Fuzzy based Automated System for Predicting Viral Infections (Chicken Pox, Swine Flu and Dengue)

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Abstract: Health protection is the improvement of health via the diagnosis, treatment and prevention of disease, illness, injury, and other mental impairments in human beings. This system is based on Fuzzy Logic, adopting Mamdani model as the fuzzy inference mechanism and list of medical diseases. With diseases like swine flu and dengue fever, chicken pox, on the rise, which have symptoms, are so closely associated that it sometimes become practically Herculean task to differentiate between the above-scribed diseases based on symptoms. Thus, it becomes inevitable to design such a system that would closely monitor the symptoms and infer the disease based on fuzzy inference system. This work is done by assigning different coefficients to each symptom of a disease and to predict and quantify the severity impact of the recognized disease. For predicting, the cure time of a disease, based on the symptoms. Perdition of cure time is clinically based on hypothetic studies and to estimate the cure time of a disease based on the symptoms. This system is inferring the current medical condition of a user relative to people who have suffered from the same disease.

Key Words: Medical, MATLAB Tool, Fuzzy Logic, Fuzzy inference model, Mamdani Model, GUI, Fuzzification, De-fuzzification.

1. INTRODUCTION:

Fuzzy logic was advanced in 1965 by Dr. Lotfi Zadeh a professor at the University of California, Berkley. One kind of uncertainty is fuzziness that is no sharp transition from complete membership to non-membership. In human reasoning much of the logic is not based on two values, it is not even multi-valued but fuzzy truth. In conventional logic everything is considered true or false, black or white but nothing in between.

The Fuzzy logic idea is similar to the human being's feeling and inference process which is a point-to-point control or range-to-range control. The output of a fuzzy controller is borrowed from fuzzifications of both inputs and outputs using the identify membership functions. A crisp input will be transformed to the different members of the identity membership functions established on its value. From this point of view, the output of a fuzzy logic controller is established on its memberships, which can be tested as a range of inputs.

The idea of fuzzy logic was advanced by Dr. Lotfi Zadeh of the University of California at Berkeley in 1965. This development was not well recognized until Dr. E. H. Mastrategymdani who is a professor at London University, related the fuzzy logic in an applied application to control an automatic steam engine in, which is approximately ten years after the fuzzy theory was created. To control cement kilns in 1976, Blue Circle Cement and SIRA in Denmark established an industrial application. That system began to operation in 1982. Fuzzier implementations have been since the 1980s, along with those utilizations in industrial manufacturing, automobile production, banks, hospitals and academic education. The main aim is to construct a control system that will provide good transient and steady state reply of the system. Fuzzy logic develops into a standard technology and is also applied in data and sensor signal analysis. Fuzzy logic has verified to be a powerful tool for decision-making systems, such as expert systems and pattern classification systems. Dr. Zadeh was working on the difficulty of computer understanding of natural language.

Formation of the fuzzy knowledge base in MATLAB can be done using a tool Fuzzy Logic Toolbox [2]. The Toolbox is a suite of software applications that make up the environment Matlab. It allows you to create fuzzy inference system and fuzzy classification in the environmental MATLAB, i.e., functionally driven to the formation of versatile classification for data systems. The base element in the Collection is the FIS-structure, i.e. the Fuzzy Inference System. FIS-structure contains the necessary functional blocks for implementation of fuzzy inference. A fuzzy expert system is an expert system that uses fuzzy logic instead of conventional binary logic. It uses a collection of fuzzy membership functions and rules to facilitate reasoning. Since it uses rules, it falls into the category of rule-based expert systems. The Medical Diagnosis System takes input in the form of symptoms and gives output in the form of a particular disease. The fuzzy rules used in the system are based on expert knowledge.

2. BACKGROUND AND RELATED WORKS:

Schuh C. et al. proposed for increasing the efficiency and reliability of health care delivery that holds great promise in fuzzy logic which is still a largely untapped area in medicine. For encapsulating the subjective decision-

making process Fuzzy logic provides an algorithm which is suitable for computer implementation [4].

Imran M. et al. proposed that the designed system can be extended to any number of inputs. On the inputs like protein, red blood cell, lymphocytes, neutrophils and eosinophils on which the normal, hemorrhage and the brain tumor are depended. As the inputs are the blood cells and the designed system use five blood cells as inputs, similarly more than five inputs may be defined to get more efficient human diagnose results. The design work is being carried out to design the art fuzzy logic medical diagnosis control system in future using FPGAs [10].

Kumar M. et al. developed following membership functions, input variables, output variables and rule base that are used in a fuzzy expert system to diagnose the heart disease. There are six input variables and output variables. With expert-doctor, the designed system has been tested. A person with any heart disease risk or not is also checked out in this system. For the diagnosis of heart diseases analysis, this is one of the simple and more efficient methods [17].

Mfon M. et al. developed a proposed fuzzy framework for cholera diagnosis and monitoring. The designed system can be increased to any number of inputs. The following membership functions like No cholera, mild cholera, moderate cholera and severe cholera all depend on the inputs diarrhea, vomiting and dehydration. We can define this system for any number of inputs. To achieve more efficient human diagnose and monitoring result, the system can be defined with more than three inputs [22].

Baruah N. et al. described the designed expert system has been tested with some set of values of patient's vital signs. This system describes a design of a fuzzy expert system for determination of the risk level of the patient, which can be used in any situation when it is necessary to predict the health status of the patient [33].

