MEDICAL EXPERT SYSTEM FOR DIAGNOSIS OF ORTHOPAEDIC DISEASES

Dissertation submitted in fulfilment of the requirements for the Degree of

MASTER OF TECHNOLOGY

in

COMPUTER SCIENCE AND ENGINEERING

By

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Sr.No.	**Parameter**	**Rating (out of 10)**
1	Project Novelty: Potential of the project to create new knowledge	6.86
2	Project Feasibility: Project can be timely carried out in-house with low-cost and available resources in the University by the students.	7.29
3	Project Academic Inputs: Project topic is relevant and makes extensive use of academic inputs in UG program and serves as a culminating effort for core study area of the degree program.	7.14
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ABSTRACT

Expert system is a system that performs the decision making capabilities like a human being. It has wide scope in different fields like agriculture, medical, airspace, mechanical, computer science. Expert system provides the efficient way to reach to conclusion. As it uses the inference engine for the rule formation. All the rules are matched with the antecedent part and corresponding fact is fired. After reading many research paper of expert system, I choose the super domain as medical domain. I found many research papers for different human diagnosis which gives the accurate results. They are beneficial for the medical as well as research purposes. Under the medical domain, I choose the orthopedics as the sub domain. There is very less research done on this field. There are various diseases like inflammatory diseases, Infection diseases, Benign growth and injuries for the various joints.

Keyword: Fuzzy logic, Fuzzy rules, Defuzzification, Inference generation.

DECLARATION STATEMENT

I hereby declare that the research work reported in the dissertation/dissertation proposal entitled "MEDICAL EXPERT SYSTEM FOR DIAGNOSIS OF ORTHOPAEDIC DISEASES" in partial fulfilment of the requirement for the award of Degree for Master of Technology in Computer Science and Engineering at Lovely Professional University, Phagwara, Punjab is an authentic work carried out under supervision of my research supervisor Mr. Rohitt Sharma. I have not submitted this work elsewhere for any degree or diploma.

I understand that the work presented herewith is in direct compliance with Lovely Professional University's Policy on plagiarism, intellectual property rights, and highest standards of moral and ethical conduct. Therefore, to the best of my knowledge, the content of this dissertation represents authentic and honest research effort conducted, in its entirety, by me. I am fully responsible for the contents of my dissertation work.

Signature of Candidate

Gagandeep Kaur

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SUPERVISOR'S CERTIFICATE

This is to certify that the work reported in the M.Tech Dissertation/dissertation proposal entitled "**MEDICAL EXPERT SYSTEM FOR DIAGNOSIS OF ORTHOPAEDIC DISEASES**", submitted by **Gagandeep kaur** at **Lovely Professional University, Phagwara, India** is a bonafide record of her original work carried out under my supervision. This work has not been submitted elsewhere for any other degree.

Signature of Supervisor

(MR.ROHITT SHARMA)

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   Internal Examiner

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I would like to express my special thanks of gratitude to my supervisor **Mr. Rohitt Sharma Assistant Professor** who gave me the golden opportunity to do this wonderful project on the topic **Medical Expert System For Diagnosis Of Orthopaedic Diseases**, which also helped me in doing a lot of Research and I came to know about so many new things I am really thankful to them.

Secondly I would also like to thank my parents and friends who helped me a lot in finalizing this project within the limited time frame.

Place : Lovely Professional University Gagandeep Kaur

Date : 30-11-2017 Reg No. 11606280

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LIST OF ABBREVIATIONS

ABBREVIATION	ABBREVIATION DESCRIPTION
MIN	Minimum
MAX	Maximum
GUI	Graphical User Interface
ACL	Anterior Cruciate Ligament
PCL	Posterior Cruciate Ligament
OA	Osteoarthritis
RA	Rheumatoid Arthritis
ESR	Erythrocyte Sedimentation Rate
FIS	Fuzzy Inference System

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CHAPTER 1
INTRODUCTION

1.1 Expert System:

Expert system is a program that performs the decision-making capabilities on a particular subject area like medical diagnose by using the database of a human who is expert in that area. Expert system uses the knowledge of human expert for reasoning and for making conclusions.

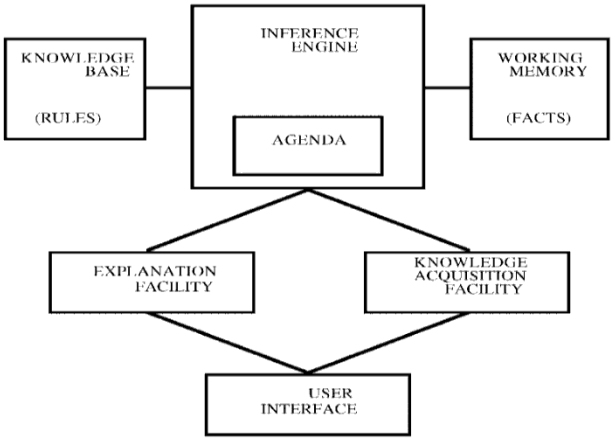

Diagram1.1: Components of Expert system

The three main components of system as shown in diagram1.1 are: Knowledge based, Fuzzy Inference Engine and User Interface.

a) **Knowledge based:** knowledge base plays an important role as it is database of the expert system where the information is stored in form of rules. All the rules are made with the help of human expert, books, specialized person. These rules are inserted in the knowledge base in the format of IF-THEN rules. These rules are treated as training data set because based on these rules the fact is fired. These rules will provide the accurate output. The programmer writes the code for the expert system in IF (antecedent) THEN (consequent) format. [14]

b) **User Interface:** Interface is for the users through which the user can give input to the expert system and get the output in friendly manner. With the help of graphical user interface, one can easily enter the information and corresponding output will be generated, which can be easily understandable to users. The expert system provides the explanation facility which means the expert system explains the whole reasoning processes, how the expert system reaches to that conclusion.

Whereas the knowledge acquisition facility is used to feed the knowledge automatically in expert system without coding.

c) **Inference Engine:** Fuzzy Inference engine is one of the important components of expert system which checks the user input and all the corresponding rules in knowledge based. There may be more than one rule which satisfied the user query. Agenda is list of rules which are satisfied or matches with the user input. The list is unordered list so it is the function of agenda to prioritize the rules. All the facts related to rules are stored in working memory. User data are stored here which is collected during the session. Inference engine pick the matched rules from agenda which is going to be fire. If any rule is not matched from agenda then inference engine ask some more questions through the user interface to the user. Inference engine matches the rules and make the conclusion.

1.2 Fuzzy rule based expert system

There is significant increase in variety of fuzzy logic like washing machines, portfolio selection, medical diagnosis and controlling process of industries. Fuzzy logic concept is start from the fuzzy set which does not have the clear boundary. Fuzzy set which does not have crisp set. Crisp set means having value in yes or no, true or false and good or bad form. It is used where there is confusion to either accept the number or to reject the number which means the number is on boundary. That number which is on the boundary line, it create confusion whether to accept that or to reject. For these types of input parameters fuzzy set is used. The development of fuzzy logic based Expert system has following steps:

- Identify all the parameters. Set the ranges for all parameters. All input and output parameters are ranged.
- The next step is fuzzification, mapping of crisp input value to the membership function. Figure 1.1 shows triangular, trapezoidal and guassian function.

