

AN EXPERT SYSTEM FOR DIAGNOSIS AND TREATMENT OF TROPICAL DISEASES

A. E. Agbo, T. A. Nwodo

Department of Electronic Engineering University of Nigeria Nsukka, Nigeria.

Abstract

This paper presents the development of an expert system, based on the Microsoft Windows Operating System, Structured Query Language (SQL) Server, and Visual Studio.NET. The system is intelligent, interactive, user-friendly, and performs a step-wise analysis of patients' complaints, filtering cognitive and emotional elements to be able to make inferences. It is intended to preserve medical expert knowledge on the diagnosis and treatment of tropical diseases. It can be very useful in areas where expert medical knowledge is scarce. Facts that constituted the knowledge base are gathered from expert medical personnel, peer review journals, and online resources. The expert system carries out its diagnostic investigations using a method referred to as Symptom Count Model (SCM). Here, the system uses library of symptom-related questionnaires to investigate the patient, and perform the symptom count to decide the likely disease. The technology can be very useful to institutions with clear objectives, rules and problems to provide consistent answers for repetitive decision-making, processes and tasks. The expert system would need to be updated periodically to cater for the new discoveries, and to enhance benefits by addressing the new changes in the medical diagnosis and treatment

Keywords: *Expert system, SQL server, Visual Studio.NET, Tropical diseases, Symptom count model.*

1.0 Introduction

In most developing nations, adequate medicare is lacking due to low standard of technological know-how, inadequate medicare facilities, as well as very high patient-to-doctor ratio. With present development of an information society, it is necessary to implement computer-aided medicare (expert system). This would be inevitable if patients are to be attended to quickly and accurately. The other applications of medicare expert system include patient care and protection, clinical administration, intensive monitoring during emergencies, surgical operations, diagnosis and automation of medical records.

It has been observed that patients are always exposed to prolonged and unnecessary stress when they want to see a doctor or to undergo any type of medical checkup in the lab or drug dispensary. This leads to most patients resorting to unprofessional practices such as self

medication for quicker treatment. Owing to the high patient to doctor ratio in our hospitals, doctors and other medical personnel are overworked at the end of the day, and are never always fit for the next day's routine.

With the current practice, disease diagnosis and drug prescription depends largely on the doctors' memory and his drugs of choice. Being human, this could be influenced by his state of mind at the moment vis-à-vis the number of patients he has had for the day and there could be occasional cases of misplacement and omissions in drug prescription. The objective of this research is to develop an expert system that can be used to diagnose tropical diseases and prescribe treatment quickly and much more accurately than would otherwise have been.

2.0 Literature Review

Human thinking is predominantly inexact. This is however, essential in the management of real-world systems-the crucial ability to summarize data and focus on decision-relevant information. Expert systems have been used to replace the inexactness of human expertise in solving various problems by improving on the accuracy of human beings. They are widely applied in production lines like manufacturing industries, agriculture, and the medical field to enhance performance of the less skilled personnel; improve motivation, satisfaction and hence increase productivity.

However, in some instances, the roles of expert systems have not been well articulated. Expert systems cannot draw analogies from other sources to solve a newly encountered problem like a human would do as they are not creative. They are based on facts and objects of a particular domain of the real world being represented in their knowledge base [1]. Whereas human experts can automatically adapt to changing environments, expert systems must be explicitly updated to align with that. Also the human expert can act based on a wide range of experiences but the expert systems are only dependent on symbolic input.

2.1 Artificial Intelligent Systems

McCulloch et.al. [2], First work led to a proposal of the "Binary Decision Unit" and later they developed a model of artificial neuron, which is seen as the artificial intelligence of today. A neural network is a network made up of binary decision units and such a network was shown to be capable of performing any logical function on its input. In his model, it is seen that neural networks perform two major types of functions; learning and recall. In general the authors showed that binary decision units could solve any logical task. The neural network is logically the same model as an individual neuron.

Turing, A.M. [3] later concluded that for any complex decision to be made or problem to solved, experts in specific areas should have particular knowledge, specific alternatives, and the chances of success. Based on these earlier concepts, expert systems were developed and have been very useful to supervisors and managers with situational assessment and long range planning [4].

Segal E. [5] defined an effective procedure as a finite, unambiguous description of a finite set of operations with strictly mechanical ways of completing them, for example set algorithms, universal Turing machine, rules of choice and recursion rules. Such effective procedures were utilized to create computer programs like the Great Problem Solver [6], created in 1957 by Newell to build a universal problem solver machine based on Newell's theoretical work on logic machines.

Expert systems have optimized patient management by helping medical groups to constantly improve healthcare. Bioinformatics is a field where expert systems have been widely applied to solve medical problems. On the other hand, medical artificial intelligence is defined by Coiera, E. et.al. [7] as primarily concerned with the Construction of AI programs that perform diagnosis and make therapy recommendations based on symbolic models of disease entities and their relationship to patient factors and clinical manifestations.

