

DEVELOPMENT OF AN ENHANCED SELECT AND TEST (ST) MODEL FOR CLASSIFICATION OF HYPERTENSION

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ABSTRACT

The World Health Organization estimated that one in three adults worldwide are affected with raised blood pressure (hypertension). A lot of efforts have been recorded in the design, development and implementation of expert systems for diagnosis of various diseases and medical conditions. The existing Select and Test (ST) approach was constrained in its ability of touching base at symptomatic level with sufficient precision. As an answer to this, this research improved the methodology for restorative diagnosis dependent on Select and Test approach using Certainty Factor. The enhanced approach demonstrated the incentive with outright assurance, and was utilized all the more proficiently and viably in touching base at diagnosis. The ST with Certainty Factor was designed, implemented and programmed in Java to classify hypertension. The model developed outperformed the existing model based on accuracy of the classification done during the evaluation. Using 100 cases for the evaluation, Select and Test gave 74% accuracy in the classification while Select and Test with Certainty factor had 97% accuracy.

Keywords: Hypertension Diagnosis, Expert system, Select and Test Algorithm, Certainty Factor.

1. INTRODUCTION

Man by nature takes decision based on past experience or the evidence produced within the context of the problem. By profession, doctors also follow the same strategy when they diagnose diseases or treat patients of their illnesses. In medical diagnosis, doctors make diagnosis on the basis of matching precise symptoms or measurements. Based on experience, expertise, awareness and observation of the doctor, medical diagnosis varies from one medical practitioner to another. The World Health Organization estimated that one in three adults worldwide are affected with raised blood pressure a condition that causes around half of all deaths from stroke and heart disease. This report is further evidence of the dramatic increase in the conditions that trigger heart disease and other chronic illnesses, particularly in low- and middle-income countries. The worldwide, high blood pressure is estimated to affect more than one in three adults aged 25 and over, or about one billion people. In 2013, this continuously increasing statistics informed the theme of the World Health Day 2013 which was “measure your blood pressure, reduce your risk (WHO, 2013). The prevalence of hypertension in Nigeria has been reported as 33.2% among males and 31.7% among female population totaling 32.5% (WHO, 2013). In the face of this threatening statistics, researchers have suggested that the situation can be alleviated if people monitor the level of their blood pressure and are encouraged to seek medical attention as and when required.

Notable efforts have been recorded in the design, development and implementation of the expert systems for diagnosis of various diseases and medical conditions. The need for individuals to have access to computer applications on their personal computers which can diagnose hypertension by reading user’s systolic blood pressure and diastolic blood pressure has been emphasized in extant literature. Much attention has been focused on design of expert systems for detection of hypertension using; fuzzy logic, rule-based and knowledge –based technique. While knowledge-based technique has been found advantageous, little attention has been given to its use and arrays of inference methods. It is in view of this that this study seeks to design and implement the use of a knowledge-based expert system capable of diagnosis and interpretation of hypertension using Select and Test (ST) algorithm along with Stanford Certainty Factor Algebra for its diagnostic reasoning.

2. LITERATURE REVIEW

Expert systems are extensively used as diagnostic tool in the medical industry. Diagnosis expert systems (DExS) used in consultation has over the years proven helpful to medical professionals in the areas of quick display of diagnosis and in addition, offering explanations on the obtained results. With expert systems, the user can interact with a computer to solve a certain problem and this is made possible by the capacity of expert systems to store heuristic knowledge (Patra et al, 2010).

Al-Kateeb (2002) attempted the design of an integrated expert system for general diagnosing systems that contains all the facilities necessary to help its users (human expert) to complete their jobs easily and efficiency. Two shells were designed and implemented: General Automatic Diagnosing Expert System (GADES) and General Automatic Code Expert System (GACES). The system is designed as two phases shell with an automatic friendly inference (expert interface), and an inference engine. The first phase is responsible for acquiring human expert knowledge in an automatic way by using menus and message windows. The second phase is concerned with the design of an inference engine together with a user interface that uses a backward chaining. Both shells however, reasons under uncertainty using the certainty factor method.

