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A Web Based Fuzzy Expert System for Human Disease Diagnosis

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***Abstract*—Fuzzy expert system has shown a remarkable tool for building of intelligent decision making systems based on expert's knowledge and observations. This work presents an approach for the treatment of patients on the basis of fuzzy rules applied on symptoms that seen in patient. For the identification of complex disease like ADHD, SLP and IBS, firstly fuzzy rules applied based on the symptoms selected by the patient and secondly for the improvement of developed system, expert learning system is proposed by which disease diagnosis accuracy has been enhanced. Through exert learning system, experience Doctors around the world can share their knowledge with the system for enhance the probability of finding diseases more accurately. Finally, a tool named "Diagnosis Portal" has to be developed for showing the proposed work and our results shows improved interpretation accuracy in treatment of patient with faster and accurate manner.**

Keywords—Fuzzy expert system, Decision making system, Expert learning, ADHD (Attention Deficit Hyperactivity Disorder), SA (Sleep Apnea), IBS (Irritable Bowel Syndrome)

I. INTRODUCTION

Traditionally to diagnose diseases, a physician is usually based on the clinical history and physical examination of the patient, examining of medical images, as well as the results of laboratory tests. As technology grows day by day with standardization in many fields, still medical diseases diagnosis is considered as an art of doctor's experience only. In medical diagnosis, the person's pathological status is determined with the help of available set of knowledge and the patient's symptoms. It is still an art only because diagnosis is a complex problem and depends on many factors, and its solution still depends on the doctor's abilities that include intuition and subconscious. Various attempts are made by researchers to make an information technology system which can help in diagnosis of medical problems [1].

Computer-based methods are increasingly used to improve the quality of medical services. Rule based expert system will be used for Medical diagnosis that includes both conventional techniques, such as database management systems, and artificial intelligence (AI) techniques, such as knowledge-based systems or expert systems [2].

With the study about diseases and diagnosis it is observed that it is more difficult to diagnose the patient rather than to cure it. For our study, we focus on three complex diseases, identify the symptoms and diagnosis them. The diseases are: (1) Attention deficit hyperactivity disorder (ADHD), (2) Sleep apnea (SA) and (3) Irritable bowel syndrome (IBS). The current work focuses on assisting doctors for diagnosis of various diseases listed above with their respective symptoms and develop a prototype computer expert system application for diagnosis and treatment of ADHD, SA and IBS.

II. DISEASES INFORMATION

In our study, we focus on three complex diseases as ADHD, SA and IBS. The complete information about each disease is given below:

A. Attention deficit hyperactivity disorder (ADHD)

Attention deficit hyperactivity disorder is related to the brain and also known as neurodevelopment psychiatric disorder in which problems arises with executive functions e.g., inhibitory control and attention control that cause poor attention power, hyperactivity, or sometimes increases violence which would be not natural at the stages of a person's life. Proper diagnosis of these symptoms needs six months. ADHD reflects in the children of age group six to twelve. In school-going children inattention symptoms often result in poor results and later affect their future. Although it causes ruination, many children with ADHD possess good attention power for doing task of their area of interest in modern society [13].

B. Sleep apnea (SA)

Sleep apnea basically is a sleep disorder due to the breathing problems while sleeping. Breathing problems are like pause in breathing or shallow breathing also sometimes sporadic breathing. Pause in breathing, called an apnea, can occur for minimum as five times in an hour. The interval of an apnea can be in seconds or in minutes. Similarly, hypopnea is uncommon shallow breathing. Dyssomnia is also a type of Sleep apnea shows the uncommon psychological behavior while sleep. Carbon dioxide increases in the bloodstream whenever symptoms of an apnea occur. This increased level of carbon dioxide is detected in the blood stream by the chemoreceptors and then brain give indications to wake up the person for proper breathe in the air. Breathing taken by person normally will increase the level of oxygen and then the person

will asleep again. Polysomnogram is term generally used to diagnosis the SA by tracking the overnight sleep test [14].

C. Irritable bowel syndrome (IBS)

The other name of Irritable bowel syndrome is spastic colon. It is based on symptom for diagnosis. It is characterized by discomfort, alteration of bowel habits, bloating and chronic abdominal pain. The IBS can be classified as Irritable bowel syndrome - Diarrhea (IBS-D), Irritable bowel syndrome - constipation (IBS-C), or Irritable bowel syndrome – alternate (IBS-A). Till date, Irritable bowel syndrome has no any known organic cause just like functional gastrointestinal disorder (FGID). IBS may often occur in patients by an infection i.e. postinfectious IBS-PI, or with a stressful life running, and also varies little with the patient age as well. The IBS in most common theoretical aspect describe as a disorder of the interaction between gastrointestinal tract and brain. For some individual persons, at least abnormalities occur in the gut flora and these abnormalities results in altered bowel function and inflammation theoretically [15].

