

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

Uncertainty is a challenging part in human's everyday life. Since the future cannot be predict, it is impossible to be certain about what exactly is going to happen day to day. The main cause of uncertainty is the information deficiency. Information may be incomplete, fragmentary, not fully reliable, vague, contradictory or deficient in some other way. These various information deficiencies may result in different types of uncertainty. The three major types of uncertainties are fuzziness (or vagueness), which results from the imprecise boundaries of fuzzy sets, non-specificity (or imprecision), which is connected with sizes (cardinalities) of relevant sets of alternatives and strife (or discord), which expresses conflicts among the various sets of alternatives (Saikat Maity, Jaya Sil 2009). However, in practice, most uncertainties are tolerable, manageable or negligible.

There is a high level of uncertainty management in intelligent systems. This is because human reasoning and decision making is fuzzy, involving a high degree of vagueness in evidence, concept utilization and mental model formulation (Wang and Elhag 2006). Human thought is fuzzy in nature, complete with uncertainties, ambiguities and contradictions. Two experts might not place the same level of importance on the same piece of information.

According to Aristotelian logic, for a given proposition or state, only two logic values are proposed: true-false, black-white, 1-0. In real life, things are not either black or white but most of the times are grey. Thus in many practical situations, it is convenient to consider intermediate logical values.

Fortunately, the traditional idealistic mathematical approach has been improved to accommodate partial truth by the introduction of fuzzy set theory invented by Professor Lotfi A. Zadeh. Unlike classical set theory, fuzzy set theory is flexible which focuses on the degree of being a member of a set. This simple notion leads to new concepts and ideas through which more realistic mathematical representation can be achieved in describing events observed with uncertainty. Fuzzy logic is a qualitative computational approach which describes uncertainty or partial truth.

2.2 Evolution of Fuzzy Logic

Fuzzy Logic was originally developed in the early 1960's by Professor Lotfi Zadeh, who claimed for the new kind of computational paradigm capable of modeling the uncertainties of human reasoning. In 1965, Zadeh published the first ideas on fuzzy sets, the key concept in Fuzzy Logic. He originally devised the technique as a means for solving problems in the soft sciences, particularly those that involved interactions between humans and/or between humans and machines. Fuzzy reasoning is nothing else than a straightforward formalism for encoding human knowledge or common sense in a numerical framework. In a fuzzy controller, human experience is coded by means of linguistic if-then rules that build up a so-called Fuzzy Inference System which computes control actions upon given conditions.

Fuzzy Logic has been applied to problems that are either difficult to face mathematically or applications where the use of Fuzzy Logic provides improved performance and/or simpler implementations. One of its main advantages lies in the fact that it offers methods to control non-linear plants, known difficult to model.

At the beginning, fuzzy logic was not accepted by the highly deterministic scientific community. But in the last years, the astonishing growth of the Japanese industry in producing a substantial number of consumer appliances using Fuzzy Controllers put Fuzzy Logic on the focus of scientific community. In 1990, the market of Fuzzy Logic Based products was estimated nearly equal to \$2 billion (Patyra, 1992). According to the investigation of the Market Intelligence Research Corporation of California in 1991, Japan captured 80% of the world wide market. In 1992, the return in fuzzy products doubled with respect to the previous year whereas companies like OMRON, held about 700 patents at that date. Germany, India, France, Korea, Taiwan and China followed Japan in Fuzzy Logic Research and Development projects.

2.3 Implementation of Fuzzy Logic

Professor Lotfi Zadeh presented fuzzy logic not as a control methodology but as a way of processing data by allowing partial set membership rather than crisp set membership or non-membership. It is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PC or workstation-based data acquisition

and control systems. It can be implemented in hardware, software or a combination of both. Fuzzy Logic provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy or missing input information. Fuzzy Logic approach to control problems imitates how a person would make decisions, much faster.

Fuzzy logic is a form of many-valued logic derived from fuzzy set theory to deal with reasoning that is fluid or approximate rather than fixed and exact. In contrast with "crisp logic", where binary sets have two-valued logic, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. In simple words, fuzzy logic is a super set of conventional logic that has been extended to handle the concept of partial truth--the truth values between completely true and completely false. Furthermore, when linguistic variables are used, these degrees may be managed by specific functions.

Fuzzy logic and probabilistic logic are mathematically similar, both have truth values ranging between 0 and 1 but conceptually distinct, due to different interpretations. Fuzzy logic corresponds to "degrees of truth", while probabilistic logic corresponds to "probability, likelihood"; as these differ, fuzzy logic and probabilistic logic yield different models of the same real-world situations.

The two most common implementations of fuzzy logic are rule based and neural networks. Both fuzzy implementations have a diverse range of applications including medicine, avionics, security and machine learning. Rule based systems explicitly collect the expert's knowledge. These rules and thinking patterns are then programmed into the system. Rule based systems do not require a large training set like that of neural network solution (Michelle LaBrunda, Andrew LaBrunda, 2008).

Unlike rule-based fuzzy logic, neural network do not require thinking patterns to be explicitly specified. Typically two datasets are created to program a neural network. The first dataset is the trainer. This set of input is passed into the neural network and processed. The processing phase consists of storing the input values among an array of memory structures called nodes. Each node remains some information and sorts the remaining information between the neighboring nodes. Once all the information has been processed it is evaluated and stored as the template for which all other datasets will be compared.

The advantage of the rule based fuzzy logic system is that it is easier for the system to rationalize its behavior to users. Rule based fuzzy logic system behavior is

determined by rules or parameters and the changes to these parameters represent the incentives to take action (Michelle La Brunda, Andrew La Brunda 2008).

2.4 Research and Development Fields of Fuzzy Logic

In the early stages, the applications of Fuzzy Logic were confined to control systems and process control where the mathematical model of the plant is unknown, complex and not well defined. But later, the areas where Fuzzy Control has been applied comprise a wide variety of applications, with different complexity and performances. Washing machines, automatic focusing for video cameras, automatic TV tuner, servo motor control, automotive anti skid brake and many other consumer appliances use the concept of fuzzy controllers. At present, the application of Fuzzy Logic exceeds the control domain since it is also employed for other knowledge based decision making tasks. It involves medical diagnosis, business forecasting, traffic control, network management, image processing, signal processing, computer vision, geology and many more (Costa A., et al., 1995).

Table 2.1 covers a range of research areas related to Fuzzy Logic as reported in the IEEE 2001 International Conference on Fuzzy Systems.

TABLE 2.1
RESEARCH AREAS IN FUZY LOGIC AS REPORTED IN IEEE 2001

Research and Development area	Main Topics
Fuzzy Mathematics	Foundations of Fuzzy Logic, appropriate reasoning, evolutionary computation, identification and learning algorithms, rule base optimization.
Control Systems	Fuzzy control theory and applications, process and environmental control, stability criterions issues, multilevel-supervisory control.
Pattern Recognition and Image Processing	Supervised and Unsupervised learning, classifiers design and integration, signal/image processing and analysis, computer vision, multimedia applications
Soft Computing and Hybrid Systems	Intelligent information systems, database systems, data mining intelligent systems,

	reliability engineering, Neuro-Fuzzy systems, Internet computing, networks traffic modeling and control.
Electronic Systems	Fuzzy hardware implementation and embedded applications.
Robotics and Automation	Fuzzy Logic in robotics, industrial automation and other industrial applications.

