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Early Diagnosis of Human Disease using Artificial Intelligence

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Abstract

In today's life healthcare become the most important aspect of everyone's life and nobody can ignore its importance. As we have limited numbers of medical facilities in terms of hi-tech hospitals and expert doctors. This is even worsened in remote rural areas where the medical facility is not adequate. Diseases are the main problems in human life and this must be diagnosed early stage. The early diagnosis of diseases is necessary so that corrective measures can be taken. Most often delayed diagnosis can create a severe problem in the patients. The above study reveals the importance of artificial intelligence in the field of human disease diagnosis and explores the possibilities of the design of an expert system. The expert system will be helpful to the medical practitioners as this could be employed to diagnose the disease early stage. It is not the substitution of doctors but this can help early detection of diseases and may provide opportunities for the exploration of Expert Healthcare System (EHC).

Keyword : Artificial Intelligence (AI), Disease Diagnosis, Expert System (ES), Expert Healthcare (EHC), Chronic Diseases (CKD).

1. INTRODUCTION

A *disease* is a particular abnormal condition that negatively affects the normal functioning of the human being and it is a medical condition that is associated with specific symptoms and signs. Sometimes symptoms are very apparent and visible which may be used to diagnose. But for chronic diseases like kidney failure, cardiac arrest, cancer, diabetes where symptoms are not very strong an early stage and hence it become very difficult to diagnose it. Chronic diseases are defined broadly as conditions that last for more than three months and required continuous medication and supervision.

The patients can live with chronic disease for a longer period through following the strict diet plan. This restricts the activities of the patients up to certain extents. Since symptoms are not visible from the beginning so it is very challenging to diagnose it. It is very necessary to diagnose the chronic disease early stage otherwise it becomes severe and creates a problem for human beings. Although there are expert doctors who used medical reports, symptoms, and history of the patients.

The doctors diagnose based on their expertise and treat them accordingly. But sometimes the diagnosis becomes difficult due to unavailability of expert doctors and medical reports which ultimately leads to a difficult situation for the patient to be treated properly.

A physician with less experience cannot assess the risk by merely reading reports of the patient. Sometimes the numeric values of attributes being tested are so closed and confusing that it is nearly impossible for less experienced medical practitioners to conclude about the disease. Like in other fields, the programmed machine or well-developed software calculates many times better than a human, it can also be applied and implemented in medical science[4].

Diagnosis of Disease with the greatest accuracy level is a significant step for the effective treatment of illness. Doctors and medical practitioners usually demand an automatic system which can help them in finding out the intensity level of disease with proper diagnosis [9].

An expert system (ES) for human disease diagnosis can play a significant role in the field of medical science that not only detects the presence of disease but also provides intensity level of the disease so that proper decisions can be made for effective treatment[13].

Computer science and Medical science are collaboratively doing work in this field to make expert systems for medical diagnosis. Experts of computers and experts of medicine draw the architecture of a machine or software for medical diagnosis. Artificial Intelligence (AI), one of the important branches of computer science, works on developing machines that can think artificially, make inferences, make decisions, and provide results [20].

In this literature survey we would like to highlight the importance of artificial intelligence for early diagnosis of chronic disease. The expert system reviewed in this literature seems to be useful in such conditions and which may help the medical community to diagnose it at early stages and therefore treatment can be started.

AI is presently being used in many areas to design and develop machines and software which replace humans. Artificial Intelligence is started with machines called robots which replace human and start working at their place. AI was officially declared as a branch of computer science for developing intelligent machines in 1956. It is now used in medical science such as robotics, medical statistics, medical diagnosis, and human biology.

A decision support system based on AI techniques and medical data can help doctors in diagnosing disease easily [22]. AI is a primary concept to design an intelligent system that presents a simulation of the real world. Today Artificial Intelligence (AI) is being used extensively for making such expert systems that can analyze medical parameters and make a decision statement that helps medical experts to diagnose the disease properly.
To design an expert system using AI, a different concept of AI i.e. Machine Learning, Artificial neural network, deep learning, and fuzzy logic are used.

2. RELATED WORK

The Fuzzy Ontology developed by C. Lee et al. [2] using a C++ programming builder consists of five respective layers. The fuzzy ontology consists of following layers fuzzy group relation, Fuzzy group domain, fuzzy knowledge, fuzzy personal, and fuzzy personal relation domain layers. This expert system diagnoses diabetes disease incorporating Semantic Decision Support Agent (SDSA) decision-making database. The experimental data set thus processed is converted into a Fuzzy Diabetes Ontology (FDO) repository.

