CHAPTER 1

INTRODUCTION

This Chapter provides a brief introduction to work done in thesis and discuss the type of problem considered to solve along with motivation and goals. This chapter also discusses the techniques of soft computing and some applications of these techniques in brief.

1.1 Soft Computing

Soft computing interchanges the traditional complex and time consuming techniques of hard computing through more intellectual handling techniques. The key phase for affecting from hard to soft computing is the reflection that the computational struggle mandatory by conventional approaches which creates in various cases the problem nearly infeasible, is a cost paid to increase accuracy that in various applications is not actually needed or, at least, can be comfortable without a significant outcome on the explanation. Soft computing is association of computing approaches which collectively deliver a substance for the Design, Deployment and Conception of Intellectual Systems. Soft computing is a branch in which strained to build intellectual and wiser machines. Intellect provides the control to originate the answer and not basically arrive to the answer. Purity of thinking, liberty to work, machine intelligence, dimensions, complication and fuzziness supervising capability increase, as we go advanced and advanced in the hierarchy. The absolute aim is to develop a computer or machines which will effort in a similar way as human beings can do. Soft computing is not accurately defined. It consists of divergent ideas and techniques; purpose of these techniques is to overcome the complications encountered in real world difficulties. These problem outcomes from the circumstance: that our world appears to be uncertain, imprecise and challenging for categorization. For example, the uncertainty in a restrained quantity is due to inherent deviations in the quantity process itself. The uncertainty in an outcome is due to the combined and gathered effects of these quantity uncertainties which were used in the control of that result [1].

The term soft computing was proposed by L. A. Zadeh. Zadeh defines soft computing as [2] a collection of methodologies that objective to exploit the tolerance for uncertainty and imprecision to achieve robustness, tractability, and low solution cost. The primary components of soft computing are fuzzy logic, neuro computing and probabilistic reasoning. It plays a progressively significant role in various application areas, including software engineering. Human mind is the role model of soft computing. Increased certainty and precision can be accomplished by a lot of effort and cost. Zadeh provides an illustration the travelling salesman problem, in which the computation time is a function of correctness and it rises exponentially [2].The leading goal of soft computing is to grow intelligent machines and to resolve nonlinear and mathematically un-modeled system problems. The Soft Computing methods are centered on the information processing in biological systems. The composite biological information processing system allows the human beings to persist with accomplishing tasks such as recognition of surrounding, planning, making prediction, and acting accordingly. Human kind information processing includes both logical and natural information processing. Soft computing is to consider as an anti-thesis to the notion of computer, which can be designated with all the adjectives such as crisp, hard, rigid, stupid and inflexible. Soft computing approaches have been applied in various real world problems.

Applications of soft computing can be found in pattern recognition, signal processing, quality assurance and industrial inspection, speech processing, business forecasting, adaptive process control, credit rating, natural language understanding and robotics control etc. Possible new application areas are programming languages, information security, computer networks, fault diagnostics, database management and user friendly application interfaces automatized programming. It signifies to a collection of computational processes in computer science, artificial intelligence, machine learning useful in engineering areas such as spacecraft, aircraft, cooling and heating, mobile robot, communication network, electric power system, inverters and converters, power electronics and motion control etc. Soft computing can also be appreciated as a foundation for the developing field of computational intelligence because computational intelligence is based on soft computing whereas artificial intelligence is based on hard computing. The controlling principle of soft computing is to exploit the tolerance for uncertainty, imprecision, partial truth, and approximation to accomplish robustness, tractability and low solution cost. Soft Computing is a term which refers the problematic in computer science whose solution find between 0 and 1. Soft computing is a term applied within computer science field which is considered by the use of inaccurate solutions to computationally hard tasks for example the solution of NP complete problems, for this problem there is no recognized algorithm which can compute a particular solution in polynomial time. Soft computing is an innovative multidisciplinary field, to build an innovative generation of Artificial Intelligence which known as Computational Intelligence. The leading goal of soft computing is to improve intelligent machine to deliver solutions to real world problems which are not demonstrated or much challenging to model mathematically.

The term Soft Computing signifies the combination of evolving problem solving technologies named as Fuzzy Logic (FL), Neural Networks (NN), Evolutionary Computation (EC) and Probabilistic Reasoning (PR).Each of these technologies deliver us with corresponding reasoning and searching approaches to resolve complex and real world problems. Figure 1.1 shows all the soft computing techniques.

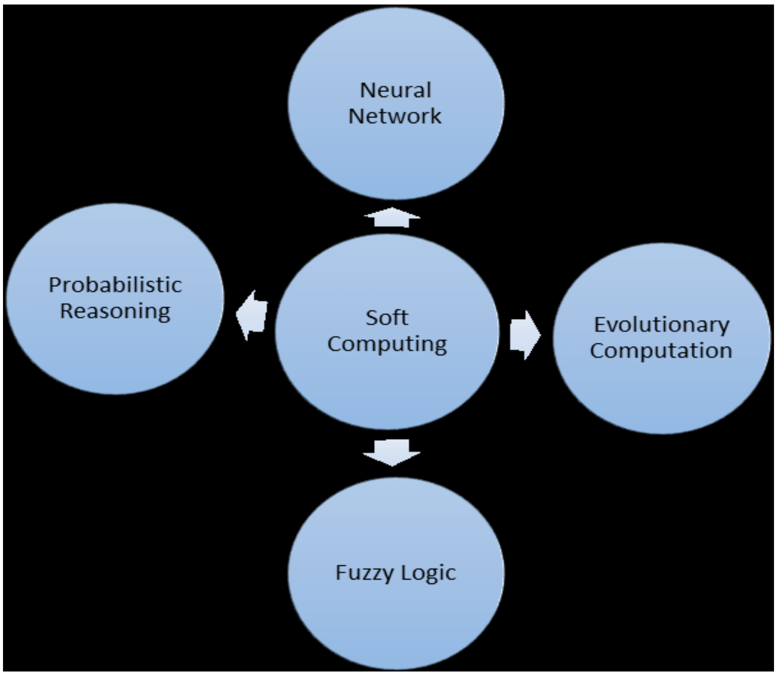

Figure 1. Soft Computing Techniques

1.2 Fuzzy System

Fuzzy System includes Fuzzy Logic and Fuzzy Set Theory both to provide a meaningful and rich accumulation to standard logic. Fuzzy systems can handle concurrently the numerical data as well as linguistic knowledge. Knowledge exist in two different forms, one is objective knowledge and subjective knowledge. The objective knowledge exists in mathematical form which is used in some engineering problems and the subjective knowledge exists in linguistic form which is generally impossible to compute. Fuzzy Systems have been simulated, modeled and replicated many real world problems. Navigation system, Information retrieval systems and robot vision are the applications of Fuzzy Systems. Figure 1.2 shows the fuzzy systems.

