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Diagnosis of Human Diseases with Fuzzy Expert System

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Abstract. One of the major problems that both the developed and under-developed countries are facing is the difficulties of treating ill health People. Medical diagnosis usually involves careful examination of a patient to check the presence and strength of some features relevant to a suspected disease in order to take a decision whether the patient suffers from that disease or not. Fuzzy logic is a simple and effective technique that can be advantageously used for medical diagnosis of a wide range of diseases. Now a days fuzzy systems are being used successfully in an increasing number of application areas they use linguistic rules to describe it. The developed fuzzy expert system composed of four components which include the knowledge base, the fuzzification, the inference engine and defuzzification. This paper describe an aim to develop a fuzzy expert system for diagnosing human diseases.

Keywords: Fuzzy expert system, fuzzy logic, human disease diagnosis knowledge base, the fuzzification, the inference engine and defuzzification.

AMS Mathematics Subject Classification (2010): 05C15

1. Introduction

In medical diagnosis, doctors make diagnosis on the basis of matching precise symptoms or measurements. As per the experience, expertise, awareness and observation of the doctor, medical diagnosis varies from one medical practitioner to another. The health care system constitutes people and resources to provide health care services to make the society healthy. In India, many people die due to improper treatment as an outcome of improper diagnosis. In urban India, there are preferably more heath care systems as compared to those in rural areas of India. Also another aspect is that in medical diagnosis there are many stages of the disease and if they are diagnosed at earlier stage then the possibility of recovery of patients increases but that too conditional that the diagnosis is correct. In India almost 60% population lives in rural areas where the availability of medical practitioner is either less or they are least expertise in diagnosis. This leads to a huge number of deaths in rural are due to lack of proper medical diagnosis followed by proper treatment. With the advent of technology and computerization of day to day working, medical practitioners too sought help of computers in many ways in their diagnosis. In this paper we explain the two software for medical diagnosis of human diseases with fuzzy expert system.

1) *Artificial Intelligence*: In artificial intelligence, an expert system is a computer system that emulates the decision making ability of a human expert. Expert system are designed to solve complex problem by reasoning through bodies of knowledge representation. The first expert system was created in the 1970 by Edward Frigenbaum and then proliferated in the 1980.Expert system were the first truly successful forms of artificial intelligence(AI) software
2) *MATLAB.(Matrix labortatory):* MATLAB is a multi paradigm numerical computing environment. Programming language was developed by mathworks, MATLAB allows plotting of functions and data, implementation of algorithm, creations of user interface.

This paper would help the researchers to contribute and ease the process of medical diagnosis. Moreover this study would set up a path and motivate them to explore the various medical diseases and accelerate the medical diagnosis with good accuracy.

2. Fuzzy medical diagnosis

Medical artificial intelligence is primarily concerned with the construction of AI programs that perform diagnosis and make therapy recommendations. Unlike medical applications based on another programming method such as purely statistical and probabilistic methods, medical AI programs are based on symbolic models of disease entities and their relationship to patient factors and clinical manifestations. Medical expert systems contain medical knowledge, usually about a very specifically defined task, and are able to reason with data from individual patients to come up with reasoned conclusions. 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 as a means to model the uncertainty of natural language.

In this paper we develop a fuzzy expert system that uses a collection of fuzzy membership functions and rules, instead of Boolean logic, to reason about data. Leung, Lau and Kwong describe 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:

(1) **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.

(2) **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.

(3) **Composition:** all of the fuzzy subsets assigned to each output variable are combined together to form a single fuzzy subset for each output variable.

(4) **Deffuzification**: 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, 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 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.

3. Methodology and methods

Medical diagnosis usually involves careful examination of a patient to check the presence and strength of some features relevant to a suspected disease in order to take a decision whether the patient suffers from that disease or not. A feature, like a runny nose for instance, may appear to be very strong for one patient but it can be moderate or even very light for another. It is the experience of the physician that tells him how to combine a set of symptoms (features and their strengths) to find out the correct diagnostic decision.

