see Dōshin Satō, *Modern Japanese Art and the Meiji State: The Politics of Beauty*, trans. Hiroshi Nara. Los Angeles: The Getty Research Institute, 2011; on early twentieth-century art magazines in Japan, see Erin Schoneveld, *Shirakaba and the Japanese Modernism: Art Magazines, Artistic Collective and the Early Avant-garde*. Leiden: BRILL, 2018; on early Japanese usages of lantern slides, see Wada Tsumiki, "Furantsu Shutettonā hakase sakusei garasu suraido no igi ni tuite: Kyōto Sen'l Daigaku Bijutsu Kōgei Shiryōkan shozō shiryō o chūshin ni" [The Significance of Dr. Franz Stoedtne's Glass Slides in the Collection of the Kyoto Institute of Technology Museum and Archives], *Journal of the Japan Society of Design* 68 (2016): 63–77.

[8] For examples, see Museum of East Asian Art, Cologne. Accessed January 3, 2021. https://mok.kulturelles-erbe-koeln.de/documents/obj/05719539, or the Metropolitan Museum of Art, New York. Accessed January 3, 2021. https://www.metmuseum.org/toah/hd/jilh/hd jilh.htm.

9 "The Digital Image," Das digitales Bild. Accessed November 19, 2020. https://www.digitalesbild.gwi.uni-muenchen.de/en/the-digital-picture/.

10 Heinrich Dilly, "Lichtbildprojektion—Prothese der Kunstbetrachtung," in *Kunstwissenschaft und Kunstvermittlung*, ed. Irene Below (Gießen: Anabas-Verlag, 1975), 153.

11 Chris Gosden and Yvonne Marshall, "The Cultural Biography of Objects," *World Archaeology* 31, no. 2 (Oct. 1999): 169–170, 172.

12 Suga Miho, *Tenjin engi no keifu* [The Lineages of T*he Karmic Origins of Deity Tenjin*] (Tokyo: Chūō Kōron Bijutsu, 2004), 4.

13 Kokushitei bunkazai nado dētabēsu.

14 Watada Minoru, "Kenkyū shiryō, kokuritsu Gime tōyō bijutsukan zō *Dajō Itokuten* Engi Emaki: Kaidai" [Research Materials, Illuminated Handscrolls of the Karmic Origins of the Deity Dajō Itokuten in the Collection of the Guimet National Museum of Asian Arts: Synopsis], *Bijutsu Kenkyū* 410 (September 2013): 282.

15 Yamamoto Yōko, *Emaki ni okeru kami to tennō hyōgen: Mienu yō ni egaku* [The Representations of Deities and Emperors in Illuminated Handscrolls: To Render Invisible] (Tokyo: Chūō Kōron Bijutsu, 2006), 184–189.

16 Namiki, *Nihon kaiga no tenkanten*, 64–65.

17 Watada, "Kenkyū Shiryō: Kaida," 284–186, 289. For a more detailed introduction to the historical and geo-political contexts of the Guimet version's creation, see also Niki Hiroshi, "Chūsei no Kaidenshō (mura) to Nakakōji-shi: Engi emaki seisaku no chiikishi-teki igi" [Kaiden Village in the Medieval Time and the Nakakōji Clan: The Regional Historical Significance of the Production of the *Illuminated Handscrolls of the Karmic Origins*], in *Nagaoka tenmangū shiryō chōsa hōkoku sho, bijutsu, chūsei hen* [Reports on the Investigation of the Historical Materials of Nagaoka Tenmangū Shrine: Art, Medieval], ed. Nagaokakyō-shi Kyōiku Iinkai (Nagaokakyō-shi: Nagaokakyō-shi Kyōiku Iinkai, 2012), 122–131.

18 The Guimet set of Tenjin handscrolls had been found missing from the local shrine since the early eighteenth century, and was rediscovered in the early 1990s in the collection of the Guimet Museum, Paris. It is unclear whether the set was acquired by the French collector Émile Guimet (1836–1918) himself during his trip to Japan in 1867, or whether it was brought overseas and came into his collection later. See Watada, "Kenkyū Shiryō: Kaidai," 279; Tamaki Reiko, "Nagaoka Tenmangū to Katura-no-miyake" [Nagaoka Tenmangū Shrine and the House of Katsura-no-miya], in *Nagaokakyō-shi shi: Honbunhen 2* [History of Nagaokakyō City: Main Text, vol. 2], ed. Nagaokakyō-shi shi hensan iinkai (Nagaokakyō: Nagaoakakyō Shiyakusho, 1997), 162; also, Tokyo National Research Institute of Cultural Properties, ed., *Kaigai shozai Nihon bijutsuhin chōsa hōkoku 6: Pari, Kokuritsu Gime Tōyō Bijutsukan, kaiga* [Investigation Reports on the Japanese Artworks in the Oversee Collections, Vol.6: Guimet National Museum of Asian Arts, Paris, Paintings] (Tokyo: The Japan Society for the Conservation of Cultural Property, 1996). As part of the basic research, the present project will continue to investigate the provenance of the artefact and the archival materials in Guimet Museum.

19 Christine Guth, "Kokuhō: From Dynastic to Artistic Treasure," *Cahiers d'Extrême-Asie* 9 (1996): 320. In other words, "the museum deprives of their cultural lifeblood." Didier Maleuvre, *Museum Memories: History, Technology, Art* (Stanford: Stanford University Press: 1999), 38.

20 Chelsea Foxwell, *Making Modern Japanese-Style Painting: Kano Hōgai and the Search for Images* (Chicago and London: University of Chicago Press, 2015), 32–33.

21 The set is reproduced and published under the title, "Kenkyū shiryō, kokuritsu Gime tōyō bijutsukan zō *Dajō Itokuten Engi Emaki*" [Research Materials, Illuminated Handscrolls of the Karmic Origins of the Deity Dajō Itokuten in the Collection of the Guimet National Museum of Asian Arts], transcribed and edited by Watada Minoru, Tsuchiya Takahiro, Ōtsuki Chifuyu, and Sato Naoko. It was published in three parts on *Bijutsu Kenkyū* 410 (September 2013): 290–311; 411 (February 2014): 353–371; 412 (March, 2014): 445–467.

22 The Photo Agency of the Réunion des Musées Nationaux – Grand Palais. www.photo.rmn.fr.

23 "Histoire du sanctuaire Kitano Tenjin (série de six makimono)." The Photo Agency. Accessed February 4, 2020. https://www.photo.rmn.fr/archive/03-015566-2C6NU04E4B0F.html.

24 "Jacqueline aux mains croisées." The Photo Agency. Accessed February 4, 2020. https://www.photo.rmn.fr/archive/16-515530-2C6NU0A42SS99.html.

25 "Les Nymphéas: Le Matin aux Saules." The Photo Agency. Accessed February 4, 2020. https://www.photo.rmn.fr/archive/10-522900-2C6NU0Q6FX0J.html.

26 The Metropolitan Museum of Art. Accessed January 3, 2021. https://www.metmuseum.org/art/collection/search/45428.

27 Elina Gertsman, "Matter Matters," in *Feeling Things: Objects and Emotions through History*, eds. Stephanie Downes, Sally Holloway, and Sarah Randles (Oxford: Oxford University Press, 2018) 29–30; for a longer literature review of object studies and thing theories, see Babette Bärbel Tischleder, *The Literary Life of Things: Case Studies in American Fiction*. Frankfurt am Main, New York: Campus Verlag, 17–29. See also Theodore Schatzki, "Materiality and Social Life," Nature and Culture 5, no. 2 (2010): 146.

28 Sarai Mai, "E no chisō saguru to iu to" Exploring the Grounds of Painting, trans. Yukio Lippit, in *Kasuga Gongen Genkie: Kōgaku chōsa hōkokusho: Kunaichō Sannomaru Shōzōkan shozō, kan 1, kan 2* [Report of the Optical Survey: The Illustrated Handscrolls of the Miracles the Kasuga Deity, in the collection of Sannomaru Museum, Scroll I and II], ed. Tokyo Research Institute for Cultural Properties (Tokyo: Tokyo Research Institute for Cultural Properties, 2017), 3.

29 Melissa Terras, "Should we just send a copy? Digitisation, Usefulness, Users," *Art Libraries Journal* 35, no. 1 (2010): 26.

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SCHEMATA – 3D CLASSIFICATION METHODS AND ARCHAEOLOGICAL IDENTIFICATION CRITERIA.
AN INTERDISCIPLINARY COLLABORATION USING THE EXAMPLE OF ANCIENT TERRACOTTA STATUETTES

MARTIN LANGNER, ALEXANDER ZECKEY, LUCIE BÖTTGER

ABSTRACT | Both in the field of applied computer science and in disciplines dealing with material artefacts, three-dimensional objects with complex shapes are inadequately classified. Archaeologists are confronted with the problem that resemblance in shape can be recognized, but is difficult to adequately describe in words. Furthermore, archaeology has yet to make sufficient use of automated 3D shape recognition to differentiate the formal relationship of similar objects. A computer, however, has no problem recognizing identically shaped objects, though it has yet to learn our human perception and understanding of similarity. The goal of this project is therefore to develop procedures for automatically generating corpora using 3D pattern recognition, as well as to reflect on the associated schematizations and how they can be applied in the computer and visual sciences. This involves developing methods of object mining in 3D data. In close cooperation between computer science and archaeology, this experimental process leads to a substantial analysis of the concept of pattern recognition as a branch of the humanities. Based on 200 terracottas of the late 4th and 3rd centuries BC, which despite their similarity differ in various details, a classification system will be elaborated using digital methods and taking into account the complexity of the artefacts.

KEYWORDS | Archaeology, classification, cultural analytics, data mining, machine learning

Introduction: Connoisseurship and verbal description of the terracottas

It is well known that pictorial works act simultaneously. A multitude of visual impressions reach the recipient, who simultaneously absorbs and often unconsciously evaluates them. This evaluation is based on socio-cultural conditions, respective viewing habits and the visual stimuli generated in the picture. This large amount of information and its weighting is difficult to determine in linguistic terms, which is why experts in the appropriate field of knowledge have a certain connoisseurship. As a hermeneutical authority, the undoubted expertise of individuals has fallen into disrepute because its results can hardly be scientifically verified.[1]

At best, the reasons for the connoisseur's expertise are expressed through the medium of language, and archaeological databases annotate the images with verbal metadata. This, however, results in a double translation process, since each individual work of art must be translated into words in the form of detailed
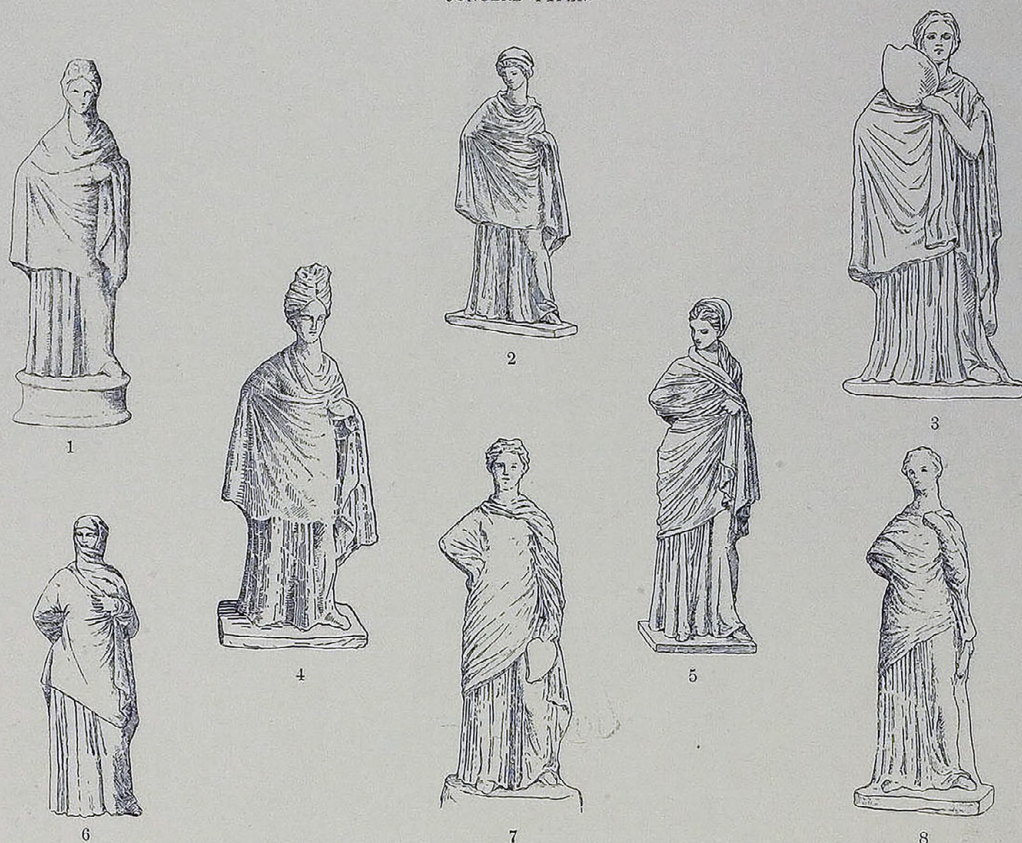
1 Dumont - Chaplain, Les céramiques de la Grèce propre Taf. XXX. — h. 0,15 m.
   b. Athen (Polytechnion 328 M. 298 und 1405). — h. 0,17 m. — Aus Tanagra.

2 British Museum 74 $\frac{11}{10}$ 107. — h. 0,15 m. — Aus Tanagra.
   b. Louvre. Heuzey Taf. 25, 3. Kopf nach links gewendet, ohne Haube. Fächer in der linken Hand. — h. 0,22 m. — Aus Tanagra.
   c. Paris, Musée Guimet. Nach vorn vorgebeugt, linkes Bein etwas weniger vorgestellt. — h. 0,13 m.
   d. Berlin, Antiquarium 8593. Kopf abgebrochen. Ohne Basis. — h. 0,115 m. — Aus Priene.
      Ähnlich: A. Athen, Centralmuseum 733. Der Mantel ist über den Kopf gezogen und fällt unten über die Kniee herüber, ähnlich wie bei der Figur S. 20 n. 3. — h. 0,19 m.
      B. Ebenda 929. Ohne Haube. Nur Oberteil erhalten. — h. 0,09 m.

3 Louvre MNB 604. — h. 0,185 m. — Aus Tanagra.
   b. Rouen, Coll. Bellon. Cartault, Terres cuites grecques Taf. VII 3. Kopf nach rechts gewendet, verhüllt und mit Hut. — h. 0,255 m. — Aus Tanagra.

4 Sammlung Calvert, Dardanellen. — h. 0,18 m. — Aus der Troas (Tschamlydja).

5 Athen, 1876 im Kunsthandel. — Aus Tanagra.
   b. Berlin, Antiquar. 7077. Griech. Terrakotten aus Tanagra und Ephesos Taf. 10. Ohne Haube. Kopf nach links und etwas nach vorn geneigt. — h. 0,19 m. — Aus Tanagra.
   c. Berlin, Sammlung des Grafen Wilhelm Pourtalès. Kekulé, Griechische Thonfiguren von Tanagra Taf. VIII. Ohne Haube. Fächer in der linken Hand. — h 0,178 m. — Aus Tanagra.
   d. Athen, 1876 im Kunsthandel. Mantel über den Kopf gezogen. — Aus Tanagra.
   e. Petersburg, Ermitage. Furtwängler, Sammlung Sabouroff Taf. CI. Wie c. — h. 0,21 m. — Aus Tanagra.

   f. Coll. Lecuyer Taf. A 3. Kopf scheint nicht zugehörig. — h. 0,20 m. — Aus Tanagra.
   g. Froehner, Coll. Gréau 1891 n. 317 Taf. XIV 1. Kopf nach links, Fächer in der linken Hand. — h. 0,156 m. — Aus Tanagra.
   h. Ebenda n. 279 Taf. XV 1. Kopf nach links gewendet, ohne Haube. Die Bewegung stärker. — h. 0,20 m. — Aus Tanagra.
   i. Coll. Milani 277. 278. — Ohne Haube. — h. 0,15 und 0,16 m. — Aus Tanagra.
   k. British Museum. Ohne Haube. — h. 0,18 m. — Aus Rhodos (Kamiros).
   l. 1893 im Kunsthandel. — h. 0,23 m. — Aus Tanagra.
   m. Athen (Polytechnion 948). Kopf gradeaus. — h. 0,19 m. — Aus Tanagra.
   n. Winterthur, Sammlung Imhoof-Blumer.
      Ähnlich: A. Odessa, Museum. E. von Stern, Das Museum der Odessaer Gesellschaft I Taf. II 1. Kopf mit Bindenkranz, gradeaus gerichtet, aufgesetzt, Gewand am Hals geschlossen. Ähnlich, nach v. Stern, eine Figur in der Ermitage 882 A. — h. 0,24 m. — Aus Olbia.
      B. Madrid. Catálogo del museo arqueológico nacional I n. 3235. Wie A, aber ohne Kranz. — h. 0,20 m. — Aus Kyrenaika.

6 Louvre. Heuzey Taf. 27 1. Gazette des Beaux-Arts 1875 II S. 63. Monuments grecs 1874 S. 8 Taf. 1 D. — h. 0,155 m. — Aus Tanagra.
   b. Athen (Polytechnion 812). — h. 0,16 m. — Aus Tanagra.
   c. Athen, Akropolismuseum. Kopf und Unterschenkel abgebrochen. — h. 0,095 m. — Aus Athen.

7 Athen (Polytechnion 1258). Basis z. T. modern. — h. 0,185 m. — Aus Tanagra.

8 Athen (Polytechnion 826). — h. 0,18 m. — Aus Tanagra.

Vgl. die Figuren aus Unteritalien S. 28.

Figure 1. Franz Winter; Die Typen figürlicher Terrakotten; 1903; in: Winter, Franz. Die Typen der figürlichen Terrakotten: Die antiken Terrakotten III (Berlin: Spemann, 1903), 22.

Figure 2 a–e. after Violaine Jeammet; Origine et diffusion des Tanagréennes; 2003; in: Tanagra: Mythe et Archéologie, ed. Violaine Jeammet (Paris: Réunion des musées nationaux, 2003), no. 118–120. © Museum for Fine Arts Boston; Different grades of similarity in ancient terracotta figurines.

descriptions, which must then be converted into machine-readable numerical values. In some ways, the simultaneity of visual impressions even contradicts the verbal analysis of images, which must emphasize and weight details in the order of description. This is important for the respective understanding of the image, but is contrary to its specific character.

The corpus of the ancient terracottas

In the heyday of archaeological corpus formation at the end of the 19th century, scholars set out to create a corpus of ancient terracottas. However, they quickly recognized the difficulties associated with this undertaking, since the ancient clay figures were not individual works, but rather serially manufactured products taken from molds.[2] Franz Winter was commissioned to create more of a catalog than a corpus. It was to cover all relevant types of antique clay statuettes and be as complete as possible.[3] The resulting arrangement can be seen as an early form of archaeological pattern recognition, where the "types" were represented in simplified drawings.

Without resorting to verbal descriptions of the types or even naming the differentiated categories, the catalog relied on expert knowledge and an established method of visual identification (the so-called "Vergleichendes Sehen"). Each supposed repetition was listed under a figure schema that was defined solely by a drawing (fig. 1). These schemas were called types, but not in the sense of the strict terminology established in sculpture research.[4] Furthermore, Winter investigated neither the degree of similarity nor the relationship of the repetitions to each other and to the "type".

Degrees of similarity: the coroplastic type

Ancient terracottas resemble each other to differing degrees. These degrees of resemblance can be precisely defined by archaeologists and evaluated progressively using classification procedures with different levels of precision:[5] Firstly, there are the figures taken from the same mold, which therefore exhibit an exact match. Secondly, there are the figures taken from the same patrices, which differ from the source object only in size (fig. 2a, b, c). Thirdly, there are the figures, which despite also being taken from the same mold subsequently show a

changed appearance due to later additions and modifications by hand, and which therefore no longer belong to the same type (fig. 2c). Then there are the terracottas which resemble each other very closely in posture and drapery of the costume, but which nevertheless do not originate from the same mold (fig. 2d). And finally, there are those terracottas in which the same figure schema occurs in various free configurations (fig. 2e). At the craftsmanship level, it can be stated that two terracottas come from the same production. If this is not the case, however, there are still no suitable criteria for determining the similarity and its gradations.

An object mining approach analogous to text mining has yet to be tested in classical archaeology. This is the aim of the project SCHEMATA, which will adopt an application-oriented approach that also emphasizes methodological reflections. Its goal is not only to analyze procedures for automatically generating corpora using 3D pattern recognition, but also to reflect on the associated schematisations and their scholarly applications. The results will be evaluated and the procedures finely calibrated in a multi-step process. A systematic investigation of formal elements (and of the organization, identification, and interpretation of sensory information in general) could serve as a key to the development of a concept for the materialization of knowledge and visualization. Three questions being pursued in the project are of particular relevance: Can figure types be captured non-verbally using digital methods of pattern recognition and if so, to what degree of precision? To what extent is verbal reasoning terminology necessary as a means of distinguishing and differentiating between the types? Can the categories developed in archaeological style research for describing types also be used for digital procedures, or are new diacritical methods needed to replace them?

Possibilities of the third dimension: advantages of 3D acquisition

The archaeological interest in the categorization of terracottas goes hand in hand with an interest in the epistemological possibilities offered by 3D imaging and automated classification of terracottas. The acquisition, analysis and publication of historically relevant objects as 3D models offers numerous advantages for art historical and archaeological disciplines:[6]

In addition to global availability, simple and contact-free handling and unlimited replicability, the main advantage is that the perspective (obtained by rotating, zooming or juxtaposing the objects, for example) can be determined individually. Compared to common documentation methods (such as orthophotography or plaster cast), the objects become much more accessible for research. With this approach, researchers can also reproduce historical conditions (in the sense of an object biography), assign fragments to objects and reconstruct their positioning. As a result, traditional academic perspectives and analytical methods are not only enhanced, but even called into question, since the large-scale virtualization of objects in collections will generally have a significant impact on visual identification processes in historical and visual disciplines. On the one hand, the comparative visualization of similarity allows the results of formal analysis to be measured and thus objectified. On the other hand, the visual identification methods used by researchers in visual disciplines must adapt to new forms of visualization, which will lead to standardization processes grounded on new methods. Based on the methodological comparisons used in the project, the question of how archaeological research can be transformed using 3D models will be explored and captured in best practice examples.

Archaeological shape analysis and digital pattern recognition

Archaeology as a scientific discipline sees its task primarily in extracting patterns from the sum of the surviving remains of past societies, allowing conclusions to be drawn about the conditions of that time. For this reason, it has always used forms of pattern recognition to describe artifacts and images, although it has preferred the terms structural analysis, typology or seriation.[7] The question arises whether the methods of archaeological 'Formenanalyse' correlate with the corresponding methods of digital pattern recognition.

Figure 3. Acquisition of 3D-models of terracotta figurines at the Museum August Kestner, Hanover. © IfDH.

Therefore, archaeological concepts for describing similarity and machine learning techniques for classification need to be compared. The resulting discussion has two goals: On the one hand, archaeology is to be provided with non-verbal forms of description that make it possible to classify not only typological dependencies, but also other degrees of similarity, and which may provide a clearer view of the ancient perception of terracottas in terms of types, variants and motifs.

The second goal is to significantly improve the object mining process so that in the future a large percentage of the data on the objects in a collection can be automatically stored in databases. On the one hand, this will revive the somewhat deadlocked debate about types and schemas by adapting established shape recognition methods from the fields of mathematics and computer science. On the other hand, concepts of comparative visual analysis developed in visual disciplines will be applied in the field of shape recognition. This project will therefore investigate theoretical aspects of practical importance, such as a modified definition of the concept of similarity. What exactly does it mean when two shapes are similar?

Measurable characteristics of the terracottas

Form, workmanship, and function are closely related. However, traditional methods of archaeological form description and analysis, based on a summary collection of individual criteria, have proven inadequate. The degree to which identity of molds and similarity in shapes, as well as workshop traditions and tendencies of contemporary styles can be identified and distinguished from one another, is often unsatisfactory.[8]
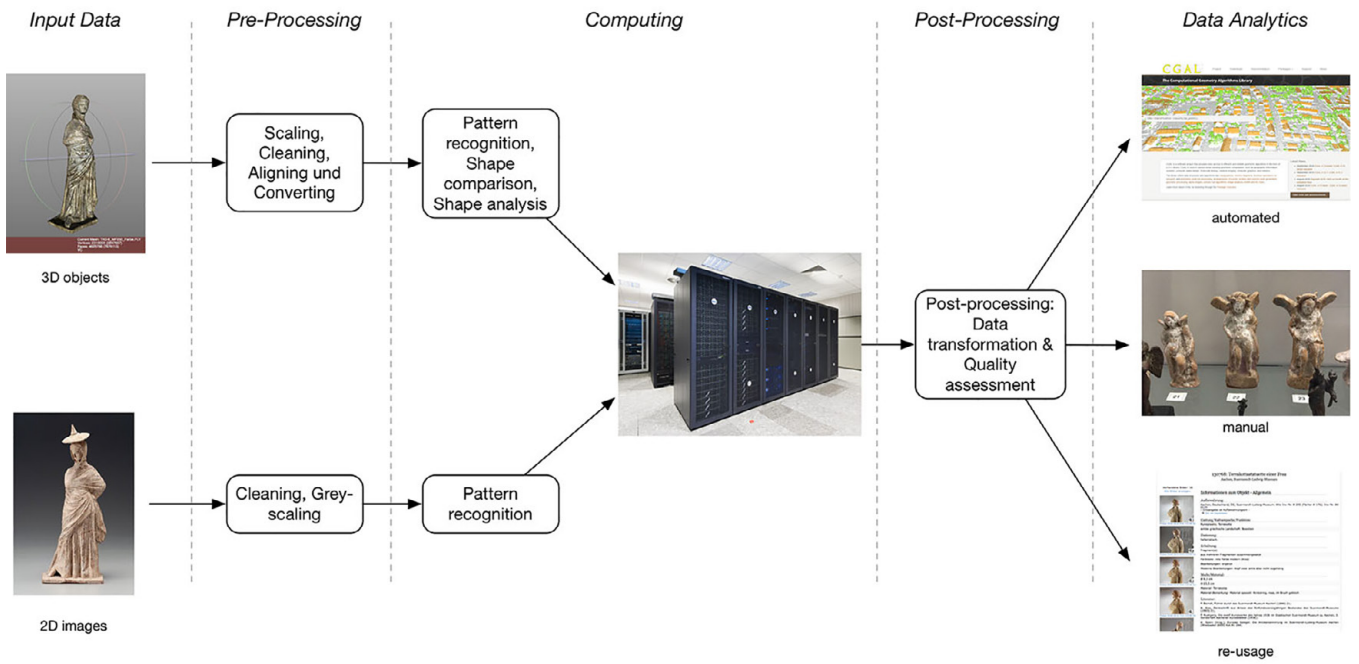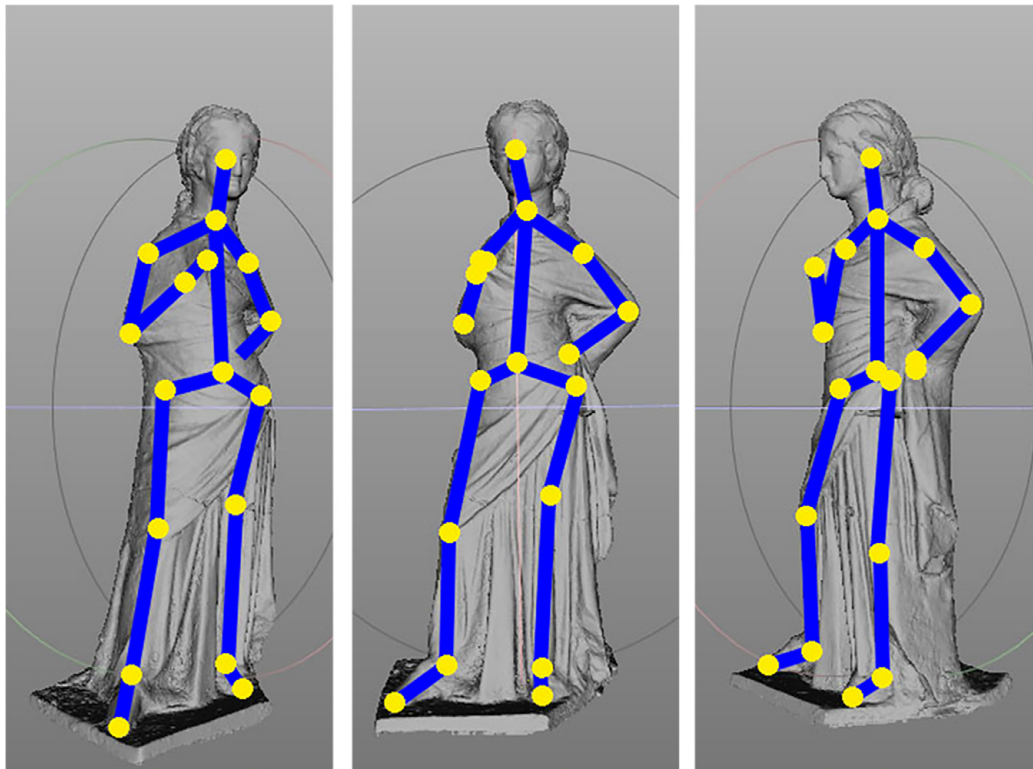
Figure 4. Data Pipeline. © IfDH.

Figure 5. Ideal skeletons of a terracotta from the Göttingen collection. © IfDH.

The project therefore entails fundamental work on the standardization of acquisition processes. All information contained in an object, such as size (length, width, height, weight and mass), shape (geometry and contours, surface, volume), composition of individual elements, texture (roughness, waviness and position) and visual appearance (color variations, brightness, reflectivity, etc.) are systematically measured, documented and analyzed using computational methods. This requires collaboration between archaeologists and computer scientists to optimize the speed and smoothness of the acquisition process, as well as the accuracy and quality of the 3D models for subsequent processing by both parties. Ultimately, a corpus will be created that is as usable as possible for a wide range of applications. Until then, the 3D scans will be made accessible in a viewer that will accompany the acquisition process.

The "New Winter" as 3D Repository

Because Franz Winter's book has established itself as a reference work, the terracottas depicted there will be used as a point of departure. In order to limit the quantity of material used in the project to a suitable amount, the project will be confined to standing female figurines of the so-called Tanagra style from early Hellenistic times.[9] Terracottas of this period were made with two or more molds and became popular burial goods. They have therefore survived in large quantities, in good condition, and in a wide variety of forms.

For our study, 200 terracotta statuettes were selected, not only because of their particular suitability due to their similarity and easy accessibility, but also because they will also provide a sufficient material basis for the ensuing investigations. To obtain suitable 3D-scans, a number of museums will be visited. The data acquisition will be carried out using a structured light scanner, which provides high-resolution 3D scans of the terracottas (fig. 3). Parallel to the data acquisition, we have begun to question the theory of the concept of type and its validity. A further sharpening of the spectrum of methods is to be expected, particularly in dealing with the theoretical discussions in other (non-classical) archaeologies.[10]

Object mining in computer science

The economic mass digitization of 3D artifacts is still an unsolved problem. Although the semantic enrichment of 3D data itself is challenging, methods of using the geometry of the 3D shape[11] for data mining are an active research area.[12] But a fast partial decomposition into simple geometric shapes[13] has so far been insufficient. Instead, suitable pattern recognition methods[14] have to be developed that link the degree of simplification and abstraction to the human way of recognizing and distinguishing patterns. Therefore, the classification of unknown objects must be evaluated and calibrated step by step. The 3D pattern recognition of the main components shape, size and color must therefore go hand in hand with suitable forms of machine learning. This is implemented in the form of a data pipeline (fig. 4), in which various procedures are developed and fine-tuned to suit the case study. This is a method which is widely used in the field of data analysis, and which is also used for Big Data applications. An input element is processed piece by piece in a series of processing steps. The data processing steps to be dealt with include pre-processing, computation, and post-processing. The goal is to extract data sets that can be used to categorize the similarity of historical art objects.[15] A repository can then be created based on the information obtained. These data can be used to find new categorizations or to link them to existing humanities categorizations as additional digital investigations.

Up to now these methods have seldom been used for the automated acquisition of artifacts, although experiments with curve recognition, for example, have already been conducted on archaeological objects. The reasons for this are, on the one hand, that there is not a sufficient number of images available as 3D models to test the applicability of these methods to any significant extent. On the other hand, works of art (as opposed to components or plants, for example) represent a great challenge to any computer-aided classification due to their high variability. The assignment of a specific instance to a more general class is much more difficult in this case, since they can differ considerably from each other in shape, size and color.

2D method: analysis of the outer contour

In the context of 2D comparisons, there are already established methods for calculating equality or, in part, similarity. These are used to calculate and compare distributions and patterns in binary and grayscale images. The 2D pattern recognition uses automated methods or manually trained data sets to find identical or similar features. For this purpose, Multiview Convolutional Neural Networks[16] are used to break down the complexity of the 3D model into the second dimension using virtual cameras. These generated 2D data are supplemented by existing object photos. In this way, for example, the outer contours of the objects can be analyzed via their geodesic distance, their depth – represented by different brightness values – or their surface distribution.

3D analysis of posture: voxelization and skeletonization

One possible approach to the analysis of 3D data, beside other methods, is a voxel-based approach, where the 3D model is compared using a logical array and different skeletonization methods (fig. 5). This is where drawn posture schemes come into play. The skeletons extracted from the object are compared with these posture schemes. This step is not only interesting for comparing the objects, but also for clarifying the difference between human and computer-based perception. After all, the manually generated comparison data in the data memory are not necessarily the only ones, since new models are to be created automatically and loaded into the data memory. Subjective influences and preferences of the researchers are removed, so that only the most numerous schemata remain, the ones also more likely to have a certain significance.

Currently, medial-axis-transformation methods are used, in which the model is reduced to its mean minimum. Also currently in progress are studies on extraction using Voronoi diagrams and topological and geometrical analyses. Such analyses use feature points and constraints in the model to determine the skeleton. Some of the results obtained so far are already useful for comparison, but have not yet reached their desired final state. The method needs to be further improved, since the figures, which are usually heavily wrapped in fabric, make it difficult for the computer to clearly recognize the corresponding body features. To compare the skeletons, procedures in the 2D and 3D range are used and supplemented by further analyses specifically used for this purpose. One of these is a backtracking search, in which the individual edges of the two skeletons to be compared are gradually compared for size ratio and angle. With this method, the different postures of the terracottas can be compared without elements of interpretive perception on the level of form alone.

Combination of different methods

In summary, various existing methods are currently being developed and evaluated in the field of shape recognition procedures, and extended primarily by means of posture comparisons, a 3D-to-2D unwrapping and a custom system with automatic extension and a weighting procedure. Thus, although all data that can feasibly be extracted are to be collected, their interpretation has to be restricted according to those weighting parameters optimized by investigation in order to obtain a suitable threshold value for defining similarity. In this way we are working on a way to determine and evaluate the degree of similarity.

Interdisciplinary collaboration: archaeological object mining

The goal of the computer science section can only be achieved in close cooperation with archaeologists.[17] In order to find suitable parameters for the algorithms to be tested, a constant review of the results by the humanities is necessary. For this purpose, joint experiments are conducted in which the framework of digital and comparative vision is checked. The aim is to determine whether or not the technical extraction of the object's features can be assigned to existing or newly developed archaeological typologies.
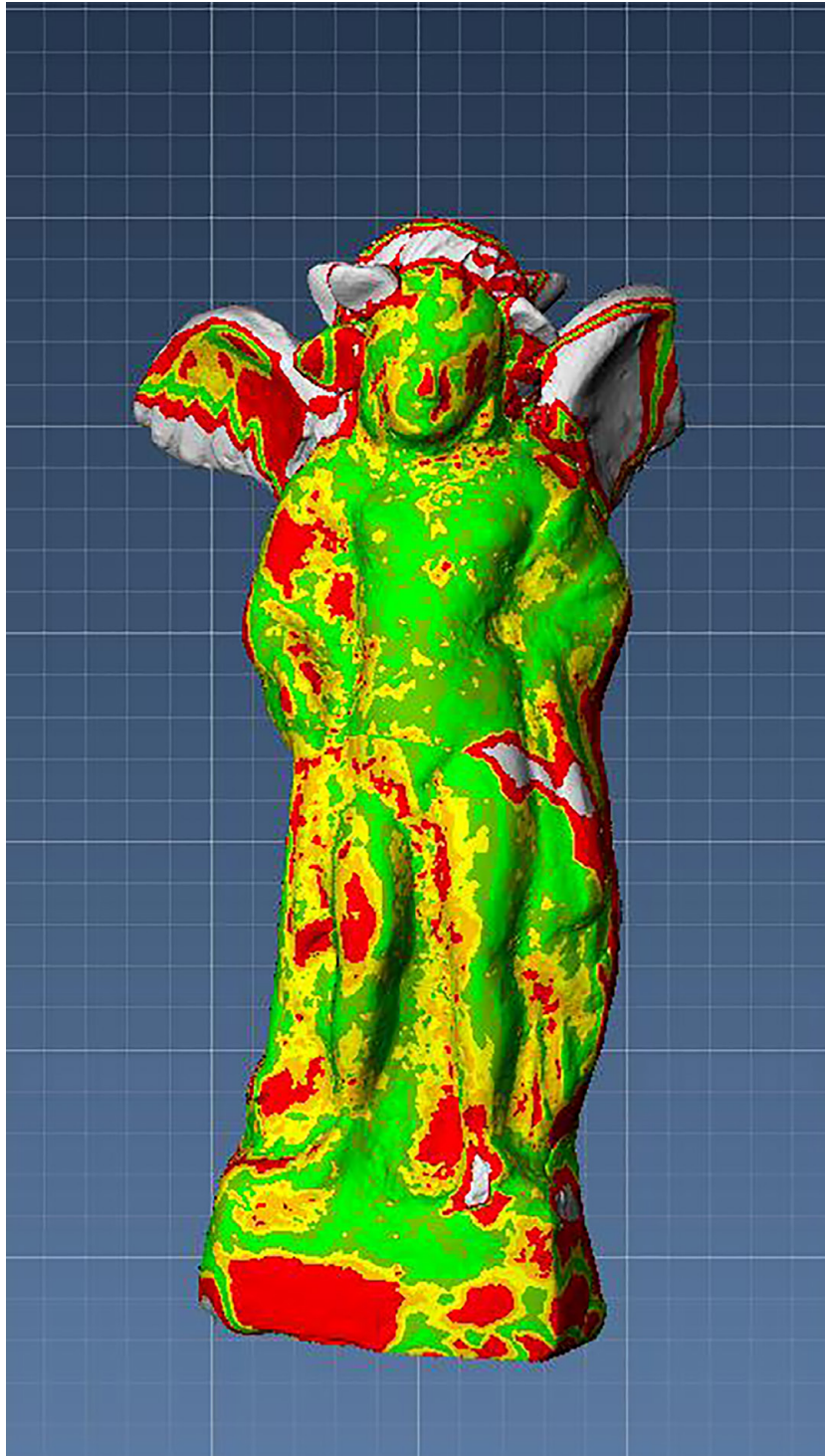
Figure 6. Best Fit Example of two terracottas from the Göttingen Collection. © IfDH.

The parameters of the algorithms are then adjusted and recalculated to improve the result using constant tuning. This includes checking to identify the extent to which the automatically extracted pattern recognition features are suitable for comparison or to determine whether or not these technical procedures will be able to match archaeological photo comparisons in the foreseeable future. This is achieved by a continuous, joint reflection of the methods on the informative value and by examining the objectivity of the algorithms. In this way it should be possible to automatically provide data for archaeologists to describe the body of an artifact, whereby the accuracy of these data must always be achieved by validating the results. In doing so, the computer science side will learn to use and improve existing methods for the automatic analysis of 2D and 3D data and to develop ideas for new ways of handling such data.

The measurement data must be checked, and standard deviations must be taken into account in order to relativize the degree of objectivity of the various methods. These must be further developed accordingly, or critically examined

for their suitability. Overall, the objectivity of the methods is of great importance throughout the project. Finally, there should be object mining that automatically compares different degrees of similarity and determines the category and subcategory (or type) to which the respective artifact belongs. In archaeological and informatics analyses new similarity criteria will be defined and evaluated in both disciplines.

In addition, further considerations will take place regarding the objectivity of all the methods used in order to prove their usefulness for further procedures in the field of 2D and 3D data processing. Finally, the questions arise: Is the potential of the tools being fully exploited? Or will there be further possibilities for data extraction by analyzing the objects created from this work? Does the degree of objectivity of a technical data analysis also apply to complex works of art? Are these ultimately useful, superior or unsuitable for further investigation? And is their granularity sufficient to interpret works of art? These questions must be answered within the context of the project in order to achieve a better understanding of the possibilities of these procedures.

Semantic similarity

To classify the type of a figure, it must be divided into the three components posture, garment, and surface design. When creating a sustainable typology,[18] however, not all attributes should be treated in the same way, since their meaning may depend on individual characteristics. The semantic meaning of the figure is often determined by details such as hairstyle, attributes and headgear, which changes the meaning of the terracottas even if they come from the same mold.

These features must therefore be extracted separately. The result is a catalog of features that can be used in a statistical analysis to determine both the frequency of certain features and the popularity of their combination. On the formal level, it becomes clear which characteristics are particularly relevant for the perception of a type as a carrier of meaning. When is it a rare variant of the same motif and when is it already a new type with a different meaning? The archaeological interest in the typological classification of terracottas goes hand in hand with the interest in the research possibilities offered by 3D recording and automated classification of terracottas.

When working with the 3D models and the dimensional comparisons according to Best Fit[19] (fig. 6), impulses for methodological reflection are self-evident, since we may initially be surprised or dissatisfied with the first results. However, these impressions should be systematized and discussed together in order to analyze the consequences of their use. The main focus should concentrate on answering the following questions: To what extent is the 3D model superior to the photo series? How high is the scientific applicability of the 3D models and algorithms and how can the expressive potential of the digital tools be exploited? How does archaeological work change when forgoing a normalized view of the artifact in favor of examining the 3D model in different positions and also visual distortions? How can a standardization of the scientific documentation nevertheless be achieved? What degree of (apparent) objectivity do the 3D scans achieve? How can this be measured and challenged on a case-by-case basis?

Ensembles in graves as a source of ancient perception

The division into figure types is important not only as a method of object recovery, but also as a classification criterion for archaeological research. However, our typologies do not reflect the perception of objects in ancient times: terracottas were not made separately by type, nor were they used in groups by type. Likewise, ancient viewers used basic information such as shape, posture, and surface design to identify objects and explain the function of the figurines.[20] For this reason, the next step is to reconstruct ancient perceptions of terracottas. In order to get a clearer overview of this, it is necessary to examine the numerical popularity of certain pictorial works. The question of which connotations were associated with which types and variants remains an unfulfilled research desideratum in classical archaeology.

In the case study of this project, burial contexts with two or more similar female terracottas are understood as ensembles in which the individual figures enclosed as a set semantically complement each other. Contextual analysis of the range of variation can reveal the extent to which two similar figures in the same grave represent

different aspects of the overall message of the burial inventory. Accordingly, types and variants can also be separated contextually. To this end, we have selected nearly 80 burials from excavation publications. There are about 200 terracottas in northern Greece and about 100 in Taranto which can be assigned to these burials. From their analysis, conclusions can be drawn about the special meaning of the individual figures. Thus, formal and semantic results of archaeological research, which up to now have been investigated separately, merge with each other at this point.

The impact of code-based epistemic methods on archaeology

The final analysis will again reflect the possibilities of creating archaeological typologies with digital methods, especially using 3D models and image recognition algorithms. The epistemological possibilities of working with 3D models and algorithms will come to the fore when we discuss the implications for cultural history research in general: How can meta- and paradata be meaningfully prepared and how can they be produced in such a way as to be available to the community? What is the relationship between form and content and how can we define it when working with digital models? How can the meaning of dimensional comparisons and similarity relations be determined without reintroducing structuralism and its deceptive authority through the back door? How can this proposal of objectivity be relativized and how can digital structures be extended to include historical components that can be evaluated?

Since the objects of archaeological study are digitized representations of the artifacts and not the artifacts themselves in their original material form, the question arises as to what extent code-based epistemic methods such as the object mining yet to be developed have categorically prejudiced the research question and analysis. How has the structure of technical processes influenced archaeological analysis and vice versa? And what opportunities for obtaining further knowledge through the focus on the digital and the ensuing need for algorithmic stringency remain untapped?

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BROWSER ART: NAVIGATING WITH STYLE

INGE HINTERWALDNER, DANIELA HÖNIGSBERG

ABSTRACT | From the mid-1990s, works of browser art emerged as a particular variant of net art or speculative software, developing alternatives to conventional internet browsers and rendering the content of web pages in a different way. Since we see them as productive image-machines, we consider both the phenomenology of their audio-visual output and their operational code level. We use an example to show why it is helpful, or even necessary, to take a closer look at programmed art works — and thus paradoxically to adopt a 'distant reading'. There are many ways of creating a seemingly identical surface effect, though this may have been caused by completely different artistic gestures. Where should we look for the evidence? We agree with Florian Cramer that the code is a crucial site for the inventive engagement of their producers and is instructive in this regard. Furthermore, we are interested in capturing the dynamics of a piece of software during its execution. For this purpose, art history's vast methodological tradition is to be enriched with software visualization tools, while the latter are endowed with art history related reasoning. Lev Manovich, who developed the 'multi-scale view' for film, along with Shane Denson and Andreas Jahn-Sudmann, who transferred it to games, paved the intellectual path for our approach.

KEYWORDS | digital art, browser application, visual thinking, interface, methodology

Software art and its (contested) visuality

Given that software art or programmed applications are pieces of written code, there are legitimate arguments for vetoing the prioritization of their phenomenological level. The literature and art history scholar Florian Cramer, for example, draws attention to the fact that one cannot arrive at an adequate appreciation of software art if one — following the tradition of Romantic philosophy — privileges aisthesis (perception) over poiesis (construction), thereby limiting the concept of art to whatever can be touched, seen, and heard.[1]

Cramer sharpened his understanding of software art — which for him is characterized by an anti-visuality — by defining as its antithesis something he called 'neo-Pythagorean digital kitsch'. It was apologists of a 'post-optical age' or of a rigorous primacy of program code over its 'secondary effects' on the monitor that prompted the objection of artist Johannes Auer (aka Frieder Rusmann), who coined the neologism 'binary idealism' for it.[2] The pendulum thus swung back again, demanding once more a turn towards something sensually perceptible. This swing back implies the statement that in the digital world the image (Bild) receives little attention — which may be surprising given the fact that everything on the screen (Bildschirm) can be seen as an image due to its pixel matrix (Bildpunktmatrix).

Admittedly – to concur with the art historian Margarete Pratschke – there still lurks the possibility that "one of the most viewed images worldwide, if not the most viewed image of the present-day, [...] is hardly perceived as such. The image so often overlooked because of its instrumental character is the so-called graphical user interface. This refers to the image or image system specified by the computer's operating system, usually displayed on the screen as soon as a computer is booted up and through which users interact with the computer."[3]

It follows from this understanding that infrastructural image systems turn "any interaction on the computer into work on an image."[4] In his plea against neglecting the visual level, Auer refers to the artist couple JODI (Dirk Paesmans and Joan Hemskerk), who have been regarded for decades as classics in their field for their programmed interventions on the internet and for their game modifications. JODI explained: "Media art is always on the surface. You have to get people very quickly."[5] Admittedly, this proposition should be taken with a pinch of salt in the case of this artist duo.

Browser Art as Image-Machines

Let us consider both aisthesis and poiesis. We speak here of 'image-machines' in procedural applications such as interactive simulations, internet browsers, or computer games. This is because the output on the screen or through the loudspeaker is generated by intervening mechanisms that 'execute' and 'compose'. These applications are generative as well as operative, and thus do not merely represent something pre-existent. This is the reason why even commercial browsers differ in how they interpret web content and render it slightly differently. However, they all remain committed to the page metaphor, and to an output of the web page according to the presumed intensions of the web developers and web designers.

We call what browsers – as information-changing image-machines – produce as output, procedurally composed, iconic artifacts. The term 'artifact' does not refer to something object-like but instead emphasizes its status of having been created in the sense of 'arte factum'. Furthermore, the browser's access to the web servers and the retrieval and processing of the data of the accessed web pages are central components of these composites.

From the mid-1990s, works of art browsers emerged as a particular variant of net art or speculative software. Whether in their functionality or in their visuality, art browsers develop alternatives to conventional browsers and replace static presentations either "with alternative, readability-resolving static presentations [...] or with dynamic, transitory presentations."[6] In the static or dynamic output, the 'objets trouvés' from the internet are each characteristically arranged and staged. In this way, they set different emphases, often offering new functionalities, and encouraging us to rethink existing categorizations. This whole output complex of browser programs with their algorithmic substructure can be discussed in terms of a (multimodal) pictoriality. How the programs sample this in each case on the fly has not yet been adequately captured or understood.

