# 1.9. What are main advantages of neural networks, who uses them and what are they used for?

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As you already know, neural networks are now very popular computer tool used for solving lot of different practical problems. If you write in Google sentence: *neural networks application* – you receive approximately 17,500,000 answers. So much!

Off course in this set of searching results are many worthless messages, as usually. But also number of serious papers, articles, books and presentations showing different neural networks application can be sure counted in millions.

Why so many researchers and practicing engineers, economists, doctors and other computer users want use neural networks?

It is because of two main advantages of this tool.

* First advantage is network learning. Using neural network I can solve many problems without finding and describing method of such problem solving, without building algorithms by myself, without developing programs, even without any case of my personal knowledge about the nature of solved problem. I must only have some examples of similar tasks with good solutions. If I have collection of such examples (successful solution of considered problem) – I can use neural network, which first can learn these results of solved problem and next can solve many another similar problems. It is really very comfortable and efficient way of problem solving!

Typical example of problem without easy algorithmic solution, which can have comfortable solution when we use neural network and engage learning process is pattern recognition. Theoretical analysis of particular type images (e.g., human faces) leads to conclusion, that we cannot give exact algorithm, which guarantee proper differentiation between faces of different persons and reliable recognize face of particular person irrespective of position, mimic look and illumination variations. But when we use learning neural network we can use many photos of the same persons in different positions and also images of different persons for differentiation and when we use these pictures as learning examples – neural network can learn method of person identification.

Another typical area, where learning neural network can be better than precisely developed algorithm is connected with prediction. We need forecasting many things: weather, money exchange rates, stock prices, results of medical treatments etc. In all prediction problems we know, that future depends on up-to-day status and on history, but in almost all non-trivial problems we cannot propose theoretical model, which can be used for algorithmic forecasting. Fortunately also for this problems neural networks can be used. As learning examples in this tasks can be used occurrences from the history. Every past event can serve as an example of functioning this not known rule combining previous situations with consecutive after-effects, where after-effects are known, because whole example is localized in the past. Having well registered history and taking into account only stationary processes we can develop many very successful neural forecasting models.

* Second advantage can be achieved if I can use neural networks realized as specialized hardware systems. Most neural networks application are based on software solutions. User performs all steps of problem solving procedure i.e. neural network formation, learning and exploiting - using computer simulation. It is most often used way, but not only one way. Now many hardware solutions for neural networks are available. Numerous electronic and optoelectronic systems was developed on the base of neural networks structures, which are working on the base of neural methods of information processing. In this case major advantage can massive parallel processing which is possible in such hardware neural network. In fact in biological brain all neurons are working simultaneously. For vision, hearing and muscle control are activated in the same time billons of biological neural cells. For artificial neural networks the same process can be exploited as well – but only in case of hardware solutions. In my laboratory in AGH University of Science and Technology (Krakow, Poland) we try build such hardware solutions for computer vision purposes using FPGA technology. For details please visit our website <http://www.ia.agh.edu.pl/lab_biocyb/>.

For illustration of usefulness of neural networks I would like show below some examples of neural networks applications. There are only random selected examples, but on the base of such examples you can imagine next neural network applications. If you not interested in this survey – you can omit it and skip directly to subchapter 1.10.

As was mentioned above recognition is most often used application of neural networks. Already first known neural network built by Frank Rosenblatt, was named Perceptron, because was dedicated to automatic perception (i.e. recognition) of different characters. Very similar application neural network for pattern recognition is discussed in paper *Character recognition using feature modification with neural networks learning feature displacement in two opposite directions* (by Kusakabe K., Kimura Y. and Odaka K., in IEICE Transactions on Information and Systems, vol.J94-D, no.6, June 2011, pp. 989-997. Optical character recognition is very often seen example of neural network application and in fact is now a little boring. More interesting task performed by neural network can be automated recognition of human actions in surveillance videos. This problem is solved in paper 3D *Convolutional Neural Networks for Human Action Recognition* (by Shuiwang Ji. Wei Xu, Ming Yang and Kai Yu in IEEE Transactions on Pattern Analysis and Machine Intelligence, vol.35, no.1, Jan. 2013, pp. 221-231). Interesting form of pattern recognition using neural network is also automatic classification of objects on satellite images for environment protection purposes. One of such applications is presented in paper *Detection and classification of oil spill and look-alike spots from SAR imagery using an Artificial Neural Network* (by Singha S., Bellerby T.J. and Trieschmann O. in IGARSS 2012 - 2012 IEEE International Geoscience and Remote Sensing Symposium. IEEE. 2012, pp. 5630-5633).

