THE ELEMENTS OF ARTIFICIAL INTELLIGENCE IN MACHINERY

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Summary

The paper presents the cardinal usage of the methods of artificial intelligence in technical diagnostics. Chosen systems were attributed a special expert part, helping the process of diagnostic inference. Logging to expert knowledge systems is often possible for experts only.

Keywords: artificial intelligence, technical diagnostics, expert systems

1. Introduction

Virtual techniques based on artificial intelligence are an important element of technological progress in this century. One of these techniques are artificial neural networks. They have a wide spectrum of possible use in engineering science. Thanks to their usefulness, artificial neural networks are increasingly popular among global corporations and, together with other elements of artificial intelligence, become an integral part of daily work.

2. Artificial neural networks

A neural network (artificial neural network) is a generic name of mathematical structures and their software or hardware models performing calculations or processing signals through some basic elements of performing an operation on their entrance called neurons [5] Artificial neural networks are formed on the basis of an interdisciplinary fusion of traditional sciences, including biology, physics and mathematics. Their rapid development occurred in recent years as a result of increased efficiency and capacity of computers, database capacity, the complexity of system software and applications. Fig. 1 shows a diagram of an artificial neural network.

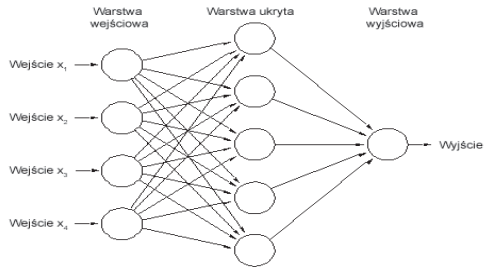

Fig. 1. A diagram of an artificial neural network

The main feature of systems based on artificial neural networks which distinguishes them from typical algorithms for information processing is the ability to generalize. Otherwise, it is defined as the ability of neural networks in approximation of functions of several variables, in contrast to enable the interpolation to obtain algorithmic processing.

3. The use of artificial neural networks

It is difficult to list all the currently frequent use of neural networks. Until now, the most commonly encountered technical application area of neural networks are the issues of recognition, especially recognition of the problem context. Neural networks also apply to the task of classification, image analysis and processing. Here we can distinguish compression, segmentation, playback and image understanding. To classify and recognize patterns, the network learns their fundamental characteristics such as geometric mapping, pixel layout pattern, the distribution pattern of the main ingredients, components of Fourier transform or other features. During the process of learning, differences are highlighted in different patterns. Another field of application is the use of neural networks in classic signal processing tasks, such as conversions, filtration and approximations, and other mapping and transformations.

More and more work describes the structure of these networks and their applications. Another frequently encountered application of neural networks relates to robotics, automation, and control theory and optimization issues, perception and movement planning. In the issues of identification and process control, dynamic neural network usually has several functions. It constitutes a nonlinear model of this process, allowing the elaboration of an appropriate signal. It also serves as a tracking system, adapting to changing environment. An important role, especially in the control of robots, is played by a function of classifier used in deciding what to proceed with. Examples of specific applications are given below:

– NASA uses neural networks to control the manipulator arm operating in the hold space shuttle, allowing the maintenance of manipulated objects in a constant position in conditions of weightlessness,
– Scientists from New York University Medical Center applied the network as an alternative to complex and time-consuming calculation tensor robot motion parameters, thus allowing the acceleration of the control system and robot work in real time,
– Company General Dynamics for U.S. Navy developed a system based on neural network classifier and diagnosing sonar signals, allowing the identification of the vessel and even building waterfronts (i.e. a helicopter hovering above the ocean surface),
– Memorial Anderson Hospital in South Carolina used neural networks for the optimization of treatment, contributing to significant savings while primarily saving the lives of dozens of patients,
– General Devices Manufacturer Missile Space Systems Division used neural networks to control the operation of 150 affarent valves for fuel and oxygen for Atlas rocket engines which were used to replace unreliable and expensive complex automation system based on hundreds of sensors,
– Eaton Corporation used neural network control system in supporting the work of large truck drivers (five-axle, eighteen wheels) in the performance of some particularly difficult manoeuvres (such as withdrawing from the trailer)
– U.S. Air Force (U.S. Air Force) use neural networks in the development of flight simulators,
– Ford Motor Company Group prepared a new diagnostic system for engines

– Airlines-TWA apply neural networks to locate bombs in their terminal at JFK airport in New York,
– In the energy sector, such as BC Hydro power station in Vancouver, neural networks are applied to forecast the demand for electrical power,
– Halliburton Company uses neural networks to identify the type of rock encountered during the conduct of drilling for oil and gas deposits.

