Autoassociative Neural Network

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Introduction

Most common backpropagation network starts with a large number of neurons in the input layer and has relatively fewer neurons in the output layer.

- Many problems involve a complex description of a situation or condition as the input, and a limited number of classes or conditions as the output.

No rule prescribing the number of neurons of a hidden layer of a three- layer neural network.

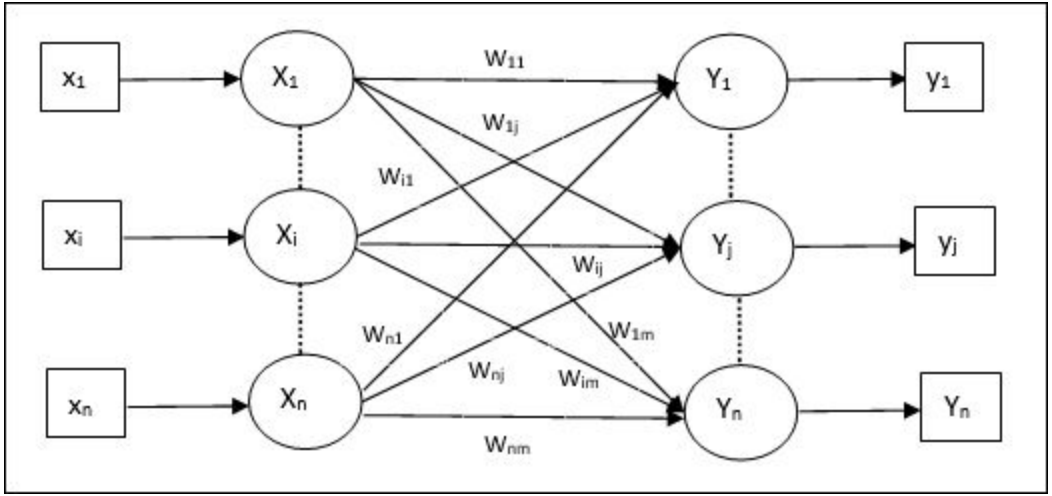
As a rule of thumb, the number of neurons in the hidden layer should be less than the number of datasets in an epoch so that the neural network does not memorize the various input datasets.

- A particular neuron in the hidden layer becomes associated with a particular dataset of an epoch.

Autoassociative Memory

This is a single layer neural network in which the input training vector and the output target vectors are the same. The weights are determined so that the network stores a set of patterns.

The architecture of Auto Associative memory network has ‘n’ number of input training vectors and similar ‘n’ number of output target vectors.



Autoassociative Neural Network

Auto associative Neural networks are the types of neural networks whose input and output vectors are identical.

- Feed forward
- Fully connected networks
- Multilayer perceptrons usually
- Trained using Backpropagation
- The number of neurons in the hidden layer may be greater or smaller than the number in the input and output.
- All neurons in the middle layer(s) must have nonlinear(logistic,arctangent or hyperbolic tangent) activation function.
- Output layer may have either a linear or nonlinear activation function.

Autoassociative Neural Network

- AANN contains five-layer perceptron feed-forward network, that can be divided into two neural networks of 3 layers each connected in series.
- It is theoretically sufficient for the autoassociative network to contain three hidden layers.
- The first of the hidden layers is called the **mapping layer**. The transfer functions of the mapping layer nodes are sigmoids, or other similar nonlinearity.
- The second hidden layer is called the **bottleneck layer**. The transfer function of the nodes in the bottleneck layer can be linear (implementing only the summation of the inputs) or nonlinear, without affecting the generality of the network. The dimension of ‘the bottleneck layer is required to be the smallest in the network.
- The third hidden layer is called the **demapping layer**. The nodal transfer functions in this layer are nonlinear, usually sigmoidal. To capture linear functionality efficiently, linear bypasses can be allowed from the input to the bottleneck layer and from the bottleneck layer to the output,