Theory of the Digital Image

If we take Cramer's announcement seriously that in programmed works the code level is the main site of their producers' engagement, one could in a first step pay attention to how theorizing on digital imagery has conceptually addressed this domain. Are there ideas in the literature on how to imagine the 'subcutaneous' levels of programmed works? Can we find statements about how to think productively about the relationship between the code, the program environment, and the output from a humanities perspective?

Or do the text analyses reveal that the technology-intensive side of software-based works remains a black box? Around the turn of the millennium – in parallel with the advent of artistic browsers – fundamental discussions on the digital image emerged. In the following we will take a brief look at one of these positions to see how far it can take us in our investigation:

If the concepts of surface – interface – subface of the computer graphics pioneer and computer scientist Frieder Nake had to be roughly assigned to what has been outlined so far, the preceding statements would speak of software
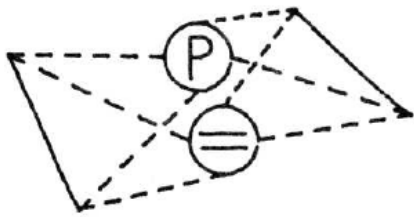
A. OPERATION DEFINITION
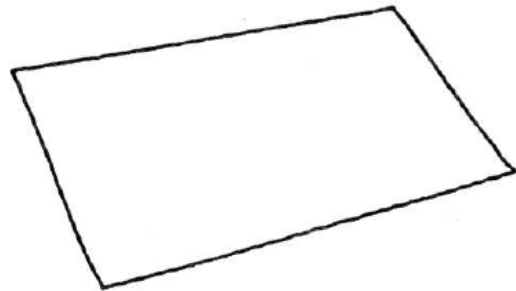
B. PICTURE TO CONSTRAIN
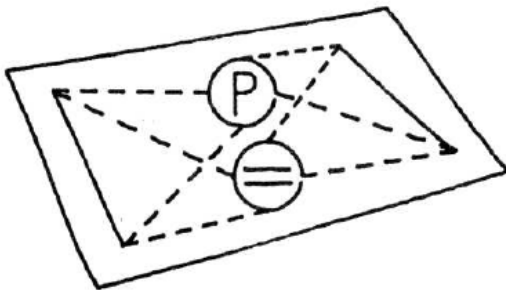
C. DEFINITION COPIED
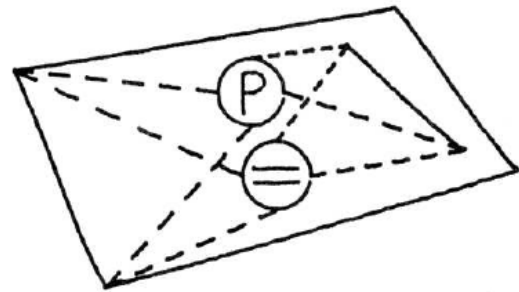
D. FIRST LINE MERGED
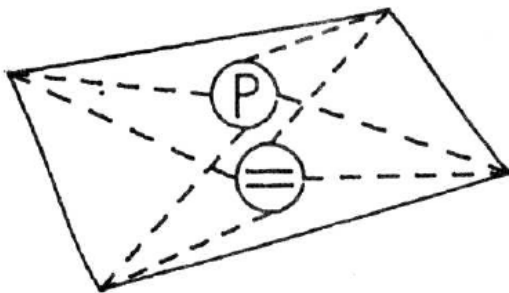
E. SECOND LINE MERGED
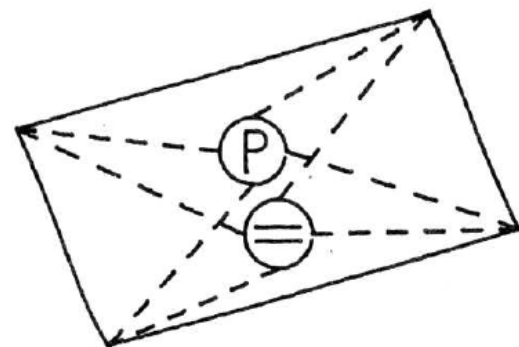
F. CONSTRAINTS SATISFIED

FIGURE 6.1. APPLYING TWO CONSTRAINTS INDIRECTLY TO TWO LINES

P PARALLELISM   = EQUAL LENGTH

Figure 1. Ivan Sutherland; Sketch depicting the application of a condition composed of two constraints (parallel, equal length). Thus the rectangle becomes a parallelogram; 1963. Ivan Sutherland; Sketchpad: A man-machine graphical communication system, PhD thesis, MIT, Cambridge 1963, fig. 6.1, p. 94. cit. in: Nake, Frieder. "Das doppelte Bild." Bildwelten des Wissens. Kunsthistorisches Jahrbuch für Bildkritik, vol. 3, no. 2 (2005): 40–50, here: 45.

art as (primarily) subface, media art as (primarily) surface. Of course, this is not mutually exclusive. According to Nake, as soon as the image became algorithmic, it doubled, in that in addition to the surface it now simultaneously possessed a "subface inwardness". He explained this with the help of an illustration found in the seminal work by Ivan Sutherland (fig. 1).

"The image as a digital image has become first and foremost *algorithmic*: It now also possesses a subface/ subfacial inwardness or is surface and subface at the same time. Both – this is decisive – are objectively present. The surface of the digital image is *visible*, while the subface is editable. The surface exists for the user, the subface for the processor. To the subface belongs solely that which exists as data structure and algorithm."[7]

Comparing two web browsers on a phenomenological level – the surface

Using examples from the body of art works we are investigating we will now illustrate how far we can get in an art historical analysis of artistic web browsers without including the source code or Nake's idea of the subface in a formal description of the artwork. To this end a basic comparison of a web page opened in Apple's Safari browser 13.0.1 and the same page opened in the Riot browser by the artist Mark Napier from 2005, both opened on the same day on January 22, 2020, seems to be a reasonable first step. The page accessed by both browsers is the former landing page of the art history website at the Karlsruhe Institute of Technology (fig. 2).

The Safari browser interface is roughly composed of a menu bar at the top of the window, including the URL input field, a scroll bar on the right side of the window, and a scalable display area, which allows for the appearance of a further scroll bar at the bottom of the web page. It is not to be expected that a more detailed description of Safari's interface would lead us to any meaningful insights since in this case the browser interface is not from the same time period and thus cannot tell us much about the similarities or differences to the Riot browser's interface regarding conventional browser interfaces of the time. Furthermore, while the interface is part of our investigation, it will not be the prime concern of this text. It is the visual output of the webpage being accessed that we are going to focus our attention on for the moment. This visual output is shown in the display area of the web browser. The way it is, or rather was, displayed in the Safari browser is supposedly the way the website developers and authors of the page intended it to be seen. The page shows a clear structure, which roughly consists of a pictorial header or banner, a menu bar on the left, a column with information boxes on the right and a scrollable section in between that contains both text and images. The first element of the middle section is a slider that changes the displayed picture every few seconds. The other parts of the page are, apart from their partial scrollability, static. There is a discernable color scheme with a neutral black for most of the text and a shade of turquoise for selected graphical elements and hyperlinks. The hyperlinks are therefore embedded in the design and structure of the page.

Even when compared to the much more recent Apple browser, Mark Napier's Riot browser is very similar in its interface. Again we find a menu bar at the top of the window, scroll bars on the right and conditionally at the bottom, and a scalable display field. The menu bar contains a label on the left with the name of the browser, a button for bookmarks, the input field for URLs with the accompanying label 'address' and a Windows logo (1992-2006) on the right. The visual output of the page, however, differs considerably from that of the Safari browser. The structure of the page is completely resolved, and images, text and links are subject to layout rules that obviously differ from those followed by the conventional browser.

At the upper left edge of the display area three URLs are listed horizontally in bright green. The first of them is the URL we just typed in, while the two others are the URLs of webpages entered by previous users of the browser. This aspect is already knowledge gained through the artistic narration accompanying the work, and not something that can be directly discerned from the image on the screen. However, there are clear indications that the origin of the content we find is not solely the accessed webpage. We see a graphic of a skull, links and text that seem to be Japanese, and a picture of a cat. None of these elements can be found on the page we accessed. What can be found on our art history homepage are the pictures that are used for the slider. But in contrast to the depiction in the Safari browser we can recognize at least three of these pictures included in the composition, temporally compressed into the same layer, into the same image. It is challenging to describe the occurring elements in a systematic way, because pictures, text and links are organized in an overlapping manner and seem to be concentrated in the

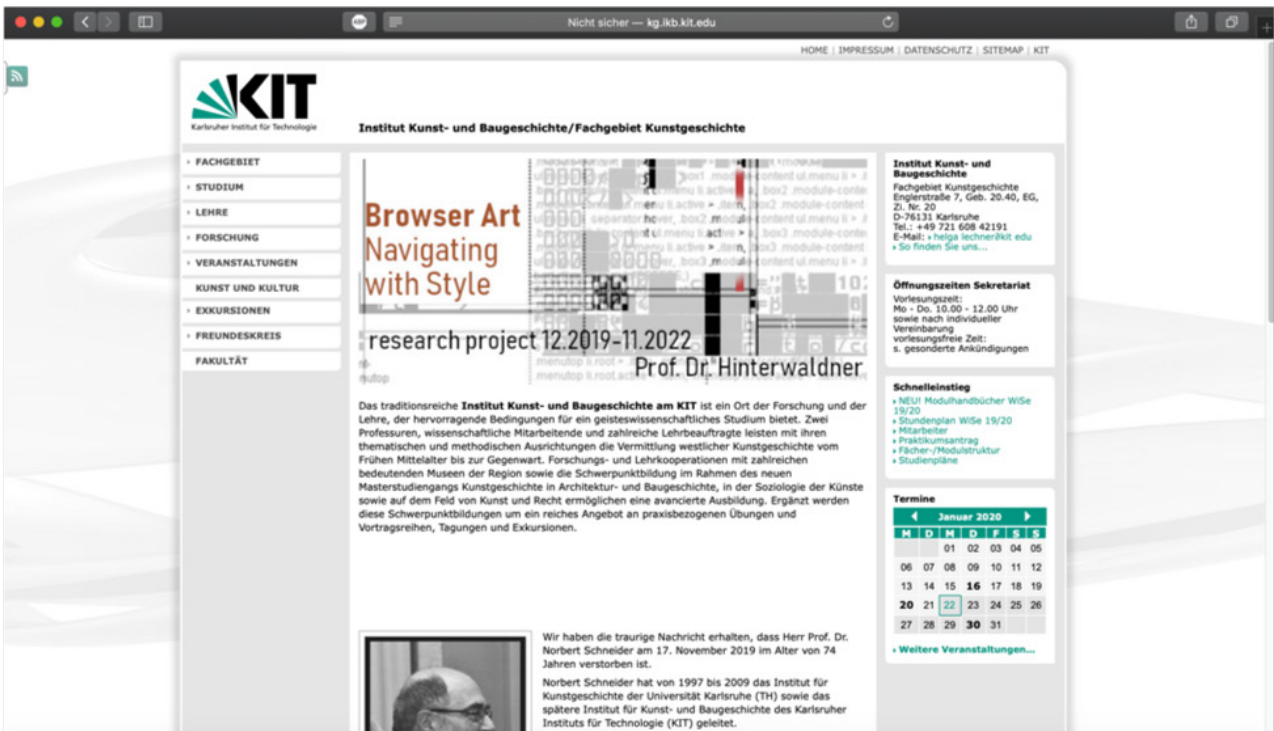*Figure 2. above: Apple; Safari Browser 13.01.; 2019; accessed page: http://kg.ikb.kit.edu/; screenshot (January 22, 2020), below: Mark Napier; Riot Browser; 2005; http://www.potatoland.org/riot/; ac-cessed page: http://kg.ikb.kit.edu/; screenshot (January 22, 2020).*

middle section of the page displayed in the browser window. And although the page remains scrollable, most of the emerging composition can be seen in the section of the browser window first displayed. All of the intended design for the color scheme and text fonts of the webpage has been discarded. The functionality of the links on the page is retained, but instead of the original turquoise they are displayed in a generic way: underlined and in a blue font.

The resulting image created by re-composing the page's content and collaging it with two other pages detracts from our ability both to recognize the boundaries of the three pages and to access the information included in the intended content of any of them. As this short formal analysis shows, an examination of the visuality produced by the browser already contains a multitude of insights and possibilities for further investigations. Is it therefore possible to answer the questions we as art historians would like to ask about the artwork? These images – one can be sure – are more than they show or at first would have us believe. Some aspects become explicitly evident during user interaction, but other aspects remain hidden within the black box and implicit(ly effective) as long as we do not care about the level of algorithms and codes. Can we describe and compare the work not only on its motivic and iconic but also on the technical-procedural, geometric, ideological and reception-oriented levels? Which parameters play a role when it comes to determining stylistic differences of programmed application? Can we actually recognize a particular artistic style? And if so, where can it be found? In the code? In the resulting image? In the concept underlying it or the interaction it enables? Should we expect information about the variety of interpretations – cast in multimodal outputs – of what a certain artistic intervention is supposed to be and how it should be carried out? Ideas about propagated website norms, user-friendliness, the (re-)education of the user's habits, etc. anchor a specific understanding of the user in each browser.

For this purpose, it seems worthwhile not only to examine the screen outputs, but also to grasp the code in its conceptual dimension. One consequence could be to use computer-assisted imaging in programmed (both artistic and scientific) works to pave the way for analytical access to all levels of design. Without thereby preaching a new positivism, we therefore advocate an expansion of the comparison zone into the creative depth, methodological breadth, and disciplinary diversity within the framework of image-centered approaches.

Why the surface inspection is not enough – the subface

Let us use an example and a small practical experiment to demonstrate why a surface inspection is not enough. This text you are reading is written in Word, a word processing program by Microsoft. Pasting or typing a few lines of text into a document of a text editor gives us a wide range of options for editing that text. Our goal is to make part of the text invisible. Although it probably does not exhaust the functionality of the program, the three most obvious solutions seem to be: a) Select the part of the text to be withdrawn from view and set the font color to the active background color. b) Obscure the text part with a shape of the same color as the background color. And c) delete the text part and optionally replace it with blank spaces. Even though very different actions were performed, and if, in the third solution, we choose to replace the text with blanks, the visual result of all three options is the same and cannot be distinguished by a purely visual inspection. The visual output of a web browser created in an artistic context is visually determined in the same way and the executed processes may be indistinguishable in the visual result.

This is not quite as trivial as the short example in Word might suggest. Several artistic browsers withdraw the visibility of the text and in some cases other visual elements on the web pages, in a very similar manner (fig. 2). Rafaël Rozendaal's and Jonas Lund's Text Free Browsing is a Chrome extension dating from 2013 that erases the text of the accessed pages. Structurally, the pages are unchanged, so that the areas where the text would be remain blank. An ostensibly identical result is produced by the plug-ins Wordless Web by Ji Lee in 2012 and The Deletionist by Nick Montfort, Amaranth Borsuk and Jesper Juul from 2013. The text is purged from the webpage in all three cases, though texts embedded in graphics are still displayed and The Deletionist selects a number of text fragments that will continue to appear in the output. Another example is the simulated browser Internet Implorer from 2000 by Rolux aka Sebastian Lütgert. In this case, both text and images are extracted, but the structure of the website still remains intact. Pages opened in the simulated browser Boxplorer by Andy Deck from 2002 are also liberated from their structural design, so that not only are images and text removed from the website, but also any visual information that could indicate the intended content of the page. The historical visual result of this

artistic intervention is primarily a composition of individually nested color fields framed in black. When used with more recent web pages, its structure is highlighted in the same way; the dominant color is white because today's way of designing web pages has changed. The same process of the browser now delivers results lacking colors and unintentionally highlights the structuredness more strongly. If it is now to be assumed that deleting content is an artistic act that differs from the artistic act of concealing, hiding, covering up or undifferentiating it, then it becomes relevant in the analysis to go beyond the mere observation and usage of a web- and computer-based work.

A web browser is a computer program and is therefore based on source code. As the code is largely determined in its interpretation, the easiest way to gain knowledge about the application would be to read the source code. This is a reasonable method used especially in the investigation of smaller applications and with a slightly different focus of inquiry. Two interconnected aspects of our investigation make this approach problematic: First, we focus explicitly on the processes of the artistic web browsers that lead to the perceivable outputs. Although the mere reading of the source code allows for various ensuing approaches, using this method to record the dynamic processes in the program flow is challenging. Second, web browsers are potentially extensive and complex programs. They act as an interface to the World Wide Web and are therefore closely linked to and integrated with the server's hardware and software systems. And so the processes that lead to the output through the browser are not exclusively determined in the web browser's source code.

This also becomes evident when we look at the schematic structure (fig. 3) of a conventional web browser, showing a diversity in infrastructure components. All these components are recorded in source code, which can potentially lead to a relatively high number of lines of code (LOC) to read, especially if all these components are implemented in the artistic projects. A higher number of LOCs does not necessarily lead to higher complexity, but it does make access by reading the code more difficult and it will significantly increase the amount of time involved. This ultimately makes the task of reading and identifying the program's flow and processes more complex. That is an obstacle that should not be underestimated, since we do not intend to limit our examination to a few exemplary artistic browsers but want to include the widest possible selection of works in our analysis. Even if we were both competent and willing to interpret each code in terms of critical hermeneutics, as called for by Mark Marino, representative of critical code studies, there is a good chance that this selection would render the enterprise unmanageable with a close reading approach. Such a 'close reading' can only be done with the help of a community and crowd sourcing.

Methodological Scuba Diving

We see the expansion of the zone of analysis in what academic texts often call 'behind' or 'beneath'. Talk of 'layering' or 'depth' ultimately touches on topological issues. 'Deep tech' refers to the coupling of scientific research and application – and we would add: design. Therefore, we can expect the resulting multimodal imagery to include data, models, parameter settings and so on. For this reason, we understand these programmed or program-based phenomena as 'deep images'. It is therefore mandatory to explore their depths. The most common view is the double-sidedness presented by Nake; besides the surface there is something like an 'underneath'. Do layering and depth represent a problematic way of thinking about our computer systems? In media theory, 'depth' suggests the underlying, the background, the more important, etc.,[8] and thereby implies that the surface is only secondary. Would there be alternative approaches like weaving/mesh[9] or rhizome (after Deleuze/Guattari) as conceptual lenses through which to examine our corpus? Each theory filter highlights something different. We pursue the goal of developing a visualization for image-machines-in-action in order to gain leverage for criticism and comparison at the level of code execution. So it is necessary to consider what basic topological structure to use as a basis. What topological structure do theorists suggest when it comes to characterizing the digital image? A lively discourse on this was developing at about the same time as the phenomena we are investigating. This historical dimension to the discourse should not pose an issue here. In order to take a step forward, we will proceed on several parallel methodical tracks.

A first path is pursued via theory building, so that the existing conceptions of digital imagery can also be incorporated in a reflected way. Several of the relevant texts describe their conceptions of the digital image vividly and metaphorically, so that the attempt of visualizing them in a 'reverse engineering' manner is obvious. A second path is application-centered and leads to an analysis of the individual source codes and their execution. This whole
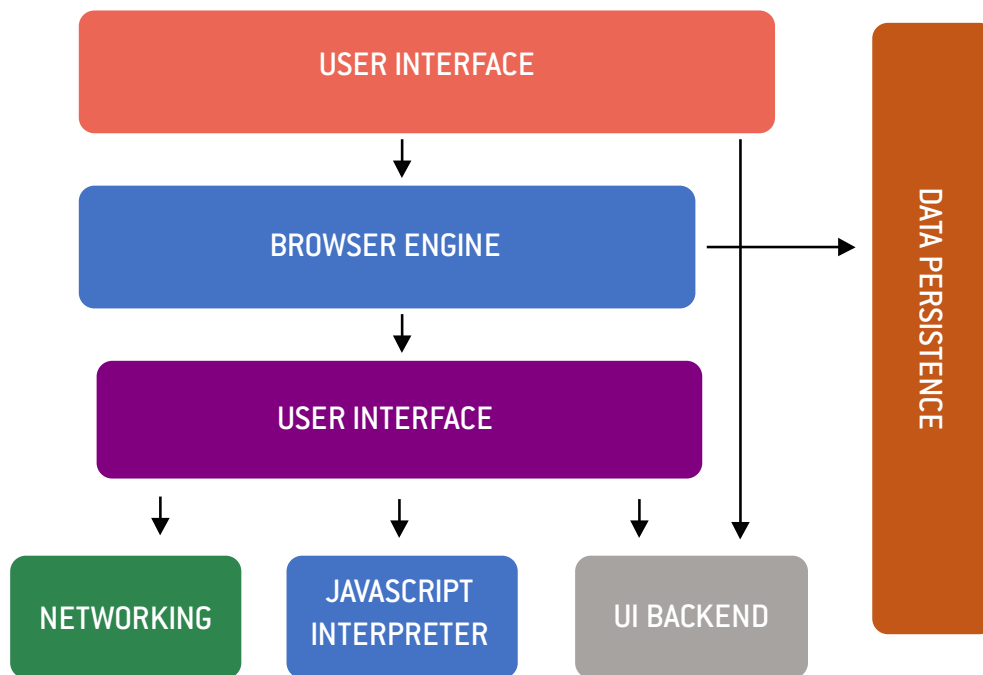
Figure 3. Tali Garsiel; "The schematic structure of a conventional web browser"; tali-garsiel.com/Projects/howbrowserswork1.htm. Refers to Alan Grosskurth; A Reference Architecture for Web Browsers, accessed January 23, 2020. https://grosskurth.ca/papers/browser-re-farch.pdf.

area – software visualization – has been a flourishing applied research field since the 1970s.[10] Visualizing the code and the implemented algorithms is often revealing even for specialists. However, this task also brings difficulties with it. Computer scientists help themselves by developing visualizations that show the program structure or the algorithmic performance of the program under investigation in a different way than through lines of text. Many different visualization approaches and implicit topological models can already be distinguished here, so that on this meta-level also image criticism could offer additional insights. An image-critical analysis of visualizations using software visualization tools is, of course, still pending. Nor are we aware of any humanities case studies that have really attempted to get to the bottom of the production of such a complex interactive real-time image-machine.[11]

Can these visualization types and visualization sources (from theory humanities and software visualization computer science) be related to each other? Is it desirable, usable, viable to do so? If one holds these two kinds of visualizations up against each other as meta-images, friction and incommensurabilities are to be expected, which can have a retroactive effect on our theory building.

Visualizing software dynamics for art history

We only know of a handful of projects utilizing advanced computer-based methods for analyzing programmed, digitally generated image worlds for humanistic ends. Most of them are to be found in game studies. Shane Denson and Andreas Jahn-Sudmann pursued the goal of comparing all existing game modifications of Super Mario Bros (originally 1983).[12] By 2014 they had collected 206 such game mods. What would be the best way of dealing with so many versions, each of which would require several hours of gaming, not to mention the need for studying the code and further para texts like the 'read me' files? Denson decided to go for a 'distant reading' at the code level. He needed a panoramic view of the 'subface'. This diagram (fig. 4) lists the different modifications vertically. The horizontal bars to the right of the titles symbolize the respective code. The orange areas mark paragraphs that were altered in comparison to the original from 1983. This helps at least to estimate the extent of the changes and to indicate where they can be found in the code. Code analysis could develop into a new auxiliary science for art history.

The term 'multi-scale view' was coined by the media and film scholar Lev Manovich. In 2007 he proposed a method termed 'Cultural Analytics' that offers a so-called 'multi-scale view' of big data pools. 'Multi-scale view' means providing a variety of tools for visualizing an artifact or a collection of artifacts on different levels of description, thus allowing for a 'distant reading'. In our view Denson and Jahn-Sudmann have begun to expand the 'multi-scale view' that Manovich had developed for the 'surface' to include the levels of programming and modelling. Code analysis and various forensic software could develop into a new auxiliary science for art history too.

This can be transmitted to browsers if it turns out the codes are sufficiently 'connatural' (related). One hypothesis to be tested is that artists have not reprogrammed all aspects of a browser but instead have adopted large portions of the code from conventional browsers that remained identical in the new application. Should this hypothesis be confirmed, the precondition for a machine-assisted comparison would be met and it would be possible to apply a visualization method such as that used by Denson and Jahn-Sudmann. Our project could thus show where artistic intervention takes place and identify those processes a web browser performs that are of intrinsic interest to artists. For it can be assumed that not all components of the web browser are equally interesting for the artistic intervention. This is also indicated by the artistic development of browser extensions (called add-ons, plug-ins or extensions, depending on the browser). These extensions modify or supplement individual functions of a conventional browser, but use the existing functions of the web browser as their basic technology.

One example is the artistic Chrome extension Text Free Browsing, which is mentioned in its general functions above. If we take a look at the complete code of the Chrome extension (fig. 5) we see there are only a few lines. This suggests that only very few lines of code are needed to generate far-reaching changes in the output of the web page. If we take a closer look at the individual sections of the code, we see that the whole section shown in figure 5a does nothing more than define the design and function of the button for the extension in the Chrome browser's interface. So only a few lines of code affect the difference in the output of the page when compared to the output of a conventional browser. If these lines of code were embedded in a browser of a similar size, such as the Chrome browser, as might be the case in the artworks that comprise a complete application, then our analysis faces the simple problem of finding these lines of code.

If a visualization technique could show these deviating sections in the source codes, it could be an extremely helpful tool. However, the application of such a tool is bound to a number of conditions, formulated above as a hypothesis. These conditions are that the artistic browsers are not only similar in some of their basic functions, but also that this functional equality is reflected in the structure of the source code. Such equality can only be presumed if common code segments are actually being used. Whether this is the case, and whether this approximation will be possible, is yet to be determined in our further investigation of the artworks.

However, if it is indeed possible to employ this tool, it will only provide an overview of the sections of the code that require a more detailed analysis. The color-marked bars in the Gantt chart visualize the sections in which the modified program differs from the original program. They do not, however, tell us anything about *what* happens in these modified areas or *when* in the program flow they come into effect, since the arrangement of the source code does not allow any conclusions to be drawn about the dynamic execution of the program. This visualization would thus only be a first step in the analysis of the source code with the objective of making visible the processes that lead to the perceptible output of the artistic browsers.

The software visualization offers many approaches for different queries concerning the program, individual program parts or program functions. Would it then be conceivable for our project to visually track the data requested from the server to the accessed website through the processes of the program? After all, we want to know how the reception and processing of the same data package can lead to displays that differ significantly from those of conventional browsers. Would it be possible to imagine the path of this data package through the program as being equivalent to a conveyor belt that is carrying a packet through a factory? Where maybe at the first station it is cut open and its contents are distributed to branching conveyor belts? And where at a subsequent station parts of the content are cut out, pasted over or rearranged and then at another station perhaps reunited with other contents of the package to arrive at the end of the assembly line as the output of the respective artistic browser?
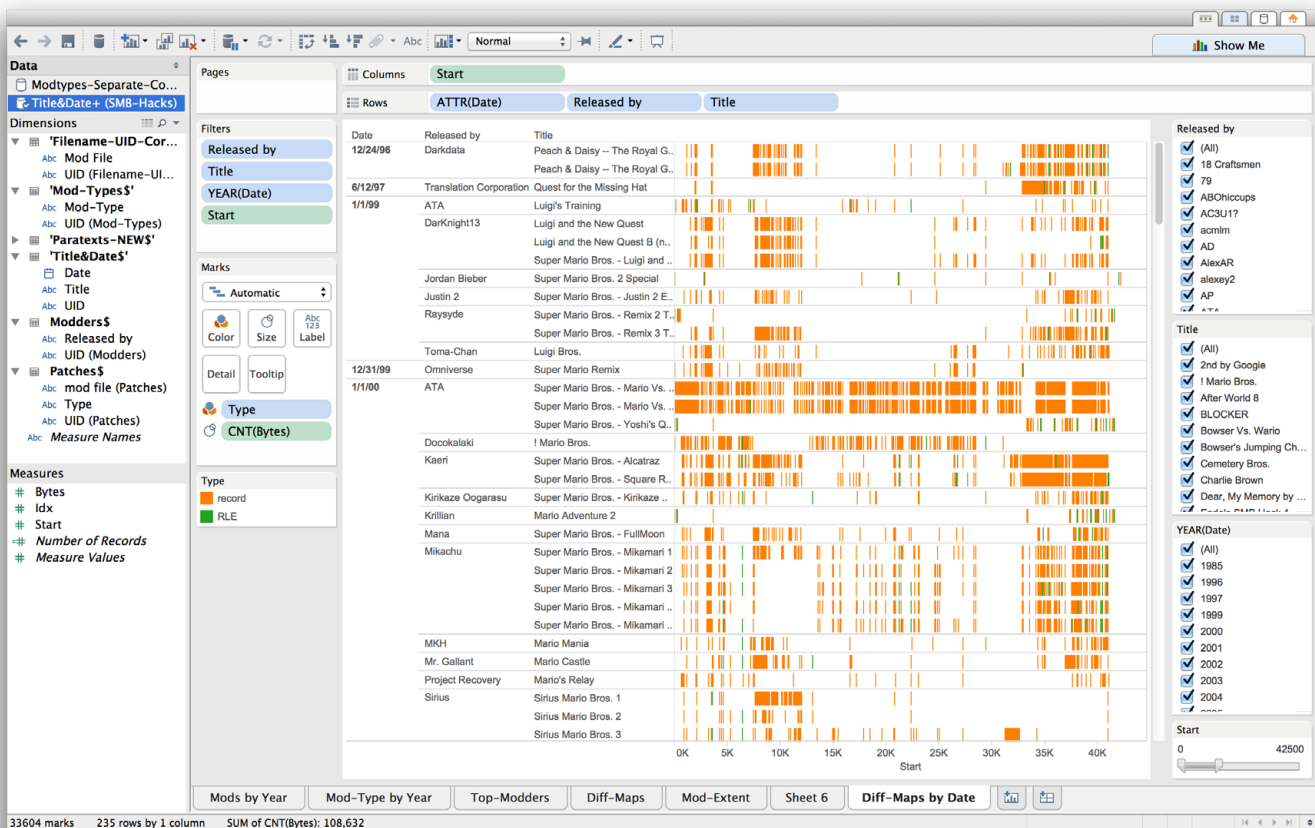
Figure 4. Shane Denson. "Super Mario Bros modifications as seen through Diffmaps by Modder"; 2014; screenshot. Shane Denson; "Visualizing Digital Seriality, Or: All Your Mods Are Belong to Us!". In Kairos. A Journal of Rhetoric, Technology, and Pedagogy, vol. 22, no. 1 (2017), fig. 11, accessed January 22, 2021. http://kairos.technorhetoric.net/22.1/topoi/denson/index.html.

Flowcharts are a common way of visualizing software in its structure and processes. For example, in figure 6 we see the control flow diagram of a rendering engine. The diagram also visualizes – although perhaps less dramatically than with our conveyor belt analogy – the path of the data through the rendering engine. However, it does not illustrate what specifically happens at each individual point. In order to be able to visualize the information about what happens at the individual steps of this process without losing the overview of the process flow in its entirety, it is necessary to increase the dimensions of the representation. The obvious additions would be those of another spatial and a temporal dimension. But the diagram can also be enhanced by further dimensions like form, color, or size of the data object and its contents. One could imagine that the idea of an assembly line operating in an image-producing factory might no longer seem that far-fetched at this point.

In an effort to produce further results for our analysis, it would be desirable to be able to compare the artistic browsers with each other. However, the visualization in which the data moves through a set environment would make such a comparison problematic. Can we assume that all process steps can be found in every browser and that those common points only differ in the operations performed on the data package? Is it not the difference in the program environment of each individual artistic browser through which the data package moves that distinguishes the browsers and the visual output they produce? As we have seen in the example of the Text Free Browsing extension, the fundamental differences in the source code of each browser are possibly only very small. In a visualization that requires a certain degree of abstraction to model the basic processes of a web browser, these differences might be hardly perceivable or displayable at all. The development of possibilities that make both the macro- and micro-variability in the individual art projects visible and comprehensible and yet which still establish comparability is another task that we will address in the further course of our project.

Conclusion

In the early 2000s the digital image is often described as something different to more familiar phenomena: Nake starts from a drawing that is seen, and attributes the innovation that comes with the digital image to an incorporated splinter of intelligence.[13] The literary scholar Mark B. N. Hansen refers to Gilles Deleuze. He agrees with the latter on setting the cinematographic image or time-image as a starting point and discusses the conditions of the continuation of the tendencies already laid out in the cinema.[14] Media scientist Wolfgang Hagen starts with photography and presents a probability-only scenario via quantum mechanical principles.[15] In his text "Das digitale Bild gibt es nicht" (The digital image does not exist), media theorist Claus Pias focuses on the conversion pipeline and the opposition of visibility and digitality.[16] The image theorist and performance artist Ingrid Hoelzl bids farewell to dichotomies of all kinds and activates an economic transaction model, pairing this with New Materialism approaches to an intra-image and a networked image with egalitarian agents of various kinds.[17]

For the sake of brevity, we cannot go into the individual results of these analyses here. They have the following in common: they all speak of the digital image as a prototypical unity/multiplicity/processuality, etc.; thus, they are not concerned with portraying a specific application.

For a better comparability of these positions, we aim conversely at visualizing the lines of argumentation of the individual texts. In the text and discourse analysis we were able to extract and sketch the subcutaneously implied topological and symbolic clues related to the respective understanding of the digital image. In fact, we would literally have to animate every text in order to witness the argumentation step by step and to filter out which topological ideas appear at what point and where they remain indeterminate.

Why do we need these pictorial textual analyses? They serve to set the conceptual-topological course for the most productive transfer of understanding to a particular programmed work. According to our questions, productivity is measured in terms of the clarification of those elements which are phenomenologically decisive for the differences. It is still unclear whether (or how) the representations resulting from the theoretical analyses of digital images *in general* are transferable to sketches of concrete programmed works.

It is confusing to attempt to highlight the components of a *specific* web browser without visual aids. In contrast, figure 3 depicts the essential components of a generic web browser. Even in this simple schema, each of these squares is a black box in itself. The diagram clearly conveys the composite nature of a web browser. There are some obvious shortcomings: First, it does not tell us anything about the individual browser. Second, this sketch is not developed in accordance with our main interests and does not support art historical analyses of artistic web browsers. Third, it does not explain in any way how the elements are actually connected via the code and the program, or how they work together dynamically.

All these elements play a role. But to grasp their coherence in actu, it is necessary to find a way to inspect them in their interlocking performance. Geoff Cox, Alex McLean, and Adrian Ward argue that — analogously to poetry — the aesthetic value of code lies in its execution, performance, or presentation, and not simply in its written form. Nor in the analyzed written form that distinguishes subsections (generative aesthetics analyzes processes anyway).

But in order to really appreciate the generative code and to grasp what is going on, we must perceive it — "we need to 'sense' the code".[18] Otherwise we would have to admit that we have only a restricted view. Consequently, scholars face the danger of a limited ability to criticize as soon as they methodically separate the code from its actions or the actions resulting from it. The written code — as revealing as the analysis of it may be, because this writing is also individually fabricated and idiosyncratically colored in many ways, despite its rigid grammar and orthography — does not yet reveal the poetic and functional qualities of its performance. In the words of Cox and colleagues: "Code is a notation of an internal structure that the computer is executing, expressing ideas, logic, and decisions that operate as an extension of the author's intentions. The written form is merely a computer-readable notation of logic, and is a representation of this process. Yet the written code is not what the computer really executes, since interpreting and compiling and linking takes place on many levels. Code is only really understandable within the context of its overall structure — this is what makes it like a language (be it source code or machine code, or even raw bytes)."[19]

```
var on = 0;
chrome.browserAction.onClicked.addListener(function(tab) {
  if(on === 0) {

    chrome.browserAction.setIcon({path: 'text-no.png'});
    chrome.browserAction.setTitle({title: "Stop Text Free Browsing"});
    on = 1;
    localStorage.setItem("textfree", "on");

    chrome.tabs.getSelected(null,function(tab) {
      chrome.tabs.sendMessage(tab.id,{method:"start"}, function(response){
      });
    });

  } else {

    on = 0;
    localStorage.setItem("textfree", "off");
    chrome.browserAction.setIcon({path: 'text-yes.png'});
    chrome.browserAction.setTitle({title: "Start Text Free Browsing"});


    chrome.tabs.getSelected(null,function(tab) {
      chrome.tabs.sendMessage(tab.id,{method:"stop"}, function(response){
      });
    });


  }
});

chrome.extension.onMessage.addListener(function(request, sender, sendResponse) {
    if (request.method == "getStatus")
      sendResponse({status: localStorage['textfree']});
    else
      sendResponse({}); // snub them.
});


chrome.tabs.onActivated.addListener(function(info) {
  var tabID = info.tabId;
  if(localStorage.getItem("textfree") === "on") {
    chrome.tabs.sendMessage(tabID, {method:"switchstart"}, function(response){
    });

  } else {
    chrome.tabs.sendMessage(tabID, {method:"switchstop"}, function(response){
    });

  }
});

//get all tabs and insert check.js
chrome.tabs.query({}, function(tabs) {
  for (var i = 0; i < tabs.length; i++) {
    var tabid = tabs[i].id;
    chrome.tabs.executeScript(tabid, {
        file: "check.js"
    });
  }
});
```

```
html {visibility: hidden;}
```

```
html {visibility: visible !important;}
```

```
var textfree = localStorage.getItem('textfree');

chrome.extension.sendMessage({method: "getStatus"}, function(response) {
  if(response.status === "on") {

    var css = '* {color: transparent !important;}',
    head = document.getElementsByTagName('head')[0],
    style = document.createElement('style');
    style.setAttribute("id","textfreestylez");

    style.type = 'text/css';
    if(style.styleSheet){
      style.styleSheet.cssText = css;
    } else{
      style.appendChild(document.createTextNode(css));
    }
    head.appendChild(style);
    document.getElementsByTagName('html')[0].style.visibility = 'visible';

  } else {
    document.getElementsByTagName('html')[0].style.visibility = 'visible';
  }

  //catch annoying weirdo html repaint issues and what not
  setTimeout(function() {
   document.getElementsByTagName('html')[0].style.visibility = 'visible';
  }, 1000);

  setTimeout(function() {
   document.getElementsByTagName('html')[0].style.visibility = 'visible';
  }, 2000);

  setTimeout(function() {
   document.getElementsByTagName('html')[0].style.visibility = 'visible';
  }, 3000);

});


chrome.extension.onMessage.addListener(function(request, sender, sendResponse) {
  var styles = document.getElementById("textfreestylez"),
      css = '* {color: transparent !important;}',
      head = document.getElementsByTagName('head')[0],
      style = document.createElement('style');
      style.setAttribute("id","textfreestylez");
      style.type = 'text/css';

      if(style.styleSheet){
        style.styleSheet.cssText = css;
      } else{
        style.appendChild(document.createTextNode(css));
      }

  if (request.method == "start") {
    head.appendChild(style);
    document.getElementsByTagName('html')[0].style.visibility = 'visible';
  }

  if(request.method == "stop") {
    if(styles) {
      styles.parentNode.removeChild(styles);
    }
    document.getElementsByTagName('html')[0].style.visibility = 'visible';
  }

  if(request.method == "switchstart") {
    if(!styles) {
      head.appendChild(style);
    }
    document.getElementsByTagName('html')[0].style.visibility = 'visible';
  }

  if(request.method == "switchstop") {

    if(styles) {
      styles.parentNode.removeChild(styles);
    }

  }

});
```

Figure 5. Rafaël Rozendaal, and Jonas Lund; Source code of the Chrome extension Text Free Browsing; 2013; screenshot; back-ground.js (p. 50, above), hiddens.html and shows.css (p. 50, below), check.js (p. 51).
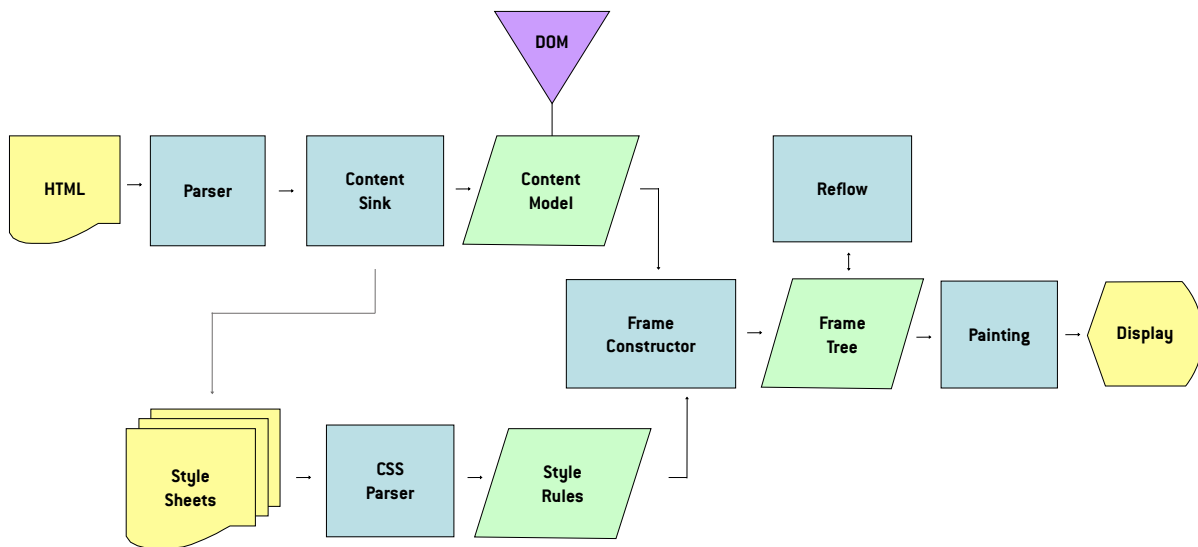
Figure 6. Tali Garsiel; Flowchart of the Mozilla's Gecko rendering engine main flow; 2011; Garsiel, Tali, and Paul Irish. "How Browsers Work: Behind the scenes of modern web browsers." Last modified August 05, 2011. https://www.html5rocks.com/en/tutorials/internals/how-browserswork/. Refers to Chris Waterson. "Mozilla's Gecko rendering engine main flow." (2002), accessed January 28, 2020. https://www.mozilla.org/de/newlayout/doc/gecko-overview.htm.

It follows that the subface must also be multiplied, and processes must be focused. A scaling problem is foreseeable. Finding a way to visualize the scanning of the decision tree of program structures of artistic internet browsers in actu involves witnessing these processes running in secret and comparing them on the level of their procedures and functional mechanisms. Time-based portraits of the respective effective mode of operation allow for observing how the synthesizing of internet content proceeds in a browser-specific way.

We therefore wish to extend the territory of analysis so that it encompasses the perceivable audio-visual screen output through to sequences of program mechanics. This could ultimately be framed as a re-phenomenologizing of generative aesthetics. For the investigation, this ultimately means we need a tool, i.e., a close reading using meta-images. We see that there is still work to be done in visualizing generative aesthetics in procedural applications, we still see a task ahead – and with browsers that means not only surfing but also diving.

NOTES

[1] Florian Cramer, "Concepts, Notations, Software, Art." *Netzliteratur.net* (March 23, 2002), accessed December 14, 2002, https://www.netzliteratur.net/cramer/concepts_notations_software_art.html.

[2] Johannes Auer, "Screaming Screen und binärer Idealismus/Screaming Screen and Binary Idealism," in *p0es1s. Ästhetik digitaler Poesie / The aesthetics of digital poetry*, ed. Friedrich W. Block, Christiane Heibach, and Karin Wenz (Ostfildern-Ruit: Hatje Cantz, 2004), 277–282.

[3] Margarete Pratschke, "Die grafische Benutzeroberfläche als Bild. Zur Rezeption von Rudolf Arnheim und Ernst Gombrich in der Computer Science der 1970er Jahre," *kritische berichte* 37, no. 4 (2009): 54. Translated by the authors.

[4] Pratschke, "Die grafische Benutzeroberfläche als Bild. 54.

[5] Dirk Paesmans, interview by Tilman Baumgärtel, October 6, 1997. See also Inge Hinterwaldner, "Programmierte Operativität und operative Bildlichkeit," in *Die Kunst der Systemik*, ed. Mikuláš Roman, Sibylle Moser, and Karin S. Wozonig, (Münster: Lit Verlag, 2013), 77–108.

[6] Thomas Dreher, "NetArt: Links (alphabetisch)," IASL online, http://iasl.uni-muenchen.de/links/NALink.html, accessed December 15, 2020. Dreher refers to: Nina Kahnwald, "Kunstbrowser. Neue Strategien der Inszenierung von Informationsstrukturen." Magisterthesis, Freie Universität Berlin, 2002. Print version: Kahnwald, Nina. *Netzkunst als Medienkritik. Neue Strategien der Inszenierung von Informationsstrukturen* (Munich: kopaed 2006).

[7] Frieder Nake, "Das doppelte Bild," *Bildwelten des Wissens. Kunsthistorisches Jahrbuch für Bildkritik* 3, no. 2 (2005): 47.

[8] Cf. Boris Groys, *Unter Verdacht. Eine Phänomenologie der Medien* (Munich: Carl Hanser, 2000).

⁹ Cf. Birgit Schneider, *Textiles Prozessieren. Eine Mediengeschichte der Lochkartenweberei* (Zurich: diaphanes, 2007).

¹⁰ Cf. John T. Stasko et al., eds. *Software Visualization* (Cambridge, London: MIT Press, 1998). Stephan Diehl, *Software Visualization: Visualizing the Structure, Behaviour, and Evolution of Software* (Berlin, Heidelberg: Springer, 2007).

¹¹ In corresponding discussions, the view repeatedly comes to light that such a positivistic approach, which also looks at small details, does not justify the effort, as marginal results are to be expected. However, it is important to know that the code explicitly and effectively implements policies and biases regarding the (role of the) users.

¹² Shane Denson, "Visualizing Digital Seriality," in *Duke Visualization Friday Forum, Durham, Duke University*, January 16, 2015, accessed April 8, 2016, https://compsci.capture.duke.edu/Panopto/Pages/Viewer.aspx?id=e4a5e2b8-1bdd-4ad5-b734-be4bc23baf2e.

¹³ Frieder Nake, "The Display as a Looking-Glass: Zu Ivan E. Sutherlands früher Vision der grafischen Datenverarbeitung," in *Geschichten der Informatik. Visionen, Paradigmen, Leitmotive*, ed. Hans Dieter Hellige (Berlin, Heidelberg: Springer, 2004), 339–365.

¹⁴ Mark B. N. Hansen, "Cinema Beyond Cybernetics, or How to Frame the Digital Image," *Configurations* 10, no. 1 (2002): 51–90.

¹⁵ Wolfgang Hagen, "Computer-Bild-Welten," in *Vortrag Kunsthalle Vaduz*, 2001, accessed December 5, 2020, https://docplayer.org/65985762-Wolfgang-hagen-computer-bild-welten.html. Wolfgang Hagen, "Es gibt kein 'digitales Bild'. Eine medienepistemologische Anmerkung," in Licht und Leitung, ed. Lorenz Engell, Bernhard Siegert, and Joseph Vogl (Weimar: Bauhaus-Universität, 2002), 103–112.

¹⁶ Claus Pias, "Das digitale Bild gibt es nicht – Über das (Nicht-)Wissen der Bilder und die informatische Illusion," *zeitenblicke* 2, no. 1 (2003), accessed May 1, 2007, http://www.zeitenblicke.historicum.net/2003/01/pias/index.html.

¹⁷ Ingrid Hoelzl, "Image-Transaction," in *Parallax, Vol. 25, Nr. 4: Networked Liminalities*, ed. Grant Bollmer and Yigit Soncul (November 2019) and in *Retracing Political Dimensions: Strategies in Contemporary New Media Art*, ed. Oliver Grau, and Inge Hinterwaldner (Berlin: De Gruyter, 2020), 19–33.

¹⁸ Geoff Cox, Alex McLean, and Adrian Ward, "The Aesthetics of Generative Code", in *International Conference on Generative Art*, 2000, accessed November 3, 2017, url: http://web.archive.org/web/20100227185447/ http://generative.net/papers/aesthetics/ (archived).

¹⁹ Cox, McLean, and Ward, "The Aesthetics of Generative Code."

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INVISIBLE LABOR: WORK UNDER THE DIGITAL REGIME OF REPRESENTATION

SUSANNE LEEB, ANA TEIXEIRA PINTO

ABSTRACT | The digital turn seems to correlate with a crisis in representation: digitalization widens the gap between phenomenological experience and the socio-economic logic that determines it, rendering certain areas, fields or aspects of the world invisible. Crucially, this logic – according to Mary L. Gray, author of *Ghost Work* – entails the restructuring, and arguably the dismantling, of formal employment, producing its own set of novel social relations. Addressing the question of the hidden labor underpinning the digital economy could be described as an exercise in making it visible. But work is not the only social category whose tangibility, or lack thereof, revolves around a specific regime of visibility. The category 'art' in Western modernity could be construed as designating the alienation of artistic labor from other forms of labor. Because creativity is seen as the opposite of work, the dividing line between work and non-work correlates with the division between art and non-art, and it is thus impossible to fundamentally alter the former without implicating the latter.