Shankar M. et al. mentioned the predicting diseases and their respective cure time based on the symptoms. The main focus was on the classification of symptoms based on their severity and importance and using this knowledge to calculate a numerical value to identify diseases. Although the method was tested in a limited environment with high accuracy, it can be extended to larger settings. Apart from this, we also estimated the cure time of a disease based on the experiences of other patients. We also provide a severity rating for the current condition, relative to the other users with similar symptoms [35].

Supriya R. et al. illustrates the use of fuzzy verdict mechanism in Fuzzy Logic based Diabetes Diagnosis System (FLDDS) which is used for the diagnosis of diabetes. Initially experimental datasets are processed into crisp values and then the crisp values are converted into fuzzy values in the fuzzification stage. Then fuzzy verdict mechanism executes the rules to make the decision on possibility of whether an individual is suffering from diabetes or not and provides the description of result. This research proves the importance of urine parameter for the diabetes diagnosis and shows the accuracy of the mechanism is improved after taking this parameter into the consideration [31].

Sharanjit S. et al. proposed paper analysis of dengue is considered. It is a deadly disease and precautions and cure is necessary. The proposed paper automatically detects the disease through the parameters inputted by user. This technique is useful in the area of health care. Because of shortage of time people have no time to go for regular checkups and they avoid the symptoms of the diseases from they are suffered. In our proposed paper we are designing a recommender system which shows about the dengue by matching out the parameters provided by the user. If the input given by the user matched with the parameters of the system then on single go we can easily detect the dengue [36].

3. PROPOSED METHODOLOGY:

- The theoretical framework of a decision making (if-then) system for defining the proper design of object-oriented software.
- The basic concept of fuzzy logic.

3.1 Theoretical framework

Online primary medical aid symptoms evaluation implies pointing out of those symptoms that are relevant for the analysis of disease and then infer from the database/rule-base the possible disease.

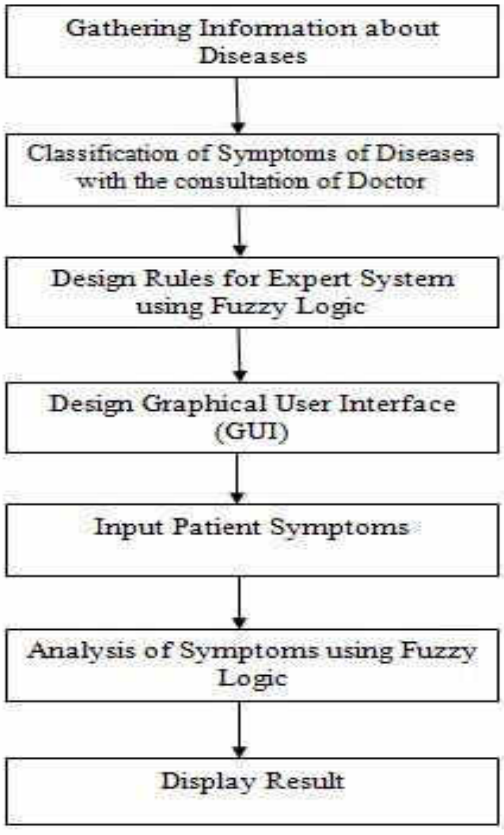

Fig -1: Theoretical framework of Design System.

3.2 Fuzzy logic

The term Fuzzy logic is a method to calculate a solution based on "degree of truth". The concept was advanced by Dr. Lotfi Zadeh of the University of California at Berkeley in the 1960s. Dr. Zadeh was going through the concept of computer understanding natural language, which is not obviously translated into the discrete terms of 0 and 1 [3]. Fuzzy logic consists of 0 and 1 as horizons of truth (or "the state of matters"), it also contains the various states of truth in between, for example, the result of identification between two things could be not "tall" or "short" instead it is.

A fuzzy expert system is an expert system that uses fuzzy logic instead of conventional logic. It uses a collection of

fuzzy membership functions and rules to facilitate reasoning. Since it uses rules, it falls into the category of rule-based expert systems. Rules can easily demonstrate human thinking as they are easily formulated. Fuzzy expert systems are used to provide non experts with some expert's skills. According to fuzzy expert systems are categorized into two types. First are fuzzy control systems. Which accepts inputs as numbers? The input number is then translated into a linguistic term. The antecedent consists of tests need to be made on the data. A fuzzy expert system is an expert system that uses fuzzy logic instead of conventional binary logic. It uses a collection of fuzzy membership functions and rules to facilitate reasoning. Since it uses rules, it falls into the category of rule-based expert systems. Fig 1.6 is represents the fuzzy expert system architecture.

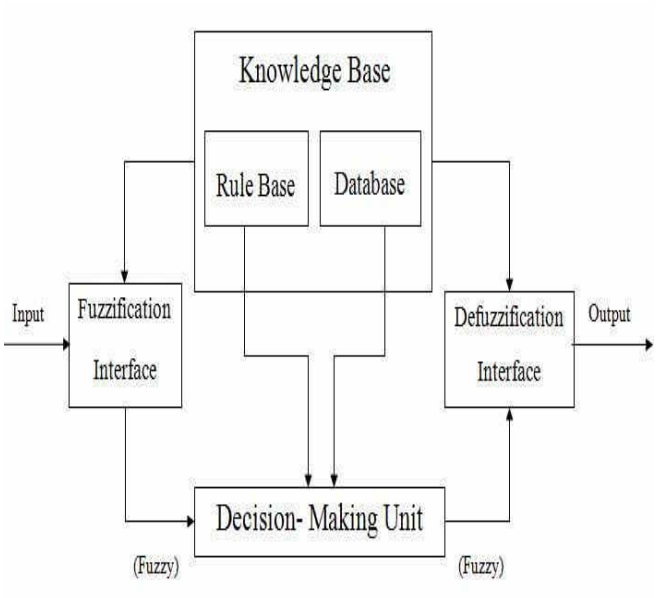

Fig -2: Fuzzy Expert System Architecture.

