CHAPTER 1
INTRODUCTION

1.1 General Background and Motivation

Decision making is a frequent problem in today’s economic, business and industrial world. Usually this type of decision making constitutes an essential decision. For instance in medical diagnosis, assigning patients to any one of the groups (at risk, less risk, not at risk) is based on some medical observations and tests. Classification rules are used in banks to differentiate solvent firms from the companies which may end up in bankruptcy. Credit card companies employ classification methods to detect small percentage of credit cards that are being used fraudulently. Examples of other applications of group classification analysis include fault detection, machine failure and decision to launch investment in a new product. All of these two-group classification decisions have significant economic and social consequences, as an error of assigning an object to the wrong group may lead to catastrophic results. Because of the importance of making the correct decision, researchers and practitioner are constantly looking for better decision making procedure.

Due to continuous advancement in industrial and commercial fields, the exchange of information and its associated uncertainty also increases which in-turn raises the complexity of decision making problem in the form of uncertainty, subjectivity and vagueness. Medical practitioners exhibit variation in decision making because of their approaches to deal with uncertainties and ambiguity in knowledge and information. The diagnostic decisions also depend upon experience, capability and observation of the practitioner.

As the complexity of system increases, it is not easy to follow a particular path of diagnosis without any mistake. Artificial Intelligence was born in 1956, stepped in many areas but not in human level machine intelligence. Now—a—days AI is used in many areas in human level machine intelligence and it is applied for decision making, diagnosis, pattern recognition and analysis of evidence [Lot05]. Very important branch of artificial intelligence is known as Expert Systems.

With the domain knowledge as background, the task of decision making is to get a best solution from the input information from the user using inference method. There are three ways to make decision in complex environment, they are
(1) Constructing a mathematical model
(2) Looking for human expert’s suggestion
(3) Constructing an Expert System or controller

Building a mathematical model is a good way. However, mathematical model exist nor can be derived for the complex domain, but the domain may not be understood thoroughly. So the first method is limited and an alternative one is second method, to get help from humans for decision making. The cost to query a human may be high and expert may not be available when a decision is to be made. Now a day’s Expert System is used in decision making. Expert System is used to deal with specific knowledge possessed by human experts in particular domain. Expert Systems are used in the environments which are rich in data. Expert System is information system to solve specific problem. Expert System contains expert facts.

Expert System clones like a human expert system, to avoid geographical and time based limitation to consult with human experts. Experts transfer the knowledge to computer; user calls the computer if there is a need. Once the knowledge is transferred, an expert doesn’t assist the user and user doesn’t maintain knowledge base.

Expert System are used for different purposes [Geo01]
- Designing and Planning - System components are build to the performance of design condition. Planning is to achieve the goals to satisfy the design constraints.
- Diagnosis - Determining the cause of malfunctions based on observed symptoms.
- Learning - Knowledge are gained with learning process.
- Decision Support - Decision are made with data.
- Interpretation - Conclusion are made from the collected raw data.
- Prediction - Projecting possible consequences for given situations.
- Monitoring - Comparison of system observed to its expected behavior.
- Instruction - To assist the education process in technical domains.
- Control - Manage the performance in complex situation.

Medical Expert System is a challenging field, requires combination of various scientific areas. In medical field, the decision making with the presence of uncertainty and imprecision makes some issues for suitable model. So, the methods based on Fuzzy Logic are very useful for decision making. Since FES is better in handling uncertainties which is associated with natural data. Diagnosis of disease by patients themselves is very popular in
the scientific world. People are very busy to visit a doctor hence they can use these type of tool to diagnosis the disease. The proposed FES helps the user to diagnosis diabetes.