The Faith-Michael E. Uzoka et al. [3] designed a diagnostic Expert System (ES) based on data set taken from 30 malaria patients and performed decision making both based on Analytical Hierarchy Process (AHP) and fuzzy methodology. Both being compared and analyzed reveals that the result of fuzzy logic is comparatively better than the normal physical AHP examination.

Ali Keles et al. [4] developed a model to diagnose breast cancer in women uses an expert system called Ex-DBC (Expert System for Diagnosis of Breast Cancer). The implementation of fuzzy rule-based brings significant results using the Ex-DBC expert system. This has a positive predictive result (96%) and specificity result (97%) for breast cancer patients.

The proposed two-tier system by Mohammad Reza Daliri [5] in which one part is a combination of Genetic algorithm and extreme learning machines for feature selection and a particular disease data classification respectively and another part is a fuzzy inference system in which data are fed and it generates a result that is used for diagnosis of that disease and further clinical applications. The data set is primarily taken from source UCI Machine Learning Repository. The 32 samples each having 56 attributes were used. The value of each attribute takes an integer between 0 and 3.

Adel Lahsasna et al. [6] in developed a fuzzy rule-based system for coronary heart disease diagnosis enabling to identify uncertainty cases of narrowing arteries causing cardiovascular complications. The development of this system incorporates four basic steps i.e. reducing the complexity of data, generating all possible fuzzy IF-Then rules, involving multi-objective genetic algorithm, and developing ensemble classifiers. The dataset obtained from UCI Repository machine learning databases with 76 attributes out of which 13 attributes were tested. The selected attributes represent test results of 303 patients out of which 270 cases were tested and verified.

The Tarig Faisal et al.[7] designed a system that accurately diagnoses dengue disease with 86.13% applied Adaptive Neuro-Fuzzy Inference System (ANFIS). The expert system is designed using two models with the help of MATLAB software package.

In another Fuzzy Expert System (FES) designed by S. Muthukaruppan et al. [8] based on particle swarm optimization (PSO) algorithm. This model consists of four steps to diagnose coronary artery disease. The missing data imputation involving nearest neighbor hot-deck imputation is done by the first step, thereafter decision tree extraction of a set of rules is done by the second step, the transformation of crisp rules into fuzzy rules using membership functions is performed by the third step and finally, the fourth stage optimizes parameters which are used by FES and provides interpretation about the disease. The dataset available at UCI (*University of California, Irvine*) dataset repository is used with 597 records each having 76 attributes but only 13 of them are used.

The Screening Expert System developed by Debabrata Pal et al. [9] detects coronary artery disease at its early stage developed using rules. This has been developed with the help of doctors and a fuzzy approach. The result set of the developed system shows 95.85% sensitivity and 83.33% specificity in coronary artery disease risk computation. The model used 500 patient's data each with 11 attributes taken form Advanced Medical Research Institute (AMRI) hospital, Salt Lake, Kolkata. Besides, that questionnaire had been developed for this purpose.

O.W. amuel et al. [10] proposed a web-based decision support system driven by fuzzy logic to diagnose Typhoid Fever (TF). It consists of mainly two parts knowledge base and fuzzy inference system. The system performs with 94% accuracy to diagnose the disease. The data set used to test this system was taken from the Federal Medical Center, Owo, Ondo State-Nigeria. It contains 30 observations of patients and each observation has 15 attributes.

The Neuro-Fuzzy System (NFS) proposed by C. Kalaiselvi and G. M. Nasira [11] diagnose diabetes and to predict cancer disease. The data set was taken from the Pima Indian Diabetes which was consists of 768 samples of patients. The data set consists of 8 attributes having numerical values.

Abbas Sheikhtaheri et al. [12] studied the importance of AI in the field of human disease diagnosis. He explained that even expert doctors can't reach some early diagnosis and thus paved the way for expert systems in the field of clinical diagnosis.

Shakil Ahmed et al. [13] designed an expert system to diagnose kidney disease. This system was designed under MATLAB software using the fuzzy logic toolbox. The data set consists of 817 samples having 7 attributes. This data set was taken from the Birdem hospital Dhaka. The accuracy of the system was 86.7% and used 30 samples.

Juan Carlos Guzman et al. [14] proposed a fuzzy rule-based expert system. This system was characterized by the features of fuzzy logic like fuzzification, defuzzification. Each data set attributed as membership function. This system was designed to diagnose Arterial hypertension. The input parameters are taken as systolic and diastolic blood pressure. The experiments were conducted on the FIS tool of MATLAB R2013. The system consists of two input and one output teach carrying 8 membership functions.