3.3 Fuzzification Process

According to fuzzifying have two meanings. The first is the process finding the fuzzy value of a crisp one. The second is finding the grade of membership of a linguistic value of a linguistic variable corresponding to a fuzzy or scalar input. The most used meaning is the second. Fuzzification is done by membership functions.

3.4 Inference Process

The next step is the inference process which involves deriving conclusions from existing data. The inference process defines a mapping from input fuzzy sets into output fuzzy sets. It determines the degree to which the antecedent is satisfied for each rule. These results in one fuzzy set assigned to each output variable for each rule

3.5 Defuzzification Process

Defuzzification is the process of converting fuzzy output sets to crisp values. According to there are three defuzzification methods used: Centroid, Average Maximum and Weighted Average. Centroid method of defuzzification is the most commonly used method. The most common defuzzification methods are center of area and maxima methods:-

3.6 Center of Area/Gravity

It is one of the most commonly used defuzzification techniques. This method determines the centre of the area of the combined membership functions calculated the centroid or centre of gravity (COG).This method (also referred to as the center-of-gravity or centroid method) is the most popular defuzzification technique.

3.7 Maxima Methods

COG is a defuzzification method regarding the area under the membership function. Maxima methods consider values with maximum membership. There are different maxima methods with different conflict resolution strategies for multiple maxima, e.g., first of maxima (FOM), last of maxima LOM), mean of maxima (MOM), and centre of maxima (median).

3.8 Assigning weights

Weighting factors are estimated values indicating the relative impact of each item in a group as compared to the other items in the group. Work priorities are established with the purpose of assigning weighting factors. The simplest way is to consider a standard fixed weight to your data set according to the specified criteria. Each individual response can then be compared to this standardized weight.

ASSIGNING: A

Low=3

Med=2

High=1

$$O[W] = \frac{Values[symptom1 + symptom2 + \cdots + symptom\ 6]}{6} \quad (1)$$

The equation (1) is used for adding up all the values of "6" inputs of symptoms and then divide the sum by "6" to get the average value. The structure of a fuzzy rule can be

divided into two parts: an if-part (also referred to as the antecedent part) and a then-part (also referred to as the consequent part)

IF<antecedent>THEN<consequent> (2)

In this equation (2) is using for antecedent describes a condition whereas consequent describes a conclusion. Fuzziness helps to evaluate the rules, but the final output of the fuzzy system has to be a crisp number. De-fuzzification is used to convert the fuzzy set value into a crisp set output. The principle of this system has two major components which are symptoms as input and the output as a disease.

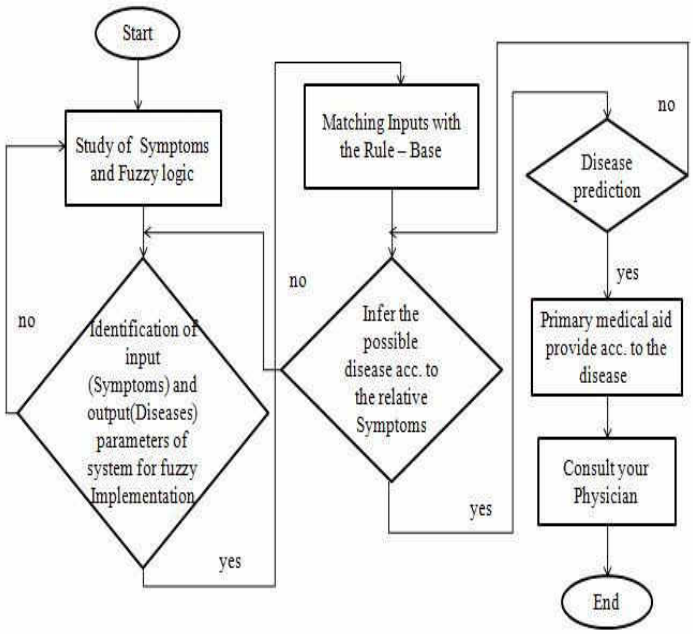

Fig -3: Methodology for disease prediction using Fuzzy Control System.

4. FUZZY DIAGNOSIS SYSTEM:

4.1 Fuzzy Interface System

To design a Fuzzy Diagnosis System, Fuzzy Inference System (FIS) Toolbox in MATLAB is a very powerful Graphical User Interface (GUI). The FIS Editor displays instruction about a fuzzy inference system. There's a simple diagram at the down that shows the names of each inputs on the left and those of each outputs on the right. However, the number of inputs may be limited by the available memory of your machine.

4.2 Input Variables

For designing the expert system six input variables i.e. temperature, cough cold, rashes, vomiting, loss of appetite and body aches are used. These inputs are called vital signs and use to predict the health status of person. After choosing the input variables the next step is to fuzzify the variables i.e. we have to determine the fuzzy sets for each input variable and the corresponding range of the belonging to each fuzzy set.

