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An Android-Based Expert System for Diagnosis of Selected Tropical Diseases Using Fuzzy-Analytic Hierarchy Process

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Abstract

Nigeria, has a high rate of occurrence of tropical diseases. The commonest ones being malaria, typhoid and tuberculosis. Malaria alone results in over 300,000 deaths every year. Adding to this, there is a serious shortage of Doctors in the health sector. Artificial Intelligence is being applied in several endeavours including medicine. The most popular application of Artificial Intelligent is the Expert System. Fuzzy Logic is a form of logic that allows for different levels of truth and falsehood to be represented. It allows symptoms such as high fever, strong headache, and moderate nausea to be logically represented. Analytic Hierarchy Process is a model for organizing and analyzing complex decisions such as disease diagnosis. This work intends to develop an android-based expert system for the diagnosis of some tropical diseases using a hybridization of Fuzzy logic and Analytic Hierarchy Process. At the knowledge acquisition stage, questionnaires will be administered to medical doctors at four hospitals. The questionnaire will obtain information on the pair-wise comparison of the symptoms that are used in the diagnosis of tropical diseases. Analytic Hierarchy Process will be used to calculate the weights of each symptom for each tropical disease. These weights will serve as the input parameters to the fuzzy system. The weights will be assigned membership functions. The membership functions will be used to derive rules which can then be used to derive output membership functions that are used for diagnosis.

Keywords: *Tropical diseases, Expert system, Fuzzy logic, Analytic hierarchy process*

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Background to the Study

Tropical diseases, according to World Health Organization (2016a), are infectious diseases that thrive in hot, humid conditions. Examples include malaria, river blindness, Lassa fever, Ebola haemorrhagic fever, and tuberculosis. These diseases are common in Nigeria (a tropical country) due to the prevalence of disease carriers like the mosquito. There are an estimated 100 million malaria cases with over 300,000 deaths per year in Nigeria (United States Embassy in Nigeria, 2011). In contrast, there is a severe shortage of physicians. The World Health Organization placed the physician density in Nigeria at 0.376 per 1000 persons (2016b). This means that a doctor is available for every 2,660 persons. Excess stress is placed on the health sector. Consequently, Doctors cannot perform at their optimum while patients may not get quality health care.

An expert system is an intelligent computer program that simulates the decisions and actions of an expert in a field by consulting a knowledge database constructed from the knowledge of experts in that field. An expert system separates the underlying knowledge from the procedural part of the system allowing the knowledge to be updated with minimal changes to the system. Analytic Hierarchy Process (AHP) developed in the 1970s by Thomas L. Saatyis a technique for organizing and analysing complex multiple criteria decisions. It decomposes a decision problem into a hierarchy of sub-problems, each of which can then be analyzed independently.

Fuzzy logic was first proposed by Lotfi A. Zadeh of the University of California at Berkeley in 1965 (Dadios, 2012). It is an information processing technique that uses linguistic variables that are vague to process data. It allows for the representation of partial truth. Fuzzy system is useful when an exact solution is not necessary but an approximate and fast solution is needed. Fuzzy logic also becomes necessary when the inputs to a problem are vague, ambiguous or not known at all.

Literature Review

Application of Artificial Intelligence to Medical Diagnosis dates back to the 1970s (Uzoka*et al,* 2016). Several research work has been carried out in improving the performance of the expert systems that are used in medical diagnosis. The following review of literature shows some soft-computing technologies that has been applied to the development of Medical Decision Support Systems.

Application of Artificial Neural Network to Medical Diagnosis

Al-Shayea (2011) proposed a feed-forward back propagation neural network based system for the diagnosis of Nephritis disease and heart disease. The system consisted of three layers: the input, hidden and output layers. The input samples were divided into training, validation and test sets. The training set was used to teach the network. The inputs to the system are symptoms and medical images. The data set contained 120 patients: 90 for training, 30 for testing the network. Neural network toolbox from MATLAB 7.9 was used to evaluate the performance of the proposed networks. The system was very accurate at diagnosing.

