Recommender Diagnosis System with Fuzzy Logic in Cloud Environment

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***Abstract*—Recommendation systems are now used in a wide range in many fields. In the medical field, recommendation systems have a great stature to both doctors and patients for its accurate prediction. It can reduce the time and efforts spent by doctors and patients. The present work introduces a simple and effective methodology for medical recommendation system based on fuzzy logic. Fuzzy logic is an important method to be used based on fuzzy input data. The input data for each patient are not the same, on which recommendation can differ. This work aims to develop techniques for handling the patient data to urge accurate lifestyle recommendations to the patient. Fuzzy logic is utilized to form different recommendations for the patient like lifestyle recommendations, medicine recommendations, and sports recommendations based on different patient factors like age, gender and patient diseases. After evaluating the system its efficiency reached 94%. This Experiment is the final module in a four modules recommendation system. The first one is responsible for diagnosing chest diseases using ECG signals. The second one makes diagnosis using X-ray images. The third is utilizing the security of the whole system through encryption when sending user data over the cloud.**

***Index Terms*—Chest disease, fuzzy logic, lifestyle recommendation system, medical diagnostic systems, cloud.**

I. Introduction

Medical artificial intelligence is primarily concerned with the construction of AI programs that perform diagnosis and make therapy recommendations. Unlike medical applications based on pure statistical and probabilistic methods, medical AI programs are based on symbolic models of disease entities and their relationship to patient factors and clinical manifestations [26]. Medical expert systems contain medical knowledge that can come up with reasoned conclusions about patients and can give recommendations to them. Recommendation systems can be based on many methodologies like fuzzy logic. Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth – truth values between ”completely true” and ”completely false”. It was introduced by Zadeh in 1965 [27] to model the uncertainty of the natural language. In his paper a fuzzy expert system that uses a collection of fuzzy membership functions and rules is developed, instead of Boolean logic, to reason about data.

Several methods are available to automate the process of medical diagnosis [1]. These include classical programs that employ statistical and probabilistic methods [2], as well as knowledge-based systems that employ artificial intelligence techniques. Large groups at MIT and the New England Medical Center used an approach for diagnosis and treatment based on theories of probability and utility [3]. Their aim was to build systems that gave probably optimal medical recommendations [4] [5]. Rule-based expert systems [6] [7] gained much popularity in the medical field. Early in 1965, MYCIN was developed to diagnose blood infections [8]. With about 450 rules, it was able to perform as well as some experts. since then rule-based systems were used as digital therapy advisors [9]. Later, CASEY is a real-world application that used Case Based Reasoning (CBR) methodology to give diagnosis for heart disorders [10] [11]. In a recent work, Phan and Chen in [12] described the application of fuzzy logic to a healthcare diagnostic system in which a set of sensors monitors body temperature, blood pressure and heart rate. However, This research is interested in giving lifestyle recommendations without adding medical recommendations. Lifestyle recommendations shall be based on user age, gender and diseases.

In this research the proposed system should be able to give recommendations to patients for enhancing their lifestyle. It can also be suitable for more than one disease diagnosed with a small modification in the system inputs and rules. Using fuzzy logic in medical diagnosis is a promising technique [13] that can easily capture the required medical knowledge and come up with sound decisions. Practically, an expert physician tends usually to specify his experience in rather fuzzy terms [14], which is more natural to him than trying to cast his knowledge in rigid rules having abrupt premises [15]. Fuzzy logic is more suitable for human consideration rather than binary logic as a reasoning model. Fuzzy logic is the perfect choice in this research because it has a number of considerations for the inputs used to build the recommendation rules (which is much homogeneous with doctors thinking) rather than binary logic which uses rules in yes or no forms only.

Our contribution during this paper is to form a way of lifestyle recommendation system that may give recommendations to the patients. Mathematical logic is utilized to create lifestyle recommendations that help patients to urge some useful recommendations without visiting doctors eliminating delays and inconveniences. This paper proposes a patient lifestyle recommendation system. Recommendation systems are beneficial to both service providers and users. They reduce the doctor visit time. Lifestyle Recommendation systems also enhances the choice-making process and quality. Medical recommendation systems (MRS) make it easy to acquire medical advice with high accuracy without leaving home. This paper uses fuzzy logic to offer recommendations to patients.

The present work introduces a simple and effective methodology to develop fuzzy expert systems for medical diagnosis on the cloud system [16] [17]. The methodology is general and can be used in diagnosing a wide range of diseases. However, to illustrate the concept we consider in this paper a set of eight upper respiratory infections to develop a prototype computer program [18] that can infer proper diagnosis and provide decisions based on patient data [19] [20].