The hybrid cloud-based Fuzzy system proposed by Chien-Hua Wu et al. [15] was consists of two-tier architecture where the neural network detects early chronic kidney problem whereas the second tier predicts the severity of the disease. The 430 samples of kidney patients were tested which yields accuracy level up to 90%.

Zewei Chen et al. [16] implemented two fuzzy classifiers on chronic kidney disease. The result shows that the former two classifiers have significantly better than that of conventional multivariate classifiers. The UCI data set was used which produces 98% accuracy.

Ramiro Meza-Palacios et al. [17] proposed a fuzzy logic-based expert system for nephropathy control assessment. This gives a result with 93.33% of accuracy. The team of doctors had provided a data set of 90 patients. Each sample has 7 attributes that were developed using MINITAB2014 software.

Tanmay Kasbe and Ravi Singh Pippal *[18]* designed a fuzzy-based expert system. This expert system was designed to diagnose heart disease. The system was used to predicts the level of risk for a patient. The employed 13 input and 1 output parameters which were tested on MATLAB software.

M.H. Fazel Zarandiand Mona Abdolkarimzadeh [19] proposed a type-1 fuzzy inference system. This system was based on real data using the Mamdani inference system. This was done to diagnose chronic kidney disease(CKD). The type-1 fuzzy inference system was enhanced later by using an adaptive neural fuzzy inference system. This system was tested on 400 CKD samples taken from Chamran Hospital, Iran. These data set were divided into two categories as CKD patients and non- CKD patients. The samples were characterized by 9 attributes like FBS (Fasting Blood Sugar), Na, K, Hemoglobin, Blood Urea, Serum Creatinine, , RBC (red blood cells), WBC (white blood cells) and age.

Juan Carlos Guzman et al. [20] proposed a Neuro-Fuzzy Hybrid system which takes two input values of blood pressure and produces a final diagnosis about blood pressure intensity level. This output is sent to the GUI system which consists of two major parts neural network and fuzzy system. This system is designed using two subsystems neural network and fuzzy system.

Gunasekaran Manogaran et al. [21] proposed a hybrid system to diagnose heart disease. This model was based on multiple kernel learning as well as an adaptive neuro-fuzzy inference system (. The input parameters were divided into heart disease patients and normal individuals. The then used to classify heart disease and healthy patients. Multiple kernel learning (MKL) was implemented in the former work whereas the neuro-fuzzy system (ANFIS) was used in later. The dataset consists of 250 observations each having 9 attributes that were used for the heart patients. In this research study

Y. Amirgaliyev et.al [22] showed the effects of clinical features to classify patients with chronic kidney. The support vector machine algorithm is used. The data set was based on the patient's clinical history, physical examinations,

and laboratory tests. Experimental results conducted yield classification of patients with results up to 93% of success. The performance parameters were tested based on accuracy, specificity, and sensitivity.

K.Thirunavukkarasu et. al [23] conducted several classification algorithms like logistic regression, K-nearest neighbor, and support vector to predict liver disease. The Accuracy score and confusion matrix both used to compare the classification algorithm.

A medical chatbot system developed by R. B. Mathew et. al [24] is a conversational agent. This requests users to give their health parameters as the symptoms which are then used for diagnosis. This system extracted symptoms based on conversations and predicts the disease as well as recommends treatment. This chatbot system was based on the k-nearest neighbor algorithm. The system proposed by

A. Mir and S. N. Dhage [25] builds a classifier model to predict diabetes disease. The Naive Bays, Support Vector Machine, Random Forest, and Simple CART algorithm were used on the WEKA tool. The study was done to predicts the best algorithm in terms of performance. The Experimental results of each algorithm were evaluated on the data set and observed that the SVM (Support Vector Machine) yields the maximum accuracy.