In the late eighteenth century a chess-playing automaton toured the courts of Europe. Known as the 'Mechanical Turk', the automaton defeated Napoleon and Benjamin Franklin before being exposed as a hoax: hiding in its innards, a human operator was, in fact, moving the chess pieces. In a way, this was a reverse Turing test, *avant la lettre*: a kind of labor requiring that humans pass for machines—with all that this passing entails, mainly a forfeiting of needs and rights, and more importantly, a forfeiting of time. In 2005 Amazon resurrected the 'Turk' but generalized its principle: the Amazon Mechanical Turk is a crowd-sourcing internet marketplace that "enables individuals and businesses to coordinate the use of human intelligence to perform tasks that computers are currently unable to do."[1]

Technically speaking, every mechanism usurps a human function. Whereas technology is usually expected to render work obsolete, to free laborers from the curse of labor, in reality it tends to render workers more pliable and prone to exploitation, and ends up extracting machine-like labor from automated humans.

Our project revolves around what Frederic Jameson called 'cognitive mapping', a term he introduced in 1988 in his eponymous essay. According to Jameson, the digital turn correlates with a crisis in representation: though equipped with a growing variety of optical media, we are increasingly unable to grasp the techno-corporate logic which surrounds us. Data's primary mode of existence, as Alex Galloway argues, is not a visual one,[2] and the twin

forces of globalization and digitalization tend to widen the gap between individual experience and the economic structures that determine it. The problem of political agency is here reconceptualized as a problem of representation: the vectors of our digital infrastructure do not lend themselves to pictorial capture; in order to render the world intelligible we need a different set of intellectual tools.

In the present paper we will describe a subchapter of our research, in which we attempt to map the points of intersection between three different pairs of categories: human and non-human; work and non-work, and last but not least, art and non-art. Crucially these categories orbit around what Rod Aitken calls a 'regime of visibility,'[3] or to quote Andrea Brighenti, depend on the "complex social, technical and political arrangements"[4] through which certain aspects of experience are mediated, hence rendered perceptible sensorially. Addressing the question of hidden labor could be described as an exercise in rendering visible, in sketching a cartography of the coordinates that underpin the diffuse world of intangible economies. This is where the concept of work intersects with visual semiotics or with the language of the image – a point we will develop further in section 3 of this essay.

1. IT as Business Model

The concepts of work and job, to paraphrase Andrea Komlosy, derive meaning from different dimensions. Whereas work can be systematized into a great number of categories – including subsistence work, voluntary work, tributary work, independent work, dependent work, forced labor, organized labor, makeshift work, regulated or unregulated work, and unpaid work – the term job usually refers to formal employment.[5]

Not all of the above listed categories of work are economic categories. In fact, as Komlosy details in *Work: The Last 1000 Years*, the narrow economic definition of work tends to push unpaid labor into the realm of non-work.[6] Household work, for instance, is a controversial and contested category whose status qua work is only symbolically, but not economically, acknowledged, hence remaining unremunerated. This brings us to the concept of shadow work. The term shadow work originates in Ivan Illich's concept of 'drudgery,' a concept that describes all the activities one cannot opt out of in a contemporary market society, yet remain unremunerated, like shopping, filing tax forms, running errands, queuing at the bank, court or welfare office. Illich's theories were famously attacked by feminist critics for denying that shadow work, though located within the economic sphere, does not create either use or exchange value.[7] Objections notwithstanding, the concept of shadow work acquired a renewed relevance due to the digitalization of the economy, because, to follow Komlosy's argument, in a shift facilitated by internet connectivity and the ubiquity of mobile phones, administrative tasks and services, once performed by paid staff, are increasingly shifted onto the user. This transfer entails an unprecedented expansion of shadow work. From online bookings and sales to unmanned supermarket cashiers, online banking, etc., digital accessibility can be construed as the creeping expansion of working time. But the platform economy also entails the rise of digital labor markets, the locus of what researchers Mary L. Gray and Siddharth Suri call 'ghost work.'[8]

Before we move to an analysis of ghost work, it would be important to recall the feminist critique and note that, though shadow work is not recognized as work, hence not remunerated, it does create value. Here we would like to bring in the concept of 'surveillance capitalism,' theorized by Shoshanna Zuboff, and argue that shadow work, in fact, creates two different kinds of value. The most obvious one is cost-saving value. Less conspicuously, however, it also enhances the control factor.[9] As researcher Shoshanna Zuboff argues, "under surveillance capitalism, people's lived experiences are unilaterally claimed by private companies and translated into proprietary data flows." A small percentage of these data are indeed used to improve products and services, but the rest are considered a 'behavioral surplus' and "valued for their rich predictive signals," that is for their contribution to the manufacturing of highly profitable prediction products that anticipate current and future consumer choices. These prediction products are then traded in what Zuboff calls 'behavioral futures markets,' markets where "surveillance capitalists sell certainty to their business customers." Google's 'clickthrough rate,' as Zuboff details, was the first globally successful prediction product; by extension, Google's advertising markets were the first to trade in human behavioral futures. 'Surveillance capitalism' is the term Zuboff uses to describe those trading operations that lay bets on future behavior, and which are no longer limited to the IT sector but have by now expanded to include ever more companies across nearly every economic sector. 'Data harvesting,' Zuboff argues, is the foundational element in a "deeply intentional and highly consequential new logic of accumulation" that "aims to predict and modify human behavior as a means to produce revenue and market control."[10]

This new economic formation, 'surveillance capitalism,' is, according to Zuboff, the emergent logic of accumulation in the network sphere, and the author describes four different types of uses that follow from computer-mediated transactions:

- data extraction and analysis

- new contractual forms due to better monitoring

- personalization and customization

- continuous experiments

For Zuboff, the examination of the character and consequences of these uses can illuminate the implicit economic logic of surveillance and the global architecture of computer mediation upon which it depends. Crucially, this logic is a business logic, not a technological logic or even a technological necessity. Big data, Zuboff maintains, "is not a technology or an inevitable technology effect. It is not an autonomous process… It originates in the social, and it is there that we must find it and know it:"

> *When it comes to the market sphere, the electronic text is already organized by the logic of accumulation in which it is embedded and the conflicts inherent to that logic. The logic of accumulation organizes perception and shapes the expression of technological affordances at their roots. It is the taken-for-granted context of any business model. Its assumptions are largely tacit, and its power to shape the field of possibilities is therefore largely invisible. It defines objectives, successes, failures, and problems. It determines what is measured, and what is passed over; how resources and people are allocated and organized; who is valued in what roles; what activities are undertaken – and to what purpose.[11]*

For the purposes of our project, there is a twofold takeaway, emerging from Zuboff's research. Firstly, it is important to emphasize that computer mediation renders events, objects, and processes visible, knowable, and shareable in a new way, a distinction that "marks the difference between 'smart' and 'dumb.'"[12] Secondly, the key point in her argument is that this logic of accumulation produces its own social relations. According to Mary L. Gray, the author of *Ghost Work* mentioned earlier, this logic entails the reorganization, and arguably the dismantling, of full-time employment. This is where we will now turn our attention.

2. The Unbankable and the Regime of Credit Visibility

The dismantling of employment could be construed as a class project, entailing a fundamental transformation of the nature of work, and by extension, of the social contract. As Tressie MacMillan Cottom argues, when one asks what an Uber driver is (a worker, or a vendor) the answer seems to be a "Platform entrepreneur."[13] Uber, MacMillan Cottom argues, claims to "offer flexibility and economic opportunity, in reality it provides a type of job-adjacent work that looks like it is embedded in the formal economy but is not governed by the same protections, shifting risk from the state or the employer to the worker."[14] The future, as MacMillan Cottom maintains, is "predicted to be less job-centric," and digital technologies—in a process that has been greatly amplified by the COVID-19 pandemic—are the driving force behind the blurring of the borders between the formal and the informal economy. This is where entrepreneurship sits. Entrepreneurship is not often theorized as work. Rather it falls into a grey zone between work and investment, with investment defined as the outlay of an asset (time, money, effort, etc.) in hopes of a future payoff greater than the original input. Here language is tasked with mobilizing affect, with those subjected to processes of racial ascription being more vulnerable to the welfare stigma linked to cultural perceptions about deservingness and individual responsibility, and by extension, to the ideology of uplift.[15] Platforms provide economic access but this inclusion has a predatory nature.

The same type of 'predatory inclusion' can be found in the field of personal finance. As Rob Aitken details in his essay "All Data is Credit Data: Constituting the Unbanked" there is a cluster of new practices "designed to make visible—and extract value from—those without formal credit scores in contemporary financial markets."[16] Personal finance provides us with a precedent: because traditional banking services excluded vast swaths of people operating on the margins of the formal economy, payday loans or prepaid cards responded to their financial needs. The World Bank claims there is a positive correlation between access to finance and firm creation, economic

growth, and poverty alleviation, and the microfinance industry has grown exponentially in the past few decades. The novelty, afforded by IT, is that projects that seek to foster 'financial inclusion' are now drawing from a range of available data that is non-financial in nature, from alternative sources, which can then be put to use to formalize credit scores for those without previous credit records or files. Alternative data sources include academic records, social media footprints, local public records, social networking patterns, mobile phone usage, psychometric test results, and payment streams. These diverse behavioral records gleaned from the users' online presence captures the hitherto 'credit invisible' to create a financial profile, and these experiments in what Aitken calls 'alternative credit scoring' are crucial to constituting the unbanked. Platforms like PayPal, Kabbage, and Square offer business loans targeted at micro-businesses and platform entrepreneurs by exploiting the vast amounts of personal data they have at their disposal. But most importantly, as Aitkens details, these attempts to "score the unbanked" also orbit around "regimes of visibility:"

> *Like all bodies, before the unbanked can be governed, they must first be made visible in particular ways, literally re-presented in forms which make them amenable to intervention. Organized attempts to "score" the unbanked are particularly preoccupied with a language of the visual. The unbanked, for example, are often most importantly framed as "credit invisible," a population defined by their lack of legible trace within any formalized mode of credit practice. Addressing the unbanked becomes, by extension, a kind of exercise in making visible, of finding methods with which they are made perceptible; an attempt "to recognize creditworthy individuals who would otherwise be difficult to identify," and to record the "behavior" of those outside of formal credit records.[17]*

To make visible is, in a way, to bring something into the regime of finance, but as Aitkens notes, capitalization is "littered with the language and metaphor of the visual, implying that to convert something into a source of financial value, to allow it to "become investment," is a process that requires making it visible and subjecting it to a certain line of sight."[18] "Capitalization" is, in this sense, governed by a particular viewpoint or gaze. Visual legibility, however, is a deeply contested terrain. Because data's primary mode of existence is not a visual one, within a digital environment the question of representation becomes mainly a problem of conversion: of how to translate abstract number into semiotic sign. Conversion is, however, not merely a technical operation, it is also an aesthetic one. Data have no form or structure; the Latin "data", as Galloway notes, means literally "the things having been given." Data have no form or structure. Whereas data are "ontologically raw," and linked to the empirical, information – as structured data, i.e. data which have taken on a form – is linked to the aesthetic.[19] The rules, conventions and modalities the conversion of data into information undertakes thus constitute a form of mediality, since the very notion of a mediation already entails the appeal to sensory perceptual and semiotic elements. In other words, conversion is a medial situation, which call for analysis in terms of a) what entities are assigned the function of a medium, and b) when do the effects of mediation become visible. The approach captured by the term mediality also shifts the focus from questions of data visualization or information design to the ways and means of mediation. One of the aims of our research project is to generate the critical vocabulary that would allow one to describe digital mediality and its mode(s) of representation. The gap between the two forms of representation – political on the one hand, cultural on the other – is a constitutive feature of communication technologies and social media: the mechanisms that enable cultural participation simultaneously generating political exclusion: Nowhere is this more apparent than in the modalities of agency they afford.

3. Ghost Work

Ghost work, and here we are paraphrasing Gray, is a concept that describes on-demand piecework such as flagging x-rated content, proofreading, transcribing audio, facilitating image recognition, monitoring social media platforms, captioning video, etc. Crucial to its definition is that this work is *intentionally* hidden in order to sustain the illusion of automation. Ghost work describes seemingly automated services that are in fact delivered by humans.[20]

Some forms of ghost work have recently enjoyed a great deal of public scrutiny because of their traumatic, PTSD-inducing nature due to continued exposure to graphic violence and otherwise extreme content. Less attention has been given to their semiotic complexity. Facebook moderators, for instance, are routinely asked to make

decisions, in a couple of seconds, on questions that are highly controversial, or the subject of intense aesthetic debate like, for instance, how to decide when a nude is to be considered art, when it is to be considered pornography, or how to interpret the ideological content of an image in the absence of cultural context. The documentary *The Cleaners* (2018) by Hans Block und Moritz Riesewieck delves into this semiotic complexity, surveying what could be perhaps described as an anti-Bilderatlas, in the sense that they radically deny the possibility of immediate visual insight. What emerges instead is an equivocal world in which the iconic image of the naked 9-year-old Phan Thi Kim Phùc, fleeing napalm bombs during the Vietnam war, can be classified as child pornography, and as a result removed from social media. Yet not all ghost work makes the news. Most, dealing with less spectacular matters, remains unseen.

Social media moderation accounts for a small percentage of ghost work. As Gray and Suri detail, ghost work is mostly generated at the intersection of different programs. When two different pieces of software, or a piece of software and a piece of hardware, need to communicate, this communication is sourced via an application programming interface (API). APIs are software intermediaries that establish a common language, enabling applications to talk to other applications. Initially, software developers wrote code for computers only. The novelty the Mechanical Turk API introduced, according to Grey and Suri was to "enable software developers to write programs&that automatically pay humans to do tasks&that are beyond a computer's capacity:"[21]

> *Businesses call this mix of APIs, rote computation, and human ingenuity "crowdsourcing," "microwork," or "crowdwork." Computer scientists call it "human computation." Any project that can be broken down into a series of discrete tasks can be solved using human computation. Software can use these APIs to manage the workflow and process the output of computers and individuals and even pay people for their contributions once they have completed the task. These people power modern AI systems, websites, and apps that we all use and take for granted.*[22]

Ghost work is intentionally rendered invisible because IT companies have an economic incentive to misrepresent the capacities and performance of machine learning. The global artificial intelligence market size was estimated at USD 39.9 billion in 2019 and is expected to reach USD 62.3 billion in 2020. The global AI market is also expected to expand at a compound annual growth rate of 50.51% during the period 2020-2021 — the only fast-growing sector at present and the sole compelling attempt to project another phase of capitalist accumulation beyond the — already exhausted — neoliberal one.

Concerns over the future of work, to return to Gray and Suri's argument, have centered on whether technology will displace humans in the workplace and, if so, what to do with growing global surpluses of labor. Less attention has been placed on the types of jobs that will be created. One of the major transformations in the world of work over the past decade has been the emergence of online digital labor platforms. In contradistinction to the vast apparatus that oversees public and private job sectors, administrative bodies do little to track or identify this sort of economic activity, which has disrupted not only existing business models but also the employment model upon which these business models relied. By breaking down jobs into "tasks," crowdwork platforms provide businesses with access to a large flexible workforce for the completion of small, often repetitive, clerical tasks. By extension these platforms also enable new ways of commodifying labor, and the rise of on-demand labor, or microtasks, as Grey and Suri argue, signals the allure of using APIs to organize, route, and schedule work, and selling it "on demand" to businesses.[23] Groups of workers that span multiple time zones offer businesses the possibility of completing projects at any time of day or night, and large numbers of workers mean that tasks can be accomplished quickly. Leveraging the power of "the crowd," a business can access thousands of workers who can, for example, process large sets of data in a relatively short time period, with no further obligation by the business to those workers. They are not employees with a term of contract beyond the single task at hand, since flexibilization of employment is exactly what an always-on labor pool, plugged into APIs, provides: a massive hidden pool of people available for ghost work. This reorientation towards contingent labor offers today's businesses a combination of human labor and AI, which can be deployed to develop new technologies. It was ghost work, it is important to note, that fuelled the recent AI revolution.[24]

4. Artificial Intelligence

In 1951, Alan Turing described a thought experiment, which became widely known as the 'Turing Test,' though Turing himself termed it 'The Imitation Game.'[25] The Imitation Game was a game conceived to tackle the issue of artificial intelligence, at that time known as machine intelligence, but the first experiment does not involve machines. Instead, Turing asks the reader to imagine two rooms, connected via computer screen and keyboard to a third room, in which a person who will be the game arbiter sits. In the first room one finds a man, in the second a woman – the two players, who are hidden from view but able to communicate via the computer terminal. The judge's job is to determine which player is the man and which is the woman, whereas the woman's job is to deceive the judge into misgendering her. The second experiment involves a variation of the same game, this time round replacing one player with a machine. Now the judge's job is to decide which of the contestants is human. If he gets it wrong oftentimes, the computer must be a passable simulation of a human being, and hence intelligent. The Imitation Game is usually misunderstood as proof that the converse is also true: if a computer passes the test it must be a passable simulation of intelligence, and hence human.

Kevin P. Murphy defines machine learning as a "set of methods that can automatically detect patterns in data, and then use the uncovered patterns to predict future data."[26] What is commonly called AI operates via correlation or visual pattern recognition; in other words, AI is a generalization of visual pattern recognition to the non-visual sphere. This is in turn divided into two subsets: classification and prediction, which are also in turn defined by a) pattern recognition and b) pattern prediction or, to put it in more precise terms, pattern generation via predictive algorithms.

Machine learning, Suri and Gray detail, typically starts with training data, for instance gathering images of dogs, sourced from social media posts. The machine-learning algorithm would compare new images against the pre-existing set and classify them accordingly, either as dog or as not dog. But not all images of furry animals can be clearly identified as dogs; sometimes the camera angle is askew, or the lighting is bad. This is where the human comes in.[27]

In another example used by Gray and Suri to illustrate the outsourcing of allegedly automated tasks, the Stanford Human Centered AI Institute attempted to train algorithms to recognize the main object in an image. The team began by writing software that would download millions of random images from the internet.[28] Next they tried to develop machine-learning algorithms to automatically label images, requesting human help if, and only if, their classifier was unable to identify the central object in the image. But the machine made too many errors. In 2007 the team turned to MTurk in order to distribute image-labeling tasks to people: 49,000 workers from 167 countries correctly labeled 3.2 million images. After two and a half years their work created ImageNet. Ever since, research teams have used ImageNet with increasing success to develop image recognition algorithms. This example points to what Gray and Suri call the recurring paradox of automation: humans train an AI only to have the AI take over the task entirely. After that task is accomplished researchers turn their attention to a new, more complex task, generating another wave of ghost work.[29]

This brings us to our second example, Forensic Architecture's 'Model Zoo', which deals with a different dimension of invisibility, that which is tied to the opaque world of the global weapons industry. As the Forensic Architecture team detail, training a classifier to recognize objects usually requires thousands of images of that object in different conditions and contexts. For certain objects, however, typically objects that circulate covertly, there are too few images available, and even where images do exist, the process of collecting and classifying them can be extremely time consuming and labor-intensive:

Since 2018, Forensic Architecture has been working with 'synthetic images'—photorealistic digital renderings of 3D models—to train classifiers to identify such munitions. Automated processes which deploy those classifiers have the potential to save months of manual, human-directed research. Forensic Architecture's 'Model Zoo' includes a growing collection of 3D models of munitions and weapons, as well as the different classifiers trained to identify them making a catalogue of some of the most horrific weapons used in conflict today. 37-40mm tear gas canisters are some of the most common munitions deployed against protesters worldwide, including places such as Hong Kong, Chile, the US, Venezuela and Sudan. Forensic Architecture is developing techniques to automate the search and identification of such projectiles amongst the mass of videos uploaded online. We modeled thousands of commonly found

variations of this object—including different degrees of deformation, scratches, charrings and labels—rendered them as images, and used these images as training data for machine learning classifiers. Machine learning classifiers that use rendered images of 3D models, or 'synthetic data', can be made to perform better when 'extreme' variations of the modelled object are included in training examples. In addition to realistic synthetic variations, we textured a model of the projectile with random patterns and images. Extreme objects refine the thresholds of machine perception and recognisability, helping the classifier better recognise their shape, contours, and edges.[30]

'Model Zoo' is of particular interest for our project is because it allows us to address not only the question of visibility/invisibility but also the question of artistic autonomy vs. artistic heteronomy. It is here that we would introduce a third pair of terms, art and non-art, whose intersections with our first set of pairs, work and non-work, human and non-human, we will attempt to describe.

Up until recently, the critical vocabulary commanded by art history and aesthetics would allow these disciplines to describe and analyze the whole scope of visual culture. With visual digital culture this is no longer the case. Visual culture is itself a misnomer when one addresses digital culture because algorithms, information and data only have a second-hand relation to the field of the visual. The disciplines which would traditionally deal with questions of representation are thus ill-equipped to describe the new forms of mediality that digital cultures engender. This question not only affects their *method of study but also their object of study*. Ultimately, the question of representability mobilizes all the disciplines in which the humanities are rooted: semiotics, hermeneutics and aesthetics.

5. Artwork

The category 'art' in Western modernity could thus be construed as designating the alienation of artistic labor from other forms of labor. Because creativity is seem as the opposite of work, the dividing line between work and non-work correlates with the division art/non-art. Labor as an alienation of experience is opposed to art as a totalization of experience. In its strict meaning, as Peter Bürger notes, the term artistic autonomy is an ideological category that blends together an element of truth (the praxis of art is not totally assimilated into social praxis) with an element of untruth (the hypostatization of this fact, the result of an historical process, is wrongly perceived as the 'essence' of art).[31] The artwork is fetishized as an exemplary product, the only object that is not subject to commodity logic. This appeal to a symbolic value beyond monetary value is that which a) guarantees the artwork's market value, and its dual status as both a priceless and pricey commodity, and b) leads to the conceptualization of art as the domain of absolute creativity in which work can be represented as 'freedom', rather than toil or drudgery, and whose compensatory quality naturalizes forms of life lived under the rule of property.[32]

The autonomy of the work of art is not its only relevant feature, but it is the feature that gives contemporary art its institutional consistency while allowing for an exceptional aesthetic fluidity.[33] In his forthcoming book *Vanishing Mediators*, art historian Andrew Stefan Wiener details how critical and scholarly accounts of contemporary art often focus on its pervasive heterogeneity: its tendency to incorporate non-artistic forms and materials, to combine distinct media, or to transcend conventional modes of aesthetic experience. In the last two decades, Wiener writes, artists have begun to position themselves as "activists, archivists, speculative philosophers, and digital privacy experts; they stage performances in public housing projects, tropical rainforests, and virtual online environments; they produce site-specific artworks in ATM vestibules, in international waters, and in the earth's orbit."[34] Even mass protests like Occupy Wall Street and the Arab Spring were claimed as public artworks, authored by the collectivity; exhibitions turned into flashpoints for debates about historical trauma and cultural reparations. It would seem, Wiener argues, that artists, critics, and an increasingly global audience have come to agree on an unlikely, seemingly paradoxical proposition: that for something to be considered art at all, it should be oriented toward something other than 'art'. We would like to wade into this debate by saying that in our view this is indeed the case because the digital turn has blurred the distinction between the categories of 'work,' and 'creativity,' and the social status of work and non-work is changing radically. These changes, in turn, call for a renegotiation of the divide between art and non-art. There is however, as Wiener maintains, little adequate historical or theoretical analysis, or even consensus on the validity of these new fields, based as they are on an apparent contradiction.[35] As projects such as Forensic Architecture make manifest, part of the reason that heteronomy proves so difficult to negotiate is that it radically impacts not just the form and content of art, but its definition, indeed its very ontology.

NOTES

[1] See Wikipedia entry on Amazon Mechanical Turk: "Amazon Mechanical Turk," Wikipedia, last modified January 24, 2021, url: https://en.wikipedia.org/wiki/Amazon_Mechanical_Turk.

[2] Alexander Galloway, "Are Some Things Unrepresentable?" *Theory, Culture & Society* 28, no. 7–8 (2011): 85–102.

[3] Rod Aitken, "'All Data Is Credit Data': Constituting the Unbanked," *Competition & Change* 21, no. 4 (2017): 274–300.

[4] Andrea M. Brighenti, *Visibility in Social Theory and Social Research* (New York: Palgrave, 2020), 3.

[5] Andrea Komlosy, *Work: The Last 1,000 Years* (New York: Verso, 2018), 70–71.

[6] See Andrea Komlosy, Work: *The Last 1,000 Years* (New York: Verso, 2018).

[7] Andrea Komlosy, *Work: The Last 1,000 Years*, 70–71.

[8] Mary L. Gray, and Siddharth Suri, *Ghost Work: How to Stop Silicon Valley from Building a New Global Underclass* (Boston: Houghton Mifflin Harcourt, 2019).

[9] Shoshana Zuboff, "Big Other: Surveillance Capitalism and the Prospects of an Information Civilization," *Journal of Information Technology* 30 (2015): 75–89.

[10] Shoshana Zuboff, "Surveillance Capitalism," *Project Syndicate* (2020), accessed January 10, 2021, url: https://www.project-syndicate.org/onpoint/surveillance-capitalism-exploiting-behavioral-data-by-shoshana-zuboff-2020-01.

[11] Zuboff, "Big Other," 75–77.

[12] Zuboff, "Big Other," 76.

[13] Tressie McMillan Cottom, "The Hustle Economy," *Dissent* (Fall 2020), accessed January 10, 2021. url: https://www.dissentmagazine.org/article/the-hustle-economy.

[14] McMillan Cottom, "The Hustle Economy."

[15] McMillan Cottom, "The Hustle Economy."

[16] Rod Aitken, "'All Data Is Credit Data': Constituting the Unbanked," *Competition & Change* 21, no. 4 (2017): 275.

[17] Aitken, "'All Data Is Credit Data': Constituting the Unbanked," 275.

[18] Aitken, "'All Data Is Credit Data': Constituting the Unbanked," 279.

[19] Galloway, "Are Some Things Unrepresentable?," 87.

[20] See Mary L Gray, and Siddharth Suri, *Ghost Work: How to Stop Silicon Valley from Building a New Global Underclass* (Boston: Houghton Mifflin Harcourt, 2019).

[21] Gray/Suri, *Ghost Work*, 15.

[22] Gray/Suri, *Ghost Work*, 15.

[23] Gray/Suri, *Ghost Work*, 15–23.

[24] Gray/Suri, *Ghost Work*, 8.

[25] A. M. Turing, "Computing Machinery and Intelligence," *Mind*. New Series, Vol. 59, No. 236 (1950): 433–460.

[26] Gray/Suri, *Ghost Work*, 6.

[27] Gray/Suri, *Ghost Work*, 7.

[28] Gray/Suri, *Ghost Work*, 6–8.

[29] Gray/Suri, *Ghost Work*, 21.

[30] "Forensic Architecture," Model Zoo, last modified February 20, 2020, url: https://forensic-architecture.org/investigation/model-zoo.

[31] Peter Bürger, *Theory of the Avant-Garde* (Minneapolis, MN: University of Minnesota Press, 1984), 46.

[32] David Lloyd, *Under Representation: The Racial Regime of Aesthetics* (New York: Fordham, 2018), 10, 77.

[33] Daniel Spaulding, "Art, Value and the Freedom Fetish," *Mute* (2015), accessed January 10, 2021, url: https://www.metamute.org/editorial/articles/art-value-and-freedom-fetish-0.

[34] Andrew S. Wiener, *Vanishing Mediators* (Berlin: Sternberg Press, 2021), 1.

[35] Wiener, *Vanishing Mediators*, 1.

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ARCHITECTURE TRANSFORMED – ARCHITECTURAL PROCESSES IN THE DIGITAL IMAGE SPACE

HUBERT LOCHER, DOMINIK LENGYEL, CATHERINE TOULOUSE, FLORIAN HENRICH

ABSTRACT | The production and conception of architecture are not only shaped by the technical-constructive aspect but also by their visual representation. Since the 1980s, with the advent of digital technologies for the design and visual representation of architecture (computer-aided design), far-reaching changes have occurred, resulting in fundamentally new possibilities for linking technical design and visual reproduction (computer rendering to virtual photography). This cooperative project undertakes an investigation of these essentially process-related relationships outlined here in design and visualization during the transition phase from analogue to digital planning and display format methods from 1980 to the present. In exemplary studies on the use and application of the new tools and their visual products (images), the aim is to determine how the 'digital image' has changed the concept and production of architecture from the perspective of art history and media criticism on the one hand, and the production aesthetic point of view of architectural and architectural image production on the other.

KEYWORDS | architecture, Computer-Aided-Design (CAD), interdisciplinary collaboration, digital image, visualization

Idea and concept of the project

The project entitled "Architecture Transformed - Architectural Processes in the Digital Image Space" is one of the projects of the DFG priority program "The Digital Image", which is largely based on the connection of two partners with very different profiles. These are on the one hand Hubert Locher, who holds a professorship in art history with the focus on "History and Theory of Visual Media" at the Philipps-University of Marburg and acts as the overall director of the project, and on the other Dominik Lengyel, incumbent of the Chair of Architecture and Visualization at the Brandenburg University of Technology Cottbus-Senftenberg, as co-director and project editor of the Cottbus subproject. The project coordinator and researcher in Marburg is Florian Henrich, the project research in Cottbus is managed by Catherine Toulouse.

At the center of the joint project is the question of the role of the digital image, of the digital visual representation of architecture in the course of architectural production in the decades from 1980 to the present, which has been significantly and increasingly influenced by digitization. Its aim is to examine the assumption of a media-specific imprinting of the architecture by digital design and presentation methods during the design process and the representation that continuously accompanies it.

When we speak in this context of architectural production and of architectural processes, we want to emphasize that we understand architecture as a complex process supported by several actors, at the end of which there may be a built artifact, but whose actual product is generally architecture as a multi-layered concept. The physically tangible and spatially perceivable building made of concrete, metal, wood, stone, glass is a part of the whole, it is the material reference object on which is tested and in which is realized what has previously been worked out and negotiated in a complex design process.

In this creative process, according to one of the basic assumptions of our project, visualization plays a central role in principle, because we build according to ideas that have to be articulated, visualized, modeled – in a word 'visualized'. Such ideas are always informed by already existing 'images', and it is by no means true that it is only images of completed buildings that shape the concept of architecture. The idea of a building requires visualization, undertaken in different ways and in different formats, both for its elaboration in the iterative process of design and for its material realization. From the initial concept as a sketch through the model-based presentation in a competition, and on to the designed representation for communication and marketing purposes, methods of visual modeling and pictorial representation are used throughout – from the drawing to the built model and photography. While the design of a building is already created by means of different pictorial procedures, the finished building itself is still marketed using pictures. The same applies, of course, to those architectural ideas that are not designed for realization from the very beginning, whether as social utopia or as technological visions of the future.

Whether as an idea, a concrete design or a physical object, architecture is always dependent on being conveyed by means of images. In this respect, we assume that the various aspects of pictorial representation, together with the associated media transformations, are to be seen both as integral parts and as processual components of what finally appears as architecture. It can therefore be supposed that architecture is fundamentally shaped by the image.

This may be generally have been true ever since pictorial representations of architecture have existed, but the meaning of the pictorial is historically variable. As early as 1994, Beatriz Colomina, for example, convincingly argued that since the beginning of the 20th century, with the wider availability of photography and the imminent flourishing of illustrated journals, architecture has become a mass media phenomenon – with significant consequences for architecture itself.[1] In this sense, Cervin Robinson and Joel Herschman, in their 1987 *History of the Photography of Buildings from 1893 to the Present*, entitled *Architecture Transformed*, also pointed out the mutability of what is understood and presented as architecture depending on the way it is presented in the media, in this case its photographic representation.[2] Not only did this change communication about architecture, the images received not only have a retrospective effect as documentation, they also change ideas prospectively. The reproductions result in new images, new concepts and ideals.

This is where our considerations start, assuming that from around the mid-1980s onwards there would once again be a far-reaching media reshaping of the architectural, in that the spectrum of visual information of the architectural process would gain in importance in the age of digitally supported architectural production and would be reformatted and spelled out in many different ways (fig. 1). Once again, we think, there is a transformation of architecture under the sign of the pictorial, which is now no longer the photographic light image, but an image that can be determined in a genuinely different way, namely the digitally generated architectural visualization.

Our project is about considering architecture as this digital image in digital space and its effects on the idea and concept of the architectural. With the advent of digital design and display tools and the associated development of computer graphics – this is its central hypothesis – a rapid and fundamental change in media took place between 1990 and 2000: the almost complete replacement of analogue design representation by digital images. Our goal is to grasp the drastic changes to which this medial change has led in the course of digitization, both at the level of architectural design and at the level of visual architectural representation.

In hardly any other area of design has digitization been so clearly reflected and led to such comprehensive transformations as in architecture. Due to the peculiar hybrid position between art and engineering, the transformations through digitization have an effect on several levels: firstly, in the area of technical construction and building practice; secondly, in the artistic figuration of the building and thus in the visual representations of the respective phases; finally also in communication, the promotion and marketing of architecture.

Research has focused primarily on the consequences of digitization for architectural production in terms of the design process, its tools and results[3], as well as on questions of digital imagery and virtual simulation[4]. In contrast, the aspect of the visual representation of architecture in the digital age has so far received only sporadic attention.[5]

increment (for example: a minute) thereafter.

Example: Ten minutes after the criteria statement the machine checks for the specified state once a minute.
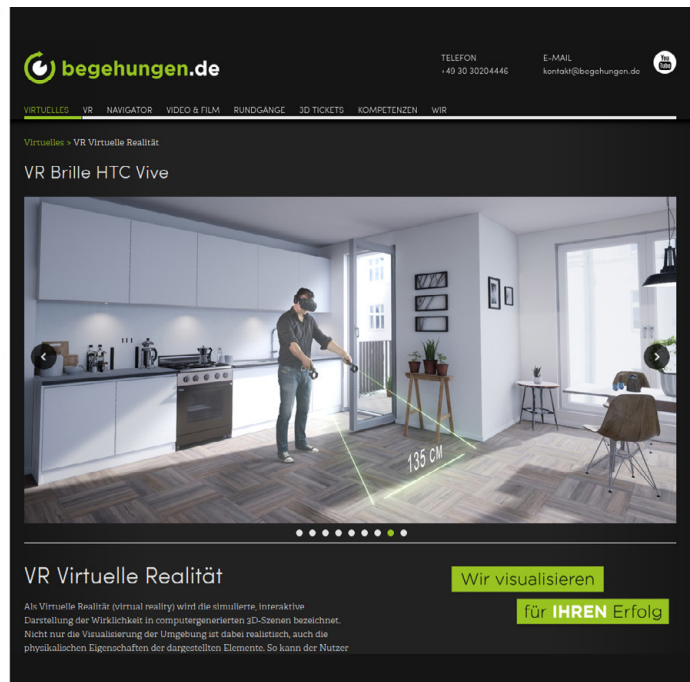
Figure 1. left: Program URBAN 5; ARCH+, no. 4 (October 1968): 67, right: www.begehungen.de; November 2020; screenshot.

The project attempts to do justice to this duality of design and representation, of construction and representation, of design and image as one of the specific characteristics of architecture through the cooperative structure of its research approach. Instead of starting from the simple assumption of a deterministic relationship between the design and image tools and the results produced with them, the aim here is rather to arrive at a theoretical reflection of the possible effects and impacts of the digital architectural image on the production, reception and interpretation of architecture in the age of digitization on the basis of an art-historical recording and description of the phenomenon, on the one hand (Marburg subproject), and a practice-oriented architectural, scientific and empirical analysis on the other (Cottbus subproject).

The two starting points for our research will be, firstly, the spread of the digital image of architecture and its reception within the discourse on the practices and effects of the increasing digitization of architectural production, which has been in the process of self-differentiation since the 1980s (fig. 2), as is comprehensible in the contemporary journal literature. Secondly, the digital design and image tools will be analyzed with regard to their concrete effects on the results achieved with them within the framework of an empirical study. The overarching question is here whether specific software-related, visually mediated standardization tendencies within design and architectural image production can be identified, named, and traced back to the use of digital design programs.

Once both subprojects have thus taken up starting positions as far away from each other as possible, the goal is to come closer and closer together through a permanent exchange of work and to continually increase the common intersections until finally the results of both projects culminate in the joint exhibition planned for its conclusion.

The exhibition "Architecture Machine", which opened in October 2020 in the Architekturmuseum in Munich, is a direct testimony to the topicality of the crucial question for the project.[6] Particularly relevant for our project, however, is the book published by Inge Hinterwaldner (fortunately represented with her own project in the SPP "The Digital Image" and certain to be an important and exceptionally competent discussion partner for us) and Sabine Ammon in 2017 under the title *Bildlichkeit im Zeitalter der Modellierung*[7], which emphasizes the importance of pictoriality in the digital design process, most emphatically also because the significance of imagery, in the digital design process especially, but also in the entire architectural discourse in general, is always controversial.
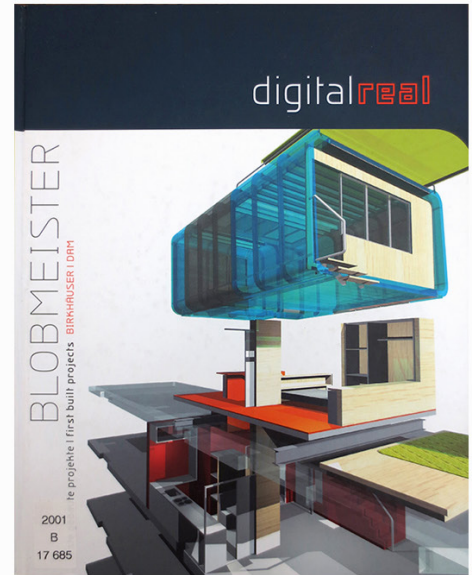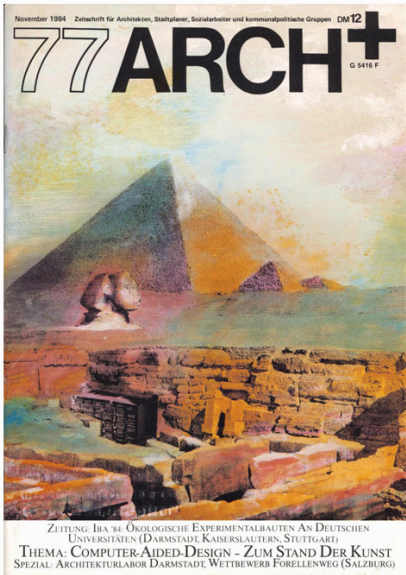
Figure 2. left: "Thema: Computer-Aided-Design – Zum Stand der Kunst"; ARCH+, no. 77 (November 1984), middle: CAD: Architektur automatisch? Texte zur Diskussion. Braunschweig and Wiesbaden: Bauwelt-Fundamente, 1986, right: digital real: Blobmeister, erste gebaute Projekte. 2001.

This is where we would like to start and, in the sense of Ammon and Hinterwaldner, decisively underline the conceptual part of the image. In doing so, however, our focus is not only, and not primarily, on the design process, nor on the technical modeling, but rather on the part that the digitally generated image plays in its own right in both architectural discourse as a means of communication and representation according to its particular aesthetics, and in the negotiation process of what architecture should be and how it should appear.

Marburg Subproject

When we ask in our project about the role and influence of the 'digital image' on concept and form of architecture from the 1980s to the present, "Architecture Transformed" is intended to indicate that we are starting from at least three different levels on which such transformative processes can be observed: firstly, the level of visual representation of architecture and the dependence of representation on the medium of representation; secondly, the architectural design process and the shaping of the design result by the design tool; thirdly, the level of the media reception of architecture and its effects and repercussions on architectural design.

While image production and the question of the design consequences of digital design tools are the starting point for the investigations in Cottbus, we want to complement this in Marburg by expanding the perspective to the aspect of reception. We want to focus not only on the digital image of architecture itself, but also on its manifold media usage contexts of communication, mediation and marketing of architecture.

We are particularly interested in the way in which the digital image of architecture influences those who deal with it. Digital architectural representations are ubiquitous, from the high-quality and artistically sophisticated design visualization on the homepage of the architectural office or in the architectural competition, through the lifestyle design magazine and the advertising of the construction or real estate company, to the trivial sign on the construction site.

Already in the design phase, the digital architectural image can evoke such a concrete idea of the future building through the creative possibilities of simulating a hypothetical situation suggestively or even persuasively close to reality and turn the prospective design into a fixed idea, that this can sometimes lead to considerable conflicts, as the example of the Elbphilharmonie Hamburg shows particularly clearly.

Last but not least, those who design and visualize architecture themselves are not exempt from the influence of the digital image of architecture, including the architects themselves, who play a decisive role in the production of architecture and images. This raises the question of whether a dialectical relationship can ultimately be assumed here, i.e. whether and to what extent digitally generated architectural image worlds in their specific visual composition and their own aesthetics have an impact not least on those who themselves design, construct, and shape architecture, and thus ultimately on the architectural artifacts of the present. This is the hypothesis to be investigated in the Marburg subproject.

What becomes evident at the same time, however, is the fact that it is not only the designing architects themselves who produce digital architectural images, but also external professional agencies that have specialized in the service of architectural visualization. In the face of such obviously deliberate atmospheric staging and the stimulation of emotions by depictions that aim to achieve this, it seems quite appropriate to speak of architectural image worlds.

It very quickly becomes clear that this obviously here concerns a lucrative business with an accordingly developed market, as can already be ascertained by means of a simple Google search inquiry. On the other hand, it should not be overlooked that the practice of external architectural visualization has a long tradition reaching far back into the pre-digital age. Rather, it leads to the fundamental question of the general relationship between design and visualization in the process of architectural production. This question seems to play a not insignificant role in an investigation of the effects of digital design and imaging tools on the results achieved with them.

The situation becomes even more complex due to the fact that digital photography under the keyword "HD" (High Dynamic Range Image) is currently showing tendencies that signify a stylistic transformation of the image away from the 'classical' photographic appearance with its still effective promise of reality and objectivity towards a somehow 'artificial' image aesthetic. Likewise, in the field of computer visualization under the keyword "CGI" (Computer Generated Imagery), the trend towards ever more perfect realistic representation continues. One consequence is that it is increasingly difficult, at least for the untrained eye, to distinguish the digitally post-processed photographic image of a real building from the digitally generated 'photorealistic' visualization of a prospective design. Not only does the 'photorealism' of digital architectural visualizations seem more convincing than just a few years ago; rather, a convergence of digital and photographic image aesthetics currently seems to be the case, with the border between the two becoming more and more blurred.

The influence of such digital image worlds has apparently reached such a point that today, when walking through the new development area, over the freshly redeveloped wasteland or the area of the former freight station, one often has the feeling: "Hey, I'm standing in the rendering!"[8] (fig. 3)

In Marburg, we want to get to the root of this phenomenon by considering the change from the analogue to the digital image of architecture itself as a media transformation process. What we intend to do is to grasp the digital image as a medium of design representation both as an aesthetic and discursive phenomenon and to trace its genesis, its use and its discussion.

Our starting point is the question of the role of the digital architectural image in the formation of stylistic concepts about what 'digital architecture' is. The focus is on possible correlations and mutual influences between, on the one hand, the introduction, spread and establishment of digital architectural representation and, on the other hand, the development of those images and conceptual concepts of 'digital architecture' that were first introduced in the years around the turn of the millennium with the term 'blob'. The historically extremely short-lived phenomenon of 'blob architecture' serves here, however, merely as a first tangible peak and thus as an entry point into a much larger field of topics that must be considered, namely the contemporary debate on the digitization of architecture, which began in Germany around the mid-1980s at the latest.

In order to work on these questions, we use the medium of architectural journals in Marburg, which will be surveyed as examples to systematically trace and analyze the entry of the digital image of architecture from 1980 to the present in the context of in-depth journal research, namely on the basis of *ARCH+* and *Bauwelt*. Both are renowned professional journals that complement each other in an almost ideal way due to the differences in their thematic conception, their content orientation and their journalistic function. Although both are German-language journals, the continuous reporting on international competition events and the debate on current issues that

Neue Zürcher Zeitung

«Hey, ich steh im Rendering!»

Am Computer erstellte Bilder spielen in vielen Bereichen eine grosse Rolle. Als Architektur-Renderings simulieren sie die Zukunft, als gäbe es sie schon. Mit Folgen für die Wirklichkeit.

Andrea Roedig 3.11.2015, 05:30 Uhr

Figure 3. left: Overbuilt industrial area in Leipzig; completion 2019; photo: Florian Henrich, right: Article by Andrea Roedig in NZZ; November 3, 2015.

extends beyond national borders also enable the international dimension of the development and dissemination of the digital architectural image to be kept in mind.

Magazines generally offer the advantage that they usually have both an image and a text layer. Thus *ARCH+* and *Bauwelt* regularly contain not only up-to-date visual material that can be captured and analyzed over time, but also descriptive, reflective, commentary and evaluative statements that reflect the respective contemporary opinions and views on the phenomenon of 'digital architecture'. These kinds of statements are available as texts of different formats and can be made accessible to scientific analysis via a corresponding methodical access. On the one hand, they offer the opportunity to discursively reconstruct the chronology, stages and central statements of the contemporary debate on 'digital architecture' accompanying the process of digitization. Equally, they make it possible to check, contrast and, if necessary, correct common assumptions or historiographical narratives about the history of 'digital architecture' that are in the process of being formed today.[9]

All the issues of all 40 volumes of both journals were systematically and completely reviewed, photographically recorded and documented, the results being stored as Excel tables together with the photos in a common cloud, which serves as a project database. The image and text material prepared in this way can be viewed there by all project participants and used for subsequent evaluation.

Regarding the content evaluation of the picture material contained in the journals, three different dimensions are in the foreground: Firstly, the qualitative development of the digital architectural image is to be examined, which is to say, an initial image-critical-aesthetic determination is to be established. It is necessary to work out significant quality changes and shifts as well as the creative specifics of digital image aesthetics and to classify equally different image types and to identify standardization tendencies in terms not only of presentation conventions or image formulas, but also of approaches to image design. Secondly, the quantitative dimension of the media diffusion of the digital image of architecture in architectural journals will be investigated chronologically. Thirdly, it is necessary to comprehend the establishment of digital design representation as a separate pictorial genre and to critically explore its functions as an image in typical and specific contexts of use.

On the textual level, the following questions are initially of primary interest: How is the digital architectural image commented on and discussed by contemporaries? Which advantages and disadvantages are attested to it in comparison to analogue representation methods? What status is it assigned? What is the relationship between the development of digital design visualization and that of CAD tools? Which interactions exist? At what point does digital design representation emancipate itself as an independent genre of architectural visualization?

Figure 4. Rüdiger Kramm; Computer drawing without and with revision; ARCH+, no. 77 (November. 1984): 40f.

Journal research was started in January 2020, beginning with *ARCH+*. To conclude, here are a few initial observations mentioned (status year 1996):

- The digital architectural image found its way into *ARCH+* at the beginning of the 1980s in graphic mode: as a plotted CAD drawing that is often revised manually (*ARCH+*, no. 77 (Nov. 1984), 40/41) (fig. 4).

- As an independent, applied design visualization, the 'digital image' first appeared in 1988 in the context of "de-construction by computer" (*ARCH+*, no. 96/97 (Dec. 1988), 52/53).

- In terms of quantity, however, the digital image of architecture rarely appeared until then. Until the mid-1990s, the predominant medium of representation was without question physical model photography.[10]

- On a discursive level, the sequence of topics dealt with shows how the reflection on designing with the computer begins in the mid-1980s. Step by step, a discussion about a completely new approach to architecture unfolds, which is far more complex in its range of content, goals and motives than buzzwords such as 'blob' or 'parametrism' would suggest.

All in all, as is already becoming evident here, it is a long way for the digital architectural image to go until the feeling arises: "Hey, I'm standing in the rendering!" In the mid-1990s this is definitely not yet the case.

Cottbus Subproject

Complementing the art-historical, media-critical perspective on the digital image of architecture in Marburg, we want to examine in the Cottbus part of the project the influence of CAD on architecture and its mediation from the perspective of the designers.

First of all, we would like to briefly explain what is meant by CAD. In full text it means Computer Aided Design, i.e. the promising claim of designing with the help of the computer. In functional terms, however, it simply means that drawing and constructing is no longer done with a pen and ruler, but with the computer mouse, which clicks and drags predefined functions to the desired geometric position.

It is as abstract as it sounds. It is only a matter of familiarization that a line is the result of three clicks: the first one on the tool, the second one on the starting point of the line and the third one on the end point. Alternatively, both the selection of the tool and the positions can be typed in as text and numerical values, which renders the working method even more abstract. Of course, the touchpad has now also found its way into this field as an input tool, but the less precise controls will take another generation to make up for the once again unfamiliar indirect steering of a computer mouse.