Not only images can be recognized using neural networks. In many papers another neural-based recognition system are discussed. For example in paper *Automatic Noise Recognition Based on Neural Network Using LPC and MFCC Feature Parameters* (by Haghmaram R., Aroudi A., Ghezel M. H. and Veisi H. in Proceedings of the 2012 Federated Conference on Computer Science and Information Systems. IEEE. 2012, pp. 69-73) the automatic noise recognition problem is discussed. Ability of neural networks to automatic solving of recognition and classification problems is often used in diagnostic applications. For example paper *Neural network broken bar detection using time domain and current spectrum data* (by Gardel P., Morinigo-Sotelo D., Duque-Perez O., Perez-Alonso M. and Garcia-Escudero L.A. in Proceedings of the 2012 XXth International Conference on Electrical Machines (ICEM). IEEE. 2012, pp. 2492-2497) gives very good overview of neural networks applications for early detection and diagnosis of electric motors faults.

In general objects recognized by neural networks can be different, for example in paper *Empirical Comparison of Feedforward Neural Networks on Two-Variable Function Approximation* (by Nonaka K., Tanaka F. and Morita M., in IEICE Transactions on Information and Systems, vol.J94-D, no.12, Dec. 2011, pp. 2114-2125) recognized objects are mathematical functions. Also nonlinear dynamic system identification (for automatic control purpose) can be performed by neural network, as was presented in paper *Dynamic neural networks with hybrid structures for nonlinear system identification* (by Jiamei Deng in Engineering Applications of Artificial Intelligence, vol.26, no.1, Jan. 2013, 281-292).

Many neural networks applications are connected with computer vision and image processing. Typical example of such type research related to medical purposes is given in paper *Automatic segmentation of dermoscopy images using self-generating neural networks seeded by genetic algorithm* (by Fengying Xie and Bovik A.C. in Pattern Recognition, vol.46, no.3, March 2013, pp. 1012-1019). Another example of medical image processing by means of neural networks can be found in paper *Pulse Coupled Neural Networks and Image Morphology for Mammogram Preprocessing* (by Wolfer J. in Proceedings of the 2012 Third International Conference on Innovations in Bio-Inspired Computing and Applications (IBICA). IEEE Computer Society. 2012, 286-290). Not only medical images are analyzed using neural networks. Paper entitled *Coastline extraction from SAR COSMO-SkyMed data using a new neural network algorithm* (by Latini D., Del Frate F., Palazzo F. and Minchella A. in IGARSS 2012 - 2012 IEEE International Geoscience and Remote Sensing Symposium. IEEE. 2012, pp. 5975-5977) show application of neural network for satellite images processing for geosciences purposes.

As was mentioned above, forecasting is one of most typical applications for neural networks. Concrete example of such application can be found in paper *Employing artificial neural networks for prediction of electrical arc furnace reactive power to improve compensator performance* (by Samet H., Farhadi M.R. and Mofrad M.R.B. in 2012 IEEE International Energy Conference (ENERGYCON 2012). IEEE. 2012, pp. 249-253). Another example of neural based forecasting is given in paper *Wind power plant prediction by using neural networks* (by Ziqiao Liu, Wenzhong Gao, Yih-Huei Wan and Muljadi E. in 2012 IEEE Energy Conversion Congress and Exposition (ECCE). IEEE. 2012, pp. 3154-3160).

Examples of neural network application can be listed even in thousands, but in fact it is not necessary. You can find many other examples using internet searching machines like Google. Important is the conclusion of above given survey: Neural networks are now very useful tool in many areas of scientific and professional activity, and therefore definitely it is worth to learn about their structures, operation and way of applications.