Melle (1978) implemented an integrated intelligent diagnosis system for diabetes named LDA-ANFIS (Linear Discriminant Analysis (LDA) and Adaptive Network Based Fuzzy Inference System (ANFIS)). The first phase of this system i.e. (LDA), is used to separate feature variables between healthy and diabetic patients' data while the ANFIS is used as a second phase classifier where the healthy and diabetic patient's features obtained from the first phase are entered. This diagnosis system is found to give reasonable results in classifying the possible diabetes patients and could be used to help clinicians reach final decision regarding their patients.

Abdullah, Zakaria and Mohammad (2011) noted that hypertension is a silent killer because it has no symptoms and can cause serious ailments if left untreated for a long time. They developed an intelligent and accurate diagnostic system that is capable of providing faster, cheaper and more accurate result compared with other traditional method. The designed system diagnoses hypertension risk for patients aged between 20 and 40 years. The diagnosis is based on fuzzy logic arguing that Fuzzy expert system design is very appropriate compared to other statistical methods because fuzzy expert system can simulate the doctor's behaviour in order to diagnose diseases.

Lee and Wang (2011) present a novel fuzzy expert system for diabetes decision support application. A five-layer fuzzy ontology, including a fuzzy knowledge layer, fuzzy group relation layer, fuzzy group domain layer, fuzzy personal relation layer, and fuzzy personal domain layer, is developed in the fuzzy expert system to describe knowledge with uncertainty.

Geman (2011) delineates a model of a fuzzy expert system, dedicated to Parkinson's disease diagnosis. The input parameters of the system are represented by amplitude, frequency, the spectral character and trembling localization. The last one signifies the main symptom that occurs in Parkinson's disease, but others can also be mentioned: small handwriting, loss of smell, trouble sleeping, soft or low voice.

Singla et al (2014) developed an expert system to identify the most important lung diseases in patients. The judgment is made using the symptoms that can be felt by the patient. This medical expert system aids the doctor or expert in building the proper diagnosis of the patient. The lung diseases have many regular symptoms and some of them are very much alike. This creates much complicatedness for the physician to reach a right conclusion. This expert system can take away this complicatedness and it works well for thirty-two lung diseases. Its correctness is 70%.

Fernando and Henskens (2013) acknowledged the challenges in developing successful medical expert systems, introduced a simplified version of algorithm and data structures required for implementing an inference engine and knowledgebase, based on a previously introduced diagnostic reasoning model. They argue that the select and test (ST) reasoning model is more comprehensive among the many diagnostic reasoning models that have been introduced. The ST algorithm models the recursive steps that are involved in real world diagnostic reasoning, using logical inferences. They had earlier provided the core structure on which, the full model can be built and recommend the use of CLAP software to develop medical expert systems so as to identify and resolve challenges associated with the development process (Fernando, Henskens and Cohen, 2012).

Ragab, Abdullah and Ismail (2005) develop expert systems for diagnosis of heart disease with certainty factor method. Heart disease is classified into 25 types of disease that is left heart failure and right heart failure in the form of semantic networks. Data is divided into patient demographic data (age and sex) and clinical data such as laboratory results and clinical examination. Knowledge representation is done by using production rules.

Handayani and Sutikno(2005) developed the design and use of expert system shell e2gLite for the diagnosis of the ear, mouth and throat diseases. The shell e2gLite must be made 2 pieces of the files containing the applet of web pages and knowledge base. The system can identify 23 types of the ear, mouth and throat diseases based on variations of 38 symptoms.

Kancere et al (2014) developed a hypertension diagnostic system for use of both practitioners in the field of medicine and in-training medical students. The system was designed to screen and determine whether or not a patient has arterial hypertension, identifies the cause and presents the treatment strategy. The trio made use of a two-window user interface, which are complementary; an interactive dialogue window and a data input and processing window. The diagnosis system was developed using Borland Delphi 7 with its knowledge base developed in the form of production rules, based on 25 diagnostic symptoms, linear discriminated functions (with threshold values) and decision trees. The reliability test of the system showed that the system gave the same diagnosis in 14 out of 18 cases.