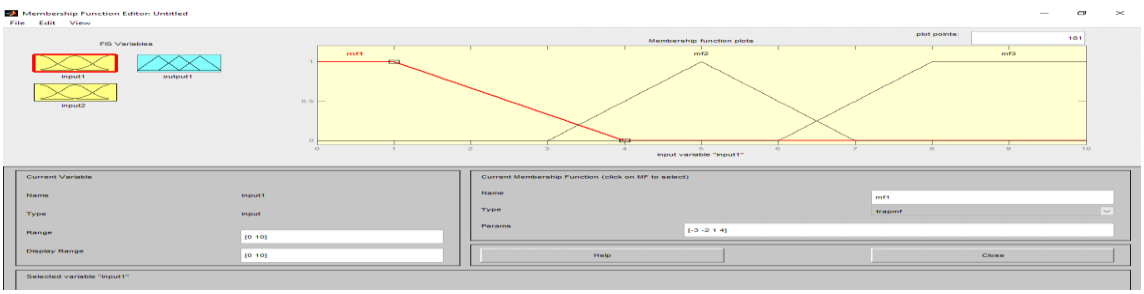

Figure 1.1: Member functions

- All the rules are formed in the fuzzy. All the rules are written in IF-THEN rule format.

  IF (Condition1… AND/OR Condition2) THEN (Action)
- In the fuzzy inference generation, implication and aggregation methods are used. For the AND operator in the rules MIN function is used where, for OR operators in the rules the MAX function is used.
- For the Defuzification, membership function value is converted back to the crisp value which is output. It uses different methods such as Center of area (COA), Bisector of area (BOA), Largest of maximum (LOM), Smallest od maximum (SOM) and Mean of maximum (MOM).

Center of area (COA): under the aggregation function, it calculates the centroid for that area.

$$Z_{COA} = \frac{\int \mu_A(z) z dz}{\int \mu_A(z) dz}$$

Bisector of area (BOA): This method basically divide the whole region into two equal part, sometimes the center of area and bisector of area lies on same line but not always.

$$\int_{\alpha}^{BOA} \mu_A \, dz = \int_{BOA}^{\beta} \mu_A(z) dz$$

Largest of Maximum (LOM): Largest value of the aggregation output membership function will be return.

Smallest of Maximum (SOM): This method of defuzzification returns the smallest value of aggregation output membership function.

Mean of Maximum(MOM): This function returns the value by calculating all maximum values, arithmetic mean of the aggregated membership functions.

$$Z_{mom} = \frac{\int z dz}{\int dz}$$

- In the last step, testing is performed. The output is tested with the observed output that is given by expert. The expected output is then matches with the system output for the testing.

1.3 Artificial Neural Network

Artificial neural network commonly known as parallel distributed processing system. Neural means neurons and network means graph like structure. Artificial Neural

network are the programs that emulates the structure and function of our body to solve any problem. [20] Directed graph have some nodes which are called vertices of the graph and these vertices are connected through the link called edge which define some property of the connection. The basic elements are: processing unit, topology, learning algorithm. [21]

Processing Unit:

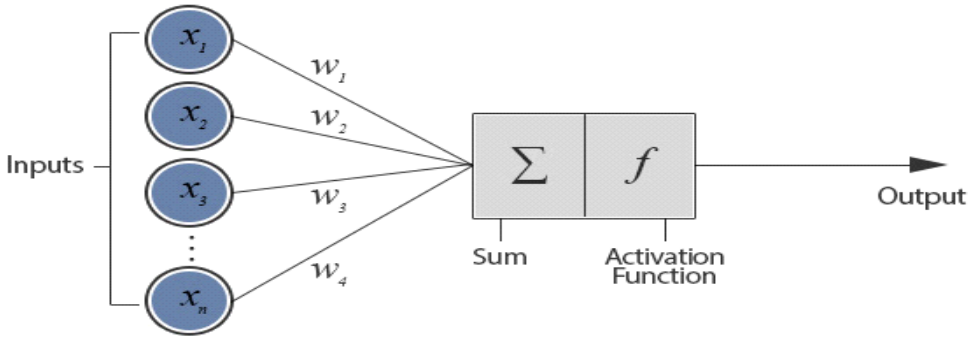

Diagram 1.2 Artificial Neural Network Processing Unit

As shown in the diagram a perceptron will have many inputs (X_1, X_2…… X_n) and these individual inputs are weighted (W_1…… W_n). [22] All the inputs are multiplied by the connected weight.

Sum= W_1X_1 + ……. W_nX_n

The summation of this is transfer to the activation function to get the result. [20]

Topology: The topology can be feed forward and feed backward network where it can be single layer, multiple layer competitive network.[20]

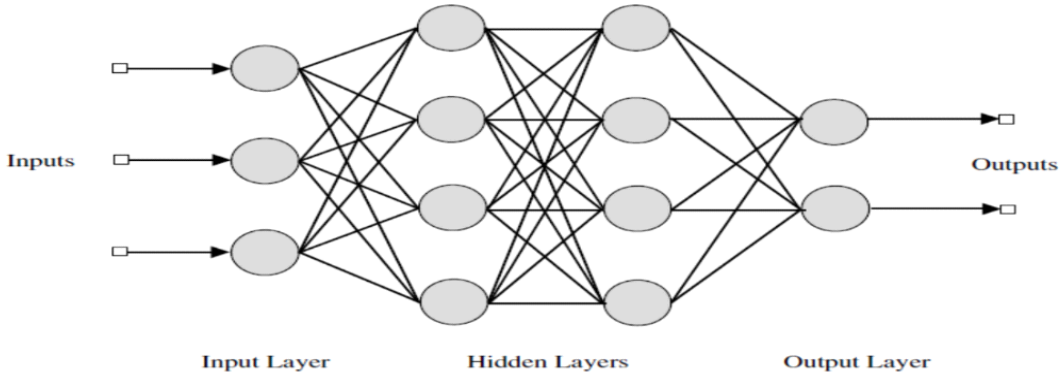

Diagram 1.3: Multilayered Artificial Neural Network

Learning Algorithm: Learning is basically the modified value of the weight (connection between the nodes) corresponding to one network. Learning can be supervised or unsupervised.

1.4 Neuro Fuzzy system:

Neuro Fuzzy system is a fuzzy system which is combination of both Fuzzy Inference and Artificial Neural network as shown in diagram 1.4. This system hybrid the human like reasoning by using fuzzy and make the connection with the use of neural network. These systems are feedforward multilayer networks normally 3 – layer where first layer as input, second considered as hidden and last for the output. The neuro fuzzy can take the input from the fuzzy system as well as from the neural network.

