END TERM EXAMINATION [MAY-JUNE 2017]
EIGHTH SEMESTER [B.TECH]
SOFT COMPUTING [ETIT-410]

Time: 3 Hrs. **Max. Marks: 75**

Note: Attempt any five questions including Q. no. 1 which is compulsory.

Q.1. (a) Differentiate between feed forward and feedback neural network. (5)

Ans.

Architecture	Feed-forward neural network	Feed-back neural network
Layout	Multiple layers of nodes including convolutional layers.	Information flows in different directions, simulating a memory effect.
Data type	Image data	Sequence data
Input/ Output	The size of the input and output are fixed (i.e. input image with fixed size and outputs the classification)	The size of the input and output may vary (i.e. receiving different texts and generating different translations for examples)
Use cases	Image classification, recognition, medical imagery, image analysis. face detection.	Text translation, natural language processing, language translation, sentiment analysis.
Drawbacks	Large training data	Slow and complex training procedures.
Description	CNN employs neuronal connection patterns. And they are inspired by the arrangement of the individual neurons in the animal visual cortex, which allows them to respond to overlapping areas of the visual field.	Time-series information is used by recurrent neural networks. For instance, a user's previous words could influence the model prediction on what he can says next.

Q.1. (b) Explain about fuzzy logics and its applications. (5)

Ans. Fuzzy Logic is defined as a many-valued logic form which may have truth values of variables in any real number between 0 and 1. It is the handle concept of partial truth. In real life, we may come across a situation where we can't decide whether the statement is true or false. At that time, fuzzy logic offers very valuable flexibility for reasoning. Fuzzy logic algorithm helps to solve a problem after considering all available data. Then it takes the best possible decision for the given the input. The FL method imitates the way of decision making in a human which consider all the possibilities between digital values T and F.

Fuzzy logic applications

- In automobiles, fuzzy logic is used for gear selection and is based on factors such as engine load, road conditions and style of driving.

• In dishwashers, fuzzy logic is used to determine the washing strategy and power needed, which is based on factors such as the number of dishes and the level of food residue on the dishes.

• In copy machines, fuzzy logic is used to adjust drum voltage based on factors such as humidity, picture density and temperature.

• In aerospace, fuzzy logic is used to manage altitude control for satellites and spacecrafts based on environmental factors.

• In medicine, fuzzy logic is used for computer-aided diagnosis, based on factors such as symptoms and medical history.

• In chemical distillation, fuzzy logic is used to control pH and temperature variables.

• In natural language processing, fuzzy logic is used to determine semantic relations between concepts represented by words and other linguistic variables.

• In environmental control systems, such as air conditioners and heaters, fuzzy logic determines output based on factors such as current temperature and target temperature.

• In a business rules engine, fuzzy logic may be used to streamline decision-making according to predetermined criteria.

Q.1. (c) Define uncertainty and its usefulness in soft computing. (5)

Ans. Uncertainty involved in any problem-solving situation is a result of some information deficiency. Information (pertaining to the model within which the situation is conceptualized) may be incomplete, fragmentary, not fully reliable, vague, contradictory, or deficient in some other way.

Uncertainty analysis aims at quantifying the variability of the output that is due to the variability of the input. The quantification is most often performed by estimating statistical quantities of interest such as mean, median, and population quantities. The estimation relies on uncertainty propagation techniques.

Q.1. (d) Explain Genetic algorithm, why these algorithms are known as Genetic Algorithm. How is it usefully over simple traditional algorithm? (5)

Ans. Genetic Algorithm (GA) is a search-based optimization technique based on the principles of **Genetics and Natural Selection.** It is frequently used to find optimal or near-optimal solutions to difficult problems which otherwise would take a lifetime to solve. It is frequently used to solve optimization problems, in research, and in machine learning.

A genetic algorithm is a search heuristic that is inspired by Charles Darwin's theory of natural evolution. This algorithm reflects the process of natural selection where the fittest individuals are selected for reproduction in order to produce offspring of the next generation that's why it is called Genetic algorithm.

Advantages of GA over simple traditional algorithm

• Does not require any derivative information (which may not be available for many real-world problems).

• Is faster and more efficient as compared to the traditional methods.

• Has very good parallel capabilities.

