MAI4CAREU

Master programmes in Artificial Intelligence 4 Careers in Europe

University of Ruse

INTELLIGENT COMPUTER SYSTEMS

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LECTURE 10

NEURAL NETWORK STRUCTURES

1. Neuron model
2. Neural network model
3. Neural networks according to typology
4. Neural networks according to connection weights
5. Neural networks according to the direction of the signal
6. Neural networks according to input and output value
7. Learning

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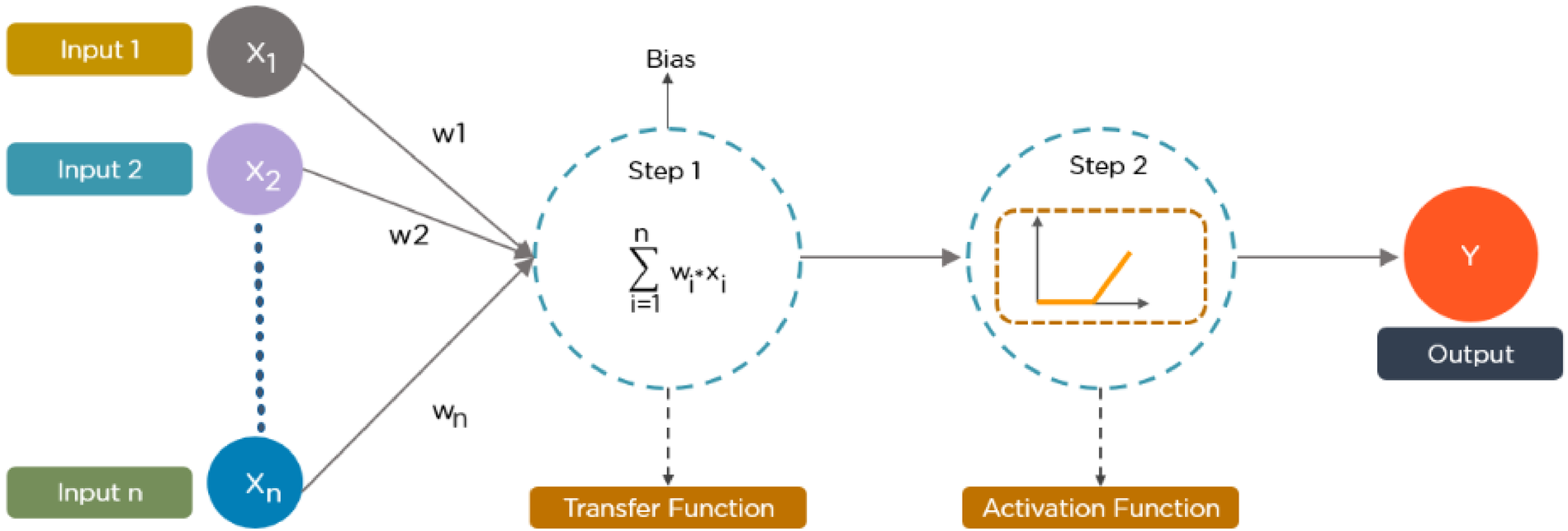
CONTENT 1

Structure of a neuron



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CONTENT 1

Input data

The basic artificial neuron model contains a set of **adaptive parameters, called weights**, as in linear regression.

Example: when shopping, we take different products with different quantities and unit price.

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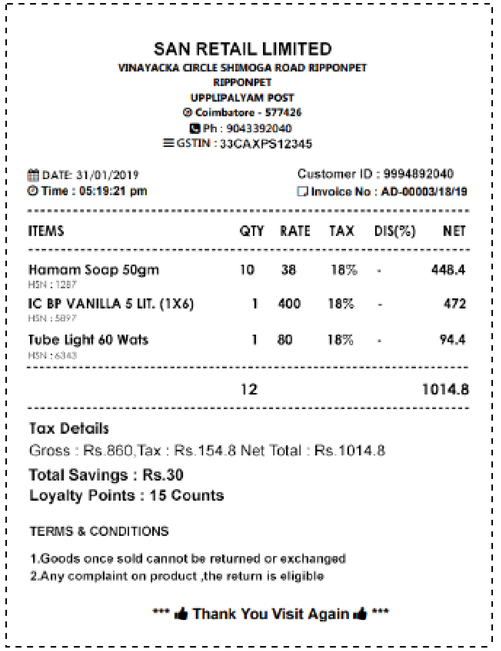
CONTENT 1

Transfer function

A weighted sum of the inputs, i.e. sum of weights multiplied by the inputs or a linear combination of the inputs. In reality, a bias is also added.

Example: the shopping bill is obtained by adding the quantity of each product multiplied by its unit price.