3. CHALLENGES IN DIAGNOSTIC EXPERT SYSTEMS

The review conducted on the diagnostic expert system by the various researchers using different approaches showed the importance of Artificial Intelligence. This shows the opportunities and challenges in the existing domain and further necessitates the research in the domain. The review work and contributions of researcher can be summarized as follows :

Author / Year	Methodology	Tool	Findings
C. Lee et al. [2]	Fuzzy Ontology and SDSA , FDO	C++ Builder	This expert system diagnose diabetes disease
Faith-Michael E. Uzoka et al. [3]	Analytical Hierarchy Process (AHP) and Fuzzy methodology.	MATLAB	This diagnose malaria patients. Based on data set taken from 30 malaria patients and performed both Analytical Hierarchy Process (AHP) and fuzzy methodology.
Ali Keles et al. [4]	Fuzzy rule based Ex-DBC expert system.	MATLAB	Diagnose breast cancer in women having positive predictive result (96%) and specificity result (97%).
Adel Lahsasna et al. [6]	fuzzy rule based system.	MATLAB	Diagnose coronary heart disease based on dataset UCI Repository machine learning. The 13 attributes out of 76 attributes were tested. Given attributes used for test results of 303 patients out of which 270 cases were verified.
Tarig Faisal et al. [7]	Adaptive Neuro-Fuzzy Inference System (ANFIS).	MATLAB	Accurately diagnose dengue disease with 86.13% applied ANFIS.
Shakil Ahmed et al. [13]	Fuzzy logic	MATLAB (fuzzy logic toolbox)	Diagnose kidney disease. The data set having 7 attributes and 817 samples. This data set was taken from the Birdem hospital Dhaka. The accuracy of system was 86.7% and used 30 samples.
Ramiro Meza-Palacios et al. [17]	Fuzzy logic	MINITAB2014 software.	Nephropathy control assessment. This gives result with 93.33% of accuracy. Data set of 90 patients. Each sample has 7 attributes
Tanmay Kasbe and Ravi Singh Pippal [18]	Rule based Fuzzy logic	MATLAB	Diagnose heart disease. The system was used to predicts the level of risk for a patient. The

			employed 13 input and 1 output parameters.
Juan Carlos Guzman et al. [20]	Neuro fuzzy hybrid system	GUI system	Takes two input values of blood pressure and produces final diagnosis about blood pressure intensity level.
A. Mir and S. N. Dhage. [25]	The Naive Bays, Support Vector Machine, Random Forest and Simple CART algorithm	WEKA tool .	Builds a classifier model to predict diabetes disease.

Table 1 : Important Findings of Diagnostic Expert Systems

4. AN APPROACH FOR RULE BASED FUZZY INFERENCE MODEL

The Most common fuzzy methodology i.e. Mamdani Fuzzy Inference model will be used in this proposed work. This methodology includes fuzzification of crisp data, inferring using knowledge base and rule base and defuzzification of fuzzy output to obtain crisp values. Fuzzification involves reading crisp data and map or translates it into fuzzy data for the use of inference system. Inferring includes reading fuzzy data and processes them on the basis of fuzzy rules and knowledge. The result obtained from inferring shows fuzziness. Thus in defuzzification, the result which is in fuzzy form is again map or translates into crisp values so that it becomes accurate and fruitful.

