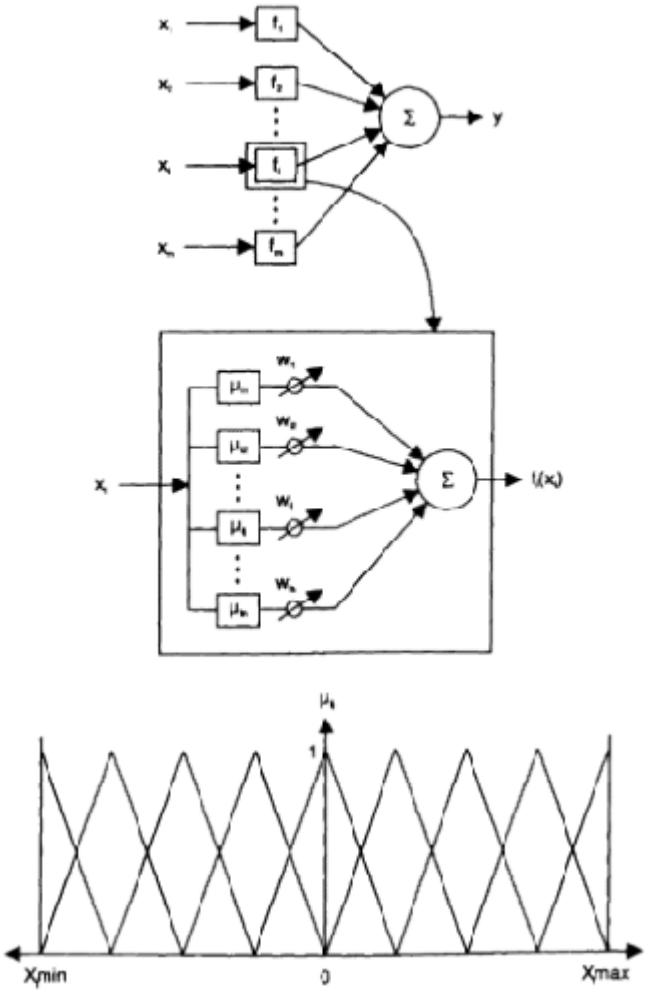
Fuzzy Neurons

Introduction:-The neural network models presented so far use variants of McCulloch and Pitt's neuron to build anetwork. New types of neurons have been introduced which use fuzzy membership functions asactivation functions or as functions attached to their connections. One of them is the so-called fuzzyneuron.

A fuzzy neuron has the following features, which distinguish it from the ordinary types of neurons:-

- The inputs to the neuron $x_1, x_2, \ldots, x_n$ represent fuzzy labels of the fuzzy input variables.
- The weights wi are replaced by functions μi which are the membership functions of the fuzzy labels x_i (i = 1, 2, . . .,n). Excitatory connections are represented by MIN operation and inhibitory connections by fuzzy logic complements followed by MIN operation.
- A threshold level is not assigned. In the fuzzy neuron there is no learning. The membership functions attached to the synaptic connections do not change. The fuzzy neuron has been successfully used for handwritten character recognition.

The **Neo-fuzzy neuron** is a further development of the fuzzy neuron.



The features of the neo-fuzzy neuron are:

- The inputs $x_1, x_2. \ldots x_n$ represent fuzzy variables.
- Each fuzzy segment x_{ij} attached to each of the fuzzy variables $x_{i,\ i}$= 1, m; j = 1, n are represented as connections between the input i and the output.
- In addition to the membership function μ_{ij}, which is bound to the input segment x_{ij}, weights $w_{ij}$are also assigned, subject to a training procedure.
- The segments $x_{i1}, x_{i2}, \ldots, x_{il}$ have standard triangular membership functions; thus an input activates only two membership functions simultaneously; the sum of the degree to which an input value x'I belongs to any two neighboring membership functions $\mu_{ik}(x'i)$ and $\mu_{i,k+1}(x'i)$ is always equal to 1. Thus the COG defuzzification does not use a division and the output of the neuron can be represented by the following simple equation:

$$f_i(x_i') = \mu_{ik}(x_i') \cdot w_{ik} + \mu_{i,k+1}(x_i') \cdot w_{i,k+1}$$

There are some training algorithms applicable to the neo-fuzzy neuron. One of them is called incremental updating (stepwise training).

Fuzzy neurons have been applied to prediction and classification problems.

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Branch: <Computer Science >

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Author: <Name of the author>

Tags: <Fuzzy-Neurons>

Questions

Q1:- What are the features of fuzzy neurons?
Q2:- What do you mean by Neo-fuzzy neuron?

Fuzzy Neural Networks

Introduction:-Similar to the way the fuzzy neuron and the neo-fuzzy neuron were created, different types of fuzzy neural networks have been developed and applied to different tasks. A fuzzy neural network (FNN) is a connectionist model for fuzzy rules implementation and inference. There is a great variety of architectures and functionalities of FNN. The FNNs developed so far differ mainly in the following parameters:

1. Type of fuzzy rules implemented; this affects the connectionist structure used.

2. Type of inference method implemented; this affects the selection of different neural network parameters and neuronal functions, such as summation, activation, and output function. It also influences the way the connection weights are initialized before training, and interpreted after training.

3. Mode of operation: we consider here three major modes of operation by:-

- Fixed mode, ''fixed membership functions-fixed set of rules," that is, a fixed set of rules is inserted in a network, the network performs inference, but does not change its weights. It cannot learn and adapt. A representative of this type of system is NPS.