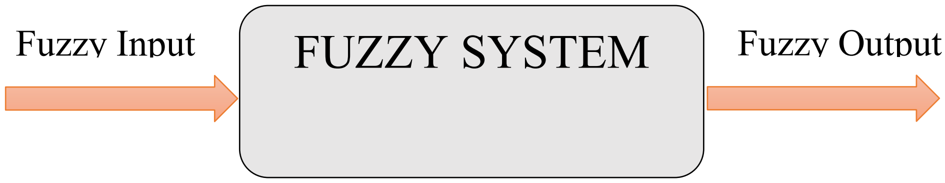

Figure 1. Fuzzy System Elements of Fuzzy Control System

Input Variables: - Input variables are the crisp values, which are transformed into fuzzification block.

Fuzzifier: -The fuzzifier takes the influence of transforming crisp measured facts into appropriate linguistic values. For example the crisp value defined as temperature is 45C and fuzzy set defined as temperature is very high.

Fuzzy Inferencing: - It is the kernel of a Fuzzy Logic Control, and it has the competence of pretending human decision making through performing approximate perceptive to achieve a desired control policy.

Fuzzy Rule Base: - It supplies the experimental knowledge of the operation of a process of the domain experts.

Defuzzifier: - It is exploited to produce a non-fuzzy decision or control achievement from a conditional fuzzy control action by the inference engine.

Output Variables: - Output variables are the variable which comes out from the Defuzzification block and transforms an output to a crisp value. Figure 1.3 shows all the elements of fuzzy control system.

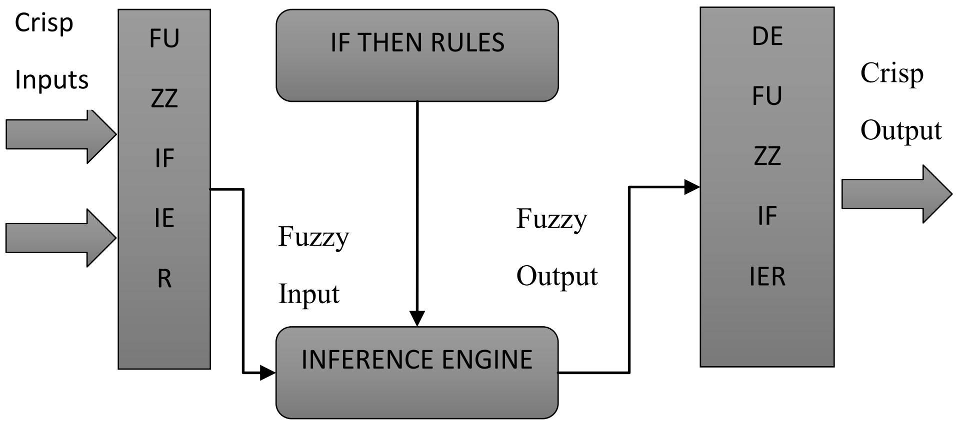

Figure 1. Block Diagram of Fuzzy Control System

1.2.1 Fuzzy Logic

It is a kind of logic that distinguishes other than simply true and false values. Propositions can be characterized with degrees of truthfulness and falsehood with fuzzy logic. A mathematical logic that do efforts to resolve problems by allocating values to an inaccurate spectrum of data in order to reach at the furthermost accurate conclusion likely. Fuzzy logic is planned to resolve problems in the equivalent way that humans do by considering all accessible information and building the greatest possible decision specified the input. Fuzzy logic is a methodology to computing based on degrees of truth rather than the traditional true or false. The innovative idea of fuzzy logic was firstly proposed by Dr. Lotfi Zadeh of the University of California in the 1960s. Zadeh was working on the issue of computer considerate of natural language. Natural language is not simply converted into the absolute terms of 0 and 1. Fuzzy logic has two different denotations. First, in a slender sense, fuzzy logic is a logical system, which is a postponement of multi-valued logic. Second, in a broader sense fuzzy logic is virtually synonymous with the concept of fuzzy sets, a concept which communicates to classes of objects with unsharp limitations in which membership is a substance of degree. Even in its further narrow definition, fuzzy logic contrasts both in theory and substance from traditional multi-valued logical systems. Fuzzy logic is determined as a set of mathematical ideologies for knowledge demonstration based on degrees of membership rather than on crisp membership of conventional binary logic.

Fuzzy Logic is a Soft Computing technique which is essential for analyzing complex systems, specifically where the data structure is categorized by various linguistic parameters. Fuzzy Logic is the core of the Fuzzy Computing which was introduced as an alternative methodology to solve problems while the classical set theory and discrete mathematics are too complex or inappropriate to use. To address a certain period of complications which a human being can resolve easily, an approach which do not trusts on mathematical accuracy and precision, however an approach fault tolerant which can handle partial truths. The basic indication behind fuzzy logic control is to integrate the expert experience of a human machinist in the strategy of a controller in controlling a procedure whose input output association is described by an assemblage of fuzzy control rules concerning linguistic variables. This utilization of fuzzy control rules, linguistic variables and approximate reasoning delivers a means to integrate human expert knowledge in designing the controller. Figure 1.4 shows the flow chart of fuzzy logic controller.