Despite a huge number of applications of neural networks, the possibility of their further use in signal processing are not yet fully explored, and it seems that they will be evolving along with the progress of information technology.

4. Types of neural networks

The types of neural networks are presented below:
– Feed-forward backprop
– Cascade-forward backpropagation
– Elman backpropagation network
– Competetive
– Feedforward time delay,
– Feedforward distributed time delay,
– Generalized regression,
– Radial basis,
– Hopfield,
– Linear Layer,
– Recurrent layer,
– LVQ (Learning Vector Quantization),
– NARX (Nonlinear AutoRegressive eXogenous English model,
– Perceptron,
– Radial basis.

Figure 2 presents a two-layer, unidirectional neural network with error back-propagation (multilayer perceptron) obtained by using the Neural Network Toolbox MATLAB program

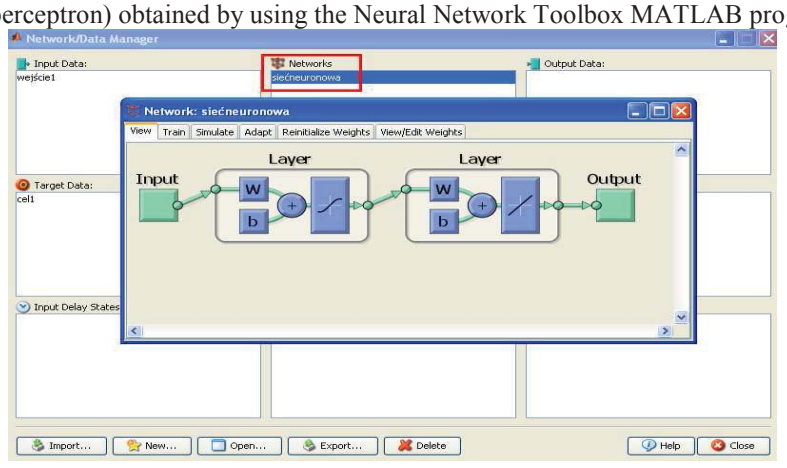

Fig. 2 Multilayer Perceptron

5. Advantages and disadvantages

Advantages

From the perspective of a programmer, artificial neural networks do not require programming. Once created, a network takes care of itself. The role of a programmer is limited to designing a network structure, which is best fitted for a problem, and then to skilful directing the learning process network. The case is analogous for each man. To be a specialist in some area, you must first have some innate abilities in the field (an appropriate structure on one's own neural network, which is the brain), and secondly – have a good teacher.

Another advantage: in case of a standard program, the smallest mistake can lead to system malfunction, data loss, and other misfortunes. However, a neural network even in case of serious damage continues its work. Of course, to some extent. Analogies can be observed – our brain continues to operate after an accident in which a small injury occurred; it works despite the destruction of neurons in the alcohol or aging process; it works for a long time without "crash", though its structure is still altered. After exceeding a certain threshold of damage, the brain refuses to obey.

Another important advantage is the ability to generalize knowledge. This means that if the network learns, say, recognize colours: red and yellow, it would recognize the pink and pale yellow, a colour similar to the known.

In short, the advantages can be summarized as:

– Parallel processing,
– The ability to generalize,
– No assumptions about the distributions of the investigated variables,
– In case of a large number of elements, the network is resistant to the damage of some elements.

Disadvantages

Nothing is perfect. Neural networks are not particularly useful when one needs clear and accurate results – that is, with a variety of complex calculations, use of bank accounts etc. This is due to the fact that the ANN is a reflection of the human brain, but this is not suitable for precise handling of numbers. When we describe someone, we do not say that he or she is 188.34 cm tall, but that the person is tall. And it is not so much because the accuracy of this information is sufficient, but because without an appropriate measuring apparatus, our brain is unable to accurately assess a certain size. Thus, the so-called PPS operates fuzzy concepts: high, low, big, small, medium, light. Often, if we expect the network to state "yes" or "no", it says, "rather yes" or "probably not".