III. BACKGROUND STUDY

To solve the real world complex problem, Expert System is one of the most common applications of artificial intelligence. It is a computer program that simulates the decision and actions of a person or an association that has specialist facts and experience in a particular field. Normally, such a system contains a knowledge base containing accumulated experience and a set of rules for applying the knowledge base to each particular situation. The major features of expert system are user interface, data representation, inference, explanations etc. Advantages of expert system are increased reliability, reduced errors, reduced cost, multiple expertise, intelligent database, reduced danger etc. Disadvantages of expert system are absence of common sense and no change with changing environment [2].

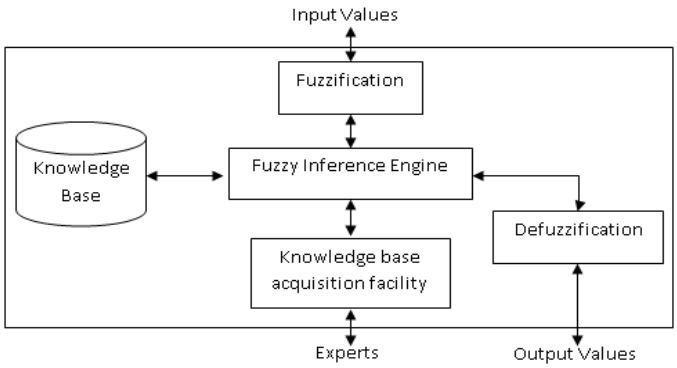

Fig 2.1 FUZZY EXPERT SYSTEM

The components of fuzzy expert system are illustrated in Fig 2.1. In the components of fuzzy expert system, the knowledge base used for the storage of all relevant information like data statics, rules that govern the data, different cases, and their relationships used by expert system. A knowledge database can be used to combine data / knowledge of multiple experts around the world. Rules define the conditional statement that can generate outcomes from different kind of possible conditions. Another important component in fuzzy expert system is fuzzy inference engine that defines relationships and extract information from the knowledge database and predicts suggestions, answers and probability of finding disease just like expert would do. The inference rules defined inside inference engine must matches with right knowledge base information and so that prediction also goes in the right direction. The next important component of fuzzy expert system is knowledge base acquisition facility. Knowledge base acquisition facility provides efficient and convenient means for gathering and storing knowledge of experts around the world in a corrected way under knowledge base.

Fuzzy logic was introduced first in the year 1965 by Zadeh. His paper on fuzzy sets gave an insight into a kind of logic which is finding an increasing usage in day to day lives. It is a form of multi-valued logic and deals with reasoning. The imprecision of human reasoning needed to be more efficiently handled. In 1971, Zadeh published the concept of quantitative fuzzy semantics which in turn led to the methodology of fuzzy logic and its applications. Fuzzy logic has been applied to many fields ranging from control applications to artificial intelligence. A wide variety of medical applications where its usage is significantly felt include cardiac, neural, lung and diabetes [3].

Mir Anamul Hasan, Khaja Md. Sher-E-Alam & Ahsan Raja Chowdhury In [4] author describe a project work of fuzzy expert system for diagnosing the human diseases, which used to exchange the health information between health care professionals and patients. Author makes a comparative analysis to identify which symptoms are major symptoms for particular diseases, then the uniform structure is made mathematical equivalence is formed which will be used to diagnosis by the fuzzy expert system. Based on the selection of problem area, expert system give symptom from which user needs to select symptoms. Now user has to answer some question that based on the knowledge and add some catalyst factor than on the basis of IF-THEN rule the expert system computes the probabilities of problem diseases and filter before showing. The proposed system is experimented on various scenarios and satisfactory results have been achieved. The system can be used by patient and practitioners for their betterment.

Another work was done by Dipanwita Biswas, Sagar Bairagi, Neelam Panse & Nirmala Shinde in paper titled “Disease diagnosis system” [5]. In this work they developed an expert system for human disease diagnosis. It works on the patient data by combining production rules and a neural network. This results in increase in knowledge representation and maintenance. They used Matlab for system design and they get satisfactory results. For future aspects training of the system can be added to improve the quality of the system. Some more patient data can be used for increasing the system utilization.

