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Fuzzy Logic Technique In Medcine

ABSTRACT

For master's degree in technical sciences

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Introduction

In several areas of biomedical domain, including prediction of the effectiveness of surgical procedures, medical tests and the discovery of relationships among clinical and diagnosis data, data mining techniques have been applied. Modern – day medical diagnosis is a very composite process, entailing precise patient data, a philosophical understanding of the medical literature and many years of clinical experience. The health care data which, unfortunately, are not ‘‘mined’’ to discover hidden information for effective decision – making are collected in a huge amount by the health care industry. Use of artificial intelligence or computer technology in the fields of medicine area diagnosis and treatment of illnesses has highly increased. The biomedical field has a challenging field because of very high complexity and uncertainty. Therefore the use of intelligent systems such as fuzzy logic has been developed. Because of the many and uncertain risk factors in the heart disease risks, sometimes heart disease diagnosis is hard for experts. In the other word, there exists no strict boundary between what is Healthy and what is diseased, thus distinguish is uncertain and vague.

There are huge data management tools available within health care systems, but analysis tools are not sufficient to discover hidden relationships amongst the data. Most of the medical information is vague, imprecise and uncertain. Medical diagnosis is a complicated task that requires operating accurately and efficiently. Fuzzy set theory and fuzzy logic have a number of characteristics that make them highly suitable for modeling uncertain information upon which medical concept forming, patient state interpretation, and diagnostic as well as therapeutic decision making is usually based. Firstly, medical entities such as symptoms, signs, test results, diseases and diagnoses, therapeutic and prognostic information can be defined as fuzzy sets. The inherent vagueness of these entities will thus be conserved. Secondly, fuzzy logic offers reasoning methods capable of drawing strict as well as approximate inferences. Medicine demands this broad range of possibilities because the body of medical theory includes definitional, causal, statistical, and heuristic knowledge. Practical medicine even has to accept incomplete medical theories where only vague and uncertain empirical information guides the necessary medical procedures. Finally, fuzzy automata maybe used as high-level patient monitoring devices with real time access to medical information systems. The advantages of Fuzzy Logic are its simplicity, flexibility of combining conventional control techniques, ability to model nonlinear functions and imprecise information, use of empirical knowledge and dependency on heuristics.

A Fuzzy Logic System is mainly comprised of four components: Fuzzifier, Defuzzifier, Fuzzy Rule Base and Fuzzy Inference Engine. These components are arranged as follows in any Fuzzy Logic System, Figureure 1.

Fuzzification is the first process that takes place in the FLS. A numeric or crisp input value is given to the Fuzzifier. The crisp input value is required to be converted to the corresponding fuzzy value as the rules for determining the result, are defined for fuzzy inputs. The Fuzzifier and then the fuzzy input values are supplied to the Fuzzy Inference Engine, which is responsible for computing the set of outputs based on the IF – THEN rules defined in the Fuzzy Rule Base, perform this task (Figure 1).

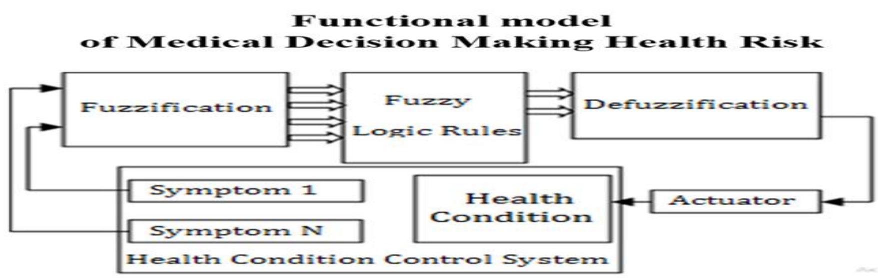


Figure 1 – Block diagram of Health Condition using fuzzy logic system

Usually, when more than one inputs are required, AND operator is used to combine them. The last process in the Fuzzy Logic System is defuzzification. It coverts the fuzzy output values into their corresponding crisp values. There are different methods for fuzzification and defuzzification. Some widely used fuzzifiers are Singleton fuzzifier, Gaussian fuzzifier and Trapezoidal or Triangle fuzzifier. Singleton fuzzifier is the simplest fuzzifier which basically assigns a precise value to the given input and hence no fuzziness is introduced by fuzzification in this case. Gaussian and Triangular fuzzifiers are used to suppress the noise in the given inputs. Examples of defuzzifiers are Maximum defuzzifier, Mean of maxima defuzzifier, Centroid defuzzifier, Height defuzzifier, Modified height defuzzifier, center of sets and center of sums.