Once CAD becomes three-dimensional, it becomes more complex, but the structure and the input are similar. However, the first danger already awaits us here, when well-intentioned offers to make working more convenient are all too readily taken up without being fully understood, not to mention critically questioned. They then lead to the so-called automatism, in which we see one of the most important reasons for the obvious convergence between tool and architectural result.

As architects we also design and visualize ourselves. Our specialization is the visualization of architecture. This includes above all the design in the visualization, but also the design of architecture and visualization in general in research and teaching. Our own experience with CAD dates back to 1986. At that time, CAD programs were only marginally represented in the field of architecture; the majority of architects continued to draw and design by hand until well into the 1990s.

Since then, the change from analogue to digital has largely been completed, both in offices and in research and teaching. As of today, practically no architectural office can be imagined without CAD.

This is why the influence of this tool seems to become so evident. The development of CAD programs is hopefully far from being finished, the list of desired features is practically endless. Up to now, no program has been able to meet all the demands of integrated planning. Basically, the programs are divided into two categories: on the one hand, programs specifically for architectural planning with connectivity to databases and exchange between specialists, engineers and urban planners – so-called integrated planning – and on the other hand, programs with geometrically precise definition and at the same time the highest possible degree of flexibility, which are commonly used in mechanical engineering and industrial design. Attempts to combine the two genres have so far almost inevitably led to concessions to their most highly developed competitors.

For both program types we have selected representatives who were trend-setting for different reasons. The concept of "Building Information Modeling", or BIM for short, has been established at the latest since the program *ArchiCAD* came onto the market in 1984. It means that not only are lines defined, which can then be combined to form surfaces or bodies, but also that objects are defined which have a clear function right from the start. BIM constructs a wall, a ceiling or a roof.

This so-called object-oriented construction method enables integrated mass determinations, cost estimates and interfaces to specialists such as civil engineers. The complexity of this implementation for architecture, however, when the design goes far beyond standard buildings in its formal language, can unfortunately still be seen in most buildings designed with BIM, a circumstance, which will probably disappear in the long term with the revival of BIM, which has gained considerable momentum in recent years.

The original and almost contradictory concept for this is that of free drawing in surface and space, which only provides for an interpretation as architecture in a second step. In 1998, sixteen years later, a new development was published based on the long-time undisputed *AutoCAD*, which exceeded the limited geometry of BIM programs: In contrast to *AutoCAD*, long considered overloaded, the CAD program *Rhinoceros* combines an intuitive interface with geometric versatility that far exceeds the needs of the majority of architects.

With *Rhinoceros*, a movement that began much earlier is now becoming more and more established. The extent to which the accuracy of fit of the tool determines the action, the workpiece, becomes clear when looking at the use of the computer by particularly progressive architects such as Peter Eisenman or Frank Gehry (fig. 5 right), who designed or realized their iconic early work with another CAD program, *CATIA*, which is even older, namely from 1977, and which was not developed by architects but by the aircraft industry in order to achieve the precision in modeling required for aerodynamic performance. The handling of *CATIA* is accordingly anything but trivial, moreover the demands on computer hardware at that time were significantly higher than those of today's PCs.
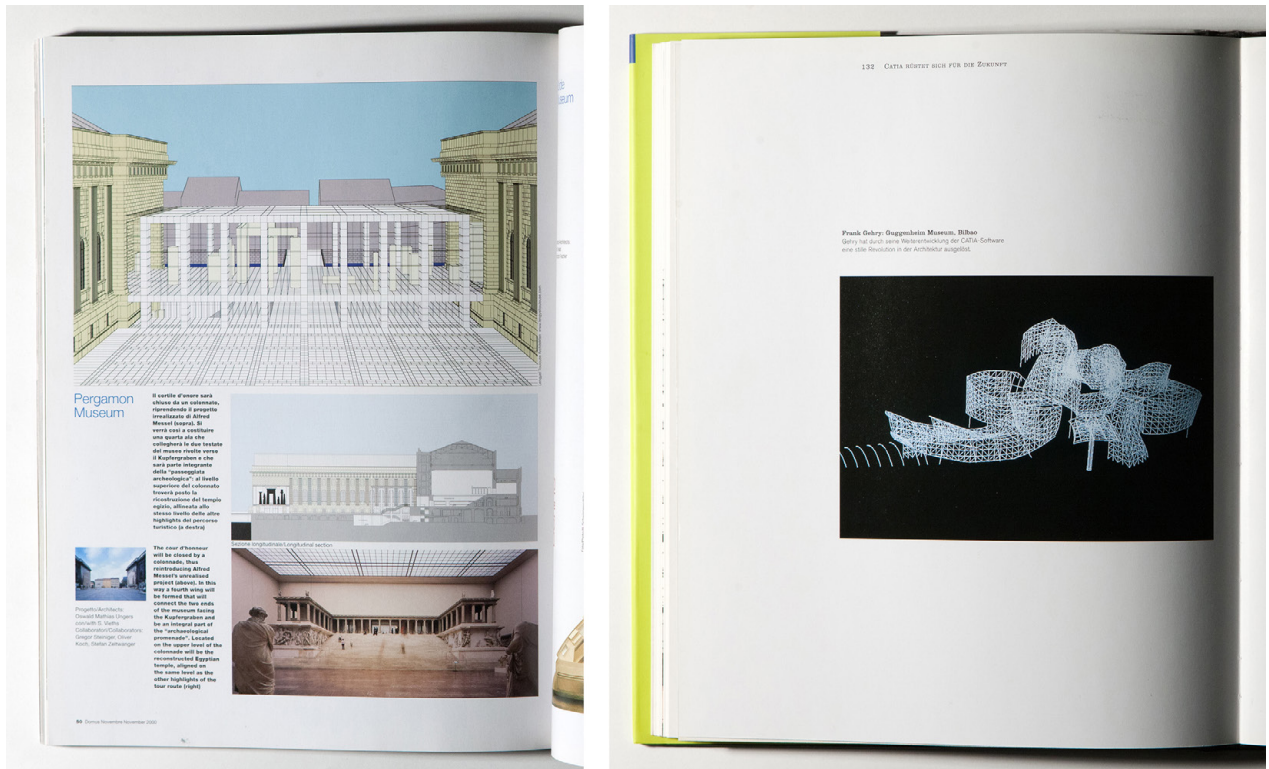
Figure 5. left: O. M. Ungers Office; Pergamon Museum Berlin; visualization: Lengyel Toulouse Architects; DOMUS ((November 2000): 50), right: Frank O. Gehry; Guggenheim Museum Bilbao; J. Steele. Architektur und Computer. Munich: Callwey, 2001: 132.

On the other hand, the differences to the *ArchiCAD* program type are already apparent in the tools palette, which is both a blessing and a curse. Efficiency and automatism can only be distinguished from each other if there is a well-developed sense of design. With *ArchiCAD*, the simple, direct path to the result leads to the definition of such objects, which can be defined with as little effort as possible using the obvious tools: straight ceilings, vertical walls and sloping roofs.

In addition, especially with such specialized architectural programs, there are object libraries. Libraries facilitate planning by providing prefabricated objects. This remains relatively harmless for furniture or building hardware. All major manufacturers provide their furniture as CAD files, usually free of charge, for the simple reason that architects can use them in their buildings and later buy them or have them bought by their clients.

But more dramatically, such objects are used for architectural components such as windows and doors or entire roof dormers. In these cases library elements can lead to completely unreflected results. A prefabricated staircase relieves the architect of a great deal of work, especially if the geometry is a little more demanding, as is often the case with staircases. The regression of mathematical education has made it increasingly necessary to use computer-aided solutions even for such rather trivial problems that were routinely solved by hand in the times before the computer.

With *Rhinoceros*, in contrast, the decision for the right tool is not as easy. No tool alone can produce a component suitable for production planning. The path to the finished component is a series of successive steps, so that it is almost irrelevant whether you start with a cuboid or with a line curved freely in space. For furniture this makes no difference. But architectural components such as windows are not available in *Rhinoceros*, so the user cannot be tempted to use prefabricated components. Formal conflicts arise in cases where, for example, free forms of the outer shell meet rectangular forms such as doors.
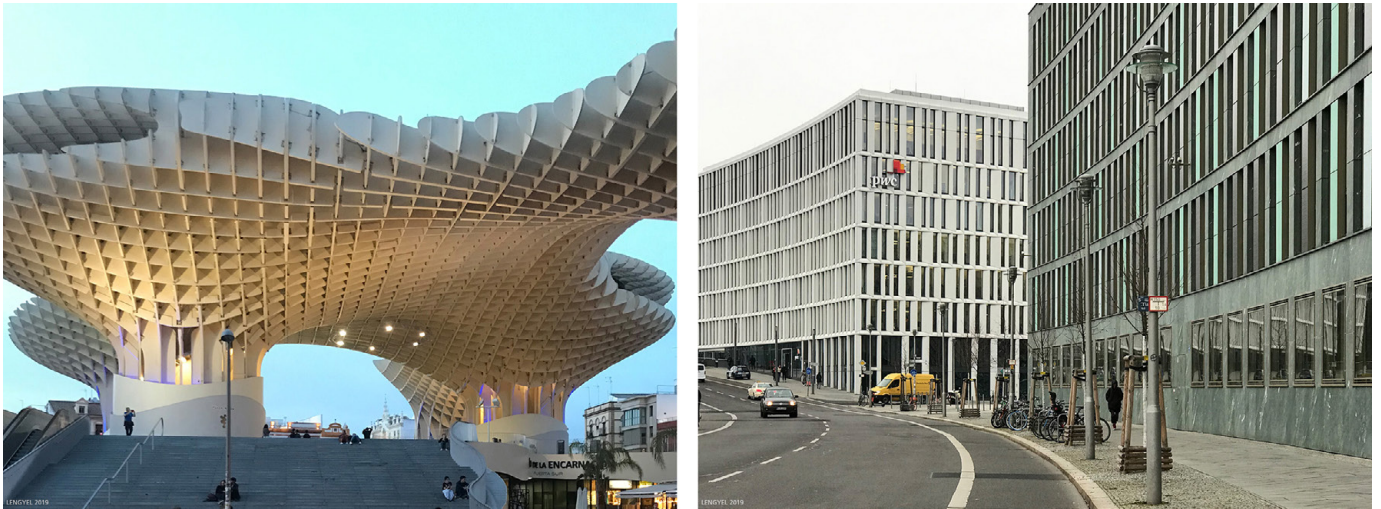
Figure 6. left: Jürgen Meyer H.; Metropol Parasol in Sevilla; finished 2011; photo: Dominik Lengyel, right: KSP Jürgen Engel Architekten; PricewaterhouseCoopers office building; finished 2015; opposite central station Berlin; photo: Dominik Lengyel.

Here too, the result is certainly determined by the creativity and enthusiasm of the user. Therefore, as a first step in the course of our project, we are also running an experimental design seminar for students of architecture, which will reveal the differences in the influence of the tool on architecture and visualization in direct comparison.

The seminar is designed to work on the same architectural task with the two opposing programs mentioned above – *ArchiCAD* and *Rhinoceros*. The subject is the classic design task retreat in the sense of a place of withdrawal for two people. The architectural vision is to be designed for a place that is only specified by a single photograph. This place is located literally and metaphorically on a green field. Beyond that there is no further concretization or restriction. The goal is the visual realization of the architectural imagination only. In contrast to the usual approach, the design here is not the complete building with floor plans, sections and views, in which the construction, details and calculations are then developed, but the digital image alone.

We understand the focus on the image not as a shortage of architectural depth, but as a commitment to visualization as the most expressive way of communicating an architectural idea. It can be said that only the image shows the architectural design intention in its genuine form, or in other words: the presentation is the project. With this task we attempt to empirically verify whether geometrically simpler software produces correspondingly geometrically simpler visions, while geometrically complex software produces likewise visions.

As CAD becomes more widespread in architectural offices, we can also observe collateral effects when these offices do not use the programs in the way they were intended. This can be considered a creative approach or just an efficient use as opposed to hand drawing. In our research project, therefore, in addition to the experimentally oriented examination of the effects of the various digital design tools in the context of the design seminar, we also want to examine cases from the visualization practice of larger and well-known architectural offices, which show how a pronounced design intent can resist the traps of seduction by CAD.

The architect Oswald Mathias Ungers, for example, did not use the *ArchiCAD* program for integrated specialist planning in the sense of BIM, nor did he use predefined library elements. His motivation was solely the digitization of the technical drawing using a software that is particularly easy to learn, more efficient reproductions, digital printing and the sending of data digitally to the repro service. Even in visualization, CAD was used as an efficient method of constructing linework perspectives. The result was images whose digitality completely vanished behind

their analogy to the earlier drawings of the office of Prof. O. M. Ungers, which had still been drawn by hand with ink pencils (fig. 5 left). In its early phase, the digital architectural image thus merely adopts the graphic mode of the technical drawing. Apparently, this is already indicated by the findings of the journal research (see above).

This rather restrained attitude towards CAD is contrasted with the open-minded approach, which attempts to find the architectural form through CAD (fig. 6). The influence of CAD is naturally more evident in such work, especially in the early days of CAD. As already mentioned, these include the architects Peter Eisenman and Frank Gehry, and later also Zaha Hadid and Greg Lynn. Even the architect Hans Kollhoff, whose architectural design is much more oriented towards the analogue era, helped CAD to develop a new visual language. His visualizations do not hide the digital, but combine a traditional architectural language with the possibilities of the digital image.

Our contribution as practicing architects to the joint research project is therefore also the examination of what is technically feasible. To this end, the third step is to assemble the development of tools for design and visualization with regard to the two exemplary programs *ArchiCAD* and Rhinoceros, sorted chronologically according to their versioning. In this way we want to relate the digital tools to the development of architecture and visualization as we find them in the material of the Marburg journal research.

Whereas in Marburg the central question is: To what extent does the digital image generally change the concept and perception of architecture, in Cottbus we are asking specifically how the digital image changes the shape of architecture. Our aim is to determine those architectural design elements or features that can be plausibly addressed as components of a 'digital architecture'. In accordance with our profession, this will have to be presented in the form of a visual argumentation.

As a result of our cooperative research project we expect to see a clearly recognizable connection between tool and image. We hope that it will be possible to express this relationship through images alone. For this reason, we are planning a joint exhibition at the end of the project, which will show the development of the architectural digital image using relevant architecture. For the first station of our exhibition, we are pleased that Hans-Dieter Nägelke from the Museum of Architecture at the TU Berlin has agreed to the use of his museum at the end of the first funding period.

NOTES

[1] Beatriz Colomina, *Privacy and Publicity: Modern Architecture As Mass Media* (Cambridge: MIT Press, 1994).

[2] Cervin Robinson and Joel Herschman, eds, *Architecture Transformed: A History of the Photography of Buildings from 1839 to the Present* (Cambridge: MIT Press, 1990). See also Hubert Locher, "Zur Einführung: Fotografie als Darstellungs-, Entwurfs- und Gestaltungsmedium der Architektur im 20. und 21. Jahrhundert," in *Architektur Fotografie: Darstellung – Verwendung – Gestaltung*, ed. Hubert Locher and Rolf Sachsse (Munich: Deutscher Kunstverlag, 2016), 9–22; Hubert Locher, "Mythogene Fotografie – Architektur, Fotografie, Gemeinschaft," in *Architektur Fotografie: Darstellung – Verwendung – Gestaltung*, ed. Hubert Locher and Rolf Sachsse (Munich: Deutscher Kunstverlag, 2016), 178–203.

[3] For example Peter Zellner, *Hybrid Space: New Forms in Digital Architecture* (London: Thames & Hudson, 1999); *digital real: Blobmeister, erste gebaute Projekte*, ed. Peter C. Schmal (Basel et al.: Birkhäuser, 2001), exhibition catalogue; Carolin Höfler, "Form und Zeit: Computerbasiertes Entwerfen in der Architektur," PhD diss., (Humboldt University Berlin, 2009); *Wendepunkte im Bauen: Von der seriellen zur digitalen Architektur*, ed. Winfried Nerdinger (Munich: Ed. Detail, 2010), exhibition catalogue; Bernhard Langer, "Computerdarstellung. Vom Programm zum digitalen Ökosystem," in *Die Medien der Architektur*, ed. Wolfgang Sonne (Munich: Deutscher Kunstverlag, 2011), 157–168; Mario Carpo, *The Digital Turn in Architecture 1992–2010* (New York: Wiley, J, 2012); Svenia Schneider, *Blob-Architektur für das 21. Jahrhundert: neues Paradigma oder Relaunch einer ehrwürdigen Tradition?* (Marburg: Tectum, 2012); Sabine Ammon and Eva Maria Froschauer, eds, *Wissenschaft entwerfen: Vom forschenden Entwerfen zur Entwurfsforschung der Architektur* (Paderborn: Fink, 2013); Ekkehard Drach, ed, *Das Verschwinden des Architekten: zur architektonischen Praxis im digitalen Zeitalter* (Bielefeld: transcript, 2016); Carin M. Schirmacher, *Paradoxien des Digital Turn in der Architektur 1990–2015: von den Verlockungen des Organischen: digitales Entwerfen zwischen informellem Denken und biomorphem Resultat* (Berlin: Pro Business GmbH, 2018); Barbara Wittmann, ed, *Werkzeuge des Entwerfens* (Zürich: Diaphanes, 2018).

[4] For example Jörg H. Gleiter, ed, *Die Realität des Imaginären: Architektur und das digitale Bild, Proceedings of 10th International Bauhaus Colloquium Weimar 2007* (Weimar: Bauhaus-Univ., 2008); Bernd Sum, "Simulation als Entwurfswerkzeug für den Architekten: Untersuchungen zur Integration in ein Curriculum am Beispiel der KIT-Fakultät für Architektur," PhD diss., (KIT Scientific Publishing 2017); Sabine Ammon and Inge Hinterwaldner, eds, *Bildlichkeit im Zeitalter der Modellierung: operative Artefakte in Entwurfsprozessen der Architektur und des Ingenieurwesens* (Paderborn: Fink, 2017). Likewise, the digitization of architecture itself has become the subject of historical research: Greg Lynn, ed, *Archaeology of the Digital: Peter Eisenman, Frank Gehry, Chuck Hoberman, Shoei Yoh* (Berlin: Sternberg Press, 2013); Andrew Goodhouse, ed, *When is the Digital in Architecture?* (Berlin: Sternberg Press, 2017).

[5] Philip Ursprung, "Photoshop und die Folgen: Das Dilemma der Architekturdarstellung," in *Die Realität des Imaginären: Architektur und das digitale Bild, Proceedings of 10th International Bauhaus Colloquium Weimar 2007*, ed. Jörg H. Gleiter (Weimar: Bauhaus-Univ., 2008), 171–176; Dominik Lengyel and Catherine Toulouse, "Die Bauphasen des Kölner Doms und seiner Vorgängerbauten: Gestaltung zwischen Architektur und Diagrammatik," in *Diagrammatik der Architektur*, ed. Dietrich Böschung and Julian Fachmann (Paderborn: Fink, 2013), 327–352; Dominik Lengyel and Catherine Toulouse, "Die digitale Visualisierung von Architektur," *Blickpunkt Archäologie*, no. 2 (2016): 91–98.

[6] *Die Architekturmaschine: die Rolle des Computers in der Architektur*, ed. Teresa Fankhänel and Andreas Lepik (Basel: Birkhäuser, 2020), exhibition catalogue. In this context, a further publication should be mentioned, also published in October 2020, in which the topic of 'digital architecture' is treated just as comprehensively: Ludger Hovestadt and Oliver Fritz, eds, *Atlas of Digital Architecture: Terminology, Concepts, Methods, Tools, Examples, Phenomena* (Basel et al.: Birkhäuser, 2020).

[7] Sabine Ammon and Inge Hinterwaldner, eds, *Bildlichkeit im Zeitalter der Modellierung: operative Artefakte in Entwurfsprozessen der Architektur und des Ingenieurwesens* (Paderborn: Fink, 2017).

[8] Andrea Roedig, "Hey, ich steh im Rendering! Über Architektur, Bild und digitalen Realismus," *Wespennest*, no. 169 (2015): 66–69.

[9] Florian Henrich's dissertation with the working title "Die Kanonisierung des Neuen Bauens – Architekturausstellungen in der Weimarer Republik 1914–1934", in which this methodical research approach is being tested on a larger scale, is in its final phase. See also Florian Henrich, "Der Ursprung und das Fagus-Werk. Architekturhistoriografie und Fotografie," in *Architektur Fotografie: Darstellung – Verwendung – Gestaltung*, ed. Hubert Locher and Rolf Sachsse (Munich: Deutscher Kunstverlag, 2016), 131–147.

[10] Florian Henrich, "An der Schwelle zum Digitalen – analoge und digitale Methoden der Architekturvisualisierung in der Bauwelt 1987," *Das digitale Bild*, May 18, 2020, url: http://www.digitalesbild.gwi.uni-muenchen.de/an-der-schwelle-zum-digitalen-analoge-und-digitale-methoden-der-architekturvisualisierung-in-der-bauwelt-1987/.

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CURATING DIGITAL IMAGES: ETHNOGRAPHIC PERSPECTIVES ON THE AFFORDANCES OF DIGITAL IMAGES IN MUSEUM AND HERITAGE CONTEXTS

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ABSTRACT | This paper provides an overview of the DFG-funded research project Curating Digital Images: Ethnographic Perspectives on the Affordances of Digital Images in Museum and Heritage Contexts, part of the DFG Priority Program The Digital Image. First, we outline the project's theoretical grounding in affordance theories and its attention to practices of curating digital images before providing two ethnographic examples from our project's main areas of work. These examples show how lay users shape their encounters with museum objects by employing digital image technologies and social media, creating new relationships between museums and everyday life. Next, we describe a new methodological approach that brings together ethnography, eye-tracking technology, and information science to study visual perception and practices of looking in digital curation. In our outlook, we indicate five key affordances of digital images for curatorial practices that we consider over the course of our project.

KEYWORDS | contemporary visual culture, digital/digitized, photography, ethnography, eye-tracking

"#museum" has appeared over 20 million times to date on Instagram alone,[1] Google's "arts and culture" project cooperates with over 2000 institutions,[2] and the web portal Europeana[3] contains more than 58 million digitized artefacts from museum collections—the ubiquity of art images online is transforming the ways in which visitors encounter and experience museum spaces and objects. The research project Curating Digital Images: Ethnographic Perspectives on the Affordances of Digital Images in Museum and Heritage Contexts examines this transformation, bringing ethnographic perspectives to bear on practices of digital curation. The project is based at the Centre for Anthropological Research on Museums and Heritage (CARMAH) at the Humboldt-Universität zu Berlin and is part of the DFG Priority Program The Digital Image. Led by Christoph Bareither, Sharon Macdonald, and Elke Greifeneder, the project combines the expertise of CARMAH with approaches from media studies, digital anthropology, and information science.[4]

The project draws on affordance theories to explore how the digital image, through its specific potentials and limitations, enables particular practices of digital curation, especially among laypeople. What is allowed or encouraged by images in digital form? Two interconnected empirical studies explore these practices ethnographically. The first, by Katharina Geis, examines how and to what ends users of digital image archives view, search, sort, alter, and rearrange

digital images. The second, by Sarah Ullrich, concentrates on the digital image practices and social media activities of museum and heritage visitors. The two ethnographic studies are complemented by an innovative eye-tracking study conducted by Vera Hillebrand and other PhD researchers at the iLab at the Berlin School of Library and Information Science.

Besides collecting valuable new empirical data for research and practice, the project aims to contribute to the conceptual and theoretical debates arising from The Digital Image program funded by the German Research Foundation. From an ethnographic perspective, the particularities of the digital image can be understood only in relation to the practices in which they are embedded. The answers to the questions "What is the digital image?" and "How does it differ from the non-digital image?" cannot be found, therefore, in theoretical reflection alone but, crucially, by examination and analysis of their lives in use.

On the Affordances of Digital Image Technologies and the Practices of Digital Curation

Our project draws on affordance theories in examining the interrelations between digital images, museum spaces, and practices of digital curation. Developed by the evolutionary psychologist James W. Gibson, affordances describe the possibilities and limitations of material environments and digital technologies that make particular practices available with or within them.[5] Donald Norman explains the concept with a much-cited example: "A chair affords ('is for') support and, therefore, affords sitting".[6] Anthropological approaches to affordances, like the one we take in our project, highlight their relational nature. For instance, in Norman's example, the chair affords sitting only for humans (or, in some cases, for animals) whose bodies know what sitting is and how to sit. In effect, affordances always depend on the incorporated knowledge of living beings. What Pierre Bourdieu famously called the "practical sense"[7] shapes what particular environments or objects afford to us. Ultimately, affordances are never independent of practice.[8]

We use this relational concept of affordances on two levels. The one level looks at material affordances to identify what museum and heritage spaces and their objects afford to human actors.[9] For example, museum spaces can afford practices of learning; practices of remembrance; practices of enacting sensory, aesthetic, and emotional experiences; practices of engaging in social exchange; and many more. To clarify, the affordance-practice relationship is neither linear nor static. What particular museum spaces and objects afford depends on the visitors' particular situation and their understanding of how to engage in museum and heritage spaces. The second level looks at how the affordances of the digital image shape the relationships between visitors and museum spaces.[10] We use the term "digital image" not simply to denote images based on binary code, but as a shorthand for a wide range of digital technologies encountered in the field of museum and heritage, including devices (smartphones, cameras, computers), platforms (digital archives, social media, forums), and contextualization tools (captions and texts, hashtags, metadata). We ask how these digital image technologies create new potentials and limitations for visitor and user practices, and we follow these practices to study the lives of digital images in use.

The most crucial among these practices are practices of digital image curation. By this we mean both the curation *of* digital images and curatorial practices enacted *through* digital images—that is, what digital images allow or encourage people to do with them. Though we use the term "curation" to refer to the activities of lay users, we do not assume a precise equivalent to professional practices. Instead, the term allows us to ask whether lay practices follow similar principles and routines as those of professionals, as well as whether they adopt their meanings and values. Accordingly, we begin from a broad understanding of curation.[11] Curation is a practice whose task "is to make junctions, to allow different elements to touch",[12] an "activity of putting together" that involves selecting, organizing as well as "enabling, making public, educating, analyzing, criticizing, theorizing, editing, staging".[13] Such practices of curation are not restricted to museum spaces. As many scholars have pointed out, they have long become an integral part of our everyday lives—especially within digital societies.[14] By looking at what laypeople in the field of museums and heritage do with digital images and at what they say about it, we will be better able to define what constitutes curation as well as what it means to those who engage in it.

Our initial empirical work has identified several practices that are key to curation: (1) practices of looking, which include browsing and searching in digital spaces, visual perception, and its accompanying bodily movements in physical spaces; (2) practices of creating, selecting, and collecting, which include taking pictures in physical spaces and downloading, capturing, or bookmarking images online; (3) practices of editing and contextualizing, such as the use of professional editing software or social media apps; (4) practices of displaying and sharing on online forums, personal archives, and social media platforms; and (5) practices of networking and circulating through shares, reposts, comments, hashtags, up/downvotes, and like. As will become clear below, we regard these practices not as distinct but as enmeshed elements in the curatorial process.

Work Area 1: Digital Image Archives

For several years now, many museums and heritage institutions have heavily invested in digitizing their collections and making them publicly accessible online. Now, people can browse museum collections from all over the world any time they want. Millions of images are available to explore and view on museum websites and web portals such as Europeana, the largest European digital archive for museum and heritage objects and a partner of our project. Many institutions provide open access to their resources, but the question of who uses the archives and what they actually do with the digital images remain largely unexplored. Our project aims to help find answers beyond user demographics and general usage data, offering ethnographic insights into how digital archives afford new kinds of museum experiences and how digital images become part of the daily life of their users.

Our ethnographic research in this work area has mainly been conducted online and, so far, includes participant observation, qualitative interviews, and the analysis of social media posts and other images and texts. Participant observation has consisted in active participation in the curatorial practices specific to each platform and website, with the aim of better understanding its affordances and communities. We have also contacted users via messenger systems or email to ask how digital curation became a part of their everyday lives.

The exploratory phase of our ethnographic fieldwork followed the paths of digital curation through the Web, leading us to social media platforms such as Instagram, Reddit, Facebook, Pinterest, Tumblr, and Twitter. Many users on these sites share visual museum content as they post accompanying texts and connect with other users. But the websites are only a starting point for understanding lived curatorial practices. While there are some practices that are enacted solely online, many also find their way into physical environments. Because "our online and offline lives [are blended] into an inseparable mesh of connections," Christine Hine writes, "fieldsites are not easily located either online or offline but involve tracing networks of connection through online and offline spaces".[15] The interconnectedness of the digital and physical spheres is of particular interest for our project. How exactly does this entanglement occur? How do users interact with and talk about digital images with others?

Let us consider an example of the interconnections between digital and physical environments created through curatorial practices. One interviewee, Anya, told us that she browses digital archives for patterns to use in her work with textiles. Below is an artefact from the British Museum (fig. 1) that Anya drew in her sketchbook (fig. 2), one of many elaborate pen drawings it contains. By returning the digital representation of a material artefact to its physical form, her curation transcends the boundary between digital and physical space. "Sometimes," Anya explains, "I will pick things just because they are pretty and interesting, and the story behind objects is good to know…because it can give inspiration in a more general sense." For Anya, the digital archive of the British Museum is more than just a museum display case; it allows users to browse objects, zoom in on details, and collect background information.

In addition to making drawings from her museum collections, Anya posts her work under the hashtag "inspiration" on Tumblr. With its options for collecting and sharing digital artwork, the platform is popular among art and history enthusiasts, who use it to create shared archives of exciting images. This complex system of exchanging, downloading and identifying images, transforming them into knowledge, and creating new art exemplifies the surprising journeys that digital images can undertake through practices of digital curation.

Figure 1. An Iznik dish at the British Museum, ca. 1625–1650 © The Trustees of the British Museum.

Anya's are just one of many curatorial practices afforded by digital image archives that we have observed during the first few months of fieldwork. The other practices we came across include making digital art, using images as inspiration for creative works, lending support to historical arguments, expressing feelings, and sharing knowledge with an interested community. We also observed educational practices, such as teachers who use digital images in lessons and hobbyists who create tutorials for making GIFs and recreating historical costumes or artefacts from archival images. The digital image technologies we study in this work area afford the creation of personal archives of inspirational or useful images, the enacting of aesthetic experiences, the gaining and sharing of knowledge, and connecting on shared interests through posting, liking, and commenting.

Work Area 2: Social Media and Visitor Practices

Another area where the affordances of digital image technologies are having a transformational effect is the experience of visitors in physical museum and heritage spaces. Digital photography and editing apps now allow museumgoers to capture, select, change, optimize, and sort what they see. Later they can contextualize the digital images on social media platforms with comments, hashtags, hyperlinks, and emojis. Our second project work area brings together two interrelated studies to illuminate very different dimensions within these practices.

The first study draws on ethnographic work examining practices of digital curation at Berlin's Memorial to the Murdered Jews of Europe.[16] It sheds light on how digital image technologies allow visitors to curate their "emotional knowledge of the historical".[17] Here, digital image technologies afford the presencing of the past[18] through the merging of epistemic and emotional practices that draw connections to the memory of the Holocaust. The published results of this research are the basis for a larger and still ongoing study of visitors' practices of digital curation in art museums and galleries.

16th century Iznik tile, V&A ↑
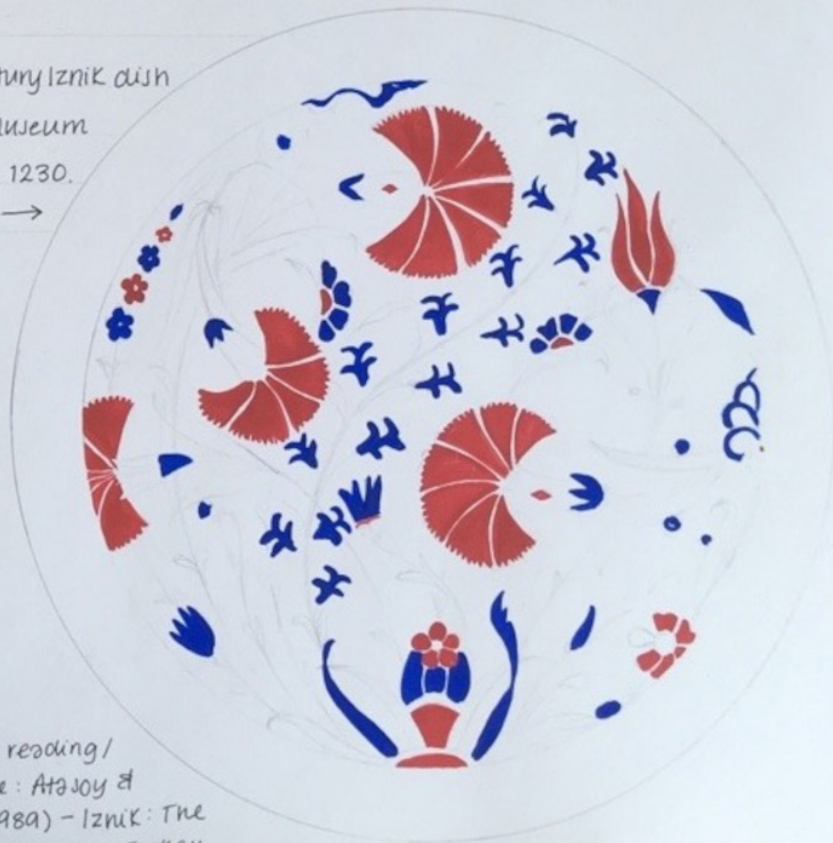Ceramics collection, #189:25-1881

16th/17th century Iznik tile, V&A ↑
Ceramics collection, #273E-1902

17th century Iznik dish
British museum
#1878, 1230.
498 →

Further reading/
reference: Atasoy &
Raby (1989) - Iznik: The
Pottery of Ottoman Turkey

Figure 2. A page from Anya's sketchbook inspired by the above Iznik dish.

So far, this second study has considered social media practices that "[build] socially acceptable profiles and behaviors within each platform" via sharing pictures, liking, commenting, and participating in virtual museums so as to establish a "co-presence".[19] The exploratory phase of the project found that the lay curation of artwork from museums is strongly shaped by the affordances of social media platforms. By focusing on Instagram, in particular, we were able to target the collection and analysis of social media posts to complement our detailed interviews with museum visitors.

One notable early finding is that museum visitors often curate their experiences with on-site digital self-portraits, which point to the role of bodily positioning and movement in lay curation.[20] Through sharing images of their bodies with others on social media platforms, the visitors join a "language of online belonging"[21] that articulates everyday experiences in dialogue with digital publics. The finding raises many questions: Do images in which visitors position their bodies in proximity to artworks change their perception of art and, if so, do they value the art more – because, say, their sense of personal connection or ownership is greater? How are exhibited objects made meaningful through the physical presence of visitors? How does the curation of museum self-portraits on social media platforms place art in personal narratives and alternative contexts? And how is value renegotiated by photographs that interweave museum spaces with everyday contexts?

One interesting practice of physical engagement that we have identified is the engagement with museum spaces and exhibits through "dressed-to-match" fashion. Figure 3 provides an example: a museum visitor poses in front of artworks dressed to reflect their aesthetic qualities. As a cultural practice, of course, fashion is not merely about clothes and accessories; it is a product of complex synergies between material, discourse, and action.[22] The dressed-to-match practice disrupts or breaches the boundaries between different forms of cultural expression: between high art and the more quotidian world of fashion, between generations, and between the spaces of the gallery and popular online sites. As one interviewee told us:

For me fashion and traditional art forms are two of the same kind. I use both to express myself and I try to carry the art that I see into the real world and I do so by wearing certain clothes. Not many young people go to art galleries these days, but almost everyone uses Instagram, I have always dealt with art and I went to a luxury school, so I know my way around the artistic world very well...I want to share my experiences.

While museums and art galleries are places whose complexity is thought to be graspable only if visitors have acquired a deep understanding of art and art history, fashion and media use are understood as areas of participation limited only by an individual's everyday knowledge. Accordingly, dressing to match can be seen to enact the transition from an exclusive to a generally accessible form of art experience.

Highlighting the similarities between artworks and clothing creates new connections between museum spaces and visitors' everyday lives. The digital image practices that result communicate artistic knowledge, aesthetic preferences, shared ideas of taste, and value attributions. The digital curation of art exhibits and their photographic depiction and online display in relation to visitors' bodies are more than mere self-representation against a pleasing backdrop. Instead, by drawing connections to museum spaces and visitors' bodies, digital image technologies afford the generation of visual meaning and renegotiate the value of art experiences.

An Innovative Methodology Combining Ethnography and Eye Tracking

If curation is a practice enacted through bodies and their incorporated knowledge, we also need to account for practices of looking.[23] How individuals look at the material environments of museums and heritage, and how they look at and through the user interfaces of digital image technologies, is integral to the digital curatorial process. Likewise, the ways in which bodies are trained to perceive, appreciate, or ignore particular aspects of the world shape the connections made in curatorial practices. But fieldwork, interviews, and other ethnographic approaches have a "blind spot." Ethnographers are unable to directly observe practices of looking in their detail and complexity. To address this, our project has designed an innovative methodology that combines approaches from ethnography
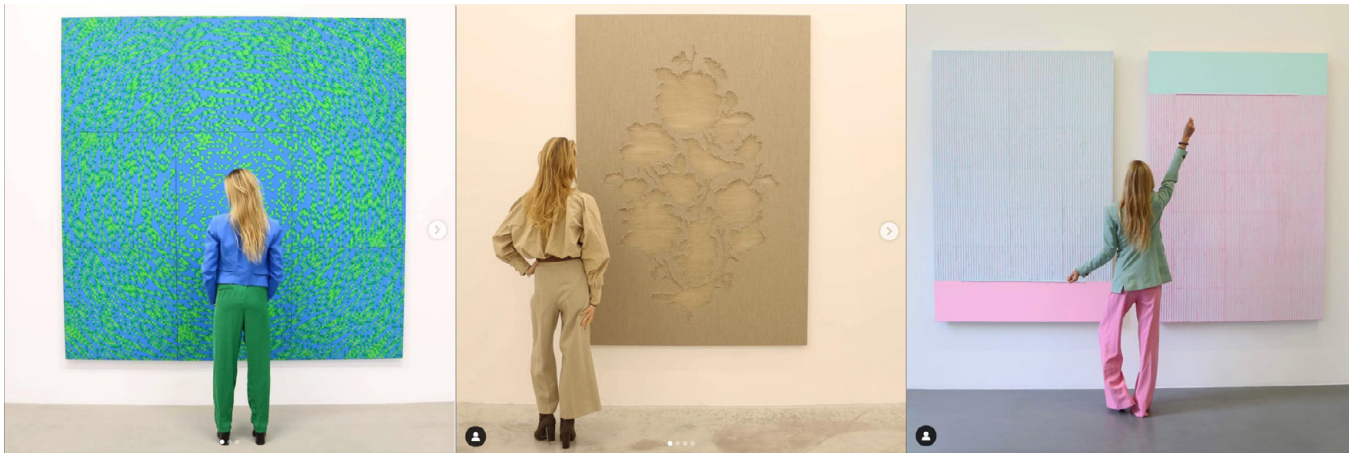
Figure 3. Salomé Montpetit; matchwithart; https://www.instagram.com/matchwithart; screenshots of matchwithart (2019–2020); engaging with exhibits and museum spaces through fash-ion.

and the eye-tracking technology used in library and information science. The latter discipline has deployed eye tracking in studies of digital libraries, in analyses of affordances, and in research on museum visitors' perception of museum spaces.[24]

In Curating Digital Images, the iLab at the Berlin School of Library and Information Science (IBI)[25] brings in a range of modern eye-tracking technologies capable of giving insights into sensory perception and facial reactions during practices of digital curation. Modern eye-trackers work with infrared light that creates a reflection in the eye and a camera that records the reflection. Eye-tracking researchers collect data on eye movements (known as saccades) and identify points of fixation. Described as the "process of determining where someone is looking",[26] eye-tracking can provide information on visual awareness and perception. As Sumartojo et al. argue, combining eye-tracking with ethnography can help "reveal a process of contextual and embodied looking, in which people make sense of the visual aspects of their surroundings using much more than visual information".[27] Eye-tracking adds a new layer of sensory analysis to ethnography, while ethnography contextualizes the results from the eye-tracking. The combination represents a new approach for understanding practices of looking in the curation of digital images.

For our research on digital image archives (work area 1), we will work with a 60 Hz eye tracker model by Smart Eye called the Aurora Remote Tracker. This device records the eye movements of individuals as they scroll through digital archives for artefact or artwork images. Besides determining how long a person gazes at different points on the screen, the software can generate heatmaps indicating the areas of a website on which users focus the most attention. By considering the pupil movements and relating them to our ethnographic findings, we hope to acquire more knowledge about which practices of looking are afforded by digital image archives, and how they relate to digital curation.

For the study of visitor photography and social media practices in physical museum spaces (work area 2), we will use Pupil Invisible, an open-source mobile eye tracker introduced in 2019 that looks like a regular pair of glasses but is connected to a camera and a smartphone. The device will allow us to capture videos of how visitors visually perceive the museum space, and how they interact with it as their attention shifts from their digital device to exhibited objects and back. This mobile eye tracker records the museum environment and then superimposes the points of fixation on the video. In contrast to older head-mounted trackers, for which participants had to carry backpacks with heavy notebooks, the Pupil Invisible device is unobtrusive, causing minimal obstruction and allowing visitors to engage in routine practices at the museum.

Drawing on affordance theories, we will use the eye-tracking data to consider how digital devices potentially reshape image perception. We also plan to expand our approach to include photo and film elicitation.[28] Using these techniques, we will examine the captured videos together with study participants after their museum visits, allowing

Figure 4. Vera Hillebrand explaining eye-tracking heatmaps; the red areas indicate eye fixations.

them to see their own looking behavior while asking them about their reactions. In this way, we hope to bridge the gap between ethnographic research and information science in order to gain new insights into visual perception as an integral part of lay curation.

Implications and Outlook

While we are still at an early stage of our research, we have already determined a number of affordances emerging from digital images. As a tentative outlook, we present below a selection of the affordances we have identified, together with a brief consideration of their potentials for the theory and practice of museums and heritage.

1. The digital image affords *personal* curation. That is, it allows laypeople to customize their experience of museums and heritage through the selection, combination, and arrangement of particular artworks or other museum artefacts, sometimes in virtual environments of their own design. Within museum practice, a movement arose some years ago to provide visitors with a more personalized experience.[29] Various technologies have been deployed to that end, such as electronic tablets for visitors that provide alternative exhibition routes and information. A better understanding of the ways in which laypeople curate museum contents can surely contribute to more effective and interesting museum offerings, both online and on-site. But efforts to personalize the museum experience have elicited some criticisms. One is that it serves more to limit than to expand educational impact.[30] If visitors get to determine what they see, the argument goes, then they will be less likely to encounter content that challenges them and broadens their horizons. More empirical research is needed to determine whether this is the case, though some recently published studies do not seem to support the argument.[31] The reason for this may lie in a tenet of pedagogy, namely that learning is more effective when it is active. This concept has been widely discussed in museum studies,[32] and has been put into practice in a variety of ways.
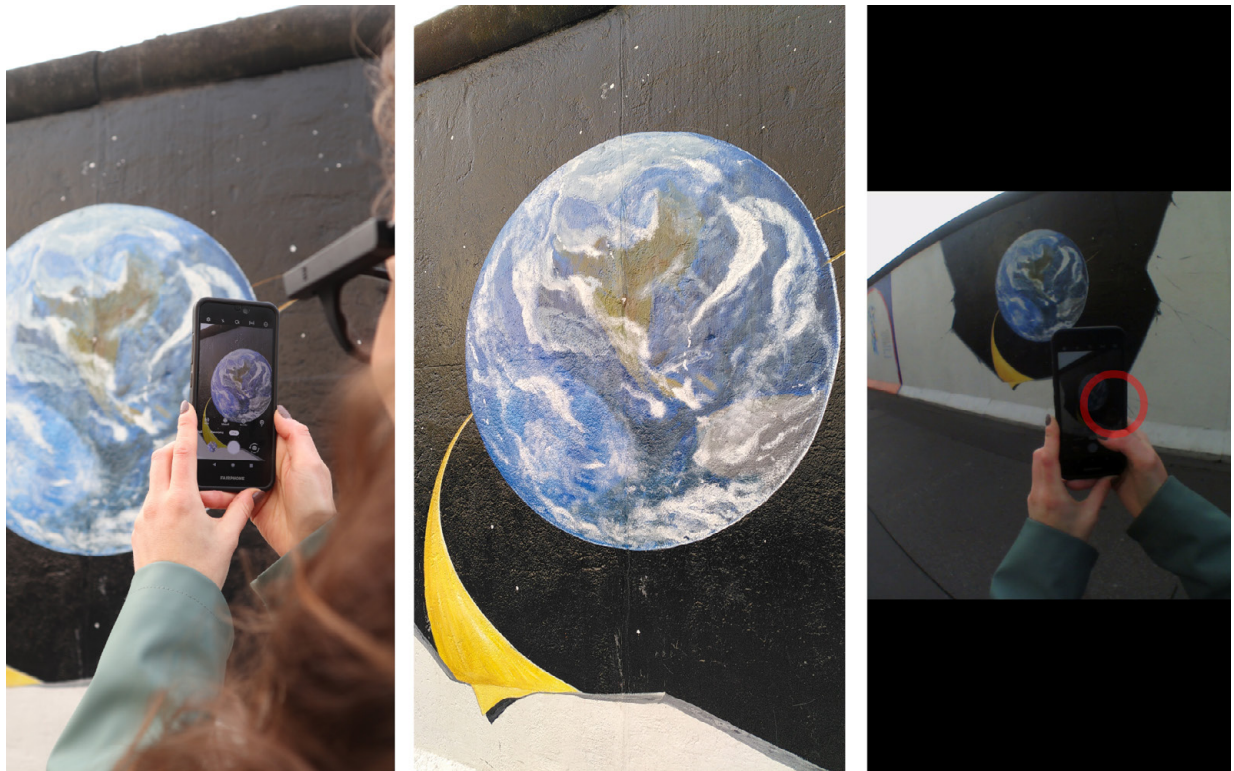
Figure 5. left: Sarah Ullrich wearing the mobile eye tracker while taking a picture of an artwork; middle: the smartphone picture; right: a still from the video footage captured by the eye tracker, indicating the current focus of the eye.

2. The digital image affords *active* engagement. While personal curation may be said to be a form of active engagement, the degrees and forms of engagement afforded by the digital exceed what is typically associated with personalization. In particular, digital technologies enable numerous forms of active engagement, such as the possibility of nuanced practices of looking—zooming in closely to artworks, focusing on brush strokes and other details.[33] Bligh and Lorenz have noted how some technologies afford what they see as the central "Art Historical practice of *comparative viewing*".[34] They do not discuss the technologies that we cover here—these were still emerging when the article appeared—but such technologies clearly have an enhanced capacity to bring different images into proximity with one another. How far users engage in such activities, and the knowledge and expertise they develop in the process, has implications for museums and heritage both in terms of what they provide online—the resolution of images in online archives, say—and the digital technology they introduce on-site. This is also true for more extensive forms of active user engagement, particularly the manipulation of images. With digital technologies, users can cut up, recolor, expand, blur, draw, or superimpose other images on what they have taken from museums. While this is not entirely impossible by analogue means, it is much easier with digital technologies. The popularity of playfully reimagined digital images—which has grown even more during the COVID pandemic[35] —clearly shows that users relish this form of active engagement. An important question for theory and practice is the extent to which reimaginings encourage learning and interest in art.

3. The digital image affords *bodily* engagement. This affordance may seem paradoxical in that the digital is often regarded as standing in opposition to the material, as disconnected from the physical and embodied. But as noted earlier, bodies are very much present in digital images made in museum settings and in some of the archival digital images shared creatively online.[36] "Embodied experiences," Olga Hubard, in an essay from 2007, writes, "not only aid in the construction of knowledge, they also help make this knowledge more meaningful…[I]t is the body and the emotions that enable people to empathize to… lend their lives to a work of art…humanizing their aesthetic encounters… [Embodiment means that] the works they see will enter their lives in more significant and memorable ways".[37] Though Hubard does not mention the digital—she focuses on drawing and the corporeal emulation of sculptures or figures in paintings—our work strongly suggests that digital technologies produce new possibilities

for similar forms of bodily engagement. In the future, we will explore the emotional, humanizing, and memorable aspects of digitally mediated bodily engagement for individual and collective experiences.

4. The digital image affords "*socially distributed curation*".[38] As our work has shown, digital images enable lay curators to share, discuss, tag, and collectively arrange or manipulate images online. Through these activities, they create and curate not only digital images but also networks, groups, and communities of users with shared interests. Some have criticized technologies of personalization used in museums, arguing that they inhibit sociality.[39] But our findings so far indicate that the curation of digital images, far from limiting social interaction in museums, creates new forms of it. More knowledge about what encourages users to form and join networks, or the kinds of content they like to share and with whom can provide important insights to museums as they develop strategies for enhancing digital sociality.