SAN RETAIL LIMITED
VINAYACKA CIRCLE SHIMOGA ROAD RIPPONPET
RIPPONPET
UPPLIPALYAM POST
Coimbatore - 577426
Ph : 9043392040
GSTIN : 33CAXPS12345

DATE: 31/01/2019 Customer ID : 9994892040
Time : 05:19:21 pm Invoice No : AD-00003/18/19

ITEMS	QTY	RATE	TAX	DIS(%)	NET
Hamam Soap 50gm HSN : 1287	10	38	18%	-	448.4
IC BP VANILLA 5 LIT. (1X6) HSN : 5897	1	400	18%	-	472
Tube Light 60 Wats HSN : 6343	1	80	18%	-	94.4
	12				1014.8

Tax Details
Gross : Rs.860,Tax : Rs.154.8 Net Total : Rs.1014.8
Total Savings : Rs.30
Loyalty Points : 15 Counts

TERMS & CONDITIONS
1.Goods once sold cannot be returned or exchanged
2.Any complaint on product ,the return is eligible

*** Thank You Visit Again ***

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CONTENT 1

Activation function

Defines the output with a given input or set of inputs.

It actually decides whether the "weighted sum" of the input along with the bias should be "shot" to the output or not.

Only non-linear activation functions allow non-trivial problems to be solved using a small number of nodes.

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CONTENT 1

Some activation functions

- **linear** - does nothing and only outputs;
- **step** - if the input value is >0, it sends a signal (ON), otherwise it does nothing (OFF);
- **sigmoid** - a "lighter" version of the step function.

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$

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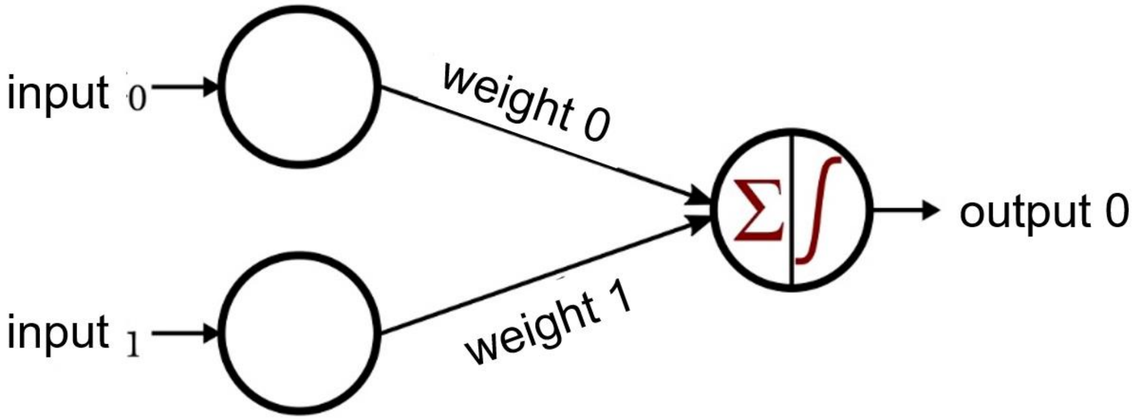
CONTENT 1

A generalized model of a neuron

- **linear** - does nothing and only outputs;
- **step** - if the input value is >0, it sends a signal (ON), otherwise it does nothing (OFF);
- **sigmoid** - a "lighter" version of the step function.



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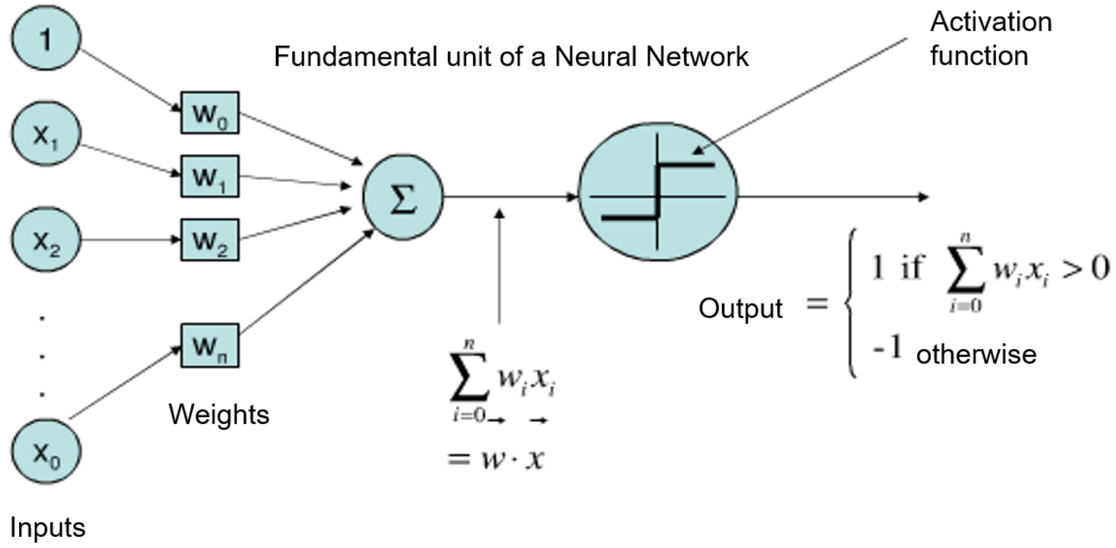
CONTENT 1

A model of a neuron with a step activation function

The sum of the products of the weights Wi and the inputs Xi is calculated at each node and compared to some **threshold** (usually 0):

- f the net value is above the threshold - the neuron is activated and takes the activated value (usually 1);
- if the net value is below the threshold - the neuron takes the deactivated value (usually -1).