3. METHODOLOGY

This research work used the experimental approach. An existing algorithm for classifying hypertension was modified by including a certainty factor. The modified algorithm was developed using Java programming language and MySQL for storage. The performance evaluation of the existing and modified algorithms was done using specificity, sensitivity and accuracy as metrics.

The proposed enhanced Select and Test (ST) algorithm discussed is a rule base expert system. It is an attempt to develop an expert system to classify hypertension with its treatment, which is based on certainty. This begins with the acquisition of demographic and medical data from medical experts and government licensed hospital to train the program developed. The system acquired knowledge from human experts into the knowledge base which was stored and used by the inference engine for execution and classifying the cases.

The data used was collected from Shekinah Medical Centre, Owode, Oyo, Oyo State. This consisted of 100 clinical reports of hypertensive patients. The data contained different variables that diagnose the presence or absence of hypertension from the result of various medical tests carried out on patients. The variables collected and used in these research are: age, sex, increased blood pressure, severe headache, fatigue, chest pain, irregular heartbeat, and blurred vision.

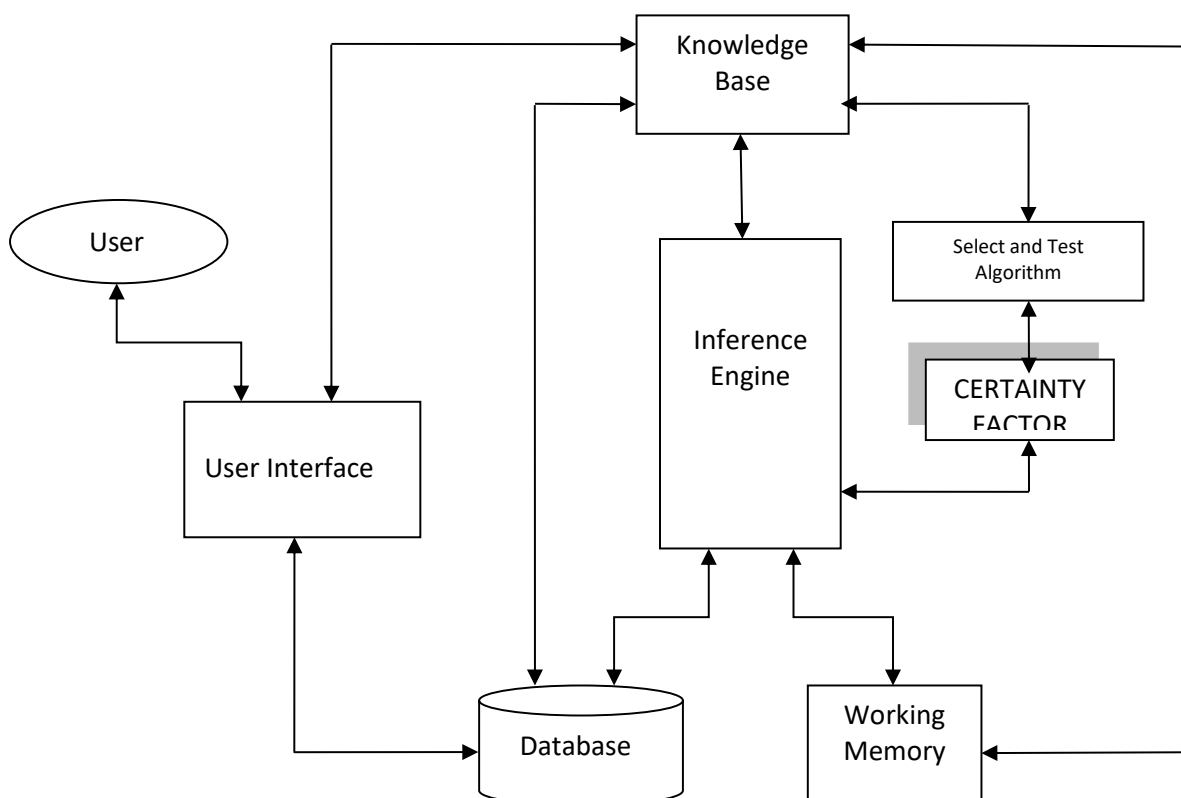


Figure 1: Architecture of Hypertension Classification System

The architecture of the hypertension diagnostic system shown in Figure 1 has eight (8) modules. The modules will be briefly discussed:

User- This user interacts with the resulting system after considering the nature of the problem to be solved by an expert system. The subsystem performs the task of communicating with the user in a form of question and answer dialog.