In the present work, we aim to capture the physician's experience and store it in a set of fuzzy tables. Fuzzy inference is employed to develop a computer program that can automatically find out the certainty whether a patient having some specified symptoms suffers from any one of a set of suspected diseases. This certainty is specified as a crisp percentage value for every suspected disease.

We consider a set of *m* diseases ***D***, and define a collective set of *n* features ***F*** relevant to these diseases. Usually we have $n>>m$. Let:

$$\boldsymbol{D} = \{d_1, d_2, d_3, \ \ldots \ , d_m\}$$

$$\boldsymbol{F} = \{ f_1, f_2, f_3, \ \ldots , f_n\}$$

To specify the symptoms of a patient, he would be checked against all features in the set ***F*** and a fuzzy value would be assigned to each feature. The fuzzy values are selected from the set:

{ Very Low, Low, Moderate, High, Very High }

For example, a single symptom can be specified as < runny nose, Moderate >. By checking the patient for all *n* features of the set ***F*** and assigning a proper fuzzy value for each feature, the set of patient's symptoms ***S*** will be obtained as follows:

$$\boldsymbol{S} = \{ <f_1, v_1>, <f_2, v_2>, <f_3, v_3>, \ \ldots , <f_n, v_n> \}$$

Where v_i is the fuzzy value assigned to the feature f_i when checking the patient, i=1, … ,n.

An expert system is divided into two subsystems, the inference engine and the knowledge base .the knowledge base represents facts and rules. The inference engine applies the rules to the known fact to deduce new fact.

Expert system=Knowledge base+ Inference engine

3.1.1. Fuzzy knowledge representation

The experience of the expert physician regarding the set of considered diseases ***D*** is captured in a set of fuzzy tables, each of which specifies the profile for one disease. We consider three fuzzy sets **Yes**, **May Be**, and **No** as shown in fig.3.1 to represent the certainty of disease presence. Entries in the disease profile tables would be selected from these fuzzy sets.

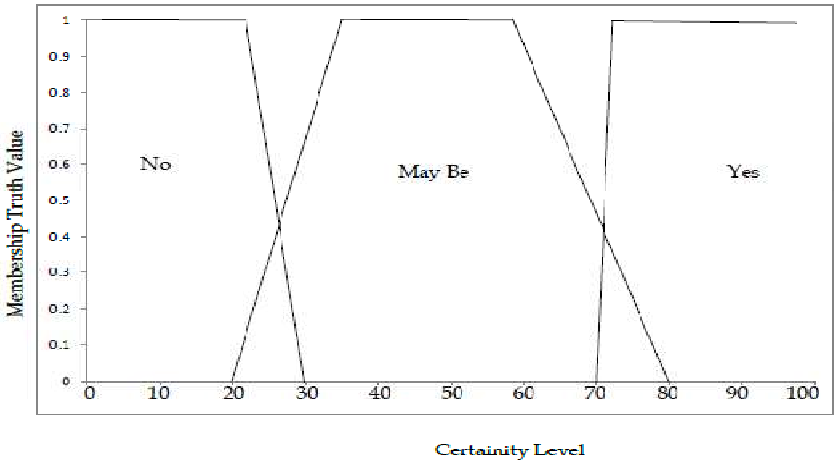

Figure 3.1: Fuzzy sets for the certainty of disease presence.

For a given disease there will be a set ***R*** of $k \le n$ relevant features which is a subset of the collective features set ***F***.

Table 3.1: Profile for the yellow fever

Attributes Features	Very Low	Low	Moderate	High	Very High
fever	No	No	No	Yes	Yes
Headache	No	May be	May be	No	No
Runny nose	No	May be	May be	yes	No
cough	No	No	May be	yes	yes
fatigue	No	No	May be	No	No
weakness	No	No	No	May be	May be
Back pain	No	May be	May be	Yes	Yes

3.1.2. Fuzzy inference

Upon examining the patient to be diagnosed, the set of his symptoms ***S*** would be obtained. A typical example for the set of symptoms is given in table 3.1 which shows fuzzy values for all features in the collective set ***F***. It is completely natural to specify the strength of a non-measurable feature by a fuzzy value. However, there are other measurable features such as the temperature, pressure, and blood sugar, etc. that can be specified by numbers. The next subsection shows how to fuzzify such features.

