1. **Neural networks concept and structure**

Neural networks are one of the most successful technologies during the last two decades. This mathematical model structure is inspired by the biological neural network. Such an algorithm can "learn" to solve the required problem by changing the weights used in the model [6].

* 1. **Neuron**

The neuron is a key part of every neural network. It is a simple mathematical model that consists of three rules: multiplication, addition, and activation. Figure 3 shows a neuron that consists of the input or so-called machine learning model properties, weights, bias, activation function and output.

Diagram

Description automatically generated

3 fig. Artificial neuron [6]

In the artificial neuron, the information comes via input and each property is individually weighted then the main part of the artificial neuron sums the multiplied properties together with the bias which is equal 1 at the beginning of the model. At the end neuron passes the results via output [6]. The simplicity of an artificial neuron is reflected in its mathematical expression:

Text

Description automatically generated with low confidence

* xi(k) is input value in discrete time k where i goes from 0 to m,
* wi(k) is weight value in discrete time k where i goes from 0 to m,
* b is bias,
* F is a transfer function,
* yi(k) is output value in discrete time k.

From a model is seen that the major unknown is transfer function. This function can be any mathematical function that describes the properties of an artificial neuron. The choice of activation function depends on the problem you are solving.

* 1. **Artificial neural network**

**Diagram

Description automatically generated**

4 fig. Artificial neural network [6]

Figure 4 shows an example of an artificial neural network consisting of an input layer marked as 1, hidden layers marked as 2 in which basic calculations are performed and an output layer marked as 3 in which a prediction is obtained. Each of these layers is made up of many artificial neurons.

A neural network is obtained by combining two or more neurons. The aggregation of individual neurons is called the neural network topology. That is the architecture of the neural network. There are many different topologies, but the two main classes are feed-forward (FNN) and recurrent (RNN) topology. In the case of a feed-forward topology information travels from the input layer to the output layer in one direction. In other words, information leaves a certain layer and does not return to it [6]. In the case of a recurrent topology, the information can return to any layer of the model, so information flows not only in one direction.

At the beginning of the model, weights are randomly assigned to the input properties. Weights at the beginning are very small and close to 0 but they are changing during the training. In the training phase of the algorithm, all input properties are multiplied by the respective weights and summed then the activation function is triggered from which the result goes to the next layer of the neural network and the same operations are performed. Only the number of neurons and their activation functions can differ [6]. After passing all the layers we get a prediction from the output layer which is compared to the real value. Then the average error of the predictions is calculated according to the selected loss function.

After calculating the average error we return to the beginning of the model where new weights are assigned to reduce the mean error of the loss function. This is done on the principle of back-propagation. This calculation method uses the calculated mean value of the error and changes the values of all the weights and biases in the model according to loss function gradient. Input properties with new weights and bias flows through all layers and a new average error is calculated. This process is repeated until a certain average error is reached or as many times as it’s specified in the model itself. This number of iterations is called epochs.

[6]  Krenker, Andrej, Janez Bešter, and Andrej Kos. ”Introduction to the artificial neural networks.” Artificial Neural Networks: Methodological Advances and Biomedical Applica-  
tions. InTech (2011): 1-18.

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