GENERAL DESCRIPTION OF WORK

Medical practitioners exhibit variation in decision making because of their approaches to deal with uncertainties and vagueness in the knowledge and information. The diagnostic decisions also depend upon experience, expertise and perception of the practitioner. As the complexity of system increases, it is not easy to follow a particular path of diagnosis without any mistake. Fuzzy logic presents powerful reasoning methods that can handle uncertainties and vagueness. The Fuzzy Expert Systems (FES) define imprecise knowledge and offers linguistic concept with excellent approximation to medical texts.1 Fuzzy logic is a method to render precise what is imprecise in the world of medicine. FES play an important role in medicine for symptomatic diagnostic remedies. The technocrats identified potential and possible areas for implementation of FES for medical diagnosis. Also, the efforts have been made by various researchers to establish a roadmap to forecast the future developments of expert systems in medical diagnosis.

MAIN RISULRS

. Overview of Expert systems and there medical applications.

2. Overview of Wireless Body Area Networks as transport system for health remote monitoring.

3. Flaw-chart of the Mamdani’s algorithm to design fuzzy inference system for Decision Making.

4. Flaw-chart of the methodology to design the Fuzzy Logic Clustering algorithm for wearable sensors networks.

5. Simulation model of the Next–Node Selection Fuzzy Logic Algorithm for WBAN

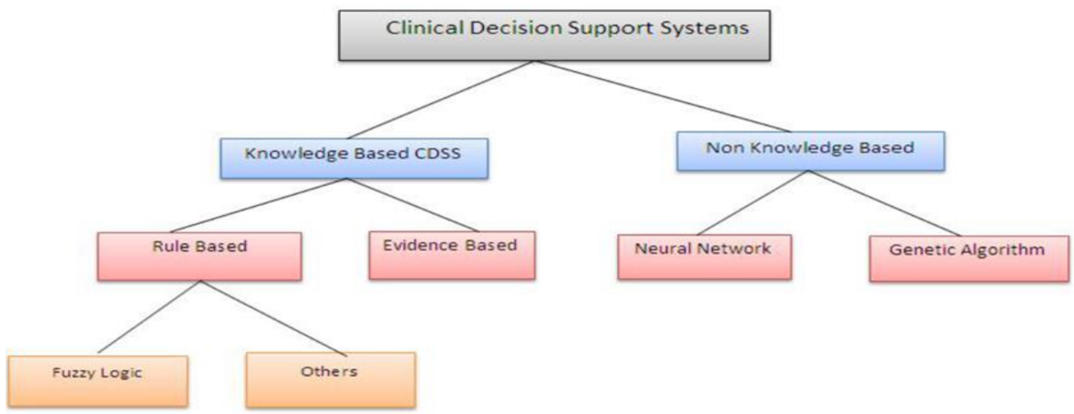
6. Simulation model of the Fuzzy Inference System Based Human Health Monitoring and Medical Decision Making Heart Risk

Expert systems in medicine

Since computer was invented, expert systems have been used for assisting medical professionals. Clinical decision support systems (CDSS) are broadly classified into two main groups depending on the methods for obtaining decision – making rules, Figure 2:

– Knowledge based CDSS;

– Non – knowledge based CDSS.



Figurer 2 – Classification of clinical decision support systems

The knowledge based clinical decision support system contains rules mostly in the form of IF – Then statements. The data is usually associated with these rules. For example, if the pain intensity is up to a certain level then generate warning etc., The knowledge based generally consists of three main parts: Knowledge base, Inference rules and a mechanism to communicate. Knowledge base contains the rules, inference engine combines rules with the patient data and the communication mechanism is used to show the result to the users as well as to provide input to the system.

CDSS based on Fuzzy Logic Rules are a form of knowledge base and has achieved several important techniques and mechanisms to diagnose the disease and pain in patient.