• Optimizes both continuous and discrete functions and also multi-objective problems.

• Provides a list of "good" solutions and not just a single solution.

- Always gets an answer to the problem, which gets better over the time.
- Useful when the search space is very large and there are a large number of parameters involved.

Q.1. (e) Explain Perceptron Model with the help of example. **(5)**

Ans. The Perceptron is a binary classifier which maps its input x (a real-valued vector) to an output value f(x) (a single binary value) across the matrix.

$$f(x) = \begin{cases} 1 \text{ if } w, x+b>0 \\ 0 \; else \end{cases}$$

where w is vector of real-valued weights and w.x is the dot product (which computes a weighted sum). b is the 'bias', constant term that does not depend on any input value.

The value of f(x) (0 ro 1) is used to classify x as either a positive or a negative instance, in the case of a binary classification problem. If b is negative, then the weighted combination of inputs must produce a positive value greater than $|b|$ in order to push the classifier neuron over the 0 threshold. Spatially, the bias alters the position (though not the orientation) of the decision boundary. The perceptron learning algorithm does not terminate if the learning set is not linearly separable.

The perceptron is considered the simplest kind of feed-forward neural network.

Q.2. (a) Explain and differentiate between Supervised and Unspervised Learning Paradigms. **(6.25)**

Ans. Refer Q.no. 2 (a) End Term Exam 2018.

Q.2. (b) Explain the significance of hidden layer. How it is useful in pattern recognition and control problem. **(6.25)**

Ans. In neural networks, a hidden layer is located between the input and output of the algorithm, in which the function applies weights to the inputs and directs them through an activation function as the output. In short, the hidden layers perform nonlinear transformations of the inputs entered into the network. Hidden layers vary depending on the function of the neural network, and similarly, the layers may vary depending on their associated weights.

The role of the Hidden Layers is to identify features from the input data and use these to correlate between a given input and the correct output. There is a well-known problem of facial recognition, where computer learns to detect human faces. Human face is a complex object, it must have eyes, a nose, a mouth, and to be in a round shape, for computer it means that there are a lot of pixels of different colors that are comprised in different shapes. And in order to decide whether there is a human face on a picture, computer has to detect all those objects. The hidden layers will break down our input image in order to identify features present in the image. The initial layers focus on low-level features such as edges while the later layers progressively get more abstract. At the end of all the layers, we have a fully connected layer with neurons for each of our classification values.

Q.3. (a) What is interpolative mode of counter propagation network? **(6.25)**

Ans. Counter propagation network (CPN) were proposed by Hecht Nielsen in 1987.They are multilayer network based on the combinations of the input, output, and clustering layers. The application of counter propagation net is data compression, function approximation and pattern association. The counter-propagation network is basically constructed from an instar-outstar model. This model is three layer neural network that performs input-output data mapping, producing an output vector y in response to input vector x, on the basis of competitive learning. The three layer in an instar-outstar model are the input layer, the hidden (competitive) layer and the output layer.

There are two stages involved in the training process of a counter propagation net. The input vector are clustered in the first stage. In the second stage of training, the weights from the cluster layer units to the output units are tuned to obtain the desired response.

Q.3. (b) Explain the limitation of back propagation learning. Describe the Boltzmann machine. (6.25)

Ans. The disadvantages of using a backpropagation algorithm are as follows:

- It prefers a matrix-based approach over a mini-batch approach.
- Data mining is sensitive to noise and irregularities.
- Performance is highly dependent on input data.
- Training is time- and resource-intensive.

Boltzmann Machine

A Boltzmann machine is a type of recurrent neural network in which nodes make binary decisions with some bias. Boltzmann machines can be strung together to make more sophisticated systems such as deep belief networks. Some important points about Boltzmann Machine –

- They use recurrent structure.
- They consist of stochastic neurons, which have one of the two possible states, either 1 or 0.
- Some of the neurons in this are adaptive free state and some are clamped frozen state.
- If we apply simulated annealing on discrete Hopfield network, then it would become Boltzmann Machine.

Q.4. (a) Discuss the properties of fuzzy sets. (6.25)

Ans. Fuzzy sets follow some of the properties satisfied by crisp sets. In fact, crisp sets can be thought of as special instances of fuzzy sets. Any fuzzy set $\bar{A}$ is a subset of the refreshment X. Also, the membership of any element belonging to the null set ϕ is 0 and the membership of any element belonging to the reference set is 1.