Ali.Adeli, Mehdi.Neshat works for the Heart Disease Diagnosis using Fuzzy Expert System [6]. They take database for the system from the Cleveland Clinic Foundation and V.A. Medical Center, Long Beach. System has 13 inputs and one output. Mamdani inference method is used for calculating the output. Input fields include chest pain type, blood pressure, cholesterol, resting blood sugar, maximum heart rate, resting electrocardiography (ECG), exercise, old peak (previous ST depression induced in patients by exercise relative to rest), thallium scan, sex and age. Basically this system identifies the presence of any heart related disease in the patient the software is designed in Matlab. The system is used and tested by the expert cardiologist and they get 94% result.

Chang-Shing Lee, Senior Member, IEEE, and Mei-Hui Wang [8] shows that all the previous ontologies cannot handle sufficiently and imprecisely, the knowledge available for some

of the real world applications due to uncertainty, but with the help of fuzzy ontology, the problem on uncertainty in knowledge and data can be resolve efficiently. They work for diabetes diseases decision support application and developed a novel fuzzy expert system to demonstrate it. Their proposed work compromises of five layers fuzzy expert system that includes knowledge layer, group relation layer, group domain layer, personal relation layer and personal domain layer. These entire layers are used to describe the uncertainty in the knowledge. They apply fuzzy ontology to diagnosis diabetes diseases and developed structure which uses diabetes knowledge. They also developed semantic decision support system, knowledge construction mechanism, semantic fuzzy decision making and generating mechanism. There proposed system work efficiently for diabetes patients with their decision support application. They conclude that, although the proposed fuzzy expert system can model diabetes domain knowledge, the approach apply for fuzzification in the fuzzy expert system is more important. Their future works defines similar models for other diseases data set or different domain with uncertain information can be constructed with similar fuzzy ontology defined herein with modifying fuzzy inference rules, domain knowledge dataset and learning mechanism.

All these studies was related with the diseases diagnosis shows that there are many type of uncertain information which a doctor have to process by their intelligence for diagnosis of a particular diseases and all the existing systems were developed for a specific type of diseases, and also there is a chance of improvement in accuracy as well.

IV. PROBLEM DEFINITION

Researches said that even the very good doctors in their fields having years and years of Experience are not able to detect the disease quickly and efficiently. He may require multiple feedbacks from the patient for the diagnosis of particular disease. It is always difficult to detect the disease more accurately and speedily. The main key problem identified behind any mis-diagnose of disease are stated below:-

- Lack of communication: - Patient may not able to communicate well with the doctors, hence not giving the right symptoms persisting to them. This can lead to wrong diagnosis of the patient.
- Sharing of Doctors Knowledge with each other is very difficult for them to.
- Lack of experience Doctors to deal with complex disease: there are many complex diseases like ADHD, Sleep Apnea and IBS etc., whose diagnosis is very difficult to?

V. PROPOSED SYSTEM

The objective of the proposed system is to help the physician or doctors for the diagnosis of the complex diseases everywhere around the world where expert's doctors will be not available. The proposed system diagnosis the complex diseases with the help of uncertain information provided by the patients and using the knowledge dataset maintain by expert doctors around the world inside the proposed system itself.

Diagnosis Portal= (experience of the doctors treating the patient in real world) + (experience of all doctors around the world treating the same patient in virtual world)

Where,

- Experience = data, facts and statistics.
- Experience of the doctor treating the patient in real world = his own data and statistics which is stored in his own brain.
- Experience of all the doctors around the world = data and statistic taken all around the world (by expert learning approach of AI).