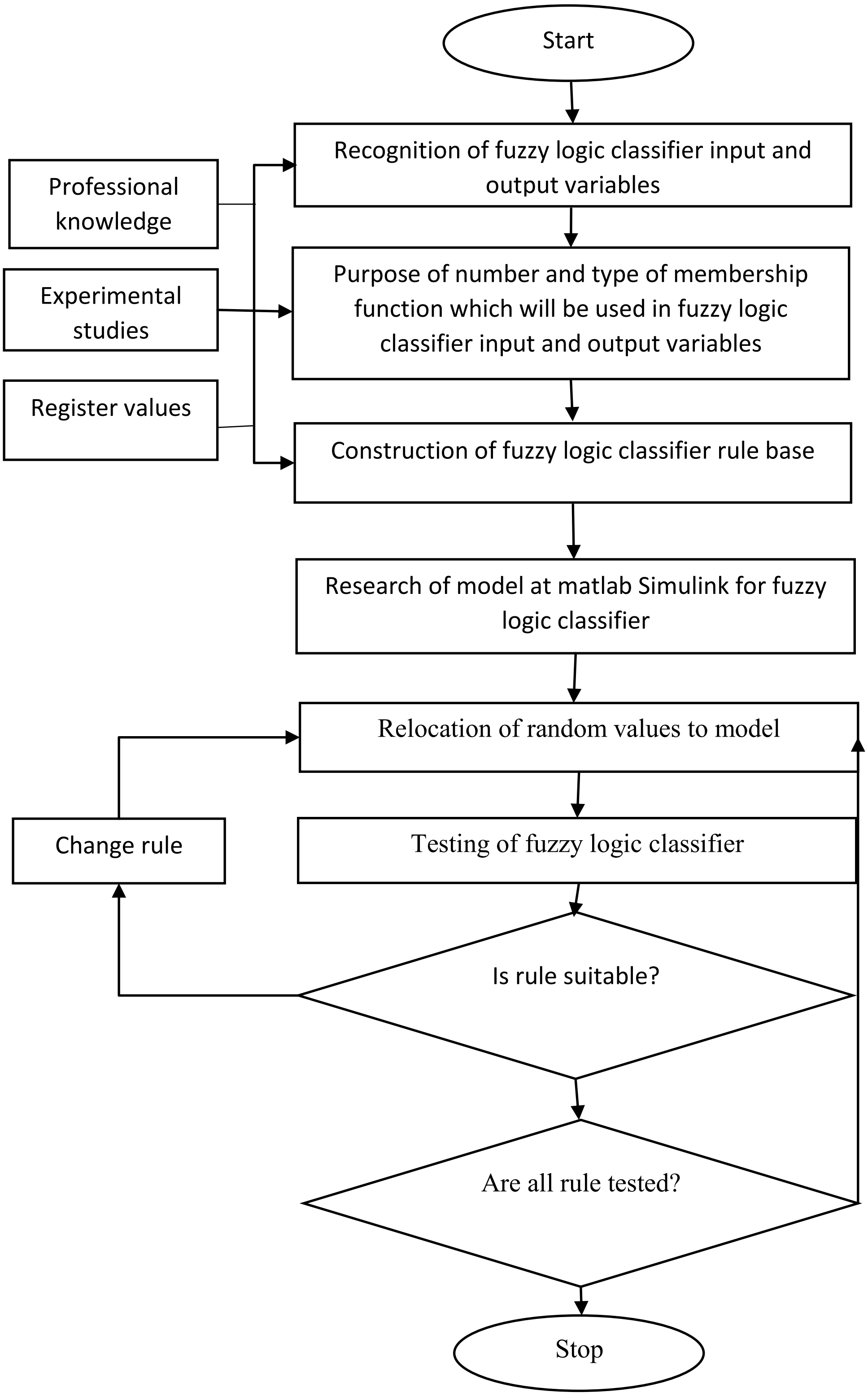

Figure 1. Flow chart of Fuzzy Logic Controller

Characteristics of fuzzy logic

Fuzzy logic is conceptually easy to understand: - The mathematical ideas behind fuzzy perceptive are very simple. Fuzzy logic is a more instinctive methodology without the far-reaching density.

Fuzzy logic is flexible: -It is easy to deposit additional functionality without starting again since scratch with any given system.

Fuzzy logic is charitable of imprecise data: -Everything is inaccurate if you look carefully adequate, but more than that most effects are inaccurate even on suspicious inspection. Fuzzy reasoning constructs this consideration into the process rather than appending it at the end of process.

Fuzzy logic can exemplary nonlinear functions of illogical complexity: -It is possible to generate a fuzzy system to match several set of input output data. This procedure is made particularly easy by adaptive performances for example Adaptive Neuro Fuzzy Inference Systems (ANFIS), which are presented in Fuzzy Logic Toolbox software.

Fuzzy logic can be made on top of the knowledge of experts: -In straight contrast to neural networks, which take exercise data and generate muddy, opaque models, fuzzy logic contracts you rely on the experience of people who already recognize your system.

Fuzzy logic can be combined with conventional control methods: - Fuzzy systems don't automatically replace conventional control approaches. In various cases fuzzy systems enhance them and simplify their implementation.

Fuzzy logic is based on natural language: -The origin for fuzzy logic is the source for human communication. This observation supports many of the other testimonials about fuzzy logic. Since fuzzy logic is constructed on the structures of qualitative explanation used in ordinary language, fuzzy logic is easy to use.

1.2.2 Fuzzy Sets

Fuzzy logic starts through the theory of a fuzzy set. A fuzzy set is a set which clearly defined boundary without a crisp. It can contain components with only a restricted degree of membership. To understand a fuzzy set, first consider the explanation of a classical set. A classical set is a container which exclusively includes or exclusively excludes any given element. The evaluations of membership of 0 and 1 relate to the two prospects of truth and false in a conventional set. The conventional Boolean operators which are used to associate sets will no longer apply; for example 1 AND 1 is 1, but what is the result of 0.7 AND 0.3. These types of problems will be enclosed in the fuzzy operations fragment. Figure 1.5 illustrates the classical set to characterize the room temperature. Figure 1.6 shows how fuzzy sets measuring the same information which is characterize in above classical set theory.

A fuzzy set has a graphical explanation which expresses how the conversion from one to another takes place. This graphical explanation is called a membership function. A fuzzy set is a set which enclosing elements that have changing degrees of membership in the set. A fuzzy set is basically defined as a set with some fuzzy boundaries and limitations. In mathematics a fuzzy set is a set which is collection of effects that belong to some definition. Several items either belong to a set or do not belong to that set.