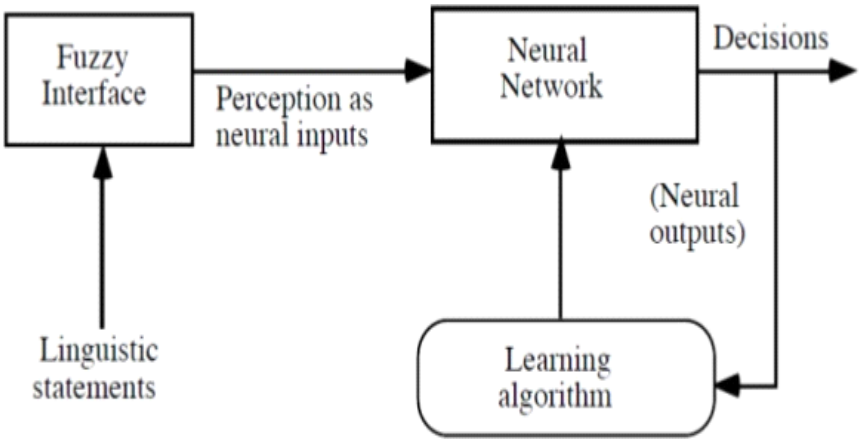

Diagram1.4: A model of Neuro-Fuzzy System

1.5 ORTHOPAEDIC DISEASES

The word orthopaedic is comprises from two Greek words ortho + paedion where ortho means straight and paedion means child.[book] previously it was an art of straightening the deformities of children. This was derived by a French physician named Ncolas Andry in the year 1741 , who was known as Father of orthopaedic.[book] With the advancement of the science, discovery of Roentgen's rays (X-rays) and discovery of bacteria by Louis Pasteur the new era of diseases of skeletal system emerged . From this various bones and joints diseases were came under orthopaedic, which are known as orthopaedic diseases.

The human skeletal is made up of 206 bones where each and every bone of skeletal system could be cover under Inflammatory, Infective, and neoplastic disorder. Moreover, the human body is comprised of various joints as Synovial fibrous, ball and socket joint, hinge joints. The diseases of which are covered by specialized bone and joint disease branch called orthopaedic. Under the orthopaedic, there are spine, elbow, knee, ankle, wrist and shoulder body parts. Knee joint is the main weight bearing joint so we have focus special attention towards those large hinge joint of the body.

1.6 KNEE

Knee is the hinge joint which plays vital role in skeletal system of human. The whole body weight is on the knee joint. Knee is comprises of three bones. The lower bone of thigh which is called Femur, upper part of the leg bone called Tibia and the knee cap bone is known as Patella. The articulation between lower femur and upper tibia are divided by ACL (Anterior Cruciate Ligament), PCL (Posterior Cruciate Ligament) and two cushions like Menisci called Medial menisci and Lateral menisci. The inner part is called medial compartment which can be identified from medial joint line and outer part is called lateral compartment which is assessed by lateral joint line. The articulation between patella and lower part of femur is known as patellofemoral joint. The cruciate and menisci of joint make the knee joint stable and act as cushions of the knee. The menisci prevent the degeneration of articular surfaces of femur and tibia through their cushion activity during the weight bearing activities.

The further stability of the knee joint is enhanced by MCL (Medial Collateral Ligament) and lateral collateral ligament. All these structures along with popliterus muscle and various tendons at the back of the knee (popliteus tossa) helps the knee to be a complex and stable joint of body during various motions. The main movements of the knee joint are flexion and extension. The varying degree of extension at the knee depends upon quadriceps tendon, anterior cruciate ligament, posterior cruciate ligament and menisci. The flexion of the knee depends upon the hamstring tendons. The medial and lateral movements at the knee are prevented by medial collateral ligament and lateral collateral ligament.

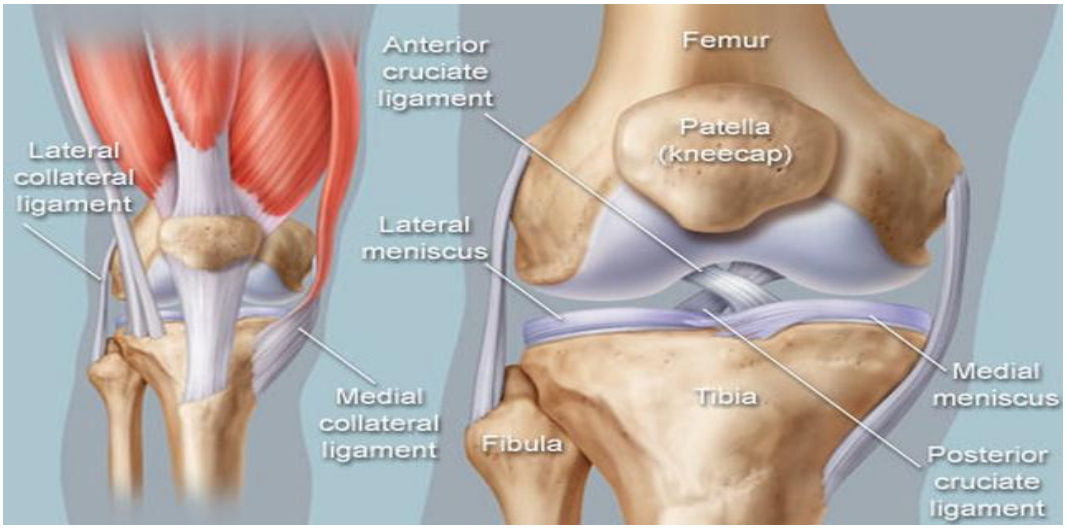

Figure 1.2 Parts of knee

1.6.1 Knee Category

The knee is the commonest site of variety of diseases. Apart from Traumatic diseases, there are various non-traumatic diseases of the knee. The trauma can be bony or soft tissue. Fracture patella is the commonest bony injury and ACL (Anterior Cruciate Ligament) and meniscus tear are common soft tissue injuries. The main area of interest in knee are inflammatory pathology that is Osteoarthritis of knee, Rheumatoid arthritis of knee and osteonecrosis of knee and infective pathology like septic arthritis which can be acute septic arthritis , chronic septic arthritis and tuberculosis of the knee. The symptoms of inflammatory region have a common resemblance but the diagnosis can be made from slight variation of symptoms. Moreover, some investigations like x-rays, MRI and blood investigations can make the diagnosis to its perfect correction. Similarly infective pathology differs on symptoms and various investigations are also needed to diagnose the disease.

Category name	**Disease 1**	**Disease 2**	**Disease 3**
Inflammatory	Osteoarthritis	Rheumatoid Arthritis	Osteonecrosis
Infective	Acute Septic	Chronic Septic	Tuberculosis
Neoplastic	Benign Growth	Malignant Growth	Osteosarcoma

Table1.1: Knee Category

1) **Inflammatory Diseases:** Inflammatory diseases means inflammation to the bony and soft tissue structures of the knee joint that causes inflammatory arthritis. Various diseases comes under the inflammatory diseases like Osteoarthritis of the knee joint, Rheumatoid arthritis of the knee joint and osteonecrosis of the knee.
   a) **Osteoarthritis:** Osteoarthritis is a common joint disorder. This is the progressive softening and disintegration of the articular cartilage. It is accompanied by new growth of cartilage and bone at the joint margin. The symptoms for the osteoarthritis disease are pain, age, swelling, deformity and restriction.
   b) **Rheumatoid arthritis:** Rheumatoid is an auto immune disease. It is the commonest cause of the chronic inflammatory disease. The most common characteristic features are elevated ESR, symmetrical polyarthritis and morning stiffness. Pathology of RA in knee, stage1 is synovitis and swelling in joint, stage 2 is early joint destruction with particular region and stage 3 is advanced joint destruction and deformity. This disease is common in all age group

(children, young, old). It can be seropositive rheumatoid arthritis or seronegative rheumatoid arthritis.

c) **Osteonecrosis:** The avascular necrosis of the medial condyle of the femur is very common in the knee joint. It is often associated with the alcoholism and drug addictive. It is three times more common in females, above the age of 60 years.