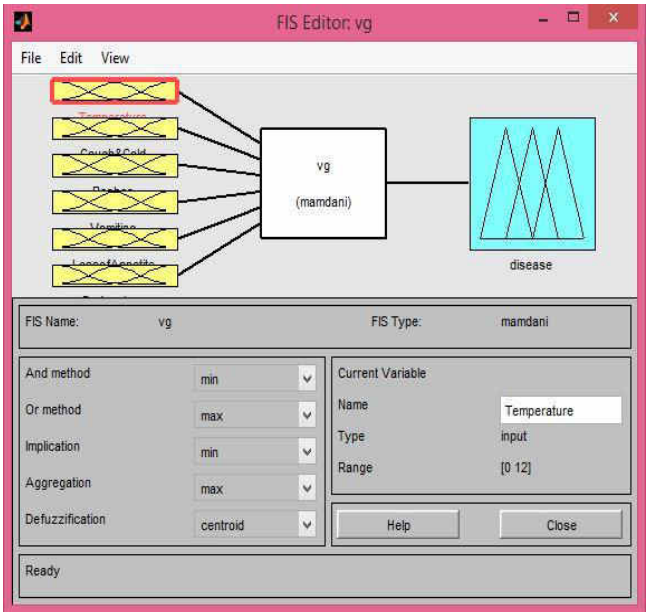

Fig -4: Mamdani FIS editor with 6 inputs & 1 output.

4.3 Membership Function Editor

Shapes of all the membership functions associated with each variable. The sample membership functions shown in the boxes are just icons and do not depict the actual shapes of the membership functions.

The Membership Function Editor is the tool that lets you display and edits all of the membership functions for the integrated fuzzy inference system, including both input and output variables.

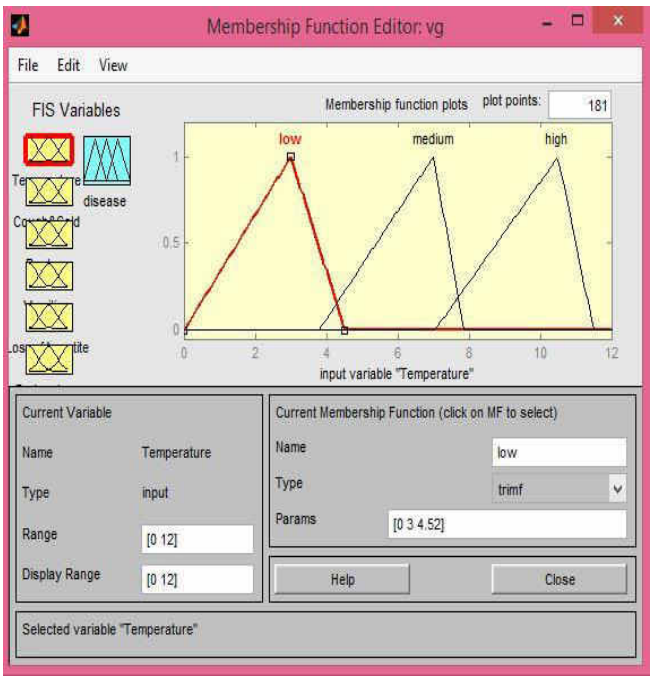

Fig -5: Membership function plots for Temperature.

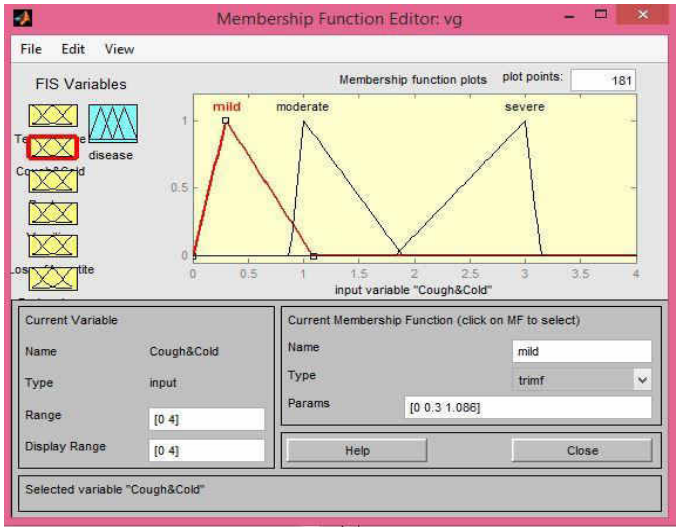

Fig -6: Membership function plots for Cough & Cold.

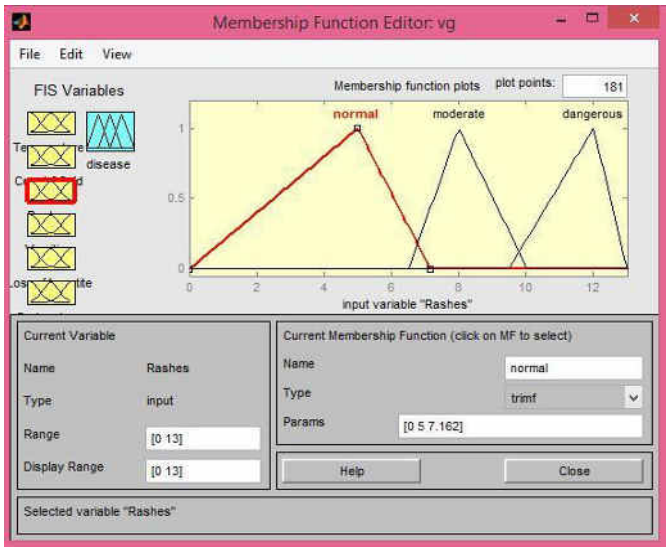

Fig -7: Membership function plots for Rashes.