A set of features, F, are provided relevant to a set of considered diseases, D. The input case to be diagnosed is described by assigning a fuzzy value to each feature of the set F. Each disease of the set D is specified by its profile in the form of a fuzzy table obtained by consulting an expert physician. Fuzzy inference (which is a good choice in medical cases that are cases of uncertainty not like neural network that needs certain inputs or need prior probability like bayes rules) is applied to obtain a decision fuzzy set for each considered disease, and crisp decision values are obtained to state the certainty of presence for each disease. A computer program prototype is developed and used to diagnose several typical input case studies. The obtained results for all cases were promising.

The paper is structured as follows. Related work is introduced in section 2. Fuzzy medical diagnosis is discussed in section 3. Section 4 introduces the developed fuzzy logic methodology for medical diagnosis. Experimental results for a typical patient case are given in Section 5. Concluding remarks and suggestions for future work are provided in section 6.

II. Related Work

Fuzzy expert system was developed [21] in order to obtain information on the risk percentage for diabetes. The authors designed a Visual User Interface (GUI) to help medical professionals in obtaining diabetes patients risk percentage, whom are not acquainted with the principle of fuzzy logic, to understand and use this method. The outcome of the diagnosis can be known within a few seconds by using this proven fuzzy expert method and can thus save diagnosis time.

A first aid model was developed in [22] using fuzzy expert system for Differential Symptoms-Based Diagnosis. The authors applied Mamdani-Sugeno-type fuzzy logic. Three new algorithms were also implemented that are utilized to incorporate the Ailment Prediction (Forward Chaining Approach and Backward Chaining Approach) and Allergy Control mechanisms of Dr. Flynxz. The prediction is verified both by a comparison of the proposed FMI Ailments Prediction Algorithm with Ada 2.37.2 (a rule-based approach) and fuzzy logic. In terms of prediction precision, experimental findings suggest performance improvement. In the field of medical diagnosis and allergy management. The proposed algorithms will be useful in the development of fuzzy inference systems of the Mamdani-Sugeno type.

A fuzzy expert system (FES) was proposed in [23] to define the current stage of chronic kidney disease. With the help of clinical practice guidelines, database, and the expertise of a team of experts, the proposed fuzzy rule-based expert system is developed. Input variables such as functionality of nephron, blood sugar, diastolic blood pressure, systolic blood pressure, age, body mass index (BMI), and smoke are used. On various input parameters, +e normality checks are applied. As shown by the response of surface analysis, +e input variables, i.e. nephron functionality, blood sugar, and BMI have a greater effect on chronic kidney disease. The current stage of the patient's kidney disease is indicated by +e device production. In the research work, a total of 80 tests were performed on the FES produced, and the output generated was compared with the expected output. It is found that in 93.75% of the experiments, the system succeeds. The +e method assists physicians in treating chronic kidney disease in patients. The diagnosis of chronic kidney disease is a severe clinical issue that suffers from inaccuracies, and it is proposed to use the fuzzy inference method to solve this problem.

A fuzzy logic approach [24] was suggested by examining implicit user profiles to predict the different news categories that are interest for users. The viral news articles and their categories were calculated and analyzed by mining social media feeds-Facebook and Twitter-depending on user interest categories. In addition, new news articles were obtained from news feeds incorporated with retrieved viral news articles provided as a recommendation regarding the diversified interest of users. The efficiency of the proposed approach to predict the general interest of users for all categories reached 84.238 percent, and the accuracy of suggestions from news feeds, Facebook, and Twitter reached 100 percent, 90 percent, and 100 percent with respect to the categories of interest of users.

A triangular fuzzy rating model was [25] proposed with interval values. This model substitutes user rating statistics data. Ratings with interval-valued triangular fuzzy numbers can calculate the preferences of users in a more rational way. The collaborative filtering recommendation algorithm is built based on interval-valued fuzzy numbers based on this model. The algorithm measures the similarity of the users by the triangular fuzzy numbers valued by the interval and considers the uncertainty of ratings in the prediction stage. The experiments show that the algorithm used can increase the accuracy of prediction and rank accuracy efficiently with a less cost compared to other fuzzy and conventional algorithms, and has an obvious advantage when implemented in a sparse data set that has more users than objects.