1.2 Fuzzy Logic

Fuzzy Logic is very impressive tool to build intelligent decision making mechanism for approximate reasoning. Fuzzy Logic helps to capture the knowledge and diagnosis the correct decision regarding the disease. Fuzzy Logic (FL) presents powerful reasoning methods that can handle uncertainties and vagueness. FL uses mathematical principles to represent knowledge with membership rather than crisp membership function used in classical binary logic [Lot03] coined by Lotfi A. Zadeh. It is one of the Artificial Intelligence technology tools to handle ambiguity and uncertainties. Traditional logic uses “True” and “False” values, Fuzzy Logic lies between Zero and One to indicate the degree of truth. FL is a methodology used to frame words, which helps for computing and reasoning. Computing of words helps to derive rules [Lot04]. Words are modeled based on human sense which plays an important role in decision making. Fuzzy Logic is an inference morphology that enables human reasoning and applied to knowledge based system. It plays a very important role in fuzzy set theory which is used in many fields such as Expert System, forecasting, fuzzy control and decision making [YTX01]. To design a Fuzzy Expert System, we use the concept of fuzzy sets and fuzzy rules.

Characteristics of Fuzzy Logic

Essential characteristics of Fuzzy Logic are given below [Che01]

- In Fuzzy Logic, exact reasoning is viewed as the limiting case of approximate reasoning.
- In Fuzzy Logic, everything deals with matter of degree.
- In Fuzzy Logic, knowledge is collection of fuzzy constraints on variables.
- Inference is a process of propagation of elastic constraints.
- Logical system can be fuzzified.

Medical diagnosis needs careful examination of patients, to make a decision regarding the patients whether they suffer from some disease or not. Fuzzy Logic reflects how human thinks. It models our sense of words, common sense and decision making. It is very new, works like human thinking, so it is termed as intelligent system. Degrees of truth value can be changed in Fuzzy Logic. In computers, Fuzzy Logic can be represented as vague and imprecise ideas, such as “low”, “medium” or “high”.

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1.3 Fuzzy Expert System

Fuzzy Expert System (FES) belongs to the field of artificial intelligence system to solve decision making problems, with the existence of uncertainty. It should be designed explicitly and systematically to trace the outcome [BLZ01]. The combination of Expert System using Fuzzy reasoning and knowledge are called Fuzzy Expert System [WJ01, Lot01]. Fuzzy systems can manage and manipulate large volume of data.

FES defines imprecise knowledge and offers linguistic concept with excellent approximation to medical texts. FES plays an important role in medicine for symptomatic diagnostic remedies. FES uses Fuzzy Logic in lieu of Boolean logic. It is a collection of fuzzy sets, fuzzy rules that are used to make an inference about data. FES includes many “IF-THEN” rules and this setup is called knowledge acquisition [HSA01]. Fuzzy Expert Systems are based as fuzzy arithmetic technique to handle numerical values [KMA01]. FES is a user friendly approach for reasoning and control of uncertainty for various problem domains. FL should fulfill the needs of human and machine with the associate of fuzzy membership function.

A Computer based information technology makes an easy consultation between doctor and patients in the form of Fuzzy Expert System. FES enables patients as users to the system and can communicate about the disease to the system as doctor. FES will provide solution to the complaints given by users. FES is capable of providing solutions to problems, in the case of uncertain data. Traditional Expert System is based on symbolic reasoning but Fuzzy Expert System is towards numerical processing.

Fuzzy Expert System should cope with inexact information having possible origin in the following sources. They are

- Inbuilt human fuzzy concept,
- Reliabilities of facts,
- Matching of related experiences,
- Imperfect information,
- Various opinions from different experts.

Diabetes is a chronic illness which requires continues medical care and self management awareness has to be given to patient to prevent disease. Diabetes care is complex and there are many issues to be controlled to manage diabetes. Standard care is intended to clinicians, patients, researchers and other interested individuals with treatment
goals and tools to evaluate diabetes. Diabetes also contributes to heart disease. More than 80% people with diabetes die from some form of heart or blood vessel disease.

Now-a-days, most of people in the world are suffering with high risk disease such as heart attack, diabetes, high blood pressure and cancer. Most of the high-risk diseases can be cured only at the early stage. Commonly prevailed high risk disease among Indians is Diabetes. Abnormal level of blood sugar is termed as Diabetes. This arises because the body produces little or insufficient insulin. There are three type of diabetes; Type 1 diabetes, Type 2 diabetes and gestational diabetes for pregnant women. Previously, Type 2 diabetes also referred to as Non-Insulin Dependent Diabetes Mellitus (NIDDM) or adult-onset diabetes. In this problem, the pancreas produces enough insulin but the insulin cannot help the glucose to enter into the cells because the cells are resistant to insulin action. There are few tendencies to develop Type 2 diabetes, such as having family history with diabetes, overweight and lack of physical activity.