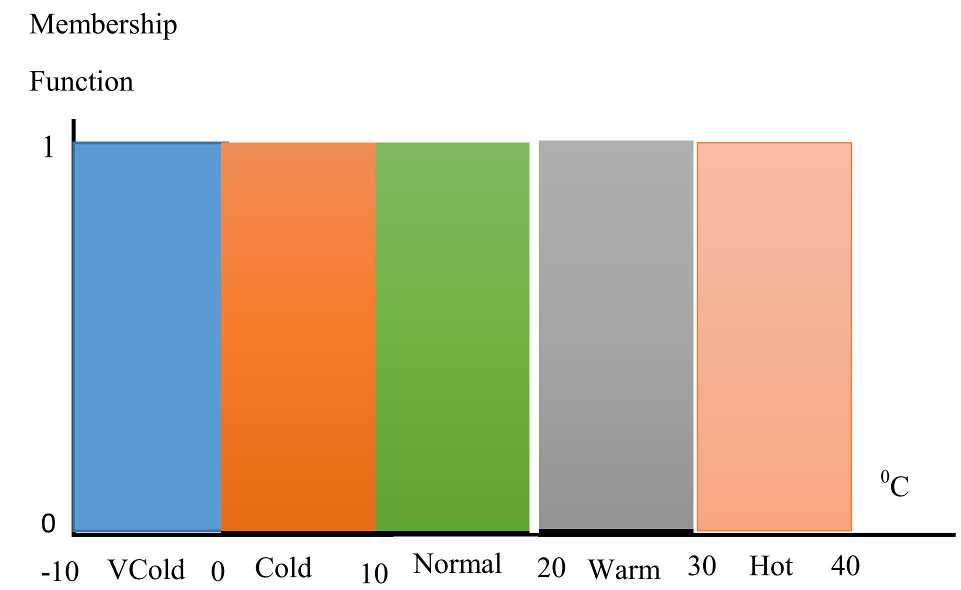

Figure 1. Classical Sets to characterize the room temperature

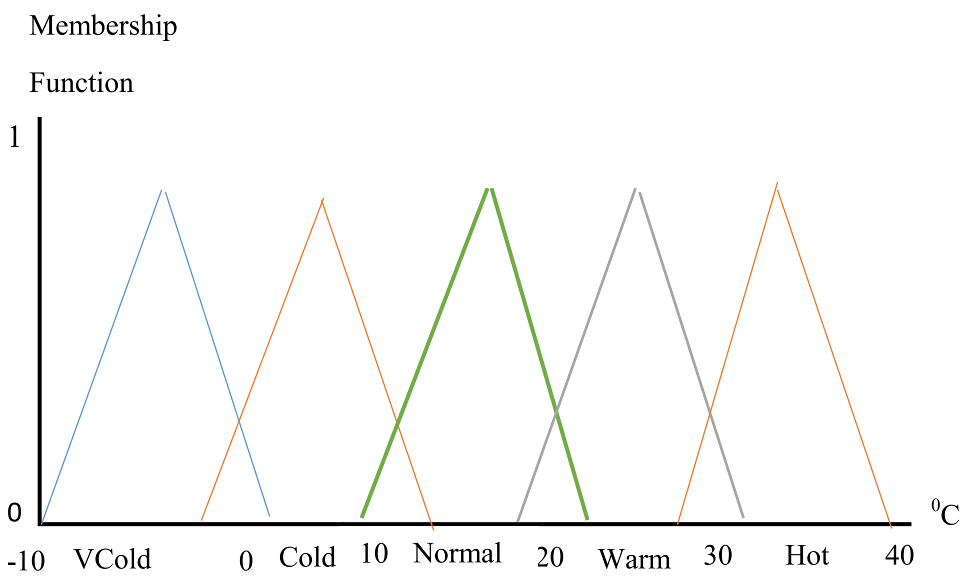

Figure 1. Fuzzy Set to characterize the room temperature

The other illustration is the set of all tall men. The taller people are defined as "the person taller than or equal to 6 feet." Another example is the set of all highly employable people. The highly employable people are defined as "the people have greater than or equal to 80% employability." This set can be denoted graphically in figure 1.7.

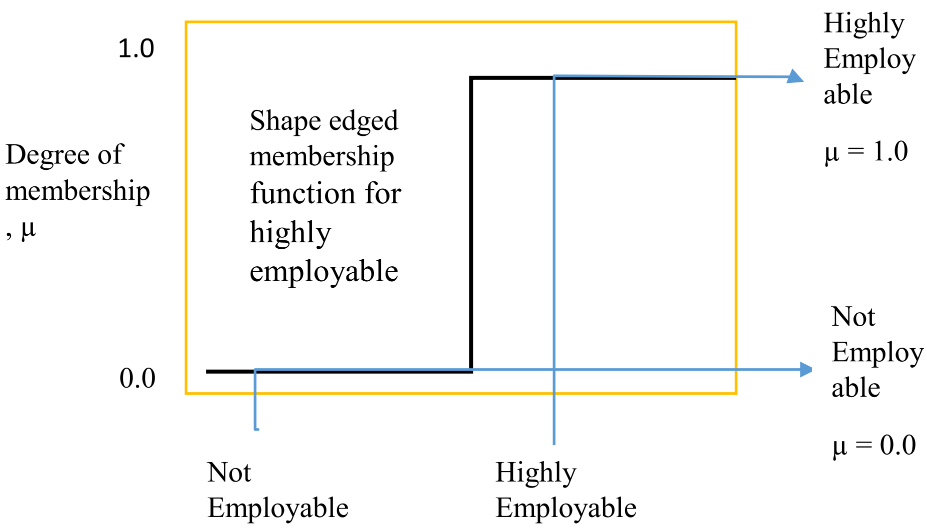

Figure 1. Classical representation of employees

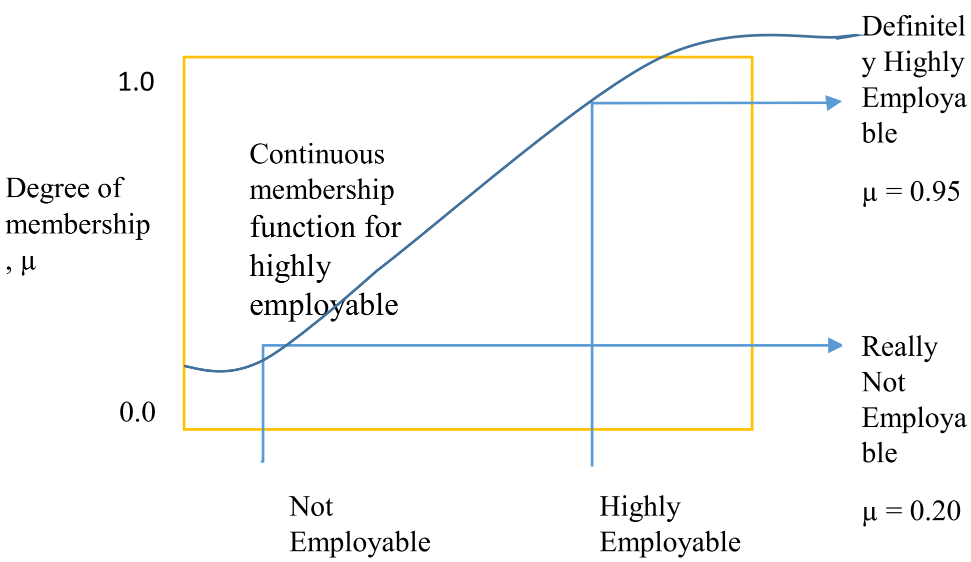

Figure 1. Continuous representation of employees

The fuzzy set approach to the set of all highly employable people provides a much better representation of the higher employability of a person. The figure 1.8 which shown below, is defined by a continuous disposing function.