Rule – Based Systems & Evidence Based Systems tend to capture the knowledge of domain experts into expressions that can be evaluated as rules.

When a large number of rules have been compiled into a rule base, the working knowledge will be evaluated against rule base by combining rules until a conclusion is obtained. It is helpful for storing a large amount of data and information. However, it is difficult for an expert to transfer their knowledge into distinct rules.

CDSS without a knowledge base are called as non – knowledge based CDSS. These systems instead used a form of artificial intelligence called as machine learning. Non – knowledge based CDSSs are then further divided into two main categories:

– CDSS based on Neural Networks;

– CDSS based on Genetic Algorithms.

To derive relationship between the symptoms and diagnosis, neural networks use the nodes and weighted connections. This fulfills the need not to write rules for input. However, the system fails to explain the reason for using the data in a particular way. So its reliability and accountability can be a reason.

Genetic Algorithms are based on evolutionary process. Selection algorithm evaluates components of solutions to a problem. Solution that comes on top are recombined and the process runs again until a proper solution is observed. The generic system goes through an iterative procedure to produce the purpose the best solution of a problem.

Review of Expert Systems in medicine based on Fuzzy logic

Fuzzy logic attempts to systematically and mathematically emulate human reasoning and decision – making. It provides an intuitive way to implement control systems, decision making and diagnostic systems in various branches of industry. Fuzzy logic represents an excellent concept to close the gap between human reasoning and computational logic. Variables like intelligence, credibility, trustworthiness and reputation employ subjectivity as well as uncertainty. Fuzzy logic attempts to systematically and mathematically emulate human reasoning and decision – making. It provides an intuitive way to implement control systems, decision making and diagnostic systems in various branches of industry.

Fuzzy logic represents an excellent concept to close the gap between human reasoning and computational logic. Variables like intelligence, credibility, trustworthiness and reputation employ subjectivity as well as uncertainty.

They cannot be represented as crisp values; however, their estimation is highly desirable. Systems are emerging technologies targeting industrial applications and added a promising new dimension to the existing domain of conventional control systems

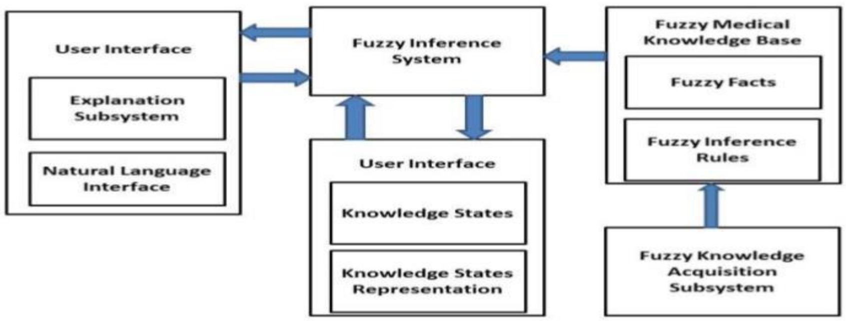


Figure 3 – Fuzzy Expert System

WBAN FOR REMOTE HEALTH MONITORING. ARCHITECTURE AND APPLICATIONS

Overview

Wireless body area network (WBAN) is a system which can continuously monitor the health conditions of patients to prevent and early risk detection by sharing the information with care takers and physicians.

Based on the operating environments this can be classified into two types one is called wearable body area network which is operated on the surface of body and another is implantable body area network which is operated inside the human body.

Wireless Body Area Networks is a forthcoming technology which utilizes wireless sensor nodes to implement real – time wearable health monitoring of patients. These sensor nodes can be worn externally or implanted inside the body to monitor multiple bio – parameters (such as bloodoxygen saturation, blood pressure and heart activity) of multiple patients at a central location in the hospital.

It is a radio frequency based wireless networking technology. Here patients' health status can be monitored anytime and anywhere without restricting his/her mobility. Thus, patient can live his/her normal daily life activities.

Thus the basic BAN applications are:

– Physiological and vital signals monitoring: blood pressure sensor, heart rate monitor, cardiac arrhythmia, motion sensor, temperature sensor, respiratory monitor, saturation of oxygen, breathing monitor, electrocardiogram, electro encephalography, electromyography, ph. Value, glucose sensor etc.