Fuzzy controllers demonstrate excellent performance in numerous applications such as industrial processes (M. Sugeno, 1985) and flexible arm control (Kuldip S. Rattan et al, 1989). Mamdani's (Mamdani E. H, 1974) work introduced this control technology that Zadeh pioneered with his work in fuzzy sets (Zadeh. L.A, 1973). There are two steps involved in the implementation of a fuzzy logic controller; fuzzification of inputs and determination of a "crisp output" (Brehm.T, Rattan K.S, 1994). Fuzzification involves dividing each input variable's universe of discourse into ranges called fuzzy subsets. A function applied across each range determines the membership of the variable's current value to the fuzzy subset. Linguistic rules express the relationship between input variables Defuzzification which is used to determine the "crisp output", resolves the applicable rules into a single output value.

Research into fuzzy control has applied classical techniques to stability analysis (Gholamresa Langari 1990) and design (Sabharwal.D and K. Rattan 1992), (L. Zheng 1992). The operation of a fuzzy controller behaves similar to a classical PD or PI controller (Gholamresa Langari 1990), (Sabharwal.D and K. Rattan 1992). For a classical PD controller, the position and derivative gains remain constant for all values of input. However, for a fuzzy controller the gains depend on the range where the control variables exist at any instant. The piecewise linearity of the fuzzy controller provides better system response than a classical controller (Li.Y and C Lau 1989), (Sabharwal.D and K. Rattan 1992). Since the operating point of the fuzzy controller is not fixed, it provides improved robustness to changes in the system parameters as compared to a classical controller. Expression of the fuzzy control action in a closed form (Gholamresa Langari 1990), (Sabharwal.D and K. Rattan 1992) provides insight into how the fuzzy subsets and output values affect the controller response.

2.5 Application of Fuzzy Control in various domains

A fuzzy control system is a system based on fuzzy logic, a mathematical system that analyzes analog input values in terms of logical variables that take on continuous values between 0 and 1, in contrast to classical or digital logic which operates on discrete values of either 0 or 1 (true or false). The Japanese had their interest in fuzzy systems and it was sparked by Seiji Yasunobu and Soji Miyamoto of Hitachi who in 1985 provided simulations that demonstrated the superiority of fuzzy control systems for the Sendai railway. Their ideas were adopted and fuzzy systems were used to control accelerating, braking and stopping when the line opened in 1987. Another event in 1987 helped promote interest in fuzzy systems. During an international meeting of fuzzy researchers in Tokyo, Takeshi Yamakawa demonstrated the use of fuzzy control, through a set of simple dedicated fuzzy logic chips, in an "inverted pendulum" experiment. This is a classic control problem in which a vehicle tries to keep a pole mounted on its top by a hinge upright by moving back and forth.

Observers were impressed with this demonstration, as well as later experiments by Yamakawa in which he mounted a wine glass containing water or even a live mouse to the top of the pendulum. The system maintained stability in both cases. Yamakawa eventually went on to organize his own fuzzy-systems research lab to help exploit his patents in the field. Following such demonstrations, Japanese engineers developed a wide range of fuzzy systems for both industrial and consumer applications. In 1988 Japan established the Laboratory for International Fuzzy Engineering (LIFE), a cooperative arrangement between 48 companies to pursue fuzzy research. Japanese consumer goods often incorporate fuzzy systems. Matsushita vacuum cleaners use microcontrollers running fuzzy algorithms to interrogate dust sensors and adjust suction power accordingly. Hitachi washing machines use fuzzy controllers to load-weight, fabric-mix and dirt sensors and automatically set the wash cycle for the best use of power, water and detergent. As a more specific example, Canon developed an auto focusing camera that uses a charge-coupled device (CCD) to measure the clarity of the image in six regions of its field of view and use the information provided to determine if the image is in focus. It also tracks the rate of change of lens movement during focusing and controls its speed to prevent overshoot.

The camera's fuzzy control system uses 12 inputs: 6 to obtain the current clarity data provided by the CCD and 6 to measure the rate of change of lens movement. The output is the position of the lens. The fuzzy control system uses 13 rules and requires 1.1 kilobytes of memory. As another example of a practical system, an industrial air conditioner designed by Mitsubishi uses 25 heating rules and 25 cooling rules. A temperature sensor provides input, with control outputs fed to an inverter, a compressor valve and a fan motor. Compared to the previous design, the fuzzy controller heats and cools five times faster, reduces power consumption by 24%, increases temperature stability by a factor of two and uses fewer sensors.

The interest of the Japanese for fuzzy logic is reflected in the wide range of other applications. They have implemented character and handwriting recognition, optical fuzzy systems, robots, including one for making Japanese flower arrangements, voice-controlled robot helicopters, inverted pendulum problem, control of flow of powders in film manufacture, elevator systems and so on.

Work on fuzzy systems is also proceeding in the United States and Europe, though not with the same interest shown in Japan. The United States Environmental Protection Agency has investigated fuzzy control for energy-efficient motors. NASA has studied fuzzy control for automated space docking. Simulations show that a fuzzy control system can greatly reduce fuel consumption. Firms such as Boeing, General Motors, Allen-Bradley, Chrysler, Eaton and Whirlpool have worked on fuzzy logic for use in low-power refrigerators, improved automotive transmissions and energy-efficient electric motors.

In 1995 Maytag introduced an "intelligent" dishwasher based on a fuzzy controller and a "one-stop sensing module" that combines a thermistor for temperature measurement, a conductivity sensor, to measure detergent level from the ions present in the wash, a turbidity sensor that measures scattered and transmitted light to measure the soiling of the wash and a magnetostrictive sensor to read spin rate. The system determines the optimum wash cycle for any load to obtain the best results with the least amount of energy, detergent and water. It even adjusts for dried-on foods by tracking the last time the door was opened and estimates the number of dishes by the number of times the door was opened. Research and development is also continuing on fuzzy applications in software design, including fuzzy expert systems and integration of fuzzy logic with neural-network and genetic

software systems, with the ultimate goal of building "self-learning" fuzzy control systems. Table 2.3 shows some successful fuzzy systems presently at work.

