СБОРНИК ДОКЛАДИ

НАУЧНА КОНФЕРЕНЦИЯ

НА МЛАДИТЕ ИЗСЛЕДОВАТЕЛИ

18 май 2018 г.

Велико Търново

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ВЕЛИКОТЪРНОВСКИ УНИВЕРСИТЕТ „СВ. СВ. КИРИЛ И МЕТОДИЙ“

ФАКУЛТЕТ „МАТЕМАТИКА И ИНФОРМАТИКА“

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CONVOLUTIONAL NEURAL NETWORK AS AN ARCHITECTURE FOR DEEP LEARNING

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Abstract: *Machine learning has become important for solving problems in many areas: computational finance, image processing and computer vision, face recognition, motion detection, object detection, tumour detection, drug discovery, DNA sequencing, energy production, price and load forecasting, automotive, aerospace, manufacturing, predictive maintenance, etc. The paper reviews the machine learning as a process for teaching computers to learn from experience or directly from data without being based on a predefined equation as a model. Then neural networks are considered. Special attention is paid to the deep learning and some architecture for deep learning are reviewed. For this research and further research the most important architecture for deep learning is convolutional neural network and we will hold on to it.*

Keywords: *machine learning, neural networks, deep learning, CNN.*

INTRODUCTION

The process that teaches computers to learn from experience is known as Machine learning. Algorithms for machine learning use methods that can learn information directly from data without using on before determined equation as a model. These algorithms give better decisions and predictions [17].

There are two techniques for machine learning:

– Unsupervised learning – this kind of learning is useful when we want to explore data but do not yet have a specific goal or we do not what at all what kind of information the data contains. Most techniques for unsupervised learning are a form of cluster analysis [17];

– Supervised learning – the algorithms for this technique for learning work with known set of input and output data and trains a model to generate predictions for new input data. There are given training examples $Z = \{z_1, z_2, \ldots, z_n\}$ with the z_i examples sampled from an unknown process $P(Z)$. Also a loss functional L which takes as argument a decision function f and an example z_i, and returns a real-valued scalar is given. The goal is to minimize the expected value of $L(f, Z)$ under the unknown generating process $P(Z)$. Each example is presented as a pair $Z = (X, Y)$ and f takes an X as argument. All supervised learning techniques are a form of classification or regression [4], [17].

– classification: Y is a finite integer which corresponds to a class index, and often is taken as loss function the negative conditional log-likelihood, with the interpretation that $f_i(X)$ estimates $P(Y = i \mid X)$: $L(f,(X,Y)) = -\log f_Y(X)$, with the constraints $\sum_i f_i(X) = 1, f_Y(X) \geq 0$

– regression: Y is a real-valued scalar or vector, the output of f is in the same set of values as Y, and we often take as loss functional the squared error $L(f,(X,Y)) = \| f(X) - Y \|^2$.

EXPOSITION

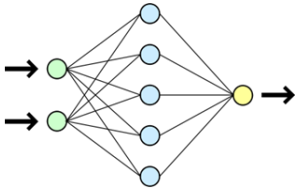
Neural networks

In the conventional programming approach, the programmers telling the computer what to do, also they break a big problems up into a lot of small problems in order to make the computer easier to perform. Otherwise, when the people work with neural network they don't tell the computer how to solve the problem. Instead, it learns from observational data, trying to give its own solution to the problem [19]. Neural network present mathematical model similar with the model of human brain. There are two types of neural networks: biological and artificial neural network.

Artificial neural network (ANN) is an algorithm for learning. It is also a paradigm for processing information. The structure of this processing information system is composed of a number of interconnected processing elements named neurons that work all together to solve specific problems. Neurons are split into layers and each layer performs a certain change in the input parameters [22]

There are three major groups of neurons (Fig. 1): **Input neurons (input layer),** in this layer of neurons, the direct neuronal network inputs from the outside world are defined and implemented in the neural processing network. **Hidden neurons (hidden layer)** or even called the middle layer, is a layer of neurons where the input is indirect and is obtained from the previous layers or directly from the input layer when it comes to neurons from the hidden layer that are placed at the very beginning the hidden layer. The last layer is the **output layer** that defines neurons that give way out of processing that is executed on the implemented input [10], [21].

