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Application of Intelligent Computing Techniques for the Interpretation and Analysis of Biological and Medical Data for Various Disease diagnosis: Review

Devashri Raich[1], P.S.Kulkarni[2]
Department of Computer Science &Engineering, RCERT, Chandrapur, R.T.M.Nagpur University, India [1,2]

Abstract

Nowadays computer science is getting more and more involved in medicines and health services. Various AI techniques and soft computing techniques are used for the diagnosis of particular diseases for the betterment of patient health. Various clinical decision support systems are also been devised by the help of AI. Recent development in medical diagnosis includes various soft computing techniques, information processing and data mining techniques. Today various data mining techniques are also used to extract hidden information through clinical data. The aim of this paper is to introduce various intelligent computing techniques used for the medical diagnosis of diseases and a brief description about Nephritis and how its diagnosis could be done.

Keywords

Medical Diagnosis, Clinical Decision Support System, Artificial Intelligence, Soft Computing Techniques, Data Mining.

1. Introduction

Health of a human being is the most important aspect of being a good human being itself. Various types of clinical decisions are taken by the physicians to diagnose the affected person to cure him fast by prescribing him proper medical help through various drugs. Medical professionals use computers for the diagnosis of diseases since the invention of computers [6]. The paper is organized as; Section 1 gives a brief introduction about medical diagnosis. Section 2 introduces various intelligent computing techniques and section 3 gives the proposed methodology of this paper.

1.1 Medical Diagnosis

Medical Diagnosis can be stated as the process of determining or identifying a possible disease or a disorder. A clinician uses several sources of data and classifies this data in order to find the disorder. A medical diagnosis is made by a physician based on assessment of symptoms and diagnostic tests [23].

1.2 Clinical Decision Support System

Since from the earlier decades machine learning was used for the analysis of medical data sets. Today machine learning is used for efficient diagnosis of disease. Artificial Intelligence has the ability to learn and take its decision [6].AI maps human intelligence into computer aided technology [8]. The following flowchart shows the clinical decision taken for the patients for the chronic kidney disease who were referred by general practitioners [25].

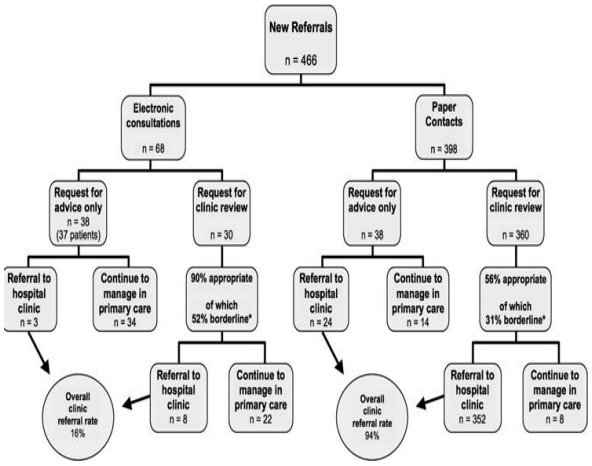

Fig 1: Flowchart for the clinical decision taken by general practitioners for CKD

A Clinical Decision Support System is an application that analyzes data to help health care providers make clinical decisions. A CDSS is an adaptation of decision support system commonly used to support business management. Physicians, nurses and other health care professionals use CDSS to prepare a diagnosis and to review the diagnosis as a means of improving the final result. Data mining may be conducted to examine the patient's medical history in conjunction with clinical research. Such analysis can help predict potential events, which can range from drug interaction to disease symptons.There are two types of CDSS [6].

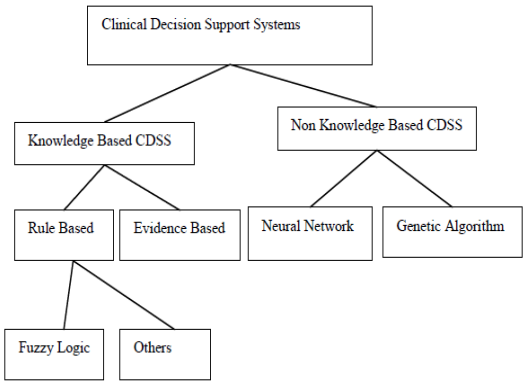

Fig 2: Different methodologies of CDSS

2. Intelligent computing techniques

There are various computing techniques which can be implemented for medical diagnosis.AI uses the effort to develop computer based systems that can behave like humans ,with the ability to learn languages,accompalish physical tasks, use the perceptual apparatus and emulate the human expertise and decision making[11]. Computing applications other than AI are also making a major impact on business, information technology; biomedical sciences etc. Organizations are using computing techniques such as neural networks, fuzzy logic, rough set logic, genetic algorithm, ant colony optimization and other intelligent agents to expand their knowledge base. These computing techniques are able to work with problems and information which are too large or complicated for humans to handle, especially in timely fashion. Intelligent systems are thus found supporting medication prescribing in clinical laboratories and educational settings for clinical surveillance or in data rich areas like the intensive care settings.