TABLE 2.2
SOME SUCCESSFUL FUZZY SYSTEMS PRESENTLY AT WORK

Industrial	Cement kiln Control (Denmark)
	Automatic train operation (Japan)
	Water treatment system (Fuji electric, Japan)
	Water treatment system (Fuji electric, Japan)
	Smart sensors (Fisher Rosemount, USA)
	Blast furnace control (NKK Fukoyama, Japan)
	Nuclear reactor control (Art Fugen, Japan)
	Fire detector (Cerberus, Switzerland)
	Camera tracking (NASA, USA)
	Target tracker in Patriot missile (MMES, USA)
Commercial	Washing machine (Matsushita, Japan)
	Home heating system and air conditions
	Photocopy machine (Sanyo, Japan)
	Fuzzy auto focus still camera (Japan)
	Vacuum cleaner (Sony, Hitachi, Sanyo, Toshiba, Sony)
	Refrigerator (Sharp)
	Rice Cooker (Matsushita, Sanyo, Sharp, Hitachi)
	Home air conditioner (Mitsubishi Heavy Industries, Japan)

	Fuzzy PLC (Klockner-Moeller, Germany)
	Fuzzy auto focus still camera (Sanyo, Japan)
	Smart sensors (Fisher-Rosemount, USA)
	Health management (OMRON, Japan-USA)
Research	Speech recognizer (NTT communication, Japan)
	Fuzzy medical expert system
	Helicopter control (LIFE, Japan)
	Fingerprint classification (NIST, USA)
	Autonomous robot control (SRI International, USA)
	Autonomous navigation of robots (ORNL, USA)
	Used car selection (A used car center in Kansai, Japan)

2.6 Utilization of Fuzzy Logic-Based Technologies in Medicine and Healthcare

Internal Medicine

Internal medicine is a classic field of research in computer-aided diagnosis which began in the 1960s with high hopes that difficult clinical problems might yield to mathematical formalism. The main areas in internal medicine can be classified into rheumatology, gastroenterology, hematology, and pulmonology. Developments in knowledge-based expert systems in medicine began with the MYCIN system about a decade after Zadeh's introduction of fuzzy logic. Designing and tuning fuzzy rule-based systems for medical diagnosis was discussed by Rotshtein .A fuzzy inference system was developed to aid in the diagnosis of pulmonary embolism using ventilation-perfusion scans and correlated chest X-rays. The Mamdani fuzzy model was successfully employed to implement the inference system (Abbod, 2005).

Cardiology and Vascular Surgery

In the mid-1990s several workers pointed to the concept of fuzzy sets in cardiovascular medicine. Implementation of fuzzy control of a total artificial heart was one application. The main task of the artificial heart control system is to maintain sufficient organ perfusion by controlling the pumping rate. Another application that incorporates fuzzy logic is a system called TOTOMES which was designed to assess cardiovascular dynamics during ventricular assistance. This involves multi-interpretation tasks and dynamic system identification as well as fuzzy reasoning for realizing state estimation and detection and diagnosis of malfunctioning. A heart condition classification system using tomography images based on fuzzy logic has achieved 94% accuracy. Other applications include coronary artery disease fuzzy classifier, ECG classification and diagnosis, and treatment and diagnosis of heart disease (Batsomboon, 1998).

Intensive Care

Intensive care applications are close to anesthesia in their medical function nevertheless, applications can be divided into blood pressure and respiration regulation, EEG monitoring and pain relief. An expert system based on fuzzy logic was designed as a warning system in the pediatric intensive care unit (PICU). It was able to make assessments at regular intervals concerning the level of abnormality in the EEG. Keeping the oxygenation status of newborn infants within physiologic limits is a crucial task in intensive care. For this purpose, several vital parameters are supervised routinely by monitors such as electrocardiographs, transcutaneous partial oxygen pressure monitors, and pulse oximeters. Many automated systems based on fuzzy logic have been developed which are capable of distinguishing between critical situations and artifacts. FLORIDA is another expert system which determines the physiological condition of patients in ICU using fuzzy logic and knowledge bases (Batsomboon, 1998). For online monitoring of patients in ICU, a system for breath detection was developed based on fuzzy sets and noninvasive sensor fusion.

Pediatrics

For unborn babies, fuzzy logic has been used to analyze the pattern and interpolation of changes in the cardiotocogram (fetal heart rate pattern plus uterine concentration) during labor, which can lead to unnecessary medical intervention or fatal injury. A knowledge-based system

using fuzzy logic for classifying/detecting distorted plethysmogram pulses in neonates and pediatric patients has also been developed and it has been shown to classify 679 (82%) valid segments and 543 (93%) distorted segments correctly.

Endocrinology

An expert system (PROTIS) used for deduction of fuzzy rules was developed for treatment of diabetes. Another decision support system for treatment of diabetic outpatients using fuzzy classification was described by Stadelmann. Fuzzy inference was utilized for a diagnostic system of diabetic patients by quantitative analysis of the dynamical responses of glucose tolerance tests. A knowledge-based system was also developed for monitoring diabetics which consisted of fuzzy rules and hierarchical neural networks.

Oncology

The use of fuzzy logic for oncology has been concerned with classification (for discriminating cancer from normal tissue) and therapy advice. Therapy was mainly based on advanced image processing magnetic resonance image analysis for tumor treatment planning and ovarian cancer has been attempted. Generally, image-clustering analysis is mostly applied for determining brain tumor segmentation. Also, a fuzzy reasoning algorithm has been used to diagnose breast tumors using three-dimensional ultrasonic echo graphic images.

Gerontology

Originally, gerontology applications were mainly concerned with the use of fuzzy logic for clustering. The same research group used different approaches for different subjects. This is a good example of how fuzzy logic could be applied in a flexible way. A fuzzy relational system was used to implement the databases for building a veterinary expert system. Later on, a few broader applications started to emerge such as the work by Lim who analyzed the difficulties of designing an inference system for the diagnosis of arthritic diseases including variations of disease manifestations under various situations and conditions.

Invasive Medicine

Surgery

In anesthesia, many applications have been reported in the use of fuzzy logic to control drug infusion for maintaining adequate levels of anesthesia, muscle relaxation, and patient monitoring and alarms. In an indirect application of fuzzy logic, it has been used within virtual reality (VR) simulation. If VR surgical simulators are to play an important

role in the future, quantitative measurement of competence would have to be a part of the system. Plastic surgery is another field where fuzzy logic is utilized as a manipulation tool for creating a new image of the patient using an unsupervised segmentation method (Abbod 2005).

Anesthesia

The application of fuzzy logic in the field of anesthesia is expanding rapidly. The first real-time expert system for advice and control (RESAC) in anesthesia was developed to advice on the concentration of inhaled volatile anesthetics. It merges clinical information and online measurements using Bayesian inference and fuzzy logic. Anesthetists were confident enough to follow the dosage advice given by RESAC in most of the patients. On the other hand, direct application of fuzzy logic rule-based controllers has been implemented for controlling drug infusion to maintain an adequate level of anesthesia by monitoring blood pressure and muscle relaxation. Evoked potentials were also used as a measure of depth of anesthesia for controlling drug infusion using fuzzy logic controllers and EEG monitoring, supervisory control or a safety shell has been used to oversee the performance of a controller and to direct the controller to take corrective actions in the case of special situation such as disturbances. More recently, fuzzy logic has been used to monitor different indicators of depth of anesthesia followed by fusing the indications together to obtain a final depth of anesthesia. Based on this indication, fuzzy logic is used to decide the amount of drug infused to maintain a constant depth of anesthesia (Abbod 2005).