– Stimulators: Cortical stimulator, deep brain stimulator, neuro stimulator, wireless capsule for drug delivery, brain – computer interface etc.

– Remote control of medical devices: Pacemaker, insulin pump, hearing aids, cochlear implant, implantable cardioverter defibrillator, retina implants, actuators etc.

– Fitness Monitoring: heart rate, speed motion, respiration monitor, temperature etc.

– Disability and Elderly people assistance: Muscle tension sensing and stimulation, fall detection, foot sensor for steps monitoring, breathing sensor, temperature sensor, movement sensor etc.

On other side the WBAN technology is the consequence of the existing wireless sensor network (WSN) technology. A number of tiny wireless sensors, strategically placed on the human body, create a wireless body area network that can monitor various vital signs, providing real – time feedback to the user and medical personnel. In a WBAN, each wearable biomedical sensor monitors different vital signs such as body temperature, blood pressure, electrocardiogram (ECG), electromyogram (EMG), electroencephalogram (EEG), oxygen saturation (SpO2) or motion sensors. The system may consist of multiple sensor nodes that monitor body motion and heart activity, a network coordinator, and a personal server running on a personal digital assistant or a personal computer.

Data collected by the medical sensors is transmitted to the coordinator. The sensors are always activated and continuously transmit data to the coordinator. This conFigureuration causes high energy consumption in all medical sensors and reduces their operational time. Hereby different types of medical sensors can be used for monitoring various vital parameters.

Figurer 3 illustrates a general three – tier communication architecture of a BAN– based health-monitoring system. Tier – 1 presents intra – BAN communications, Tier – 2 – inter – BAN communications and Tier – 3 – beyond – BAN communications.

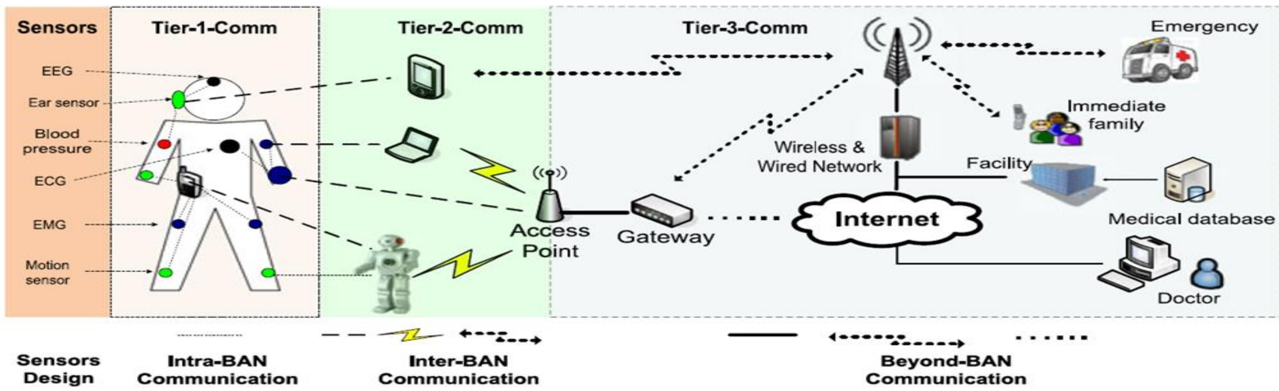


Figure 4 – Wearable communications of WBAN

Wearable Sensors for Remote Health Monitoring

Cardiovascular Monitoring System

Electrocardiograms (ECGs) represent a non – invasive approach for measuring and recording the fluctuations of cardiac potential. This is the most widely used and effective diagnostic tool that physicians have used for decades to identify heart – related problems such as different forms of arrhythmias.

Although many arrhythmias are not life – threatening, some results from weak or damaged heart such as myocardial infarction (MI) that may lead to cardiac arrest, if not managed immediately. After a heart attack, patients are required to receive immediate medical attention, which, otherwise, may turn fatal. These complications can be avoided if any inconsistency in cardiac activity is detected and treated in an early stage that calls for outpatient ambulatory monitoring of ECG. Some rare, serious arrhythmias are infrequent and only detected on prolonged monitoring. Figurer 5 shows one cycle of a typical ECG signal.