2.2 Expert System Applications in Medicine

Expert systems previously developed within Bioinformatics include APACHE III, which is used to predict an individual's risk of dying in the hospital, and so far, is performing at 95% accuracy. Others are MYCIN, NEOMYCIN, PUFF, CENTUAR, Gideon, VM, developed for purposes of diagnosis of infectious diseases and suggesting corresponding therapy and GERMWATCHER. There are other expert systems that were developed

specifically to predict biological pathways of organisms both procaryotes and eucalyotes. Biological pathway finding system is one of them that have been developed at the National Institute of Science of the Health in Japan, [8]. One of these systems is based on the cell signaling networks data-base (CSNDB) in humans. The system can infer reactions between two molecules by connecting individual reaction steps using a set of rules stored in the knowledgebase.

Another system developed is based on annotation strategies, an open source genome annotation system that allows both manual and automated annotation of prokaryotic genomes [9]. This system implements a rule-based auto annotation tool intended to simulate the annotation process of a human expert.

GeneNet a hypertext database system [10] developed for description, visualization and modeling of gene networks is in flat form so that it supports an object oriented approach. The concepts of genetic networks are the basis for information structuring in this database. Each of the so-far-characterized genes is considered a node of a genetic network, while the links between the nodes represent the interactions of genes or their products.

The SWISS-PROT, established in 1986, is the most widely used protein sequence database since it distinguishes itself from other sequence databases by some criteria; minimal redundancy. Many sequence databases contain for a given protein sequence, separate entries, which correspond to different literature reports. This system minimizes the redundancy. The second criterion is the integration with other databases, which, provides the users of bimolecular databases with a degree of integration between the three types of sequence-related databases (nucleic acid sequences, protein sequences and protein tertiary structures) as well as with specialized data collections- it is currently cross-referenced with 30 different databases.

3.0 Methodology

3.1 The Expert System Development

The choice of the software package for expert system development is often determined by the hardware and its processing power. The system is developed using the traditional classical life cycle system and the user case evolutionary model development process which follows iteration through the stages of specification, analysis, design, implementation, testing and evaluation. Facts about the diagnosis and treatment of tropical diseases, as well as literature on expert system development and applications, particularly in medicine, were incorporated into VB.NET scripts used in creating the interfaces for the Microsoft SQL Server database system supporting the knowledge engine of the expert system.

3.2 Knowledge Acquisition

The facts that were included in the knowledgebase as knowledge domain were gotten from oral interviews of medical experts, patients' treatment histories, evaluation of returned forms, professional manuals and journals, etc. The knowledge experts appreciated that being scarce, the system would be very helpful in preserving their expertise in a databank using well structured data management environment, especially since the experts are relatively unavailable.

3.3 The System Specification

This system was developed for use with the following specifications:

- a. A complete set of computer, at least Pentium III CPU: 700MHZ or a higher CPU speed with a reasonable and sizeable hard disk of at least 20GB, Up to 515MB of processing RAM.
- b. A networked environment to ensure the collection of data and records to central database storage device.
- c. The shareable resources, such as the printer, the fax machines, the scanners

etc, can also be connected so that the users can make use of it.

- d. Standard input such as keyboard, tape drive, Microsoft compatible mouse.
- e. Electricals such as current stabilizer, UPS devices, air conditioner unit, and VGA color monitor.

3.4 The Expert System Architectural Design

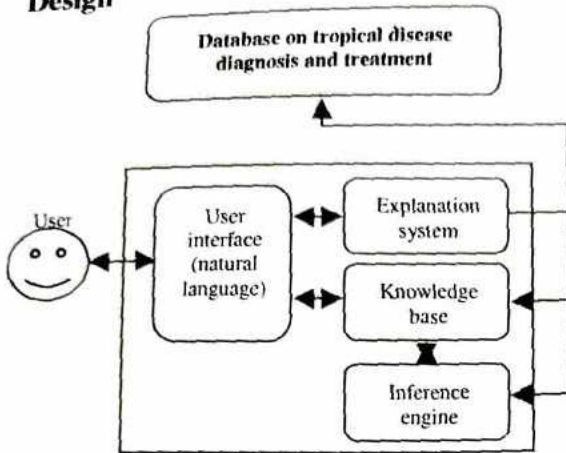


Figure 1: The expert system architecture

The expert system architecture (Figure 1) consists of the knowledgebase, the inference engine, the explanation system and the user interface. The knowledgebase is made up of the production rules presented in frames, which are based on facts about the diseases characteristics and treatment types used in this study. The inference engine examines the existing facts and rules to decide the order of inference upon consultation of the knowledgebase. The natural language user interface enables users to interact with the expert system by insertion of the appropriate symptoms to query the system for the right disease and treatment.

The expert system carries out its diagnostic investigations using a method referred to as Symptom Count Model (SCM). Here, the system uses library of symptom-related questionnaires to investigate the patient, and then perform symptom count to decide the likely disease. After each diagnosis, the system sources treatment report from the inbuilt

disease reference library and uses it to complete a report which will finally be printed out for the Patient or exported into various file formats such as PDF, Word documents, etc.