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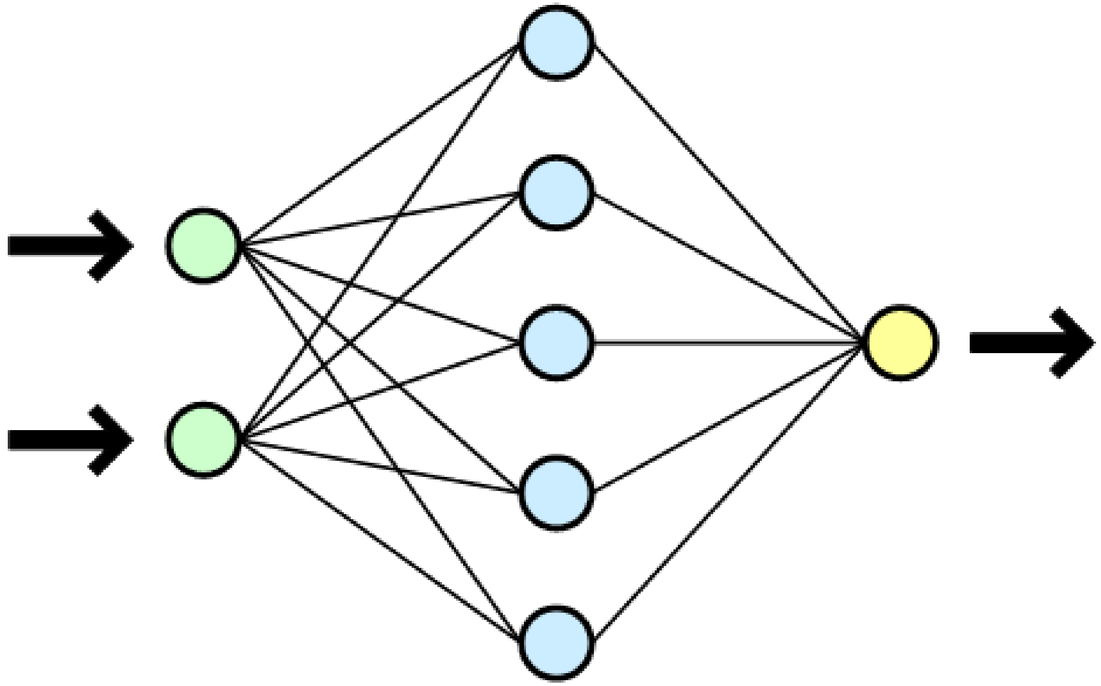
General architecture of NN



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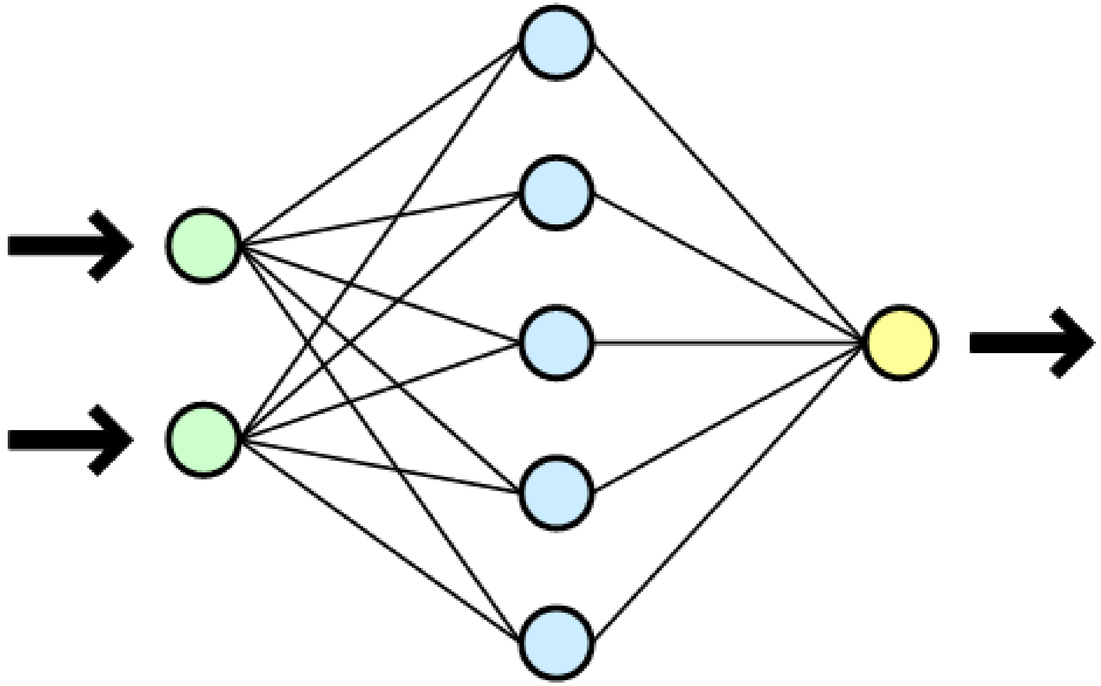
NN topology

Most often, NNs are composed of several successive layers of elements:

- **the elements of the lowest layer** play the role of input devices of the network by perceiving signals from the external environment;
- **the elements of the top layer** play the role of output devices of the network by outputting the result of the operation of the network, which is obtained based on the input signals and the weights of the connections between the elements.