Gynecology

Tumor diagnosis, treatment of intra-uterine fetal distress, monitoring of preterm infants and differentiating bursts of ultrasonic data are applications that have all used fuzzy mathematics. A system based on fuzzy logic aids the diagnosis of breast cancer by analyzing the oblation. A computer system called ToxoNet has also been described as being able to process the results of serological antibody tests having been performed during pregnancy by means of a fuzzy knowledge base containing medical knowledge on the interpretation of toxoplasmosis serology tests. The time intervals between two subsequent tests have been modeled as fuzzy sets, since they allow the formal description of the temporal uncertainties. Finally, a manuscript by Sarmento includes interesting

references on image denoising methods based on wavelet and fuzzy theories and examples of applications to ultrasound- mammography imaging modalities are given (Batsomboon, 1998).

Dermatology

In a paper by Acha, a new system for burn diagnosis is proposed. The aim of the system is to separate burn wounds from healthy skin and to identify the various types of burns (burn depths) from each other. After the burn is segmented, some color and texture descriptors are calculated and they are the inputs to a Fuzzy-ARTMAP neural network. Clinical effectiveness of the method was demonstrated on 62 clinical burn wound images obtained from digital color photographs yielding an average classification success rate of 82% compared to expert classified images.

Ophthalmology

In ophthalmology, fuzzy reasoning has been applied to eye movement. Prochazka used fuzzy logic control to describe in a “biologically compatible” way the sensor motor behavior. Also, it was utilized for diagnosis of glaucoma which is one of the leading causes of blindness worldwide. In a different study, a classification system for the effects of diabetes mellitus (DM) on blood flow hemodynamic of the ophthalmic arteries by using a neuro-fuzzy system was described. Test results suggested that 85% success rates were reached from the data of right ophthalmic arteries, and 87.5% success rates were reached from the data of left ophthalmic arteries.

Urology

The application of fuzzy set theory in urology is mainly concerned with diagnosis. A dramatic improvement in the diagnosis of erectile dysfunction has been achieved. A urologic post surgical monitoring system has been developed to monitor catheterized, post surgery patients specifically to assist care providers in the reduction of clot retention. Fuzzy logic was also used to correlate with the linguistic descriptors used by medical experts. Another fuzzy expert system has been developed mainly for diagnosis and treatment of a typical adenomatous hyperplasia (AAH) of the prostate and its distinction from well-differentiated prostatic Aden carcinoma with small acinar pattern. A new system for prostate diagnostics based on multifeature tissue characterization has also been proposed. Two adaptive

neuro-fuzzy inference systems (FIS) working in parallel have been utilized. The system has been evaluated on 100 patients undergoing radical prostatectomy.

Neuromedicine

Neurology

The paradigm of the fuzzy logical model of perception (FLMP) has been extended to the domain of perception and recognition of facial affect. The FLMP fits the judgments from two features experiments significantly better than an additive model. A neural network based cognitive architecture termed Concept Hierarchy Memory Model (CHMM) for conceptual knowledge representation and commonsense reasoning with fuzzy relations between concepts was presented in terms of weights and on the links connecting them. Using a unified inference mechanism based on code firing, CHMM performs an important class of commonsense reasoning, including concept recognition and property inheritance. Fuzzy sets have also been used to conduct a comparative study on traditional crisp set to fuzzy set representations of quantitative estimates of drug use. This is to investigate what survey respondents recall about their drug use. All numeric estimates of drug use fuzzy set properties. Compared to traditional self-reports of drug use, fuzzy set representations provide a more complete and detailed description of what participants recall about past drug use(Abbod 2005).

Psychiatry

A complex psychiatric computer expert system, including functions that help the physicians and the hospital staff in administrative, diagnostic, therapeutic, statistical and scientific work has been developed. The diagnostic decision support system is based on fuzzy logic and backward chaining. A multivariate classification technique based on fuzzy set mathematics was applied to the demographic, historical mental-state data on dementia praecox cases and manic-depressive insanity cases. Logic and analogy pose a fundamental problem in psychiatry. The latter has been explored again with the use of fuzzy logic.

Image and Signal Processing

Signal Processing

Dynamic state recognition and event prediction are fundamental tasks in biomedical signal processing. Fuzzy logic was early applied in medical systems for signal processing. Some of the fields of application for signal processing are listed here:

monitoring the electrical responses of nerve fibers, R-spike detection for rhythm monitoring, clustering of gradient-echo functional MRI in the human visual cortex, magnetic resonance imaging, clustering approach to evoked potentials, expert system or evaluation tools for EEG interpretation, matrix-assisted laser desorption/ionization mass spectrometry, feedback control, improved monitoring of preterm infants, detection of rapid eye movement or visual evoked potential, discrimination of vowels in the cochlear implant signal, pattern recognition methods to classify esophageal motility records, rule-based labeling of computed tomography images, segmentation of ventricular angiographic images, and medical image restoration (Abbod 2005).

Radiation Medicine

Diagnostic imaging and treatment planning for radiation therapy has been the most commonly applied topic in this field using fuzzy logic. It is mainly concerned with image processing using fuzzy techniques (i.e., matching two image volumes in terms of their surface elements—tiles). Fuzzy logic has been utilized to register the surfaces of two volumes acquired by different medical imaging modalities. Apart from image processing, diagnosis of chronic liver disease from liver scintiscans based on scintigraphic results by fuzzy reasoning gave a better accuracy in diagnosis than a conventional scoring system. In terms of treatment, a fuzzy system for modeling and optimization of radiotherapy treatment planning was developed by Sadati and Mortazavi. A similar system was also developed which was based on three-dimensional radiotherapy of cancer patients. Further, an expert system was developed for prediction of radiation damage in organs.

Radiology

Fuzzy c-means clustering segmentation techniques for tissue differentiation in conjunction with a fuzzy model for segmentation and edge detection have been applied very successfully in many applications. The brain and the heart are most often investigated as well as breast cancer diagnosis, diagnosis of rheumatic diseases, search for lung nodules and interpretation of X-ray-fluorescence spectra. Other diagnosis concerns are malformations and degenerative disturbances.

Laboratory

Biomedical Laboratory Tests

Classification of constitution of blood, interpretation of path physiological background, controlling the bioprocess, analysis of tests, assistance in diagnosis and solving clinical problems with expert systems are areas where fuzzy logic has been utilized. Fuzzy logic has also been used in conjunction with neural networks in clinical laboratory computing with application to integrated monitoring and also in clinical test database systems. The features that fuzzy logic provides make approximate reasoning and interpolation of laboratory tests suitable for its incorporation into expert systems. This framework makes it possible for precise laboratory tests to be interpreted in terms of fuzzy propositions. Furthermore, with the recent emergence of genomics in the medical science, fuzzy logic has also been successfully exploited in this field.