5. The digital image affords the *disrupting and reshaping* of the status quo. Far from simply being reproductions of physical artefacts and artworks, digital images give users new forms of control and, in the process, allow them to transcend boundaries and hierarchies. How far such processes afford the crafting of genuinely new modes of apprehending and engaging with images is one of the key questions to which Curating Digital Images will contribute.

NOTES

[1] "#museum," Instagram, accessed December 1, 2020, url: https://www.instagram.com/explore/tags/museum/.

[2] "Partner with Us," Google Arts & Culture, Last Modified December 1, 2020. https://about.artsandculture.google.com/partners/.

[3] "Our Mission," Europeana, Last Modified December 1, 2020. https://pro.europeana.eu/about-us/mission.

[4] Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – GZ: BA 6440/2-1 AOBJ: 660775.

[5] See James W. Gibson, *The Ecological Approach to Visual Perception: Resources for Ecological Psychology* (Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers, 1986). For an overview on the topic, see Christoph Bareither, "Affordanz," in *Kulturtheoretisch Argumentieren: Ein Arbeitsbuch*, ed. Timo Heimerdinger and Markus Tauschek (Münster: Waxmann, 2020), 32–55.

[6] Donald A. Norman, *The Design of Everyday Things, Revised and Expanded edition* (New York: Basic Books, 2013), 11.

[7] Pierre Bourdieu, *The Logic of Practice* (Cambridge: Polity Press, 1990), 66.

[8] Elisabetta Costa has coined the useful term "affordances-in-practice". See her "Affordances-in-Practice: An Ethnographic Critique of Social Media Logic and Context Collapse," *New Media & Society* 22, no. 1 (2018): 1–16.

[9] For the topic of material affordances see, for example, Tim Ingold, *The Perception of the Environment: Essays on Livelihood*, Dwelling and Skill, Repr (London: Routledge, 2000); Norman, *The Design of Everyday Things* (New York: Basic Books, 2013). For the topic of affordances and museum/heritage spaces see Christoph Bareither, "Capture the Feeling: Memory Practices in between the Emotional Affordances of Heritage Sites and Digital Media," *Memory Studies, Special Issue: Locating "Placeless" Memories: The Role of Place in Digital Constructions of Memory and Identity* 14, no. 3 (Forthcoming); Paul Basu and Ferdinand Jong, "Utopian Archives, Decolonial Affordances Introduction to Special Issue," *Social Anthropology* 24, no. 1 (January 1, 2016): 5–19; Sharon Macdonald, Memorylands: *Heritage and Identity in Europe Today* (London, New York: Routledge, 2013).

[10] For affordances of the digital image see Julian Hopkins, "The Concept of Affordances in Digital Media," in *Handbuch Soziale Praktiken und Digitale Alltagswelten*, ed. Heidrun Friese et al., Living Reference Work, continuously updated edition, Springer Reference Sozialwissenschaften (Wiesbaden: Springer Fachmedien, 2016), 1–8; Ian Hutchby, "Technologies, Texts and Affordances," *Sociology* 35 (January 1, 2001): 441–56; Mirca Madianou and Daniel Miller, "Polymedia: Towards a New Theory of Digital Media in Interpersonal Communication," *International Journal of Cultural Studies* 16, no. 2 (January 1, 2012): 169–87. For a more detailed discussion of the relationships between visitors and museum spaces see Christoph Bareither, "Doing Emotion Through Digital Media: An Ethnographic Perspective on Media Practices and Emotional Affordances," *Ethnologia Europaea* 49, no. 1 (January 1, 2019): 7–23; Christoph Bareither, "Affordanz," in *Kulturtheoretisch Argumentieren. Ein Arbeitsbuch*, ed. Timo Heimerdinger and Markus Tauschek (Münster: Waxmann, 2020), 32–55; Bareither, "Capture the Feeling: Memory Practices in between the Emotional Affordances of Heritage Sites and Digital Media."

[11] See Sharon Macdonald, "Curatorship," in *Dictionary of Museology*, ed. Francois Mairesse (ICOM, Forthcoming).

[12] Hans Ulrich Obrist, *Ways of Curating* (New York: Farrar, Straus and Giroux, 2014), chap. Prologue.

[13] Beatrice von Bismarck, Jörn Schafaff, and Thomas Weski, "Introduction," in *Cultures of the Curatorial*, ed. Beatrice von Bismarck, Jörn Schafaff, and Thomas Weski (Berlin: SternbergPress, 2012), 8–15, 8.

[14] See, for example, Stefan Krankenhagen, "Geschichte Kuratieren," in *Geschichte Kuratieren: Kultur- Und Kunstwissenschaftliche An-Ordnungen der Vergangenheit*, ed. Stefan Krankenhagen and Viola Vahrson (Cologne; Weimar; Vienna: Böhlau Verlag,

2017), 9–14; Sophia B. Liu, "Socially Distributed Curation of the Bhopal Disaster: A Case of Grassroots Heritage in the Crisis Context," in *Heritage and Social Media: Understanding Heritage in a Participatory Culture*, ed. Elisa Giaccardi, 1st ed. (Abingdon, Oxon: Routledge, 2012), 30–55; Leah Scolere and Lee Humphreys, "Pinning Design: The Curatorial Labor of Creative Professionals," *Social Media + Society* 2, no. 1 (January 1, 2016): 1–13.

[15] Christine Hine, "From Virtual Ethnography to the Embedded, Embodied, Everyday Internet," in *The Routledge Companion to Digital Ethnography*, ed. Larissa Hjorth et al. (New York; London: Routledge, 2017), 21–28, 22.

[16] See Bareither, "Doing Emotion Through Digital Media: An Ethnographic Perspective on Media Practices and Emotional Affordances"; Christoph Bareither, "Difficult Heritage and Digital Media: 'Selfie Culture' and Emotional Practices at the Memorial to the Murdered Jews of Europe," *International Journal of Heritage Studies*, July 7, 2020, 1–16; Bareither, "Capture the Feeling: Memory Practices in between the Emotional Affordances of Heritage Sites and Digital Media."

[17] Bernhard Tschofen, "'Eingeatmete Geschichtsträchtigkeit': Konzepte des Erlebens in der Geschichtskultur," in *Doing History: Performative Praktiken in der Geschichtskultur*, ed. Sarah Willner et al., 1st ed. (Münster; New York: Waxmann, 2016), 137–50, 144, translated by the authors.

[18] See Sharon Macdonald, "Presencing Europe's Pasts," in *A Companion to the Anthropology of Europe*, ed. Ullrich Kockel, Máiréad Nic Craith, and Jonas Frykman (Chichester, UK: John Wiley & Sons, Ltd, 2012), 231–52.

[19] For the topic of building socially acceptable profiles see Christine Hine, *Ethnography for the Internet: Embedded, Embodied and Everyday* (London: Bloomsbury, 2015), 36. For the topic of establishing a co-presence see Sarah Pink et al., *Digital Ethnography: Principles and Practice* (Los Angeles: Sage, 2016), 134.2016

[20] See, for example, Maria Schreiber, "Audiences, Aesthetics and Affordances: Analysing Practices of Visual Communication on Social Media," *Digital Culture & Society* 3, no. 2 (January 1, 2017): 143–64.

[21] Meghan Lundrigan, "#Holocaust #Auschwitz: Performing Holocaust Memory on Social Media," in *A Companion to the Holocaust*, ed. Simone Gigliotti and Hilary Earl, 1st ed. (Wiley, 2020), 639–55.

[22] See Gertrud Lehnert, *Mode: Theorie, Geschichte und Ästhetik einer kulturellen Praxis*, Fashion studies 1 (Bielefeld: Transcript, 2013).

[23] See Lisa Cartwright and Marita Sturken, *Practices of Looking: An Introduction to Visual Culture*, 3rd ed., 2018.

[24] For eye tracking in studies of digital libraries see, for example, Jonathan Sykes et al., "A New Focus on End Users: Eye-Tracking Analysis for Digital Libraries," in *Research and Advanced Technology for Digital Libraries*, ed. David Hutchison et al., Lecture Notes in Computer Science, vol. 6273 (Berlin, Heidelberg: Springer, 2010), 510–13. For eye-tracking in analyses of affordances, see Leonardo Burlamaqui, and Andy Dong, "Eye Gaze Experiment into the Recognition of Intended Affordances," in *Proceedings of the ASME 2017 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference IDETC2017 August 6-9, 2017, Cleveland, Ohio, USA*, 2017, 1–9. For eye-tracking in research on museum visitors' perception, see Kira Eghbal-Azar and Thomas Widlok, "Potentials and Limitations of Mobile Eye Tracking in Visitor Studies," *Social Science Computer Review* 31, no. 1 (January 1, 2013): 103–18; Eva Mayr, Kristin Knipfer, and Daniel Wessel, "In-Sights into Mobile Learning: An Exploration of Mobile Eye Tracking Methodology for Learning in Museums," in *Researching Mobile Learning: Frameworks, Tools and Research Designs*, ed. Giasemi Vavoula (Oxford; Bern; Berlin; Bruxelles; Frankfurt am Main, New York, Vienna: Lang, 2009), 189–204; Takumi Toyama et al., "Gaze Guided Object Recognition Using a Head-Mounted Eye Tracker," in *Proceedings of the Symposium on Eye Tracking Research and Applications - ETRA '12*, ed. Carlos H. Morimoto et al. (New York: ACM Press, 2012), 91.

[25] See Mareen Reichardt and Elke Greifeneder, "Das iLab: Hands-on-Forschung am Institut Für Bibliotheks- und Informationswissenschaft," *Bibliotheksdienst* 51, no. 5 (January 1, 2017).

[26] Aga Bojko, *Eye Tracking the User Experience: A Practical Guide to Research* (Brooklyn, NY: Rosenfeld Media, 2013), 6.

[27] Shanti Sumartojo et al., "Ethnography Through the Digital Eye: What Do We See When We Look?," in *Refiguring Techniques in Digital Visual Research*, ed. Edgar Gómez Cruz, Shanti Sumartojo, and Sarah Pink (Cham: Springer International Publishing, 2017), 67–80.

[28] See, for example, Elisa Bignante, "The Use of Photo-Elicitation in Field Research: Exploring Maasai Representations and Use of Natural Resources," *EchoGéo*, no. 11 (February 24, 2010); Veronica M. Richard and Maria K.E. Lahman, "Photo-Elicitation: Reflexivity on Method, Analysis, and Graphic Portraits," *International Journal of Research & Method in Education* 38, no. 1 (January 1, 2015): 3–22.

[29] See Sharon Macdonald, "Interconnecting: Museum Visiting and Exhibition Design," *CoDesign* 3, no. sup1 (January 1, 2007): 149–62, 153; Alison Mckay, "Affective Communication: Towards the Personalisation of a Museum Exhibition," CoDesign 3, no. sup1 (January 2007): 163–173.

[30] See Keir Winesmith and Susan Anderson, *The Digital Future of Museums: Conversations and Provocations* (Abingdon, Oxon: Routledge, 2020).

[31] See, for example, Gabi Arrigoni and Areti Galani, "Recasting Witnessing in Museums: Digital Interactive Displays for Dialogic Remembering," *International Journal of Heritage Studies* (July 27, 2020): 1–15.

[32] See, for example, George Hein, "Museum Education," in *A Companion to Museum Studies*, ed. Sharon Macdonald (Oxford: Whiley & Blackwell, 2006), 340–52.

[33] See also Haidy Geismar, *Museum Object Lessons in the Digital Age* (London: UCL Press, 2018); Hubertus Kohle, *Museen Digital: Eine Gedächtnisinstitution sucht den Anschluss an die Zukunft* (Heidelberg: Heidelberg University Publishing, 2018); Susana Smith Bautista, *Museums in the Digital Age: Changing Meanings of Place, Community, and Culture* (Lanham, MD: AltaMira Press, 2014).

34 Brett Bligh and Katharina Lorenz, "The Rhetoric of Multidisplay Learning Spaces: Exploratory Experiences in Visual Art Disciplines," *International Journal of Media, Technology and Lifelong Learning* 6, no. 1 (2010): 7–27, 10.

35 See Sarah Ullrich, and Katharina Geis, "Ethnographic Observations of Digital Museum Practices during the Covid-19 Crisis. *CARMAH Reflections Blog*, August 17, 2020, http://www.carmah.berlin/reflections/digital-museum-practices/.

36 See, for example, "Tussen Kunst En Quarantine" "#tussenkunstenquarantaine," Instagram, accessed December 1, 2020, url: https://www.instagram.com/explore/tags/tussenkunstenquarantaine/.

37 Olga Hubard, "Concepts as Context: Thematic Museum Education and Its Influence on Meaning Making," *International Journal of Art & Design Education* 33, no. 1 (February 2014): 103–15.

38 See Liu, "Socially Distributed Curation of the Bhopal Disaster: A Case of Grassroots Heritage in the Crisis Context."

39 See Lesley Fosh et al., "Personal and Social? Designing Personalised Experiences for Groups in Museums." MW2015: Museums and the Web 2015. Published January 30, 2015. Accessed December 23, 2020. https://mw2015.museumsandtheweb.com/paper/personal-and-social-designing-personalised-experiences-for-groups-in-museums/.

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BEHIND THE DIGITAL IMAGE. PUBLIC PHOTOGRAPHS ON COMMUNITY PLATFORMS AND TWITTER AS REPOSITORIES FOR MACHINE LEARNING AND JOURNALISTIC PUBLICATIONS

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ABSTRACT | My project "Behind the Digital Image: Public Photographs on Community Platforms and Twitter as Repositories for Machine Learning and Journalistic Publications" investigates the specificities of social media and photo-sharing platforms as public image repositories, daily media practices and legal practices, and considers ethical questions relating to the digital image as both a research tool and a research object. I pursue two sub-projects, both of which are relevant to understanding the commodification and monetization of vernacular digital images. Nuclear investigations of these projects refer to the relationship of amateur photographers, also referred to as citizen photojournalists, para photojournalists or accidental journalists, and professional stakeholders within the global image market. Since the digital world is quickly changing, field work is needed to understand processes and procedures as they happen. Therefore, I use multidimensional methods, including media ethnography; digital methods; qualitative approaches, such as in-depths interviews and participatory observation, and social media analytic tools. This paper presents an overview of the proposed project and sheds light on both the preliminary results and possible areas of future research.

KEYWORDS | image rights, mixed-method, vernacular visual media, photojournalism, image repositories

Introduction

Chunks of ice pile up behind two black cars, hitting the roadside. The ice 'bergs' almost reach the height of the streetlamps. A man on the road raises his smartphone to face level, apparently filming or preparing a selfie. On 24 February 2019, David Piano photographs this scene and posts the aforementioned photo alongside two similar shots on Twitter. He writes: "This ice tsunami is one of the craziest things I've ever witnessed. Starting to bulldoze trees and streetlamps. [...]"[1] Several of the replies he receives to his tweet are from photo editors, among them CNN and AP. The latter asks: "Hi David, I'm Julie Jacobson with the Associated Press in New York City. Did you shoot these photos of the ice shove in your tweet. If so, can we use them?" Piano's answer is short: "Yes I did. Go ahead and use with credit."[2]

Conversations like this exemplary one about rights of use and underlying legal, ethical and social issues of image sharing are the subject of my research project "Behind the Digital Image: Photographs on Community Platforms and on Twitter as Repositories for Machine Learning and Journalistic Publications". It consists of two parts, entitled "Crowd-Sourced Images – A Repository for Critical Research and Artificial Intelligence" and "A Closer Look into

Terms of Use: Photo-Editors' Use of Twitter to Retrieve Amateurs' Photographs". My project is one of twelve projects selected by the German Research Foundation (DFG) for funding under the new Priority Program "The Digital Image" (SPP 2172, DFG project number 421462167). Initiated and coordinated by Professors Hubertus Kohle, Ludwig-Maximilians-University of Munich, and Hubert Locher, Philipps-University of Marburg, this Priority Program aims to contribute to the theorization of the digital image in art, science, and culture, to foster the understanding of the digital turn as a visual digital turn, and to understand various practices of digital image technologies. The first of two three-year-funding phases started in December 2019; it includes for instance projects from the fields of art history, archaeology, ethnography, and media studies. The aim is also to examine the conditions of current digital image culture from multiple perspectives.

In my work, I perceive digital images as networked popular visual media, based on socio-cultural and socio-technical interactions while at the same time connecting technology, society, and individuals – so-called networked images.[3] My project "Behind the Digital Image. Public Photographs on Community Platforms and Twitter as Repositories for Machine Learning and Journalistic Publications" focuses on media ecology, circulation and practices of image sharing, negotiation of rights of use and commodification of the digital image. These aspects are investigated through collecting and interpreting public negotiations on social media about eyewitnesses' photographic material that photo editors request for publication in journalistic media, and through photo platforms using uploaded images as material for machine learning. This paper offers an overview of my research project and its two sub-projects, with a stark focus on the sub-project "A Closer Look into Terms of Use: Photo-Editors' Use of Twitter to Retrieve Amateurs' Photographs", and a fairly short outline of the subsequent sub-project "Crowd-Sourced Images – A Repository for Critical Research and Artificial Intelligence" that will start at a later stage.[4] Main research questions are: How do photo agencies integrate user-generated photos, some of which can be understood as citizen journalists' products, into their offerings? What purposes do photo editors, photo curators and the creators themselves pursue by participating in digital image sharing? How does non-human photo curation impact aesthetics and content of (publicly uploaded) digital images? What is the status of ethics in digital visual cultures, both for media practitioners and researchers? My aim is to collect data 'onlife'[5], at the interplay between technology, society, and the individual. Digital images will be analyzed as representations and as objects between public-private memories, as will be shown in my case study about Twitter pictures (Twitpics) from terror attacks and the increasing interest of photo-editors in this eyewitness material. Eventually my investigation will dive into what we cannot (yet) see, namely the relevance of artificial data and machine learning in the curation of images, such as is provided by some photo-community platforms.

This paper is structured as follows: Firstly, the literature review informs about the current state of research and the state of the global (journalistic) image market and its latest developments; secondly, the sub-project "A Closer Look into Term of Use" addresses Twitter as a source for user generated visual content and presents preliminary results of the first research phase, including three different encounters between citizen photojournalists and professional photo editors, and public critique of AP's buy-out-contracts. Thirdly, the second sub-project "Crowd-Sourced Images" suggests future subsequent research. The conclusion summarizes the next steps.[6]

The Global Image Market

Globalization theorists point out that globalization does not only mean diversification but also monopolization and interconnectedness.[7] These aspects have been dealt with for the media sector, focusing, for instance, on companies such as TV stations.[8] However, research on the development in the global image market, including stock and news photography, and especially cooperation between image banks and photo sharing platforms, has been neglected to date. When Frosh, Bruhn and Ullrich first published their works on the global image market in the early 2000s, with their focus on stock photography, photo-sharing platforms did not yet play the role they do today: while they did not even exist then, they are nowadays considered to be an everyday practice, along with the integration of amateurs' photographic work in photo agencies and image databases.

The global circulation of news photographs has lately been investigated by media ethnographic scholars, with a focus on the competition between news photo agencies[9], key wording routines in an international news photo production[10], and the changing work practices of photojournalists in the digital age.[11] Media ethnographer Zeynep

Devrim Gürsel primarily frames power struggles in the global image market as "battles over visual worldmaking".[12] She refers to intermediaries between photographers and editorial staff as image brokers; the term 'broker' hails from the business world, in which brokers mediate between buyers and sellers and finance themselves through commissions. Referring to the global image market, 'broker' emphasizes the commodification of images: The advent of digital photography puts photojournalists under pressure, money-wise and time-wise alike. The recent international mobility of photojournalists and the outsourcing of photojournalistic work to locals also has implications for content diversity. A new division of labor can be seen: "[t]here are many more local photographers producing excellent work today, and drastically reduced budgets mean personal vision is less valid in journalism at large," says Gürsel.[13]

Research on the global image market currently focuses on creative industries and visual content providers such as Getty Images, on the global distribution of news photos, on professional field research on photojournalists in editorial organizations and foreign reporting, as well as on platform economics and visual vernacular language, for example most recently and preeminently on Instagram.[14] The research project described here is located at the interface of these fields: their impact on each other cannot be clearly distinguished. Some articles already demonstrate the mechanisms and implications of monopolization and interconnectedness on the global image market with an emphasis on stock photography.[15] The merger of the image banks Getty Images and Corbis in January 2016 indicates that what is needed is a close look at strategies of acquisition, including the implementation of non-professional photographs through cooperation with various photo-sharing platforms.[16] Existing literature on stock photography focuses on content and topics, including "the visual politics of gender"[17], and the "increasing global importance of image banks in corporate media", also examining the Getty images of women.[18] By tracing the multiple sales of the Bettmann Archive and its eventual merger into Corbis it has been possible to investigate the rise of Corbis up until the developments of 2011.[19] The main literature on the global stock photography market, and on the power of stock photography and super-agencies like Getty Images and Corbis, reflect on the 1990's changes.[20] At their core, some of the aspects identified in these studies remain true to this day: aesthetic guidelines based on marketability and reproducibility of recognized stereotypes; corporate expansion via the purchase of existing agencies and archives; and the invisibility of the images' creators. Images function simultaneously as product and commodity, exchanged, and traded in multiple forms.[21]

Nevertheless, the existing literature does not investigate the relation between stock images and new images, even though they are sold by the same picture agencies. Stock images are integrated in journalistic online media without the readers being informed of the respective origin and purpose of a stock image.[22] Furthermore, current studies do not investigate the alliances between image banks and photo agencies with photo sharing platforms like Flickr. The users who engage with these vernacular photo communities can be considered as 'produsers'[23], a term intended to describe a hybrid of producer and user; the two can no longer be separated due to the daily media practices of producing and uploading content such as digital images. Axel Bruns coined the term 'produser' – a mix of 'producer' and 'user', following Alvin Toffler's term 'prosumer', a hybrid of 'producer' and 'consumer'.[24] The term 'produser' emphasizes the active role of users and will therefore be used in this paper.

My research project reflects these developments in order to improve the understanding of the – mostly invisible – mechanisms behind the digital image and its distribution infrastructure, and to promote a critical discourse on the media practice of the produser, the status of the photographer and the photographic image in the networked society.[25]

A Closer Look at Terms of Use: Photo-Editors' Use of Twitter to Retrieve Amateurs' Photographs

The first eyewitness photo on Twitter that generated a major international response was taken by Janis Krums on 15 January 2009: it shows a half-sunken Airbus 320 in the Hudson River in New York City, with people sitting on the life rafts folded open at the aircraft doors. Krums tweeted a photo alongside the lines: "There's a plane in the Hudson. I'm on the ferry going to pick up the people. Crazy."[26] On the tenth anniversary of the "Miracle of the Hudson River" – the hashtag #MiracleOnTheHudson has since emerged – users shared photos on Twitter of newborn babies who would not have been born years later if the emergency landing had gone wrong, and of children dressing up as

A320 pilot Captain Sully. Krums' picture is one of the most famous posts on Twitter by an eyewitness of an event, and Krums is one of the few eyewitnesses who has become (and remained) well-known beyond the instantaneous posting of his Twitpic. Since the initial Twitpic, Krums' Twitter conversations have shown that he has been contacted by a wide range of people – for example CNBC editors requesting an interview and students wanting to use his picture in their thesis on social media.

Twitter has gained in importance as a platform for researching newsworthy photos. At the same time, new ways of dealing with the clarification of rights are becoming apparent. Visual material that eyewitnesses post, for example, of terrorist attacks (such as in Brussels, Nice or Munich in 2016), demonstrations, natural disasters such as earthquakes, floods or tsunamis, the 2020's forest fires in Australia or extreme weather situations, but also of events such as the Corona crisis, form the starting point of the research project. It can be observed that eyewitness material from private individuals triggers reactions from photo editors: They write to users on Twitter and ask for permission to use tweeted photos in journalistic publications or even for photo agencies. Sometimes the editors send along special Social Media Release Forms in which the companies declare that they recognize the copyright, want to have the temporally and spatially unlimited rights to the further distribution (and utilization) of the respective images transferred, but will not pay for their use.

These conversations arising from social media images can be found regularly, both for unpredictable large-scale events such as terror attacks, natural disasters, or extreme weather events, and events of local interest, such as helping neighbors, overcrowded subway stations and other 'everyday life' happenings. An exemplary conversation about rights of use between eyewitnesses and photo editors on Twitter goes like this: After eyewitnesses have tweeted their picture – including the location, information about what is visible in the picture and sometimes additional information such as witnessing an explosion – photo editors get in touch. Some introduce themselves with their name and professional institution. Some ask how the eyewitnesses are doing before asking for permission to use the photo in question: "May I use your photo? Could we use them?" Often eyewitnesses answer with a simple "yes", sometimes they ask for more details via direct message. In individual cases, photo editors send along declarations of consent (Social Media Release Forms), for the unlimited right of use of the photo, and for future media that are not yet known. An honorarium is not offered; on the contrary, image sharing is regarded as honorary. In general, eyewitnesses do not ask for payment – presumably because they do not consider themselves photojournalists and do not see their photo and its further dissemination in terms of usability and salability. Some reserve the right not to have their photos used for commercial publicity purposes and refuse such requests.

It is unclear whether eyewitnesses are aware of the rights of use they are conceding, and the extent to which they are conceding them. One hypothesis is that this kind of conversation and (non-) negotiation of rights of use reveals that the sharing economy exerts an influence on journalistic image communication: image sharing at the interface of amateur and journalistic visual communication adopts practices from the sharing economy, of sharing and redistributing content free of charge, which at the same time goes beyond visible social media appreciation through likes and retweets.

The corpus of material being developed consists of tweeted photos and conversations by and with photo editors. Photojournalists usually take photos of the scenes at a later stage: when editors have assessed the event as newsworthy and want to commission their own material instead of pictures from photo agencies or eyewitnesses. The corpus is based on Twitter queries, including search phrases such as "Could we use your photo", or "May we use your photo". Based on this, three (preliminary) categories or scenarios will be examined: These are, firstly, negotiation of dissemination through simple yes-no conversations and more complex social media release forms, secondly, the publication and transformation of a tweet into a story, and finally, countermovement and protests against unpaid work. These three aspects are demonstrated on found material in the following paragraphs. In a further step, produsers and editors will be asked to participate in a questionnaire and interview to address research questions such as: To what extent do eyewitnesses understand the purpose of the pre-formulated consent forms sent to them, and the ensuing legal consequences? To what extent are conditions of use influenced by social media companies, photo-sharing platforms, and journalistic needs?

Scenario 1: Negotiating dissemination through simple yes-no conversations and more complex social media release forms

As previously mentioned, some photo editors tweet consent forms to which the image creators must agree without the option of negotiation. The most comprehensive is the so-called social media release form of the US news agency Associated Press (AP), describing in detail the rights the agency is interested in. The British news and sports agency PA Media provides Twitter-friendly paragraphs: "By agreeing for PA to use your content you confirm that: - You are happy for it to be distributed at any time to any national and international publishers (eg. the BBC, ITV, Guardian, Independent and MSN) - You own the copyright (ie you filmed, photographed or otherwise created the content yourself). Allowing PA to use your content does not affect your rights: you will still own the copyright."[27]

When comparing different social media release forms, it is remarkable that fundamental aspects are emphasized: Authors do not lose their rights of use, and certainly not their copyright. This explicit statement of a legal fact leads to the conclusion the produsers are presumably not aware of the difference between copyright and rights of use. A formulation like the one quoted here can also be interpreted as a response to an anticipated "no". The research project aims to clarify how image creators understand these social media release forms and their legal consequences. Although image sharing is globalized, there are different understandings of copyright in Europe and the USA that need to be considered in future research.

Scenario 2: Publishing and Turning a Tweet into a Story

The girl with a bun looks through a glass door. In her left hand she holds a pad or a clipboard. A man with a baseball cap kneels in front of the door. He looks back and points to a flipchart. The viewers of this photo take the position of the girl's photographing father: Josh Anderson posted the photo on his Twitter on 28th March 2020. His text explains: "My 6th grader emailed her math teacher for some help so he came over & worked through the problem with her on our front porch. @Chriswaba9, our neighbour, MMS teacher & MHS Wrestling Coach. #KidsFirst @MadisonMSNews @Mark0sports @dakotasportsnow @dakotanews_now @stwalter20".[28]

Anderson shows and describes his daughter asking her math teacher for help during the Corona crisis. He reveals the teacher's name via his Twitterhandle @Chriswaba9 – and receives the following request in response, alongside thousands of likes, from a user with the Twitterhandle @cherinicita: "Hello Josh! I work for Fox TV stations and we absolutely love this story! May we use your photo on all platforms until further notice, with a courtesy to you of course? Please let me know. Thanks so much!"[29] Anderson replied positively, "You sure can. Thanks for your interest. Please send me the link to your story so we can view it as well!"[30] A few hours later, the Fox TV employee sent a link to the website where the article had been published under the headline "Math teacher brings over whiteboard to help student through glass door".[31] In the first sentence, the article, whose author is not identified by name, refers to the current Corona crisis: "Even during a pandemic, some teachers are showing that they're still willing to go above and beyond for their students." The next five paragraphs elaborate on what Anderson already said in the two sentences of his tweet – Fox TV even knits a plot with these details: "It wasn't a long trip for Waba – Anderson says he happens to be their neighbour." By using phrases like "Anderson says", Fox TV gives the impression of having spoken to Anderson. Finally, the embedded tweet and the phone number of Florida's Covid 19 emergency center follow.

This example shows how journalistic 'stories' are generated from tweets that attracted the editors due to the twitpic – published with little further information or journalistic research that for instance would consist of personal interviews with the protagonists. In the context of the project, research questions arise such as: Are the image creators – if not financially remunerated – made aware of the publication via link? Are the resulting reports primarily cheap user-generated content, or do they give rise to further journalistic research?

Scenario 3: Countermovement and Protest Against Unpaid work

Some tweets show that produsers who were initially positive about a publication change their minds in the course of time. One produser, for example, found the media requests too much: she had posted a photo of a broken window in her living room, which had been smashed by a Christmas tree whirled by the wind. After firstly responding positively to several media requests to use her photo, she turned down further requests for radio interviews.[32] This can be interpreted as indicating that it takes relatively little time to consent to a photo release via tweeting; but also implies that produsers do not want to spend more time giving interviews beyond that, possibly also because the event is only locally newsworthy.

A surprising version of non-consent can be found in a kind of informal countermovement that sharply criticizes calls from media companies to submit photos. In July 2019, CNN asked on Twitter, "Are you affected by Hurricane Barry? When it's safe, text, iMessage or WhatsApp your videos, photos and stories to CNN […]."[33] A user named John Robertson commented: "Just wow. I'm making sure from now on in journalism class I teach my kiddos to say NO to 'hello I'm from X May we use your photo with credit to you of course' tweets. They're a business folks, make them PAY YOU for your content they're going to make money on."[34] This tweet refers solely to journalistic media companies wanting to profit from produsers' digital image content. The user overlooks the fact that his own engagement in social media also generates revenue for Twitter. Research questions relate to the trust of produsers in journalistic media versus social media companies and the appreciation of the digital image.

It should be noted that in spring 2020, several technology-oriented online publications such as DPReview and Techdirt garnered criticism from Twitter and the blogosphere about the Associated Press Social Media Release Forms, as presented in scenario 1.[35] Essentially, they summarize a Twitter thread by Mike Dunford – according to his Twitter bio a lawyer – explaining in detail the AP Social Media Release Form also in terms of its legal implications. Dunford formulates the core criticism in a single tweet – the planned procedure, presumably legally secured by AP lawyers, for which the AP (picture) editors were trained, the clarification of the rights of use and copyright and the written consent: "So @AP reporters and editors have clearly been trained to do three things before using anything on social media: (1) Ask for permission to use it; (2) Confirm that the person giving permission took the photo/video; (3) Get them to agree to a release presented as an image."[36] In contrast to contracts in paper or PDF, it is not possible to make changes on a social media release form that is presented as a digital image, for example by crossing sentences or sections out – clearly it is not intended that authors negotiate this contract. If produsers do not agree to this contract, it is more common not to reply at all than to explicitly answer 'no'.

Dunford calls AP's way of formulating and enforcing legal wishes "abusive and unethical", also since the produsers shall indemnify AP from any legal responsibility – if a lawsuit is filed, the produsers bear all the risk. Seemingly, AP has never reacted to the accusations – presumably also out of knowledge of its own economic strength: produsers can rarely set limits, for example by collectively negotiating the scope of use, royalties, and (bestseller) remuneration. As dispersed produsers, who do not identify as photojournalists, they do not unionize.

Future Research: Crowd-Sourced Images – A Repository for Critical Research and Artificial Intelligence

In addition to social media platforms such as Twitter, which are known to a broader public audience and have been researched widely,[37] there are internet platforms specializing in photographic images, which are aimed at ambitious amateur photographers. Inspired by early photo community platforms such as Flickr, they take the idea of building a community to discuss photos further and create a business model to possibly sell select photos through distribution partnerships with globalized photo agencies and image banks. These photo platforms offer automatic keywording as well as automatic analysis of the aesthetic content of uploaded images. The keywording is usually (still) not as detailed as it would be if human beings were doing it – i.e. it mostly offers generic terms such as mountain, man, outdoor –, and it does not correspond to the keywording standards of the so-called W-questions (who, when, what, where, why etc.) in journalistic picture agencies.[38] Research questions here deal with the differences in aesthetics

and selection of photos by human versus non-human photo curation. Behind the visible digital image, the question arises as to whether we can still speak of image agencies and photo platforms in the future, or whether these 'photo communities' are rather technology companies focusing on collecting and monetizing data instead of 'the image'.[39]

Conclusions

When photo editors ask producers whether they may use their image, this is done out of the necessity to secure the rights of use. The request can also be interpreted as an act of fairness towards produsers, although – as it becomes clear in social media release forms – they are not considered or treated as equal business partners. The social media release forms presented correspond in essence to the buy-out contracts that media companies present to their freelancers, for example, and professional photo agencies to their photographers and models. When acquiring image material – and the requests from photo editors to Twitter users are nothing else – it can be assumed that the media companies take advantage of the produsers' ignorance. The terms of use of social media companies are to be criticized in the same way: They, too, stipulate that posted images may be used without fee. On the other hand, users regard the sharing of images as an unpaid (media) practice.

Nevertheless, in the course of my research project the intention will be to discuss whether produsers whose photos attract interest from photo editors see themselves as photojournalists. Tanja Aitamurto published a study on crowdfunding and new journalistic media in 2011. She concluded that it was enough for citizens to donate and they had little motivation to become journalistically active themselves in the sense of a culture of participation: "They perceive the journalist as the expert on the topic, and therefore he or she needs to do the work."[40] Based on this finding, one hypothesis of my project is that the self-image of 'citizen photojournalists' is similarly distanced: Their self-image and self-concept differs from those of (professional) photojournalists. This could be another reason why, in the data available so far, none of the produsers asked for a fee. Another hypothesis is that this (non-) negotiation of rights of use reveals that the 'sharing economy'[41] has an influence on journalistic image communication: 'image sharing' at the interface of amateur and journalistic image communication adopts practices of the 'sharing economy', the gratuitous sharing and redistribution of content, which at the same time go beyond the (valuation) through likes.

The research project considers the digital image as part of digital visual journalism: acquiring image material online is relevant for locally operating media companies who use citizen photojournalism to bond readers to the respective media product. Also, image sharing practices might be one result of more and more precarious working conditions in journalism in general: photo editors obtain permission to distribute and redistribute and/or sell the images (if the message is answered by produsers) in quite an effective way by sending out social media release forms and receiving responds unbureaucratically with a reply tweet. When discussing rights of use, as presented in this paper, it must be considered that the requesting photo editors have a knowledge advantage due to their profession. The produsers will usually not be so well versed in the production business that they are able to appreciate all the consequences that might arise from a seemingly simple "yes" as consent to the use of their photo. It is unlikely that amateur photographers will organize themselves, for example, to demand fees for the use of their images – on the one hand, because these requests may remain sporadic, and on the other hand, because produsers may have come to understand that free image sharing seems to be the norm for digital images. Against the backdrop of the transformations of photojournalism through digitalization, however, this should be viewed critically: Viewing photographs in general as a free good might minimize the fees of professional photojournalists. It may make sense to think about the question of remuneration for produsers and to consider new concepts, for example a kind of bestseller remuneration: if a newspaper or photo agency were to earn a lot of money with a picture, produsers could share in it. However, social media release forms exclude a remuneration of photos acquired online so far.

As media spectators, consumers, and digital image creators, the produsers' role is threefold. This may explain why consent to use the images is given spontaneously and generously: digital image sharing is understood as a widespread and mostly unquestioned media practice. The interplay of image sharing, internet platforms and rights of use for images that can be attributed to citizen journalism raises a multitude of research questions that could only be hinted at exemplarily in this paper. Future research can be expanded to videos and moving images, and the utilization of bots to select or request photos. It is also important to address differences in US and European copyright law.

Photo editors, photojournalists, social media professionals, and produsers who experience or work with digital photo sharing practices described in this article are cordially invited to contact me to participate in the study.

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TOWARDS A PRAXEOLOGICAL MEDIA PHILOSOPHY OF THE DIGITAL IMAGE THEORIZING PICTORIAL PICTURE CRITIQUE IN SOCIAL MEDIA

KEVIN PAULIKS, JENS RUCHATZ

ABSTRACT | This article explores the theory and methodology of the project "Pictorial Picture Critique in Social Media. Explicit and Tacit Theorizing of the Digital Image." In order to gain elements of a theory of the digital image from the inside perspective of digital images themselves, the aim of the project is to analyze user-generated forms of pictures that criticize other pictures on social media. This inside view is theorized through media philosophy, which is a philosophy of media by media. Assuming that media have knowledge about media, this diffuse knowledge needs to be clarified. Therefore, a praxeological approach is chosen to conceptualize this media knowledge. Both approaches are combined into a praxeological media philosophy of social media imagery from a socio-cultural perspective. Methodically, the picture practice analysis is designed to ascertain such media knowledge from the collected phenomena, which operate in the case of pictorial picture critique on two levels: knowing that aspects of a picture are criticized, and knowing how the picture is used for criticism. Finally, this approach is exemplified by a case study on Insta Repeat, which criticizes the practice of curating in social media.

KEYWORDS | contemporary visual culture, media theory, methodology, vernacular visual media, social media content

Introduction

On June 2, 2020, Instagram and other social media sites literally went black. In the course of so-called Blackout Tuesday, social media users posted black squares to promote Black Lives Matter, a worldwide protest movement against white supremacy and police brutality towards people of color. Instagram, a platform where millions of pictures are posted every day, was suddenly interspersed with these black squares, blocking out the everyday picture production, creating black homogeneity on the screen. In a way, this presumably political action implied that the void produced by blacking out pictures was more meaningful than the entire photo flow in the Instagram feed. Hence, Blackout Tuesday was not just social criticism a performative critique of social media that reflects on the homogeneity and banality of social media imagery. It did not take long for activists to criticize Blackout Tuesday for blocking out not only pictures, but the entire information flow under hashtags like #BlackLivesMatter. On Twitter, users lamented that this protest action was merely slacktivism, not really helping the protests on the streets in any way. The discourse around Blackout Tuesday demonstrates that criticism of social media and its digital imagery is frequently articulated by the users themselves, who are affected by digitalization in their daily lives. Whereas academic, political and journalistic criticism of digital images does get a lot of public attention, vernacular critical

practices like the ones described above are often not taken seriously as such and remain understudied, even though nowadays users can easily turn into critics on social media. Indeed, users do reflect on, and therefore effectively theorize digital imagery in their criticism of social media, even if this theoretical practice must be characterized as implicit and performative compared to academic theories.[1] In the context of Blackout Tuesday, a particularly telling example of this is a post created by Emma Sheffer on her Instagram account called Insta Repeat. A few days prior to Blackout Tuesday, Sheffer showed solidarity with the protest movement by labeling three of her posts with the words "BLACK," "LIVES," and "MATTER" (fig. 1). Instead of black squares, Sheffer used a collage of drone shots found on Instagram to create monochrome, but at the same time mosaic-like, shaded backgrounds, assimilating the political statement to the composition and aesthetics of her previous Instagram picture production. Sheffer does not black out the picture flow, but stresses the uniformity of Instagram's picture production by turning snippets from it into a writing surface for a political message, a background devoid of proper content. By combining various shades of dark colors instead of a uniform black, the political message can take on a slightly different meaning as well, visualizing the multiple shades and the beauty hidden behind the generic term 'black.'

What this opening example illustrates is that not only do users in social media criticize digital imagery but that there may also be media-theoretical implications to this criticism. The project "Pictorial Picture Critique in Social Media. Explicit and Tacit Theorizing of the Digital Image" aims to uncover these implications in order to build a theory of the digital image by reformulating media philosophy within practice theory. From the perspective of media philosophy, it is neither necessary nor insightful to look at media from the outside, it being preferable instead to adopt an inner perspective of media, which are already 'theorizing' themselves.[2] Doing media philosophy is to philosophize with the media about the media in order to explore their own philosophy and translate it into scientific language — typically speech or writing. This shift of perspective to an inside view of media is necessary in order to formulate a context-specific media theory of digital imagery that starts out from concrete pictorial phenomena of digital culture as the proposal of the Priority Program requested, instead of drafting a grand theory of digital images or simply insisting on their ontological non-existence.[3] However, media philosophy is usually not interested in the actual media practices or the media knowledge of the users — unless they are a "genius film-maker"[4] — but favors a somewhat diffuse and non-situated knowledge of the media about the media. Our approach, which will be presented in the following sections, proposes a way to substantiate this media knowledge in socio-cultural terms by taking media practices into account, yet without ethnographically observing or interviewing their users.[5] We will argue that this is possible as pictures themselves are a form of materialized practice. In short, the media-philosophical question of what media know about media and their imagery will be addressed in terms of practice theory by analyzing what we call 'pictorial picture critique.'

Pictorial Picture Critique

Criticism of the digital image (and the image in general) is no longer restricted to intellectuals, artists, journalists or politicians, but is a relevant and highly visible part of digital production in social media as an everyday practice, an often creative and playful one. It does not only occur in the course of singular events such as Blackout Tuesday, but is a common part of social media activities, e.g. on Instagram, where users share pictures to criticize visual stereotypes that prevail on this same sharing site. Instances of this kind of critique are gathered under hashtags like #instagramvsreality and #bodypositive, or on Instagram accounts like Insta Repeat. More often than not, it is taken for granted that criticism, regardless of whether it is aimed at digital or analog media, is a written – or even literary – practice.[6] Roland Barthes prominently emphasizes that "criticism is discourse upon a discourse," which implies in linguistic terms "a second language, or a metalanguage […]."[7] The seemingly self-evident premise that this metalanguage takes on a written form remains unquestioned in terms of its limitations. Current publications on digital media criticism show that this dominance still persists. Peter B. Orlik's comprehensive book on *Media Criticism in a Digital Age* only mentions examples published in print media: newspapers, TV guides, and other magazines.[8] This predominance of criticism in writing does not rule out that other media, pictures in particular, can produce their own forms of media criticism, even if these tend to be less obvious. "Just as words […], images are themselves capable of becoming critical tools."[9] According to Jörg Huber, three kinds of picture critique can be distinguished: First, picture critique is used for didactic and/or entertaining purposes, e.g. art history's long ingrained practice of comparative double projection, or the reviewing of the 'picture of the week' in the feuilleton. Second, there is the wide field of image theory interested in the epistemology of the image by examining how pictures operate. These two practices of picture critique, once again, transpose the visuality of pictures into a linguistic and textual form. To conclude, Huber identifies a third kind of picture critique, namely pictorial picture critique, where pictures criticize other pictures. In this sense, pictures become tools or even agents of criticism. Huber notes that virtually no research has been undertaken on this topic so far.[10]

We want to close this research gap by gathering phenomena that fit the definition of pictorial picture critique on social media. This critique involves a form of "fault-finding, or at least […] judgment,"[11] which aims at the digital mediality of the picture in the form of parody, juxtaposition, comment etc. While critique in written or spoken form can be defined, using Barthes' theories, as a metalanguage, pictorial picture critique can be grasped with what W. J. T. Mitchell calls "metapictures."[12] In both cases, critique implies a particular kind of reflexivity. Metapictures are typically "media objects that reflect on their own constitution,"[13] which means that they do observe the mediality of imagery. Media reflexivity, thus, can be considered a critical practice directed at creating medial self-knowledge.[14] In this respect, the project is founded on the media-philosophical conviction that pictorial picture critique offers inside access to the mediality of digital images, as it lays bare the self-reflexive logic of the medium. The objective of the project is not a second-order observation of digital media, as criticism already is, but a third-order observation of digital media reflecting on digital media.[15] According to Lorenz Engell, media philosophy does not mean using a philosophical approach to think about media but is instead a philosophy *with* media that know about themselves as media. Media hold knowledge about themselves because in their representation of the world they inevitably include a representation of themselves, as they are part of the world they represent.[16] "So, if you want to find out what media are, or what they want, or what they in fact do, just ask them."[17] From a practice-theoretical perspective, we insist that this reflexive media knowledge should be situated in the various media practices and we thus try to uncover it by observing the media-reflexive practices of pictorial picture critique. Whereas all picture practices rely on some (often tacit) knowledge about how pictures 'work,' pictorial picture critique is an exceptionally fruitful case, because it also, consciously and explicitly, exhibits knowledge about itself, i.e. the image. As the reflexive knowledge resides in the current performance of a specific practice, it does not aim at a fully-fledged systematic theory but rather performs a processual and piecemeal 'theorizing.'[18] By drawing theoretical knowledge from media practice, we follow Mitchell's claim that "no theory of media can rise above the media themselves, and that what is required are forms of vernacular theory, embedded in media practices."[19] Exactly how we can manage the convergence of media philosophy and practice theory in terms of methodology will be discussed in the next section.

Picture Practice Analysis

The praxeological or practice turn has affected visual studies and photography research immensely during the last decade in general, and digital photography even more intensely. This turn has shifted the focus from the pictures themselves towards the practices of producing, circulating and viewing digital images. The picture itself – what it shows and how it is designed – fades from the spotlight as it is perceived as an obstacle for understanding visual culture. Rather than focusing on the aesthetic form or semantic content, the non-representative properties of pictures are prioritized. Edgar Gómez Cruz, for instance, urges digital photography studies to look beyond images to distance "it[self] from the model within which the images are the central element, instead positioning photography in a broader set of digital practices [...]."[20] In such an approach, pictures should be observed in the context of the social practices surrounding them. The claim is that it is inevitable to take recourse to social science and ethnographic methods such as participant observation and interviewing, i.e. either observe the actors or interview them about their actions in order to reconstruct the overall meaning of an image.[21]

In our view, this approach alone is not convincing for two reasons. First, we think it is questionable whether practices can be fully reconstructed this way because interviewing creates a new knowledge according to its own logic instead of just revealing what is already there and giving insights into the actual practice, i.e. the know-how of the actor. Therefore, it is hard to tell the knowledge constructed by the actor during the interview apart from the one used in the everyday habitualized practice, i.e. outside the interview. In other words, interviews are a practice in themselves and therefore generate a knowledge of their own.[22] This is not the only reason ethnography reaches its limits here: Since digital images can be easily circulated online, they appear in various contexts, where they are interpreted by users in different ways. Martin Hand, who actually uses ethnographic methodology himself, argues that "in-depth interviewing potentially ignores compositional and technological issues, rarely moving beyond localized contexts that arguably miss the more challenging aspects of *circulation* [...]."[23] There is supposedly no alternative to using quantitative/digital methods for analyzing the circulation of images in social media. We beg to differ by introducing a qualitative method beyond ethnographical and sociological research.