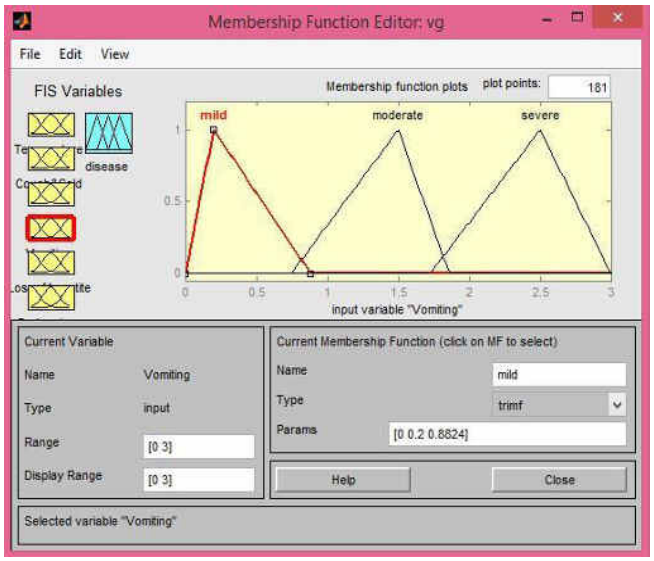

Fig -8: Membership function plots for Vomiting.

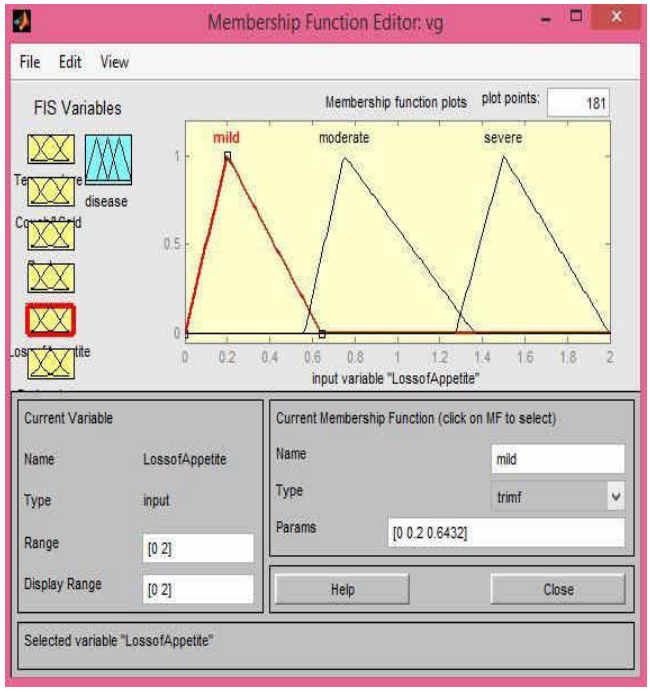

Fig -9: Membership function plots for Loss of Appetite.

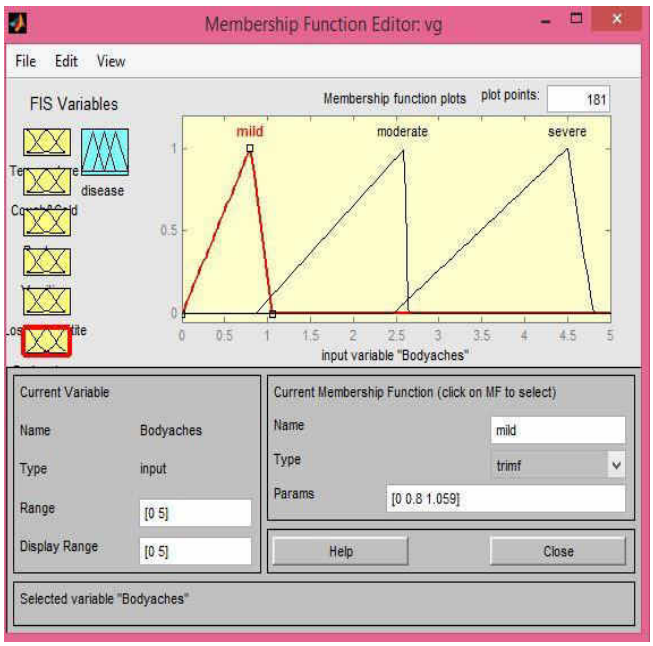

Fig -10: Membership function plots for Body aches.

It is the process of the unification of the rules. The membership functions of all the rule consequents previously clipped during rule evaluation are taken and combined into a single fuzzy set. The process a number of clipped consequent membership functions are changed into one fuzzy set for each output variable. The inference methodology used is the Mamdani inference method.