Basic Science

Medical Reasoning and Decision Support

Basic rule-based fuzzy logic controllers such as PI, PD, and PID are designed either from the expert (anesthetists). This includes tuning the membership functions in terms of the shape, width, and position. This type of controller is widely used and is the most applicable control type in anesthesia. Self-learning systems are concerned with the control of systems with unknown or time-varying structure or parameters. The self-organizing fuzzy logic controller has the ability to realize adaptation by building its fuzzy rules online as it controls the process, altering and adding as many rules as it judge's necessary from off-line criteria. This approach has many successful applications in the control of muscle relaxation and simultaneous control of blood pressure and muscle relaxation. Reasoning with fuzzy logic is possible without the need for much data because the backbone of the logic is expressed as if-then rules. However, the rules cannot be expressed when there are unknown logical relationships unless the logic is defined. Thus, attempts are being made to combine different techniques such as neural networks and genetic algorithms with fuzzy logic organizing the mapping relationship by learning.

A totally fuzzy logic based hierarchical architecture for manipulating procedures on a complex process (i.e., the patient) has been developed. The novel hierarchical architecture for fuzzy logic monitoring and control of intravenous anesthesia has two main

objectives: the primary task is to utilize auditory evoked response signals for augmenting cardiovascular and body function signs into a multi sensor fuzzy model-based strategy for anesthesia monitoring and control. The secondary task is to extend an existing fuzzy patient model for use as a training simulator. As for supervisory control, a multiple drug hemodynamic control system by means of a fuzzy rule-based adaptive control system has been developed for controlling mean arterial pressure and cardiac output. Supervisory capabilities are added to ensure adequate drug delivery.

Pharmacology/Biochemistry

Pharmacology and biochemistry have also benefited from the application of fuzzy set theory. One application is the prediction of the rodent carcinogenicity of organic compounds using a fuzzy adaptive least-squares method. Other applications are pharmacokinetic modeling, classification of nucleotide sequence, assignment of peptides with nonstandard amino acids and segmentation of protein surfaces.

Education

The use of fuzzy logic for education has different facets. Fuzzy mathematics was utilized for training and evaluating the teaching of students in a clinical setting. Evaluation of the self-taught ability of nursing administrators with fuzzy medicine was also reported.

Public Health and Health Policy and Management

Healthcare studies have been increasing recently due to a greater interest among people. There are many uncertainties in healthcare that can be detected. Some topics that can be reviewed include evaluation of drinking water quality, driving fatigue, health risks in work environment in terms of injury, illnesses, safety, evaluation for health policy, security issues among hospitals in Japan and its feasible solutions and health services management in the tropics. The first application of fuzzy logic in healthcare was the development of an index to assess the health of the patient. The index was developed using a fuzzy approach since the boundaries of status are not sharply defined. In terms of hospital healthcare, waiting list management is another topic to which fuzzy mathematical programming has been applied. Another expert system was designed to help physicians and hospital staff in administrative, diagnostic, therapeutic, statistical and scientific work. In this system, there are separate data-storing, health insurance supporting and simple advisory programs. Other applications relate to designing control strategies for

administering measles vaccines, optimizing food diets, diagnosing bacterial infection in hospitalized patients, medical record validation and prioritization of organ transplant patient waiting lists (Abbod 2005) (Batsomboon, 1998).

Eastern Medicine

The use of fuzzy logic in Chinese medical diagnostic systems was based on utilizing the theory as a mathematical tool for diagnosis inside an expert system. Another expert system for traditional Chinese medicine was developed using the PROLOG language. One important organ in Chinese medicine diagnosis is the tongue. The chromatic distribution helps in the diagnosis procedure. Fuzzy sets were used to fit a model for the distribution. The preparation of the drug was also another area where fuzzy logic was used. A machine was designed based on fuzzy logic for decocting the medicine and it achieved almost the same drug produced by ancient process. There also exist many expert systems based on fuzzy logic for Chinese medicine, diagnosis and treatment (Abbod 2005).

2.7 Empirical Reviews

Kim M. Moulton, Aurel Cornell and Emil Petriu (2001) designed a fuzzy error correction control system that describes a fuzzy error correction control to navigate a robot along an easily modifiable path in a well-structured environment. An array of Hall sensors mounted on the bottom of a robot gathers sensory information from a path of ferromagnetic disks placed on the ground. This sensory input is processed by an analog-to-digital converter and the output signals are then inputted into a fuzzy logic engine. The fuzzy engine outputs commands for the robot wheels. These commands determine the necessary angle of rotation to correct the direction of travel in order for the robot to remain on the path. The fuzzy logic controller stores prior disk information to predict a path trajectory when no path is detected. If the controller senses a path, it anchors on it and starts following it.

Angela Torres and Juan J. Nieto (2006) provided a review article on Fuzzy Logic in Medicine and Bioinformatics. It presents the difficulties of crisp representation of a disease. This study also emphasizes that fuzzy logic is the best way to represent and model the medical domain as it contains a lot of uncertainties. In this paper, the sources of uncertainties and the important role played by Fuzzy Logic in medicine is emphasized.

R. Radha and S.P. Rajagopalan (2007) described the fuzzy set frame work to model the diagnostic process of Diabetes Mellitus. In this study, Diabetes related diseases and other symptoms are taken. The physician's medical knowledge is represented as fuzzy relation between symptoms and diseases. Fuzzy membership values for representing different symptoms are framed and they are used for forming the relation.

Mohan.V et al., (2007) provided the information about the epidemiology of type 2 diabetes in India in 2007. This work provides the seriousness and the prevalence of Diabetes in India and the need for proper treatment.. According to the Diabetes Atlas 2006 published by the International Diabetes Federation, the number of people with diabetes in India currently around 40.9 million is expected to rise to 69.9 million by 2025 unless urgent preventive steps are taken. This work also investigated the evolution of the diabetes, urban-rural differences in diabetes prevalence, burden of diabetes related complications in India, prediabetes, causes of the rise in prevalence of diabetes and early identification and prevention.

A. Ramachandran, C. Snehalatha and Vijay Viswanathan (2002), Diabetes Research Centre and M.V. Hospital for Diabetes discussed about the burden of type 2 diabetes and its complications in Indian scenario. This work highlights the rising prevalence of diabetes in the urban areas. It discusses about the major complications related to diabetes like coronary artery disease, neuropathy, nephropathy and retinopathy due to lack of good control of glycaemia and hypertension, behavioral factors, direct and indirect costs involved in the treatment of the chronic disease. It also discusses about the urgent need to implement preventive measures which will ultimately reduce high morbidity and mortality.