2) **Infective Diseases:** Infective disease means when the joint is invaded by bacteria (disease produces germs), then it is known as infective pathology. Under this category, various diseases are Acute septic arthritis, Chronic septic arthritis and Tuberculosis of the knee.

a) **Septic Arthritis:** Knee is very superficial joint so it is more commonly invaded by bacteria externally no doubt haematogenous spread in the knee joint also exist.

Acute Septic Arthritis: knee commonest site usually in children, acute outset with higher fever and rigor, hot and tender joint, aspiration of pus from the joint makes the diagnosis, ESR raised from mild to moderate.

Chronic Septic Arthritis: This disease is usually in adults, presence of active and healed sinuses, minimal swelling associated deformity present in the knee joint. Inguinal lymph nodes enlarged, firm and may be tender.

b) **Tuberculosis:** In tuberculosis of the knee, triple deformity of the joint having flexion contraction of knee, subluxation of knee backward and rotated internally. The disease symptoms are swelling, painful, tender joint with limitation of the joint movements and deformity. The joint is usually inflamed and joint line is tender. In some cases inguinal lymph nodes are enlarged. The quadriceps and calf muscles are usually wasted and in some cases lymph of the affected extremity is present.

3) **Neoplastic Diseases:** The common diseases under the neoplastic category of the knee are Benign soft tissue growth, Malignant soft tissue growth and Osteosarcoma.

CHAPTER 2
REVIEW OF LITERATURE

Maryam Zolnoori, Mohammad Hossein Fazel Zarandi & Mostafa Moin & Shahram Teimorian (2010) "Fuzzy Rule-Based Expert System for Assessment Severity of Asthma", stated that the fuzzy system diagnosis the severity of asthma disease. For the input parameters, it took five factors as respiratory, bronchial obstruction, instability of asthma, quality of life, and severity of asthma. The output parameter was asthma severity which was ranged from 0-10, that was further fuzzified. The patient having asthma was categorized by Mild Intermittent (MI), Mild Persistent (MP), Moderate Persistent (MOP), and Severe Persistent (SP) membership function. Under Mamdani inference system was rules were made to diagnose the disease. This system was tested on 28 patients that introduce the slight difference for the assigned categories of asthma severity. [1]

Engin Avci (2011) "A New Expert System for Diagnosis of Lung Cancer: GDA—LS_SVM", designed the expert diagnose system for the cancer of lung which was situated on General Discriminant Analysis (GDA) method and Least Square Support Vector Machine (LS-SVM) method. The whole process was divided into two stages. In first stage, feature extraction and reduction were done where dataset of lung cancer which were having 57 features, reduced to eight features with the help of General Discriminant Analysis method. In second stage classification, the features were reduced and inserted into least square support vector machine which used Gaussian kernels (σ) and the regularization factor (C). The value of parameter kernel (σ) was changed between 0.5 and 30 whereas the value of C parameter was changed between 0.1 and 1,000 where 96.875% accuracy was acquired from system. [2]

Taesup Moon et al (2011) "Fuzzy rule-based inference of reasons for high effluent quality in municipal wastewater treatment plant", classified the state of pollutant quality in municipal wastewater treatment plants (WWTPs) and designed the fuzzy inference system which used decision tree algorithm and fuzzy technique. Under decision tree, classification and regression tree (CART) algorithm were used and for the fuzzy IF-THEN rules were used where it set the crisp boundaries. A Mamdani model was used with Min-Max operator. For the input values of fuzzy system trapezoidal and triangular membership function were used. For the defuzzification center of area (COA) method was used. A fuzzy inference system (FIS), which could classify the state of waste

chemical oxygen demand (COD), suspended solid (SS) and total nitrogen (TN), and identify visually the reasons for the high effluent state. [3]

Sachidanand Singh et al (2012), "Diagnosis of Arthritis through Fuzzy Inference System", designed the fuzzy system for diagnosis the arthritis disease which was inflammatory disease. Fuzzy logic controller was used to model the doctor's knowledge. The symptoms and range for the input were rest pain [0-12], morning stiffness [0-2], ESR [0-100], anticcp [0-100], rheumatoid factor [0-100], body pain [0-100], swelling [0-100], symmetry of joint [0-100]. [4] Except the symmetry of joint symptom, all other symptoms were divided into three membership function (no, min, max). The severity of the arthritis was output (No arthritis, Osteoarthritis and Rheumatoid arthritis). Centroid method was used for defuzzification. There were 30 rules made for diagnosis the arthritis.

Smita S Sikchi, Sushil Sikchi, M S Ali (2012), "Design of Fuzzy Expert System for Diagnosis of Cardiac Diseases", developed the generic fuzzy expert system to the diagnosis of Heart diseases. The feature used for graphical user interface was visual basic and Matlab software. The database was made of 700 rules which was having laboratory tests and manifested symptoms as input values. [5] The general symptoms were pain, swelling, habits, organ, feeling, blood and loss. Primary symptoms for heart disease were Blood Pressure, heart rate, diabetes, ECG, exercise and smoking. Based on the primary and general symptoms, corresponding rules from database were checked and result the diagnosis of disease.

Emuoyi bofarhe O. Justice, Taiwo K.F (2012), "Fuzzy-Based System for Determining the Severity Level of Knee Osteoarthritis", developed a fuzzy based expert system using MatLab software for diagnosis of severity level of knee disease Osteoarthritis, which was an inflammatory disease. The input parameters were Knee pain [1-10], age [45-75], stiffness and crepitus. Output variable was severity of the disease which was categorized suchas very mild, mild, moderate, severe and very severe. The knowledge base was consisting of 500 rules. [6] Triangular membership function was used for all input and output parameters. There were four membership functions for the knee pain and for the rest of input parameters five membership functions were used. Based on the fuzzy rules the severity level of knee osteoarthritis was checked. Centroid method was used for the defuzzification.

S. Krishna Anand, R. Kalpana and S. Vijayalakshmi (2013) "Design and Implementation of a Fuzzy Expert System for Detecting and Estimating the Level of Asthma and Chronic Obstructive Pulmonary Disease", designed the fuzzy expert system to detect the problems related to lungs as Acute Asthma and Chronic Obstructive Pulmonary Disease (COPD). The input parameters such as Age, Cough, Fever, Nocturnal Symptoms, Oral Steroids, Respiratory Rate, Smoking, Time of the day, Wheeze and output parameters Asthma, Tuberculosis and COPD were taken for the system. The proposed system used the triangular and trapezoidal membership functions for all parameters. The expert system contained total four intelligent controllers which were used to generate the correct and accurate output. As an output, it diagnoses the appropriate pulmonary disease (Asthma, Tuberculosis and COPD). [7]

Adnan Shaout and Mohamed Khalid Yousif (2014), **"Employee Performance Appraisal System",** designed and implemented a system for an organization that represented the performance appraisal of an employee using fuzzy logic (if-then rules). MS Access database was used for taking parameters of criteria elements, evaluation scale, relations between these elements and employee master data (nationality, division, position). Inference engine performed calculation for relation, aggregation method using min operator, sub-min, algebraic product. Taking similar measures, the system analyzed and reported the final result. [8]