- Learning mode, that is, a neural network is structurally defined to capture knowledge in a certain format, for example, some type of fuzzy rules. The network architecture is randomly initialized and trained with a set of data. Rules are then extracted from the structured network. The rules can be interpreted either in the same network structure or by using other inference methods.

- Adaptation mode. A neural network is structurally set according to a set of existing rules, "hints," heuristics. The network is then trained with new data and updated rules are extracted from its structure.

FNNs have two major aspects:-

1. Structural. A set of rules is used to define the initial structure of a neural network; two types of neural networks have been mainly used so far: (a) multilayer perceptrons (MLPs), and (b) radial-basis functions networks.

2. Functional, parametric. After having defined the structure of a neural network and possibly havingtrained it with data, some parameters can be observed that would explain the inference which the network performs. Those parameters can be used to derive a (fuzzy) rule-based system represented in linguistic terms.

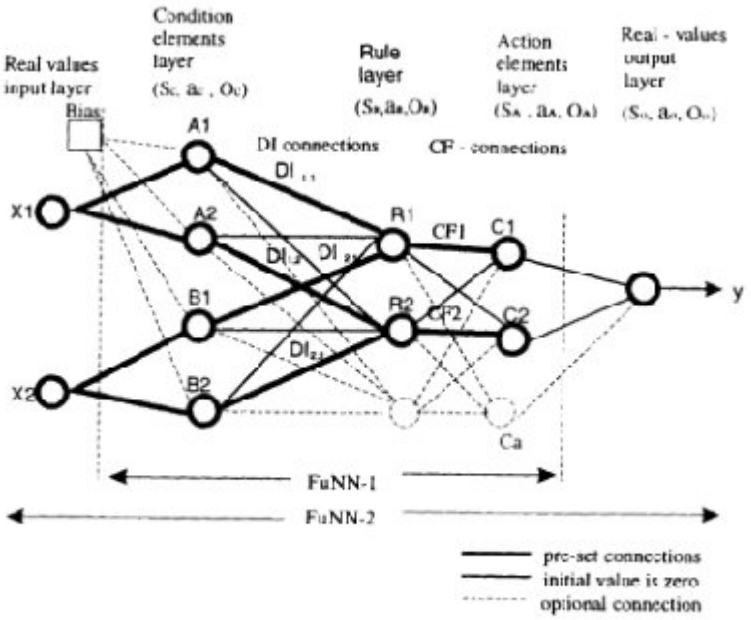

Figure 4.38
General architecture of FuNN (fuzzy neural network).

FuNN is an model of an FNN. It facilitates learning from data, fuzzy rules extraction, and approximate reasoning. FuNN uses an MLP network and a backpropagation training algorithm. It is an adaptable FNN as the membership functions of the fuzzy predicates, as well as the fuzzy rules inserted before training (adaptation), may adapt and change according to the training data. The general architecture of FuNN consists of five following layers.In the input layer—a node represents an input variable. In the condition elements layer—each node represents a fuzzy predicate of an input variable. The activation values of the nodes represent the membership degrees of the input variables. Different summation function sc, activation function ac, and output function sc can be used for the neurons of this layer.

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Questions

Q1:- What is FuNN?

Q2:-Write down the modes of operation of FNN?

Hierarchical and Modular Connectionist Systems

Introduction:-The flexibility of intelligence comes from the enormous number of different information-processing rules, modules, and the levels of operation of such modules. Hierarchical models are biologically and psychologicallyplausible.

Modular systems are systems consisting of several modules linked together for solving a given problem. Representing a system for solving a problem as a modular system may be justified for the following reasons:-

- The whole task may be represented as a collection of simpler subtasks, each being solved in one submodel of the whole system, so each module solves a different part of the whole problem, for example, one module is used for feature extraction, and another for pattern classification (which is usually the case in speech recognition systems).

- Different modules may provide alternative solutions, the final one being the best of them or a combination of them; different modules may imitate different experts on the same problem, the final solution being a weighted compromise between the outputs from the modules.

Different modules in a multimodular system may specialize during training to give a good approximation of the solution for a subspace of the whole problem space. They become local experts.
If each of the modules in a modular system is realized in a connectionist way, the system is called aconnectionist modular system. A connectionist modular system can be flat, if all the modules have the same priority for information processing; or hierarchical, if some modules have higher priority than other modules in the system. According to the types of neural networks used in a modular neural network, the latter can be classified as homogeneous, that is, all the neural networks are of the sametype; or heterogeneous, that is, different types of neural networks are used in one system; this is the casein the example below.

According to the type of connectivity between neural networks in modular neural network systems, the latter can be classified as fully connected, where every neural network is connected to every other one by at least one link, or partially connected, where only selected neural networks are linked together.

According to the way the neural networks in a modular system are used for solving a task, there are three types of operating modes in a system:

1. Sequential mode. Neural networks are used sequentially when different subtasks of the global task are performed; different neural networks are trained either separately or in conjunction with one another.
2. Parallel mode. All neural networks work in parallel, either on alternative solutions of one subtask, after which a final solution is worked out based on a given criterion,or on different subtasks if the problem allows a parallel solution.
3. Mixed mode. Both of the above modes are implemented in one modular system.

Modular and hierarchical multinetwork systems have been used for:-

· Robot control;
· Time-series forecasting.
· Classification of remotely sensed satellite images.
· Geometrical transformation and theorem-proving.

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Questions

Q1:-Write a note on Hierarchical and Modular Connectionist Systems.
Q2:-What are the applications of Modular and hierarchical multinetwork systems.