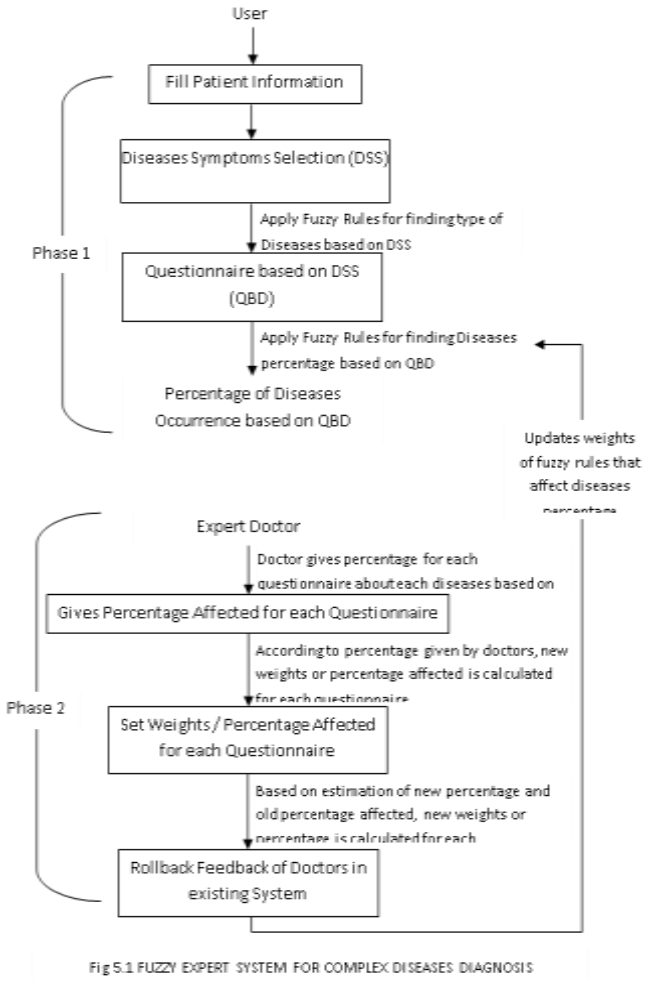

Fig 5.1 FUZZY EXPERT SYSTEM FOR COMPLEX DISEASES DIAGNOSIS

The proposed architecture for the diagnosis of complex diseases shown in Fig 5.1 consists of two main phases. The phase 1 is used for the diagnosis of the complex diseases and the phase 2 is used for the expert learning system where expert doctors can share their knowledge for the improvement of the system.

In phase 1 of proposed system, there are three main stages where fuzzy rules are applied for the diagnosis of complex diseases like ADHD, SA and IBS. The stages are:

- Stage 1: - (Symptoms Identification) Where diseases symptoms will be selected by the user which patient has to be expecting.
- Stage 2: - (Diseases Identification) Medical counseling will be done, asking question for identifying type of diseases, which is most expected by our tool Diagnosis Portal.
- Stage 3: - (Percentage Affected Identification) Based on diseases identified, again questionnaire is ask by the tools by which calculation will be done giving maximum probability of the disease which patient have suffering from.

In phase 2, Expert Learning System is proposed where expert Doctors around the world can share their knowledge with the system using their authentications.

A. Attention Deficit Hyperactivity Disorder (ADHD)

Stage 1: - Following are the disease symptoms which are commonly misdiagnosed as ADHD:

- Chronic fear syndrome
- Epilepsy (Pemital seizures)
- Emotional problem syndrome
- Learning dis-abilities syndrome
- Frustration (Irritability)
- Deafness (Hearing problem)
- Ear infection
- Neurosis (anxiety)
- Depression
- Temporal lope epilepsy
- Diabetes
- Anemia
- Asperger syndrome
- Obsessive compulsive syndrome
- Lead poisoning
- Intellectual disability
- Inattention
- School problem (child abuse, food allergy, miscellaneous)

After entering the above disease symptoms patient will move to the second stage of diagnosis.

Stage 2: - Questions are asked by the patient based on the symptoms selection in stage 1. These questionnaires will be contributing towards the finding of the correct disease in the patient.

Q.1 Do you often forget important dates, events functions etc.?
Q.2 Do you often not able to complete your assignment, work etc. on schedule?
Q.3 Are you enough punctual?
Q.4 Do you have symptoms of excessive talking?
Q.5 Do you have symptoms of inattention?
Q.6 Do you often forget to wear your spectacles while going to the office or school?
Q.7 Do you feel difficult to concentrate in the class?
Q.8 Do you feel sluggish and slow to response for certain activities?
Q.9 Are you talkative in class?
Q.10 Do you feel difficulty in sitting in the class?
Q.11 Do you have certain weird symptoms foot movement, pencil movement, saliva creation, pencil tapping?
Q.12 Do you have head injury during the age group 0-5
Q.13 Do your parent (mother and father) have a habit of smoking?

Diseases Identification (Q.n) = If yes, Found ADHD
If no, ADHD not found
For all n = 1 to 13, listed above

Stage 3: - Based on the results of stage 2, questions from the stage 3 asked to the patients. This questionnaire helps in identifying the probability in terms of percentage of diseases the patient may have.