1.2.3 Fuzzy Set Operation

The valuations of the fuzzy rules and the combination of the outcomes of the specific rules are implemented using fuzzy set operations. The actions on fuzzy sets are dissimilar than the actions on non-fuzzy sets. A fuzzy set procedure is a procedure on fuzzy sets. These procedures are simplification of crisp set procedures. In this there is more than one possible simplification. The most commonly used operations are called regular fuzzy set operations. The fuzzy set operations involve intersection, union and complement.

1.2.4 Linguistic Variables

Linguistic variables are defined as the input or output variables of a system, values of these variables are words or sentences from a natural language, instead of numerical values. A linguistic variable is usually decomposed into a set of linguistic expressions. For example very cold, cold, warm, hot and very hot are values of temperature, so temperature is a linguistic variable. Linguistic variable is a significant concept in fuzzy logic and it plays a significant role in its applications, specifically in the fuzzy expert system. Linguistic variables accumulate elements into related groups where we can deal with less accurately and handle further complex systems. Linguistic variables characterize crisp information in a procedure and precision suitable for the problem. Linguistic variables provide a standardized number system whose purpose is dependent on the significance requirements of the application. Linguistic variables provide an ordinary smooth conversion between opposing rules describing different approaches. Linguistic rules concentration on problem solution, not on problem analysis. Linguistic variables denote the facts or data which used in fuzzy systems. Fuzzy systems can store linguistic values rather than numerical values. The linguistic variable can be observed as a set of fuzzy sets. Every fuzzy set contains some values which are allocated to variable, and inside a variable the fuzzy sets are generally called fuzzy labels.

1.2.5 Membership Function

The difference between crisp or classical sets and fuzzy sets is recognized by membership function. Membership functions are basically used in the fuzzification and defuzzification steps of a fuzzy logic system, for mapping the non-fuzzy input values to fuzzy linguistic expressions. A membership function is used to calculate a linguistic expression. Figure 1.9 shows the membership functions for temperature are very cold, cold, normal, warm and hot.

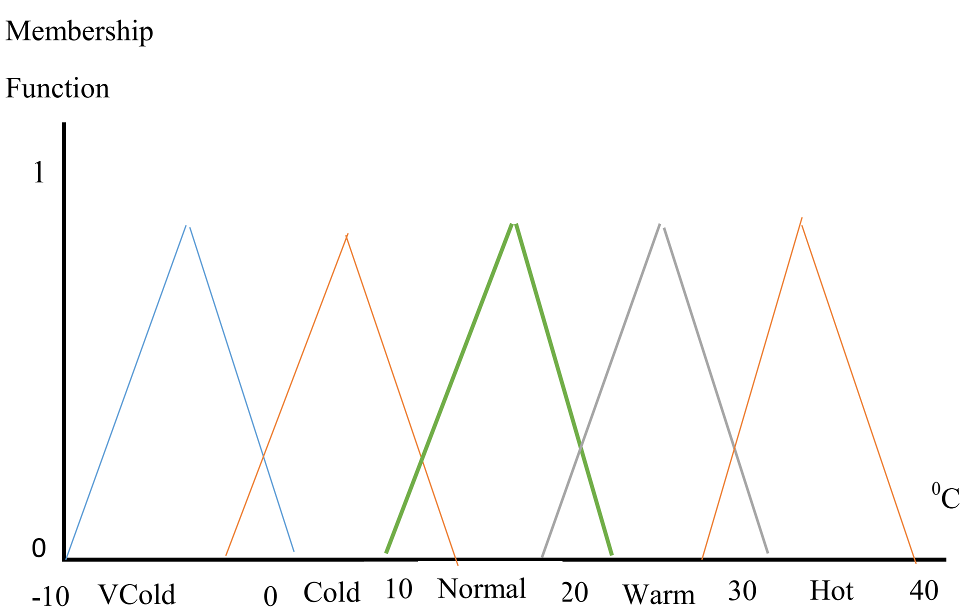

Figure 1. Membership function of the temperature

There are four ways of demonstrating fuzzy membership functions named as graphical representation, geometric representation, tabular and list representation and analytic representation. Graphical representation is the furthermost common in the literature. The second method of representation is the geometric representation and it is used for demonstrating finite sets. The third method of representation is tabular and list representation and this is used for finite sets. In this kind of representation, each and every element of the set is combined with its degree of membership. The two different notations have been used in the literature for tabular and list representation. At last analytical representation is another substitute to graphical representation in demonstrating infinite sets, for example a set of real numbers.

1.2.6 Fuzzy Relations

Fuzzy Relations were introduced to replace classical crisp relations. Instead of describing the full existence or full nonexistence of association of elements of many sets in the instance of crisp relations, fuzzy relations designate the degree of these associations. This provides fuzzy relations the ability to capture the vagueness and uncertainty in relations between sets and elements of a set. Moreover, it allows fuzzy relations to capture the broader theories expressed in fuzzy linguistic expressions when describing the relation among two or more sets. For example, while classical sets are used to designate the equality relation, it can describe only the concept of “x is equal to y” with complete certainty. In this case if x is equal to y with unrestricted precision, then x is related to y, else x is not related to y, even if it was somewhat different. So that it is not possible to designate the concept of “x is approximately equal to y”. Fuzzy Relations create the explanation of such a concept likely. The most common approaches of signifying fuzzy relations are *n*-tuples, matrices, formulas, mappings and directed graphs. The mathematical and logical operations on fuzzy sets are also applicable to fuzzy relations.

1.2.7 Fuzzy Inference Process

Fuzzy inference is the procedure of expressing the mapping between specified inputs to an output using fuzzy logic. The procedure of fuzzy inference includes all of the pieces which are designated in Membership Functions, If Then Rules and Logical Operations. The basic structure of the fuzzy inference process is shown in figure 1.10