Diabetes is one of the high-risk diseases that arise day by day in India. Almost all people are not much care to see the physician to check their healthy level if they feel nothing abnormal happened at their body. Diabetes will become worst day by day if the person with diabetes do not get any treatment from physician. At the critical level, diabetes will cause blindness, kidney failure, ulcer, heart disease and foot wounds which lead to foot and leg amputations. Although, there are some other factors that make people not to see the physician if they are not really sick. Most of us are not comfortable queuing long time to see the physician. Now-a-days there are technologies which will reduce the number of diabetes case arises and also support to check whether they have a risk in getting diabetes or not. At the same time, awareness will be given to user about their healthy level. Thus, the user can consult the doctor for further treatment, if they really in high risk of getting diabetes.

Diabetes and its complications require significant economic consequences on persons, families, health systems, and countries. Improving health education of human resources is a time-consuming and costly solution. If the people continue to disregard diabetes and its complications creates additional burden to the Government. So, we need an early detection and assessment tool to serve people in the society, and this tool also serves as an educational tool for diabetic people, and detects early signs of complications.
Applications of Fuzzy Expert System

Knowledge based, Expert System, decision support system and management information system are used to solve the problem or to make decision regarding the problem. But they are based on the crisp values or non-fuzzy. A research idea was given to solve the problem by using theory of fuzzy set. The architecture of this module has interface module, knowledge base module and interface engine [Dar01].

Fuzzy concepts are very much used in human reasoning and decision making. A fuzzy expert database system is an integration of Fuzzy Expert System tool called SYSTEM Z-II and database management system called as Rdb/VMS. Fuzzy data are extracted and stored in database for reasoning in Expert System. Fuzzy queries are used in database which is used in Expert System [LWL01]. Design of Expert System, management of uncertainty and analysis helps to make perfect conclusion. A General Purpose Fuzzy Expert System (GPFES) tool was modeled to manage uncertainty in Expert System. In inference method, equivalence operator is used instead of implication operator, in which framework is designed using the concept of complication [KA01]. Fuzzy Expert System uses fuzzy data, fuzzy propositions, Fuzzy Logic and fuzzy rules [Abr01].

To design, develop and maintain data on World Wide Web, Fuzzy Expert System was developed. This allows the users to access the data easily and provide designer to maintain and distribute information from central location. Digital forensics plays a very important role in the field of computer to retrieve and discover information about the crime which makes the digital evidence. An Expert System with Fuzzy Logic was developed for network forensics. By using this FES it can analyze the crimes in network environment and automatically makes digital evidences. This information is very much useful for forensic experts and the cost and time is reduced in forensic investigation [JMB01]. Mota L.T.M. et al. developed a FES to forecast the load behavior during reinstallation of power systems after entire or partial blackouts and Expert System was developed using Fuzzy logic. The Fuzzy Expert System uses linguistic variable and fuzzy rules. The proposed method was tested in electrical power substations [MMM01]. Very important problem in the modern world is the environment pollution due to the energy usage and fuels. So this causes a heavy damage to human life and natural life. Emission of nitrogen oxide causes acid rain. Decrease of emission is one of the important problems in daily life. A study was made for alteration of CO2 content in air and
emission parameter of turbo diesel engine on oxide. For this study FES was developed using Mamdani interface. The result ratio is 99.87% [IM01].