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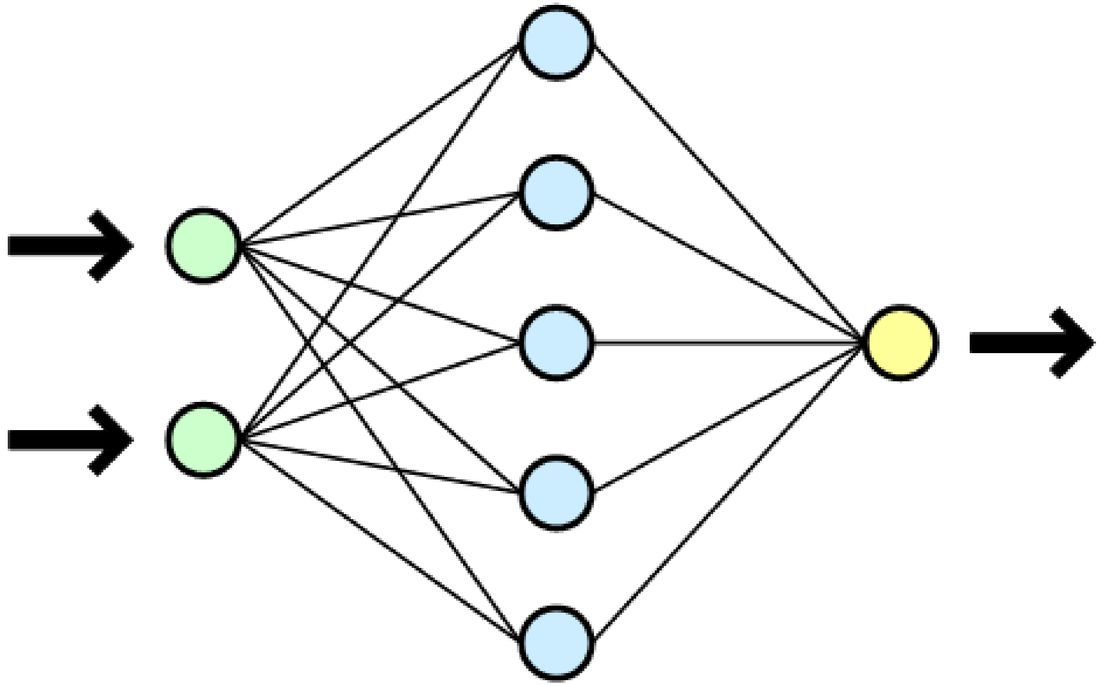
Input layer

Input layer - consists of neurons that receive the input data directly from the dataset.

The number of elements of the input layer - is determined by the dimensionality of the input data;

Example: in an image recognition task, the input layer will use as input the pixel values from the given image.



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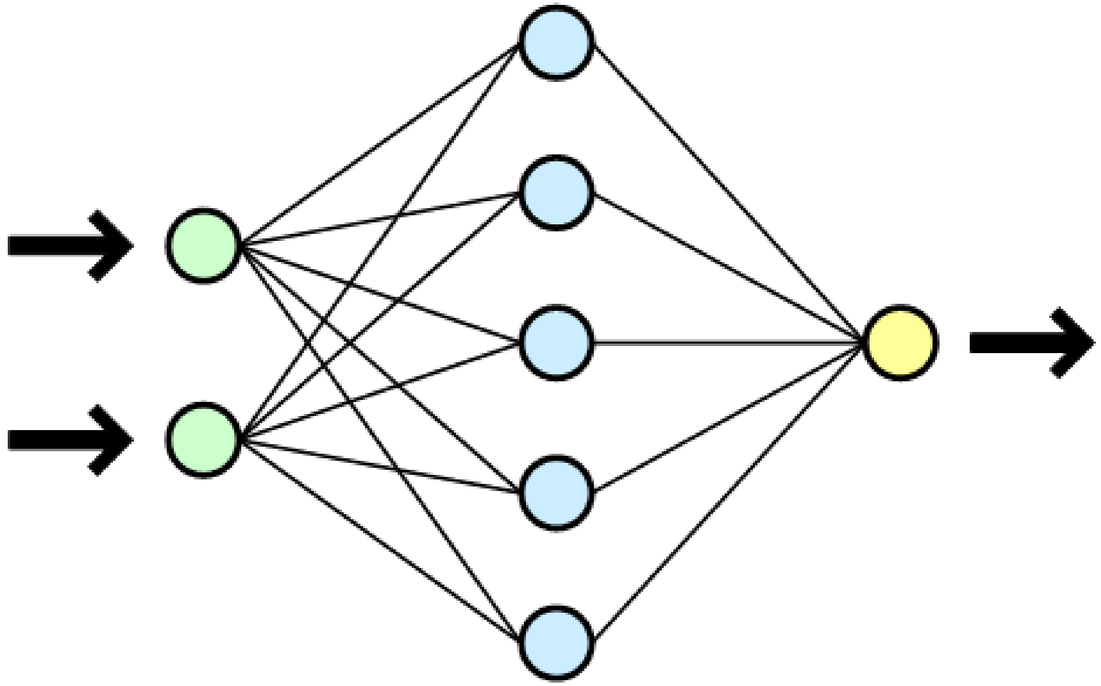
Internal layers

Hidden layers use as input the output data of previous neurons, and their output data is used for input data of subsequent neural layers. The number and sizes of hidden layers are determined iteratively depending on the subject area and the specific task.