User Interface - The user interface is designed on a dialog system using question and answer subsystem. The information provided the system with 'yes' or 'no' to identify the presence or absence of the disease.

Knowledge Base (KB) - Knowledge base (KB) stores the human expert knowledge about hypertension disease using the components of the system. The KB is used by the inference engine subsystem to reach diagnostic result after the system has inquired the answer of the relevant question. The system stores the human expert knowledge in the database. It uses the rule base representation to formulate the knowledge in the form of 'If...Then' rules and store them as facts in the databases. Two types of databases are provided which are internal database (working memory) and external database (to store knowledge base). The internal database (i) stores the user answers about a given questions and uses this answer to check if the question already exist and (ii) stores the user answers about a given questions and uses the information later in case the question is asked later. The external database stores the information obtained from the expert during the expert interface module.

Inference Engine - An inference engine manipulates the knowledge represented in the knowledge base of the system and operates on the fact set, which is looked upon as the global working memory for the production rules. The inference mechanism describes a cyclical process that uses the logical inferences, abduction, deduction, and induction. The diagnostic reasoning searches for symptoms and later arrives at diagnoses based on the symptoms found in the previous step. The inference engine searches the external database to get the specified question and tries to prove/ disprove it in order to get conclusion(s). In this aspect, the reasoning is based on certainty factor (CF) to reflect uncertainty.

Certainty Factor - Certainty Factor shows the absolute certainty of the symptoms given, ranging their effectiveness between -1 to 1 and specifically declares the symptoms responsible for hypertension. Certainty Factor is described as:

$$CF(H, E) = MB(H, E) MD(HE) \quad (1)$$

where

CF(H,E) : certainty factor from hypothesis H influenced by evidence E. CF value is from -1 to 1. Value of -1 shows absolute uncertainty whereas value of 1 shows absolute certainty.

MB(H,E) : measure of increased belief to hypothesis H influenced by evidence E.

MD(H,E) : measure of increased disbelief on hypothesis H influenced by evidence E.

The classification system was developed using the algorithm given as Algorithm 1.

ALGORITHM I

Step 1: start

Step 2: login interface

If user is not registered then

Register

Else

Login with userID and password

Step 3: acquire data

Step 4: implement the ST model shown in Figure 1

Step 5: perform diagnosis

User answers the probable question
 If there are more questions
 Ask next question
 Else
 Match answers to ST + CF model
 Step 6: check the probabilistic values for the hypertension nodes.
 Step 7: if values<0 then
 Patient has no hypertension. Move to step 9
 Else if values>0 then
 The Patient has hypertension
 Return probabilistic of patient having hypertension
 Step 8: offer prescription based on result of step 7
 Step 9: Stop

Algorithm 1: The ST with CF Algorithm

4. RESULTS AND DISCUSSION

The developed model was taken to two private hospitals, (Shekinah Medical Center, Owode, Oyo, and Favour Land Medical Centre, Gedu Scheme, Oyo) at the space of six (6) weeks to check for its operations on patients. One hundred (100) patients were attended to with the help of paramedics and the results were compared with the doctors diagnosis. Some questions were asked to know their health status, in order to diagnose if and if not they are hypertensive. Hypertensive related questions that were asked were grouped into different stages as shown below:

- A – How old are you?
 - B – What is the range of your blood pressure?
 - C – How often do you experience severe headache?
 - D – How often do you feel chest discomfort?
 - E – How often is your heartbeat irregular?
 - F – How often do you get tired?
- User's Response: Key: 4 = Always, 3 = Occasionally, 2 = Sometimes, 1 = Never.