III. Proposed Model

This model is divided into four phases as follows:

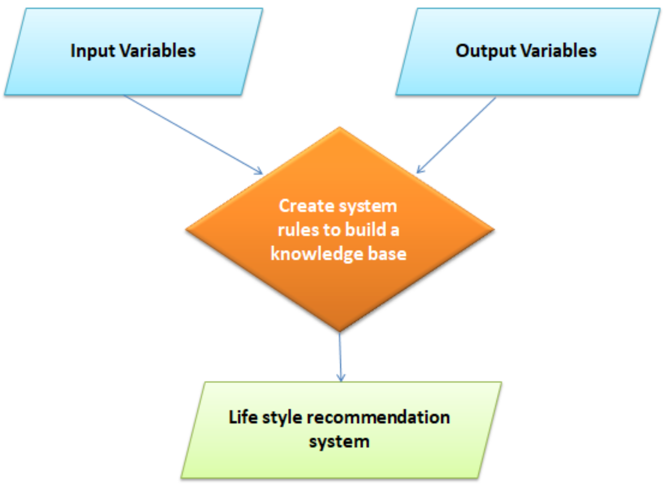

Fig. 1. The Proposed Model

- Phase one: Data set This Experiment is done over 590 patients as a data set for the fuzzy system. Those 590 patients are available with their clinical data and personal factors like age and gender.
- Phase two: take patient diagnosis from ECG and X-ray which uploaded on a cloud after doing needed encryption and other patient factors like age and gender as the input of the fuzzy inference system also add outputs factors.
- Phase three: make fuzzy inference system rules and input membership function to build a knowledge base based on the system inputs and outputs.
- Phase four: After adding rules, system can now give life style recommendations based on these rules “Fig. 1’.

IV. Fuzzy Medical Diagnosis

Leung, Lau and Kwong [28] described a general structure of a fuzzy system to be used as the core part of a fuzzy application. The structure can be summarized in the following four steps, carried out in order: Fuzzification: the membership functions defined on the input variables are applied to their actual values, to determine the degree of truth for each rule premise. Inference: the truth value for the premise of each rule is computed and applied to the conclusion part of each rule. This result in one fuzzy subset to be assigned to each output variable for each rule. Composition: all of the fuzzy subsets assigned to each output variable are combined together to form a single fuzzy subset for each output variable. Defuzzification: is an optional step which is used when it is useful to convert the fuzzy output set to a crisp number. Many defuzzification methods are available [29], however two of the more common techniques are the CENTROID (center of area) and the MAXIMUM methods. In the CENTROID method, the crisp value of the output variable is computed by finding the variable value of the center of gravity of the membership function for the fuzzy value. In the MAXIMUM method, one of the variable values at which the fuzzy subset has its maximum truth value is chosen as the crisp value for the output variable. The developed fuzzy expert system prototype would query the user data for the relevant patient symptoms. The strength of each single symptom is specified by a fuzzy value such as low, moderate, and high for those symptoms that cannot be measured quantitatively. Other measurable symptoms such as the temperature or blood sugar for instance would be input directly as numeric values that would be properly fuzzified. The prototype proceeds through the above-mentioned inference process and provides a percent value for the certainty of presence for each one of the considered eight diseases.

A. Fuzzy logic in recommendation system

The employment of symbolic logic has been studied in various areas, not limited to engineering science, like automatic group recommendations, knowledge-based recommendations, software project management, and E-Learning. There are mainly some functional blocks as shown in Fig. 1. Fuzzification interface unit converts the input variables in numerical forms into linguistic variables. A knowledge base which consists of rule base and membership functions. Defuzzification interface unit converts the fuzzy quantities into crisp quantities. To construct a Fuzzy Inference System (FIS) which is the system that is fed by input variables and output variables. Membership functions are cited for each input variable. Based on that membership functions some rules are determined to generate an effective recommendation system), first linguistic variables and terms need to be defined. Then for each linguistic variable, a membership function will be described. The construction of fuzzy rules can be utilized using the construction of membership functions. Predefined facts about the world and expert’s knowledge are saved in the database. Then fuzzification takes place, means crisp input will be converted into fuzzy data sets using membership functions. Then fuzzy inference system will perform a decision-making task. It evaluates the rules in the rule base and combines results from each rule. The last step is de-fuzzification where output data is converted into non-fuzzy values.

V. Expeiment

As shown in “Fig. 2”, fuzzy logic inference system has some steps that need to be done to get the expert system. Our fuzzy system has the following functional blocks:

1) The crisp input numbers are transformed to fuzzy set by Fuzzification Module.