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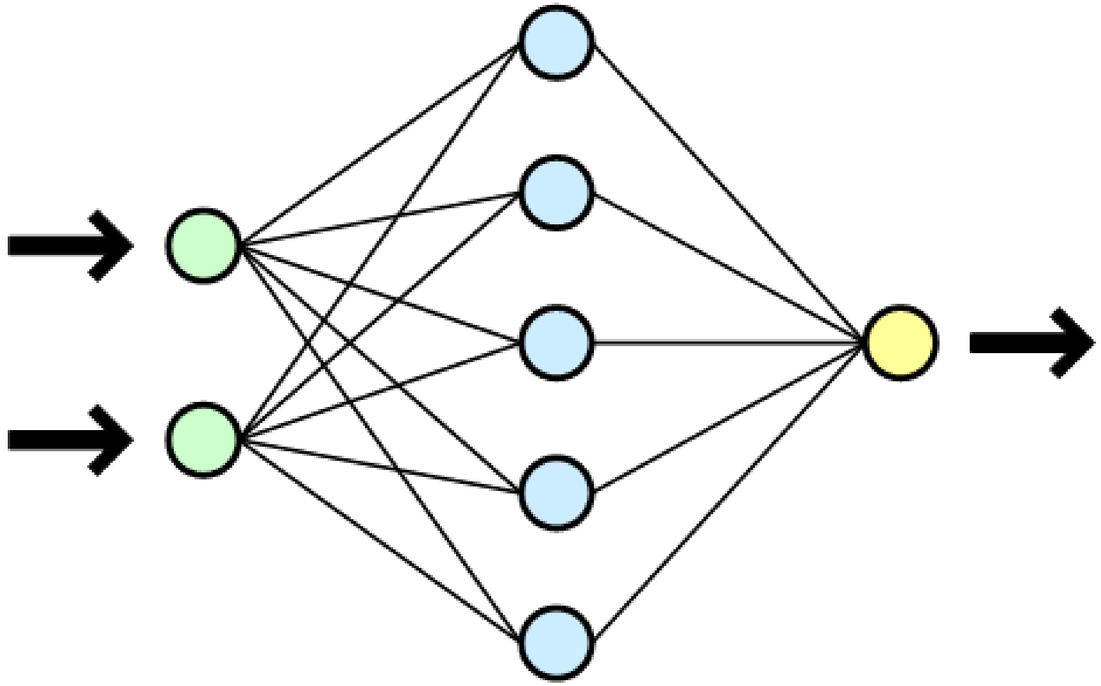
Output layer

The output layer - outputs the output data for the entire network.

The number of elements from the output layer - is determined by the number of recognized classes.



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Perceptron

A basic neural model with a stepwise activation function.

One of the earliest models of neural computation.

A classic example of a multilayer network is the so-called a multilayer perceptron based on the error backpropagation algorithm.

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CONTENT 3

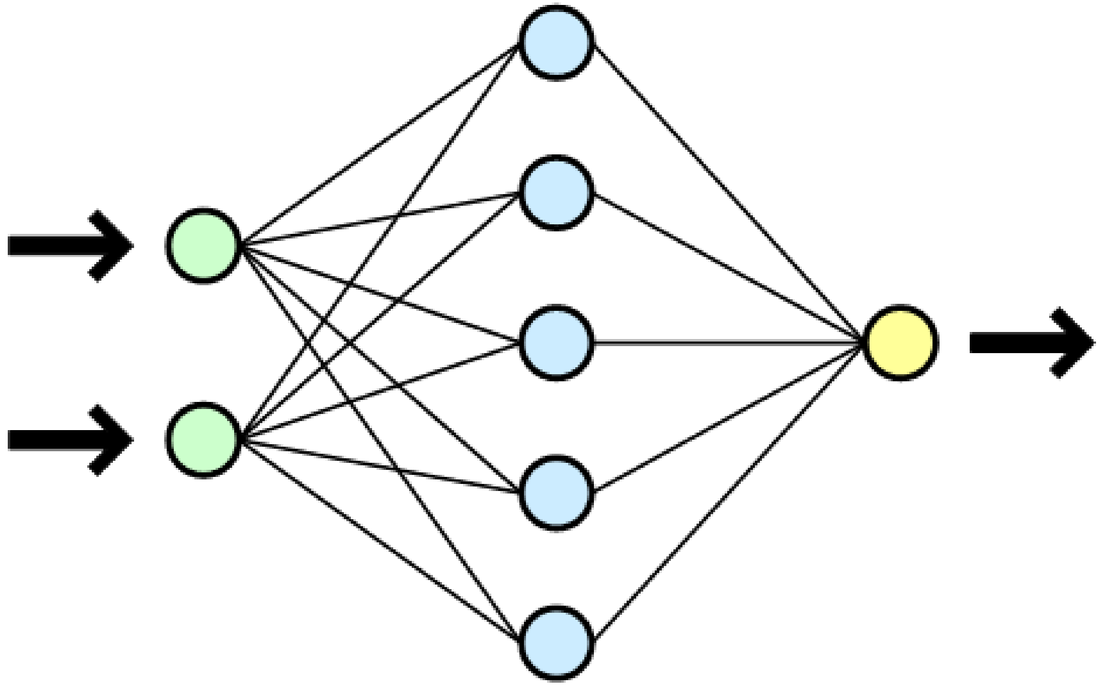
NN according to the typology of the network

Depending on the number of layers:

- **single-layer** (sometimes called two-layer) - one input and one output layer, lacking the so-called internal or hidden layers;
- **multi-layered** - has at least one hidden layer:

➢ shallow;

➢ deep.