Jimoh Ibrahim A. and Ayangbekun Oluwafemi J (2015) "Expert System for Diagnosis Neurodegenerative Diseases", developed the expert system to diagnosis brain related diseases. Under the brain diseases, Neurodegenerative diseases were classified as a general area which included Alzheimer's disease, Parkinson's disease, Huntington's disease, Multiple Sclerosis and Creutzfeldt - Jakob disease. The system was implemented by using computer programming C#.NET and Microsoft SQL Server 2012 where SQL Server served as the Relational Database Management System (RDBMS) to store the data. This system used symptoms and facts to diagnose the disease. Symptoms related to Alzheimer's diseases which were taken as input parameters were Forgetfulness (FG), Memory Problem (MP), Impaired judgment (IJ), Hallucinations (HL), Speech Difficulties (SPD), Sleep disturbances (SD), Moodiness/Depression (MD). For the efficient use of the system, graphical user interface was designed to interact with the users. Under interface

the Login pane, Admin pane, Diagnose pane and Treatment pane were used to show the final report and outcome of the disease. [9]

Navneet Walia, Sharad Kumar Tiwari and Rahul Malhotra (2015) "Design and Identification of Tuberculosis using Fuzzy Based Decision Support System", developed the system which detect the stages of pulmonary disease tuberculosis. Mamdani's MAX-MIN fuzzy inference engine was used to surmise data. The integer input parameters taken were Coughing, Fever and Smoking addiction and Haemoptysis, Loss of Appetite, BCG vaccine, Malaise, Weight loss as Boolean input variables. The output of system showed the stage of bacterium with the membership functions of mild, moderate, severe and very severe. Fuzzy logic provided better deal with problems of fuzziness, impreciseness and provided precise results. The newly proposed diagnosability approach helped in decision making of pulmonary physicians in giving the diagnosis and treatment. [10]

Varinder Pabbi (2015), "Fuzzy Expert System for Medical Diagnosis", designed a fuzzy rule based expert system to diagnose the different type of dengue fever. The proposed system took lab features and clinical symptoms for input values. The fuzzy inference system took five input parameters (Age, Blood Pressure, Platelets count, TLC, SGOT/SGPT) and one output was type of dengue fever. Output was fuzzified into four membership functions as No dengue disease, dengue fever, dengue hemorrhagic fever and dengue shock syndrome. All input and output parameters used the triangular membership function to plot the range values. By using fuzzy IF-THEN rules, total 729 rules were made to diagnose the type of dengue. [11]

Peter Buba Zirra, Timothy Umar Maigari and Wallace Ebinum Ossai(2016), "A Fuzzy Based System for Determining the Severity Level of Osteomyelitis", diagnosed the severity level of osteomyelitis which is bone infection disease usually affect the long bones like arms and legs in children and adults. To diagnose this disease fuzzy system took four parameters (pain, age, swelling, fever) as input and severity level as output. Primary symptom was pain which creates problem in walking. The symptoms for acute osteomyelitis and chronic osteomyelitis were almost same. Range for all input parameter was taken from 0 to 1 and membership function used was Gaussian. The parameter pain was categorized as case 1 ignore pain, case 2, case 3 and case 4 severe pain whereas swelling and fever were categorized as very mild, mild, moderate, severe and very severe.

Total 500 rules were made for diagnosis of severity level of osteomyelitis (very mild, mild, moderate, severe and very severe). [12]

Dimple Sethi, Prateek Agrawal, Vishu Madaan and Sanjay Kumar Singh(2016), "X-Gyno: Fuzzy Method based Medical Expert System for Gynaecology", designed a fuzzy logic based system for gynaecology in MATLAB software, where Inflammatory disease were taken as broad area. Fuzzy system diagnosed Acute Cerviticis, Chronic Cerviticis, Acute Endometritis, Chronic Endometritis, Atrophic Endometeritis, Acute Salpingo-oophortis, Chronic Salpingo-oophoritis diseases. Cosine Amplitude Method and Max-Min Method were used for the calculations of defuzzification. Input parameters taken were Vaginal discharge, lower abdomen pain, Frequency of micturition, amenorrhea. The output parameter was Chronic Cerviticis. The system was tested on 144 patients where the system achieved 96.1% of efficiency. [13]

Dimple Sethi, Prateek Agrawal and Vishu Madaan (2016), "X-Tumour: Fuzzy Rule Based Medical Expert System to Detect Tumours in Gynaecology", designed the medical expert system for gynaecology to diagnose the tumour disease. The system diagnosed Adenomyosis, Myoma, Carcinoma, Endometrial, Sacroma of uterus, Choriocarcinoma of vagina as the input variables and tested the level of tumor where rules were made using fuzzy rule format of IF-THEN rules. Mamdani inference system was used in this expert system. There were three stages of Endometrial Carcinoma which defined the output. The positive predictive value of test was 96% and sensitivity was 90%. [14]

Amandeep Kaur, Vishu Madaan, Prateek Agrawal, Ranjit Kaur (2016) "Fuzzy Rule based Expert System for Evaluating Defaulter Risk in Banking Sector", stated the problems of credit risk as customer defaulter risk and credit risk. Fuzzy expert system used the data from Indian Overseas Bank (IOB) branches and classified into two categories defaulter and non- defaulter where for the defaulter class parameters were CS (CIBIL Score), LVR (Loan to Value Ratio), AAL (Already Availed Loan), IRF (Income Ratio Factor). It provided the help to new employee for the loan approval and for decision making process. For the fuzzification, three triangular membership function for input and output parameters were used by the system. The Mamdani Inference system used, which took four inputs and one output parameters. The proposed system used the centroid method for the defuzzification. After that rank were given to the output value which was

used to check the accuracy of the system. Graphical user interface was designed to interact with customer where inputs to the fuzzy rules were match and corresponding result shown whether the customer was defaulter or not, also it tells about the risk if bank assign loan to that customer. [15]

Shivanand S. Gornale, Pooja U. Patravali, Ramesh R. Manza (2016), "Detection of Osteoarthritis using Knee X-Ray Image Analyses: A Machine Vision based Approach", had evaluated the knee joint disease Osteoarthritis using image processing. For the segmentation of X-rays Active contour segmentation technique was used. With the help of Random Forest classifier, number of features like statistical, haralick, Texture and shape were classified. For the image acquisition author used 200 knee x-rays for data set and for image pre-processing 250x250 pixels used. Contrast adjustment method was used for image enhancement. Clinical symptoms and radiological assessments (X-rays, MRI) were used for the output whether Normal or Affected knee x-rays. The accuracy examined by this proposed model was 87.92%. [16]

Angbera, Ature, et al (2016), "Efficient Fuzzy-Based System for the Diagnosis and Treatment of Tuberculosis", designed a fuzzy system to diagnose Tuberculosis by taking 18 input parameters and five output parameters. The input parameters were Chest pain (CP), cough duration (CD), fever duration (FV), night sweats (NS), weight loss (WL), loss of appetite (LOA), change in bowel habits (CBH), variations in mental behaviour (VMB), masses along the neck (MAN), draining sinus (DS), coma (seizure) (CO), stiff Neck (SN), headache (HD), abdominal Pain (AP), painful or uncomfortable urination (PU), hemopysis (coughing up blood) (CUB), fatigue (FA) and blood present in urine (BPU). The output defined the class of the disease. Java fuzzy logic, XHTML, MySQL database was used to design the system. It also defined the four treatment regimen of tuberculosis. Triangular membership function was used for input and output parameters. For all the input variables three membership functions were made which were categorized as low (0-3), medium (3-7), high (7-10). [17]