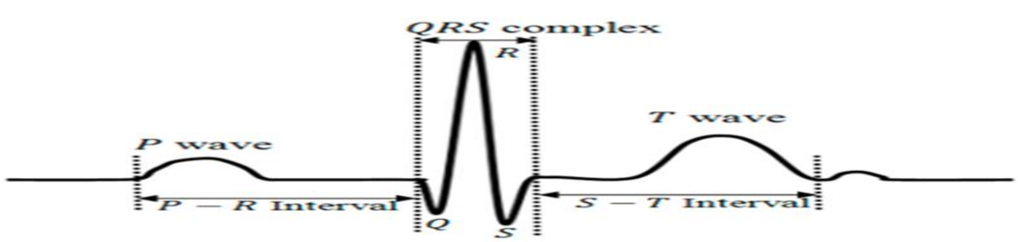


Figure 2.19 – One cycle of a typical ECG signal

FUZZY LOGIC TECHNIQUE IN MATHLAB

Fuzzy Inference Process

Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping then provides a basis from which decisions can be made, or patterns discerned. The process of fuzzy inference involves all the pieces that are described in “Membership Functions”, “Logical Operations, and “If – Then Rules”. This section describes the fuzzy inference process and uses the example of the two – input, one – output, three – rule tipping problem from “The Basic Tipping Problem”(Figure 4).

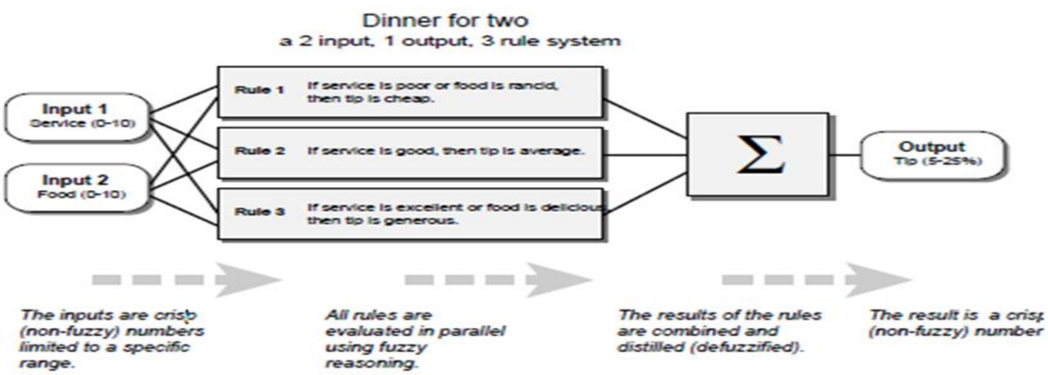


Figure 6 – Describes the fuzzy inference process

Nature of the rules is an important aspect of fuzzy logic systems. Instead of sharp switching between modes based on breakpoints, logic flows smoothly from regions where one rule or another dominates.

Fuzzy inference process comprises of five parts:

Fuzzification of the input variables;

–Application of the fuzzy operator (AND or OR) in the antecedent;

–Implication from the antecedent to the consequent;

–Aggregation of the consequents across the rules;

– Defuzzification.

A fuzzy inference diagram displays all parts of the fuzzy inference process – from atifuzzificon through defuzzification.

Fuzzy Logic Toolbox Graphical User Interface Tools

This example shows how to build a fuzzy inference system (FIS) for the tipping example, described in "The Basic Tipping Problem", using the Fuzzy Logic Toolbox UI tools. You use the following tools to build, edit,and view fuzzy inference systems:

–Fuzzy Logic Designer to handle the high – level issues for the system – How many input and output variables? What are their names? Fuzzy Logic Toolbox software does not limit the number of inputs. However, the number of inputs may be limited by the available memory of your machine. If the number of inputs is too large, or the number of membership functions is too big, then it may also be difficult to analyze the FIS using the other tools;

–Membership Function Edito to define the shapes of all the membership functions associated with each variable;

–Rule Editor to edit the list of rules that defines the behavior of the system;

–Rule Viewer to view the fuzzy inference diagram. Use this viewer as a diagnostic to see, for example, which rules are active, or how individual membership function shapes influence the results;

–Surface Viewer to view the dependency of one of the outputs on any one or two of the inputs—that is, it generates and plots an output surface map for the system.

