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9TH SYMPOSIUM ON LEGAL DATA PROCESSING IN EUROPE (CJ-IJ Symp)

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A NEUTRAL NETWORK TO IDENTIFY LEGAL PRECEDENTS

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A NEURAL NETWORK TO IDENTIFY LEGAL PRECEDENTS

Abstract

The authors explore how the special abilities of neural networks (learning of arbitrary input-output pattern combinations, to a limited extent generalisation of ascertained regularities when non-learned patterns are presented) can be used to build up an artificial system which can record and identify legal precedents.

A method will be introduced in which precedents in the area of the law of immaterial damages can be identified by use of a neural network : The system shall, with the aid of a previously supplied list of court decisions, "learn" to predict the magnitude of the expected immaterial damages based on the factual circumstances (type, seriousness and duration of the injury, seriousness and duration of consequences, etc). The network is feasible not only in a combinatorial background (with binary pattern combinations as input and output), but in an analog background (with analog input and output values) as well. In the first instance, the network operates as a kind of "pattern classificator", in the second instance a function is interpolated from the trained input and output values which synthesises the correct output values for the respective input values.

I. The Neural Networks Approach

"Neural networks" / "neural computing" / "parallel distributed processing" in the past three years has become a key word in the area of artificial intelligence research. The amazing successes which have been achieved in some fields through the use of simulated neural networks have awakened the hope that with this approach the well-known narrow limits of the current object - or rule-based expert systems can be overcome.

The application of neural networks opens new perspectives, in particular, in areas in which incomplete or distorted data is to be processed or where no clear and complete rule system can be found. For example, neural networks have been used, among other things, to transform written texts to phonemes (1), to classify sonar targets with the aid of the reflected sonar signals (2), to predict the weather based on the development of the atmospheric pressure during the course of the day (3), and even to predict the future development of the stock index based on its previous development (4). The approach is the same in all cases: The respective input and output are converted into binary or analog values, which shall then form the respective input and output of the network. Based on a sufficient number of sample pattern combinations, the network will be "trained" until it produces the desired output pattern when provided with the respective input pattern. Since through the architecture of the network similar input patterns produce similar output patterns, after completion of the learning process the system can, within certain limits, find correct or nearly correct output patterns even for distorted or non-learned input patterns. In this fashion, the text-transforming network described above can, after the learning phase, also transform non-learned words with a high rate of accuracy: that is "generalise" or based on the examples "abstract" the rule from the sample patterns.

II. Transfer to the Area of Law

Based on the thesis put forward some years ago by Philipps (5) that legal thinking can be described as a special kind of pattern recognition, a possible application of such neural network simulations is apparent in the area of law : Precedents, scholarly opinions, etc. can be presented to a neural network as combinations of training patterns, in which the respective factual circumstances and the legal consequences resulting according the court decision or the academic opinion are converted into a binary or analog pattern. In the same manner the connection between the factual circumstances and the elements of the offence or between the elements of the offence and the legal consequences could be trained by presenting the respecting input and output as a binary or analog pattern.

This thesis will now be made clear by a concrete application :

III. An application : Learning precedents in the Law of Immaterial Damages

The applications of a neural network for the determination of legal precedents is only interesting if the above-described ability of neural networks to generalise can be used. This is only possible if a relatively large number of training patterns is presented because only then consistencies in the presented input patterns can be recognised and transferred to unknown patterns.

The German jurisdiction of immaterial damages is therefore well-suited as a data base for such a project: An enormous number of precedential cases in table form is available; the respective factual circumstances are relatively closely described (through criteria such as type, severity and duration of injury and their effects, etc.) and the legal consequences can be summarised in a single figger, namely, the amount of the immaterial damages awarded.

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(1) Sejnowski & Rosenberg, Parallel Networks that Learn to Pronounce English Text

(2) Gorman & Sejnowski, Analysis of Hidden Units in a Layered Network Trained to classify Sonar Targets

(3) Described in NeuralWareInc, NeuralWorks Explorer Networks I pp 382-384

(4) NeuralWareInc, NeuralWorks Explorer Networks I, pp 455-457

(5) Philipps, Täter und Teilnehmer - Versuch und Irrtum; ein Modell für die rechtswissenschaftliche Analyse, Rechtstheorie Band 5 (1974), pp 125-146

1. Preparation of the Factual Circumstances and Legal Consequences

The precedents can be prepared as data basis as follows :

Type, severity and duration of the injury : A certain number of different injuries can be distinguished according to the respective body part affected (e.g. head injury, injury of the hand, shock, etc.) so that all the elements of an offence can be categorised. For each injured part of the body the severity and duration of the injury is then determined.

Input : Severity and duration of the effects : The severity of the effects of the entire injury is divided into levels according to the degree of diminishment of earning capacity (DEC). For each level (10%, 20% DEC, etc.) a period of time is determined during which this diminished capacity existed. Further criteria which could be important in some way for the determination of the amount of the immaterial damages : The sex of the injured person (male/female), whether the occupation of the injured person had played an especially important role (yes/no) and whether the injury occurred due to medical malpractice (yes/no).

Output : The amount of the immaterial damages (adjusted for the comparative contributory negligence of the injured person).