Billy Ambara, Darma Putra and Dwi Rusjayanthi (2017), "Fuzzy Expert System of Dental and Oral Disease with Certainty Factor", made the fuzzy system for diagnosis of dental and oral diseases. There were 27 questions framed for the user, which were taken as input. Based on the answers of those questions, system diagnosed the nine types of diseases (pulpitis reversible, pulpitis irreversible, nekrosis pilpa, dental abscess,

gingivitis, dental fraktur, periondontitis, stomatitis, halitosis). A curve was used to describe the membership function and interval for the data values were 0 to 1. The value used for the yes answer was 100 and 0 for no answer. For the defuzzification method, it used the sum of average of all weights. With the certainty factor and fuzzy, the accuracy was 94.627%. [18]

Fatemeh Mohammadi Amiri, Ameneh Khadivar(2017), "A Fuzzy Expert System For Diagnosis And Treatment of Musculoskeletal Disorders In Wrist", designed the fuzzy system to diagnose the seven types of disorders in wrist and also defined treatment for the diseases in MATLAB software. Mamdani inference system was used for the diagnosis of musculoskeletal disorders in wrist. The method used for the collection of data was Fuzzy Delphi. Based on the input parameters fuzzy system generated the output in form of score. From the score, the disease was diagnosed. The accuracy of that system was 86.7% which was compared by SPSS software. [19]

CHAPTER 3
SCOPE OF THE STUDY

3.1 Problem Formulation

The problem "MEDICAL EXPERT SYSTEM FOR DIAGNOSIS OF ORTHOPAEDIC DISEASES", states that the expert sytem will diagnose the orthopaedic diseases under the different categories. Under the orthopaedic, diseases regarding knee joint will diagnosis based on the symptoms. The system will diagnose the severity level of the disease and result will be shown on the graphical user interface and about the treatment of the disease.

3.2 Scope

The scope of this study is that proposed expert system can be used for the technical as well as social purposes. As the Artificial intelligence is a demanding technology in every field. Expert systems are used in various fields such as medical, computer science, and airspace, mechanical field.

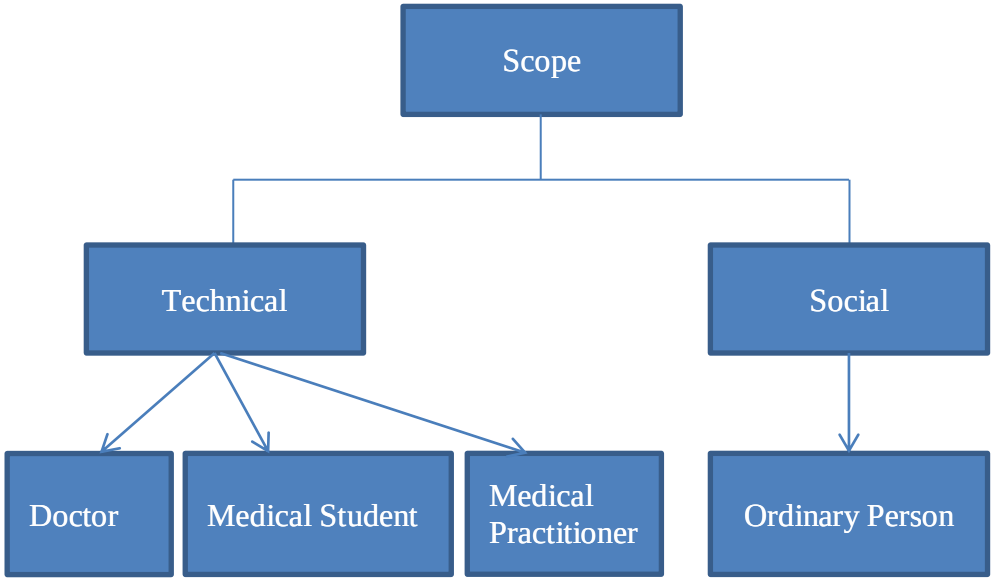

Diagram3.1 Scope of study

Technical Scope: Expert system for the Orthopaedic diseases is beneficial for the doctors who have done specialization in that field. They can complete their work with more accuracy as expert system will take care of all the parameters for conclusion. Expert system helps the doctors for decision making strategies with more accuracy. Moreover, time will be saved. Medical students who are doing research in that domain

they can use this expert system for their experiments. As the knee joint diseases are the commonest site.

Social Scope: Expert system can be used socially. The ordinary person can use expert system, as it is very simple to use. Normal person has to communicate with the graphic user interface, where they have to define the symptoms of the disease and they will get related result. The symptoms which will be shown on GUI, will be in very simple form so that everyone can easily understand that symptoms. The output will be shown on GUI where the severity of disease and treatment defined.

CHAPTER 4
OBJECTIVE OF THE STUDY

Humans have astonishing capability to do reasoning and to make decisions in an environment where uncertainty, imprecision, incompleteness of information, and partiality of knowledge, truth and class membership can be there. The principal objective of fuzzy logic is formalization/mechanization of this remarkable capability.

1. **Diagnosis of Orthopaedic diseases:** The foremost objective is to diagnose the diseases of orthopaedic by using fuzzy logic. All the parameters of diseases are identified. Fuzzification, mapping of crisp value using the membership function to the fuzzified value. Symptoms are identified and basis on these symptoms, inference engine fires the rule by matching with fact. The output is shown to the patient about the disease.
2. **Determine stages of disease:** In this, expert system defines the level of disease. If the patients have any disease, the fuzzy expert system will define the level or stage of disease.
3. **Treatment plan:** When fuzzy system diagnose any disease, the graphical user interface which displays the result in form of report. The report defines whether patient has positive report or negative and if it diagnoses disease, it will provide the treatment plan for disease. It will be beneficial for the ordinary people as they can check by sitting at home.

CHAPTER 5
RESEARCH METHODOLOGY

The software used for the implementation of proposed work is MatLab (Matrix Laboratory). For the fuzzification, fuzzy Mamdani Inference System is used.

1. **Collection of Data:** The data is collected from the various sources such as research papers, books. Under the orthopaedic diseases, there are various categories of the knee joint. Major categories of the Knee joint are Inflammatory diseases, Infective Diseases and Neoplastic diseases.

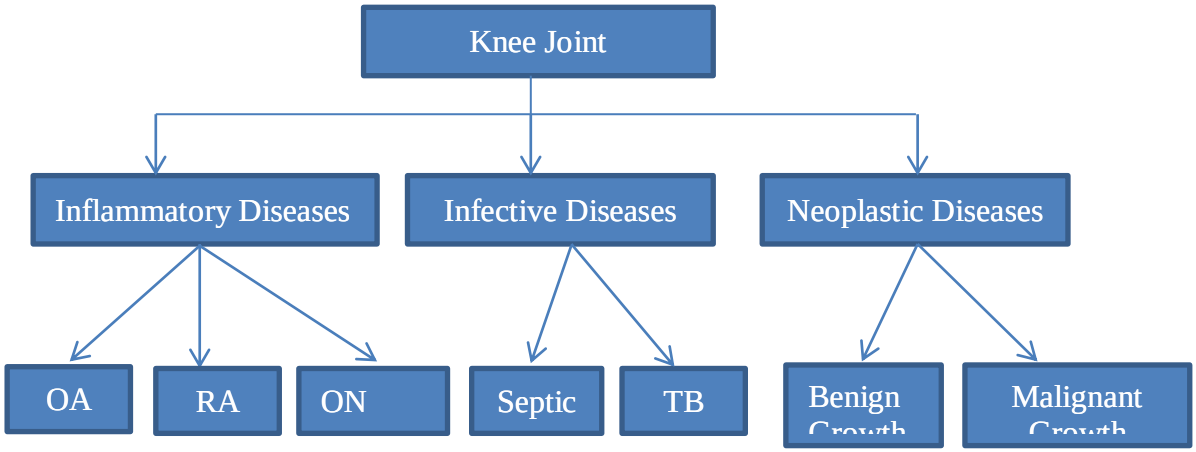

Diagram 5.1 Knee categories and diseases

2. **Refinement of data:** From the above data collected, refinement of data is performed. The symptoms are categorized as Primary symptoms and Secondary symptoms.