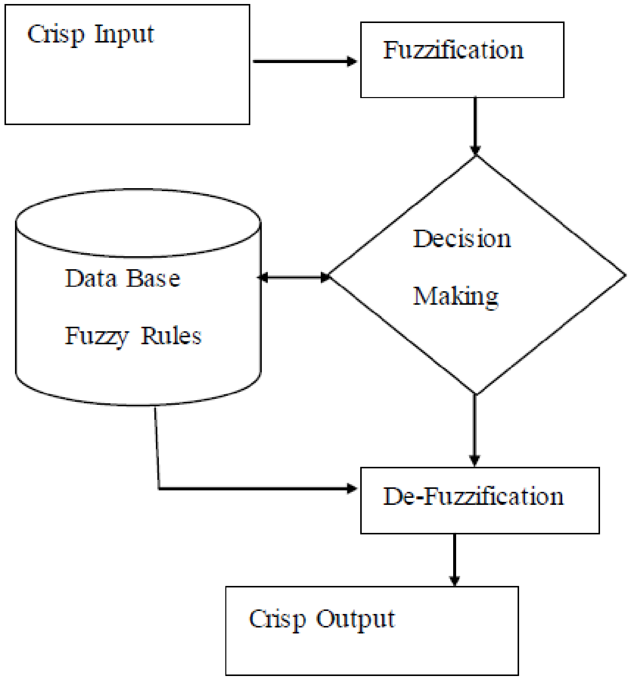

Fig. 2. The Functional Blocks of Fuzzy Inference System (FIS)[29]

2) The IF-THEN rules in the fuzzy logic provided by the developers are stored in the Knowledge Base.
3) The inference engine infer the input rules - based on human reasoning.
4) The de-fuzzification module is to transform the fuzzy set to crisp value [30].

In the implementation part of this paper, fuzzy logic control will be used based on a Mamdani fuzzy logic inference system which is Well-suited to human input. It is well-suited to expert system applications where the rules are created from human expert knowledge, such as medical diagnostics.Mamdani fuzzy logic uses MIMO (Multiple Input and Multiple Output) systems which is suitable in our medical recommend -er system However, below is the meaning of fuzzy relations and their inputs and outputs. The inputs: disease (D), patient gender (G) and patient age (A) The outputs: sports system (S), food system (F) and medicine system (M)

"Fig. 3",shows FIS editor structure of the system. There are 3 inputs and 3 outputs. The 3 inputs are: age, Gender, and Disease. The 3 outputs are: Food system (F), Medicine system (M), and Sports system (S)

"Fig. 4",shows the membership function for each input variable for the fuzzy system. The first input variable is Age; the trimf [30] (Triangular membership functions are represented as inputs to the networks by the three intersection points of the triangle and that is suitable in our case and means three degrees of every input parameter) is utilized as a membership [31] [32] [33] function for this variable. There are different membership degrees according to four different ranges [34] [35] that are used for the primary input variable

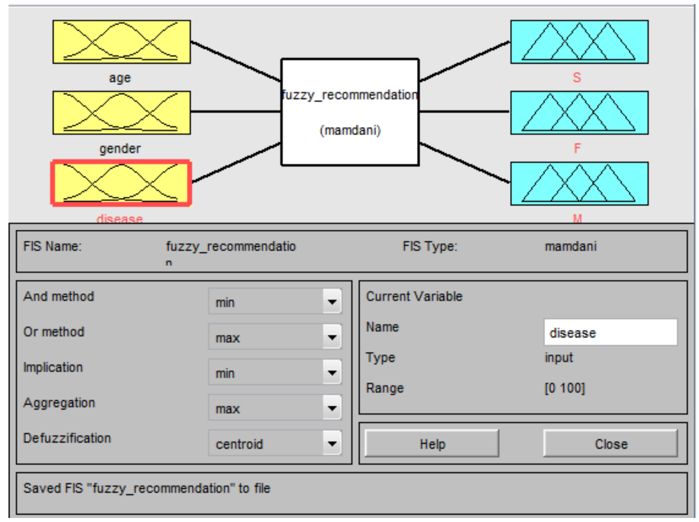

Fig. 3. fuzzy relation for inputs and outputs

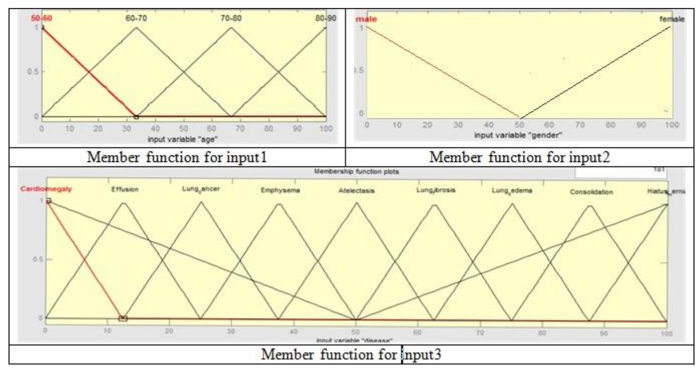

Fig. 4. Member function for inputs

which are:

1) 50-60
2) 60-70
3) 70-80
4) 80-90

The second input variable is gender (which is a binary variable that is take zero or one and is very important in giving special recommendations)); the type of membership function used is trimf. Also, we can use any number of membership degrees for the membership function of a variable. There are two membership degrees have been used for the second input variable according to gender types which are:

1) Male
2) Female

For the third input variable, disease, in this work the type of membership function is trimf. Any number of membership degrees is utilized for the membership function of a variable. There are 10 membership degrees have been used for the third input variable values and these values are:

1) Cardiomegaly
2) Herna

3) Effusion
4) Emphysema
5) Atelectasis
6) Emphysema-pneumothorax
7) Pleural—thickening
8) Fibrosis
9) Edema
10) Consolidation

Each input after added to the FIS it gives some fuzzy ranges for each disease which illustrate the severity of the disease. It is as follows which established according to the linguistic input variables as follows: The fuzzy inputs are (1) disease, (2) age, and (3) gender. the linguistic variables of the disease are defined as ‘low’, ‘medium, ‘high, matching the ranges parameters of -12.5 0 12.5 for the first disease (Cardiomegaly), 0, 12.5, 25 for Effusion,12.5 25 37.5 for lung cancer, 25 37.5 50 for Emphysema, 37.5 50 62.5 for Atelectasis, 50 62.5 75 for Lung_fibrosis, 62.5 75 87.5 for Lung_oedema, 75 87.5 100 for Consolidation, and 87.5 100 112.5 for Hiatus_Hernia. The membership value is also confined to the closed range of [0,100]. For the age input the ranges parameters will be -33.33 0 33.33 for the first category (50-60) years, 0 33.33 66.67 for the second category (60-70) years, 33.33 66.67 100 for the third category (70-80) years and 66.67 100 133.3 for the last category (80-90) years. The membership value is also confined to the closed range of [0,100]. Also, for the gender input the ranges parameters will be -100 0 100 for male and 0 100 200 for female. The membership value is also confined to the closed range of [0,1].

VI. Results

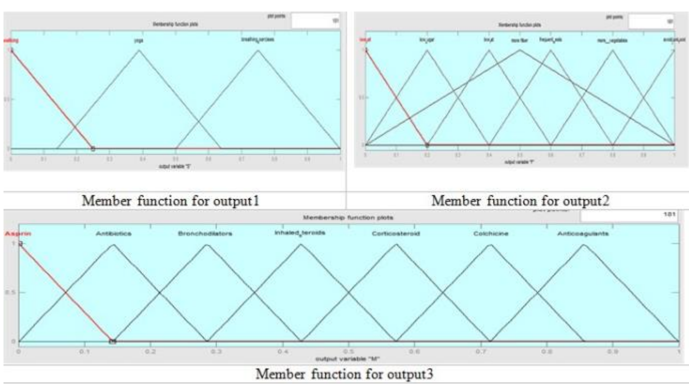

Fig. 5. Member function for outputs

“Fig. 5”,illustrates the first output variable which is sports. The type of membership function used is triMF (Triangle-Shaped Membership Function). There are 3 membership degrees have been used for the first output values. The values of the first output are:

1) Walking slowly
2) Yoga
3) Breath exercises

For the second output variable (food system) the type of membership function utilized is triMF. There are 7 membership degrees have been used for this output values and that values are:

1) low salt
2) Low sugar
3) Low fat
4) Frequent meals
5) More vegetable
6) Avoid junk food
7) More fiber

For the third output variable (medicine system) the type of membership function used is triMF. There are 7 membership degrees have been used for the third variable values and that values are:

1) Asprin
2) Antibiotics
3) diuretic
4) Inhaled steroid
5) Corticosteroid
6) Colchicine
7) Anticoagulants