Application of Fuzzy Logic to Medical Diagnosis

Obi, Eke, and Osagba (2018) proffered a diagnostic system that will aid medical practitioners in the fast and accurate diagnosis of tuberculosis, early treatment by prescribing appropriate medications based on the patient complaints, the signs and symptoms and isolation of carrier to curtail further spread of the disease. The authors stressed the importance of fast and accurate diagnosis to the worldwide control of tuberculosis. They made use of Fuzzy Logic Mining Techniques to model uncertainty inherent in diagnosis. A knowledge base deduced from 36 fuzzy rules was used for diagnosis. The fuzzy system had 11 attributes. The proposed system was simulated using MATLAB (R2010a) using the Fuzzy Logic Design Toolbox version 7.10.0. The inputs were fuzzified using the trapezoidal membership function and the output was defuzzified using the Weighted Average method. The system was implemented using Hypertext Pre-processor. MYSQL was used as the database and WAMP server as the server technology. The proposed system made use of forward chaining reasoning to determine the rules that fires.

Hybridization of Soft-Computing Techniques in Medical Diagnosis

Obi and Imianvan (2011) analyzed the medical diagnosis of leukaemia using neuro-fuzzy inference procedure. The system contained 14 symptoms needed for the diagnosis of Leukaemia. The inference engine consists of reasoning algorithm driven by production rules. These production rules are evaluated by using forward chaining approach of reasoning. The system is interactive and could tell the patient his current condition as regards Leukaemia. The system contains several subsystems, two of which are: The Cognitive filter and the emotional filter. The cognitive filter ranks the patient on the presence or absence of Leukaemia disease while the emotional filter ranks the patient on the extent of his Leukaemia disease.

Nagarajasri and Padmavathamma (2013) developed a hardware system that uses threshold neuro fuzzy expert system for the diagnosis of breast cancer. The hardware used is the ARM Cortex-M3. The neuro-fuzzy system has a 3 layered feed forward architecture. The first layer corresponds to the input variables and has five input units (mass shape, mass margin, mass density, calcification and calcification distribution). The second layer holds the fuzzy rules. The second layer consists of six output units. The aim of their work is to assist physicians and radiologists in clinical diagnosis.

Uzoka*et al* (2016) presented a framework for diagnosis of confusing tropical diseases based on the Fuzzy-Cognitive Map Hybridization. Malaria, Typhoid, Chicken Pox, Measles, Hepatitis, Yellow Fever and Urinary Tract Infection was considered in the study and an accuracy of 85% was achieved in diagnosis. The work intended to collect data from 200 physicians in Nigeria. 60% of collected data would be used as training set while 40% would be used as test set. The knowledge base was composed of quantitative (structured) and qualitative (unstructured) knowledge of medical diagnosis. The structured knowledge is concerned with facts, rules and events. The unstructured knowledge is heuristic knowledge.

From the foregoing, it is evident that it has become a popular trend to develop Medical Decision Support Systems based on the hybridization of two or more soft-computing technologies. Examples are the Neuro-Fuzzy (Obi and Imianvan, 2011) and the Fuzzy-

Cognitive Map (Uzoka*et al,* 2016). The goal of hybridization soft-computing techniques is to increase the accuracy of the resulting system. Also, it is noticed that very few medical decision support systems have been developed on the Android platform for application in the hospitals.