FES was developed to estimate ignition timing to tune Toyota corolla 4 cylinders, 1.81 hydrogen power cars. Ignition prediction is very important problem, so decision support system can be used. Fuzzy sets, variables, and 136 rules are constructed. The input parameters use various triangular, trapezoidal and bell-shaped membership functions for ignition timing [TV01]. An artificial aggregate system equipment selection is presented which is based on Fuzzy Expert System for decision making. Practice has been made on the system which proves the design quality and effectiveness has been improved in decision making process. In further research initial values of risk and reliability have to improved [QMD01]. FES was developed to improve desk studies. The developed FES was different from the conventional desk study as it incorporates the rigid mathematical framework based on fuzzy set, improves the quality of desk study and expenditure for field demonstration and lab analysis. The study was validated in degraded terrain for hazard map [DK01]. Fuzzy Expert System is used to determine the optimal level of enforcement called FESOLE. Electronic payment is very important in intelligent transportation system. In electronic fee collection, level of enforcement should be determined, so need of FES is very essential [Pri01]. In the field of forecasting, to evaluate the real options an Expert System using Fuzzy Logic was developed. The existing model is very difficult, complex and has strong inherent assumption which is not widely used by corporate managers. So FES was developed to solve all these problems. The developed system is very much useful for forecasting, to find the relationship between input and output values and for qualitative and quantitative analysis [MFM01]. Risk analysis can be classified into two types. They are quantitative and qualitative risk. For quantitative risk analysis, techniques are insufficient for assessing risks. So a flexible technique was developed to assess the risk. With the expert group the FES was developed for risk assessment [RD01]. Xiaoguang Chang and John H. Lilly [XJ01] developed an evolutionary approach to derive a compact fuzzy classification system directly from the data without any prior knowledge or ascertain from the data.

Expert System was developed in agriculture to determine the lime recommendation for soil in the case of humid tropics. Documentation is made regarding the lime requirement for weathered soils. With the knowledge and experience an Expert System is constructed for diagnosis [RGM01]. Anton Setiawan Honggowibowo [Ant01] developed an Expert System to diagnosis rice disease. The Web Based Expert System was designed using rule based
reasoning. The rules are modified with forward chaining inference and backward chaining. This system helps the farmers to diagnosis the disease in the rice plant and to get very high yield.

Fuzzy set theory has its own properties which are used for formalizing uncertain medical information for diagnosis and treatment. Fuzzy set are formed with linguistic variables. Inference method in Fuzzy Logic is used for medical diagnosis. The proposed system is verified with medical Expert System CADIAG-2 which has fuzzy set and Fuzzy Logic for diagnosis purpose [Kla01]. FES helps to use and share information in new way for all users [Tod01]. Zahan S. et al. [ZBC01] designed a Fuzzy Expert System to diagnosis cardiovascular disease. Performance evaluation of Fuzzy Expert System was conducted to evaluate the system. The test was performed with clinical data of 92 patients during the 1998-99. The system output was compared with three independent diagnosis given by physicians. For 85 patients, the system diagnosis was correct with accuracy 92.39%.

Salem Abdel- Badeeh .M and Bagoury Bassant M. E [SB01] designed an Expert System for diagnosis of thyroid cancer disease by combining neural networks and Certainty Factors. The system is constructed with three phases, each phase uses single network for learning process. The system was tested with 820 cases of thyroid patients from National Cancer Institute of Egypt. The diagnostic performance rate was given as 99.47%. Ragab Abdul Hamid .M et al. [RFR01] developed an Expert System to diagnosis heart disease with Certainty Factor. Heart disease was classified into 25 types of disease; they are left heart failure and right heart failure in the form of semantic network. Data are taken related to the age and sex. Clinical data such as laboratory data and clinical examination are used to test the system. Knowledge is represented in the form of rules. Marakakis Emmanuil et al. [MVK01] developed an Expert System for diagnosis of disease epilepsy with Certainty Factor. Data were taken for 50 types are epilepsy. Each epilepsy is expressed with 28 diagnostic conditions. The knowledge is gained by examination of patients and laboratory results. The system was tested with 45 children’s and the test results are correct for 35 children’s and the performance rate is 83.3%. Campos-Delgado D.U. et al. [CHF01] developed an advisory control algorithm that incorporates a mamdami type fuzzy-based controller that incorporates expert knowledge to regulate the blood glucose level. Paolo Magni and Riccardo Bellazzi [PB01] devised a stochastic model to extract variability from a self-monitoring blood sugar level time series. The proposed method are validated with two data sets and tested with three patients. Laercio Brito Goncalves et al. [LMM01] introduced an inverted hierarchical neuro-
fuzzy BSP system; neuro fuzzy model has been created for pattern classification and rule extraction from diabetes databases. Kemal Polat and Salih Gunes [KS01] designed an Expert System to diagnose the diabetes disease based on principal component analysis and adaptive neuro fuzzy inference system. The aim of this study is to improve the accuracy of diabetes disease. In the first stage 8 features are reduced to 4 features using principal component analysis. In the second part diagnosis of diabetes is conducted by adaptive neuro fuzzy inference system. The American Diabetes Association [ADA01] categorizes diabetes for children and young adults as Type-1 diabetes and Type-2 diabetes, i.e., the most common form of diabetes that the body does not produce adequate insulin.