Andrei Effimov, Lyubov Sckolova, Maxim Sckolov (2001) proposed a paper on Diabetes Mellitus and Coronary Heart Disease. The purpose of this study is to investigate the prevalence of coronary artery stenosis and collateral blood flow in coronary heart disease. The study included 140 Coronary Heart Disease patients, 30 of them with type 2 diabetes and 110 without diabetes. It concludes that diabetes mellitus is associated with higher prevalence of coronary artery stenosis, higher prevalence of low grade stenosis, total artery occlusion and less developed collateral blood flow. These factors of coronary

artery disease could contribute to the higher incidence and worse outcome of myocardial infarction in patients with diabetes mellitus.

Sarika Arora, MD (2010), Assistant Professor discussed about the renal function in diabetic nephropathy. Diabetic nephropathy is the kidney disease that occurs as a result of diabetes. Cardiovascular and renal complications share common risk factors such as blood pressure, blood lipids and glycemic control. Thus, chronic kidney disease may predict cardiovascular disease in the general population. The impact of diabetes on renal impairment changes with increasing age. Glomerular Filtration Rate remains an independent and significant predictor after adjustment for conventional risk factors including age, sex, duration of diabetes, smoking, obesity, blood pressure, glycemic and lipid control, as well as presence of diabetic retinopathy.

Ferdinando C. Sasso, MD (2006), PhD, et al., proposed a paper on cardiovascular risk factors and disease management in Type 2 Diabetic Patients with Diabetic Nephropathy. The purpose of this study is to assess the prevalence of cardiorenal risk factors, their management in a routine clinical setting and the actual achievement of international guideline targets in a large coherent of type 2 diabetic patients with diabetic nephropathy.

Michelle LaBrunda and Andrew LaBrunda (2008) presented a article about fuzzy logic in medicine. This article explores the use of fuzzy logic in the medical field. While giving a comparison of classic and fuzzy logic, the various uses of the applications made possible by fuzzy logic, focusing on diagnosis and treatment. The ever evolving technology making the line between medicine and technology thinner every year helps to make the treatment of disease and the mending of injury easier for medical professionals.

Novruz Allahverdi, Serhat Torun and Ismail Saritas (2007) proposed a fuzzy expert system to determine the coronary heart disease risk (CHD) of patient for the next ten-years. The designed system gives user the ratio of the risk and it recommends one of the three results: (1) normal life, (2) diet and (3) drug treatment. The result of this fuzzy expert system is 79% as compared with the expert's analysis.

Ali.Adeli, Mehdi.Neshat (2010) proposed a fuzzy expert system for heart disease diagnosis. The system has 13 input fields and one output field. Input fields are chest pain type, blood pressure, cholesterol, resting blood sugar, maximum heart rate, resting

electrocardiography (ECG), exercise, old peak (ST depression induced by exercise relative to rest), thallium scan, sex and age. The output field refers to the presence of heart disease in the patient. It is integer valued from 0 (no presence) to 4 (distinguish presence (values 1, 2, 3, 4)). This system uses Mamdani Inference method. The results obtained from designed system are compared with the data in upon database and observed results of designed system are correct in 94%. This system is designed in Mat Lab software.

P.B. Khannale and R.P Ambilwade (2010) proposed a fuzzy inference system for diagnosis of hypothyroidism. This system will diagnose the thyroid disorders effectively as the risk factors for thyroid seems to be very uncertain. Particularly in rural part of India, the correct diagnosis of the disease for female patients takes place at a very later stage and hence the patient suffers physically and economically. An accuracy of 88% is achieved in diagnosis of hypothyroidism. Such system is helpful for patients and doctors to identify the disease at early stage.

Defuzzification is an important component of Fuzzy Logic Controller. Pereira JCR, Tonelli PA, Barros LC and Ortega NRS (2002) presented a classification of patients through relational fuzzy signs/disease matrices. These relational matrices were elaborated based on real cases and through max-min composition and Gödel implication. In this work, the results were compared and discussed in the medical point of view. The results of this study were suggestive that fuzzy diagnostic systems should perhaps rule out defuzzification in favour of providing information about relations and leaving decision to medical judgment.

Tetsuhiko Yoshimura and Kouichi Kanzaki (1996) designed a Fuzzy Expert System for laying out forest roads based on the risk assessment. Since it is very difficult to construct forest roads due to the steep topography and slope failures, a quantitative risk assessment has been made to estimate the degrees of slope failure potentials using topographic maps. The objective of this work is to support decision-making for the layout of forest roads in mountainous areas based on the risk assessment. In particular, this work focused on decision-making based on the selection of passing points of forest roads using the fuzzy theory. The advantage of this method is that a computer can make the decision on where to lay out forest roads automatically as if it were a human being. It makes it

much easier to plan forest roads in mountainous areas avoiding the danger that the areas considered collapse.

Faith-Michael E. Uzoka (2009) proposed a fuzzy expert system that utilizes intelligent technologies to develop a methodology that could assist enterprise information system users, managers and entrepreneurs in analyzing cost-benefit of EIS. The cost benefit analysis would assist in determining the worthiness (or otherwise) of investment in IS. There are difficulties in analyzing cost-benefit because of highly unstructured nature of IS evaluation variables. This work proposes a framework for the inclusion of the unstructured variables in an IS Cost Benefit Analysis model and it also makes rigorous effort at providing a platform for inclusion of rating confidence of domain experts and decision makers in the EIS evaluation matrix in a consensus based environment. The study takes high cognizance of intangible variables and vagueness / imprecision in human group decision making that requires a good level of consensus.

Neshat, M. Yaghoobi, M. Naghibi, M.B. Esmaelzadeh. A (2008) proposed a Fuzzy Expert System Design for Diagnosis of Liver Disorders. In this work, fuzzy theory is used to overcome the existence of uncertainty in the medical field. For this work, the required data has been chosen from trusty database (UCI) that has 345 records and 6 fields as the input parameters and rate of liver disorder risks is used as the system resulting. This system in comparison with other traditional diagnostic systems is faster, cheaper, more reliable and more accurate. This system can be used as a specialist assistant for training medical students.

Garibaldi J.M, J. Tilbury, E.C. Ifeachor (2000) designed the validation of a fuzzy expert system for umbilical cord acid-base analysis to validate and interpret acid base data using fuzzy logic. The performance of the system was evaluated in a rigorous validation study. This system demonstrated excellent agreement with the experts for the numeric outputs and agreement on par with the experts for the linguistic outputs. One output of the fuzzy expert system is a novel single dimensional measure that accurately represents the severity of acid-base results.

Mehdi.Neshat, Mehdi.Yaghoobi (2009) designed an adaptive neural fuzzy system using ANFIS and FIS tools for diagnosing the hepatitis B intensity rate. The main problem in determining the disease intensity is not having information about the data variation rate

and its resulting effect on the system. In the fuzzy expert system, accuracy of diagnosing the HB intensity was 94.24%, however, in the adaptive neural expert system because of the use of back propagation and least means square training methods with the purpose of estimating membership function parameters in the fuzzy expert system, the HB intensity rate can be estimated with a higher accuracy.