Inflammatory	**Symptom 1**	**Symptom 2**	**Symptom 3**	**Symptom 4**	**Symptom 5**
Osteoarthritis	Pain	Age	Swelling	Deformity	Restriction
Rheumatoid Arthritis	Pain	ESR	Age	Bilateral Swelling	Bilateral Tenderness
Osteonecrosis	Pain	Swelling	Medial joint Tenderness	Restriction	

Table5.1 Inflammatory Diseases and refinement of Symptoms

3. **Building of individual Fuzzy Systems:** All the symptoms are fuzzified. Range is decided for all the input and output parameters.

3.1 Fuzzification: Crisp input is map to membership function, all the symptoms are fuzzified. There are various membership functions like trap, tri. Define the range and membership function for the individual parameter. For any particular input parameter there can be n fuzzy member like for the swelling parameter considers mild, moderate and severe. For these inputs range [0-10] is mild (0-3), moderate (3-7), severe (7-10).

3.2 Rules: With the help of expert, rules are made. All the rules are made in IF-THEN rule format. Two operators are used for the formation of rules as AND, OR. The format followed will be: IF (Condition 1 AND Condition 2…….. AND Condition n) THEN (Action).

3.3 Inference system: Mamdani fuzzy Inference system matches all the rules with the facts, corresponding result is shown. Implication and aggregation method is used by the inference system.

4. **Merge and Defuzzification (COA, BOA, LOM, SOM, and MOM):** In Defuzification, membership function value is converted back to the crisp value. There are various Defuzzification methods: Center of area (COA), Bisector of area (BOA), Largest of Maximum (LOM), Smallest of Maximum (SOM), Mean of Maximum (MOM).

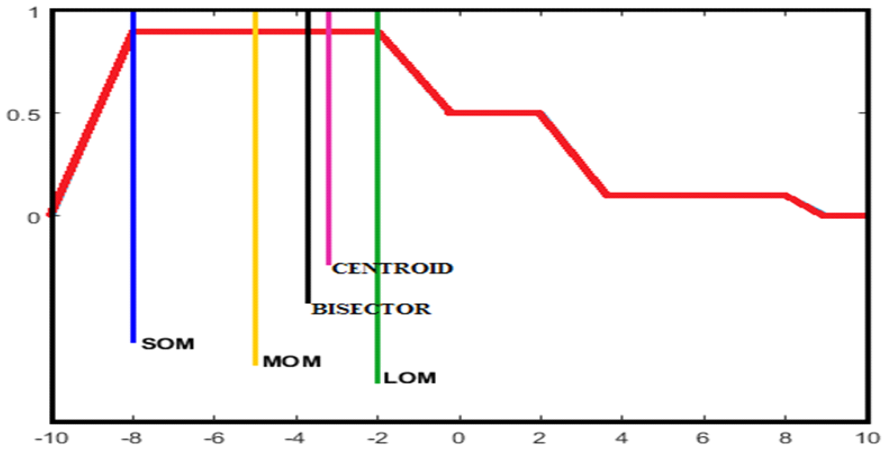

Figure5.1 Defuzzification

5. **Validation and Testing of Inference Rules:** Validation and Testing of the inference rules will be done with the expected outcome. The expected outcome given by the expert will be compared with the output generated by expert system.

6. **Graphical User Interface:** For the user friendly, graphical user interface will be made. All the symptoms should be written under the specific category, user or doctor will select the symptoms corresponding output will be shown.
7. **Tool Used:** Matlab (Matrix laboratory) is software which will be used for designing of fuzzy expert system. Mamdani fuzzy inference engine will used for the implementation. For the view, rule viewer and surface viewer will be used under the Mamdani fuzzy inference system.