That brings us to our second point. We are convinced that media studies has its own tools for analyzing images and forms in general that can help to reconstruct picture practices. Hence it is neither productive nor creative to simply turn media studies into "media sociology,"[24] as Nick Couldry proposes. Both disciplines have epistemologies and methodologies of their own, yielding specific kinds of insights. From a media studies perspective, it is important to stress that the picture itself, as the result and starting point of practices alike, carries signs of those practices that make it possible to reconstruct them without taking recourse to producer and/or user statements, as sociologists would do. This is what we mean by 'materialized practice.' A picture materializes a practice insofar as it is the result of a practice that gains a perceivable, definable and at least to some extent stabilized (because reproducible) form in the aesthetic object.[25] At the same time, the picture is imbued with the power to instigate ensuing practices (not infrequently leading to the production of more pictures, e.g. in the case of internet memes). Thus, the picture can be reconstructed not as a representation but as a trace of the practices that are inscribed into its form because, as Bernd Stiegler puts it, "human actions are turned into images."[26] Of course, in order to understand a picture as a token of a particular practice, it is necessary to include the context in the analysis, i.e. on which platforms the picture appears, how it is tagged, arranged in a feed, positioned in a blog etc. Mirroring the production of social media content, which is always directed at a specific audience on a specific platform at a specific point in time, the reception is context-sensitive, a fact which also has to be considered by researchers.[27]

To conclude both points made, the project decidedly pursues a methodological interest in bringing together practice theory and image analysis, combining them into a *praxeological media philosophy* which understands the picture itself as materialized practice acting as a site of reflexive media knowledge. It is important to shift the emphasis from the actors/users to the practice itself to realize that it is practice that implies knowledge, whether or not the actors/users can provide insights into the concepts informing their doings. One might then argue: Why jump on the bandwagon of practice theory in the first place? What have media studies to gain from this move other than the risk of turning into a poor imitation of sociology? The answer is that looking at practices is now more crucial than ever for media studies since digital media such as photography, film, video, computer games etc. tend to blend inside the raster grid of pixels, but are distinguishable in their actual practices, which socially construct

how media are perceived as distinct and individual. Digitization questions this status of what were formerly known as mono-media.[28] For example, digital images can look like paintings and feature photographic properties like lens flare at the same time and yet still be entirely computer-generated.[29] Consequently, it is hard to grasp what the digital image actually *is* or can *be*. Maybe this is the reason why there is no general theory of the digital image so far, apart from the theorem of its ontological non-existence. Ontological thinking, which emphasizes the changing status of digital imaging per se, cannot cover the digital image in all its varying manifestations but only aspects of it, which is why recent studies prefer to start out from concrete practices and social uses of these pictures.[30]

Consequently, we want to propose a method that intervenes in current debates on media and image theory in order to provide a form-sensitive complement as well as an alternative to sociologically and ethnographically founded approaches to digital visual studies. This method aims at extracting media knowledge from within the picture. Pictorial picture critique makes a particularly interesting case for analyzing media this way since it holds knowledge about certain aspects of the pictorial media it addresses as well as knowledge about the pictorial medium it uses. Thus, media knowledge about digital images operates on two levels: On the one hand, digital images are the object of criticism. Any form of critique logically presumes prior and conscious reflection about its object. Hence, pictorial picture critique cannot but be media-conscious. As an aesthetic form, the critical picture visualizes knowledge about the type of picture it addresses. On this level, we ask what kind of knowledge the picture exhibits about other pictures by analyzing the content of these pictures in their original contexts. On the other hand, digital images come into play as the medium in which the pictorial form of critique is located. This knowledge about the qualities and options of digital images is a prerequisite for the pictorial form in which criticism is practised. The form that the pictorial critique takes is based on knowledge about the multiple options of designing digital images and what kinds of pictures are viable at the moment. In this sense, we analyze the picture in terms of composition, montage, captioning, and other picture practices — all operations which imply specific know-how. Thus, the analysis operates at a formal and aesthetic level as well. The coexistence of these two levels lends itself to an examination of how their relation is brought into play. They may possibly support each other or produce a contradiction if a trait of digital imagery is criticized which applies to its own pictorial status.

Following Gilbert Ryle, these levels can be theoretically conceptualized as "knowing that" pictures are pictorially criticized and "knowing how" pictures can pictorially criticize.[31] Both levels can be either explicit and/ or tacit. Arguably, pictures rely heavily on and exhibit tacit knowledge as they show more than their producers can consciously tell, very much like Michael Polanyi once wrote: "We can know more than we can tell."[32] Then again, as the saying goes, 'A picture is worth a thousand words,' explicitly pointing to specific contents and contexts that cannot be easily captured by language. This may especially apply to metapictures, i.e. pictures about pictures, as is the case for internet memes and other self-reflexive social media imagery. Even so, the relationship between 'tacit knowledge' and 'knowing how,' respectively 'explicit knowledge' and 'knowing that,' is rather complex. Contrary to a common scientific understanding, the terminology is not synonymous.[33] The level of 'knowing that' can be tacit at times, e.g. when internet memes mystify their origin, or can be rather explicit, e.g. in case of juxtaposition. The level of 'knowing how' is typically tacit because practices are usually not articulated but performed. However, they can be reflected and become more explicit — particularly in pictorial media. In terms of participation, it could be worth considering if the opposition of explicit and tacit knowledge 'in practice' tends to look more like a continuum ranging from "producing media texts and artefacts" (e.g. creating memes, writing blogs etc.) to more "automated user participation" (e.g. sharing content, connecting with people etc.) on social media.[34] This is what Mikko Villi and Janne Matikainen are proposing for a broader understanding of social media practices, which could be adopted and specified for digital picture practices.

The shift from *what* pictures depict to *how* pictures depict is also addressed by the 'documentary method,' which is designed, in the traditions of Karl Mannheim and Erwin Panofsky, to analyze people in pictures and/ or the producer of the picture through the picture itself.[35] In contrast, our approach is to reconstruct the media knowledge of the picture by extrapolating materialized picture practices. The difference between both methods is the media-philosophical epistemology of the picture practice analysis compared to the knowledge-sociological epistemology of the documentary method. By primarily focusing on the content of the picture, the latter is the exact opposite of the "non-representational methodologies"[36] that we mentioned above. It is important to note that our approach is not meant to replace but to complement those social-scientific methodologies. By applying the picture practice analysis, we focus on praxeologically analyzing the mediality of the digital image from within social media

imagery. This reconstructed media knowledge about the digital image can in turn be triangulated with sociological or ethnographical findings. If we approach the material with already existing knowledge, this might be inevitable in order to avoid circularity in our findings. However, we want to make the pictures 'speak' for themselves, which is why we have gathered a broad range of cases of pictorial picture critique which we will then inductively examine in order to methodically control our own interpretation.

For this purpose, we use a knowledge database (lexiCan) to organize and analyze the images we collect. This database mainly consists of screenshots, which have the advantage over loose images that they provide metadata such as captions, hashtags, links etc., which can help to contextualize the image. For the time being, the corpus of phenomena we have collected is structured by five key practices (editing, imitating, captioning, tagging, curating). We use these key practices of pictorial picture critique to sift through different platforms like Instagram, Reddit, Tumblr, Twitter etc. in search of pictorial phenomena that are edited, imitate pictures, have captions/tags and/or are curated with a media critical impetus, for example dank memes, anti-selfies, photoshop fails, stocking, facial editing etc. In many of the cases, we found several of the designated practices combine. Our initial set of practices is open to new entries, of course. In lexiCan, it is possible to display, sort and tag the screenshots found this way as well as provide them with sources to the original posts. Tagging is itself a practice of digital culture, which can be found not only almost everywhere in social media, but also in professional image databases. However, we do not use arbitrary tags in our database, as is perhaps common in social media, but rather strive for a systematic coding in the sense of qualitative research. In this vein, we inductively reason the codes from the screenshots and document them in a code book. The focus of coding is naturally on the picture practices used, including various sub-practices such as cutting, pasting or posing, but also on the forms that result from them and the platforms in which they are embedded. The code book serves to enable us to keep track of research as well as to establish intersubjectivity, defining the pictorial practices and putting them into relation. The picture practice analysis is directly undertaken in lexiCan, which also serves as a text processing program. Conducting case studies directly in the knowledge database has the advantage that we can interlink the phenomena and practices to each other, much like the hypertext structure of the internet itself. In the following, we will present such a case study that will give an example of the pictorial phenomena we have observed as well as an account of how we use the picture practice analysis in practice.

Case Study on Insta Repeat

This exemplary case study returns to the picture practices of Insta Repeat, which Emma Sheffer designed to illustrate the aesthetic repetition in digital travel photography. For this purpose, various formally similar Instagram posts are montaged into one overall picture. Each of these overall pictures is composed of 12 single shots taken by Instagram influencers. We categorized this pictorial phenomenon under the practice of curating. To discuss how (and if) this practice works and which knowledge is implied in the context of social media, we will take an exemplary look at six of Sheffer's curations (fig. 2).

On the 'knowing that' level of the picture practice analyses, we consider what the curated pictures are about and who took them. Obviously, they are digital photographs, all taken from inside a tent. Each photograph depicts a so-called 'tent hole' which serves as a window to the outside world. Through these tent holes mountains, lakes, beaches, forests and deserts are visible and suggest a rough, untouched nature. However, almost all of the places shown are well-known tourist locations such as the mountains Seceda, Tre Cime di Lavaredo, and Matterhorn. Most of the photographs, roughly 70% (50 out of 72 pictures), show mountainsides. This motif was arguably so frequently chosen because "mountains" have – in terms of Walter Benjamin – an "aura" to them, defined as "the unique apparition of a distance, however near it may be."[37] Each mountain is a singular formation in nature, none like the other. In contrast, this is exactly what these digital photographs are missing. They fetishize the mountains as a motif to feign a uniqueness that digital photography simply cannot achieve. Just like Benjamin, not in writing, but pictorially, Insta Repeat is pointing out that these pictures are actually not unique but rather common and reproducible. In comparison, the photographs of mountains do not seem as unique as mountains in nature due to the reproducibility of the medium. However, this digital reproducibility is not necessarily afforded by the platform
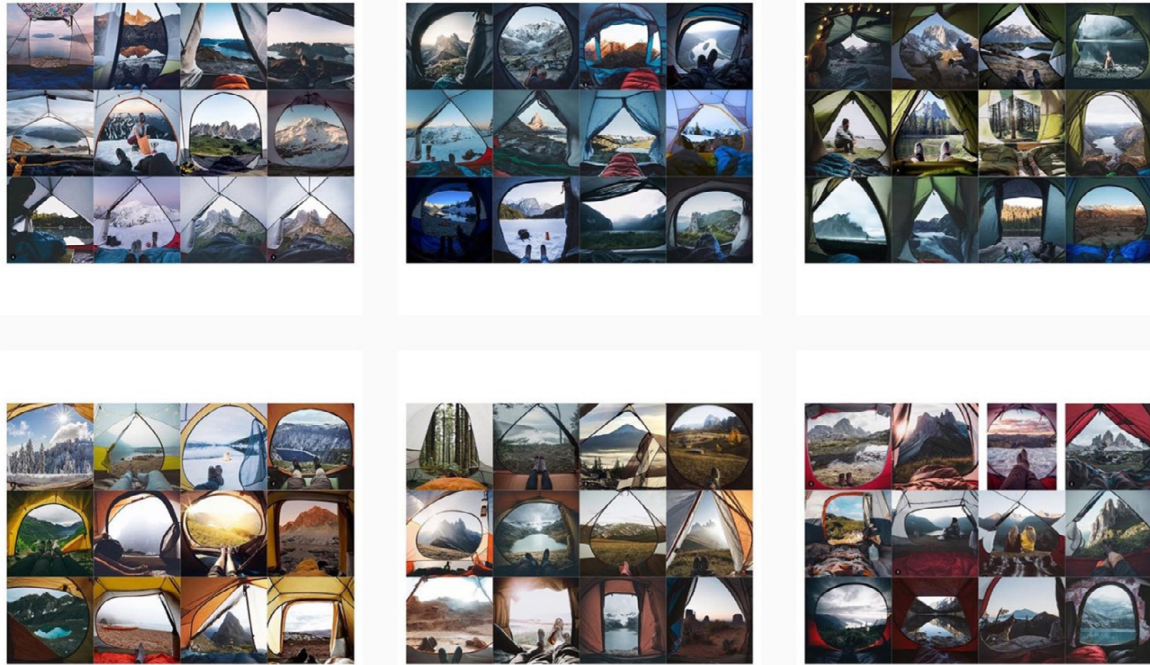
Figure 2. Emma Sheffer; Insta Repeat; 2018; https://www.instagram.com/insta_repeat; screenshot of Insta that shows a curation of several tent shots (2018).

itself as other people's pictures cannot easily be copied on Instagram.[38] Instead, other users, who are familiar with these kinds of pictures, imitate the picture practices of travel photography.

For example, the photos by Thilo Axnick and Tom Fechtner (fig. 3 and 4, curated in the first image of fig. 2) look almost exactly the same.[39] From the white tent to the blue sleeping bag to the angle of the mountain shot of the Seceda – everything is identical. Just the color temperature is a bit different. A quick research shows that Thilo and Tom are cousins. One might speculate that creating photographs with this particular aesthetic could be a family-related practice. However, it is noteworthy that their kinship is not disclosed anywhere in their posts. Actually, both posts are designed to appear unique. Insta Repeat reveals that this is not the case on an even larger scale. Lots of tourist sites, especially mountainsides, are pictured as tent shots. What varies, at least in some part, are the operators themselves, who are present in most of the photographs. In the extreme case of Thilo and Tom, their bodies staged here, hidden within sleeping bags, look quite alike. In other cases, however, the bodies of the influencers are shown with visible differences: some wear shoes or socks, some are barefoot, and others lie in their sleeping bags. These human contingencies make the photographs distinguishable and, ironically, more unique than the nature pictured, which is irritated by these so-called 'feet shots' of Instagram influencers.

Feet and tent shots are a popular form on Instagram. Up to now, tent shots have been curated by Sheffer in 29 posts, i.e. 348 single photographs. Feet shots, i.e. photographs of one's feet, are even more common, curated in 59 posts. These selfies are taken on the one hand to convey the subjective sensation of what the influencers have witnessed in the 'wild.' On the other hand, these selfies are self-marketing. By staging their own bodies, travel selfies are not just intended to document the backpacking experience but to mediate the presence of the influencers.[40] This 'selfie-branding' gives the photograph an individual touch and a glance at the backstage that is, of course, staged as well. By bringing the self to the fore, "the viewer is invited to establish their own relation to both the subject

Figure 3. Thilo Axnick; thiloaxnick; 2017; https://www.instagram.com/p/BY_arlznTk_/; screenshot of the photograph of the Seceda posted by Thilo Axnick (2017).

Figure 4. Tom Fechtner; tom.fechtner; 2017; https://www.instagram.com/p/BX8Ug6jlQmQ; screenshot of the photograph of the Seceda posted by Tom Fechtner (2017).

and the pictured object […].”[41] This relationship is exactly what influencing is all about since influencers are most interested in accumulating as many followers as possible, who can be affected by promotion. In this way, a “high follower count can be monetized on Instagram,” which is why “within the travel genre the most-followed users are, in effect, businesspeople [sic!].”[42] Our research shows that the 52 travel influencers marked in the overall pictures by Sheffer, have at least several thousand followers, actually ranging from 7.500 (flolanni) to 1.5 million (hannes_becker). Hannes Becker, for example, is openly advertising a camera of the company Olympus in his post, which is disclosed with: “Paid partnership with olympuscameras” and “Werbung,” the German word for ‘advertisement.’[43] This example demonstrates that these travel selfies are not just about self-branding, but in some cases actual marketing and paid promotions, reaching millions of people, as with Hannes Becker. But Becker is not the only such case, even though he is the most influential in Sheffer’s curation. 37% (19 out of 52) of the influencers marked in Sheffer’s curation are actively advertising in their posts, some more explicitly than others. Overall, the content of their posts is more often about promoting than describing the photographed nature, which only occurs in 31% of the cases (16 out of 52 influencers). The analysis of the ‘knowing that’ reveals that, content-wise, these photographs are not just about nature or backpacking adventures but advertorials, and almost always self(ie)-branding.

On the ‘knowing how’ level of the picture practice analysis, we reconstruct how the curation is formally executed. In the case of Insta Repeat, the 12 travel photographs are organized into a chess-like mosaic, which reveals their likeness (in conjunction with their variation). In fig. 2, each of the 72 photos can be qualified as a so-called ‘tent shot,’ i.e. a point-of-view shot that was taken from inside a tent. To gather material evidence that they actually look alike, Sheffer searched the Instagram pages of the influencers for photographs that share one similar perspective, consisting of a POV, a tent hole, and the view outside into nature. The form of the tent shot is responsible for the similarity of these 72 photographs. Most of the selected photographs vary in some way, however. For example, the tent holes vary in shape due to different tents, the landscape is depicted in variable angles, or – as stated above – the influencers themselves cause contingencies in the photographs. Nevertheless, some of the photographs are almost identical as, for instance, in the curation of Thilo Axnick’s and Tom Fechtner’s photographs, which is valid also for other curated photographs of the Seceda.[44] Therefore, each of the mosaics is iconically organized by genre (travel photography), motif (e.g. the Seceda mountainside), and form (e.g. tent shots).

Furthermore, this iconic arrangement is structured by color. This means that each mosaic has its own color scheme, which is expressed in the captions of the posts: “Purply blueish tent hole” / “Blueish tent hole” / “Greenish tent hole” / “Yellowish tent hole” / “Orangish tent hole” / “Red tent hole.”[45] These captions are an explicit cue that Sheffer searched for similar tent shots but also sorted them by color. This sorting takes place on two different levels. First, photographs with a similar color are montaged together. In most cases, the color is defined by the tone of the tent, which is mainly responsible for the color scheme. For example, in the last mosaic all tents have reddish parts – some more than others. In other cases, it is not the tent but the nature that colorizes the photograph, for instance the sun in the fourth mosaic. On their own, most of the photographs do not actually seem very colorful at all and/or could be easily described by another color. In combination, however, they form distinct mosaics that differ in color and hue. Pictorially, the curation is criticizing exactly this: that these photographs appear quite special on their own but put together they easily form a unity. By putting these digital photographs side by side, Insta Repeat powerfully demonstrates how similar Instagram photography actually looks. The supposed uniqueness of Instagram photography is challenged by Sheffer’s curation. The result is a mosaic-like ‘Gesamtkunstwerk.’

Second, the color scheme indicates that the mosaics themselves are sequenced by color. Sheffer explains this in the captions of the photographs and with the dates they were posted. A sequence can adopt the form of a series, stringing together variations on a common form or theme, if the posts appear interconnected. This is precisely what happens: By using the theme of ‘color,’ Sheffer serializes the mosaics, which were posted within a week, based on the color spectrum – from red to violet. That means the red mosaic was posted first on December 9, 2018, then the orange mosaic a day later, then the yellow mosaic a day after, and so on. While repeating the form of the ‘tent shot’ in each post, Sheffer varies the color scheme and description of the mosaics. This serialization can be understood as a tacit self-critique of the picture practice applied, because Insta Repeat is actually a curation of curations. While curating is usually a practice at home in museums and art galleries, it is appropriated by Sheffer for social media. On her website, she explicitly lists Insta Repeat under curations and defines it as an “*[e]xamination of an internet copy machine*.”[46] Appropriately enough, ‘repeating’ is how Sheffer labels her practice in the name of her profile. She repeatedly (in a series of posts) repeats (by appropriating images already posted) what others have repeated (the pictorial stereotypes). In this case, curating combines with another common practice of pictorial picture critique: imitating.

Conclusion

Insta Repeat questions the individuality of Instagram photography, and instead places it within a larger framework of photographic practices, i.e. routines. In the analyzed examples, these photographic routines are materialized into the form of feet and tent shots. Taking photographs this way is a common practice on Instagram, which is not only showcased by Insta Repeat, but is actually acknowledged by some users. In the curated photographs, 15% (8 out of 52 influencers) reference this photographic form in the caption of their posts. For example, Seya Eggler calls his "tent view game over 9000!" and is "[m]aking a 'Outofthetent'-Shot" in another post.[47] At the same time, these photographs do not want to appear ordinary but rather extraordinary, since they are designed for self(ie)-branding and advertising. Hence most posts obscure the fact that there are already hundreds of very similar looking tent shots out there on Instagram. These tent shots are collected and exhibited by Sheffer to expose their similarity, which only becomes explicit through curation (fig. 2). In the examples analyzed, at least two sub-practices – captioning and serializing – are used to facilitate this curation. Captioning these photographic mosaics explicitly brings the posts into an order that is tacitly serialized by color scheme. In a very similar way, Sheffer used these sub-practices to curate the words "BLACK LIVES MATTER" (fig. 1), to criticize the homogeneity of Instagram, disguised as individuality, by uniformly serializing her own posts. Rather than dissociating itself from homogeneity in order to criticize it, Insta Repeat is itself characterized by homogeneity. In a manner quite similar to pop art, social media is reflected through the means of social media, implying that the uniformity of pictures is not a problem per se, but rather the myth of their uniqueness is.

The critique of tourist snapshots as repetitive is not limited to digital photography or new in any way, but is a staple of cultural critique of the tourist experience as inauthentic.[48] For example, the artist Penelope Umbrico curates travel photography as well, which she collects from Flickr, but does not exhibit on social media. Her curations are shown in art galleries.[49] In a similar vein, Erik Kessels collected thousands of foot selfies posted on the internet and materialized them into an installation on which museum visitors can walk to set their own feet in relation to the pictured ones culled from the massive vaults of the internet.[50] Both projects are mentioned here, because they clearly exhibit parallels to Sheffer's curations. At the same time, they stand for an important strand in contemporary artistic practice, namely appropriation art, typically connected to the concept of postmodernism.[51] In contrast to Sheffer's project, however, Kessels' and Umbrico's curated appropriations do not involve the internal perspective of self-critique, as in the case of Insta Repeat. First, it is a critique supported by sites of institutionalized cultural power: art galleries and museums, whereas Sheffer's curations appear inside the same 'institution' and virtually next door to the pictures she critically addresses. Second, by leaving digital image culture and materializing the digital shots as prints, the potential of the installations to be repeated – (re)appropriated and circulated – has been minimized.

Still, there might even be an artistic aspiration to Sheffer's project, although she remains a social media user in the end. When she criticizes Instagram from within, it is not without self-criticism. Certainly, self-critique is an important part of pictorial picture critique in social media since it brings to light the circularity of the digital image. The influencers are explicitly marked by Sheffer in her posts and therefore made accountable for their actions, which is not the case in the art gallery, where the origins of the photographs used by Umbrico and Kessels are rendered anonymous. In a sense, Sheffer becomes herself a meta-influencer by accumulating and appropriating the 'art' of others, while criticizing the practices of others (and her own) with metapictures. By curating curations, the pictorial picture critique of Insta Repeat implies media knowledge about the digital image in social media using images of social media, giving us a critical inside perspective of Instagram. By putting 12 similar-looking photographs together into one 'Gesamtkunstwerk,' she criticizes the similarity of Instagram photography in a rather artistic manner, creating a new curation of photographs that have already been curated by influencers. According to Lev Manovich, photographs on Instagram are "designed photos [that] aim for *originality* in terms of how subjects are shown, at the same time for very tight *control* of an image – ideally consisting from smaller number of clear differentiated elements organized to achieve strong visual contrast and rhythm."[52] This apparent originality and definitive controllability of digital travel photography is exactly what Sheffer points out in her curation while she criticizes the practice of "curating"[53] on social media. While doing so, however, she has to curate her own content, i.e. her curations on social media. This is exactly what we mean by 'curation of curations.' Sheffer is a curator on Instagram as well, not just in an artistic way but as a social media user. Ironically, her curated mosaics look homogenous, too, for instance the many curated car shots, drone shots, feet shots, tent shots etc., which ultimately result in exasperated comments by other users like this: "Enough with the tent holes, we get it."[54]

NOTES

1 For an overview of criticism of digital media, mostly from an academic and journalistic perspective, see Otto Peters, *Against the Tide*: *Critics of Digitalisation*. (Oldenburg: BIS-Verlag, 2013).

2 Cf. Lorenz Engell, "Medientheorien der Medien selbst," in *Handbuch Medienwissenschaft*, ed. Jens Schröter (Stuttgart: J.B. Metzler, 2014), 207.

3 See Wolfgang Hagen, "Es gibt kein 'digitales Bild.' – Eine medienepistemologische Anmerkung," *Licht und Leitung – Archiv für Mediengeschichte* 2 (2002): 103–112 and Claus Pias, "Das digitale Bild gibt es nicht: Über das (Nicht-)Wissen der Bilder und die informatische Illusion," *zeitenblicke* 2, no. 1 (2003): 1–25. For digital photography see Lev Manovich, "The Paradoxes of Digital Photography," in *The Photography Reader*, ed. Liz Wells (London: Routledge, 2003), 240–249.

4 Lorenz Engell, "Ontogenetic Machinery," *Radical Philosophy*, no. 169 (2011): 10.

5 Engell himself actually suggests this praxeological reading when he frames media philosophy as a practice of media, cf. Lorenz Engell, "Tasten, Wählen, Denken: Genese und Funktion einer philosophischen Apparatur," in *Medienphilosophie: Beiträge zur Klärung eines Begriffs*, ed. Stefan Münker, Alexander Roesler and Mike Sandbothe (Frankfurt am Main: Fischer, 2003), 53.

6 Cf. Raymond Williams, "Criticism," in *Keywords: A Vocabulary of Culture and Society*, ed. Raymond Williams, 2nd ed. (Oxford University Press: New York, 1983), 85. See also Jürgen Habermas, *Strukturwandel der* Öffentlichkeit: *Untersuchungen zu einer Kategorie der bürgerlichen Gesellschaft* (Frankfurt am Main: Suhrkamp, 1990), 105.

7 Roland Barthes, "What Is Criticism?," in *Critical Essays*, ed. Roland Barthes (Evanston: Northwestern University Press, 1972), 258.

8 Cf. Peter B. Orlik, *Media Criticism in a Digital Age*: *Professional and Consumer Considerations* (New York: Routledge, 2016). See also Anandam P. Kavoori, *Digital Media Criticism* (New York: Lang, 2010), who gives guidelines for writing critiques on digital media.

9 Georges Didi-Huberman, "Critical Image/Imaging Critique," *Oxford Art Journal* 40, no. 2 (2017): 260.

10 Cf. Jörg Huber, "Bildkritik: Über Taktilität und die Armut des Einzelnen," in *Ästhetik der Kritik oder verdeckte Ermittlung*, ed. Jörg Huber et al. (Zurich, Vienna: Springer, 2007), 95–97.

11 Raymond Williams, "Criticism," in *Keywords: A Vocabulary of Culture and Society*, ed. Raymond Williams, 2nd ed. (Oxford University Press: New York, 1983), 83.

12 12 W. J. T. Mitchell, *Picture Theory*: *Essays on Verbal and Visual Representation* (Chicago, London: University of Chicago Press, 1995), 38.

13 Mitchell, "Picture Theory: Essays on Verbal and Visual Representation," 210.

14 Cf. Kay Kirchmann and Jens Ruchatz, "Einleitung: Wie Filme Medien beobachten: Zur kinematografischen Konstruktion von Medialität," in *Medienreflexion im Film: Ein Handbuch*, ed. Kay Kirchmann and Jens Ruchatz (Bielefeld: Transcript, 2014), 9.

15 See for criticism as a second-order observation Niklas Luhmann, *Die neuzeitlichen Wissenschaften und die Phänomenologie* (Vienna: Picus, 1996), 17.

16 Cf. Lorenz Engell, "Medientheorien der Medien selbst," in *Handbuch Medienwissenschaft*, ed. Jens Schröter (Stuttgart: J.B. Metzler, 2014), 207.

17 Lorenz Engell, "Ontogenetic Machinery," *Radical Philosophy*, no. 169 (2011): 10.

18 Cf. Lorenz Engell, "Medientheorien der Medien selbst," in *Handbuch Medienwissenschaft*, ed. Jens Schröter (Stuttgart: J.B. Metzler, 2014), 207 and W. J. T. Mitchell, *What Do Pictures Want? The Lives and Loves of Images* (Chicago, London: University of Chicago Press, 2005), 6.

19 W. J. T. Mitchell, *Picture Theory*: *Essays on Verbal and Visual Representation* (Chicago, London: University of Chicago Press, 1995), 210.

20 Edgar Gómez Cruz, "Digital Photography Studies. From Images to Material Visual Practices," in *Handbuch Soziale Praktiken und Digitale Alltagswelten*, ed. Heidrun Friese et al. (Wiesbaden: Springer, 2020), 100. For pre-digital photography see Elizabeth Edwards, "Objects of Affect: Photography Beyond the Image," *Annual Review of Anthropology* 41, no. 1 (2012): 221–234.

21 Formative for such an ethnographical approach is Larsen, Jonas. "Practices and Flows of Digital Photography: An Ethnographic Framework," *Mobilities* 3, no. 1 (2008): 141–160.

22 Cf. Paul Atkinson and David Silverman, "Kundera's Immortality: The Interview Society and the Invention of the Self," *Qualitative Inquiry* 3, no. 3 (1997): 304–325 and David Silverman, "How Was It for You? The Interview Society and the Irresistible Rise of the (Poorly Analyzed) Interview," *Qualitative Research* 17, no. 2 (2017): 144–158.

23 Martin Hand, "Visuality in Social Media: Researching Images, Circulations and Practices," in *The Sage Handbook of Social Media Research Methods*, ed. Luke Sloan and Anabel Quan-Haase (Los Angeles: SAGE, 2017), 224.

24 Nick Couldry, "Theorising Media as Practice," in *Theorising Media and Practice*, ed. Birgit Bräuchler and John Postill (New York: Berghahn Books, 2010), 41.

25 On a technical level, this materialization can be understood quite literally because digital data is formed into an image on the screen, for example on the basis of liquid crystals (LCD).

26 Bernd Stiegler, "How to Do Things with Photographs: Towards a Praxeology of Photography," in *The Routledge Companion to Photography and Visual Culture*, ed. Moritz Neumüller (New York, London: Routledge, 2018), 5.

27 André Gunthert, "The Conversational Image: New Uses of Digital Photography," Études *photographiques* 18, no. 31 (2014), accessed December 3, 2020, url: https://journals.openedition.org/etudesphotographiques/3546.

28 Cf. Jens Schröter, "Das ur-intermediale Netzwerk und die (Neu-)Erfindung des Mediums im (digitalen) Modernismus: Ein Versuch," in *Intermedialität – Analog/Digital: Theorien, Methoden, Analysen*, ed. Joachim Paech and Jens Schröter (Munich: Fink, 2008), 590. William J. Mitchell, *The Reconfigured Eye: Visual Truth in the Post-Photographic Era*, 4th ed. (Cambridge: MIT Press, 2001), 4-5.

29 Jens Schröter, "Das ur-intermediale Netzwerk und die (Neu-)Erfindung des Mediums im (digitalen) Modernismus: Ein Versuch," in *Intermedialität – Analog/Digital: Theorien, Methoden, Analysen*, ed. Joachim Paech and Jens Schröter (Munich: Fink, 2008), 588.

30 Cf. Jens Schröter, "Digitales Bild," *IMAGE*, no. 25 (2017): 91. A current example of this is Martin Hand, "Photography Meets Social Media: Image Making and Sharing in a Continually Networked Present," in *The Handbook of Photography Studies*, ed. Gil Pasternak (London, New York: Bloomsbury, 2020), 310–326

31 Gilbert Ryle, "Knowing How and Knowing That," *Proceedings of the Aristotelian Society* 46 (1945–1946): 4.

32 Michael Polanyi, *The Tacit Dimension* (Chicago, London: University of Chicago Press, 1966), 4.

33 For this consideration, we would like to thank Christoph Ernst, who gave us feedback on our talk "Bildpraxisanalyse: Erschließen, was Praktiken in Sozialen Medien vom digitalen Bild wissen" that we held at the Priority Program workshop "Das digitale Bild – Methodik und Methodologie: fachspezifisch oder transdisziplinär?" on November 12, 2020. See also Kjeld Schmidt, "The Trouble with 'Tacit Knowledge,'" *Computer Supported Cooperative Work* 21, 2–3 (2012): 209.

34 Mikko Villi and Janne Matikainen, "Participation in Social Media: Studying Explicit and Implicit Forms of Participation in Communicative Social Networks," *Media and Communication* 4, no. 4 (2016): 110.

35 Ralf Bohnsack, "The Interpretation of Pictures and the Documentary Method," *Historical Social Research* 34, no. 2 (2009): 300-301.

36 Phillip Vannini, "Non-Representational Research Methodologies: An Introduction," in *Non-Representational Methodologies: Re-Envisioning Research*, ed. Phillip Vannini (New York, Abingdon: Routledge, 2015), 2.

37 Walter Benjamin, "The Work of Art in the Age of Its Technological Reproducibility: Second Version," in *The Work of Art in the Age of Its Technological Reproducibility, and Other Writings on Media*, ed. Michael W. Jennings, Brigid Doherty and Thomas Y. Levin (Cambridge, London: Belknap Press, 2008), 23. The modern aesthetic interest in mountains as 'picturesque' – put in simple terms: as particularly picture-worthy – originated in the late 18th century, cf. David S. Miall: "Representing the Picturesque: William Gilpin and the Laws of Nature," *Interdisciplinary Studies in Literature and Environment* 12 (2005), No. 2, 75–93.

38 On Instagram, pictures cannot be downloaded directly to a smartphone or PC. Sharing a post like on Facebook, for example, is only privately possible, or outside of Instagram itself.

39 The photograph by Thilo Axnick can be seen here: Thilo Axnick, "Seceda," Instagram, September 13, 2017, accessed November 30, 2020, url: https://www.instagram.com/p/BY_arlznTk_. Tom Fechtner's photograph can be found here: Tom Fechtner, "Seceda," Instagram, August 18, 2017, accessed November 30, 2020., url: https://www.instagram.com/p/BX8Ug6jIQmQ.

40 Mikko Villi, "'Hey, I'm Here Right Now': Camera Phone Photographs and Mediated Presence," *Photographies* 8, no. 1 (2015): 6-7.

41 Sean P. Smith, "Landscapes for 'Likes': Capitalizing on Travel with Instagram," *Social Semiotics* 29 (2019): 8, accessed November 30, 2020, url: https://doi.org/10.1080/10350330.2019.1664579.

42 Smith, "Landscapes for 'Likes': Capitalizing on Travel with Instagram," 7.

43 His post can be seen here: Hannes Becker, "Midi–Pyrenees, France," Instagram, October 31, 2017, accessed November 30, 2020, url: https://www.instagram.com/p/Ba7IOIyAqXa.

44 For example, the photograph by Florian Lanni that can be seen here: Florian Lanni, "Seceda–2500m," Instagram, July 16, 2017, accessed November 30, 2020, url: https://www.instagram.com/p/BWnG7ZQFgpV. Steven Weisbach's photo-graph, which can be found here: Steven Weisbach, "Seceda–2500," Instagram, May 31, 2017, accessed November 30, 2020, url: https://www.instagram.com/p/BUw68NOAcUy. And the photograph by Fábio Luz, which is shown here: Fábio Luz, "Seceda–2500m," Instagram, June 15, 2018, accessed November 30, 2020, url: https://www.instagram.com/p/BkDbA6uhqjY.

45 The captions can be looked up in the same order as described:
insta_repeat, "Purply blueish tent hole," Instagram, December 15, 2018, accessed November 30, 2020, url: https://www.instagram.com/p/BrY4JZaAC1Z/; insta_repeat, "Blueish tent hole," Instagram, December 13, 2018, accessed November 30, 2020, url: https://www.instagram.com/p/BrUPkAYABJ2/; insta_repeat, "Greenish tent hole, " Instagram, December 12, 2018, accessed November 30, 2020, url: https://www.instagram.com/p/BrRS9NpghWc/; insta_repeat, "Yellowish tent hole, " Instagram, December 11, 2018, accessed November 30, 2020, url: https://www.instagram.com/p/BrO9IoqgxF8/; insta_repeat, "Orangish tent hole, " Instagram, December 10, 2018, accessed November 30, 2020, url: https://www.instagram.com/p/BrMko9IgPN8/; insta_repeat, "Red tent hole," Instagram, December 10, 2018, accessed November 30, 2020, url: https://www.instagram.com/p/BrKGsiIAs-0.

46 Her website can be found here: Emma Sheffer, last modified November 30, 2020, url: https://emmasheffer.com/index.php/curations/curations.

47 Both posts can be found here: Seya Eggler, "Vierwaldstättersee," Instagram, July 9, 2017, accessed November 30, 2020, url: https://www.instagram.com/p/BWVgkmWFM_C/. and Seya Eggler, "Berggasthaus Seealpsee," Instagram, April 9, 2017, accessed November 30, 2020, url: https://www.instagram.com/p/BSrcEJ2FTYi.

48 Cf. Donald L. Redfoot, "Touristic Authenticity, Touristic Angst, and Modern Reality," *Qualitative Sociology* 7, no. 4 (1984): 291–309; Olivia Jenkins, "Photography and Travel Brochures: The Circle of Representation," *Tourism Geographies* 5, no. 3

(2003): 305–328; Lynn Berger, "Snapshots, or: Visual Culture's Clichés," *Photographies* 4, no. 2 (2011): 175–176; Annebella Pollen, "When Is a Cliché Not a Cliché? Reconsidering Mass-Produced Sunsets," in *Photography Reframed: New Visions in Contemporary Photographic Culture*, ed. Benedict Burbridge and Annebella Pollen (London et al.: Bloomsbury, 2019), 74–81.

[49] Clément Chéroux et al., *From Here On*: *Postphotography in the Age of Internet and the Mobile Phone* (Barcelona: Editorial RM, 2013), 88: "For Penelope Umbrico the world is already image-saturated so what's needed is a recycling strategy that injects new life into existing photographs. Penelope Umbrico's gambit consists in exploring all sort of situations, accumulating graphic information and then picking out and conceptualising her discoveries." An extract of the curation "Suns from Sunsets from Flickr" can be seen here: "Suns from Sunsets from Flickr," Penelope Umbrico, last modified December 14, 2020, url: http://www.penelopeumbrico.net/index.php/project/suns-from-sunsets-from-flickr. See for further contextualization of Umbrico's curation: A, Pollen, "When Is a Cliché Not a Cliché? Reconsidering Mass-Produced Sunsets," in *Photography Reframed: New Visions in Contemporary Photographic Culture*, ed. Benedict Burbridge and Annebella Pollen (London et al.: Bloomsbury, 2019), 79.

[50] Erik Kessels, *The Many Lives of Erik Kessels* (New York: Aperture, 2017), 347–360, Cf. also Erik Kessels, "My Feet," last modified December 14, 2020, url: https://www.erikkessels.com/my-feet.

[51] Cf. Douglas Crimp, *On the Museum's Ruins* (Cambridge: MIT Press, 1993), 126–137.

[52] Lev Manovich, *Instagram and Contemporary Image* (San Diego: Qualcomm Institute, 2017), accessed December 2, 2020, url: http://manovich.net/index.php/projects/instagram-and-contemporary-image, 99.

[53] Manovich, "Instagram and Contemporary Image," 99.

[54] The comment of the user noah_sc_photo can be read here: insta_repeat, "Greenish tent hole," Instagram, December 12, 2018, accessed January 19, 2021, url: https://www.instagram.com/p/BrRS9NpghWc/c/17878877302288490/.

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WHAT IS THE COLOR OF THE PAST? THE TRUTH OF THE ARCHIVE AND THE TRUTH OF SIMULATION

PETER GEIMER

ABSTRACT | Recently, the digital recoloring of black-and-white film has become a standard of historical documentation. Since the documented events originally took place in color, the argument goes, recoloring the images brings them closer to reality. Using the example of the French documentary film series *Apocalypse – la 2ème Guerre Mondiale*, a digital re-coloring of historical black-and-white footage, the article discusses the historiographical concepts behind this kind of simulation. Is digital recoloring an authentic and vivid animation of past events (as the authors of *Apocalypse claim*)? Or is it rather a questionable overwriting of archival material (as art historian Georges Didi-Huberman claims)? This article discusses various arguments for and against this technology of animation and ultimately takes the side of the critics: It is undeniable that every historical reconstruction is a subsequent interpretation. But shouldn't pictorial sources be left in their surviving visual integrity – as one would undoubtedly do with written documents? The historical archive is no tabula rasa. But changing the visual integrity of pictures is no reanimation of the "real", but rather an erasure of historical material.

KEYWORDS | digital/digitized, historiography, media theory, recoloring, authenticity

The Promise of Color

The following text is part of the research project "The Digital Past – Facticity and Fiction in Visualizations of History," carried out by Peter Geimer and Luca Beisel at the Freie Universität Berlin. The project studies the role of digital imaging in our understanding and imagination of past events and epochs. The focus lies on reconstructions that are ascribed with a documentary, factual character.

Beside the cinematic documentations addressed in this article by Peter Geimer, Luca Beisel studies the mediation of history in virtual reality exhibits. From animated dinosaurs to the reconstruction of the Temple in Jerusalem, VR technology is credited with facilitating a "look into the past" and provide a first-hand experience of history. The common question is what new forms of an understanding of history arise from digital reconstructions and simulations, especially from the promise of a new immediacy of history through immersion.

In September 2009, seventy years after the German invasion of Poland, French television showed the six-part film documentary Apocalypse – *La 2ème Guerre Mondiale*. Approximately six hundred hours of historical footage were viewed and edited into a six-hour documentary – from the Nazi Party Congress in Nuremberg to the Allied landings

in Normandy and the ruins of Hiroshima. A soundtrack and a spoken commentary in 5.1 multichannel sound were added to the silent images, and Japanese composer Kenji Kawai provided the background music. *Apocalypse* gained its notoriety, however, primarily for its specific use of color. Thirty percent of the footage consists of historical color shots, i.e. film images shot in the 1940s using the Agfacolor or Technicolor process; the majority, on the other hand, was originally shot in black-and-white and has been recolored in the course of its digital remontage.

Since the images are viewed together, it is no longer possible to tell which parts of the historical material were originally black-and-white and which parts were in color. Also noteworthy is filmmakers Isabelle Clarke and Danielle Costelle's deliberate abandonment of some of the common standards of current television documentaries. In *Apocalypse* there are no reenactments of historical events as they have become common in the docu-drama genre – no scene re-enacted by actors is intended to break the integrity of the surviving footage. The film also refrains from interviewing contemporary witnesses, as has characterized the documentation of history on television since the 1980s – no testimony from the present should interrupt the historical flow of images. Finally, the filmmakers also forgo the presence of experts as they appear in numerous historical documentaries, usually in front of a filled wall of books, in order to lend the additional aura of scientific seriousness to what is shown.

So while on the one hand established standards of authentication are renounced in the name of the integrity of the surviving visual material, on the other hand the intervention is all the more decisive. "I give the images back their color," says François Montpellier, who was responsible for the digital processing of the historical photographs. The colorization was done "as close to reality as possible," he says. "People didn't live in black and white!"[1]

"Giving the images their color back" – this sounds as if the colorfulness of the surviving recordings had been taken away in the mode of black and white; as if a parasitic instance had stepped between the reality of history and its cinematic representation, the distortions of which now had to be neutralized again. "During the Battle of Dunkirk in June 1940, the sky was of an oppressive spring blue" (Montpellier). This blue color, *Apocalypse* promises, is now returning to its historical place of origin after more than seven decades. The color was therefore not added to the images after the fact: somewhere under the layer of black and white, a reflection of that past sky blue seemed to have remained hidden, which has now been "returned" to the images – in a discreet act of restitution.

The claim of merely restoring a state where in fact they actually produce it has already been refuted by the filmmakers themselves through the documentation of their colorization techniques – in the DVD version of the film, for instance, through the Making Of. However, the traces of editing are also effortlessly visible in the pictures themselves. For the paleness of the added colors imitates the color scale of the faded Agfacolor and Technicolor films, with which the black-and-white footage was brought into line. After all, the colorized sequences were not adapted to the colors of a past reality – how could that be possible? Who could say what shade of blue the sky over Dunkirk had in June 1940? – but to the genuine colorfulness of the surviving film material. In this respect, the point of reference of Apocalypse is not the past reality of the Second World War, but the mode of appearance and state of preservation of visual artifacts. On the homepage of ImaginColor, run by François Montpellier, it says accordingly: "Extensive studies have been made to find out how the colors of the different film reels from different periods of the film have aged. Conversely, this allows us to reliably reconstruct time-related color distortions." What is reconstructed, then, is not the colorfulness of historical settings and events, but "time-related color distortions."[2]

Actualizing the Past? Or Fictionalizing the Archive?

According to French historian Michel de Certeau any historical discourse is dominated by absence. De Certeau reminds us that history cannot be reconstructed in its original state: historians are administrators of fragments, traces and remains. For de Certeau this unrepeatability of the past marks the unavoidable condition with which every serious study of history has to begin. De Certeau compares the historian to a clochard who assembles from fragments of waste the image of a world he will never enter.[3] Strictly speaking, this does not restore the past; for him or her there is no going back to past factuality, no repetition, no merging of temporal horizons.

De Certeau argues as a scholar and a historian. However, the historiographical condition he describes should also be a challenge for authors of historical films – at least if they pursue a documentary claim and do not associate

the work with an explicitly fictitious approach to history. Instead of reflecting these conditions, the authors of Apocalypse focus on recreation, repetition and reanimation. Costelle and Clark, according to historian Thierry Bonzon, want to actualize the past, "eliminate the distance between the spectator and the past." Apocalypse "is first and foremost a spectacle, which as such aims to adapt the visuals in the recycling to the modalities of current perception: by reproducing the images in high resolution, in 16/9 format and provided with 5.1 multichannel sound."[4] The colorization of historical images is part of this enterprise. According to the authors the war was experienced in color seventy years ago, so consequently the colorization of the images will guarantee a greater proximity to the historical events. "Color," says Isabelle Costelle, "has brought the war from the past to the present."[5] At the same time, however, this attempt at a sensual visualization remains bound to the claim of unconditional truthfulness – as if even the individual after-experience still requires first and foremost the corroboration of facts. Accordingly, the authors invoke the authority of historical knowledge: "The colors have to be accurate, historians have worked on that. The uniforms of the Wehrmacht in winter are not the same as in summer. They changed over the course of the war. You have to show the wear and tear. For days we were looking for the shades of green of the color field gray."[6]

Unlike docudrama and its procedures of reenactment or simulation of past events, Apocalypse presents itself in the tradition of documentary research. In the Making Of, which is included with the DVD version of the series, the authors find the formula for this claim: "100% archives." The history of the Second World War is advertised here along the lines of a fruit juice manufacturer who promises one hundred percent direct juice for his product – without the addition of diluting substances: the one hundred percent content of historical factuality with no fictional admixtures. But how can this claim to reproduce and preserve the sources be reconciled with their simultaneous alteration through subsequent coloring? In the words of historian Robert Belot, the post-colorization of the historical black-and-white material corresponds to a fictionalization of the archive: "The colors want to make the reality of the war more accessible, while this editing actually has the effect of "fictionalizing" and thus derealizing this reality " – as if this documentary wanted to escape its documentary status in order to approach that of fiction."[7] Belot's critique goes beyond what has been said so far. By contrasting documentary and fiction, thinking about the colors of Apocalypse becomes a discourse on truth and fiction, historical reality and its "derealization." In view of the colorful images of Apocalypse, then, must we speak of an attempt at deception, of lies and deceit?

A few days after the first episode of Apocalypse aired in France, Georges Didi-Huberman published a vehement critique of the series in the French daily Libération: "Images make history visible to us. They are crucial to understanding what has happened around us."[8] The fact that Didi-Huberman does not see this potential of images realized in Apocalypse can probably only be understood against the background of his reflections on the historical testimony of the photographic image, as he presented it in 2004 in Images malgré tout. An image acquires its value "solely through the position it occupies within a montage, in which, of course, other, selected images are added, but also words, thoughts, statements on history."[9] In the case of Apocalypse, however, the montage transforms the originally heterogeneous visual material into a visual unity. The story proceeds discontinuously and is captured from an endless number of perspectives. Apocalypse, on the other hand, replaces this discontinuity with an arrangement that tells the story from only one point of view and does not even name this point of view as such.

Didi-Huberman cites the recoloring of the images as a decisive means of this unification: "Coloring means adding another visible thing to a visible thing. It means, henceforth, to cover something of a surface, as any beauty product does."[10] What the authors of Apocalypse want to be understood as the restoration of an original reality, as the liberation of images from the deficient colorfulness of black and white, represents in Didi-Huberman's eyes an act of substitution and replacement. The colorization does not find a tabula rasa, it covers up what exists and replaces one historically handed-down visibility with another. The colorization of the pictures is at the same time also a decolorization, the addition of color presupposes a disappearance of color, the making visible corresponds to making invisible.

Already in Images malgré tout Didi-Huberman's criticism was directed at the editing of the photographs from Auschwitz, which were repeatedly reproduced in a retouched form. The attempt to make the historical photographs "more readable" in this way, he argued, rather marked a formal, historical, ethical, and ontological intervention. In his critique of postcoloring, Didi-Huberman draws on an old metaphor: "Coloring, a technique as old as the world, is nothing other than makeup: the application of a certain color to a ground prepared for that purpose."[11]

The metaphor of makeup comes from an ancient tradition of critique of concealment. Didi-Huberman's intervention acquires an ontological undertone: he distinguishes supplementary manipulation from an original, unvarnished truth, the "real traces of time" from the "bluff" of montage, from lies and deception: "This is how one makes the real traces of time on a face invisible – or even the images of history. The lie is not that images have been edited here, but in the claim to show us a naked and truthful face of war, where we are offered a made-up face, a bluff." It is not, then, the fact of intervention and manipulation that would be the object of criticism of *Apocalypse*. "It is precisely not a matter of purism: nothing here is pure and "pure," and every image is – from the moment it is taken – the result of a technical operation, of mediation, and thus of manipulation."[12] But what then is Didi-Huberman's critique of the "bluff" of montage based on, when at the same time he reminds us that every image is the result of a "mediation and thus a manipulation"? And if the colors in *Apocalypse* are an inauthentic ingredient – what unvarnished truth would emerge if the images were stripped of their colors again?