Fadzilah Siraj, and Rafikha Aliana A. Raof (2004) designed a fuzzy expert system for diagnosing myocardial infarction. This work allows the knowledge to be encoded in a form that reflects the way experts think about a complex problem. Since fuzzy expert approach model imprecise information, it improves the cognitive modeling of the problem and therefore makes it more powerful. This paper presents the use fuzzy logic and expert system for myocardial infarction known as FEMInS. The system assists the general medical practitioners in handling heart attack cases that have been referred to them. Unlike conventional expert systems, FEMInS implemented the fuzzy logic technique in its inference engine. Since fuzzy logic can be used for prediction and expert system can provide explanation and reasoning, the combination of both fields is able to cope with the problems of uncertainty.

Najjaran.H, R. Sadiq, B. Rajani (2006) designed a fuzzy logic expert system which is capable of predicting the deterioration of cast and ductile iron water mains based on surrounding soil properties. The proposed model consists of two modules: a knowledge base and an inference mechanism. The knowledge base provides information for better decision-making and is developed in a two-tier fuzzy modeling process. First in direct approach, the expert knowledge generates a subjective model to describe the characteristics of the system using fuzzy linguistic variables. Later in system identification, the field data is used to develop an objective model, which is eventually used in conjunction with the subjective model to provide a more reliable knowledge base for the expert system. The inference mechanism uses fuzzy approximate reasoning methods to process the encoded information of the knowledge base.

Laleh Kardar et.al (2008) designed an advisory/control algorithm which incorporates expert knowledge about the treatment of the disease by using Mamdani type fuzzy logic controllers to regulate the blood glucose level (BGL) when the diabetic patient is subjected to a glucose meal disturbance or fluctuations in the measured glucose level due

to error in the measuring instrument. The algorithm has designed as two-level architecture for control system. The goal of the Low Level Module is to suggest the next insulin dosage of both short and intermediate acting insulin (Regular and NPH) formulation that are programmed in a three-shot daily basis before meals, depending on the blood glucose measurement. The combined preparation is then injected by the patient through a subcutaneous route. The High Level Module adjusts the maximum amounts of insulin provided to the patient in a time-scale of days. This module aims to work as a supervisor of the low level module. Simulations are illustrated, using a flow-limited model for diabetes mellitus based on the work of Puckett.

Ismail SARITAS et al. (2003) designed a fuzzy expert system design for diagnosing, analyzing and learning purpose of the prostate cancer diseases. Prostate specific antigen (PSA), age and prostate volume (PV) are used as input parameters and prostate cancer risk (PCR) as output. This system allows determining if there is a need for the biopsy and it gives to user a range of the risk of the cancer diseases. This system is rapid, economical and can be used as learning system for medicine students.

P. K. Dash, S. Mishra, M. M. A. Salama, and A. C. Liew (2000) presented a hybrid scheme using a Fourier Linear Combiner and a fuzzy expert system for the classification of transient disturbance waveforms in a power system. The captured voltage or current waveforms are passed through a Fourier Linear Combiner block to provide normalized peak amplitude and phase at every sampling instant. The normalized peak amplitude and computed slope of the waveforms are then passed on to a diagnostic module that computes the truth value of the signal combination and determines the class to which the waveform belongs.

Human disease diagnosis is a complicated process and requires high level of expertise. Mir Anamul Hasan et al, (2010), developed a web-based fuzzy expert system for diagnosing human diseases. This work focuses on the research and development of a web-based clinical tool designed to improve the quality of the exchange of health information between health care professionals and patients. Practitioners can also use this web-based tool to corroborate diagnosis.

Gavin Fleming et al. (2007) describes an early warning GIS prototype tool aimed at identifying favorable preconditions for cholera outbreaks using an expert system approach.

The model is based on the assumption that endemic reservoirs of cholera occur and that environmental conditions, especially algal blooms, trigger *Vibrio* growth in the natural environment. This paper focuses on the environmental preconditions. The methodology described relies on capturing expert knowledge and historic data that integrate climatic and biophysical parameters with epidemiological data to produce a fuzzy surface of cholera outbreak risk potential.

Jean-Louis Chiasson et al. (2003) presented a review paper on Diagnosis and treatment of diabetic ketoacidosis and the hyperglycemic hyperosmolar state. Diabetic ketoacidosis and the hyperglycemic hyperosmolar state are the most serious complications of diabetic decompensation and remain associated with excess mortality. Insulin deficiency is the main underlying abnormality. Associated with elevated levels of counter regulatory hormones, insulin deficiency can trigger hepatic glucose production and reduced glucose uptake, resulting in hyperglycemia, and can also stimulate lipolysis and ketogenesis, resulting in ketoacidosis. Both hyperglycemia and hyperketonemia will induce osmotic diuresis, which leads to dehydration. Clinical diagnosis is based on the finding of dehydration along with high capillary glucose levels with or without ketones in the urine or plasma.

Rahim F, Deshpande A, Hosseini A (2007) incorporated the fuzzy techniques and developed a fuzzy expert system for fluid management in general anesthesia. Mean Arterial Pressure(MAP) and hourly urine output are the input to fuzzy expert system and the output is defuzzified value of Intravenous Fluid Rate(IFR).

Daisuke Takahashi, Yang Xiao, and Fei Hu (2008), presented a Survey paper on Insulin-Dependent Diabetes and Control Methods which deals with blood glucose control schemes for insulin-dependent diabetes therapies and systems. These schemes largely rely on mathematical models of the insulin-glucose relations. The model is represented in both empirical and biological mechanisms. Along with several mathematical models, researchers develop autonomous systems whether they involve medical devices or not to compensate metabolic disorders and these autonomous systems employ their own control methods. Basically, in insulin-dependent diabetes therapies, control methods are classified into three categories: open-loop, closed-loop, and partially closed-loop controls. The main difference among these methods is how much the systems are open to the outside people.

Jobe TH, Helgason CM (1998) compared the probability and fuzzy paradigm to find out which one best represented the complex multi-causal clinical phenomenon-stroke. They showed that the fuzzy logic paradigm better represented clinical complexity in cerebrovascular disease than current probability theory based methodology. This finding can be generalizable to all of clinical science since multiple concomitant causal factors are involved in nearly all known pathological processes.

Luigi Di Lascio et al (2002), designed a new model for the fuzzy-based analysis of diabetic neuropathy. The underlying algebraic structure is a commutative \mathcal{L} -monoid, whose support is a set of classifications based on the concept of linguistic variable introduced by Zadeh. The analysis is carried out by means of patient's anagraphical and clinical data, e.g. age, sex, duration of the disease, insulimic needs, severity of diabetes and possible presence of complications. The results obtained are identical with medical diagnoses.