The latter tendency may be either a network fault, and an advantage – it depends on how you look at it. An artificial neural network does not work well if the specifics of the problem requires multi-step reasoning. When you need to strenuously assert certain conclusions based on the results of earlier reasoning and use these conclusions further – a network will fail. It will solve the task at once, in one step. Even if there are some intermediate conclusions, it does not have access to them. This last feature may seem strange to someone who has grown used to the idea that the ANN simulates the operation of the brain. After all, a man argues step by step, drawing conclusions from one another.

That's a fact, but the reasoning can be divided into individual stages, in which we operate "at a time." We have some data and draw a proposal from them. This proposal will serve to draw the

next, even in such a single process. Reasoning that this model would correspond to the whole team rather different neural networks, and it is not necessarily connected linearly. Data from the output of a network could occur at the entrance of another network.

6. Solving decision problems

Neural networks are used mostly as a mechanism to control processes or as a mechanism for decision-making. Currently neural networks can solve the following issues:
– Data Analysis,
– Classification,
– Prediction,
– Optimization,
– Filtering signals.

Data Analysis

Neural networks are used for searching data in terms of causality, or incidentality. This analysis identifies the causes of failure, while in the case of economic data analyzes company's financial condition or capital market.

Rating

Neural networks can predict the ID class. With them you cannot have the expertise to recognize and find relevant user data. There are many possible uses: an image recognition, handwriting, face, identify regions at risk of unemployment.

Prediction

Prediction allows identification on the basis of input and output parameters. Capacity network applications in this field may be: forecasting demand for workers, predictive capability of machines, credit rating, prediction of selected indicators of macro and microeconomic prediction of crop yield in agricultural forecasting bank failures. Despite the lack of data on the mechanisms controlling data processes through a neural network you can get the ability to predict output signals, only under observation. Jurisdiction shall be used primarily with reference to problems that are not available or algorithms that are usually difficult to obtain.

Optimization

Neural networks make it possible to find optimum solutions to the problem under consideration; you can apply neural networks to optimize dynamic and static, as well as to solve linear and nonlinear equations.

Filtration of signals

The filtering of signals is most commonly used for telecommunications equipment and devices for automatic medical diagnosis. Filtering can include the removal of these inputs, which will cause deliberate interference while getting rid of systematic errors, and supplementing incomplete data, which contrasts with statistical methods.

7. Neural network in neural network toolbox

Artificial neural networks are used for many problems in research work. Tests were carried out during the creation and training of artificial neural networks that solve the analysis problem of bearing qualifications. Bearing vibration tests were performed at the Department of Mechanical Engineering UTP in Bydgoszcz.

Table 1 presents examples of measurement results for nine measurements made on a weekly basis. The aim of this study was to observe changes in the technical condition of the bearings. To examine the condition multiple measures of the process such as RMS vibration were used.

In order to implement the first example of a neural network for machine condition a part of the results marked with green and yellow was selected.

The results of the first measurement of the bearings are capable of results for the subject.

Table 1. The measurements results of vibrations in the bearings

WYNIKI BADAŃ P.Z. DLA 20 SESJI, ŁOŻYSKO I, PRZY PRĘDKOŚCI V1									
Sygnał	Uśr	U(t)rms	U(f)rms	RMS(p)	Umax	Umin	Kurtosis	Sesgo	Od.stand.
1L1V1	0,063	0,080	0,132	0,003	0,250	0,230	3,249	0,195	0,080
2L1V1	0,051	0,064	0,107	0,002	0,234	0,189	2,963	0,153	0,062
3L1V1	0,048	0,060	0,101	0,002	0,216	0,169	3,015	0,023	0,058
4L1V1	0,048	0,061	0,104	0,002	0,201	0,180	3,193	-0,092	0,060
5L1V1	0,048	0,062	0,107	0,002	0,270	0,270	3,693	-0,392	0,062
6L1V1	0,050	0,064	0,111	0,002	0,245	0,193	3,441	0,291	0,064
7L1V1	0,052	0,067	0,114	0,003	0,217	0,206	3,278	0,112	0,067
8L1V1	0,062	0,079	0,120	0,003	0,260	0,260	3,243	-0,143	0,079
9L1V1	0,077	0,101	0,146	0,002	0,398	0,375	3,752	0,242	0,100

Neural Network Toolbox networking takes place as follows:
– Run the program – MATLAB Neural Network Toolbox,
– Set the parameters for variable names,
– Define the type of network to be created – Feed–forward backdrop – one-way network with error back-propagation (multilayer perceptron),
– Choose Training function – train.lm (Levenberg-Marquardt method),
– Select weighting functions for the correction – learned (straight from the momentum gradient),
– Define an objective function – MSE,
– Define the characteristics of neural network layers,
– The number of layers – 2,
– The number of neurons in layers – 10,
– Activation function: first layer – tansig, the second layer – tansig.