Input variable	Membership function	Parameters
Temperature	Low	[0 3 4.52]
	Medium	[3.79 7 7.86]
	High	[7.64 10.5 11.5]
Cough & Cold	Mild	[0 0.3 1.086]
	Moderate	[0.872 1 1.896]
	Severe	[1.82 3 3.14]
Rashes	Normal	[0 5 7.162]
	Moderate	[6.5 8 10.04]
	Dangerous	[9.486 12 13]
Vomiting	Mild	[0 0.2 0.8824]
	Moderate	[0.7459 1.5 1.86]
	Severe	[1.724 2.5 3]
Loss of Appetite	Mild	[0 0.2 0.6432]
	Moderate	[0.5607 0.75 1.364]
	Severe	[1.273 1.5 2]
Body aches	Mild	[0 0.8 1.059]
	Moderate	[0.8586 2.6 2.64]
	Severe	[2.462 4.5 4.8]

Table - 1: Membership function parameters for the input variables.

4.4 Rule Editor

Rule Editor is for editing the list of rules that defines the behavior of the system. The Rule Editor consists of a large editable text field for displaying and editing rules. Rule Editor is also has some familiar landmarks similar to those in the FIS (fuzzy inference system) Editor and Membership Function Editor, including the menu bar and the status line.

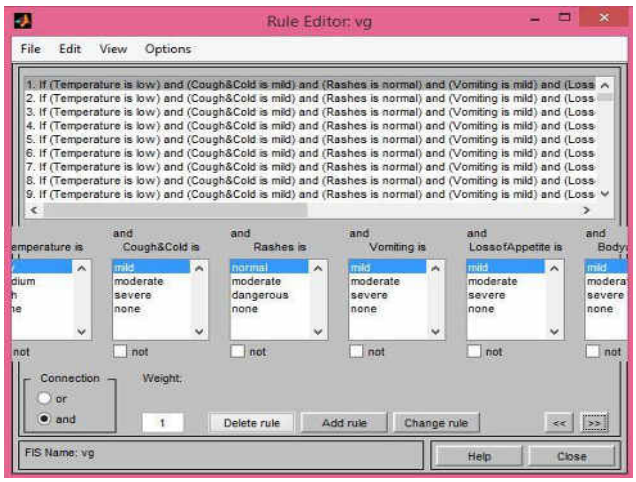

Fig - 11: Fuzzy Inference System Rules.

Rule No.	Temperature	Cough & Cold	Rashes	Vomiting	Loss of Appetite	Body aches	Severity of Disease	Disease
1	Low	Mild	Normal	Mild	Mild	Mild	Mild	Swine Flu
2	Medium	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Swine Flu
3	High	Mild	Dangerous	Moderate	Severe	Severe	Severe	Chicken Pox
4	High	Moderate	Dangerous	Mild	Moderate	Mild	Moderate	Chicken Pox
5	High	Severe	Moderate	Severe	Severe	Severe	Severe	Dengue Fever
6	Medium	Mild	Normal	Severe	Mild	Mild	Mild	Swine Flu
7	High	Severe	Dangerous	Mild	Severe	Severe	Severe	Dengue Fever
8	High	Severe	Dangerous	Severe	Moderate	Mild	Severe	Chicken Pox

Table - 2: Sample of Fuzzy Rules.

4.5 Fuzzification and Defuzzification

Fuzzification is the first step in the design of any fuzzy expert system. It is the process of mapping a crisp value of an input to membership degrees in different Fuzzy Linguistic variables. Defuzzification is the inverse process of fuzzification. It is the process of combining fuzzy output of all the rules to give one crisp value. Thus crisp value output is given by the defuzzification process after estimating its input value.

4.6 Rule Viewer of some fields as follow:

Rule Viewer to view the fuzzy inference diagram. Use this viewer as a diagnostic to see for example, the individual membership function shapes significance the results. The Rule Viewer displays the instructions of the whole fuzzy inference process. In addition, there are the now intimate items like the status line and the menu bar. In the lower right, there is a text field where you can enter a specific input value.

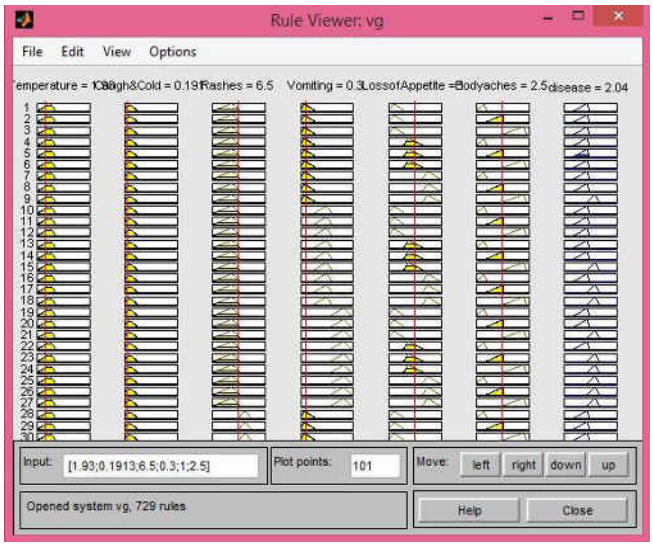

Fig -12: Rule Viewer showing a simulation result of the designed system.

4.7 Surface Viewer of some fields as follow:

Surface Viewer to view the dependency of one of the outputs on any one or two of the inputs-that is, it generates and plots an output surface map for the FIS (fuzzy inference system). It generates a 3-d surface from two input variables and one output variable of a FIS.