The properties satisfied by fuzzy sets are:

Commutativity:
$$\bar{A} \cup \bar{B} = \bar{B} \cup \bar{A}$$
$$\bar{A} \cap \bar{B} = \bar{B} \cap \bar{A}$$

Associativity:
$$\bar{A} \cup (\bar{B} \cup \bar{C}) = (\bar{A} \cup \bar{B}) \cup \bar{C}$$
$$\bar{A} \cap (\bar{B} \cap \bar{C}) = (\bar{A} \cap \bar{B}) \cap \bar{C}$$

Distributivity:
$$\bar{A} \cup (\bar{B} \cap \bar{C}) = (\bar{A} \cup \bar{B}) \cap (\bar{A} \cup \bar{C})$$
$$\bar{A} \cap (\bar{B} \cup \bar{C}) = (\bar{A} \cap \bar{B}) \cup (\bar{A} \cup \bar{C})$$

Idempotence:
$$\bar{A} \cup \bar{A} = \bar{A}$$
$$\bar{A} \cap \bar{A} = \bar{A}$$

Identity:
$$\bar{A} \cup \phi = \bar{A}$$

$$\bar{A} \cup X = \bar{A}$$

$$\bar{A} \cap \phi = \phi$$

$$\bar{A} \cup X = X$$

Transitivity: If $\bar{A} \subseteq \bar{B} \subseteq \bar{C}$, then $\bar{A} \subseteq \bar{C}$

Involution: $\left(\bar{A}\right)^c = \bar{A}$

De Morgan's laws: $\left(\bar{A} \cap\right)^c = \left(\bar{A}^c \cup \bar{B}^c\right)$

$$\left(\bar{A} \cup\right)^c = \left(\bar{A}^c \cap \bar{B}^c\right)$$

Since fuzzy sets can overlap, the laws of excluded middle do not hold good.

Thus, $\bar{A} \cup \bar{A}^c \neq X$

$$\bar{A} \cap \bar{A}^c \neq \phi \qquad (6.25)$$

Q.4 (b) Explain fuzzy rule generation with examples?

Ans. Fuzzy Rule Generation

1. apply fuzzy clustering $X \Rightarrow$ fuzy partition matrix $U = [u_{ij}]$
2. use obtained $U = [u_{ij}]$ to define membership functions
- usually X us multidimensional
- assigning labels for one-dimensional domains is easier $\Rightarrow$
1. project U down to $X_1, \ldots, X_p$ axis, respectively
2. only consider upper envelope of membership degrees
3. linear interpolate membership values $\Rightarrow$ membership functions
4. cylindrically extend membership functions
- original clusters are interpreted as conjunction of cyl. extensions
- e.g., cylindrical extensions "x_1 is low", "x_2 is high"

$\Rightarrow$ multidimensional cluster label "x_1 is low and x_2 is high"

- labeled clusters = classes characterized by labels
- every cluster = one fuzzy rule

Q.5. (a) Discuss and explain Crisp sets with its fundamental concept? (6.25)

Ans. A set defined using a characteristic function that assigns a value of either 0 or 1 to each element of the universe, thereby discriminating between members and non-members of the crisp set under consideration. In the context of fuzzy sets theory, we often refer to crisp sets as "classical" or "ordinary" sets.

The following properties of sets are important for further manipulation of sets.

Commutativity: $A \cup B = B \cup A$

$$A \cap B = B \cap A$$

Associativity: $(A \cup B) \cup C = A \cup (B \cup C)$

$$(A \cap B) \cap C = A \cap (B \cap C)$$

Distributivity: $A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$

$$A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$$

Idempotence: $A \cup A = A$

$$A \cap A = A$$

Identify:

$$A \cup \varnothing = A$$
$$A \cap E = A$$
$$A \cap \varnothing = \varnothing$$
$$A \cup E = E$$

Law of Absorption: $A \cup (A \cap B) = A$

$A \cap (A \cup B) = A$

Transitivity: If $A \subseteq B$, $B \subseteq C$ then $A \subseteq C$

Involution: $(A^c) = A$

Law of the Excluded Middle: $A \cup A^c = E$

Law of Contradiction: $A \cap A^c = \phi$

De Morgan's laws: $(A \cup B)^c = A^c \cap B^c$

$(A \cap B)^c = A^c \cup B^c$

Q.5. (b) Discuss the operations performed on crisp relation? (6.25)

Ans. Operations performed on Crisp relation

We will be using the following sets for further discussion:

$X = \{1, 2, 3, 4, 5, 6\}$; $A = \{1, 2, 3\}$; $B = \{2, 3, 4\}$; $C = \{5, 6\}$

Involution:

Involution states that the complement of complement of set A would be set A itself.

