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# Artificial Intelligence in Hypertension Diagnosis: A Review

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***Abstract*— Artificial Intelligence methods are becoming very popular in medical applications due to high reliability and ease. From the past decades, Artificial Intelligence techniques such as Artificial Neural Networks, Fuzzy Expert Systems, Robotics etc have found an increased usage in disease diagnosis, patient monitoring, disease risk evaluation, predicting effect of new medicines and robotic handling of surgeries. This paper presents an introduction and survey on different artificial intelligence methods used by researchers for the application of diagnosing or predicting Hypertension.**

***Keywords*-- Hypertension, Artificial Neural Networks, Fuzzy Systems.**

## I. INTRODUCTION

Hypertension or increased Blood Pressure is a major public health problem all over the world, causing risks of stroke, heart diseases and renal diseases. Hypertension risk increases in older age whereas its control becomes difficult with increasing age [15]. An increased blood pressure reading in a patient may be due to recently occurred circumstances or fear at the time of examination. In order to correctly evaluate the risk of permanent hypertension in a patient, physicians analyse numerous other factors from physical examinations of the patient. These factors include diabetes, heart conditions, renal conditions etc. Since the risk evaluation of hypertension depends on numerous factors, the physician may misunderstand the probability of hypertension in case the available data is incomplete or noisy. Thus, the early diagnosis and treatment of hypertension is a critical issue. Researchers have been proposing artificial intelligence techniques including Fuzzy and Neural Networks for the purpose of evaluating hypertension risk. This paper presents a review of the techniques used in this field.

This paper has been arranged into different sections as follows: The next two sections provide a brief introduction to Artificial Intelligence techniques namely Artificial Neural Network and Fuzzy techniques respectively followed by a detailed Literature Survey in Section IV presenting the research works of various authors in the application of hypertension diagnosis using the above mentioned techniques. Section V presents a problem definition for hypertension diagnostic systems based on the literature survey. The paper concludes in Section VI with a brief future scope of AI techniques for hypertension risk assessment.

## II. ARTIFICIAL NEURAL NETWORKS

Artificial Neural Network is a system modelled to work like the biological human brain that simulates multiple layers of simple processing elements called neurons. Each neuron is linked to its neighbours with varying coefficients of connectivity called weights as shown in Fig.1. These weights represent strength of connection between the neurons. Each neuron has an associated activation function which is performed on the input to get the output. Output from a neuron with input X and weight W is obtained as follows:

$$a_k = \sum_{i=1,n} W_{i,k} X_i$$

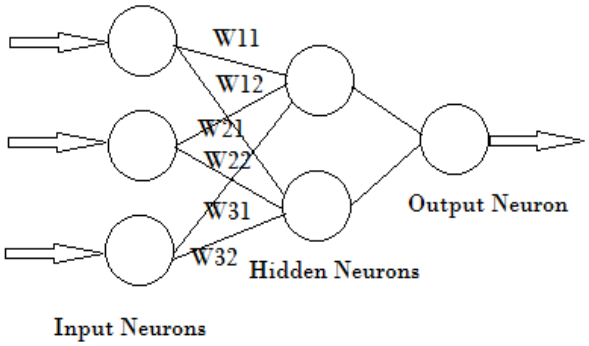


Fig. 1 Artificial Neural Network

Artificial Neural Networks are called machine learning algorithms. Neural Networks can learn to solve problems of a specific type when they are trained by adjusting weights according to some sample problems of same kind. The strength of connection between the neurons is stored as weight-value for the specific connection. The system learns new knowledge by adjusting these connection weights. Once trained, Artificial Neural Networks can generalize to solve other similar problems with different data values containing same input parameters. Learning and generalization ability of the neural network depends on its architecture and the algorithm chosen for its training.

Artificial Neural Networks with varying architectures and algorithms have been successfully employed for diagnosing wide spread diseases such as heart diseases [2], cancers [3], diabetes [4], thyroid [11], respiratory problems [5], influenza [10] etc.