Q.1 Are you ambidextrous (ability to work with both hands)?
IF (Ambidextrous = true) and (patient age <= 10 years) then
x1 = 12 % Chance of ADHD

Q.2 Do you have oppositional deficient syndrome
IF (Oppositional Deficient Syndrome = true) then
x2 = 22.5 % Chance of ADHD

Q.3 Do you have problem of hyper –tension?
IF (Hypertension = true) then
x3 = Percentage ADHD Found * 4 (4 times of result)

Q.4 Are these activities are first noticed by your teacher?(85% chances)
IF (Noticed first by Teacher = true) then
x4 = 85 % Chance of ADHD

Q.5 Gender based Calculation
IF (Gender = Male) then
x5 = 25 % more chance of ADHD

B. Sleep apnea (SA)

Stage 1: - Following are the disease symptoms which are commonly misdiagnosed as SA:

- Depression
- Hepatitis C
- Celiac disease
- Seizure disorder (Epilepsy)
- Palpitation
- Sinus tachycardia
- Insomnia.
- Pre-menopauses
- Chronic fatigue symptoms

After entering the above disease symptoms patient will move to the second stage of diagnosis.

Stage 2: - Questions are asked by the patient based on the symptoms selection in stage 1. These questionnaires will be contributing towards the finding of the correct disease in the patient.

Q.1 Do you have problem of snoring at night?
Q.2 Do you have short breath, during work or otherwise?
Q.3 Do you fell often depressed?
Q.4 Do you have problem of erectile dysfunction?
Q.5 Do you lose your energy very quickly?
Q.6 Do you feel day time sleepiness?

Diseases Identification (Q.n) = If yes, Found SA
If no, SA not found
For all n = 1 to 6, listed above

Stage 3: - Based on the results of stage 2, questions from the stage 3 asked to the patients. This questionnaire helps in identifying the probability in terms of percentage of diseases the patient may have.

Q.1 Do you have any heart problem like stroke, feeling uneasy at chest or like that?

IF (Heart Problem = true) then

x1 = 50 % More chance of SA

Q.2 Do you have problem of palpitation i.e. increased of heart rate?

IF (Palpitation = true) then

x2 = 62.5 % More chance of SA

Q.3 Find out whether body-weight ratio (obesity) of the patient is correct?

IF (Obesity = true) then

x3 = 70 % More chance of SA

Q.4 Is size of the neck of the patient if it is abnormal i.e. greater than 17 inches?

IF (Size of the Neck is Abnormal = true) then

x4 = 30 % More chance of SA

Q.5 Age based Calculation

IF (Age > 65 Years) then

x5 = 100 % Chance of SA

C. Irritable Bowel Syndrome (IBS)

Stage 1: - Following are the disease symptoms which are commonly misdiagnosed as IBS:

- Coeliac Disease
- Helicobacter Pylori
- Parasites
- Fibromyalgia
- Multiple Sclerosis
- Lupus
- Polycystic Ovary Syndrome
- Appendicitis
- Endometriosis
- Migraines
- Cluster Headaches
- Hypothyroidism
- Inflammatory bowel disease

Stage 2: - Questions are asked by the patient based on the symptoms selection in stage 1. These questionnaires will be contributing towards the finding of the correct disease in the patient.

Q.1 Do you often have complains of Abdominal Pain, Gastritis or Diarrhea?

Q.2 Do you often have feeling of bloating, incomplete evacuation, or abdominal distension?

Q.3 Do you often feel Headache, Tiredness, Nausea or Flatulence?

Q.4 Do you often have symptoms related to the chronic fatigue syndrome, genitourinary system, or fibromyalgia?

Q.5 Do you often have psychiatric symptoms such as depression and anxiety?

Q.6 Do you often have problem of Cramping?

Diseases Identification (Q.n) = If yes, Found IBS

If no, IBS not found

For all n = 1 to 6, listed above

Stage 3: - Based on the results of stage 2, questions from the stage 3 asked to the patients. This questionnaire helps in identifying the probability in terms of percentage of diseases the patient may have.

Q.1 Do you have symptoms of Loss of Appetite & Weight Loss?

IF (Weight Loss = true) then

x1 = 34 % Chance of IBS

Q.2 Do you have symptoms of Stress, Anxiety & Depression?

IF (Stress, Anxiety & Depression = true) then

x2 = 5 % Chance of IBS

Q.3 Do you have symptoms of Frequent Pain in Abdomen?