For the given data,

$A' = X - A = \{4, 5, 6\}$

$(A')' = X - A' = \{1, 2, 3\} = A$

Commutativity:

The commutativity property states that the operation can be performed irrespective of the order of the operand. For example, addition is a commutative operator, so 2 + 3 or 3 + 2 yields the same result. But, subtraction is not commutative, so $3 - 2 \neq 2 - 3$.

Proving union is commutative:

$A \cup B = \{1, 2, 3, 4\} \rightarrow$ LHS

$B \cup A = \{1, 2, 3, 4\} \rightarrow$ RHS

Proving intersection is commutative:

$A \cap B = \{2, 3\} \rightarrow$ LHS

$B \cap A = \{2, 3\} \rightarrow$ RHS

Associativity:

The associativity property allows us to perform the operations by grouping the operands and keeping them in similar order.

$(A \cup B) \cup C = A \cup (B \cup C)$

For given data:

$A \cup B = \{1, 2, 3, 4\}$

$(A \cup B) \cup C = \{1, 2, 3, 4, 5, 6\} \rightarrow$ LHS

$B \cup C = \{2, 3, 4, 5, 6\}$

$A \cup (B \cup C) = \{1, 2, 3, 4, 5, 6\} \rightarrow$ RHS

$(A \cap B) \cap C = A \cap (B \cap C)$

For given data:

$A \cap B = \{2, 3\}$

$(A \cap B) \cap C = \phi \rightarrow$ LHS

$B \cap C = \phi$

$A \cap (B \cap C) = \phi \rightarrow$ RHS

Distributivity:

Mathematically it is defined as,

$A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$

$B \cap C = \phi$

$A \cup (B \cap C) = \{1, 2, 3\} \rightarrow$ LHS

$A \cup B = \{1, 2, 3, 4\}$

$A \cup C = \{1, 2, 3, 5, 6\}$

$(A \cup B) \cap (A \cup C) = \{1, 2, 3\} \rightarrow$ RHS

$A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$

$B \cup C = \{2, 3, 4, 5, 6\}$

$A \cap (B \cup C) = \{2, 3\} \rightarrow$ LHS

$A \cap B = \{2, 3\}$

$A \cap C = \phi$

$(A \cap B) \cup (A \cap C) = \{2, 3\} \rightarrow$ RHS

Absorption:

Mathematically absorption is defined as,

$A \cup (A \cap B) = A$

For the given data:

$A \cap B = \{2, 3\}$

Identify: $A \cup \varnothing = A$

$A \cap E = A$

$A \cap \varnothing = \varnothing$

$A \cup E = E$

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Proving intersection is commutative:

$A \cap B$ = {2, 3} → LHS

$B \cap A$ = {2, 3} → RHS

Associativity:

The associativity property allows us to perform the operations by grouping the operands and keeping them in similar order.

$(A \cup B) \cup C = A \cup (B \cup C)$

For given data:

$A \cup B$ = {1, 2, 3, 4}

$(A \cup B) \cup C$={1, 2, 3, 4, 5, 6} → LHS

$B \cup C$ = {2, 3, 4, 5, 6}

$A \cup (B \cup C)$ = {1, 2, 3, 4, 5, 6} → RHS

$(A \cap B) \cap C = A \cap (B \cap C)$

For given data:

$A \cap B$ = {2, 3}

$(A \cap B) \cap C = \phi$ → LHS

$B \cap C = \phi$

$A \cap (B \cap C) = \phi$ → RHS

Distributivity:

Mathematically it is defined as,

$A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$

$B \cap C = \phi$

$A \cup (B \cap C)$ = {1, 2, 3}→LHS

$A \cup B$ = {1, 2, 3, 4}

$A \cup C$ = {1, 2, 3, 5, 6}

$(A \cup B) \cap (A \cup C)$ = {1, 2, 3} → RHS

$A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$

$B \cup C$ = {2, 3, 4, 5, 6}

$A \cap (B \cup C)$ = {2, 3} → LHS

$A \cap B$ = {2, 3}

$A \cap C = \phi$

$(A \cap B) \cup (A \cap C)$ = {2, 3} → RHS

Absorption:

Mathematically absorption is defined as,

$A \cup (A \cap B) = A$

For the given data:

$A \cap B$ = {2, 3}

$A \cup (A \cap B) = \{1, 2, 3\} = A$

$A \cap (A \cup B) = A$

For the given data:

$A \cup B = \{1, 2, 3, 4\}$

$A \cap (A \cup B) = \{1, 2, 3\} = A$

Idempotency/Tautology:

Idempotency is defined as,

$A \cup A = A$

$A \cap A = A$

For the given data,

$A \cup A = \{1, 2, 3\} = A$

$A \cap A = \{1, 2, 3\} = A$

Identity:

Mathematically, we can define this property as,

$A \cup X = X$

$A \cap X = A$

$A \cup \phi = A$

$A \cap \phi = \phi$

For the given data,

$A \cup X = \{1, 2, 3, 4, 5, 6\} = X$

$A \cap X = \{1, 2, 3\} = A$

$A \cup \phi = \{1, 2, 3\} = A$

$A \cap \phi = \{\,\} = \phi$

De Morgan's Laws:

Mathematically, De Morgan's laws are defined as,

Law 1: $(A \cup B)' = A' \cap B'$

For the given data:

$A \cup B = \{1, 2, 3, 4\}$

$(A \cup B)' = \{5, 6\} \rightarrow$ LHS

$A' = \{4, 5, 6\}$

$B' = \{1, 5, 6\}$

$A' \cap B' = \{5, 6\} = (A \cup B)' \rightarrow$ RHS

$(A \cup B)' = A' \cap B'$

Law 2: $(A \cap B)' = A' \cup B'$

For the given data:

$A \cap B = \{2, 3\}$

$(A \cap B)' = \{1, 4, 5, 6\} \rightarrow$ LHS

$A' = \{4, 5, 6\}$

$B' = \{1, 5, 6\}$

$A' \cup B' = \{1, 4, 5, 6\} = (A \cap B)' \rightarrow$ RHS

$(A \cap B)' = A' \cup B$

Law of Contradiction:

Mathematically it is defined as,

$A \cap A' = \phi$

For the given data:

$A' = \{4, 5, 6\}$

$A \cap A' = \{\,\} = \phi$

Law of Excluded Middle:

Mathematically it is defined as,

$A \cup A' = X$

For the given data:

$A' = \{4, 5, 6\}$

$A \cup A' = \{1, 2, 3, 4, 5, 6\} = X$

Q.6. (a) Discuss learning in Neural network compare different learning rules. (6.25)

Ans. Refer Q.no. 7(a) End Term Examination 2018.

Q.6. (b) Explain back propagation training algorithm with an example. (6.25)

Ans. (a) Refer Q.no. 7(b) End Term Examination 2018.

Q.7. (a) Explain the various properties of Fuzzy Arithmetic and Lattice of fuzzy numbers. (6.25)

Ans. Refer Q.no. 4(a) End Term Examination 2018.

Q.7. (b) Discuss the operations of fuzzy sets and its usefulness. (6.25)

Ans. 1. Union: The union of two fuzzy sets A and B is a new fuzzy set also on X with a membership function defined as.