## III.

## IV. FUZZY SYSTEMS

Facts which do not have sharply defined boundaries are called Fuzzy – for example, thin, tall, smaller, older etc. Fuzzy theory is based upon relative graded membership of a fuzzy set rather than binary membership or non-membership. A human brain works with fuzzy concepts, whereas computers may be artificially made compatible with such concepts with the use of Fuzzy Systems.

A fuzzy system comprises of a Fuzzy Rule Base and a Fuzzy Inference Engine as shown in Fig. 2.

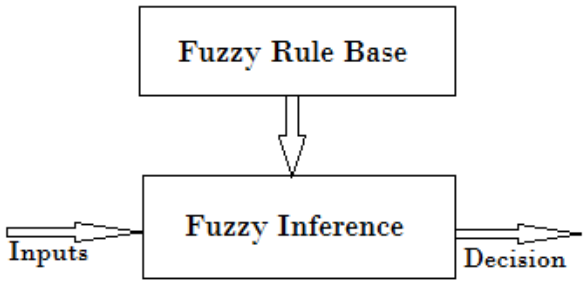


Fig. 2 Fuzzy System

The Fuzzy Rule Base contains a set of rules that are required to form decision from the given inputs. For example, IF $I_1$ is $A_n$ AND/OR $I_2$ is $B_n$ AND/OR ..…. $I_n$ is $N_n$ THEN Decision is $D_n$.

The Fuzzy inference mechanism consists of the steps as presented in Fig.3.

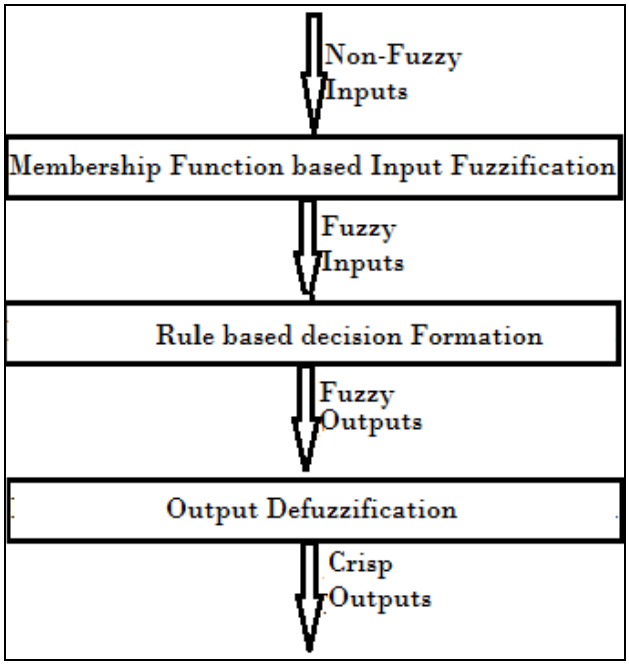


Fig.3 Fuzzy Inference Process

## V. LITERATURE SURVEY

One of the oldest works found regarding the use of AI in hypertension diagnosis is by **Riccardo, et al. (1991)** [17]. The authors of this paper presented a Neural Network based tool named Hypernet for hypertension diagnosis using Artificial Neural Networks. It presents a Graphical User Interface for training and testing of Hypernet.

Since then, many researchers have been using Artificial Intelligence techniques to diagnose risk of Hypertension. Researchers increase the reliability of their systems by varying Neural Network Architectures, Fuzzy Systems and Neuro-Fuzzy Systems. Researchers have chosen varying sets of input parameters to diagnose the disease more accurately. Aim of these works is to create or propose systems with maximum reliability which can act as an aid to the physician or can be used in the absence of the physician. Some examples of the reviewed literatures in this context have been presented here.

**Mevult Ture, et.al. (2005)** [16] has made a comparison between Decision Tree Approach, Statistical Algorithms and Neural Network Approach for diagnosing Hypertension by taking input factors from 694 subjects as age, sex, triglicerides, uric acid, cholesterol, BMI, lipoprotein, smoking habits and family history of hypertension. The paper concludes that the MLP and RBF Neural Networks proved best for this purpose.