Table 3.2: Typical symptoms for a given input case.

Features	Fuzzy Value*	**Features**	Fuzzy Value*
Severe headache	H	vomiting	VH
Back pain	VL	fatigue	L
General body aches	VL	Diarrhea	L
nausea	H	Sore throat	M
Runny nose	L	Joints pain	VH
Fever	H	Itching	L
Cough	M	Weakness	H
Rashes	VL	Vomiting	VH
Whooping cough	L	White spots inside cheek	VL
Body aches strong	L	Loss of appetite	M
Abdominal pain	L	Jaundice	VL

* *VH=very high, H=high, M=moderate, L=low, and VL=very low.*

Let

$s[f]$ = fuzzy value for the feature f of the input case's symptoms.

r_{ij} = j^{th} relevant feature of the i^{th} disease.

$P_{ij}[r_{ij}, v]$ = certainty of presence of the i^{th} disease when the relevant feature r_{ij} has a fuzzy value v.

δ_{ij} = diagnosis decision of the i^{th} disease based on the relevant feature r_{ij} .

k_i = total number of relevant features for the i^{th} disease.

w_{ij} = weight of the r_{ij} feature in diagnosing the i^{th} disease.

σ_i = overall diagnosis decision for the i^{th} disease.

The effect of the r_{ij} feature on the diagnosis decision can be directly obtained from the disease profile table $P_{ij}[r_{ij}, v]$. The fuzzy value v is obtained from the patient's symptoms for the feature r_{ij} as $s[r_{ij}]$. This effect δ_{ij} would be one of the fuzzy sets **Yes**, **May Be**, and **No**.

It can be represented as follows:

$$\delta_{ij} = P_{ij}[r_{ij}, s[r_{ij}]] \qquad (3.1)$$

By summing up the effect of all k_i relevant features, the overall diagnosis decision for the i^{th} disease would be obtained as follows:

$$\sigma_i = (\sum_{j=1}^{j=k_i} w_{ij}\delta_{ij})/(\sum_{j=1}^{j=k_i} w_{ij}) \qquad (3.2)$$

The weighting factor w_{ij} is introduced here to allow the physician to specify that some features can have more or less significance than others when diagnosing a disease, and he should set proper relative values to the weights. If he considers that all features have the same significance, then the weighting factor will be unity for all features. In this case equation (3.2) can be simplified to be:

$$\sigma_i = \frac{1}{k_i}\sum_{j=1}^{j=k_i}\delta_{ij} \qquad (3.3)$$

The final step is to obtain crisp values specifying the certainty of presence for every disease in the set ***D***.

The center of area method is considered for defuzzification. Let:

c_i = centroid of the overall diagnosis decision fuzzy set
c_y = centroid for the **Yes** fuzzy set
q_i = certainty of presence of the considered disease d_i in percent

Consequently, the crisp decision value for the disease d_i will be computed as shown below. It should be noted that if the results were **Yes** for all relevant features of d_i, the decision would be 100%.

$$q_i = (c_i / c_y) \times 100\% \qquad (3.4)$$

3.2. Expert system with MATLAB

Lack of awareness and uncertainty of the early notification of the disease may cause many deaths. Thus, early notification is very important in avoiding the condition for further spreading. The purpose of this research is to help an individual, in this case, patients performing consultations for self analysis. This system will behave like an expert in this case, like performing interviews with the patients. It also gives easier ways decrease the doctor's burden. The importance of this system to help medical practitioners in analysis of some extreme diseases It offers many advantages both to the medical practioners and patients. The principle of this system has two major components which are symptoms as input and the output as a disease.