Some fuzzy rules (revised by a medical expert) of the FIS system (350 rule) are developed to be used in the recommedation system (Mamdani model using Max-Min Inference Method)as follows:

1) IF Gender= Male & Age between 50-60 & Disease = Cardiomegaly THEN sports recommendations is Walk and medical recommendation is diuretic and food recommendation is low salt

2) IF Gender= Male & Age between 70-80 & Disease = Emphysema THEN sports recommendations is breath exercises and medical recommendation is antibiotics and food recommendation is frequent meals

3) IF Gender= Male & Age between 80-90 & Disease = Effusion THEN sports recommendations is Walk and medical recommendation is diuretic and food recommendation is low salt.

different rules and different recommendations for each rule condition. In rule number 1 when the gender is male, age between 50 to 60 and the patient disease is cardiomegaly so some sports recommendation like walking, medical recommendation like Aspirin and food recommendation like low salt are the output of the fuzzy also for other rules in the table there is a different recommendation for each rule.

A. Making recommendations with fuzzy logic

Some rules are generated by the control unit which contains the data base and the membership functions of the input variables.

“Fig. 6”, shows the different rules of the fuzzy logic system. The first rule mentions that when the age is between 50 to 60 years, gender is male and the disease is cardiomegaly with some membership function the food advice will be low fat,

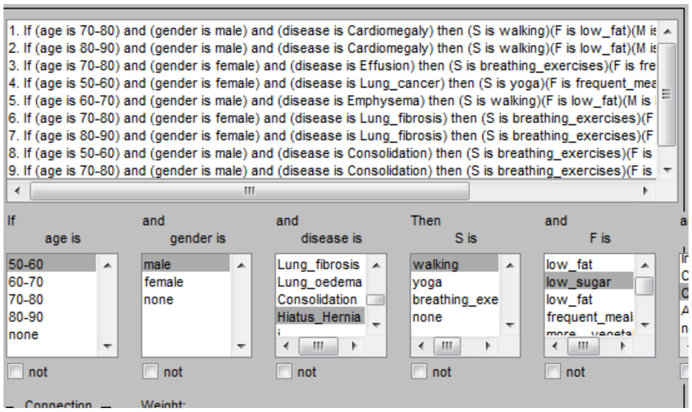

Fig. 6. Fuzzy logic rules editor

sports advice will be walking, and medical advice will be taking Aspirin.

The efficiency of the proposed system to predict the out recommendation for all categories reached 94

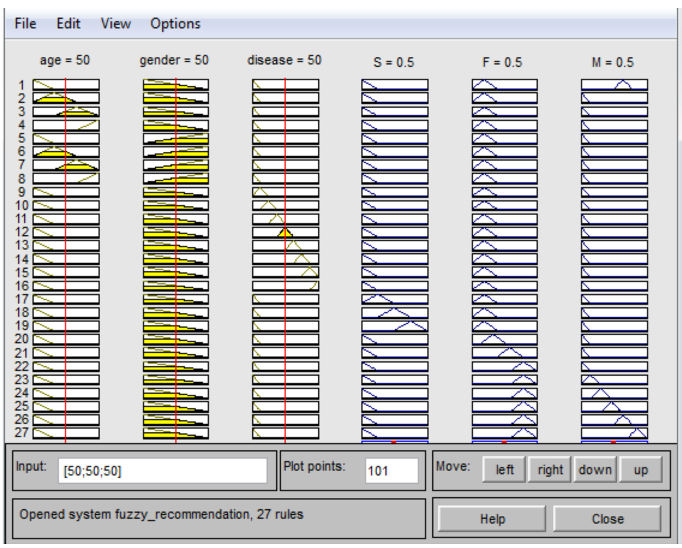

Fig. 7. Rule viewer

A roadmap of the whole fuzzy inference process is described in "Fig. 7", Each of the characterizations of each of the variables is specified with respect to the input index line. It shows that the rule viewer consists of the inference mechanism and the value of defuzzification.

Conclusion

Chest diseases such as Effusion and Emphysema are very common in the whole world. Most cases must have lifestyle programs to improve their health. Most cases also have other diseases which have to be treated also using medicine, food and sport system to enhance their life style. This paper introduces fuzzy logic inference system which is an excellent choice for making recommendations in such overlapping rules. This system can give the user good recommendations according to his symptoms and the membership function for each symptom. It can be applied in the remote places where no doctor is available for the analysis. The medical recommendation system can make the result of recommendations scheme more reasonable. It is user friendly and most importantly can be utilized by users to obtain self-notified without a doctor assistant.

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