**X.Y. Djam, et.al. (2011)** [13] has developed a Web based Fuzzy Expert System for the public to diagnose hypertension risk. Systolic Blood Pressure, Diastolic Blood Pressure, Age and BMI have been taken as input parameters. The output is in the form of Mild, Moderate and Severe risk. The paper explains the created system in detail using UML diagrams and screen shots of the web pages. The paper concludes that the created Fuzzy System proved to handle real patient situations like a Medical Expert.

**Azian Azamimi Abdullah, et.al. (2011)** [12] has proposed a Fuzzy Expert system with 9 fuzzy rules for the diagnosis of hypertension using Age, BMI, Heart Rate and BP as input factors. Output is in the form of Low, Medium and High risk. The paper proves that Fuzzy Expert System is an easy and cheap method for the problem of diagnosing the risk of hypertension.

**B. Sumathi, et.al. (2011)** [14] has used Feed Forward Back Propagation Network with 8 inputs containing risk factors for hypertension as Obesity, Smoking, Lack of Exercise, Salt intake, Alcohol consumption, Stress, Diabetes, Blood Pressure, Cholesterol, Kidney Disease and Thyroid Disease. The paper concludes that the results of the system were found reliable when verified with the physician.

**N. Shehu, et.al. (2013)** [8] has made a comparison between statistical and neural approach for the diagnosis of hypertension status. The paper concludes that Neural Network approach gives better result as compared to Logistic Regression and Discriminant Analysis.

**Rahul Samant, et.al. (2013)** [6] has used LM Back Propagation training algorithm in Feed Forward Network and decided the best configuration for the diagnosis of hypertension in the form of number of hidden layers and hidden neurons. 13 input parameters have been taken including age, pulse, systolic blood pressure, diastolic blood pressure, Serum Proteins, Serum Albumin, Hematocrit, Erythrocyte Sedimentation Rate, Serum Cholesterol, Serum Triglycerides, Whole Blood Viscosity, Plasma Viscosity and Red Cell Aggregation.

Again, **Rahul Samant, et.al. (2013)** [7] has made a comparison of Feed Forward Back Propagation Network, Element Back Propagation Network and Cascade Forward Back Propagation Network using LM training algorithm. The paper has divided the input data into four datasets comprising of Diabetic, Non Diabetic, Hypertensive and Non Hypertensive samples. It concludes that Element Back Propagation Network proved best for 3 datasets and Cascade Forward Network proved best for 1 of the datasets.

**Pankaj Shrivastava, et.al. (2013)** [9] has presented a Fuzzy expert system with Age, BMI, BP and Heart Rate as input variables. Each variable has been represented as very precise Fuzzy Sets in order to improve the performance of the Fuzzy System.

**Sujit Das, et.al. (2013)** [1] has made a comparison between Fuzzy and Neuro-Fuzzy System for the purpose of Hypertension Diagnosis. The Data used in this study includes four input parameters viz. Age, Blood Pressure Heart Rate and BMI. The paper has also compared LM, GD and BR Back Propagation Algorithm for the same. It concludes that the Neuro-Fuzzy System with LM training algorithm has proven the best among the compared systems.

## VI. PROBLEM DEFINITION

Hypertension is a very wide spread disease causing numerous other health problems. Hypertension diagnosis is a complex problem with a variety of risk factors. It is required that the risk factors taken as inputs to the Hypertension Diagnosis systems be chosen very carefully with expert suggestions. It has been found in the literature survey that all the existing works with Artificial Neural networks have used a wide variety of input variables whereas Fuzzy Systems as well as Hybrid Neuro-Fuzzy Systems have been performed with a maximum of four input risk factors. A Hybrid Neuro-Fuzzy System like in [1] can represent the knowledge of a physician better than simple Neural Network Systems or Fuzzy Systems. More important factors such as Lipid Profiles, Glucose, Renal Function Profiles need to be included in the input parameters to such hybrid systems. The results of the system can be improved by employing performance optimization methods.

## VII. CONCLUSIONS

It may be concluded from the above literature review that Artificial Neural Networks and Fuzzy Systems have been successfully employed by researchers for diagnosis of Hypertension Risk. A number of research works have proven that Artificial Intelligence techniques are much more reliable and accurate as compared to conventional statistical methods for this problem. Future scope is in proposing an optimized hypertension diagnosis system with important input variables by using hybrid AI technologies.

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