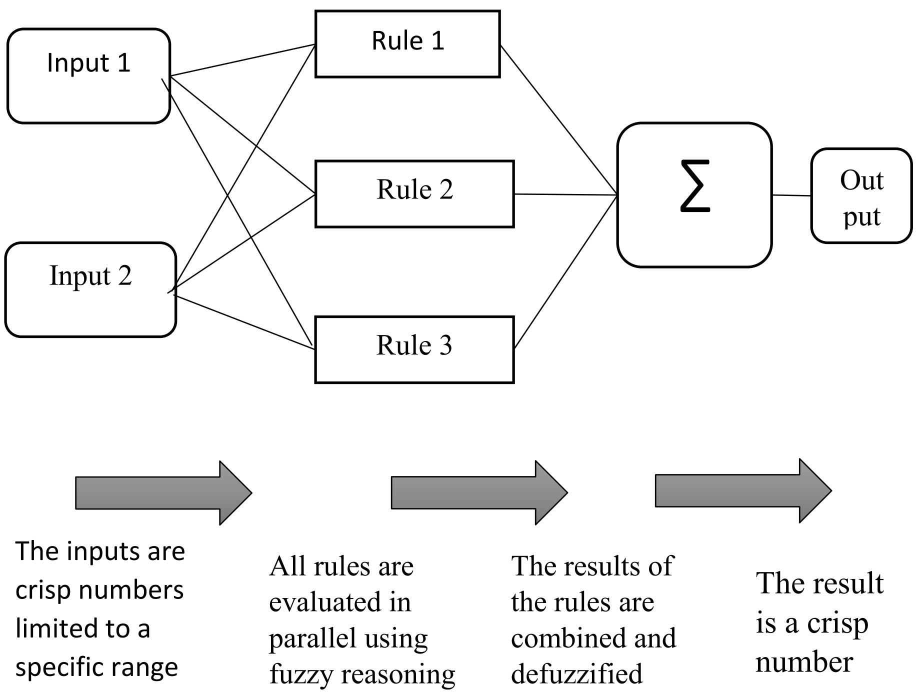

Figure 1. Fuzzy Inference Process having two inputs, three rules and one output

In this figure, information flows from left (two inputs) to right (one output). The corresponding nature of the rules is one of the more significant features of fuzzy logic systems. Instead of sharp swapping between modes built on breakpoints, logic flows efficiently from areas where the system's behavior is controlled by either one rule or another.

1.2.7.1 Parts of Fuzzy inference process

Fuzzified Inputs: - The first step is to yield the inputs and regulate the degree to which they belong to each of the suitable fuzzy sets through membership functions. In Fuzzy Logic Toolbox software, the input is a crisp numerical value inadequate to the universe of dialogue of the input variable and the output is a fuzzy degree of membership in the succeeding linguistic set. Fuzzification of the input quantities is either a table lookup or a function valuation.

Apply Fuzzy Operator: - Once the inputs are fuzzified, the degree to which every part of the originator is satisfied for each rule. If the originator of a specified rule has more than one part, the fuzzy operator is applied to acquire one number which signifies the result of the originator for that rule. Now this number is applied to the output function. The output is an only truth value.

Apply Implication or Inference Method: - Before applying the inference method, Firstly, determine the rule's weight. Each rule has a weight, which is applied to the number specified by the originator. Usually, this weight is 1 and therefore has no effect at all on the inference process. From time to time change its weight value to rather than 1. After appropriate weighting has been allocated to each rule, the inference method is implemented. The subsequent is a fuzzy set suggested by a membership function, which weights appropriately the linguistic characteristics that are recognized to it.

Aggregate All Outputs: - Aggregation is a procedure by which the fuzzy sets that characterize the outputs of each rule are combined into a particular fuzzy set. Aggregation occurs only once for each output variable, just earlier to the fifth and final step named as, defuzzification. The input of the aggregation procedure is the list of abbreviated output functions resumed by the inference process for each rule. The output of the aggregation procedure is a one fuzzy set for respectively output variable.

Defuzzification: -A fuzzy set is an input to the defuzzification process and a single number is output. As much as fuzziness supports the rule valuation during the intermediate steps, the final preferred output for each variable is usually a single number. However, the comprehensive of a fuzzy set incorporates a range of output values, and so must be defuzzified in order to resolve a single output value from the set. The most common defuzzification method is the centroid calculation, which revenues the center of area below the curve. There are five built-in methods which supported to defuzzification named as centroid, bisector, largest of maximum, middle of maximum and smallest of maximum.

1.2.7.2 Types of Fuzzy Inference Systems

Mamdani Type Inference: - Mamdani's fuzzy inference technique is the most usually seen fuzzy approach. Mamdani's technique was amid the first control systems constructed using fuzzy set theory. This technique was proposed by Ebrahim Mamdani in 1975 [3] as a challenge to control a steam engine and boiler mixture by combining a set of linguistic control rules acquired from knowledgeable human operators. Mamdani's effort was based on Lotfi Zadeh's paper on fuzzy algorithms for complex systems and decision processes proposed in 1973 [4]. Mamdani type inference *a*ssumes the output membership functions to be fuzzy sets. After the aggregation procedure, there is a fuzzy set for every output variable which needs defuzzification. It increases the efficiency of the defuzzification procedure because it seriously simplifies the computation mandatory by the more common Mamdani method, which calculates the centroid of a two dimensional functions. Due to its multidisciplinary nature, fuzzy inference systems are connected with a many names, like fuzzy rule based systems, fuzzy modeling, fuzzy expert systems, fuzzy logic controllers, fuzzy associative memory, and ambiguously fuzzy systems.

Sugeno Type Inference: -Instead of integrating through the two dimensional function to calculate the centroid, use the weighted average of a few data points. For the weighted average, Sugeno type system is supported. This technique was introduced in 1985 [5] by M. Sugeno. Sugeno type inference system is very similar to the Mamdani type inference in various respects. The first two parts of the fuzzy inference process named as fuzzified the inputs and apply the fuzzy operator, are accurately the same. Usually, Sugeno type systems can be used to model several inference systems in which the output membership functions are either linear or constant. It is a more compact and computationally effective demonstration rather than a Mamdani inference system, the Sugeno inference system provides itself to the use of adaptive methods for building fuzzy models. These adaptive methods can be used to modify the membership functions by which the fuzzy system finest models the data.

1.3 Neural Network

The neural networks try to figure the biological utilities of the human brain. This indicates to the invention of the neurons as distinct units of circulated processing. Its global or local connections intimate of a net also are unrealistic, thus foremost to the capability of the nervous system in integrating, learning or to predict feedbacks or decisions to be taken. The leading characteristic of the neural networks is the circumstance that these structures can acquire with examples. The neural networks revises its internal configuration and the weights of the relations between its artificial neurons to create the mapping, with a level of conventional error for the application, of the relative input or output that characterize the behavior of the exhibited system. An Artificial Neural Network is an information processing hypothesis which is inspired by the technique biological nervous systems, like the brain, process information. The significant element of this hypothesis is the unique structure of the information processing system. It is basically composed of a huge number of extremely interconnected processing components which are working in unison to resolve specific problems. An Artificial Neural Network is organized for a precise application, such as data classification or pattern recognition, with the help of a learning process. Learning in biological systems includes alterations to the synaptic connections which exist between the neurons. The figure 1.11 shows design of neural network.