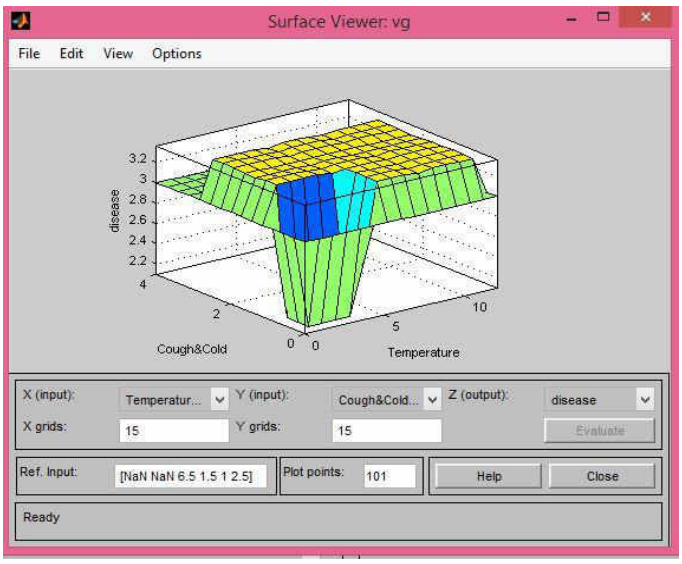

Fig - 13: Surface Viewer of Cough & Cold and Temperature.

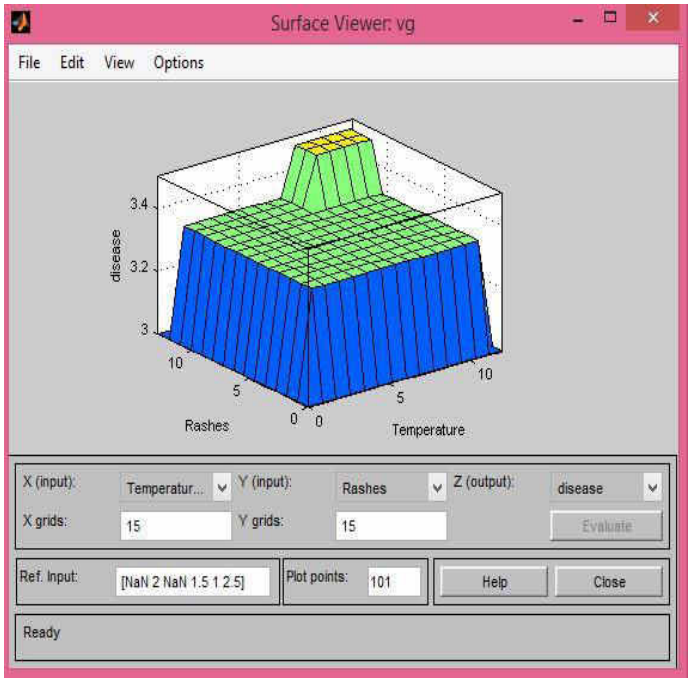

Fig - 14: Surface Viewer of Rashes and Temperature.