Artificial neural networks consist of the following components: inputs, which are multiplied by weight coefficients, and then are computed by some mathematical function (like summation function and transfer function) which determines the activation of the neuron (activation function) and at the end there is an output (Fig. 2) [10], [21].



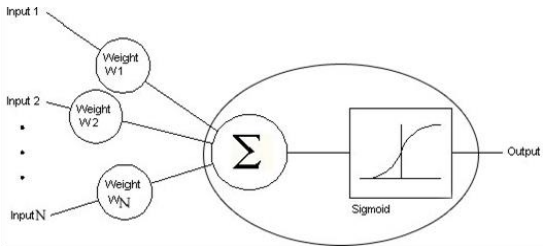


Fig. 1. *Artificial neural network* ***Fig. 2.*** *Artificial neural networks components*

The most important features of artificial neural networks are:

1. Have the ability to learn
2. Have the ability to generalize
3. They are resistant to wrong input and noise

Modern neural networks are tools for non-linear statistical data modeling. Neuronal networks, with their extraordinary ability to derive meaning from complicated or imprecise data, can be used to produce patterns and detect trends that are too complex to be noticed by humans or other computing techniques. A trained neural network can be considered as an expert in the category of information that is given to be analyzed. Then, this expert can be used to provide forecasts in given situations in the domain of interest, and to answer the questions of the type "what if ...?".

Artificial neural networks (ANNs) provide a general, practical method for learning real-valued, discrete-valued and vector-valued functions. ANN learning is successfully applied to issues such as interpretation of visual scenes, speech recognition, and robot learning strategies.

Deep learning

Deep Learning is a new area of Machine Learning research that learns features and tasks directly from data. This data can include images, text, or sound. Also this method is based on learning data representations. Learning can be supervised, partially supervised or unsupervised. Deep learning can also be defined as an AI method, a powerful set of techniques for learning in neural networks. It allows computational models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction and is almost everywhere: Object recognition, Object classification, Object detection, segmentation, pose estimation, Image captioning, question answering, Machine translation, Speech recognition, Robotics [14], [25].

The work of deep learning is given on Fig. 3.

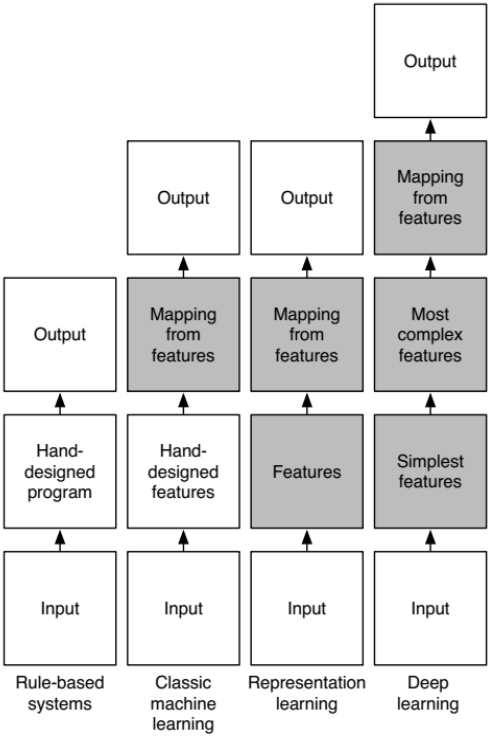


Fig. 3. *Work of deep learning (Bengio, 2015)*

Deep learning (also known as hierarchical learning) is the application to learning tasks of artificial neural networks (ANNs) that contains more than one hidden layers. There are many different architectures for deep learning such as deep neural networks, deep belief networks, recurrent neural networks and convolutional neural network and they have been applied to fields such as computer vision, speech recognition, natural language processing, audio recognition, social network filtering, machine translation and bioinformatics.

Different architecture for deep learning

A **deep neural network** (DNN) is an ANN with a certain level of complexity, with multiple hidden layers between the input and

output layers. This networks use sophisticated mathematical modelling to process data in complex ways. Each layer performs specific types of sorting and ordering in a process known as feature hierarchy. These sophisticated neural networks are often used to work with unlabelled or unstructured data (Techopedia).