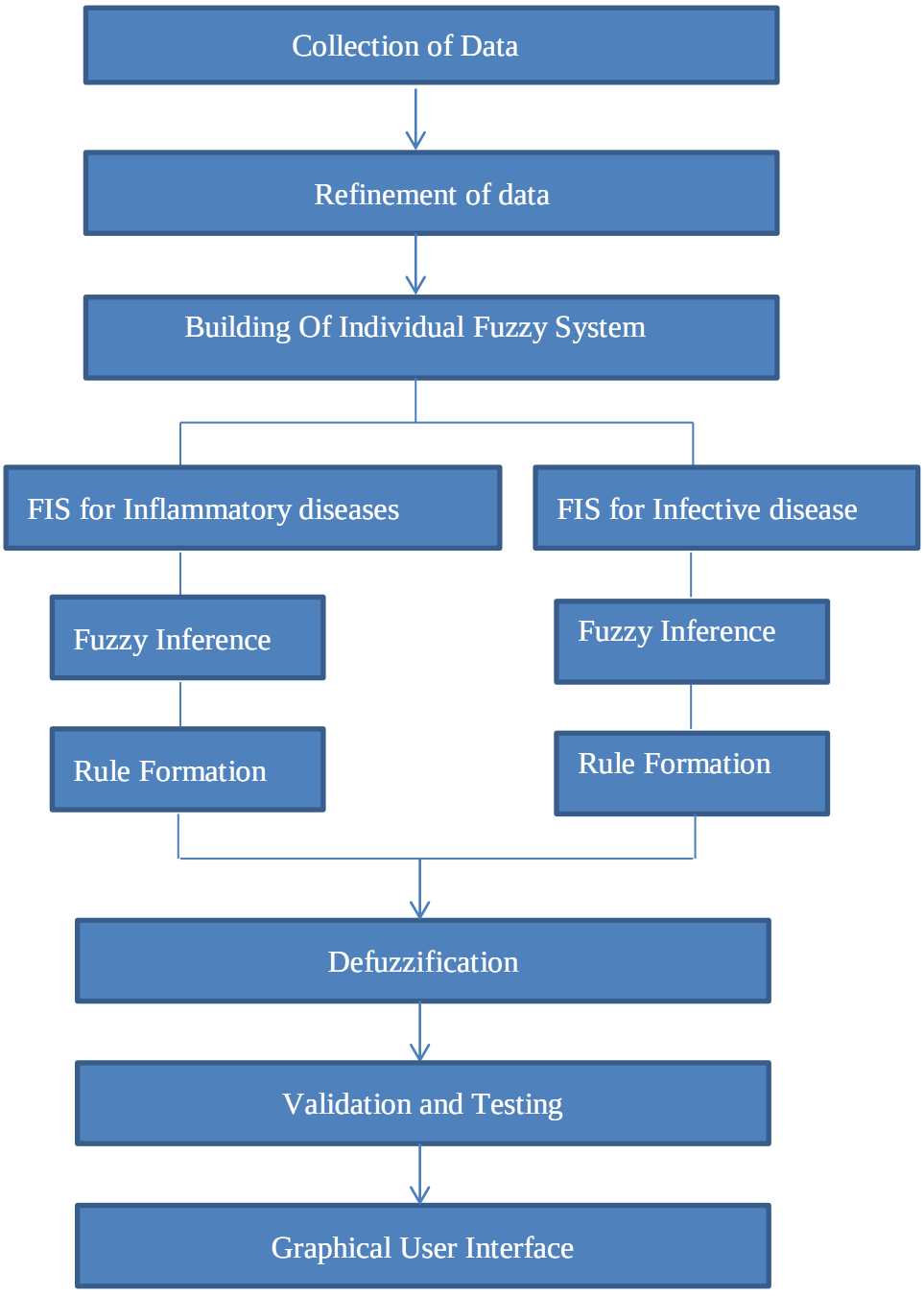

Diagram 5.2 Flow Chart for Proposed Work Plan

CHAPTER 6
EXPECTED OUTCOME AND RESULT

Graphical User Interface: All the symptoms of the category will be shown on the interface. It will provide friendly interface which can be understandable and easy to use. There will be one output shown which will tell about the disease and treatment.

Fuzzification: Crisp input will be mapped into membership function with the help of Mamdani Fuzzy Inference System for the diseases of knee joint.

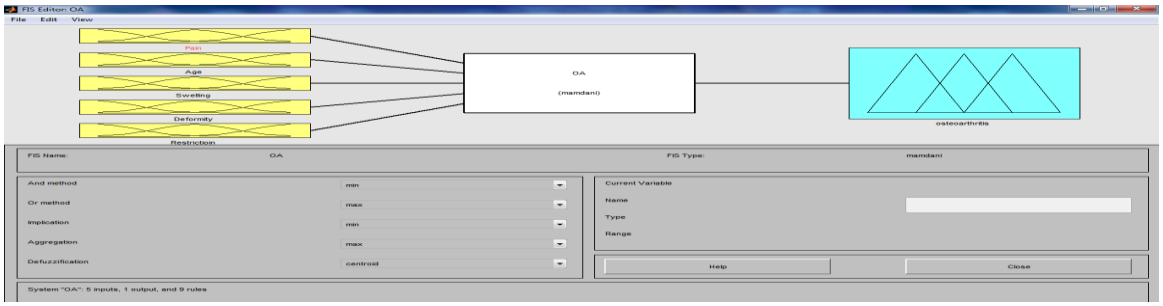

Figure 6.1 Osteoarthritis FIS

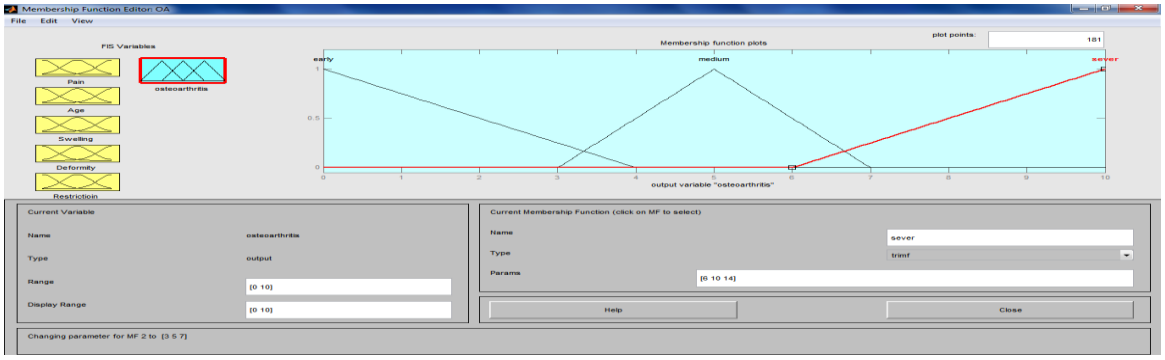

Figure 6.2 Fuzzy Membership of OA

Rules: By using fuzzy IF_THEN rules, all the rules for the respective diseases with the help of expert will made.

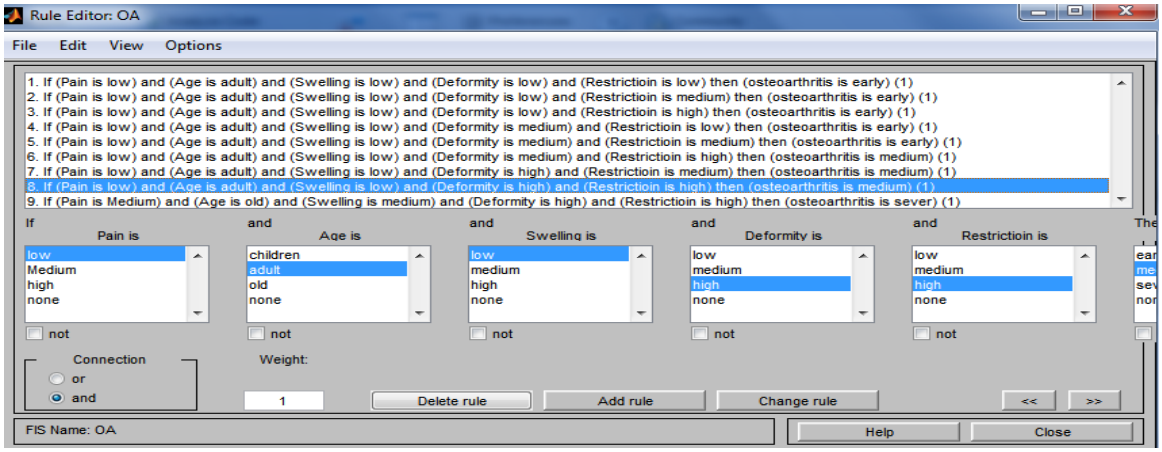

Figure 6.3 OA Fuzzy Rules

Surface Viewer: Rule viewer and Surface viewer will be used to check the plotted variables and corresponding results.

Result: The result will be shown with testing where the expert system outcome will match with the expected outcome given by the expert. Based on these values, the false positive and false negative will check.

Expert system for the orthopaedic diseases, will diagnosed the disease of two main category named inflammatory diseases and infective disease. The inflammatory diseases will be Osteoarthritis of the knee and Rheumatoid arthritis of the knee whereas for the infective, Septic disease will diagnose to check whether the diseases will Acute septic or Chronic septic based on some input symptoms.

CHAPTER 7

SUMMARY AND CONCLUSION

This report gives the problem “MEDICAL EXPERT SYSTEM FOR DIAGNOSIS OF ORTHOPAEDIC DISEASES” that will design a fuzzy expert system to diagnose the orthopaedic disease for the knee joint. The introduction of the Expert system and its various components which are User Interface, Knowlegde base and Fuzzy Inference sytem are define in the report. The major five steps are Input parameter, Fuzzification, Rule formation, Inference and Defuzzification. For the Inference, Mamdani fuzzy inference system is used and there are five methods of Defuzzification which are center of area, largest of maximum, minimum of maximum, bisector of area and mean of maximum. Matlab software will use to develop the expert system.

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