Table 1 and 2 below gave the analysis of the user's response after their interactions with the expert system. Table 1 shows the predictions on an existing ST model and it was able to predict out of 50 hypertensive patients, that 24 patients have stage 2 hypertension, 15 patients have stage 1 hypertension. From the remaining 50 patients that were hypertension free, the model recorded that 35 patients have no hypertension and only 15 patients have pre-hypertension. Table 2 on the other hand shows the predictions on the new ST and CF model. The prediction out of 50 patients that were hypertensive, gave 26 patients with stage 2 hypertension, 21 patients with stage 1 hypertension. And from the remaining 50 patients that were hypertension free, predicted that 35 patients have no hypertension.

Table 1: Analysis for ST model

Cases	50 Cases		50 Cases	
Population Number	Stage 2 hypertension	Stage 1 hypertension	Pre-hypertension	No hypertension
100	24	15	15	35

Table 2: Analysis for ST + CF model

Cases	50 Cases (Patients)		50 Cases (Healthy)	
Population Number	Stage 2 hypertension	Stage 1 hypertension	Pre-hypertension	No hypertension
100	26	21	0	50

Sample user interfaces are shown in Figures 2 and 3. In Figure 2, stage 2 hypertension was diagnose after the patient has carefully supplied the necessary answer into the system and the patient is asked to seek medical care immediately. Figure 3 diagnoses stage 1 hypertension and the patient should seek medical care at the hospital.



Figure 2: Result page for stage 2 Hypertension

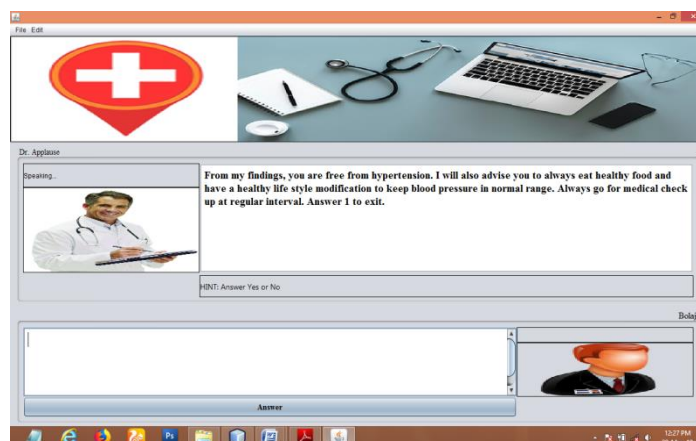


Figure 3: Result page for no Hypertension

4.1 Performance Evaluation

After the implementation of the model for 100 patients at the selected hospitals, the results of the implementation was checked for its: Accuracy, Sensitivity, and Specificity.

4.1.1 Performance Evaluation of ST with CT model:

From the 50 patients attended to, 47 patients were diagnosed correctly while 3 were reported healthy.

- i. Sensitivity: From the 50 patients, the test has diagnosed 47 patients. Therefore, its sensitivity is 47 divided by 50 or 94%.
- ii. Specificity: From the 50 healthy people, the test has correctly pointed out all the 50. Therefore, its specificity is 50 divided by 50 or 100%.
- iii. Accuracy: From all the 100 cases that have been tested, the test could determine 47 patients and 50 healthy cases correctly. Therefore, the accuracy of the test is equal to 97 divided by 100 or 97%.

4.1.2 Performance Evaluation of ST algorithm:

From the 50 patients attended to, the test diagnosed 39 patients correctly while 11 were reported healthy.

- i. Sensitivity: From the 50 patients, the test has diagnose 39 patients. Therefore, its sensitivity is 39 divided by 50 or 78%.
- ii. Specificity: From the 50 healthy people, the test has correctly pointed out 35. Therefore, its specificity is 35 divided by 50 or 70%.
- iii. Accuracy: Of all the 100 cases that have been tested, the test could determine 39 patients and 35 healthy cases correctly. Therefore, the accuracy of the test is equal to 74 divided by 100 or 74%.

Table 3: comparison between ST and ST algorithm with CF

Algorithm	ST	ST & CF
Specificity	70%	100%
Sensitivity	78%	94%
Accuracy	74%	97%

5. CONCLUSION

The use of certainty factor (CF) along with the normal Select and test (ST) model gave better results in the classification of hypertension. This research work has helped to develop a system that can classify hypertension with ninety-seven percent (97%) accuracy. The system will help the doctors and paramedics to classify and treat hypertension quickly and reliably.

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