Kemal Polat et al. [KSA01] also developed a cascade learning system using Generalized Discriminant Analysis and Least Square Support Vector Machine to diagnose the diabetes. The proposed method has two stages. In the first stage generalized Discriminant Analysis is used to discriminate features between healthy people and diabetic patient. In second stage Least Square Support Vector Machine is used to classify the diabetes dataset. Neshat et al. [NYN01] developed a fuzzy system to diagnosis liver disorder. Data are taken from UCI which has 345 records and 6 fields as parameters and liver disorder risk rates are the result obtained from the system. The system is constructed in a perfect way; the accuracy rate of the system is about 91% and shows improvement in the diagnosis of liver disorder. Humar Kahramanli and Novruz Allahverdi [HN01] designed a hybrid neural network system which includes artificial neural network and fuzzy neural network for classification of the diabetes and heart diseases from Pima Indian Diabetes and Cleveland heart disease dataset. Ali Adeli and Mehdi Neshat [AM01] designed Expert System with Fuzzy Logic to diagnosis heart disease. The system uses 11 variables as input and output attributes. Inference used is mamdani method and defuzzification method is centroid. The results are tested with 303 patients and the accuracy rate of the system is 94%. Mirza M et al. [MGH01] designed a clinically useful tool to detect the critical events during anesthesia by a diagnostic alarm system. The performance of the system is validated by off-line tests. During surgical procedure, detection of hypovolaemia, a significant level of agreement was observed between Fuzzy Logic monitoring system and anesthetist. Zarandi Fazel M. H et al. [ZZM01] designed an Expert System for diagnosis of asthma disease by using Fuzzy Logic. Knowledge acquisition is done by semantic network and knowledge is represented by rules. Fuzzy inference method used is mamdani method and defuzzification method used is centroid. The system is tested with 53 patients with asthma and 53 non-asthma patients.
response rates are given as 100% and 94%. Azian Azamimi Abdullah et al. [AZN01] designed a Fuzzy Expert System to diagnosis the hypertension for patients between ages 20’s, 30’s and 40’s and data is divided into male and female. Input data is collected from 10 peoples with different genders and background. The input parameters used are age, blood pressure, Body Mass Index (BMI) and heart rate. Chang-Shing Lee and Mei-Hui Wang [CM01] designed as Fuzzy Expert System for diabetes decision support application based on the fuzzy ontology with five layer fuzzy ontology. Five layers are fuzzy knowledge layer, fuzzy group relation layer, fuzzy group domain layer, fuzzy personal relation layer and fuzzy personal domain layer. Fuzzy Logic model was developed to diagnosis the disease in domestic animals with its neurological sign. With basic health factor and neurological signs an FES was developed which reduces the uncertainty. There is large dissimilarity in animal species, which is exclusive for each animal, but the above system is achieved by neurological sign [MMA01].

FES was developed in various domains according to the user needs. In the field of medicine FES are applied in many areas. Because of the food habits and life style, the patients are affected by diabetes in modern world. Communication between the patient and doctor is very important to diagnosis the diabetes. Consultation time constraints also lead to inadequate information to diagnosis diabetes. So to overcome these limitations the Fuzzy Expert System is essential to diagnosis diabetes.

1.4 Construction of Fuzzy Expert System

Fuzzy Expert System is

- Simple to build and debug.
- Easy to understand.
- Easy and cheap to maintain.