Zahlmann G, Kochner B, Ugi I, et al. (2000) discussed a hybrid fuzzy image-processing system for situation assessment of diabetic retinopathy. The hybrid approach is motivated by the characteristics of the medical data and of the diagnostic decision-making process. The aim of the system is to support the early detection of diabetic retinopathy in a primary-care environment. For this purpose, both internal medicine (diabetes) and ophthalmology have to be considered. The main input data are ophthalmological parameters, such as visual acuity, status of the anterior segment, status of the fundus, and previous therapies, and dialectological status that is metabolic data. To reduce the huge number of parameters that have to be extracted by the ophthalmologist, image-processing methods for the automatic analysis of fundus photographs have been developed. The extraction is done by a multistage model-based approach. The segmentation results are used as an input to an overall fuzzy system that produces the final decision outcome.

King H, Aubert RE, Herman WH (1998) estimated the prevalence of diabetes and the number of people with diabetes who are greater than or equal to 20 years of age in all countries of the world for three points in time that is, the years 1995, 2000, and 2025 and to calculate additional parameters such as sex ratio, urban-rural ratio, and the age structure of the diabetic population.

A. Ramachandran (2005) presented a paper on Epidemiology of Diabetes in India: Three Decades of Research. In this study, he emphasis on increasing rate of diabetic people

in India and its reasons. Metabolic syndrome which is a constellation of cardiovascular risk factors of which hyperglycemia and insulin resistance are components is also widely prevalent. The conversion to diabetes is enhanced by the low thresholds for the risk factors, such as age, body mass index and upper body adiposity. Indians have a genetic phenotype characterized by low body mass index but with high upper body adiposity, high body fat percentage and high level of insulin resistance. With a high genetic predisposition and the high susceptibility to the environmental insults, the Indian population faces a high risk for diabetes and its associated complications.

C. Berrón and J.A. De Abreu-García (2005) designed a fuzzy logic controller based on a system characterization obtained via off-line experimental data. The results from the tests revealed that the fuzzy controller is well suited for pumping blood for normal flow in which traditional control strategies may not perform well. The methodology developed for designing a fuzzy controller can be applied to any centrifugal pump where flow regulation is desired regardless of pump head disturbances.

M.S. Ibbini, M.A. Masadeh, and M.M. Bani Amer (2003) proposed a fuzzy logic control scheme as a means of maintaining the normoglycemic average of 4.5 mmol/L as well as normal conditions for free plasma insulin concentration, in spite of glucose like meal-disturbance and variations in model parameters. Computer simulations are used to demonstrate the efficiency of fuzzy logic controllers in handling disturbances and severe patient conditions. The results are compared to those resulted from well-known conventional controllers such as Proportional-Integral-Derivative (PID) and continuous insulin infusion control strategies.

M.W. Kurzynski (2003) dealt with the fuzzy inference systems for multistage recognition based on a decision tree scheme. For the given learning set two conceptually different fuzzy methods are presented and discussed. The first method which uses the fuzzy rule based technique is developed to the multistage approach known as Mamdani inference engine with rules generated from the learning set. In the second approach fuzzy relation between decisions set and feature space is constructed, which next is used to decision making. Both methods were practically applied to the computer-aided medical diagnosis of acute renal failure and results of comparative experimental analysis are also given.

Prof. Jiann-Shing Shieh (2005) and his team developed a fuzzy-model algorithm in order to calculate the daily mobility of elders like movement, opening and closing book cases, door via mechanical switch sensors, daily consuming time of using electrical appliances is monitored and supervised via internet. However, the system still needs a longer series of real testing at home, perhaps to refine the rule-bases, and certainly to see how widely they are appreciable.

Prof Fabrizio Aversa et al., (2002) developed a prototype of a decision support system in Medicine. The fuzzy system architecture proposed in this prototype is used to indicate the suitability degree of beta-blockers therapy to avoid uncertainty.

Prof Rudolf Seising, Christian Schruh, Klaus-Peter Adlassnig (1993) stated the fuzzy control techniques recently applied in various medical processes such as pain control, blood pressure control. Fuzzy control compared to classical control theory, fuzzy logic approach has the advantages like, systems with non-linear responses that are difficult to analyze may respond to fuzzy control approach. Fuzzy control can be used efficiently to represent an expert's knowledge about a problem. Complex processes can be controlled by relatively few logic rules, permitting an easily comprehensible controller design and faster computation for real-time applications.

Prof Yuefi et al., (2001) analyzed the use of information technology with fuzzy logic in transplantation of organs in human body. They developed an internet based fuzzy logic expert system to assist physicians in solving multi-criteria kidney allocation problem. The simulated experiment based on the real patient data confirms that fuzzy logic system can represent the experts thinking in a satisfactory manner.

Summary

Fuzzy systems are indicating good promise in consumer products, industrial and commercial systems and decision support systems. The term "fuzzy" refers to the ability of dealing with imprecise or vague inputs. Instead of using complex mathematical equations, fuzzy logic uses linguistic descriptions to define the relationship between the input information and the output action. In engineering systems, fuzzy logic provides a convenient and user-friendly front-end to develop control programs, helping designers to concentrate on the functional objectives, not on the mathematics. Fuzzy logic is a very powerful tool that is pervading every field and signing successful implementations.

Fuzzy Logic has proved to be an excellent choice for many control system applications since it mimics human control logic. It can be built into anything from small, hand-held products to large computerized process control systems. It uses an imprecise but very descriptive language to deal with input data more like a human operator. Fuzzy Logic has reached its Zenith because of its power of representing everything as a matter of degree, viewing exact reasoning as a limiting case of approximate reasoning, fuzzification of any logical system and representation of inference as a process of propagation of elastic constraints.

In this chapter, the contents are organized carefully starting from the evolution of fuzzy logic. It differentiates the probabilistic theory and fuzzy logic, because both looks mathematically similar. It also discusses about the two most common types of fuzzy logic, the rule base and neural networks. Japanese invasion of fuzzy logic has stated clearly and it also emphasis the important of fuzzy logic in research and development. In this Chapter, the designing, validating, experimenting and implementation of Fuzzy Logic Controller has discussed in various domains like industrial, commercial and Health Care.

Fuzzy logic plays a very important role in medicine as this field is full of uncertain, vague and imprecise information. It has made its way in Internal medicine, Cardiology and Vascular Surgery, Intensive care, Pediatrics, Endocrinology, Oncology and Gerontology. It also steps into invasive medicine like Surgery, Anesthesia, Gynecology, Dermatology, Ophthalmology, Urology and Neuromedicine.

The number of medical publications using fuzzy logic has been increasing tremendously (Angeles Torres, 2006). The review of literature motivates to design a methodology of a controller for the impact of Diabetes Mellitus on Cardiac and Renal using fuzzy logic. As cardiac and renal are the major impediments of Diabetes Mellitus, this controller is designed to predict the functioning level of cardiac and renal based on the main seven risk factors. This controller is a well-suited controller for simultaneously monitoring and controlling the risk factors so as to prevent and protect the organs at an early stage.