2.1 Medical diagnosis using Neural Networks

An artificial neuron is a computational model inspired by the natural neurons. Natural neurons receive signals through synapses located on the dendrites or membrane of the neuron.When the signals received are strong enough, the neuron is activated and emits signals through the axon. This signal may be sent to another synapse and might activate the other neurons.

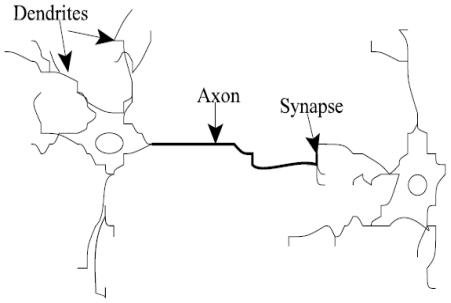

Fig 3: Neural networks (natural neuron)

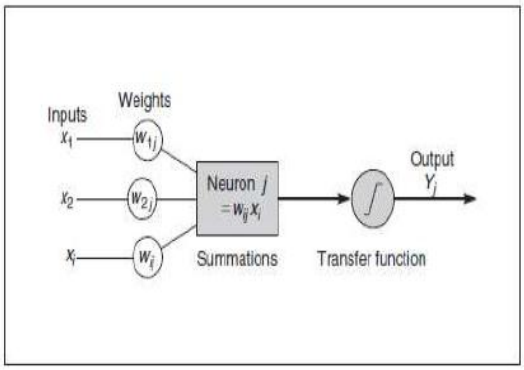

Fig 4: Mathematical model of neuron where w= weight vector and i = input vector is the activation function.

ANN is one of the recent areas of research in the field of biomedical sciences. Various methods like radial basis function, back propagation, perceptrons, SOMs, can be used for training so that a better diagnosis of disease can be done. In [9] the author had predicted the heart disease by using a redial basis function. The detail information about the patient was gathered as input. About 300 patients data was collected from the hospital, and then the radial basis function was applied to heart disease data for prediction of medical prescription of heart diseases. Following flowchart shows the proposed methodology. In [27] the author had classified the Parkinson's disease using NN and feature selection. In this paper a multilayer perceptron with back propagation learning algorithm are used for classification. The accuracy is in training data set was found to be 82.051% and in validation data set was found to be 83.33%. The author concluded that the feature selection helps in classification accuracy and thus improves efficiency.

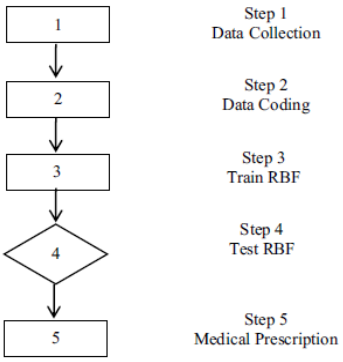

Fig 5: Flowchart for methodology used in [9]

In [28] the author has designed an expert system for diagnosis of Hepatitis B using ANN. The paper proposes the use of generalize regression neural network for classification of patients to be infected or immune mentioning the causes and severity.

2.2 Medical diagnosis using Fuzzy systems

Fuzzy logic is able to create rules by inferring knowledge from imprecise, uncertain, or unreliable information. Various terminologies are used in fuzzy logic such as fuzzification , defuzzification, membership functions, linguistic variables, domain rules, etc. the membership functions are a series of if-then rules, however fuzzy logic code requires fewer if-then rules than traditional code, which makes it simpler to use and to write.[4]In this paper the author uses fuzzy logic design for the medical diagnosis of hemorrhage and brain tumor. This research work proposes to develop a control system to enhance the efficiency of diagnosis of disease related to brain.

The fuzzy set can be interpreted by a family of Crisp Sets and fuzzy sets operators can be defined using standard set operators. Let U be a finite and non empty set called Universe. A fuzzy set A of U is defined by a membership function:-

$$\mu_A : U \longrightarrow [0, 1].$$

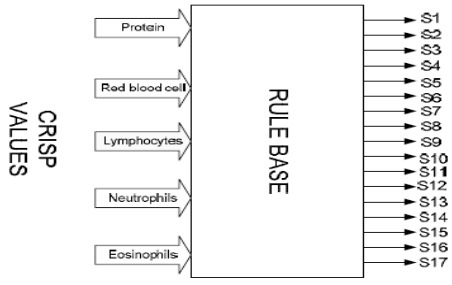

Fig 6: Block of rule base for fuzzy logic medical diagnosis control system

With the MIN-MAX system proposed by Zadah [20] fuzzy set operators are defined by,

$$\mu_{\neg A}(x) = 1 - \mu_A(x),$$
$$\mu_{A \cap B}(x) = \min[\mu_A(x), \mu_B(x)],$$
$$\mu_{A \cup B}(x) = \max[\mu_A(x), \mu_B(x)].$$

The diagnosis of renal failure is studied through [7]. In this, the author uses the adaptive neuro fuzzy inference system for the diagnosis of renal failure disease .In this model three rules and a Gaussian Membership functions are chosen .Seven parameters of patient were considered for diagnosis. Rules were determined by subtractive clustering method .This method assigns density to each data point,

$$P_i = \sum_{j=1}^{m} e^{\left(\frac{\|x_i - x_j\|^2}{\left(\frac{r_a}{2}\right)^2} \right)}$$

Where r_a is the positive constant and defines the neighborhood radius.