Human knowledge is unclear and inexact. Human thinking and reasoning inexact information, certainty about the information is not absolute, uncertainty occurs. Construction of Fuzzy Expert System undergoes the following steps [SRT01]. The overall design of Fuzzy Expert System is shown in Figure 1.1.
a) Critical Factors, Membership Function and Fuzzy Sets are identified

To construct a Fuzzy Expert System the first step is to identify the critical factors which act as input variable. The next part is to identify the membership function such as triangular, trapezoidal or Gaussian function, to form fuzzy sets. Fuzzy operator T norm (MIN) and T-Conorm (MAX) are used. Fuzzy sets are formed with list of Fuzzy numbers; Fuzzy uncertainty is modeled with some concepts. Fuzzy number is like ordinary numbers which uses arithmetic operators. The result of the fuzzy number is another Fuzzy number. In Expert System Fuzzy number is used to handle fuzziness. Fuzzy inference process is selected based on the output variable as mamdani (or) Takagi- sugeno fuzzy model. This step is very important part in the construction of Fuzzy Expert System. From the numerical data it is very complex to identify the fuzzy set and its membership function.

b) Determination of Fuzzification Method

Fuzzification method is determined with the study of all the variables (input and output variable). If the data are uncertain, the fuzzification is necessary. Select fuzzification method and membership functions of fuzzy sets. If there is no uncertainty, singleton state variables are used.

c) Determination of the shapes of fuzzy sets

It is necessary to determine the shapes of fuzzy sets and their membership functions for the partitioned input spaces and output spaces.

d) Construction of Fuzzy rule

Knowledge is acquired from database, books, human observations and flow chart to construct rules. The rules are constructed with IF (Condition) THEN (action) form.

e) Method to perform Fuzzy Inference in Expert System

Encode the fuzzy set and fuzzy rule, where the actual construction of Fuzzy Expert System starts. We can build the system, using programming language C or Pascal or by MATLAB Fuzzy Logic Toolbox to develop the Fuzzy Expert System. MATLAB Fuzzy Logic Toolbox is the best choice which is based on graphical editor.
Tune and evaluate the system to improve performance

The system is evaluated with the condition that it should satisfy the requirement of the end user. In Fuzzy Logic, tool box surface is generated to analysis the performance of system tuning. System tuning is very important part and takes more time than construction of fuzzy sets and rules. Many factors are involved to tune the system. By tuning the system, the performance of the system is improved and easy to evaluate the system. Tuning of the system has to be done in the following order,

1. Input and output variables are reviewed. Units of the variable should be same in universe of discourse.
2. Fuzzy sets are reviewed, if there is a need, additional fuzzy sets are added to universe of discourse. If more fuzzy sets are added performance of the system becomes low.
3. There should be sufficient overlap between sets. Overlapping between them should be 25% to 50% of their bases.
4. Rules are reviewed, if there is need new rules are added.
5. Rules are given with certain weights.
6. Review the shapes of fuzzy sets.

f) Defuzzification

Defuzzification is the last step in the construction of Fuzzy Expert System. Mostly centroid method is used for defuzzification. The defuzzification helps to transform the fuzzy values from the fuzzy inference to crisp values. The crisp values are given to the user to diagnosis the results. There are many methods in the defuzzification stage. They are,

- Centroid Method
- Mean of Maxima Method
- Smallest of Maxima Method
- Largest of Maxima Method
- Bisector Method
FES is widely recognized for their capability to handle vague, inexact and subjective inputs. FES is the only way to provide robust realistic solution to the decision problem, because without the quantification of vagueness, uncertainty and subjectivity, the obtained decision will be inferior or impracticable. Other diagnostic quantitative approaches, either stochastic or certainty, do not have the ability to include qualitative or subjective input variables. The inclusion of qualitative or subjective input variables is necessary to provide a realistic solution. FES provides a natural way to include human expertise in the form of “IF-THEN” decision rules, based on and very close to the linguistic description of the human expert. Therefore, a FES was proposed in this study to develop an early detection and assessment tool for diabetic people.