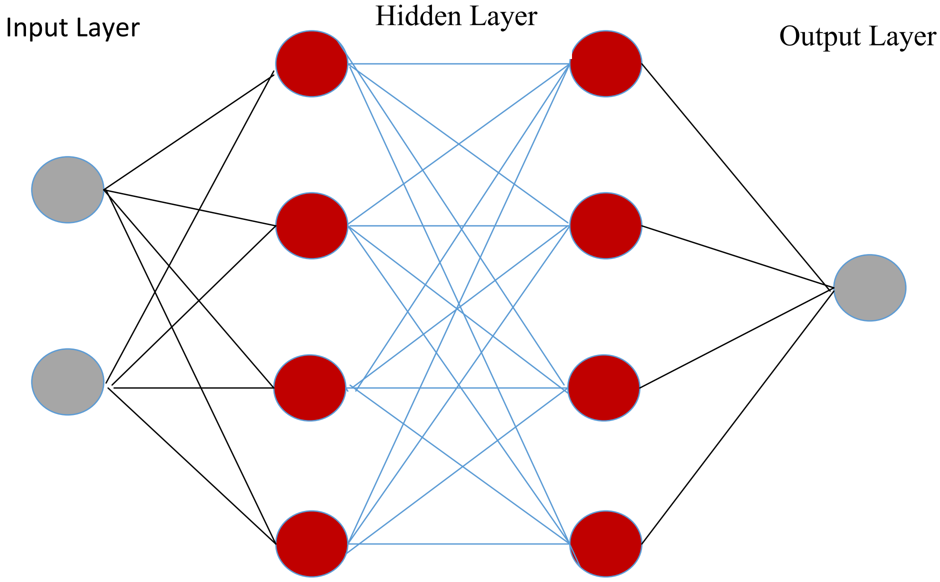

Figure 1. Basic design of Neural Networks

Neural networks, with their significant ability to originate meaning from complicated or inaccurate data, can be used to citation patterns and identify trends which are too complex to be observed by either humans or further computer techniques. A proficient neural network can be understood as an expert in the classification of information it has been specified to analyze. This expert can be used to provide predictions given new circumstances of interest.

1.3.1 Advantages of Neural Network

Adaptive learning: - A capability to learn in what way to do tasks based on the facts or data given for exercise or initial experience.

Self-Organization: - An Artificial Neural Network can construct its personal organization or demonstration of the information which obtains during learning time.

Real Time Operation: - Artificial Neural Network computations may be carried out in corresponding, and distinctive hardware devices are being manufactured and designed which take benefit of this ability.

Fault Tolerance via Redundant Information Coding: Partial damage of a network leads to corresponding deprivation of performance. However, certain network abilities may be reserved even with main network damage.

1.3.2 Architecture of Neural Network

Feed Forward Networks: - Feed Forward Artificial Neural Network allows the signals to travel in one way, from input to output only. In this there is no feedback or loops. Any layer does not affected by the output of any layer. Feed Forward Artificial Neural Networks tend to be traditional forward networks which associate inputs with the outputs. They are comprehensively used in pattern recognition. This kind of organization is also discussed to as bottom up or top down.

Feedback Networks: -Feedback networks allow signals to travelling in both directions with the help of loops in the network. It is very powerful and it can grow exceedingly complicated. Feedback networks are self-motivated and their state is fluctuating continuously until they reach a stability point. They continue at the stability point until the input changes and a new stability needs to be established. Feedback architectures are moreover discussed to as interactive or repeated, while the concluding term is often used to signify feedback connections in a distinct layer organization.

1.3.3 Neuro fuzzy System

Fuzzy systems become very popular in industrialized application, the community supposed that the improvement of a fuzzy system with better performance is not an easy task. The difficulty of finding membership functions and suitable rules is repeatedly a tiring procedure of attempt and error. This is the idea of applying knowledgeable algorithms to the fuzzy systems. The neural networks which have effective learning algorithms had been accessible as an alternative to systematize or to support the improvement of tuning fuzzy systems. The majority of the leading applications were in procedure control. Progressively, its application range for all the areas of the information like data classification, data analysis, support to decision-making and imperfections detection. Fuzzy Systems and Neural networks can be combined to joint its advantages and to cure its individual sickness. Neural networks introduce the computational characteristics of knowledge in the fuzzy systems and obtain from them the clarity and interpretation of systems representation. So that, the disadvantages of fuzzy systems are remunerated by the measurements of the neural networks. These methods are complementary which validates its use together.

1.3.4 Neuro Fuzzy Logic Control System

Fuzzy logic and artificial neural networks [66][67] both are analogous tools for crafting systems that deal with expectation and classification tasks. The idea of different terminologies for neuro-fuzzy systems introduced in the literature was neuro-fuzzy systems [68]. The term neuro-fuzzy system is usually a shortening of adaptive fuzzy systems industrialized by manipulating the similarities among fuzzy systems and neural networks methods. The two techniques of fuzzy logic and neural networks have combined in several different ways. In general, there are three combinations of these techniques. One is neural-fuzzy systems, another one is fuzzy neural networks and third one is fuzzy-neural hybrid systems.

Neural Fuzzy Systems: - The neural network is used to regulate the functions and representing the fuzzy sets which are operated as fuzzy rules. The neural network deviation its weight in the training for the expectation of diminishing the mean square error amid the tangible output of the networks and the targets. L. Wang, J. Mendel, Y. Shi and M. Mizumo to propose some illustrations of this approach [69, 70, 71,]. Neural fuzzy system is used in controller systems.

Fuzzy Neural Networks: - A fuzzy neural network introduced memory connections for classification and weight connections for selection, so that it solves concurrently two foremost problems in pattern recognition that is pattern classification and feature selection. Fuzzy neural systems are used in pattern recognition applications. Lin and Lee presented a neural network in 1996 which composed of fuzzy neurons [72].