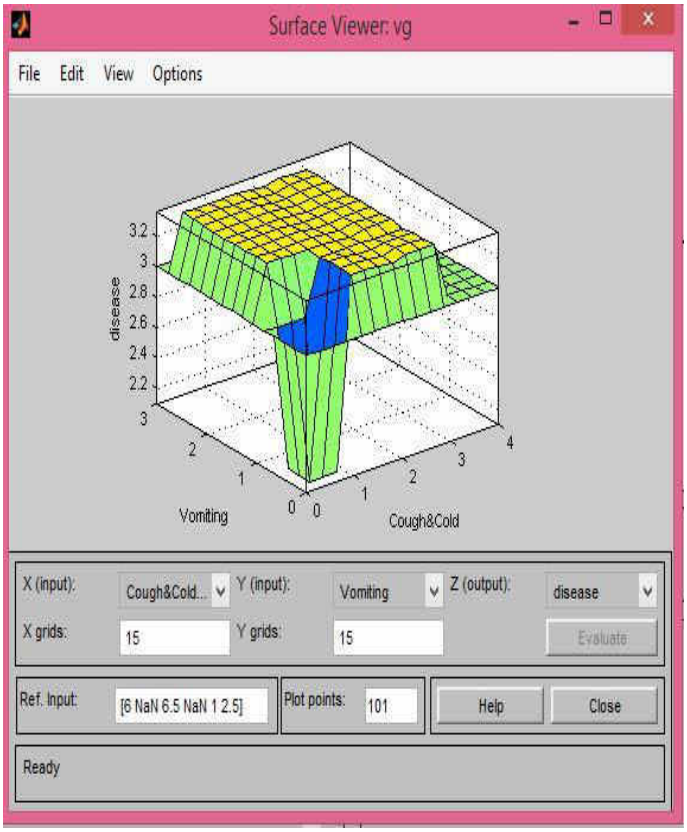

Fig - 16: Surface Viewer of Vomiting and Cough & Cold

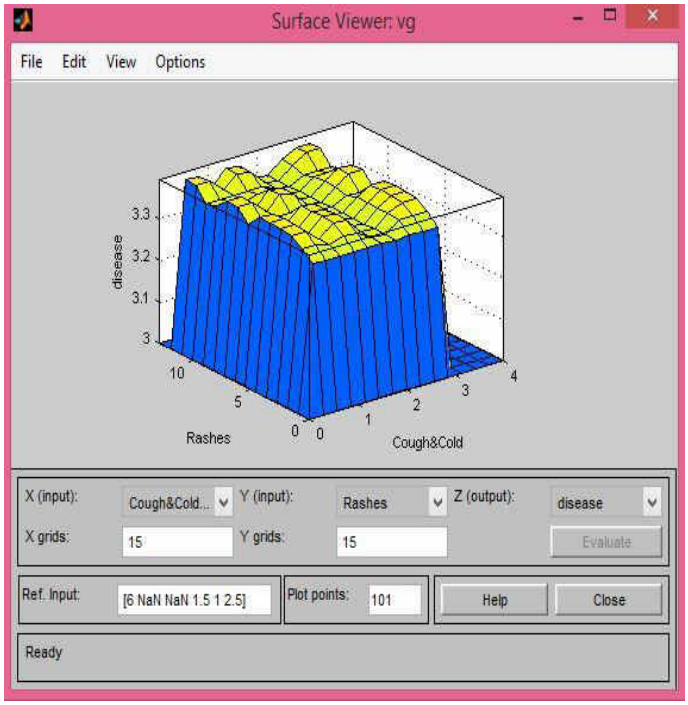

Fig - 15: Surface Viewer of Rashes and Cough & Cold.

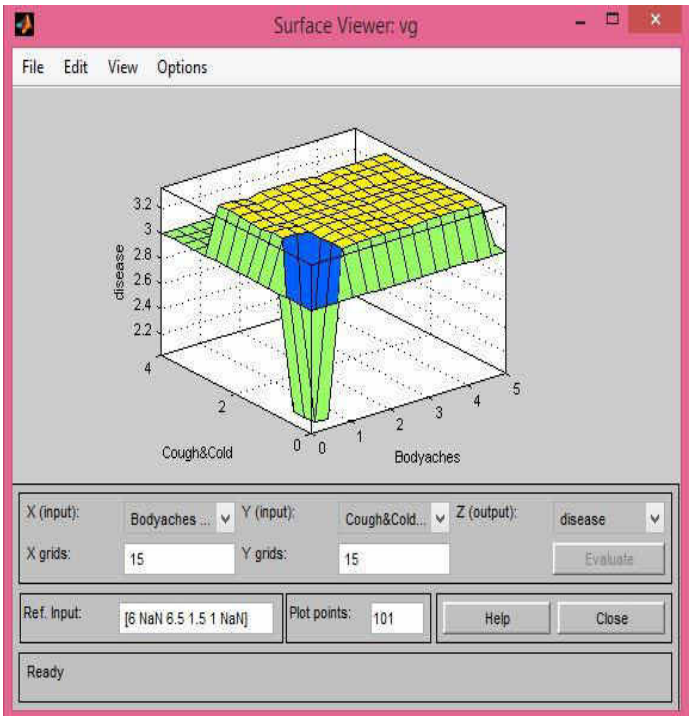

Fig - 17: Surface Viewer of Cough & Cold and Body aches.

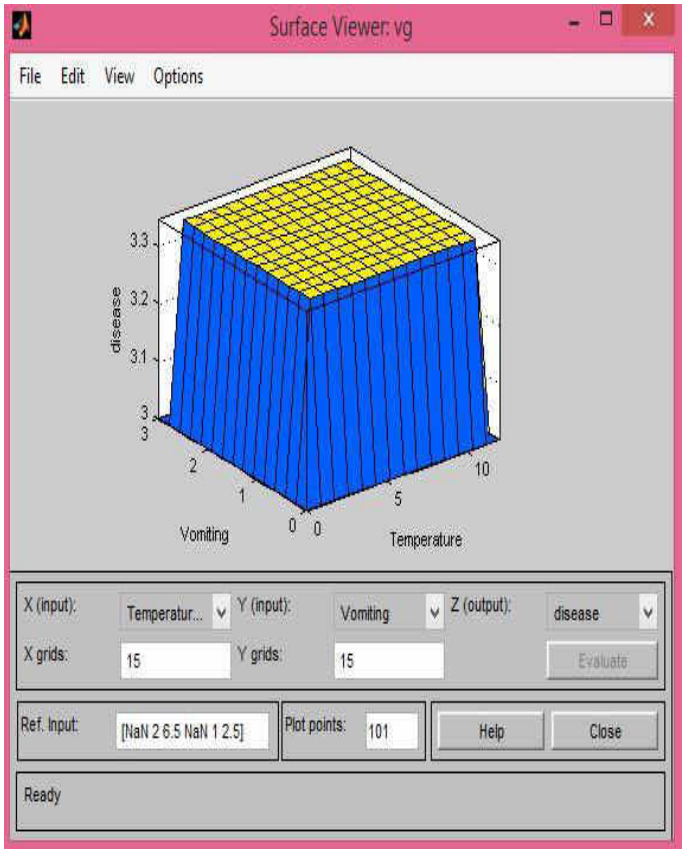

Fig - 18: Surface Viewer of Temperature and Vomiting.

5. CONCLUSION & FUTURE SCOPE:

Fuzzy logic is used for medical diagnosis of a wide range of diseases. This work proposed a methodology to capture the experience of expert physicians. It can be used to provide diagnosis decisions in fuzzy inference system techniques. Complete agreement with the diagnosis of human expert specialists has been obtained in many experiments with different input symptoms by various researchers. Fuzzy logic provides an alternative way to represent linguistic and subjective attributes or variables. This work can focus on using the medical history of the user with current symptoms in the prediction of diseases. The test results for various medical conditions can be used to further improve the accuracy of the system. The future work can focus on the classification of symptoms based on their severity and using this knowledge to calculate a numerical value to identify diseases.

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