Autoassociative Neural Network

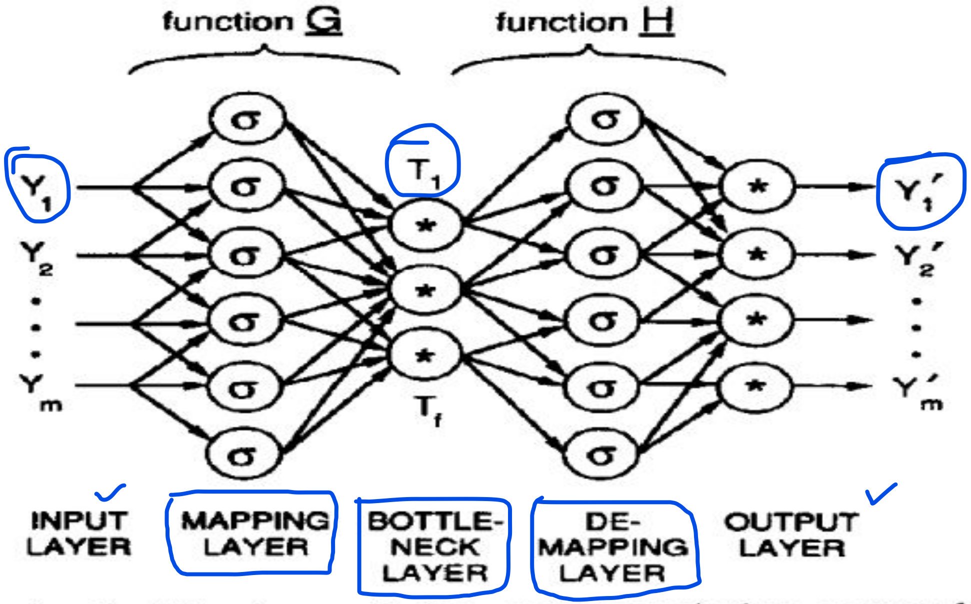


Fig. 1. Architecture of the autoassociative network. σ indicate sigmoidal nodes, * indicates sigmoidal or linear nodes.

Autoassociative Neural Network

- The bottleneck layer plays the key role in the functionality of the autoassociative network.
- The bottleneck layer prevents a simple one-to-one or “straight-through” mapping from developing during the training of the network.
- The bottleneck forces an internal encoding and compression of the inputs, with a subsequent decoding or decompression after the bottleneck to produce the network outputs.
- For the network to accurately reproduce the network inputs at the output layer, the information in the input must be preserved in the representation developed at the bottleneck layer.

Autoassociative Neural Network

- The training process selects network weights so that the re-created measurement vector at the output layer matches the input as closely as possible, in a least-squares sense, over the set of training examples.
- This assures that the internal representation developed by the network retains the maximum possible amount of information from the original data set for the given degree of dimensional compression represented by the bottleneck layer.
- The autoassociative network should be viewed as a serial combination of two single-hidden layer networks.

Autoassociative Neural Network

- The input, mapping and bottleneck layers together represent nonlinear function G which projects the inputs to a lower dimension space, called the feature or factor space. This mapping is described by:

$$T_i = G_i(Y),\ i = 1 \ldots\ldots f \quad (1)$$

where Ti is the output of the ith bottleneck node and Y={Y1, YZ,..., Y,} are the network inputs.

Autoassociative Neural Network

The bottleneck layer, the demapping layer and the output layer represent a second network H that reproduces an approximation of the inputs from the factors at the output of the bottleneck layer:

$$Y_i = H_j(T),\ j = 1 \ldots\ldots m \quad (2)$$

For generality, the subnets representing G and H must each be capable of representing nonlinear functions of arbitrary form. This can be achieved by providing each subnetwork with a single hidden layer containing a sufficiently large number of nodes. The mapping layer is the hidden layer of the subnet representing G, and the demapping layer is the hidden layer of the subnet representing H.

Autoassociative Neural Network

- Networks of the type used here require "supervised" training, where a desired output is specified for each training example.
- One cannot train the network representing G by itself, since the output T is initially unknown. Similarly the network H cannot be trained separately, even though the desired outputs are known (the target output is Y). because the corresponding inputs T are unknown.
- Therefore, direct supervised training of each of these networks individually is infeasible.
- To circumvent this problem, the two networks are combined in series so that G feeds directly into H, resulting in a network whose inputs and desired outputs are known.

Applications

Auto-associative Neural Networks can be used in many fields:

- Pattern Recognition
- Bioinformatics
- Voice Recognition
- Signal Validation etc.