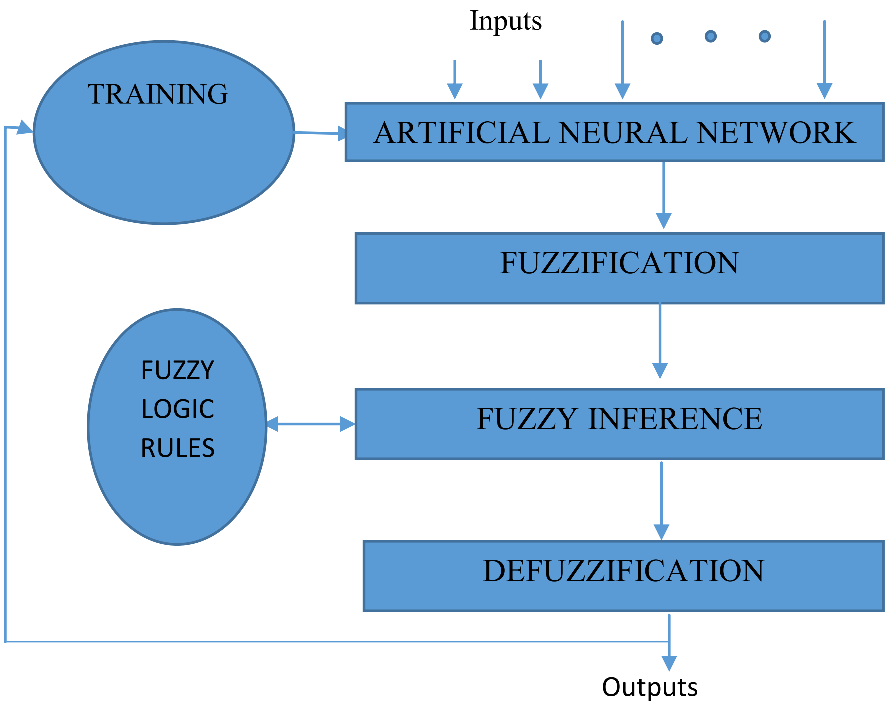

Figure 1. Neural Fuzzy System

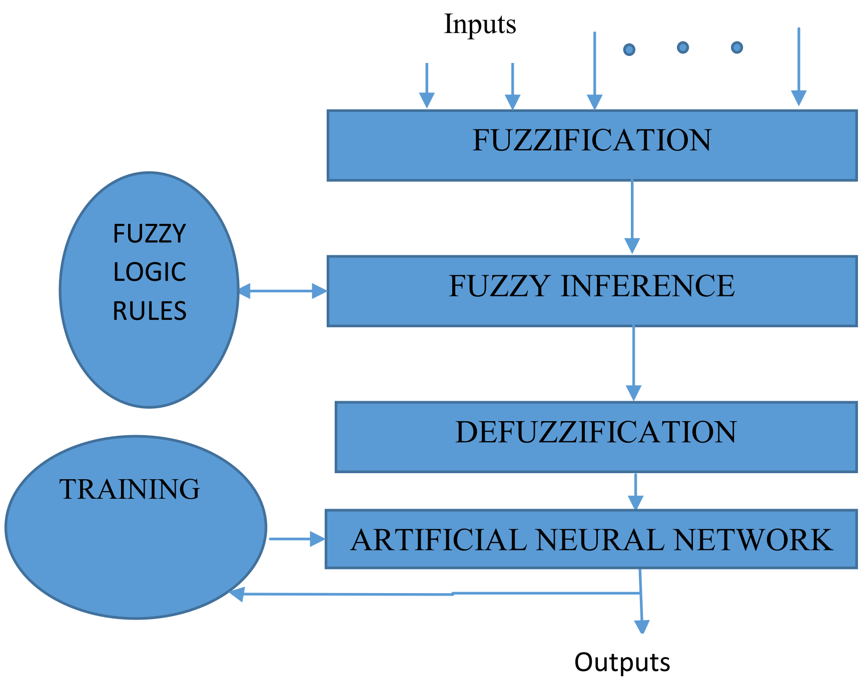

Figure 1. Fuzzy Neural Network

Fuzzy Neural Hybrid Systems: - A fuzzy neural hybrid system is prepared individually from both fuzzy logic and neural network techniques to bring out solicitations such as control systems and pattern recognition. The lead objective of the fuzzy neural hybrid system can be proficient by having each technique do its task by incorporating and approving one another. This kind of inclusion is application oriented and appropriate for control and pattern recognition applications both. The worthy example of hybrid neuro fuzzy are GARIC, ARIC, ANFIS the NNDFR model [73, 74, 75, 76, 77].

1.3.5 ANFIS Structure

The adaptive neuro fuzzy inference system (ANFIS) is a commercial approach which is combined the two techniques such as a neural network and a fuzzy logic to generate a complete shell [75] Fundamentally the system of ANFIS applies the method of the artificial neural network learning rules to conclude and adjust the fuzzy inference systems parameters and structure. Many important features of ANFIS can support the system to achieve a task intensely; these features are considered as fast and accurate learning, easy to implement, excellent explanation facilities, strong generalization abilities, through fuzzy rules. It is easy to integrate both linguistic and numeric acquaintance for problem solving [75, 76, 78, 79, 80, 81,]. This system is measured as an adaptive fuzzy inference system through the competency of learning fuzzy rules from data and as a connectionist manner provided with linguistic significance. A hybrid neuro-fuzzy inference expert system had developed by Jang that works in Takagi Sugeno type fuzzy inference system [82, 83, 84, 85, 86]. ANFIS method is used as a teaching technique for Sugeno-type fuzzy systems. System constraints are identified by the support of

ANFIS. When ANFIS is applying, generally the number and type of fuzzy system membership functions are well defined by user. ANFIS technique is a hybrid technique, which consists two parts, one is gradient technique which is applied to calculation of input membership function parameters, and another one is least square technique which is applied to calculation of output function parameters.

1.4 Chapter Wise Brief Summary of Thesis

This thesis is divided into six chapters. The first chapter provide brief introduction about thesis, introduction to soft computing and techniques of soft computing named as fuzzy logic, neural fuzzy logic, evolutionary computational, probabilistic reasoning and organization of thesis.

Chapter 2 provides details of work done previously by various researches using fuzzy logic and neuro fuzzy logic. This chapter also list application of fuzzy logic control system in different area.

Chapter 3 contains detailed description of employability, three basic employability skills named as education, understanding power and personal development, this chapter also provide the another employability skills and level of employability along with previous work and their possible area of application.

Chapter 4 outlines the CPU scheduling algorithm, basic features of algorithm and preemptive and non-preemptive techniques of CPU scheduling and design of modified fuzzy based scheduling in order to improve performance of CPU. This chapter also includes the job shop scheduling, already existing gupta’s heuristic algorithm and introduced a new job shop scheduling with the help of fuzzy logic to improve performance of scheduling.

Chapter 5 contains the detailed description of conventional system, air conditioning system with fuzzy logic and neuro fuzzy logic. This concern chapter also discusses the traditional duct system and two way ducting system with the help of fuzzy logic to improve the performance and maintain the temperature of the specified area.

Chapter 6 summarizes and concludes the complete thesis and also suggests some future work followed by references.