In general, FES is constructed with Fuzzy Inference Mechanism which uses fuzzy sets, membership function, uncertainties are managed with Certainty Factors and rules are constructed using fuzzy sets. Reinforced Fuzzy Assessment Mechanisms holds the algorithms such as Fuzzy Assessment Methodology; Enhanced Fuzzy Assessment Methodology; T Fuzzy Assessment Methodology and S Fuzzy Assessment Methodology. The final enhanced algorithm was implemented in another domain i.e., agriculture to test the efficiency of algorithm. The proposed FES is constructed using the algorithm Reinforced Fuzzy Assessment Mechanisms which uses MMMSDV (Mean, Minimum, Maximum and Standard Deviation Values) to construct membership function, with the membership function the overlapping are measured with K ratio. In the proposed algorithm the rules are constructed and similarity between all the fuzzy set and fuzzy rules is measured using T Fuzzy Similarity.

Figure 1.1: General Frame Work of Fuzzy Expert System
Measure. Uncertainties are managed by calculating S Value using fuzzy rule in the proposed algorithm. FES is implemented using MATLAB Fuzzy Logic Toolbox. The Accuracy of the proposed FES is very efficient compared to the existing FES.

1.5 Objective of Research

Specifically the term diagnosis plays a vital role in Fuzzy Expert System. The accuracy of the diagnosis will improve based on the exploration of fuzzy knowledge. As a part of improving fuzzy knowledge this research carries objectives in two folds. They are,

- First, to analyze the performance of three elements of Fuzzy Expert System they are, uncertainty management, overlapping between the membership function and similarity measure for fuzzy set and fuzzy rules.
- Secondly, design and development of Fuzzy Expert System which should be proficient to improve the efficiency of decision making. The desired result is to manifest the capability of Fuzzy Expert System in assisting decision makers by using the Reinforced Fuzzy Assessment Mechanisms.

1.6 Scope of Research

The early warning of Diabetes Mellitus and its complications will reduce the economic cost on the government, insurance companies, and families. Because with the knowledge acquired through this tool, people will protect themselves and become more aware of their cases, and maintain their quality of life.

The scope of this research covers the use of three elements (membership function, similarity measure and uncertainty) of fuzzy sets and rules of Fuzzy Expert System. This also extend its arms to real the world application domain such as health care and agriculture. The below said two research results are described in each chapter of this thesis.

1. Significant improvement of fuzzy sets and rules.
2. Implementation of Reinforced Fuzzy Assessment Mechanisms in health care and agriculture fields for diagnosis and decision making.

1.7 Contribution to the thesis

Thesis is contributed with five postures which are given below,

Posture I: Fuzzy Assessment Methodology using Fact Values to find the uncertainty using evidence and hypothesis. The Fact Values (FV) derived helps to handle uncertainty in rules. Correlation Fuzzy Logic is used to find the relationship between fuzzy numbers and membership functions. The parameters for the membership function are fixed by using the
methodology called MMMSDV (Mean, Minimum, Maximum and Standard Deviation Values).

**Posture II:** Enhanced Fuzzy Assessment Methodology, to find the overlapping between membership function using K ratio. Membership function and overlapping between the membership function is very important part in Enhanced Fuzzy Assessment Methodology. To find the overlapping between the membership function K ratio is derived with some criteria. K ratio finds whether the membership function overlap between each other or not.

**Posture III:** In this posture similarity between fuzzy sets, fuzzy numbers and fuzzy rules are measured using T Fuzzy Assessment Methodology. To study the similarity between fuzzy sets, fuzzy numbers and rules T Fuzzy Assessment Methodology is used. If there are similar fuzzy sets and rules, the computation time of FES takes long time. So similarity measure is very essential in FES.

**Posture IV:** Measure of Uncertainty using S Fuzzy Assessment Methodology. S Value helps to find the uncertainty in data by using the fuzzy rules. With T Value and F Value we compute S Value using fuzzy rules to manage uncertainty.

**Posture V:** Implementation of this Advanced Fuzzy Assessment Methodology in the field of Agriculture. Advanced Fuzzy Assessment Methodology is used to diagnosis the yield of rice. With the input variables and output variables, fuzzy set and fuzzy membership function are derived. With the fuzzy set and membership function fuzzy rules are constructed. K ratio and T Similarity Measure are essential features in AFAM. Uncertainty in data is managed by using S Value in AFAM.