A **deep belief network** (DBN) is a generative graphical model, or alternatively a type of deep neural network, composed of multiple layers of hidden units, with connections (edges) between the layers but not between the units within each layer. DBN can also be defined as a class of deep neural network which comprises of multiple layer of graphical model having both directed and undirected edges. In the DBN, the input layer represents the raw sensory inputs, and each hidden layer learns abstract representations of this input. The output layer, which is treated somewhat differently than the other layers, implements the network classification. Training occurs in two steps: unsupervised pre-training and supervised fine-tuning [4], [29].

The **recurrent neural networks** (RNN) is one of the base network architectures from which other deep learning architectures are built. The primary difference between a typical multilayer network and a recurrent network is that rather than completely feed-forward connections, a recurrent network might have connections that feed back into prior layers (or into the same layer). This feedback allows RNNs to maintain memory of past inputs and model problems in time. The key differentiator is feedback within the network, which could manifest itself from a hidden layer, the output layer, or some combination thereof. [14]

A **convolutional neural network** (CNN) is comprised of one or more convolutional layers and then followed by one or more fully connected layers as in a standard multilayer neural network. They are extremely effective at complex image recognition problems because their architecture is designed to take advantage of the 2D structure of an input image. Beside images, the CNN has been successfully applied to video recognition and various tasks within natural language processing. The LeNet CNN architecture is made up of several layers that implement feature extraction, and then classification (Fig.4.) [30], [2], [6].

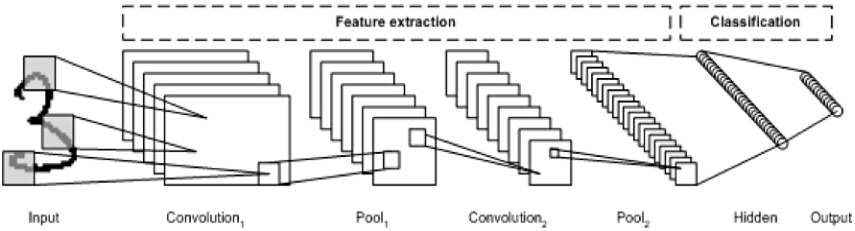


Fig. 4. *CNN architecture*

The image is divided into receptive fields that feed into a convolutional layer, which then extracts features from the input image. The next step is pooling, which reduces the dimensionality of the extracted features (through down-sampling) while retaining the most important information (typically through max pooling). Another convolutional and pooling step is then performed that feeds into a fully connected multilayer perceptron. The final output layer of this network is a set of nodes that identify features of the image (in this case, a node per identified number). The network is trained by using back-propagation [23], [8].

The first layer in a CNN is always a Convolutional Layer. The input to this convolution is an image where m is the height and width of the image and r is the number of channels, e.g. an RGB image has $r = 3$. The convolutional layer have k filters of size $n \times n \times q$ where n is smaller than the dimension of the image and q can either be the same as the number of channels r or smaller and may vary for each filter. The filters produce k feature maps of size $m-n+1$. Each map is then subsampled typically with mean or max pooling over $p \times p$ contiguous regions where p ranges between 2 for small images and is usually not more than 5 for larger inputs. Either before or after the subsampling layer an additive bias and sigmoidal nonlinearity is applied to each feature map [14], [27], [12].

In addition, some of the main shortcomings of these techniques are presented and also are explored research that seeks solutions to overcome them, as following:

In the paper [7] the difficulties involved in training deep neural networks are given. To improve deep learning architectures an analysis is given of the activation values in four different architectures using

various activation functions. Current state of the art classifiers use dropout, max-pooling as well as the maxout activation function. New components may further improve the architecture by providing a better solution for the diminishing gradient problem.

Deep Learning have shown promising results, but such techniques find it difficult to process natural language. Calibrated Quantum Mesh (CQM), on the other hand, is an AI specifically developed for language (Project Coseer). CQM is designed to emulate cognitive steps of humans when they solve any problem, such as understanding a text written in natural language.

According to [16] in the field of deep learning in the five subsequent years wasn't discovered something new. Against a background of considerable progress in areas such as speech recognition, image recognition, and game playing, and considerable enthusiasm in the popular press, he present ten concerns for deep learning, and suggest that deep learning must be supplemented by other techniques.

CONCLUSION

In this paper, we make an overview at recent studies about machine learning, neural network, deep learning and architecture for deep learning. In the future research we will concern mainly on CNN as an architecture for deep learning because we are going to work with object recognition in images. It is known that with the development of CNN architectures, a computer can be better than human performance in object recognition task under some specific conditions, as in case of face recognition [11].

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