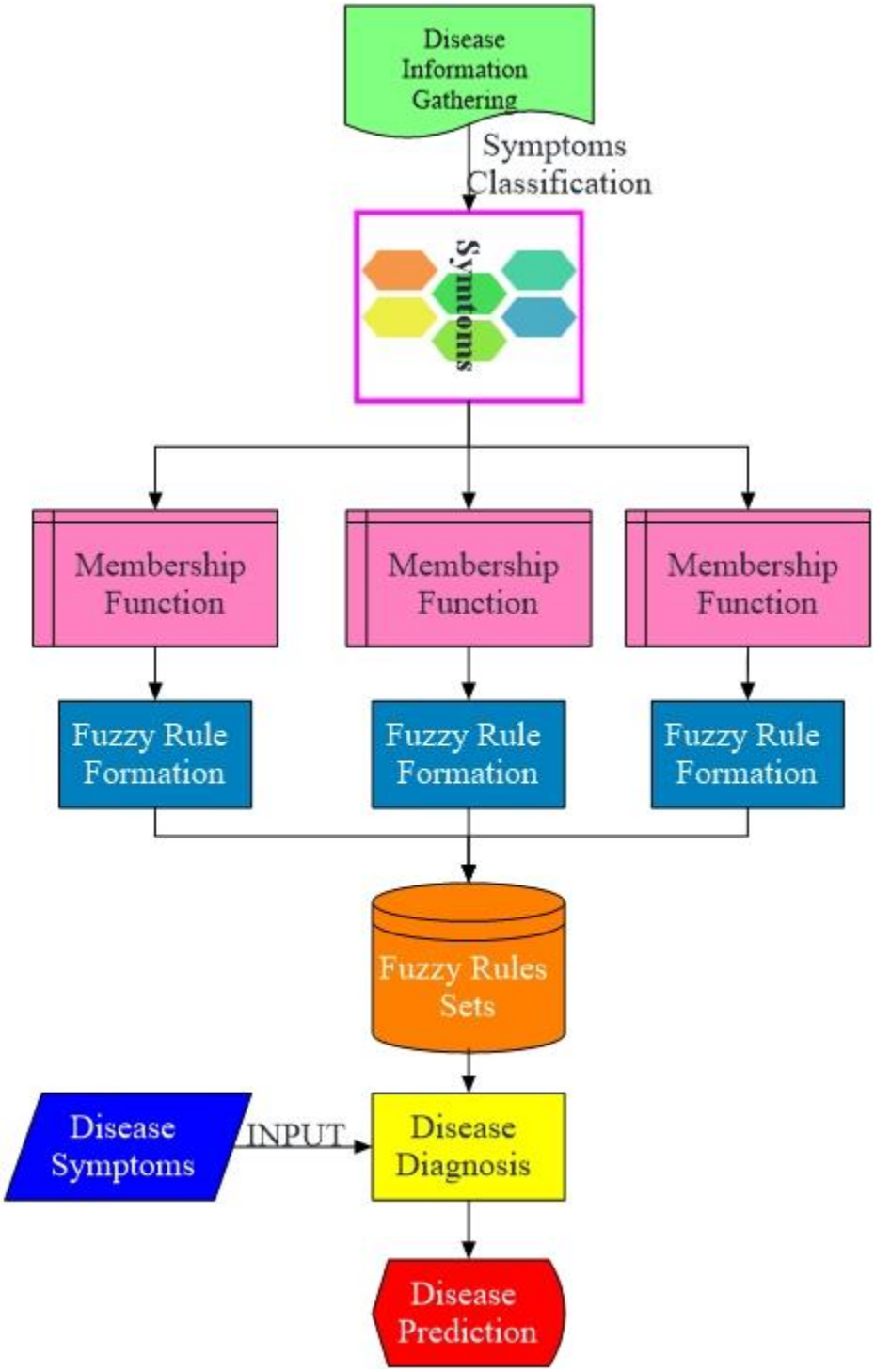

Fig.1: Methodology of Rule Based Fuzzy Inference Model

4. 1 PROCESS DESCRIPTION

There are many steps to follow that model the concept into implementing form. These steps are necessary and effective.

Step 1: Disease Information Gathering: To diagnose any disease it is much necessary and important to have a complete database of the disease. History, root causes, symptoms, and later effects of the disease are fed into the database of the system. The data thus collected is referred to as Expert Knowledge Base (EKB)

Step 2: Classification of symptoms: With the help of medical experts and physicians, symptoms and signs of disease are classified as there are several numbers of identical symptoms that exist in various diseases. It helps the inference system to apply logical rules on the given input.

Step 3: Fuzzy Rules Formation: Several logical rules are developed with attributes of sample disease. It involves developing rules using the IF-THEN structure with multiple logical AND and OR operators.

Step 4: Input Disease Symptoms: This is the step where the system is given input obtained from a laboratory test. The system then forwards these values of parameters to the inference mechanism.

Step 5: Disease Diagnosis using Fuzzy Logic: This is the core part of the system where parameters of the disease are analyzed by the inference engine of the expert system using a rule base and knowledge base and the result is concluded.

Step 6: Display result (Disease Prediction): The final result obtained from the inference engine is displayed in the crisp form that can be understood and explained by humans.

5. CONCLUSION AND FUTURE SCOPE

The intensive review of existing literature explored the work done in the domain of human disease diagnosis using artificial intelligence. The involvement of artificial intelligence may enhance the chance of early detection of the disease. The existing study reveals the importance of artificial intelligence in the diagnosis of human disease. The above literature review envisages the need for an expert system in different disease diagnosis. The accuracy of predictions based on the sample size of a patient's data poses the challenges in this domain. The use of methodologies under AI which ultimately leads the correct diagnosis motivates us to explore future work in this domain. This study helped us to find the possibilities of the design of Expert System (ES) based on paradigms of AI which would yield better results and accuracy.

This may assist medical professionals to diagnose their patients at the earliest possible time, especially in chronic diseases. The above review facilitates the opportunity to design an expert system using AI.

Although there are different paradigms of AI like Neural Network, Machine Learning, Deep Learning, and Fuzzy Logic the application of Fuzzy logic is versatile and gives the accurate prediction where ever approximation diagnosis is required.

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