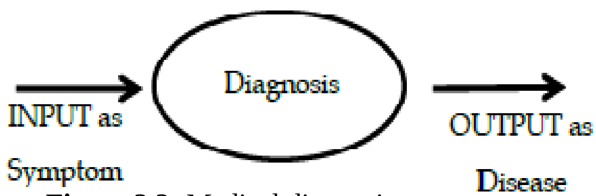

Figure 3.2: Medical diagnosis system

MATLAB fuzzy logic tool box facilitates the development of fuzzy logic system using graphical user interface (GUI) tools and command line functionality. This tool can be used to build

(1) Fuzzy expert system
(2) Adaptive Neuro – fuzzy inference systems(ANFIS)

Graphical user interface (GUI) tools :There are five primary GUI tools for building , editing and observing fuzzy inference systems in fuzzy logic toolbox

Fuzzy Inference system (FIS) Editor*:* The FIS editor opens and shows a diagram of the Fuzzyinference system with the titles of each input variable on the left, and those of each output variable on the right. We adjust fuzzy inference functions.

Membership function editor *:* We edit the attributes of membership function and also edit the values of current variable.

Rule editor *:* The Fuzzy control rules are found in rules editor in MATLAB. Here the rules are constructed in the basis of input and output variables. Here the rules are automatically updated. We create and edit the rules

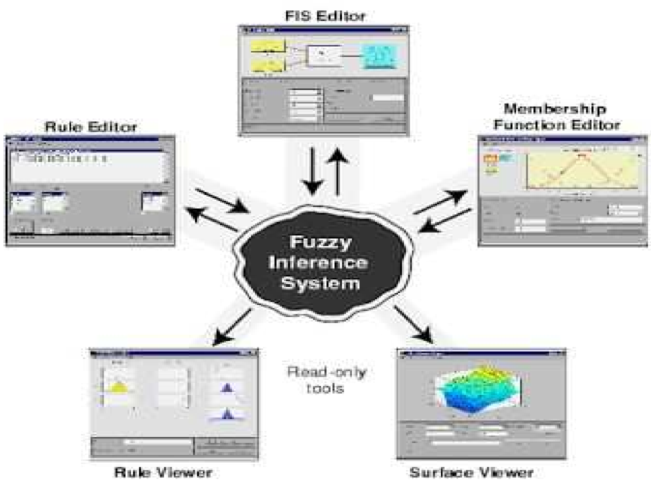

Figure 3.3:

Rule Viewer *:* Each of the characterizations of each of the variables is specified with respect to the input index line. It shows the rule viewer consists the inference mechanism and the value of defuzzification.

Surface viewer : The surface viewer which represents the response of outputs with respect to inputs.

4. Conclusion

According to SRS report the mortality rate was very high in Madhya Pradesh, Assam, Odisha, Uttar Pradesh .Diseases such as tuberculosis and typhoid fever account for are some of the major causes of deaths in India. In most cases, the reasons are traced to misdiagnosis and late diagnosis. Health outcomes from these diseases are usually poor due to ignorance, poverty, limited access to quality healthcare, self-medication and bad personal health practices. Several studies have shown that symptoms of some tropical diseases such as malaria, tuberculosis, typhoid fever, often overlap and become 'confusable'. The 'confusion' caused by the ambiguity, vagueness, and imprecision of symptoms of these diseases presents a challenge to physicians especially the inexperienced ones. Occasionally, patients cannot clearly characterize their symptoms and similarly. Artificial Intelligence and MATLAB process will not only benefit the "at risk" populations particularly in the rural region of India, it can be applied in the remote places where no doctor is available for the analysis. The medical diagnosis system can make the result of diagnosis and treatment scheme more reasonable. Human shave been applied to test the system. Because of this, the system really is supposed to be a trusted system. It is user friendly and most importantly can be utilized by users to obtain self notified without the assistant.

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