These UIs are dynamically linked, in that changes you make to the FIS using one of them, affect what you see on any of the other open UIs. For example, if you change the names of the membership functions in the Membership Function Editor, the changes are reflected in the rules shown in the Rule Editor. You can use the UIs to read and write variables both to the MATLAB workspace and to a file, (the read – only viewers can still exchange plots with the workspace and save them to a file). You can have any or all of them open for any given system or have multiple editors open for any number of FIS systems (Figure 5).

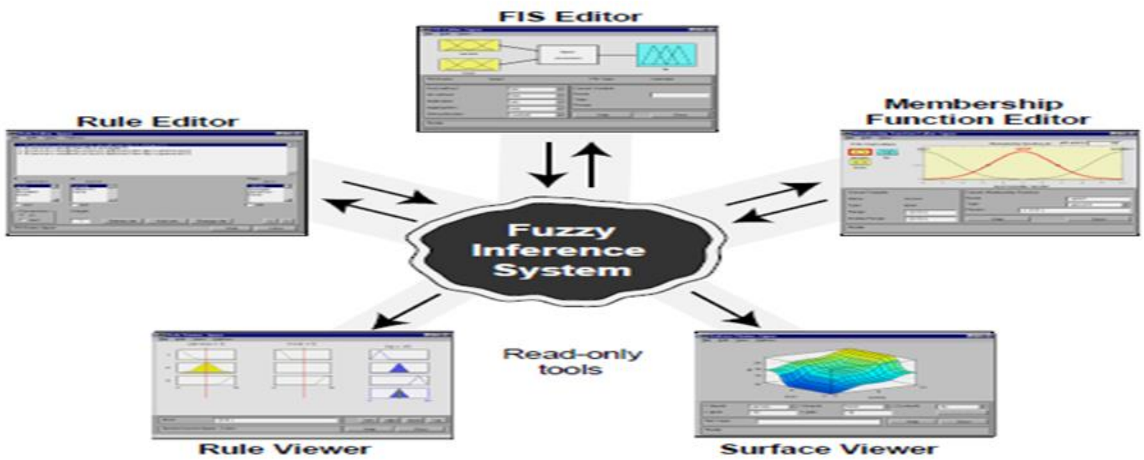
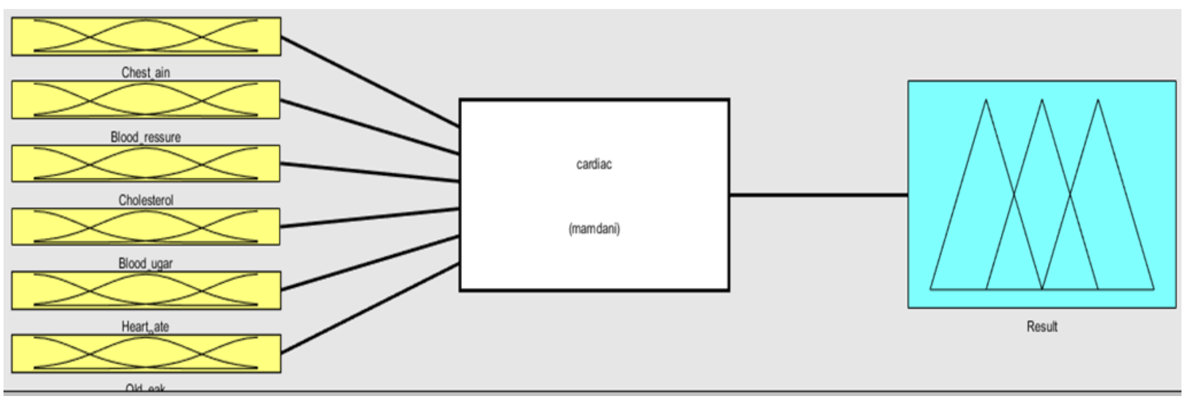


Figure 5 – Diagram of fuzzy interface system

Fuzz inference system based human health monitoring and medical decision making for heart rick

Dataset for the designed system is collected from various Hospitals and by consulting the expert in the field of heart disease. The purpose of this dataset is to diagnose the presence or absence of heart disease given the results of various medical tests carried out on a patient. This system uses 6 attributes for input and 1 attribute for output (Figure 6).