IF (Frequent Pain in Abdomen = true) then

x3 = 51 % Chance of IBS

D. Probability of Expected Disease

Probability of expected disease shows the chances of disease in terms of percentage for a particular patient may have. Based on the diagnosis of disease in stage 3 for each type of disease, probability is calculated in terms of percentage using the formula below:

$$Probability\ of\ expected\ disease = (x1\% + x2\% + ... + xn\%) / n$$

Where, x1, x2, x3…… xn are percentage of disease found in stage 3.

E. Expected Benefits

The expected benefits of this research are a prototype expert system for diagnosis of ADHD, SA and IBS diseases, which will be helpful for:

- An assistant or advice for relevant person and expertise in above mention diseases.
- Precise identification of the diseases mention above.

VI. IMPLEMENTATION & RESULT ANALYSIS

The tool is design as a web application with very user friendly GUI, while keeping in mind to use it as simple as possible and without any extra information. If user just wants to diagnosis diseases then he/she also not has to register as well with the system. The tool contains two separate phases, one for the diseases diagnosis and second for the expert learning through expert doctors around the world. The design of phase 1 contains the web pages for diseases diagnosis. They are as follows:

- Patient Information
- Diseases Symptoms Selection
- Symptoms Filtration
- Diseases Probability Questionnaire
- Results showing chance of diseases in terms of percentage.

The design of phase 2 contains the web pages for expert learning system. They are as follows:

- Login Page
- Registration Page
- Expert Learning Page
- Logout Page

Execution of Phase 1 (For Diseases Diagnosis):

a. Diagnosis of diseases starts with the input the basic information about the patient.
b. After that user of the system select diseases symptoms under the supervision of some consultant.
c. Based on symptoms selection, system asked some question for the confirmation about the type of diseases. User has to give answers of the following question.
d. Based on the answers about the diseases predication, diseases are identified by the system. After that system ask about few more questions relevant about the diseases identified.
e. Based on the answers of the relevant diseases questions, probabilities for particular diseases are identified and result is shown to the user.

Execution of Phase 2 (Expert Learning System):

a. Learning phase starts with the registration and or login process of the expert doctors that authenticate the expert Doctors.
b. Once authenticated, Doctor has to go on learning page of the system.
c. On the learning page, Doctors has to give percentage affected based on the experience he/she have, for each questionnaire asked by the system for all three type of diseases.
d. Once percentage affected was filled by the Doctor, system will calculate new weights/percentage affected for each questionnaire.
e. The new weights/percentage then used for further diagnosis of the patient.

The executions of both the phases are separate with each other, but share the common knowledge dataset. Phase 2 updates the knowledge dataset and phase1 used the knowledge dataset for the diagnosis of the diseases.

As there are two main phases of our proposed system, each phase has been analyzed and experimentally tested. For the proposed system, two main tests conducted, one for each phase of the system, the first test for the phase 1 i.e., diseases diagnosis phase, where patient with doctor or physician would input values in the system for a specific case and then system predict about the complex diseases like ADHD, SA and IBS are present or not in the patient, and the second test for the phase 2 i.e. training phase, where training of the knowledge dataset of the proposed system has been carried out with the help of expert doctors around the world. To optimize the proposed system performance, some parameters were modified to achieve relationship between both the phases and also reflect their effects on the overall proposed system performance. Finally, the optimized set of input output parameters are selected and used for future diagnosis of diseases in the systems.

Based on the results obtained, it is clearly found that the developed Fuzzy Expert System gives excellent achievements using training dataset and achieved maximum accuracy while diagnosis the diseases for a patients.

VII. CONCLUSION

The objective of this research work is to develop a prototype expert system for the diagnosis of complex diseases like ADHD, SA and IBS. It will help mankind by helping doctors with expert knowledgeable doctors around the world. Hence a genuine work has been carried out in this field by developing a web based application, combing all the experience in the form of data and statistics all around the world. It will also important that cost of diagnosis should be as low as possible. This website can act as an interface between a poor people for diagnosis of complex diseases and provides a better diagnosis about a particular disease. As we developed a diagnosis cum learning tool, that always is in learning stage as well. So the tool gives best result in diagnosis particular diseases as the knowledge of the developed tool is increases as with doctors share their knowledge with it. It indicates the tool always gives better results for the diagnosis of diseases with time. Future works should test fuzzification approach used here for other tasks similar to our work, or for other complex diseases datasets available to evaluate capability of the system for producing similar accuracy.

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