$$\mu_{A \cup B}(x) = \max(\mu_A(x), \mu_B(x))$$

or

$$\mu_{A \cup B}(x) = \mu_A(x) \vee \mu_B(x)$$

2. Intersection: The intersection of two fuzzy sets A and B is a new fuzzy $A \cap B$ with membership function defined as

$$\mu_{A \cap B}(x) = \mu_A(x) \wedge \mu_B(x)$$

$$\mu_{A \cap B}(x) = \min(\mu_A(x), \mu_B(x)$$

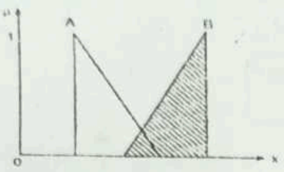


Fig. Union of fuzzy sets

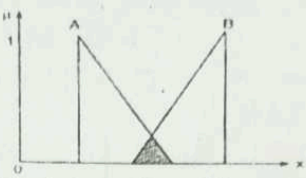


Fig. Intersection of fuzzy sets

3. Complement: The complement of a fuzzy set A is a new fuzzy set is a new fuzzy set A with A membership function

$$\mu_A(x) = 1 - \mu_A(x)$$

4. Product of two fuzzy sets: The product of two fuzzy sets A and B is a new fuzzy A.B whose, membership function is defined as

$$\mu_{A \cap B}(x) = \mu_A(x), \mu_B(x)$$

5. Equality: Two fuzzy sets A and B are said to be equal (A = B) $\mu_A(x) = \mu_B(x)$.

6. Product of a fuzzy set with a crisp number: Multiplying a fuzzy set A by a crisp number result in a new fuzzy set product a. A with the membership function $\mu_{a.A}(x) = a.\ \mu_A(x)$.

7. Power of a fuzzy set: The α power of fuzzy set is a new fuzzy set A whose membership function is given by

$$\mu_A^a(x) = (\mu_A(x))^a$$

Raising a fuzzy set to its second power is called concent (CON) taking the square rool is called Dilation (DIL).

8. Difference: The difference of two fuzzy sets N and B is a new fuzzy set A – B defined as

$$\underline{A} - \underline{B} = \left(\underline{A} \cap \overline{\underline{B}}\right)$$

9. Disjunctive SUM: The disjunctive sum of two fuzzy sets $\underline{A}$ and $\overline{\underline{B}}$ is a fuzzy set $\underline{A} \oplus \underline{B}$ defined as

$$\underline{A} \oplus \underline{B} = (\overline{A} \cap B) \cup (A \cap \overline{B}).$$

Q.8. Write short note on any two:

Q.8. (a) Associative Memories **(6.25)**

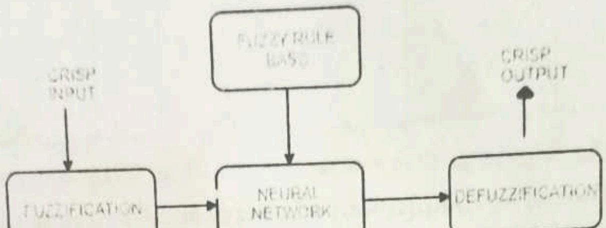
Ans. Refer Q.no. 8(c) End Term Examination 2018.

Q.8. (b) Hopfield's Network

Ans. Refer Q.no. 1 (c) End Term Examination 2018.

Q.8. (c) Neuro Fuzzy System

Ans. The Neuro-fuzzy system is based on fuzzy system which is trained on the basis of the working of neural network theory. The learning process operates only on the local information and causes only local changes in the underlying fuzzy system. A neuro-fuzzy system can be seen as a 3-layer feed forward neural network. The first layer represents input variables, the middle (hidden) layer represents fuzzy rules and the third layer represents output variables. Fuzzy sets are encoded as connection weights within the layers of the network, which provides functionality in processing and training the model.



Working flow:

- In the input layer, each neuron transmits external crisp signals directly to the next layer.
- Each fuzzification neuron receives a crisp input and determines the degree to which the input belongs to the input fuzzy set.
- The fuzzy rule layer receives neurons that represent fuzzy sets.
- An output neuron combines all inputs using fuzzy operation UNION.
- Each defuzzification neuron represents the single output of the neuro-fuzzy system.

Advantages:

- It can handle numeric, linguistic, logic, etc kind of information.
- It can manage imprecise, partial, vague, or imperfect information.
- It can resolve conflicts by collaboration and aggregation.
- It has self-learning, self-organizing and self-tuning capabilities.
- It can mimic the human decision-making process.

Disadvantages:

- Hard to develop a model from a fuzzy system.
- Problems of finding suitable membership values for fuzzy systems.
- Neural networks cannot be used if training data is not available.

Applications:

- Student Modelling
- Medical systems
- Traffic control systems
- Forecasting and predictions