Research Methodology
System Architecture

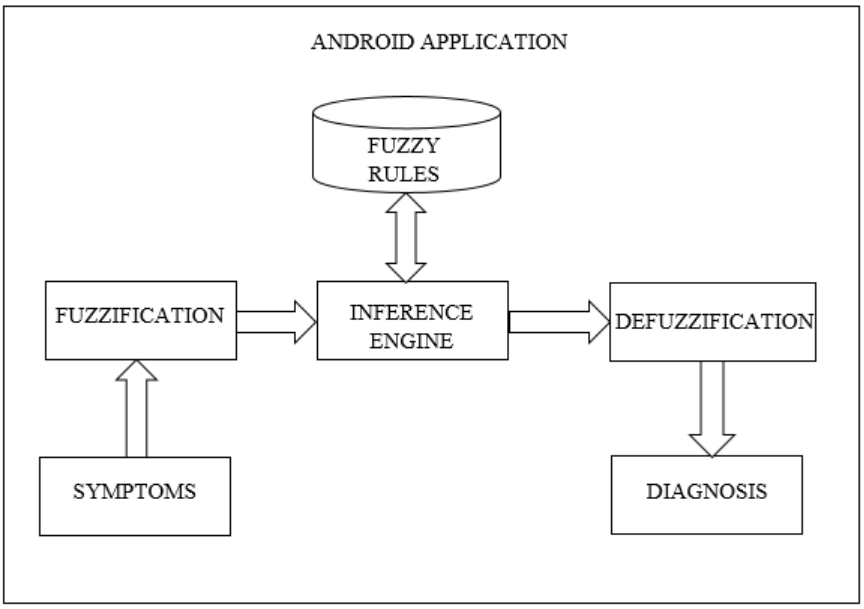

Figure 1: Proposed System Architecture of the F-AHP system

The proposed system architecture is shown in figure 1. The patient supplies his symptoms through the User Interface to the system. The system fuzzifies these symptoms using Trapezoidal membership function. The inference engine then fire rules in the rule base to diagnose based on the symptoms inputted. Once diagnosis is done, it is defuzzified using Weighed average method and presented to the user through the User Interface.

Data Acquisition
This work will consider Malaria, Tuberculosis, pneumonia and Cholera. The expert knowledge on these tropical diseases is gathered through structured interviewing of medical professionals. Questionnaires are being distributed to medical doctors at Ekiti State University Teaching Hospital (EKSUTH), Federal Medical Centre (FMC) Ido-Ekiti, Obafemi Awolowo University Teaching Hospital (OAUTH), Ile-Ife and University College Hospital (UCH), Ibadan. The questionnaire will help to gather the knowledge of the doctors in the form of pair wise comparison of the symptoms used in the diagnosis of the selected tropical diseases. The questionnaire contains a table, shown below as table 1, to help the respondents rate the importance of the symptoms for each tropical diseases.

Table 1.

Symptoms	Not important	Moderately important		Strongly important		Very strongly important		Extremely important	
	1	2	3	4	5	6	7	8	9
Abdominal Pain									
Chest pain									
Chills									
Constipation									
Cough									
Dehydration									
Diarrhea									
Fatigue									
Fever									
Headache									
Jaundice									
Loss of Appetite									
Nausea									
Rashes									
Runny nose									
Shortness of breath									
Vomiting									

Data Analysis

Analytic Hierarchy Process

For each of the tropical diseases considered in this work, Analytic Hierarchy Process will be used to process the pairwise comparison obtained from the questionnaire to generate the weights/eigenvectors of each symptom. The weight/eigenvector of the symptom is the importance of that symptom in making the final diagnosis. These weights will be used to develop fuzzy IF-THEN rules that will serve as the knowledge base for the Fuzzy Inference System. The Fuzzy Inference System will be a Mamdani Inference System that uses IF-THEN propositions of the form:

$$IF\ x_1\ is \underline{A}_1^k\ and\ x_2\ is \underline{A}_2^k\ and\ \dots and\ x_n\ is \underline{A}_n^k\ THEN\ y^k\ is \underline{B}^k$$

The system will apply a max-min inference method.

Fuzzy Logic

The Fuzzy Inference System will be a Mamdani Inference System that uses IF-THEN propositions of the form:

$$IF\ x_1\ is \underline{A}_1^k\ and\ x_2\ is \underline{A}_2^k\ and\ \dots and\ x_n\ is \underline{A}_n^k\ THEN\ y^k\ is \underline{B}^k$$

The system will apply a max-min inference method.

System Design and Development

The Integrated Development Environment (IDE) that is being used for the development of the Android Application is Android studio version 2.2. The app's functionality is being written in Java while its User Interface is being written in Extensible Mark-up Language (XML).

System Evaluation

The system will be evaluated by comparing with existing medical decision support systems in terms of accuracy.

Conclusion

Fuzzy logic and Analytic Hierarchy Process can be combined to develop an accurate and fast system for the diagnosis of tropical diseases. The Analytical Hierarchy Process is used to process data from medical experts to obtain the weights of each symptoms for each of the diseases considered. The Fuzzy logic allowed vague, incomplete and imprecise data to be used. The system being developed will improve the accuracy of diagnosing the tropical diseases included in the study thereby reducing their mortality rate. Nigeria faces shortage of medical practitioners. This shortage results in long queues at the hospitals. Due to the stressed placed on the medical system, both Doctors and patients are frustrated. The system will reduce the stress on our medical resources. This will result in patients getting more quality health care at the hospitals.

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