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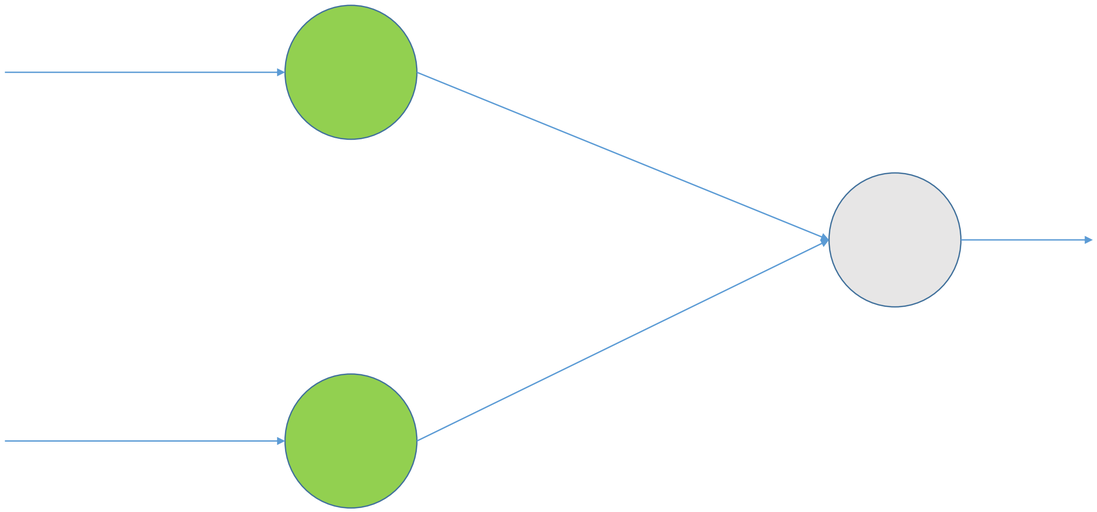
CONTENT 3

Single-layer NN

The simplest form of single-layer NN is the perceptron.

There is only 1 layer of input nodes that send weighted inputs to the next layer of receiving nodes, or in some cases only one.

Information moves in only one direction: through the inputs to the output.



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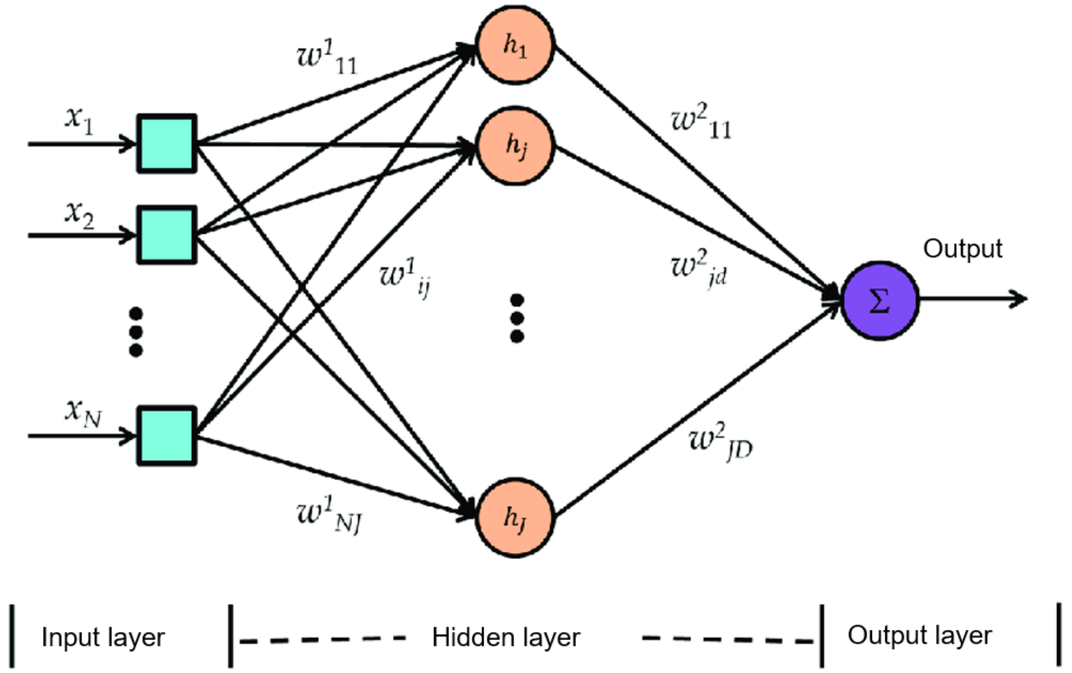
CONTENT 3

Multi-layer NN

It contains layers of neurons or nodes that vary greatly in design. They usually have at least 1 input layer that sends weighted inputs to a series of hidden layers, and an output layer at the end.