The Input attributes are chest pain type, blood pressure, cholesterol, blood sugar, maximum heart rate and old, the output field refers to the presence of heart disease in the patient. It is integer value from 0 (no presence) to 1; increasing value shows increasing heart disease risk. Fuzzy logic is a form of multi – valued logic derived from fuzzy set theory to deal with reasoning that is approximate rather than precise. In contrast with binary sets having binary logic, also known as crisp logic, the fuzzy logic variables may have a membership value of only 0 or 1. Firstly there is a need to make a dataset to decide the range of parameters on which the heart diseases are depending.

Chest pain: In input attribute Chest pain, we choose five different membership functions which are very low, low, moderate, high and very high. The range of this attribute is given in table 4.8 and figure 6.

Fuzzy Inference System Wireless Body Area Network System (FIS – WBAN)

In this proposed work, we have implemented the 16 nodes into the network where central coordinator could be a Smartphone or a RF – node placed on the waist and ankle of the patient. Coordinator node will collect data from the remote nodes and this will behave as hub or gateway for other remote sites which provides the instructions to sensors and actuators. In real life applications, multi hop WBAN network is formed. The proposed FIS – WBAN with 4 inputs, 1 output and 81 fuzzy rules is implemented as shown in Figure5.1:

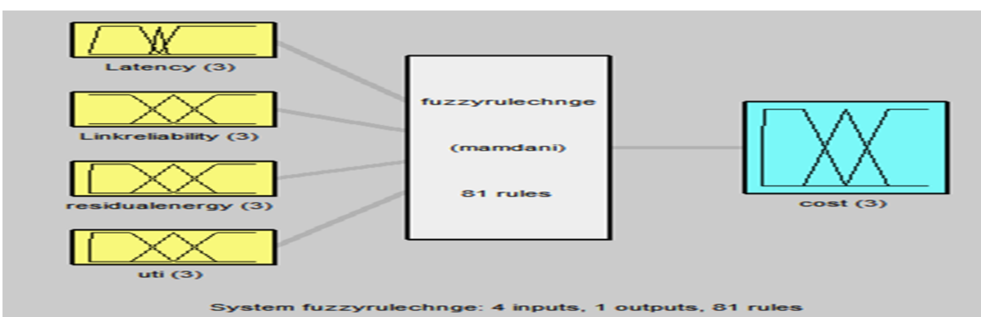


Figure 5.1 – FIS – WBAN

Conclusion

In this paper, we give a systematic introduction to concepts in fuzzy logic as well as neuro – fuzzy systems and Expert System. Fuzzy logic provides effective tools for modeling uncertainty in human reasoning. A fuzzy inference system represents knowledge in IF – THEN rules, and implements fuzzy reasoning. Whereas Expert systems technology is an emerging area which is finding applications in a number of diverse areas. Organizations are employing expert systems to capture the problem – solving skills of human experts to either assist the expert or use them in those situations where the expert is not available. This paper has provided a brief overview of this technology too and has discussed its application in the area of science. Applications of expert systems in the sciences are expected to increase in the near future. Expert system has a wide scope in the development of the medical industry. In future, we can be made work to derived the neuro – fuzzy medical diagnose. This would definitely increase the accuracy to 99.9%, reduce the cost and save time.

This review paper describes different expert systems in medical diagnosis and evaluates the contributions made by different researchers. Some researchers have evaluated their medical expert systems in hospitals from the experts and retrieved various parameters like accuracy and precision. Using these parameters, they have calculated the performance of their expert systems. The accuracy and other parameters of expert system depend on the knowledge base. The knowledge base should have relevant knowledge. There should be stress on knowledge acquisition, a stage in which knowledge is gathered. So performance of expert system depends on all these factors. One can increase the performance of expert system by making knowledge base more accurate and very little work is done using neuro – fuzzy, ANN and fuzzy logic in medical diagnosis. So we will go for these in medical diagnosis.