Input :			Output :
Type of injury	Body part 1	: Duration Severity	Amount of immaterial damages in German Marks
	Body part 2	: Duration Severity	
	(...)		
	Body part X	: Duration Severity	
Effects DEC	10%	: Duration	
	20%	: Duration	
	(...)		
	100%	: Duration	
Sex		: Male/Female	
Occupation crucial		: yes/no	
Particular severity		: yes/no	
Medical malpractice		: yes/no	

As data basis for our experiments we took 200 court decisions from the immaterial damages table of the ADAC (German Automobile Club). From these, 32 different types of injuries/body parts and degrees of diminishes earning capacity were deterimined. The length and degree of injury capacity were each divided into four levels. Through this process, the most important factual characteristics which are or could be essential for the amount of immaterial damages can be determined. This exact classification has the advantage that inconsistencies within the trained input/output patterns (same input, different output) can be held to a minimum. The remaining inconsistencies must be accepted, as the law in the area of immaterial damages is anything other than uniform.

2. Transfer to the Input-Output Pattern

This data basis can now be transferred to the concrete input/output pattern for the network. For a classical network of neurons based on McCulloch's model, the input/output pattern is conceivable as a binary as well as an analog background; the network can then be trained according to the back propagation algorithm.

Both possibilities are currently being investigated by us in a software simulation. The first results are very promising; however, due to the very limited computing capacity available to us (PC 80386 with 80387 co-processor) no conclusive results can yet be presented because the simulation of networks of this magnitude requires an enormous amount of calculating. For this reason, both possibilities shall only be briefly introduced :

a) Binary Background

For each level of the severity and duration of an injury and the duration of the respective diminishment in earning capacity, an input neuron is reserved as the binary input. For four levels each these are therefore :

32 body parts * each (4 levels of severity of injury
+4 levels of duration of injury)

\+ 5 gradations of diminishment of earning capacity * 4 levels of duration

\+ 1 neuron to distinguish male/female

\+ 1 neuron occupation yes/no

\+ 1 neuron particular severity yes/no

\+ 1 neuron medical malpractice yes/no

= 32 * 8 + 5 * 4 + 4 = 280 input neurons assigned (!).

for the creation of the output pattern, the awarded amount of immaterial damages are divides into 13 levels for which one output neuron is reserved for each, resulting in a total of 13 output neurons.

The Network has one or more hidden layers. As activation function, a sigmoid function is employed for all neurons of the hidden and output cells.

b) Analog Background :

One analog cell is sufficient for the severity and duration of the injury and the duration of the respective diminishment of earning capacity. This results in a number of

32 body parts * each (1 levels of severity of injury
+1 levels of duration of injury)

+ 5 gradations of diminishment of earning capacity * 1 neuron for duration

+ 1 neuron to distinguish male/female

+ 1 neuron occupation yes/no

+ 1 neuron particular severity yes/no

+ 1 neuron medical malpractice yes/no

32 body parts * 2 + 5 * 1 + 4 = 73 input neurons.

For the output values to be trained, only one analog neuron is required. The activation function of the output cells must have a value range of at least 1-300,000 (hightest German Mark value of out training court awards). For example, a simple linear activation function is usable.

Based on the experience gathered thus far, a combination of hidden cells with sigmoid and those with sinus activation function is usable. Based on the experience gathered thus far, a combination of hidden cells with sigmoid and those with sinus activation functions are preferred for synthesising an analog output value from input values. In reality, the system interpolates from the trained example values a function (in our case with 74 dimensions!) which for the learned input values results in the correct output values and for the non-learned input values in at least acceptable output values.

APPENDIX

I. A short introduction into the neural networks idea

The basic idea of a neural network is the idea that an artificial system of the human brain with similar abilities such as associative and abstract thinking can only be achieved if it is based on an architecture and working method which is similar to the human brain : Similar to the brain, neural networks consist of a multitude of single cells (neurons) which are closely interconnected. Each neuron processes the signals sent to it from an adjoining cell in accordance with a simple mathematical or logical function and further sends the result to the neurons connected at its output side. If a signal from the outside is given to a number of neurons (input neurons), this signal is spread over the network and is transformed into an output signal which is emitted by the output neurons.

A neural network is not to be programmed, but it is trained : if the input-output combination which is to be learned is aplied to the input and output side, the connections between the neurons are so marked or weakened, that later, each time the input signal is applied, the corresponding output signal will be produced independently. The learning process therefore does not take place in the neurons, but rather in the connections (with respect to the brain, the synapses).

With respect to our simulations, we followed the classical model of the neuron as set forth by McCulloch and, in particular, Rosenblatt. We used a feed-forward network, which is to be trained by the backpropagation algorithmus. An exact mathematical description of this network and the employed model is not to be given here, since there is already a lot of literature about this subject. (1)

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(1) An introduction is given in McClelland : Rumelhart, Volume 1 : Foundations, Cambridge Massachusetts USA 1985.

An overview is given by Weick. M., Hopfield Model. Boltzmann Machine, Multilayer Perceptron and Selected Applications in Haken (ed.) Neural and Synergetic Computers, pp. 111-119.