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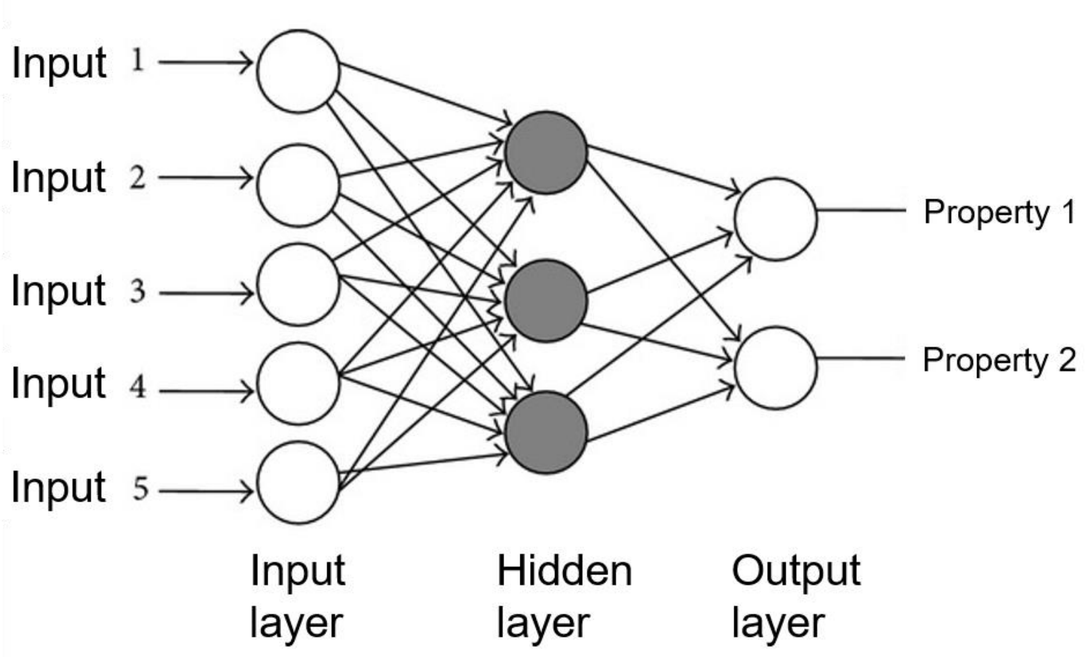
CONTENT 3

Multi-layer NN - example

The network serves to separate the incoming data into 2 groups according to property 1 and 2.



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CONTENT 4

NN according to the weights of the connections

According to the type of connection weights, NNs can be divided into:

- **simulative** – with connections with positive weights;
- **suppressive** – with connections with negative weights.

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CONTENT 5

NN according to the direction of the signal

- **straightforward (feedforward)** - connections are one-way and are oriented from the elements of a given layer to the elements of the layer immediately above it;
- **recurrent (feedback)** - each element is connected by two-way connections with all its neighbors. Here the concept of layer largely loses its meaning.

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CONTENT 5

Straightforward NN

It consists of a large number of simple neurons organized in layers. Each unit in a layer is related to some units in the previous layer. Connections are not equal: each connection can have a different weight.

Data enters the inputs and travels through the network, layer by layer, until it reaches the outputs. During normal operation, i.e. when acting as a classifier, there is no feedback between layers.

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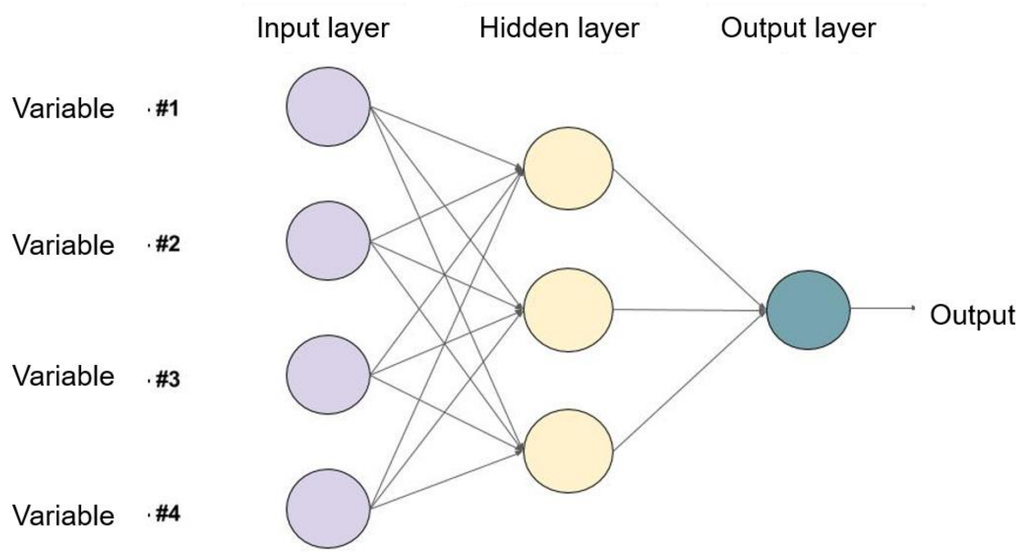
CONTENT 5

Structure of a straightforward network



Example of Feedforward NM with one hidden layer (with 3 neurons).