2.3 Medical Diagnosis Using Rough Set Theory

Rough sets are one of the hot research areas nowadays. Rough sets were proposed by Pawlak. Rough Sets is one of the mathematical tools to process fuzzy and uncertain information [3, 15, and 20]. Rough sets process uncertain or high dimensional data but it is sensitive to noise.

Let S be the information System which can be expressed as,

S=< U, R, V, f> where U is a non empty but finite object set that U= {x1,x2…..xn} is called Universe of discourse.

f = U * X -> V is an information function. It specifies the U in the x properly value of each object that

$$\forall x \in U, \ \forall a \in R, \text{have } f_a(x) \in V_a$$

For each subset, $X \subseteq U$

and indiscernibility relation B, the upper approximate limit and lower approximate limit of X can be defined as,

$$\underline{B}(x) = \{x \in : B(x) \subseteq X\}$$
$$B(X) = \{x \in U : B(x) \cap X \neq \Phi\}$$

In [10] the author has used a rough set theory for the diagnosis of renal disease using back propagation model. [12] shows an example how rough sets can be

used for medical diagnosis of mitochondrial encephalomyopathies in a child. A new induction algorithm is tried to be devised with the help of medical diagnostic rules defined from upper approximation in [9] by the author.

2.4 Medical diagnosis using Hybrid technologies

Medical diagnosis is a vast domain. Each and every information about a patient is important aspect of diagnosis of the disease. Considering human health as a key factor a best system has to be designed in order to have perfect diagnosis; however the use of a particular technique or soft computing tool depends on the following parameters:

1. What is the problem domain?
2. What can be the solution?
3. Amount of data available..
4. Researchers choice and purpose..

In [6], the author has suggested various soft computing techniques. In [10] a hybrid combination of rough set and neural networks is used for diagnosis. [7] uses neuro fuzzy inference system. The author in [29] proposes a plan of utilizing 4 types of neural networks for diagnosis of valve physiological heart disease from heart sounds.

3. Proposed methodology

Our main aim is to propose a better methodology for the efficient diagnosis of Nephritis with the aim to reduce the cost of diagnostic tests performed by the patient. Nephritis is inflammation of the kidney. The most prevalent form of acute nephritis is glomerulonephritis. This condition affects children and teenagers far more often than it affects adults. It is inflammation of the glomeruli, or small round filters located in the kidney. Pyelonephritis affects adults more than children, and is recognized as inflammation of the kidney and upper urinary tract. A third type of nephritis is hereditary nephritis, a rare inherited condition.

Diagnosis of nephritis is based on:

- the patient's symptoms and medical history
- physical examination
- laboratory tests
- kidney function tests
- imaging studies such as ultrasound or x rays to determine blockage and inflammation.

The diagnosis mainly focuses on artificial neural networks, fuzzy sets and rough set theory. The proposed plan is based on the diagnosis of patients by taking various laboratory test reports as input, applying different above mentioned techniques for the diagnosis of disease.

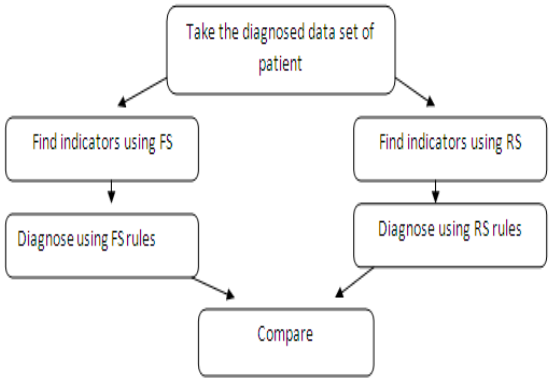

Figure 7: Categorization

4. Conclusion

With the development of science and technology, it is more and more important to utilize mathematical modeling and quantitative research methods to deal with various types of practical problems. Neural networks based on rough sets are one of the recent areas of research. Rough sets are used to determine uncertainly questions, while neural networks have the strongly fault tolerance, self-organization, massively parallel processing and self-adapted. Hybrid systems can be used for optimization of problem. Many other data mining applications other that biomedical can be analyzed using different soft computing techniques.

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Prof. Devashri Raich was born at Nagpur on 12th April 1983.Currently pursuing Mtech in Computer Science and Engineering. Recently working as an Assistant Professor in Rajiv Gandhi College of Engineering Research and Technology. She is a member of Institution of Engineers.

Prof. P.S.Kulkarni was born on 18th Nov. Currently pursuing Ph.D in Electronics Communication and working as Associate Professor in Rajiv Gandhi College of Engineering Research And Technology. Member of IE, ISTE.