Various understandings of authenticity

In her discussion of Didi-Huberman's critique of *Apocalypse* (as well as a contribution I wrote on the same topic), philosopher Maria Muhle posed precisely this question. The criticism of the supposed realism of the post-colored images, she answers, seems for its part "to be based on an implicit claim to realism: For although no return to an impossible purism of the images is at issue, the manner of reconstruction, that is, the colorization undertaken in *Apocalypse*, is presented as highly objectionable."[13] Muhle reminds us that criticism of the recoloring of historical black-and-white can easily take the form of a "naïve faith" – the belief "that the omission of manipulation promises the safeguarding of historical truth – be it ever so fragmentary." Its defenders, Muhle argues, give the black-and-white picture of history an aura of historical originality. In an exact reversal of this belief, Muhle concedes the higher cognitive value to the post-colored image. It achieves this value not through its greater closeness to reality, but through the fact that it obviously displays its artificiality. For "precisely the reenacting strategies – specifically: the post-colored images of the Second World War" evoke "*malgré eux* an alienation effect" that "allows greater insight into the problematic constitution of history than do the (black-and-white) images of a critical documentarism that ultimately runs the risk of reinforcing the belief in an undisturbed depictive relationship and closing off the process of historical representation."[14] In other words: the more obvious the manipulation of images, the clearer the insight into the construction of history. And vice versa: the more discreet the artificial dressing of the images, the greater the danger of falling prey to the naïve belief in an undisturbed relationship of representation.

Muhle has brought a crucial twist to the discussion of *Apocalypse* by shifting attention to the level of images – their potential to create a counter-narrative. No matter what the authors of *Apocalypse* might say about the veracity of the visual reconstruction of history – the images work against it. Where Didi-Huberman accuses the untruthfulness of a montage that obscures a given visible with another visible, Muhle recognizes the truth of a montage that flaunts its own construction and artificiality and thus denies any claim to truthfulness: "What the colorful images of *Apocalypse* do, then, is to demonstrate the operation of the effects of reality and, in this sense, to think further about the questioning of the purism of images by making visible, in the manipulation of images, those techniques of representation that still sophisticated realists such as Geimer or Didi-Huberman, precisely, want to abridge in favor of the result of representation."[15]

What can the "sophisticated realists" answer to this? First of all, it is necessary to ask why the insistence on the black and white colorfulness of the pictures should be motivated by the "belief in an undisturbed relationship of representation." Why are the black-and-white archival images "mystifying because they lend evidence to the 'myth of reality' "?[16] The reference to the historical black and white of the images is not a mystification, but describes first of all nothing else than the technical conditions under which these films were taken. Being black and white was a characteristic of the images, a historical given, which in itself does not include any instrumentalization by the "myth of reality." Their projection in black-and-white corresponded to the aesthetic expectation of the historical filmmakers – their awareness that the colored world before their eyes would be transformed into the scale of black-and-white.

It is precisely the diversity of the historical materialm – partly shot in color, partly in black-and-white – that would have offered the possibility of a reflection on the meaning and function of color. Its leveling erases the film's media signature. The black and white is part of the historicity of the images, part of their function as testimony, document, and historical trace. To change this condition is to change the archive, to overwrite what has been handed down in it. As Didi-Huberman rightly reminds us, this critique does not vote for documentary purism. It goes without saying that transmission is not a neutral process that would pass on the content of the sources untouched. Even if the metaphor of the "source" gives the impression "as if from this 'spring' the information of the past were bubbling up and flowing directly to us," through every interpretation "a certain perspective is already taken, the material is presorted, a certain aspect is emphasized, and the possibility of other points of view is excluded."[17]

Thus the images of history are also part of a tradition, a constant repetition and reinterpretation, a recycling that makes it impossible to find a place of origin where the images would still be completely "themselves." No one demands that films of the past be shown exclusively in historic movie theaters, accompanied by the rattling of projectors. The mere passing of time forces abstraction, each repetition puts the repeated into a new context. But does it follow from this that the images do not oppose their rededication, that they are empty containers of their later reuse? The historical archive is no tabula rasa. The critique of *Apocalypse* does not refer to the re-montage of the images, their right or wrong interpretation, but to the preservation of their material integrity. A source is also " 'a relic,' a (so literally) 'remnant' from the past that should be taken seriously in its mediality and materiality." In his critique of *Apocalypse*, Didi-Huberman rather casually brought into play a term aimed at this kind of consideration: it is a matter of whether one "stifles the historical images" or "deals with them tactfully" ("étouffer les images ou bien les traiter avec tact"). Dealing with what has been handed down would thus also be a question of tact, of the consideration of a posterity for what has been handed down to it. To "meet the images with tact" – that would mean to acknowledge their mediality and materiality. From this perspective, the digital recoloring of the images is neither the reclamation of a past, colorful reality (as the authors of *Apocalypse* see it) nor an involuntary enlightenment about the machinations of the historiographic "reality machinery" (as Maria Muhle sees it), but a staging intervention that takes away part of the images' historicity in the name of making them present.

With the colorization of the black-and-white images, according to Muhle, "a blocking moment is drawn into the sources" that "always reminds us of the uncertain status of historical documents." But doesn't one rather preserve the uncertain status of the sources by leaving them in their historical constitution? If, as Belot notes, the "pedagogical intention" of the montage is to "facilitate the attention of a generation to whom the era of black and white is unknown,"[18] one can ask whether the unfamiliarity with historical black and white would not have been precisely a reason to leave it at the alienating appearance of the images? The strangeness of the past is not an obstacle, but a condition of its recognizability. As film historian Gertrud Koch puts it: "The idea of seeing something historically means being able to see something at a distance."[19]

NOTES

[1] François Montpellier, quoted by Marion Festraëts, in: Marion Festraëts, "Comment *Apocalypse* a redonné des couleurs à la guerre," *L'Express*, September 8, 2009, accessed March 1, 2021, url: http://www.lexpress.fr/culture/tele/comment-apocalypse-a-redonne-des-couleurs-a-la-guerre_784414.html. (All translations from French or German by the author.)

[2] ImaginColor, "Technique et Développements", last modified 2016, url: http://www.imagincolor.com/la-technique/.

[3] Michel de Certeau, *Histoire et psychoanalyse: Entre science et fiction.* (Paris: Éditions Gallimard, 1987), 189.

[4] Thierry Bonzon, "Usages et mésusages des images d'archives dans la série Apocalypse," *Vingtième Siècle. Revue d'histoire* 107 (2010): 179.

[5] Jürg Altwegg, "Im Gespräch: Isabelle Clarke und Daniel Costelle; Macht Farbe den Krieg verständlicher?" *Frankfurter Allgemeine Zeitung*, March 13, 2010, 6.

[6] Altwegg, "Im Gespräch: Isabelle Clarke und Daniel Costelle: Macht Farbe den Krieg verständlicher?," 6.

[7] Robert Belot, "*Apocalypse*, un documentaire sur la Seconde Guerre mondiale," *Vingtième Siècle : Revue d'histoire* 107 (2010): 171.

[8] Georges Didi-Huberman, "En mettre plein les yeux et rendre Apocalypse irregardable," *Libération*, September 22, 2009, accessed March 1, 2021, url: http://ecrans.liberation.fr/ecrans/2009/09/22/en-mettre-plein-les-yeux-et-rendre-apocalypse-irregardable_952332.

[9] Didi-Huberman, "En mettre plein les yeux et rendre Apocalypse irregardable."

[10] Didi-Huberman, "En mettre plein les yeux et rendre Apocalypse irregardable."

[11] Didi-Huberman, "En mettre plein les yeux et rendre Apocalypse irregardable."

[12]   Didi-Huberman, "En mettre plein les yeux et rendre Apocalypse irregardable."

[13] Maria Muhle, "Krieg in Farbe: Darstellung und Nachstellung," *Mittelweg 36*, no 2 (2015): 96.

[14] Muhle, "Krieg in Farbe: Darstellung und Nachstellung," 85.

[15] Muhle, "Krieg in Farbe: Darstellung und Nachstellung," 85.

[16] Muhle, "Krieg in Farbe: Darstellung und Nachstellung," 85.

[17] Achim Landwehr, *Die anwesende Abwesenheit der Vergangenheit: Essays zur Geschichtstheorie* (Frankfurt am Main: Fischer Verlag, 2016), 58–59.

[18] Belot, "*Apocalypse*, un documentaire sur la Seconde Guerre mondiale," 171.

[19] Gertrud Koch, "Kracauers Theorie der Geschichte und des Films," in *Film und Geschichte: Produktion und Erfahrung von Geschichte durch Bewegtbild und Ton*, ed. Delia González de Reufels, Rasmus Greiner, and Winfried Pauleit (Berlin: Bertz und Fischer, 2015), 124.

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ADAPTIVE IMAGES. CHALLENGES FOR VISUAL STUDIES AND MEDIA THEORY

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ABSTRACT | Digital images increasingly determine the way people interact with their environment. New imaging and sensing technologies register, process, and transmit information about the physical world in real time and make it possible to continuously adapt visualizations to specific spatio-temporal settings and in relation to motion, location and perspective. With this constant feedback loop between image and environment, images gain in perceptive and practical importance. The convergence of visual, spatial and performative dimensions heralds a new type of visual media described here as "adaptive images". Drawing on selected cases of adaptive techniques in applied contexts, such as surgery, entertainment, industrial manufacturing and psychotherapy, the paper introduces the emerging field of adaptive imaging and discusses its respective aesthetic, spatial, and operational conditions and implications. It thereby provides a tentative survey of how adaptive images challenge visual studies and media theory, and claims that their analysis requires an interdisciplinary approach.

KEYWORDS | Adaptive images, extended reality, computer vision, media theory, 3D space

Situative Digital Imaging

Digital images have become able to respond to real environments in a seemingly self-acting manner. Due to the improvement of computer performance and of display and sensor technology, imaging processes have become increasingly dynamic, interactive and capable of capturing and processing physical bodies and objects. Digital imaging devices can register and transmit information about the physical world in real time and make it possible to continuously adapt vizualisations to the spatial environment in relation to shape, motion, location and perspective. They do not only demonstrate an advancement in regard to rendering or responsiveness but also determine the way people interact with each other and with the physical space that surrounds them.

While the transition from analogue to digital images has significantly changed the ontological, epistemological and operational status of images since the 1970s, we are now confronted with a new generation of tools that not only assist human action but guide and even anticipate it. In certain situations, digital images have even become a precondition of action and perception. This is particularly evident in the field of life sciences, where image-based tools have established an essential co-dependency of humans and machines, but also in areas such as transportation, security or military, where images determine the possibilities of decision making and perception. With the ability

to integrate situative and customized information into digital media, images particularly gain in importance within operative contexts, as they support, extend, and control a wide range of human-machine interaction, such as navigating a digital map on a smartphone or using a virtual reality application. These practices of situative or context-specific digital imaging in media applications are based on visualization techniques that continuously synchronize image, action, and space and herald a new type of visual media subsumed here as *adaptive images*.

With regard to images, adaptation (or adaptiveness) does not aim at a perfect match between a given reality and its digital representation, i.e. in terms of a convincing optical simulation, but rather refers to criteria such as responsiveness, individual usability and perception. On a technological level, adaptive images combine the process of data visualization with a topographical registration of physical space. While digital images usually separate the object and its representation from each other spatially, adaptive imaging technologies promise to blend computer-generated images with the physical world. Based on a spatial reference system that transforms the surface of bodies and objects into geometrical forms, images can be correlated both with the orientation of a user or a device and with bodies or objects. The increase in computational power and storage capacities, in combination with the advances in machine learning and sensor technology, fosters a new generation of digital applications, some of which are already used in the professional contexts of image-guided medicine, rapid manufacturing in architecture and product design, or in visually navigated drone missions. Due to increased miniaturization, mobilization, and connectivity of imaging devices, adaptive images also establish in the consumer field, for example in the context of gaming and education.

While various forms of adaptive media have been explored in art and technology for some decades and have also been criticized in art history since their earliest stages,[1] the current success of the concept of adaptation in imaging applications requires a discussion of their overall impact, notably in view of research that has substantiated notorious cognitive, cultural and social effects of extended reality. The notion of the "adaptive" is meant to fill a void in image theory, created by the dependence of human action and perception on imaging processes. The technology and aesthetics of adaptive images are a central focus of the homonymous research project at Karlsruhe University of Arts and Design. Based on application-related case studies, the project explores the particular visual, epistemic and operational facets of adaptive images and the representational problems they entail. By doing so, it aims to reveal the tense relationship between the technical foundations of image processing and the aesthetic conditions of their use, and the role that situative operationalization plays within this complex. This working paper introduces the emerging field of adaptive imaging and provides a tentative survey of how adaptive images challenge existing notions and concepts of visual studies and media theory.

Technical Interdependencies Beyond Representation

The possibilities of instantaneous image production, processing and transmission have multiple consequences for practical applications. Accompanied by an improved capability of sensor technologies, displays have become mobile, touch-sensitive and, most recently, flexible and transparent. While usual computer monitors are not adaptive to the user's position and line of sight, head-mounted screens overcome the offset between projected image and real space, notably when they are combined with mixed reality techniques and used to couple overlay vision with spatially related actions, for example in industrial production. Figure 1 shows a use case from aircraft manufacturing, where a transparent display of a head-mounted device is seen to improve hand-eye coordination when compared with classical screen-based instructions. Switching back and forth between a screen and the workpiece may result in disadvantages for hand-eye coordination, as many manufacturing situations require continuous comparison. Adaptive imaging technology connects them in a joint perceptual space. The superimposition of transparent mobile interfaces onto the field of vision presents a new quality of imaging that is intrinsically related to spatial information and redefines technical vision as interaction.

Marketing campaigns of large tech corporations and venture capitalists suggest that "reality" is now measurable in real time, with the image becoming a new super-platform for joint virtual action. Under such circumstances, image criticism has to adapt as well: How can visual epistemology and methodology comply with a disposition that extends the scope of digital media into the physical domain? When the physical space becomes computable and algorithmic, how does this affect its perception and access? Such questions are accompanied by a fundamental change of

Figure 1 a (above) and b (lower). Microsoft Inc.; 2019; A case study conducted by Airbus seeks to combine the construction site and instructions into a joint perceptual space by eliminating the offset between image and object.

perspective, leading to the hypothesis that adaptive images need to be understood in the context of a spatial situation, and have a function entirely relative to it. The analysis comprises the interrelation of image and action at the level of data processing (such as the prescription of work routines by imaging algorithms), at the level of visualization (such as the design of graphic and tactile interfaces), and at the level of operation (as it results from certain arrangements of humans and machines).[2] Accordingly, "adaptivity" as a problem does not only describe a new type or digital aesthetic, defined by properties such as transparency or opacity. Instead, its analysis must take into account situations and processes of application which can only be perceived from an individual angle and thus remain relative in time and space.

Regardless of the technical complexity of adaptive imaging (and the problem of documentation it involves), adaptivity also involves a certain surplus in a long-term or historical sense, for example when seen in relation to a question raised in the mid-19th century by architect Gottfried Semper (1803-1879) who, in view of the new possibilities of industrial production, redefined "style" as the result of basic materials, manufacturing techniques, and the purpose of their application. The concept of style might be of particular interest here in that it entails applied, technology-related and anonymous patterns (that have challenged art historical theory), just as the iconographical approach (that was also developed in the course of the late 19th century) proved to be helpful for the discussion of popular and mass-produced imagery.[3] Similar connections can be drawn from industrial ornaments to the screen matrix, or from post-1900 iconology to the virtual "hyperimage".[4]

Such intersections of image and technology, now recurring in the field of adaptive, imaging, remain an enduring challenge for art history, visual culture and image theory, and oblige them to update their methodology. The relevance of the research field can already be deduced from the path that it has taken over the last decades, beginning in the 1980s with a rather technical "image science" (which was primarily concerned with data processing, image recognition and long-term archiving), followed by a mostly German-language *Bildwissenschaft* dedicated, among other things, to the cognitive aspects of screen-based imagery, and a renewed picture theory and picture historiography that defines an "art history of science" in its own right. In turn, visual problems in medicine, technology, and the sciences have not ceased to flow into the methodology of art and media studies and their curriculum. Despite some shortcomings, this new field of study has helped actualize and broaden art historical research, which in the long run has also led to the DFG Priority Program "The Digital Image".

The Body Screwed into the Picture

The project emphasizes the importance of *practice* for the analysis of digital images, and this importance becomes even more apparent in the context of the mentioned Priority Program. In surgery, for instance, its significance can be directly gauged because new visualization tools challenge diagnostic routines and the common modes of 'comparative vision', i.e. the correlating of medical images with anatomical structures. Even computerized imaging techniques like the CT scanner follow the tradition of X-ray images displayed as two-dimensional black-and-white structures on the screen. Physicians are trained to study cross-sectional or "sliced" images one after another, to render them cognitively, and to ascribe them to the three-dimensional body during an intervention. In practice, this implies that surgical site and CT scan are separated in space and time, resulting in a gap between image and body that can have negative effects on the outcome of an intervention.

A new generation of imaging devices is now able to overlay stereoscopic images on the surgical site so that position and scale of anatomical structures coincide. By looking through a transparent head-mounted display, physicians can superimpose a digital layer onto their point of view. The device annotates, diminishes, or enhances the view of the surgical site with visual information in a joint perceptual space (fig. 2). However, representation and the represented are inextricably intertwined; the human body is fitted into the apparatus and overlaid with digital imagery, to an extent that the "digital twin" begins to replace the real body as the primary object of reference. Working in such "situations" in which simulation and intervention are short-circuited[5] entails a new type of image-based action and decision making that can only be understood in terms of their application.

In turn, this image-based practice entails a series of questions, such as what the term "adaptation" is to describe in technology and design, or what made the term "application" so ubiquitous in contemporary society.[6] In the same context, dazzling terms like "simulation" and "interaction" need to be sharpened. The integration of localization and
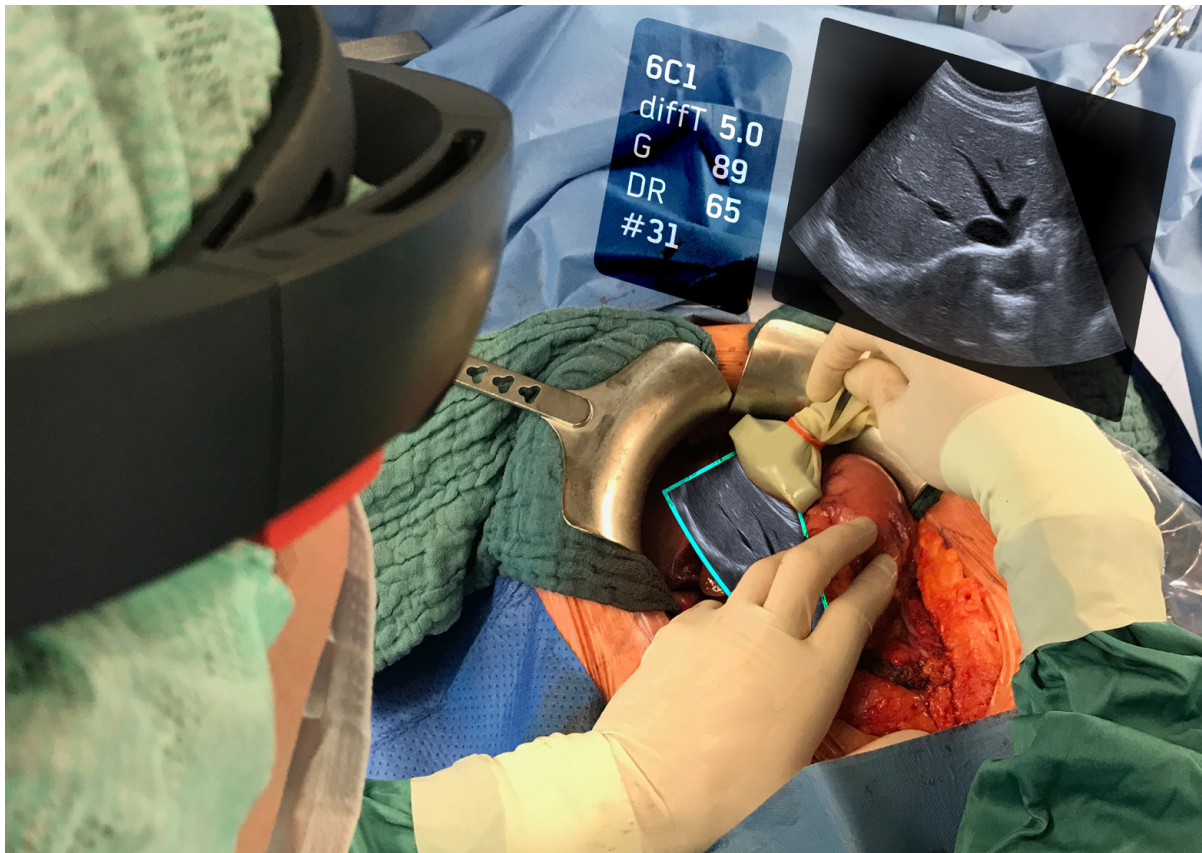
Figure 2. M. Pogorzhelskyi, M. Queisner; 2018; Alignment of an ultrasound transducer with the ultrasound image using a transparent head-mounted display.

surveillance technologies in adaptive imaging requires a new understanding of the conception and use of interfaces and of the formatting of images. Moreover there are particular design aspects that have not yet been subject of systematic research; only a fraction of existing research papers related to adaptive imaging technologies even address topics such as the construction of user interfaces and the modes of interaction.[7]

The project therefore aims to show what kind of "visual knowledge" is required to make anatomical structures and volumes visible - and usable. This concerns parameters such as color, contrast, texture, contour, illumination or transparency, as well as the question whether interventions based on images are manageable or justifiable at all in a surgical context. Sociological aspects of digital imaging may have been studied to a greater extent in the context of history of medicine or science and technology studies (STS).[8] However, although medicine is increasingly based on visual media and relying on human-machine interaction, there is still no particular school that captures and reflects the aesthetic, operational and social implications of this practice. In addition to the professional fields of interaction design, psychology, engineering and computer science, there is also a growing demand to rely on the visual and theoretical competence of art history and media studies. In the best case, a theory of the "digital image" will not limit itself to collecting, categorizing and commenting on the visible traces and manifestations of a new technology, but also aim to change the contents, methods and questions of its own research and education.

Sensory-Motoric Engagements

The coupling of image and situation becomes particularly obvious in virtual reality applications. On the level of composition and design, virtual reality images follow regularities other than the established formats of moving images. In contrast to usual motion pictures and their editing (cutting, zooming, framing), virtual reality images

adapt to the user's position and movement in real time, which means that the body itself becomes the input medium for image control. The "camera" depends on the user's perspective and location. Users can be teleported, or objects scaled in relation to the user. This linking of sensory and motor system with imaging technology points to an increasing convergence between the virtual and physical world as viewers not only perceive an image but enter it, participating in a three-dimensional scene at any scale and from any perspective. However, this individual disposition excludes a collective vision, which in return makes it difficult to grasp and to study it in a joint perspective.

This becomes particularly apparent in virtual reality applications for behavioral therapy of post-traumatic stress disorder following wartime deployments. One example is the therapeutic setting of the application *Bravemind*, developed by the Institute for Creative Technologies at the University of Southern California for therapy of PTSD of soldiers. Clinical symptoms of PTSD include sleep disturbances, irritability, and flashbacks, which can be triggered by confrontation with a variety of experiences. In the area of virtual therapy, the therapeutic rationale promises that through the use of virtual reality technologies, patients can re-experience a traumatic scenario in a protected environment and achieve a reduction in symptoms through exposure and repetition as well as simultaneous conversation with a therapist (fig. 3).

The situative therapeutic setting consists – schematically speaking – of three main actors which adapt to each other. First, patients wearing a head-mounted display in which virtual scenarios are visualized adaptively to head and body movements, intended to immersively recreate the experience of traumatic experiences. Figure 4 illustrates an example of a virtual scenario designed in the *Unity* game engine and therefore strongly reminiscent of current computer games in its visual aesthetics. Further tactile or even olfactory triggers, such as dummies of machine guns, are supposed to reinforce the visual triggers.

Secondly, the media-based therapeutic setting incorporates therapists, who control the virtual scenario which can be seen in the head-mounted display via a so-called *Clinician Controller Interface*. Figure 5 shows a screenshot of a *Clinician Controller Interface* in which different components for the near-real-time design of the virtual scenario can be selected – for example by bomb explosions or radio calls. Therapists are in direct communication with patients during a session to match reactions and experiences and can influence visual triggers accordingly via the controller interface.

Thirdly, the virtual therapy system itself can also be seen as an actor in the adaptive assemblage. The system consists of hardware and software components that are ideally intended to instructively affect the patient's body, imagination, and behavior in the therapeutic setting. Therefore, a detailed analysis of the technological conditions and the sociocultural implications of virtual therapy based on adaptive imaging processes also needs to include the examination of the deep layering of digital imaging technologies, such as data models inscribed in the software that basically prescribe the range of actions for other actors and their dynamic relations.

Closely related to this analytical perspective is the question of behavioral economies that presuppose, constitute, and – in the case of virtual therapy – grant a therapeutic efficiency to adaptive images. According to the developers of *Bravemind* virtual therapy for post-war PTSD promises an "efficient" confrontation with traumatic situations and memories compared to established methods of exposure therapy: "While the efficacy of imaginal exposure has been established in multiple studies with diverse trauma populations [...], it is reported that some clients are unwilling or unable to effectively visualize the traumatic event [...]. In fact, research on this aspect of PTSD treatment suggests that the inability to emotionally engage (in imagination) is a predictor for negative treatment outcomes [...]."[9] According to this statement, particularly when patients are "unable" or "unwilling" to engage imaginatively with traumatic situations, the use of virtual therapy is intended to open up the literal visualization of traumatic events and thus their emotional processing in a behaviorally economical manner.

This brief sketch of the setting of virtual therapy points towards various challenges of critically analyzing the practices of adaptive imaging. Besides the need for the clarification of terms like "adaptivity" and "image", methodological issues become apparent: How can the situated and dynamic relations between the physical environment of application, the user's involvement and the supposedly "efficient" aesthetics of near-real-time visualizations be described and analyzed? How can such interdependencies be systematically grasped without falling into mere relationalism? In this working paper we can only sketch out these questions, as they demand not only a thorough review and the reconceptualization of existing methods to analyze digital images and imaging practices but also the formulation of a coherent approach that draws specific attention to the adaptive properties of imaging.

Figure 3. USC Institute for Creative Technologies; 2014; "Virtual Reality Therapy: Bravemind and STRIVE," https://youtu.be/LRLOTzrNtVc; Setting of the virtual therapy application Bravemind.

Figure 4. USC Institute for Creative Technologies; 2014; "Virtual Reality Therapy: Bravemind and STRIVE," https://youtu.be/ LRLOTzrNtVc; Screenshot of a virtual scenario used in Bravemind.
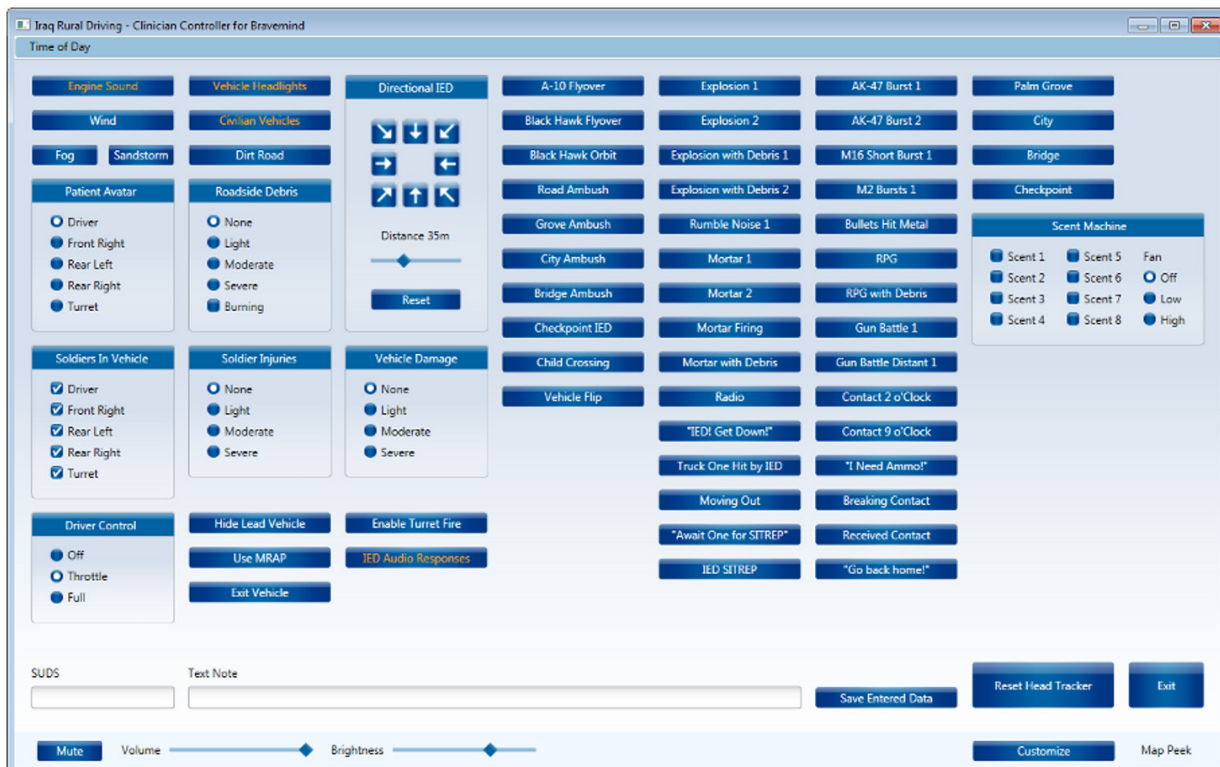
Figure. 5. USC Institute for Creative Technologies, MedVR Lab; 2014; Virtual Reality Exposure Thera-py Application for Post-Traumatic Stress Disorder Bravemind; User Manual; Version 1.0.; http://128.125.133.25/arizzo/Manual/Bravemind%20Manual%203-2014.pdf; Screenshot of the Clini-cian Controller Interface.

Adaptive Images: an Interdisciplinary Challenge

The technological change that comes along with the mobilization of smartphones or smart glasses stands for a fundamental shift in the way that individual perception and motion are mediated by digital devices and applications. Just as photography and film have created and shaped a new iconosphere permeated by technology, adaptive media might define a new form of "digital visuality" where vision and action are networked with the environment. One central task will be to explore the range of developments regarding adaptivity (in terms of personalization, interactivity, responsiveness) and to relate them genealogically to phenomena from the pre-electronic to the digital age. Given that the concept of adaptation has numerous further meanings (e.g. in evolutionary biology, in sociology or economy), it may also be helpful to include the historic dimensions of the the concept to bring out more clearly its recent technological specificities.

It has been questioned on various occasions whether there can be a "digital image" and a corresponding theory, or whether the problem area addressed by it can be precisely described.[10] In this context, screen-based media that incorporate and support adaptive technologies may provide a number of substantial examples. One might think of the use of graphics cards whose specific architecture has played out its advantages in gaming and interactive applications, followed by their intense use in the field of machine learning. In the entertainment industry, imaging technologies help identify potential areas for product placement, employing AI-based computer vision to analyze video feed (fig. 6).[11] Since personalized advertising based on the metrics of the social web began to accelerate the decline of the classic TV commercial, the subsequent image production has been automated and controlled by software technologies to an extent that affects content creation down to the level of a single frame and up to the viewing experience of the individual user. Brand names can be displayed in unoccupied areas of a news stream,

Figure. 6. Mirriad Inc.; 2019; https://youtu.be/npWOOTWOWLƐ; Rendering virtual content into a video based on image analysis using artificial neural networks.

Figure. 7. Supponor Ltd.; 2018; https://youtu.be/AJtLAYmdgTw; Virtual billboard advertising in a soccer stadium.

products can be added to a movie scene, and billboards in a soccer stadium can be superimposed and extended with virtual content in a way that does not obscure players or objects on the field (fig. 7). The result is no longer an exclusive physical situation in the stadium and on the pitch, but a graphically manipulated image that can be individually adapted to specific regions, user profiles or the course of the game, such as premium advertising at the moment of the goal celebration. Sports advertisement adapts to streaming locations, game situations, or even camera angles; song contest auditions are personalized right down to the jury's coffee cups decorated with virtual brands to meet the taste of the viewer's online-shop orders — all happening in real time.

While viewers have become more skilled in identifying product placements and bypassing advertising, for example by clicking it away, the concept of virtual product placement and replacement implies that our perception of these images is always situatively under someone's (or most likely an AI) control. In other words, digital images increasingly amalgamate with the situation and context of their presentation. The confocal imagery of photography and video merges with the technology it is controlled and manipulated with, on the basis of metadata. This subtle engineering, increasingly invisible to the audience, requires an informed image critique that understands what happens in front of and behind the screen. Hence, a theory of adaptive images will not only link aesthetics with new technical developments, it must also take into account the operative dimension of images and the spatial complexity of situations. In view of this, any closer examination of adaptive images will most likely be an interdisciplinary one (not to mention the fact that electronic imaging alone already implies the expertise of a number of disciplines). The same applies to the functions of interface elements such as touch or gesture controls that are used equally (and thus developed, tested, improved) in medicine or in gaming.

For such reasons, the examples discussed above are intended to sketch out the frontier of a new research field rather than to formulate, in the abstract, the lowest common denominator of a series of phenomena. The case studies of the project aim to show, by means of concrete examples, that the connection of body, image and space in contemporary media and by means of advanced localization and surveillance technologies not only poses a technical challenge, but also requires new approaches to the design, use and interpretation of the corresponding interfaces, visual patterns and image formats. The project "Adaptive Images" is the result of inquiries carried out by the project team at the Hermann von Helmholtz Center for Cultural Techniques and the Cluster of Excellence "Image Knowledge Gestaltung," both part of Humboldt University Berlin, and is thus embedded in a larger network of participants. In the course of preliminary projects, collaborations have been established with medical institutions and experts, notably the Charité - Universitätsmedizin Berlin. This is emphasized here because of joint research and teaching experiences with these institutions, as a response to professional needs expressed by their members. Because of such requests, it is worth noting that every interdisciplinary exchange relies on specialist rigor — including the rigor of theory.

NOTES

[1] See e.g. Söke Dinkla, *Pioniere interaktiver Kunst von 1970 bis heute* (Ostfildern: Hatje Cantz, 1997).

[2] See Harun Farocki, Tom Holert, and Sybille Krämer, "Operative Bildlichkeit," in *Logik des Bildlichen: Zur Kritik der ikonischen Vernunft,* ed. Martina Heßler and Dieter Mersch (Bielefeld: transcript Verlag, 2009), 94–122. Also Inge Hinterwaldner, *The Systemic Image* (Cambridge: MIT Press, 2017); Inge Hinterwaldner and Markus Buschhaus, *The Picture's Image: Wissenschaftliche Visualisierungen als Komposit* (Munich: Wilhelm Fink Verlag, 2006).

[3] Brian S. Baigrie, *Picturing knowledge: Historical and Philosophical Problems Concerning the Use of Art in Science* (Toronto: University of Toronto Press, 1996); Caroline A. Jones and Peter Galison, *Picturing Science, Producing Art* (New York: Routledge, 1998); James Elkins, *The Domain of Images* (Ithaca: Cornell University Press, 1999); Hans Holländer, *Erkenntnis, Erfindung, Konstruktion: Studien zur Bildgeschichte von Naturwissenschaften und Technik vom 16. bis zum 19. Jahrhundert* (Berlin: Mann, 2000); Claudia Blümle, Horst Bredekamp, Matthias Bruhn and Katja Müller-Helle, *Bildwelten des Wissens. Kunsthistorisches Jahrbuch für Bildkritik* (Berlin: De Gruyter, 2003ff); Horst Bredekamp, Vera Dünkel and Birgit Schneider, *The Technical Image: A History of Styles in Scientific Imagery* (Chicago, IL: University of Chicago Press, 2015); Matthias Bruhn, "Images without Knowledge?" In *Images of Knowledge: The Epistemic Lives of Pictures and Visualisations,* ed. Nora S. Vaage, Rasmus T. Slaattelid, Trine Krigsvoll Haagensen, and Samantha L. Smith (Frankfurt am Main: Lang, 2016), 221–227.

[4] See Birgit Schneider, *Textiles Prozessieren* (Zurich: Diaphanes, 2007); Felix Thürlemann, *Mehr als ein Bild:* Für eine Kunstgeschichte des *Hyperimage* (Munich: Wilhelm Fink, 2013).

[5] Kathrin Friedrich, Moritz Queisner and Anna Roethe, *Image Guidance* (Berlin: De Gruyter, 2016); Marta Kersten-Oertel, Pierre Jannin Louise D. Collins, "The State of the Art of Visualization in Mixed Reality Image Guided Surgery," *Computerized Medical Imaging and Graphics*, no. 37 (2) (2013): 98–112, 108–109, accessed March 19, 2021. url: http://doi.org/10.1016/j.compmedimag.2013.01.009.

[6] On the notion of "application" (or German "Anwendung") and its role in 20th century French epistemology see Sandra Pravica, *Bachelards tentative Wissenschaftsphilosophie* (Vienna: Passagen, 2015), 169–180.

[7] See Oliver Ruf, *Smartphone-Ästhetik: Zur Philosophie und Gestaltung mobiler Medien* (Bielefeld: transcript Verlag, 2018).

[8] Lisa Cartwright, *Screening the Body: Tracing Medicine's Visual Culture,* 2nd print (Minneapolis, MN: University of Minnesota Press, 1997); Joseph Dumit, *Picturing Personhood: Brain Scans and Biomedical Identity* (Princeton, NJ: Princeton University Press, 2004); Regula Valérie Burri, *Doing Images: Zur Praxis medizinischer Bilder* (Bielefeld: transcript Verlag, 2008); Kelly Joyce, *Magnetic Appeal: MRI and the Myth of Transparency* (Ithaca, NY: Cornell University Press, 2008); Kathrin Friedrich, *Medienbefunde: Digitale Bildgebung und diagnostische Radiologie* (Berlin: De Gruyter, 2018).

[9] Skip Rizzo, Belinda Lange, and Sebastian Koening, "Clinical Virtual Reality," in *Handbook of Virtual Environments: Design, Implementation and Applications,* ed. Kelly S. Hale and Kay M. Stanney (London/New York: CRC Press, 2015), 1159–1204, 1164.

[10] This could be compared with W. J. T. Mitchell's thesis that there can be no "visual media" because media by definition are always more than just visual. The "digital image" in the collective singular is just as difficult to grasp as "the image" as such.

[11] See Matthias Planitzer, "Der angepasste Blick. Personalisierte Werbung in Zeiten maschinellen Lernens." In *Adaptivität,* edited by Matthias Bruhn, Kathrin Friedrich, and Moritz Queisner. Munich/Marburg, 2021 (Munich/Marburg: Open Publishing LMU, 2021.).

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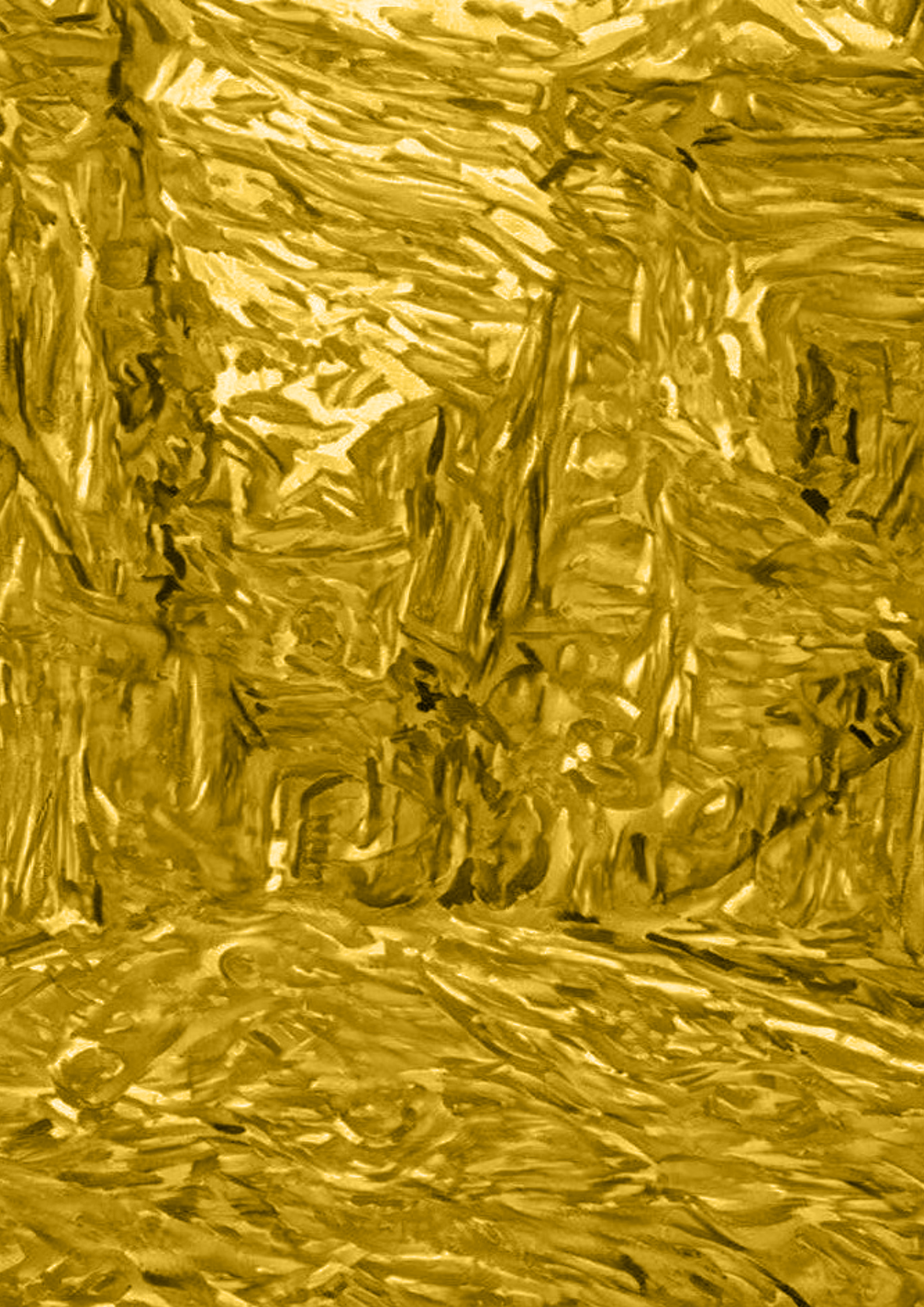
IMAGE SYNTHESIS AS A METHOD OF KNOWLEDGE PRODUCTION IN ART HISTORY

MATTHIAS WRIGHT, BJÖRN OMMER

ABSTRACT | Digital images enable us to virtually assemble, group, and rearrange works of art as image datasets. The highly complex similarities and dissimilarities between data points in an image dataset can be analyzed. Understanding the meaning of computationally defined similarities and dissimilarities, however, requires disentangling the representations learned by the computer in the process. By utilizing generative methods from deep learning, we aim to design a new methodology for the analysis and interpretation of digital images. Building on refined methods of disentanglement from computer science, our goal is to establish the synthetic image as a novel means of knowledge production in art history.

Computer Vision

The field of computer vision has its origin in the early 1970s.[1] In the beginning, it was merely intended to be the visual perception component of a system that mimics human intelligence.[2] Some of the early pioneers of artificial intelligence believed that creating this component would be fairly easy compared to problems such as higher-level reasoning or planning.[3] In 1966, Marvin Minsky even asked an undergraduate student to "spend the summer linking a camera to a computer and getting the computer to describe what it saw".[4]

From its beginnings in the early 1970s up until the 1990s computer vision research was mostly concerned with perception – describing objects or scenes in images.[5] However, during the 1990s, computer vision and computer graphics became more and more intertwined,[6] a trend that continued to the present day.

Over the past decade, the field of computer vision has become increasingly dominated by deep learning, a class of machine learning methods that are "representation-learning methods with multiple levels of representation, obtained by composing simple but non-linear modules that each transform the representation at one level (starting with the raw input) into a representation at a higher, slightly more abstract level".[7]

Representations

The concept of representations is central for the field of computer vision. In the words of David Marr: "A representation is a formal system for making explicit certain entities or types of information, together with a specification of how the system does this".[8] The result of using a representation to describe some entity is then called a description of the entity in that representation.[9] We use representations every day, sometimes even without knowing it. For example, the same number may be represented in different numeral systems.[10]

The notion of representations is powerful because how information is represented "can greatly affect how easy it is to do different things with it".[11] This is not just true for computer vision but also for mathematics. Just consider the eigendecomposition of a matrix. If certain conditions are satisfied, a square matrix can be represented as the product of three matrices. This representation exhibits information about the functional properties of the matrix not apparent from the canonical matrix representation.[12]

In the context of computer vision, we usually deal with data arising from the complicated interaction of many factors. For example, an image consists of the interaction between one or several light sources, the shapes of the objects, the material of the surfaces that occur in the image, and the viewpoint[13]. If our task is object classification, we would want a representation of the image that is invariant to light and viewpoint but not to object shape or material. This is because a dog is always a dog, no matter how bright the image is. The viewpoint from which the dog is depicted, should not affect the classification result either.

However, our choice of invariant features generally depends on the task we are trying to accomplish. If our goal was to determine whether or not an image was taken by day or by night, light would suddenly become an important factor.

Unfortunately, in many cases we do not know a priori which set of features and variations will be relevant for our task.[14] Therefore, the most robust approach is to "disentangle as many factors as possible, discarding as little information about the data as is practical".[15]

The definition of a disentangled representation is based on three criteria: modularity, compactness, and explicitness.[16] A representation is modular if each component of the representation contains information about at most one factor.[17] A representation is compact if a given factor is associated with only one or a few components of the representation.[18] A representation is explicit if there is a simple mapping from the component to the value of a factor.[19]

Computer Vision and Art History

A great advantage of digital images is their potential to bring large numbers of artifacts together virtually in order to then easily link them to related samples, to flexibly rearrange them, or simply to order them in database systems. Much like in Aby Warburg's mnemosyne atlas, digital images are therefore constantly being brought into relation to another. However, relations and similarities or dissimilarities between artworks are based on potentially fairly abstract representations. Especially when computers establish such relations.

In recent years, there has been a surge of deep learning approaches that are generative in nature.[20] These methods allow the direct visualization of the abstract representations that they learn. A relevant example of this is Neural Style Transfer, which refers to a class of image synthesis algorithms that aim to render an image into the style of a given artwork. See fig. 1 and fig. 2 for example images.

The original method was proposed by Gatys, Ecker, and Bethge[21] and consisted of an iterative optimization procedure, which optimized a combination of two objective functions. The first objective function ensures that the stylized image still contains the content from the original image, which is measured by the learned image representations of a convolutional neural network that was trained for image classification. The second objective function encourages the stylized image to have a similar style to the given artwork, which is measured using the Gramian matrices of the learned image representations.
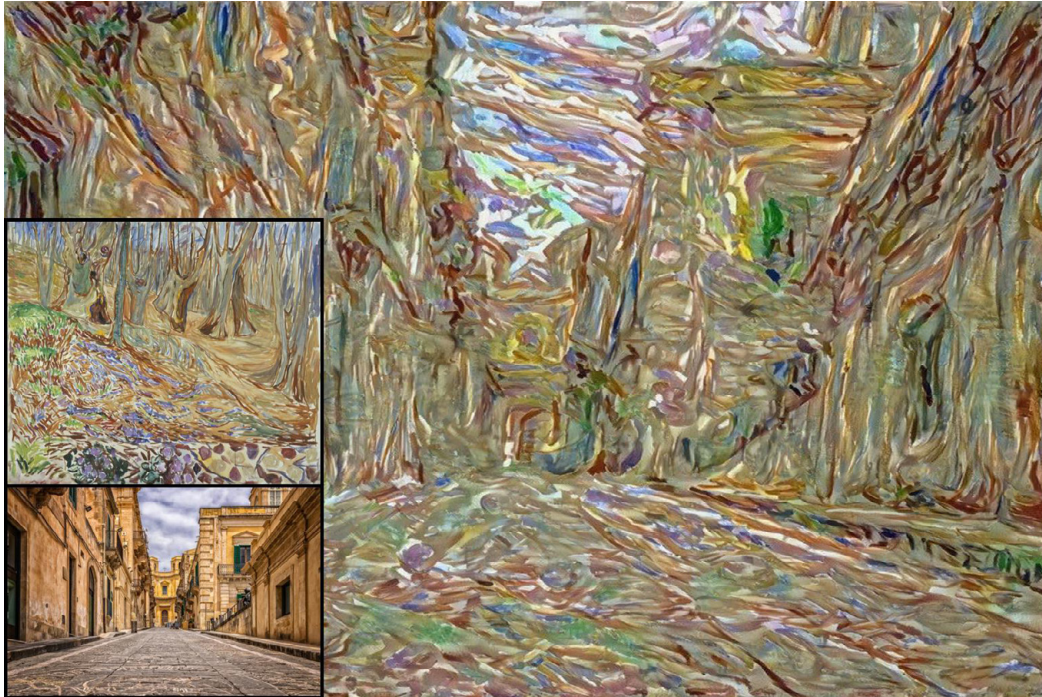
Figure 1. An image of a road rendered in the style of "Spring in the Elm Forest" by Edvard Munch; rendering by the authors; 2020.