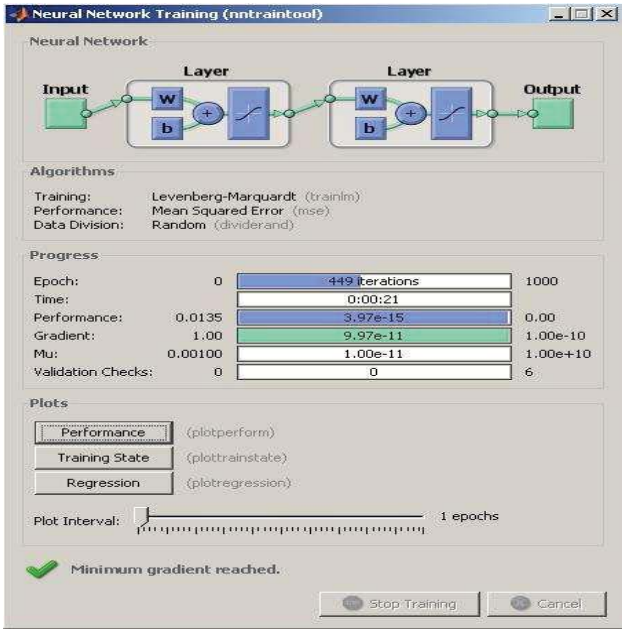

Fig. 3. Neural network training

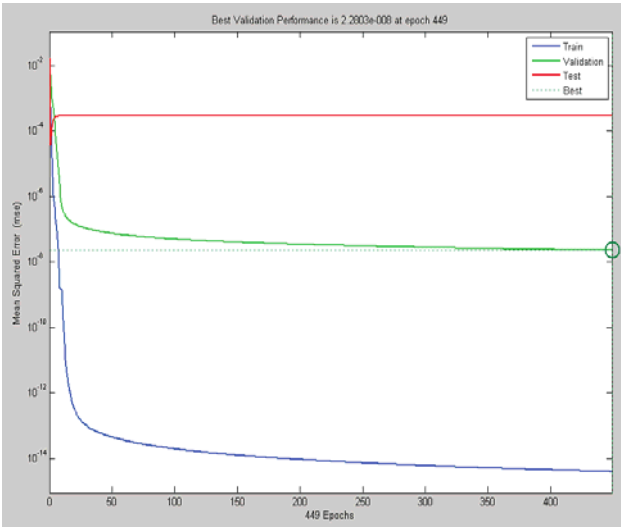

Fig. 4. Flow diagram shows network training parameters

Network parameter training included 1000 reiterations, while the expected error occurres in 449 iterations.

8. Conclusion

Neural networks offer many opportunities for decision – making problems. The study is the first one to see machinery condition as optimizing technological processes. The resulting measurement data can be treated as input vectors to the neural network.

After establishing that the target value is the desired condition of technical equipment, you can create neural networks that optimize processes. One of the three Operational Programmes – Innovative Economy – puts big emphasis on the use of innovative technologies in industry and construction. The use of ultra-modern analytical techniques of measurement data improves the existing machinery condition.

The application of artificial intelligence is a future direction of information development technology, as well as a helpful element in many areas of social life.

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ELEMENTY SZTUCZNEJ INTELIGENCJI W MASZYNACH

Streszczenie

W pracy przedstawiono główne zastosowania metod sztucznej inteligencji w diagnostyce technicznej maszyn. Wybrany system ekspertowy w diagnostyce stanowi podstawowe zagadnienie wspomagania wnioskowania diagnostycznego. Wiedza dla systemu ekspertowego pozyskiwana jest od ekspertów. Zapisanie tej wiedzy za pomocą slotów i ram pozwala zaimplementować ją do komputera, gdzie w różny sposób może być wykorzystywana.

Słowa kluczowe: sztuczna inteligencja, system ekspertowy, baza wiedzy, wnioskowanie

This paper is a part of **WND-POIG.01.03.01-00-212/09** project.

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