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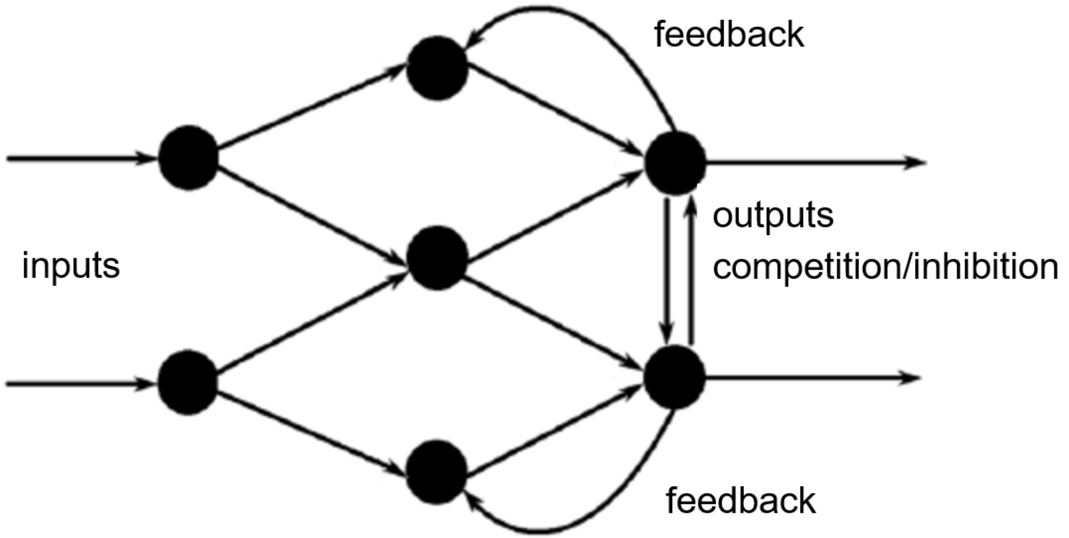
CONTENT 5

Recurrent NN

When NM has some internal recurrence, i.e. signals feed back to some neuron or layer that has already received and processed that signal, the network is of the feedback type. Most of the feedback networks are single layer.



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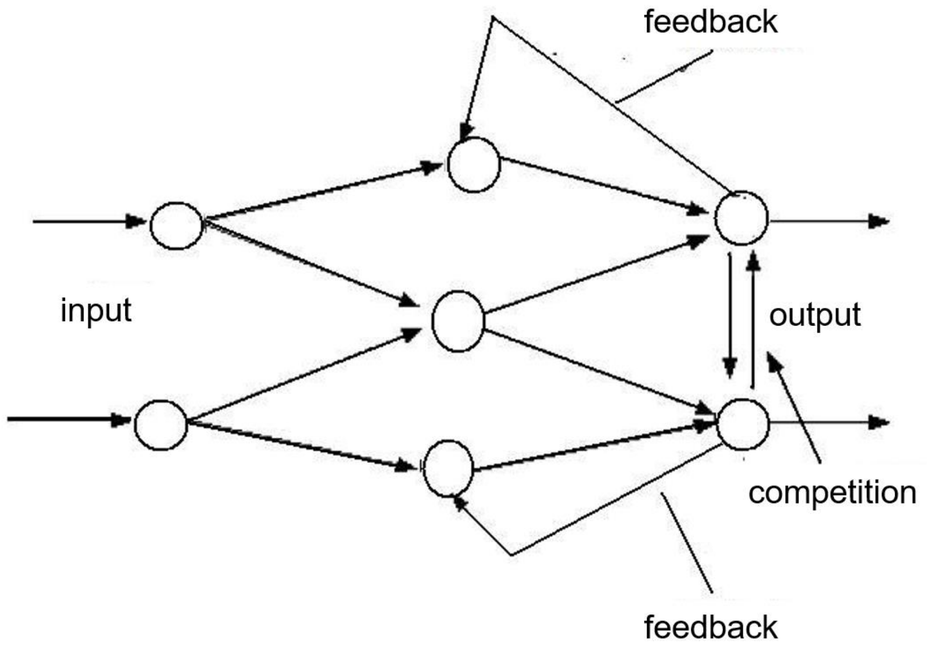
CONTENT 5

Structure of recurrent NN

When NM has some internal recurrence, i.e. signals feed back to some neuron or layer that has already received and processed that signal, the network is of the feedback type. Most of the feedback networks are single layer.



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CONTENT 6

NN according to the type of input and output values

The input values of the network, i.e. the signals received by the elements of the input layer, as well as the output values of the network, i.e. the signals that the output layer elements output to the environment can be:

- **binary** - 0 or 1;
- **analog** – real numbers.

In case that the output values of the network must be binary, additional requirements are imposed on the activation function.

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CONTENT 7

Learning stage

One of the most important characteristics of NN is the ability to learn, i.e. adapting the network to better handle a task by considering sample observations.

This is done for better result by minimizing observed errors.

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