Several methods have been proposed that employ a neural network to approximate the optimization objective from Gatys, Ecker, and Bethge[22] for a specific artwork.[23] The underlying problem that Neural Style Transfer methods aim to solve is a disentangling of style and content. The algorithm needs to extract the semantic content from the input image and render it into the style that was distilled from the artwork. This problem is highly relevant, even beyond the area of Neural Style Transfer. Imagine our goal is to group a large collection of different artworks with respect to their content. This is not a trivial task, because the same object might look very different when depicted in two different styles. Just compare a portrait painted by Picasso with a portrait from Da Vinci. Image representations for those artworks that decompose into separate style and content representations would enable us to find semantic correspondence between artworks across a wide range of different styles. Techniques from Neural Style Transfer[24] have also been employed for controlled image synthesis.[25] The proposed method learned a disentangling of high-level attributes (e.g. of human faces) as well as stochastic variation of low-level features.[26]

This project will work with neural networks that synthetically generate digital images to explain the representations they have learned for art collections. These representations can give novel insights into cultural artifacts that are not tangible through human natural language.[27] The generated synthetic digital images establish a new means of access to concepts in collections of digital or digitized art by distillation. Consequently, our goal in this project is to challenge the way art history views the digital image. The digital image should convert towards an epistemic instrument. Rather than only being the object of an art historical analysis, we will empower synthetic digital images to become a valuable tool for the analysis process. The project tackles the hermeneutic questions of reading not only a 'computer generated image' but the underlying manifold.

NOTES

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[2] Szeliski, *Computer Vision: Algorithms and Applications,* 11.

[3] Szeliski, *Computer Vision: Algorithms and Applications,* 11.

[4] Margaret Boden, *Mind as Machine: A History of Cognitive Science* (Oxford: Oxford University Press, 2006), 781.

[5] Richard Szeliski, *Computer Vision: Algorithms and Applications* (Berlin: Springer, 2010), 10–18.

[6] Szeliski, *Computer Vision: Algorithms and Applications*, 17.

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[8] David Marr, *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information*. (Cambridge: MIT Press, 2010), 20.

[9] Marr, *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information*, 20.

[10] Marr, *Vision: A Computational Investigation into the Human Representation and Processing of Visual*, 20.

[11] Marr, *Vision: A Computational Investigation into the Human Representation and Processing of Visual*, 21.

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[15] Bengio, "Deep Learning of Representations: Looking Forward," 20.

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[19] Ridgeway and Mozer, "Learning deep disentangled embedding with the f-statistic loss".

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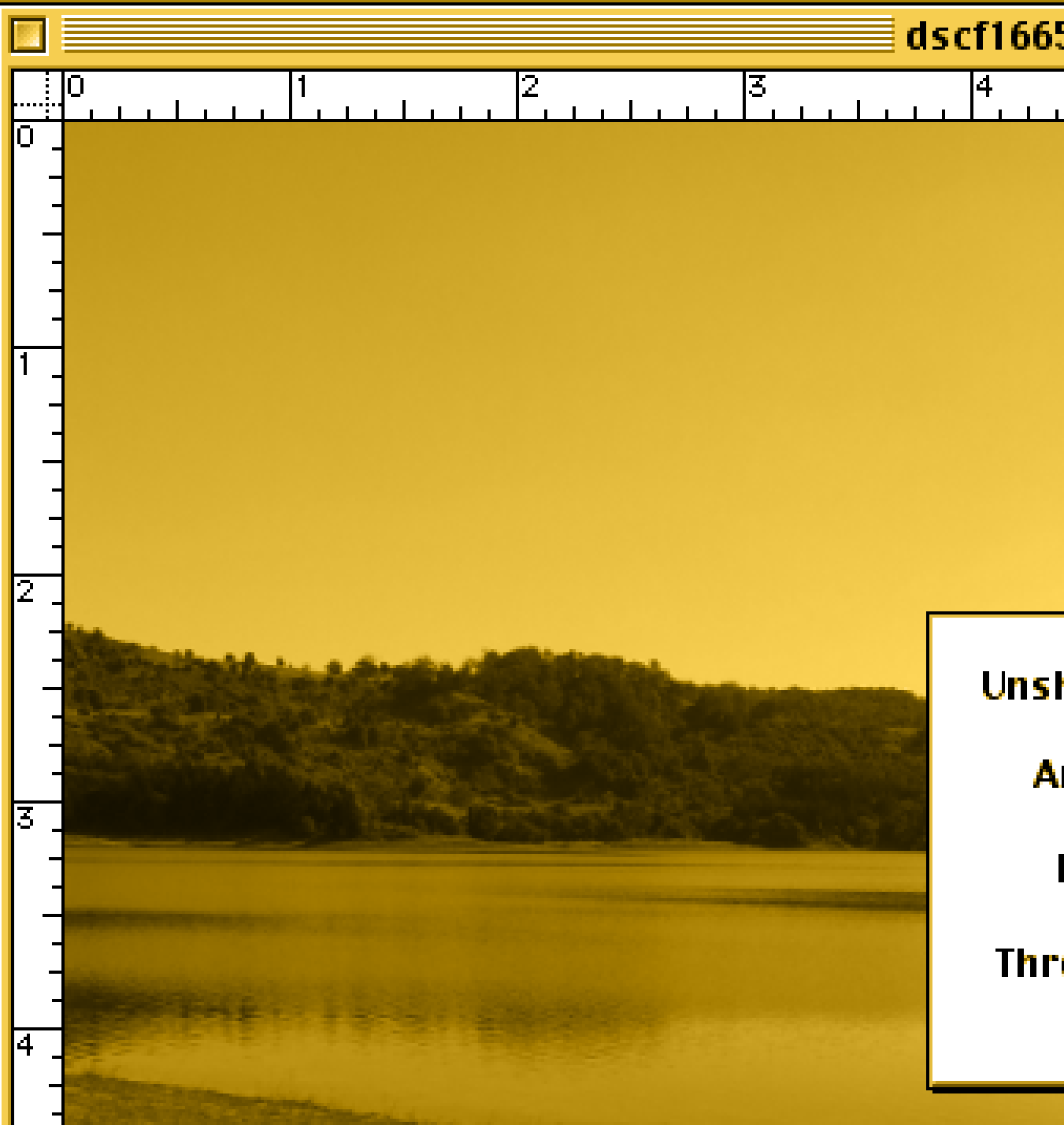Correspondence e-mail: matthias.wright@iwr.uni-heidelberg.de

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dscf1665

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PROCESSED PICTURES, PHOTOSHOP, AND UNSHARP MASK

TILL A. HEILMANN

ABSTRACT | The project presented here examines techniques and practices of digital image processing using the consumer application Adobe Photoshop as an example. My study aims at a theory of contemporary visual culture that addresses digital images in their distinct quality of being processed pictures instead of in general terms or abstract notions of digitality. To achieve this goal, I will conduct an in-depth investigation of Photoshop at the levels of both the cultural layer of interfaces and uses, and the computational layer of code and data structures. Using the methodologies of software studies and media archaeology, the project will give a first comprehensive account of Photoshop as one of the most influential tools for the production of digital culture. I illustrate the application of the software studies approach to image processing by giving a short but exemplary analysis of Photoshop's popular Unsharp Mask feature.

KEYWORDS | contemporary visual culture, digital/digitized, image processing, media theory, photography

Premise and Goal of the Project

The project "The Processed Picture" aims at improving our understanding of contemporary visual culture by way of studying digital image processing. To this end, I am conducting an in-depth cultural analysis of the software Adobe Photoshop, one of the most popular tools for digital image processing and editing.[1]

The project has three main goals: first, to give a comprehensive account of Photoshop's cultural logic of image manipulation; second, to establish a framework for reflecting digital image processing in its significance for visual culture and a general theory of digital media; and third, to conceptualize the phenomenon of digital images in their distinct quality of being processed pictures instead of in general terms or abstract notions of digitality.

The premise of the project, echoing a famous slogan in German media theory from the early 2000s, is that the digital image does not exist. However, unlike authors like Hagen and Pias[2] I want to argue that while there is no such thing as 'the' digital image, scarcely conceivable as a singular abstraction, there are many different kinds of digital images. These images can therefore only be properly analyzed and interpreted if their manifold modes of

existence as video game graphics, computer tomography, visual effects in movies, scientific data visualizations, retouched photographs, and so on are all taken into account. Digital processing is but one moment in the complex operational chain of producing, storing, transmitting, displaying, and interacting with digital images. Nevertheless, it is an important one that has mainly been discussed in relation to "the danger posed to 'truth' by computer-manipulated photographic imagery."[3] In my project, on the other hand, I will focus on the productive effects of digital image processing for epistemic and aesthetic purposes. The sciences and new media art provide ample material for illustration.

Today, Photoshop is slowly losing ground to new competitors in the PC software market. At the same time, it is facing the challenge of new photographic devices like smartphones and new visual regimes like computational photography. The dominance of Photoshop as the premier tool for image editing and processing is coming to an end. But this does not mean that Photoshop has lost its importance. On the contrary, the program's normalizing effect on digital visual culture over the last three decades can be seen not only in the images themselves but also, and maybe more importantly, in the increasing automation of image processing by mobile photography apps and computational photography. Instagram's popular filters, for example, were modeled on Photoshop's algorithms.[4] Even if Photoshop were to disappear altogether as a discrete software application, its processing logic has already permeated our contemporary visual culture and is deeply ingrained in everyday imaging technologies.

Methodology

Methodologically, I will take the software studies approach, using analytic and interpretive techniques like interface critique and critical code reading. To elaborate on the historical and practical dimensions of digital image processing, I will rely on the methods of media archaeology, oral history, and discourse and media analysis. On the theoretical side, I will build on and continue work on the nexus between imaging, knowledge, and mediation.[5] In particular, I will draw upon recent studies on aesthetic and epistemic aspects of digital imaging.[6]

Software studies is a relatively new branch of academic research that emerged from media studies in the early 2000s in response to the digital transformation of media culture and also as a reaction to the narrow focus of media theory on hardware issues.[7] The digitization of telecommunication and media industries since the 1980s has led to traditional media like print, television, and photography being increasingly remodeled or remediated in software.[8] Since the core component of computing hardware, the microchip, is usually of a general-purpose architecture, the actual specification or shaping of a digital medium is determined by the program(s) running on the hardware. Therefore, the task of describing and interpreting digital media has effectively become the task of analyzing software. Because of the relative novelty of the approach and the fact that there have been very few actual case studies of major consumer applications like Photoshop, my project will also serve as a methodological test run for software studies.

In software studies, we examine the object in question in its peculiar dual existence, i.e. on the cultural layer of user interfaces, features provided, typical uses and effects, etc., and on the computational layer of algorithms, data structures, protocols, file formats, and so on.[9] When it comes to programs like Adobe Photoshop, this means that we systematically relate the aesthetic 'surface' of digital images to their technical 'subface'[10] in order to better understand the link between cultures and codes of digital images.

A frequent obstacle to the study of software is the fact that the source codes of programs, i.e. the human-readable forms of software written in high-level programming languages, are not disclosed to the public. This is particularly true in the case of commercial applications like Adobe Photoshop where the source codes typically remain well guarded and legally protected corporate secrets. Analyses and interpretations of software often have to admit defeat at this point. Luckily, Adobe released the source code for the first version of Photoshop in 2013.[11] This makes it possible to see how Photoshop's image processing features and data structures were originally implemented in version 1.0 (written in Object Pascal and 68000 assembly language) for Macintosh computers. Since this first version of the program is also available for emulation on modern machines, we can study Photoshop 1.0 in detail on both the cultural and the computational layer.
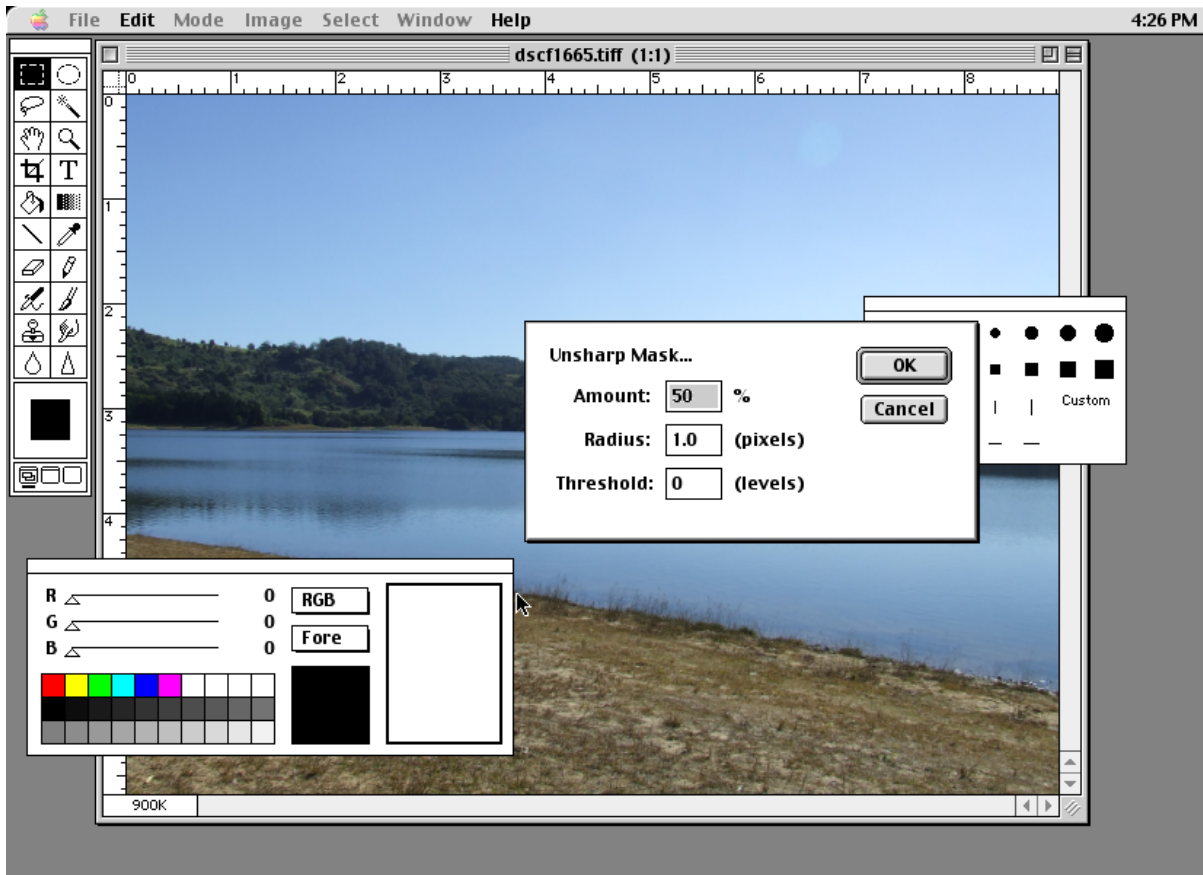
Figure 1. Unsharp Mask dialog box in Adobe Photoshop 1.0.7; 2021; screenshot.
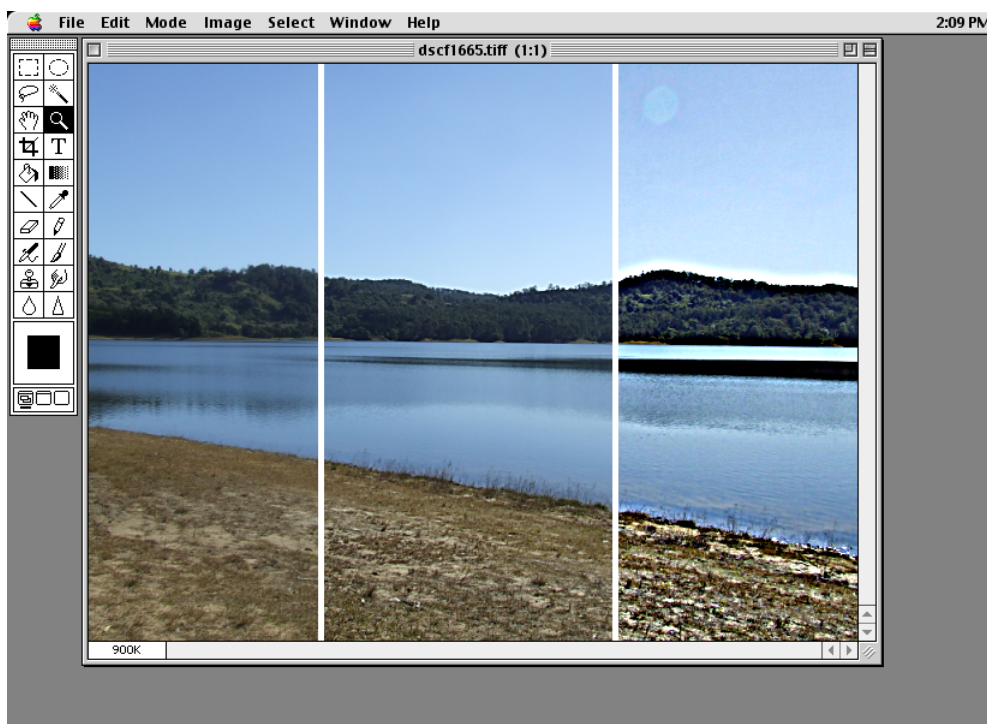

Figure 2. Comparison of Unsharp Mask filter effects in Adobe Photoshop 1.0.7. Left pane: filter not applied; middle pane: Amount: 80, Radius: 2.0, Threshold: 1; right pane: Amount: 300, Radius: 5.0, Threshold: 0; 2021; screenshot.

Unsharp Mask: Cultural Layer

In the remainder of this text, I will demonstrate a short analysis of one particular image processing feature of Photoshop to illustrate the program's visual logic.[12] The feature in question is the Unsharp Mask filter. Unsharp Mask is considered by many professionals to be one of the most important and historically significant features of Photoshop. The image filter—its name somewhat misleading for laymen—has been an integral part of the software since the first version of the program and serves as the primary tool for sharpening images. As the Official Adobe Photoshop Handbook from 1991 states succinctly, "Unsharp Mask is the most accurate way of creating a controlled sharpening effect."[13] In the following pages, I can only give a cursory impression of what analyzing and interpreting Photoshop from the perspectives of software studies and media archaeology might look like. I will limit myself to a few remarks on three aspects of the Unsharp Mask filter as it was realized in the first version of the program in 1990: its interface, its implementation in code, and its genealogy and evolution.

Our analytical and archaeological descent[14] into Adobe Photoshop's workings and history starts at the surface or on the cultural layer of the program, with a description of the Unsharp Mask filter as it appears to the user. How does Unsharp Mask present itself and its operations graphically on the screen?

Unsurprisingly, perhaps, for the first version of a program from the beginning of the 1990s, the feature is quite plain in appearance. Unsharp Mask is listed under its name as the last item of twenty-two filters in the according menu. The dialog box that pops up when you select the filter from the menu is also kept very simple and shows only three input fields for entering numerical parameters labeled Strength, Radius, and, since version 1.0.7, Threshold (fig. 1). After you have chosen the parameters and pressed the OK button, Photoshop's algorithms will increase the contrast at edges automatically determined in the image by emphasizing changes in brightness or color, i.e. by lightening light edges and darkening dark edges. If applied correctly, Unsharp Mask can make pictures clearer and crisper. If the parameters are set too high, the noise in the image will become more noticeable, colors can shift and halos may appear (fig. 2).

The rather simple controls and functionality of the Unsharp Mask filter have not changed substantially since the first version of Photoshop. Part of the feature's simplicity lies, of course, in the fact that we commonly do not have insight into the computational processes that take place 'below' the cultural layer of the graphical user interface (GUI). On the surface of the application, the actual processing is revealed merely through an animated progress bar (in early versions of the program), through a small preview area (only in later versions of the program), and, of course, in the resulting image at the end. Exactly how Photoshop determines edges in the picture and how the chosen parameters affect the operation of the filter remains hidden from the user's view.

As a 'surface' phenomenon of the GUI, the Unsharp Mask filter—like the rest of Photoshop's filters—stands in stark contrast to the picture it processes in three different ways: firstly, in spatial opposition insofar as the filter feature occupies its own place in the GUI as a list item in the menu, as a dialog box, and as a progress bar placed next to or 'over' the image, but in any case outside the picture itself; secondly, in logical opposition insofar as the feature represents the measure of its impact on the picture in a definitely nonpictorial manner, i.e. through text and, above all, through numbers; and thirdly, in temporal opposition insofar as it occurs in between two states of the picture—the unprocessed version before and the processed version after—without making the transition from one state to the other, the process of processing, visible in the picture itself.

Unsharp Mask: Computational Layer

If one wants to know more about how the Unsharp Mask feature works on the computational layer, the user manual for Photoshop (again: the one for the first release of the program) provides some hints:

The Unsharp Mask filter sharpens pixels using a variable radius. You specify a radius (in pixels) around the current pixel, which is being evaluated. The Unsharp Mask filter then blurs a selection according to the specified radius. A fraction of this blurred result is then subtracted from the original data, resulting in a sharpening effect. The larger the radius, the more information is included in the filter's calculations. If you specify a high value for the radius, the lower frequencies will be amplified; if you specify a low value,

only high-frequency areas will be amplified. You can also specify the percentage of the filter's effect. The higher the percentage, the stronger the effect of the Unsharp filter mask on a selection. If you specify a low value, only a fraction of the effect is applied; if you specify a high value, most of the effect is applied.[15]

The Unsharp Mask feature works, we learn, by using the brightness information from a blurred copy of the image to alter the original image. The blurred or 'unsharp' copy—from which the filter gets its name—acts as a digital mask through which the unprocessed image data is algorithmically filtered to emerge from the process with increased edge contrast.

While analyses of computer programs usually come to a halt at the boundaries of the software's cultural layer, in the case of Adobe Photoshop we may continue our descent down to the 'subface' computational layer of codes, algorithms, and data structures. Of course, having access to the source for Photoshop 1.0 alone is not enough. To examine the program according to the principles of Critical Code Studies,[16] further conditions must be met. In particular, at least some basic knowledge of the programming languages used is necessary. Within the scope of this article, I can only give a sketch of how such an analysis might be conducted.

The source code for version 1.0.1 of Photoshop comprises 178 individual files (excluding the text file ChangeHistory.txt with version notes).[17] It is from these files that the ready-to-run application for consumers was compiled (with the help of many additional files from the MacApp framework).

Even before looking inside the files and examining the code in detail, we can learn important things by performing a basic 'distant reading' of the source code. The majority of files—144 to be exact—were written in the high-level programming language Pascal (extensions .p and .inc). Twenty-one files were written in assembly language (extension .a), the rest are files containing data encoded in different formats (extensions .r, .t, .h) and files controlling the compilation process. A simple count with the basic Unix tool wc ($ wc -l *.p *.inc *.a) gives us a total of 116,587 physical lines of code, including comments and blank lines. Using the more specialized tool cloc ($ cloc --force-lang="Assembly",a --force-lang="Pascal",inc --exclude-ext=r *), we find that there are 63,004 lines of Pascal and 8,228 lines of assembly in Photoshop's source, not counting comments and blank lines—a ratio of approximately 8:1.

In the form of a special object-oriented version developed by Apple, Pascal was the main programming language for writing software for Macintosh computers until the early 1990s, when it was gradually replaced in that role by C++. Object Pascal was closely linked to Apple's MacApp application framework which provided the generic functions, structures, and objects (such as menus, dialog boxes, input fields, etc.) needed by programs to fit seamlessly into the environment of the Macintosh operating system and GUI.[18] Taken together, Object Pascal and MacApp made it possible for software developers to build applications more quickly and more easily from ready-made parts than would have been the case if they had been designing them from the ground up. The choice of (Object) Pascal as the main implementation language for Photoshop, therefore, signals a desire for maximum conformity with Apple's digital ecosystem as well as the economic constraints of commercial software development. Lastly, the language design of Pascal stands for a certain style of writing programs in a clear, efficient, and logical manner—a programming paradigm which had been known as structured programming since the 1970s and which promised better control and management of the ever-increasing complexity of software.[19]

Assembly code, on the other hand, is the counterpart to high-level languages like Pascal: a terse symbolic transliteration of the computer's monotonous binary machine language, strictly tied in its mnemonic vocabulary of opcodes to the specific architecture of the microprocessor (in this case, a Motorola 6800 series CPU). Since the 1980s, assembly has only been used where and when maximum efficiency of code is required, i.e. for the highest possible speed of calculation and the smallest possible memory footprint. It is therefore hardly surprising that only a few files of Photoshop's source code are written in assembly. And it is all the more telling when we look to see what these files are about. The second largest one of them ($ wc -l *.alsort -r) is called UFilters.a.[20] The name suggests that the code in this file concerns elementary algorithmic procedures for Photoshop's filter features and that these procedures are among the most computationally expensive parts of the program. Implementing the basic filter procedures on the computational layer in the much more convenient Pascal language would not have resulted in the calculating speed expected on the cultural layer of the program. Letting the user stare at the screen while she waited for the computations to complete and the processed picture to appear was simply not an option.

```
                                                    UFilters.a
;               Set up constants

                MOVE.W      #255,D4
                MOVE.L      #$08000,D5

;               Compute new values

                CLR.W       D2
@1              CLR.W       D3
                MOVE.B      (A0)+,D2
                MOVE.B      (A1),D3
                SUB.W       D2,D3
                MULS.W      D1,D3
                LSL.L       #4,D3
                ADD.L       D5,D3
                SWAP        D3
                SUB.W       D3,D2
                BPL.S       @2
                CLR.W       D2
@2              CMP.W       D4,D2
                BLE.S       @3
                MOVE.W      D4,D2
@3              MOVE.B      D2,(A1)+
                DBF         D0,@1

;               Clean up and exit

                MOVEM.L     (SP)+,D3-D5
                UNLK        A6
                MOVE.L      (SP)+,A0
```

Figure 3. File UFilters.a from source code for Adobe Photoshop 1.0.1, lines 1299–1326; 2021; screenshot.

Examining the file UFilters.a more closely, we can find within "the endless litany of 'read,' 'write,' 'move,' and 'load' [...] called *assembly language*"[21] some reader-friendly labels like DoBoxFilter, DoWeightedFilter, DoMedianFilter, and also DoUnsharpMaskLine (in lines 95, 182, 1336, and 1258). Presumably, these are the names by which the respective procedures are called from elsewhere in the source code of Photoshop. And without any further knowledge of assembly language, we can see that the latter procedure referencing the Unsharp Mask feature is only thirty-three lines of code long (not counting comments, directives for constants, and blank lines). And the core of this procedure, marked "Compute new values" in the comment on line 1304, counts a mere seventeen assembly commands (lines 1306-1322). Compared to the total amount of Pascal and assembly code (71,232 lines), the presumed algorithmic nucleus of the Unsharp Mask feature seems downright tiny (fig. 3).

The spatial, logical, and temporal break separating the Unsharp Mask filter from the image to be filtered on the cultural layer is reflected on the computational layer. There, it appears as the divide between the concise and direct assembly instructions for speed-optimized computation of the pixel values on the one hand and the highly structured and abstract Pascal objects for integrating the feature into the application's graphical user interface on the other. The tension between machine-oriented procedures for elementary image processing operations and the overall framework of the program, abstracted away from the underlying hardware in a higher programming language and structured as a complex hierarchy of objects, runs through the entire source code of Photoshop.

Here, I want to end my brief description of Photoshop's computational layer. I would only add that a further search for traces of the Unsharp Mask feature in the program's source with the help of the Unix tool grep ($ grep -ni unsharp *) brings to light sixteen more places, among them a procedure of the Pascal class TUnsharpMaskFilter called .DoFilter (UFilter.p, lines 1268-1328). This procedure does not call only the procedure DoUnsharpMaskLine (line 1313) but, before it, a .DoFilter procedure (line 1293) 'inherited' by its parent class TGaussianFilter. This inherited .DoFilter procedure, in turn, finally calls an assembly procedure called DoWeightedFilter (UFilters.inc1.p, lines 168 and 220).

Before it proceeds to compute the new brightness of pixels with DoUnsharpMaskLine, the Unsharp Mask feature seems to apply a Gaussian filter—i.e. one weighted according to the normal distribution—to the original image (DoWeightedFilter). Apparently, this step of processing creates the blurred copy of the image mentioned in the Adobe Photoshop User Guide ("The Unsharp Mask filter then blurs a selection according to the specified radius"), which is subtracted from the original image to achieve the desired sharpening effect ("A fraction of this blurred result is then subtracted from the original data, resulting in a sharpening effect").[22]

Unsharp Mask: Genealogy

With the subject of the Gaussian filter, we have arrived at the question of the Unsharp Mask's genealogy. For the blurred image produced by Photoshop's DoWeightedFilter assembly procedure has two distinct precursors in media history. On the one hand, the use of filters for signal processing predates digital computing, or at least digital image processing, by quite a bit. Image processing features like the Gaussian filter or the high-pass filter in Photoshop are really digital simulations of earlier electronic filters developed for analog signal processing. Methods for brightness interpolation and noise removal had been realized with analog circuitry since the first half of the 20th century, primarily within the context of wireless and telephone technology.[23] On the other hand, and this brings me to my final point, the technique of the Unsharp Mask was known long before it was turned into digital code. Again, the first Photoshop User Guide tells us more: "The [Unsharp Mask] filter is commonly used in pre-press production to enhance details in the separations by producing exaggerated density at the borders of a color change."[24]

Historically, the technique of unsharp masking came to digital image processing from the graphics industry. There, it was used as a pre-press procedure to prepare the printing plates. A common problem in the reproduction of color images is that dissimilar but adjacent colors can 'bleed' or mix and their tones get distorted. To reduce color distortions and improve the print quality, the images to be printed are first filtered through unsharp masks to enhance the edge contrast of colors.[25] Before digital Gaussian filters, unsharp masks were created photographically by copying the original negative with soft light or a diffusor plate. The result was a slightly blurred positive. When this low-contrast positive—the unsharp mask—was combined in-register with the original negative for producing a color separation, it acted as a filter that partially canceled information in the negative. In bright areas of the original negative, it let less light pass through, and vice versa. Because it had been blurred (intentionally), the unsharp mask only canceled low-frequency information from the original. The result was a color separation with increased acutance and less color bleeding in the prints.

The parallels between the pre-press technique of unsharp masking and the digital Unsharp Mask filter are obvious. The Gaussian filter used for blurring images in the digital domain corresponds to the soft light or diffusor plate used to produce the low-contrast positive in analog printing; the mathematical operation of subtraction from the original data in the computer corresponds to the combined projection of low-contrast positive and original negative in photomechanical reproduction. In both cases, an original image is first copied and then enhanced by combining it with its low-quality duplicate. In this perspective, the Unsharp Mask feature of Photoshop constitutes a digital simulation of an analog technique from photography and the printing industry. Or put the other way around: In retrospect, the older technique turns out to be an analog form of image processing.

However, neither the historical nor the technological relationship of analog and digital unsharp masking are quite as straightforward as my brief account suggests. For the digital Unsharp Mask feature of Photoshop has gradually reduced the method to a single purpose: the increase of acutance in photographic images. As the repeatedly cited user guide for the program shows, this was not always the case. In the pre-digital stage of image processing, unsharp masking was used primarily to solve technical problems in the reproduction of images (like color bleeding in the printing industry).

Unsharp masking was popularized, above all, in the 1970s by David Malin, a British-Australian astronomer. Malin used the technique to detect and preserve faint structures and details in astronomical photographs. Though these were present on the photographic plates that Malin had exposed, they could not be seen and reproduced when copied onto film or paper for subsequent reproduction without the application of unsharp masking techniques.[26] And indeed, this was the main purpose of the photographic method since its earliest days: to enable a controlled reduction of the dynamic range of original negatives. The first description of the technique was given around 1930 by the German medical physicist Gottfried Spiegler and his radiographer Kalman Juris at the Röntgentechnische Versuchsanstalt (X-ray lab) of the Vienna General Hospital. Spiegler and Juris did not use the term 'unsharp mask' but called their invention "a new copying process for producing ideally harmonious copies from high-contrast negatives."[27] The challenge they faced was how to copy images with large high-density regions—as is typical for X-ray photographs—without losing any diagnostically important details in very dark or very light parts of the picture. The problem to be solved was not the poor quality of radiographic pictures but the technical difficulties with their reproducibility or 'duplicability.'[28]

Without going into further technical details, we note the following: Before the triumph of digital image processing, sharpening of edges achieved by photographic unsharp masking techniques was a means to an end (e.g., in the preparation of color separations for printing) or an unintended, if useful, side effect (e.g., in Spiegler's and Juris's radiography or Malin's astrophotography), not an end in itself. Improving picture quality was not the intention; preserving picture quality in reproductions was. The problem, in other words, was not a lack of information in the original picture; on the contrary, it was the high amount of information in images, their broad range of tonal values, that could not be reproduced without loss when transferred to other media. In a nutshell, unsharp masking was not for correcting defects in images but for dealing with deficiencies of imaging technology.

Remarkably, this was still true in the early days of image processing with personal computers. Before digital cameras took the consumer market by storm in the 2000s, photographs had to be digitized with a scanner before you could edit and process them using a program like Photoshop.[29] Due to the low resolution of scanners at the time and constraints inherent to the sensor technology, scanned negatives and prints often suffered from slight blurring at the edges. And the sharpening features of Photoshop were originally intended as a remedy against the blur introduced by the scanning process. Photoshop's digital image filter, to put it briefly, was designed to dissimulate the digitizing of images.[30]

Early Photoshop user manuals and handbooks tell you about this. Adobe's first official tutorial for the program from 1993, for instance, remarks: "[T]he scanning process can cause an image to appear slightly out of focus or 'soft.' You can sharpen an image using the Adobe Photoshop sharpening filters."[31] One year later, the second edition of the tutorial has this to say: "The Unsharp Mask filter adjusts the contrast of edge detail, creating the illusion of more image sharpness. This filter can be useful for refocusing an image that has become blurry from interpolation or scanning."[32] And even in the year 2002, most of the reasons for using the Unsharp Mask feature given by Photoshop's online help concerned the reproduction of images: "The Unsharp Mask filter corrects blurring introduced during photographing, scanning, resampling, or printing."[33]

Of course, things changed some time ago. The pictures that are processed and edited today are usually 'born digital', captured with digital cameras, while the sensor technology has improved considerably. Compensating for losses from the scanning process with digital sharpening filters hardly seems necessary anymore. But sharpening of photographs with Unsharp Mask and the like still happens, possibly more than ever. By the end of the 1990s, the Unsharp Mask feature had completed its cultural transformation from a specialized filter for correcting scanned pictures to a universal image enhancement tool. In 1998, for example, renowned Photoshop expert Dan Margulis described it as an all-around optimization instrument in his popular column Makeready: "Unsharp masking is an artificial method of making images appear more in focus. It is useful in virtually all graphic scenarios[.]"[34] And a few years later, Margulis followed up with the statement that digital sharpening not only benefits even high-quality pictures but should, in fact, be done routinely: "Almost every picture needs it, and not because photographers don't know how to focus their cameras."[35]

The changed purpose of the filter is also reflected in the literature on Photoshop. Tellingly, Adobe's current reference for the software omits the photographic tradition of unsharp masking and mentions the filter's original intent only in passing. The program's various sharpening filters are now summarized as follows: "Whether your images come from a digital camera or a scanner, most images can benefit from sharpening."[36] If you want further proof of the feature's transformation, YouTube offers plenty of evidence. In popular video tutorials hosted by the site, Unsharp Mask is discussed almost exclusively as a general method for image improvement.

The most momentous shift, however, concerns the filter's role within the Photoshop program itself. Since the turn of the millennium, digital unsharp masking has been elevated to an integral part of Adobe's image processing pipeline. Introduced in 2003, the plug-in software Camera Raw is a digital darkroom, so to speak, that allows users to work on the 'raw', unprocessed information from the camera before it is converted into an image in the TIFF, JPEG, Photoshop's proprietary PSD, or some other file format for more editing and compositing.[37] In addition to various features for image adjustment such as cropping, setting the white balance, adjusting contrast and color, and so on, Camera Raw presents users with a range of default settings that control the conversion of raw data into pictures—including one for sharpening the image with the Unsharp Mask algorithm (fig. 4).[38] Unsharp masking has become an 'always-on' filter that all Photoshop images must pass through.
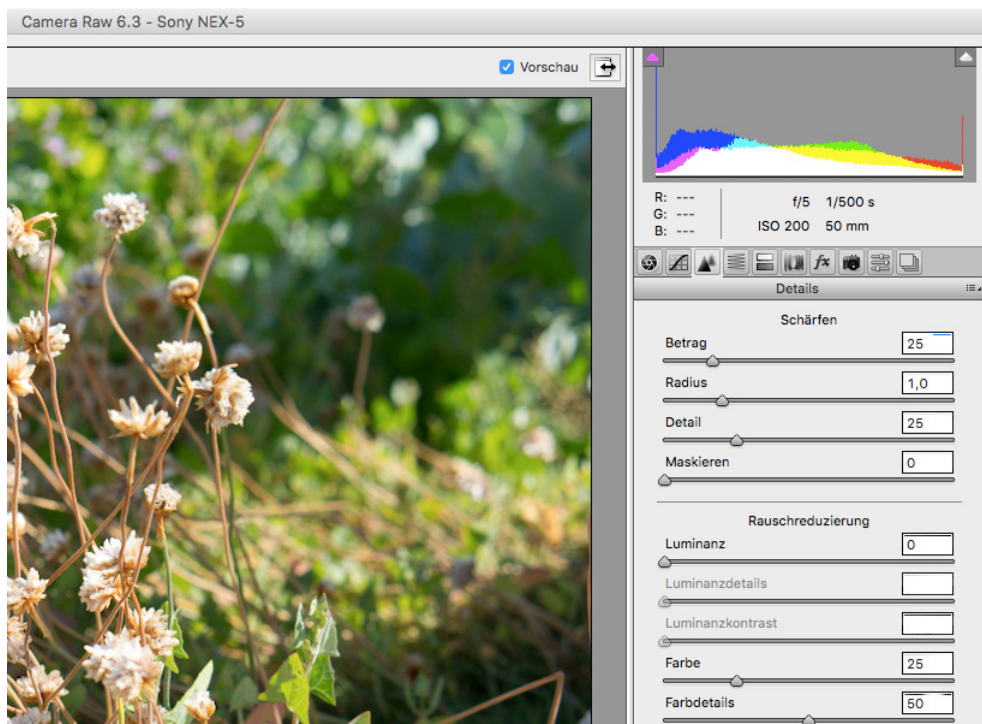
Figure 4. Unsharp Mask defaults in Adobe Camera Raw 6.3. German localization "Betrag", "Radius", "Detail", and "Maskieren" for Amount, Radius, Detail, and Masking; 2021; screenshot.

It could be argued that digital images should always be sharpened with Unsharp Mask or similar image processing features. Because the color values of individual pixels captured by regular sensor technology with Bayer filters have to be interpolated from multiple adjacent sensor pixels, edges in digital photographs are always somewhat 'blurred'. However, this does not change the fact that the method of unsharp masking has turned from a photographic technique to control the density range of pictures in the first half of the twentieth century into an algorithmic image enhancement procedure that is now routinely applied to all digital photographs.

Conclusion

Over the course of its evolution from the Röntgentechnische Versuchsanstalt Wien to Photoshop, the digital transformation of unsharp masking has resulted in a reduction of the method to one single purpose—edge sharpening—on the one hand, and in a generalization of this purpose for all photographs on the other hand. Image processing and editing applications for PCs and digital cameras themselves have already automated unsharp masking to a large extent. Current and future imaging soft- and hardware, like Instagram and computational photography with next-generation smartphones[39] will amplify this effect. We may assume that all of this contributes to a change in our perception of images, our expectations of what good, 'sharp' pictures should look like as well. This topic, however, needs to be addressed in another study.

NOTES

[1] A note on terminology: We commonly distinguish between image processing and image editing. While the former term means global modifications made to images through largely automated processes (e.g. the redistribution of tonal values), the latter term refers to manually applied corrections to select parts of an image (e.g. the gradual retouching of skin blemishes in a portrait with a digital repair brush). In practical use, however, the two forms of image manipulation often overlap and rely on similar or the same computational methods and processes. Therefore, I will use the two terms synonymously.

[2] Wolfgang Hagen, "Es gibt kein 'digitales Bild'," *Archiv für Mediengeschichte*, no. 2 (2002): 103–111; Claus Pias, "Das digitale Bild gibt es nicht: über das (Nicht-)Wissen der Bilder und die informatische Illusion," *zeitenblicke* 2, no. 1 (2003), accessed February 17, 2021, url: http://www.zeitenblicke.de/2003/01/pias/.

[3] Martha Rosler, "Image Simulations, Computer Manipulations," *Afterimage*, November 1989: 7.

[4] Kevin Systrom, "Answer to What Do the Different Image Filters on Path, Instagram, Oink, Etc. Actually Do?" January 4, 2012, accessed February 17, 2021, https://www.quora.com/What-do-the-different-image-filters-on-Path-Instagram-Oink-etc-actually-do/answer/Kevin-Systrom.

[5] William J.T Mitchell, *Image Science: Iconology, Visual Culture, and Media Aesthetics* (Chicago: University of Chicago Press, 2018); Hartmut Winkler, *Prozessieren: Die dritte, vernachlässigte Medienfunktion* (Paderborn: Wilhelm Fink, 2015); Vilém Flusser, *Into the Universe of Technical Images* (Minneapolis, MN: University of Minnesota Press, 2011); Karin Knorr-Cetina, *Epistemic Cultures: How the Sciences Make Knowledge* (Cambridge, MA: Harvard University Press, 1999); Jay David Bolter and Richard Grusin, *Remediation: Understanding New Media* (Cambridge, MA: MIT Press, 1999).

[6] Steve F. Anderson, *Technologies of Vision: The War Between Data and Images* (Cambridge, MA: MIT Press, 2017); Ingrid Hoelzl and Rémi Marie, *Softimage: Towards a New Theory of the Digital Image* (Chicago, Ill.: University of Chicago Press, 2015); Hubertus Kohle, *Digitale Bildwissenschaft* (Glückstadt: Werner Hülsbusch, 2013); Inge Hinterwaldner, *Das systemische Bild: Ikonizität im Rahmen computerbasierter Echtzeitsimulationen* (Munich: Wilhelm Fink, 2010); Mark B. N. Hansen, *New Philosophy for New Media* (Cambridge, MA: MIT Press, 2006).

[7] Lev Manovich, *The Language of New Media* (Cambridge, MA: MIT Press, 2001), 45–48; Lev Manovich, *Software Takes Command* (New York: Bloomsbury Academic, 2013), 10–20, accessed February 17, 2021, url: http://issuu.com/bloomsburypublishing/docs/9781623566722_web?e=3257035/4651685; Friedrich Kittler, "There Is No Software." In *The Truth of the Technological World*, ed. Hans Ulrich Gumbrecht (Stanford, CA: Stanford University Press, 2013), 219–229.

[8] Bolter and Grusin, *Remediation*, 19.

[9] Manovich, *The Language of New Media*, 46–47.

[10] Frieder Nake, "The Disappearing Masterpiece: Digital Image & Algorithmic Revolution," In *4th Conference on Computation, Communication, Aesthetics and X*, Bergamo, July 7–8, 2016, 12–27.

[11] Len Shustek, "Adobe Photoshop Source Code" (Computer History Museum, February 13, 2012), https://computerhistory.org/blog/adobe-photoshop-source-code/.

[12] The following is adapted from my German article Till A. Heilmann, "Blackbox Bildfilter: Unscharfe Maske von Photoshop zur Röntgentechnischen Versuchsanstalt Wien," *Navigationen*, no. 2 (2020): 75–93.

[13] David Biedny and Bert Monroy, *The Official Adobe Photoshop Handbook* (Toronto et al.: Bantam Books, 1991), 204.

[14] Jussi Parikka, *What Is Media Archaeology?* (Cambridge–Malden, MA: Polity Press, 2012), 80.

[15] Adobe Systems, *Adobe Photoshop User Guide* (Mountain View, CA: Adobe Systems, 1990), 306. https://archive.computerhistory.org/resources/access/text/2013/01/102640940-05-01-acc.pdf.

[16] Mark C. Marino, *Critical Code Studies* (Cambridge, MA: MIT Press, 2020).

[17] You can download the source code from the website https://computerhistory.org/blogs/ photoshop-software-license-agreement/.

[18] Kurt J. Schmucker, *Object-Oriented Programming for the Macintosh* (Hasbrouck Heights, N. J.: Hayden Book Company, 1986).

[19] Ole-Johan Dahl, Edsger W. Dijkstra, and Charles Antony Richard Hoare, *Structured Programming* (London: Academic Press Ltd., 1972).

[20] The largest assembly file of the Photoshop source code is USeparation.a, the part of the program performing the complex calculations involved when converting images from RGB to CMYK and vice versa.

[21] Friedrich Kittler, "Protected Mode," in *The Truth of the Technological World*, ed. Hans Ulrich Gumbrecht (Stanford, CA: Stanford University Press, 2013), 217.

[22] Adobe Systems, *Adobe Photoshop User Guide*, 306.

[23] Vitold Belevitch, "Summary of the History of Circuit Theory," *Proceedings of the IRE* 50, no. 5 (1962): 848–855.

[24] Adobe Systems, *Adobe Photoshop User Guide*, 306.

[25] Helmut Kipphan, ed, *Handbuch der Printmedien: Technologien und Produktionsverfahren* (Berlin: Springer, 2000), 519.

[26] Adobe Systems, "Stargazer" (Adobe Systems, 2006), accessed February 17, 2021, https://www.adobe.com/digitalimag/pdfs/davidmalin.pdf; David F. Malin, "Unsharp Masking," *AAS Photo-Bulletin*, no. 16 (1977): 10–13.

[27] Gottfried Spiegler and Kalman Juris, "Ein neues Kopierverfahren zur Herstellung ideal harmonischer Kopien nach kontrastreichen Negativen," *Fortschritte auf dem Gebiet der Röntgenstrahlen* 42 (1930): 509.

[28] Spiegler and Juris, "Ein neues Kopierverfahren zur Herstellung ideal harmonischer Kopien nach kontrastreichen Negativen," 513.

[29] Biedny and Monroy, *The Official Adobe Photoshop Handbook*, 394.

[30] In a remarkable recurrence of events twenty years later, the mobile photo app Instagram was designed to make up for the low quality of early smartphone photography. Company founder and app developer Kevin Systrom introduced Instagram's filters

feature because his girlfriend at the time did not like the pictures she had taken with her iPhone 4 and wanted a way to make them look better; Jemima Kiss, "Instagram Ceo Kevin Systrom: 'We're Working on Time Travel'," *The Guardian*, October 2, 2015, accessed February 17, 2021, https://www.theguardian.com/technology/2015/oct/02/instagram-kevin-systrom-interview-working-on-time-travel.

31 Adobe Systems, *Adobe Photoshop: Classroom in a Book* (Carmel, IN: Hayden Books, 1993), 134.

32 Adobe Systems, *Advanced Adobe Photoshop: Classroom in a Book* (Indianapolis, IN: Hayden Books, 1994), 179.

33 Adobe Systems, *Adobe Photoshop 7.0: Classroom in a Book* (Berkeley, CA: Peachpit Press, 2002), 96.

34 Dan Margulis, "Sharpening with a Stiletto," *Electronic Publishing*, no. 2 (1998), accessed February 17, 2021, https://www.ledet.com/margulis/Makeready/MA27-Sharpening_With_Stiletto.pdf.

35 Dan Margulis, "Life on the Edge," *Electronic Publishing*, no. 1 (2005), accessed February 17, 2021, https://www.ledet.com/margulis/Makeready/MA69-Life_on_the_Edge.pdf.

36 Adobe Systems, "Adobe Photoshop CC Help," February 2, 2018, 436, accessed February 17, 2021, https://helpx.adobe.com/pdf/photoshop_reference.pdf.

37 Most consumer cameras and smartphones, however, will save pictures as JPEGs and sharpen them automatically.

38 Adobe Systems, *Adobe Photoshop CS User Guide* (Mountain View, CA: Adobe Systems, 2003), 68.

39 Vasily Zubarev, "Computational Photography: From Selfies to Black Holes," *Vas3k Blog*, July 1, 2019, https://vas3k.com/blog/computational_photography/.

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"THE DIGITAL IMAGE" – A TRANSDISCIPLINARY RESEARCH CLUSTER

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