In first posture Fuzzy Assessment Methodology was framed and the system was used to diagnosis diabetes. In the posture II, III, IV the enhancement is made in the algorithm Fuzzy Assessment Methodology and the accuracy of the system is tested. Posture V gives in detail about the final proposed algorithm and it is tested in another domain. The best domain to test the algorithm is agriculture. In each posture there is an improvement in accuracy and proposed algorithm works more efficiently than the earlier ones. In all the postures the algorithm is tested by using MATLAB Fuzzy Logic Toolbox. The postures of research work are represented in Figure 1.2.
1.8 Organization of the thesis

The thesis is fragmented into nine chapters. They are as follows,

**Chapter 2** starts with examination of key topics in the field of Fuzzy Expert System. A literature regarding uncertainty, membership functions, overlapping between membership functions, Fuzzy Similarity Measure are reviewed and problems are defined in this chapter. A detailed study has been done using FES in the field of medicine and agriculture.

**Chapter 3** the methods used in uncertainty measures is probability theory, Bayesian reasoning, Baye’s rule and Certainty Factor are described. To overcome the pitfalls of Certainty Factor a new methodology has been arrived to manage uncertainty. This new methodology uses Fact Values to manage uncertainty in rules. The Fuzzy Assessment Methodology has been evaluated with facts and data for diagnosis of diabetes.

**Chapter 4** a detailed study was made on fuzzy membership function, its type and overlapping between the membership functions (overlapping ratio). The disadvantage of the overlapping ratio has been rectified through a methodology called Enhanced Fuzzy Assessment Methodology using K ratio with an example.

**Chapter 5** studies were made on similarity measure of fuzzy sets and its methods, fuzzy numbers and fuzzy rules. Similarity based reduction and merging of rules are also studied. To overcome the drawbacks of these similarity measures between fuzzy sets, fuzzy numbers and fuzzy rules a methodology is derived called as T Fuzzy Assessment Methodology using T Fuzzy Similarity Measure.

**Chapter 6** the importance of uncertainty in FES, methods for uncertainty using Fuzzy Logic are studied. Drawbacks in uncertainty using Fuzzy Logic and Fact Values are rectified by using S Fuzzy Assessment Methodology with S Value.

**Chapter 7** describes the literature regarding the use of Expert System and FES in agriculture field. In this chapter the final algorithm was tested with another domain *i.e.*, in the field of agriculture and proved that the algorithm works effectively in agriculture domain. Advanced Fuzzy Assessment Methodology is applied in the field of agriculture to diagnosis the yield of rice.

**Chapter 8** brings the results of all postures of algorithm. Discussions are made upon the accuracy of the proposed algorithm.

**Chapter 9** furnishes the concluding comments about the research and recommendations for future research that may arise from the work presented in thesis.
Each chapter in this thesis is given in details about the proposed algorithm, design, data to test the algorithm and results obtained from the algorithm.

**Posture I**

![Fuzzy Assessment Methodology- Fact Values](image)

**Posture II**

![Enhanced Fuzzy Assessment Methodology- K ratio](image)

**Posture III**

![T Fuzzy Assessment Methodology - T Fuzzy Similarity Measure](image)

**Posture IV**

![S Fuzzy Assessment Methodology - S Value](image)

**Posture V**

![Application of Advanced Fuzzy Assessment Methodology Agriculture](image)

**Figure 1.2:** Methodology of Research work
1.9 Summary
This research gives the overview of Fuzzy Expert System. Concept of Fuzzy Logic is essential to construct Fuzzy Expert System. Five attributes are associated with FES. They are,

1. Input variables.
2. Output variables.
3. Subset of input and output membership functions which leads to fuzzy sets.
4. Rules to connect input and output fuzzy sets.
5. Defuzzification methods.

To design a FES we need the basic knowledge regarding the fuzzy sets and rules. Fuzzy rule plays a vital role in FES. FES can be constructed using the algorithm Reinforced Fuzzy Assessment Mechanisms and it is implemented using MATLAB Fuzzy Logic Toolbox. The accuracy of the proposed FES is very efficient compared to the existing method. The main objective and scope of the research are discussed briefly. The way in which the thesis is organized is mentioned to know the overall structure of the thesis. FES plays an important role in medicine for symptomatic diagnostic remedies.