3.5 The Integrated System Design

In this research, the design is divided into three different modules. These modules perform a particular task. At the end, the whole system is integrated to achieve the research aim. The modules are:

- a. The system registration module. In the system registration module the patient is register by entering his/her data as required by the system, then the patient gains access to the expert diagnostic area. If the patient has already been registered, he/she simply type in the user name and password to enter the diagnostic area.
- b. The system diagnosis module. The system diagnosis module, here the diagnosis takes place, and the patient is required to answer the following questions; the background questions, the basic diagnosis questions and the advanced diagnosis questions.
- c. The system result/reporting module. In this module the result of the diagnosis and the treatment required is displayed and the report can be printed.

The terminals at different locations are connected to the medical knowledgebase management system of the expert system. All the files, user forms, diagnostic forms and associated programs are networked. The design also provides necessary control, both manual and automated, to help maintain the integrity of the database files.

The integrated system (figure 2) is show below' it shows the sequence of operation needed for solving a particular problem.

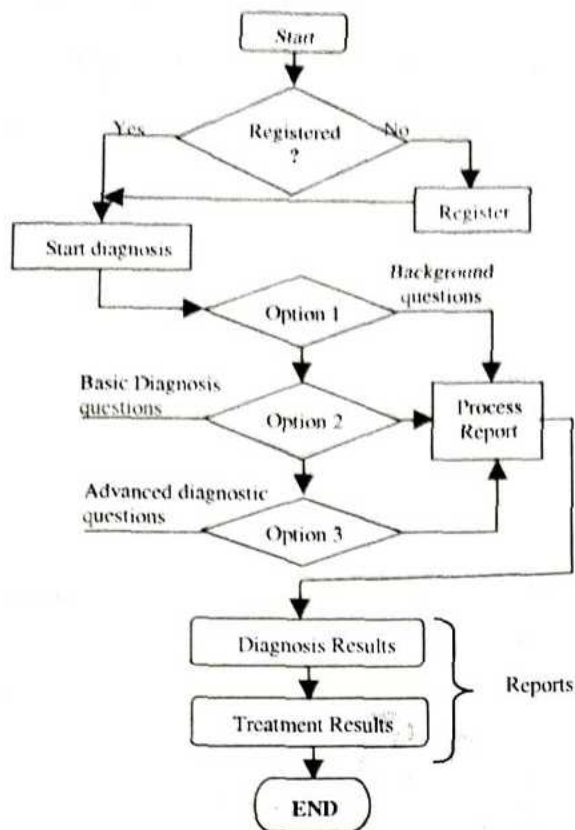


Figure 2: The Integrated System

3.6 The Database Design

In any good database design, effort should be made to remove complexity or at worst reduce redundancy. The normalized database design in the software is achieved using Microsoft SQL Server. The following are the expert system database format:

Table 1: Patients registration

Fields	Field Type	Field Size
Patient ID	Text	20
Patient name	Text	50
Sex	Text	10
Age	Integer	3
Address	Text	200
Phone	Text	13
Date /Time	Integer	
Note	Text	200

Table 2: Symptoms diagnosis

Fields	Field Type	Field Size
Patient ID	Text	20
Symptom No.	Integer	8
Symptom Title	Text	30
Symptom Description	Text	200
Disease	Text	20

Table 3: Disease diagnosis

Fields	Field Type	Field Size
Patient ID	Text	20
Disease No.	Integer	8
Disease Title	Text	30
Disease Description	Text	200

Table 4: Disease data

Field	Field Type	Field Size
Disease No.	Integer	4
Disease Name	Text	30
Disease Description	Text	200
Symptoms count	Integer	3

Table 5: Symptom data

Field	Field Type	Field Size
Symptom No.	Integer	4
Symptom Name	Text	30
Symptom Description	Text	200
Disease No.	Integer	4

Table 6: Report

Field	Field Type	Field Size
Report ID	Integer	4
Patient ID	Text	20
Diseases	Text	30
Symptom No.	Integer	4
Report Description	Text	500
Date /Time	Integer	
Reporting parameter	Text	50
Treatment ID	Integer	4

Table 7: Treatment

Field	Field Type	Field Size
Treatment ID	Integer	4
Disease	Text	30
Treatment	Text	200

4.0 Implementation And Results

4.1 Software Testing

This defines the test requirements, which the software should meet while it is

progressively integrated into a complete package. The process of test plan is concerned with ensuring that a package produces correct and expected results for all possible process steps and input data. For this software testing, three basic testing are carried out; Module testing, Integration testing, and System testing.

4.2.1 Module Testing

In this design there are three modules which when triggered up at certain events perform a specific function. So, module testing involves testing each of the modules in software to verify that they meet their respective objectives. Module testing was carried out to ensure that information flows properly into and out of the program module under test.

4.2.2 Integration Testing

Sometimes, the modules can perform their respective functions but when put together, they fail to function together. So this test therefore checks that when the module is integrated they can combine to perform their respective functions. Hence, integration testing was done on entire program structure to uncover errors associated with interfacing. These errors were debugged to produce desired results. The essence of integration testing is to ascertain that these modules do not lose their efficiency and reliability. The integration involved the main form which serves as a coordinator and driver for other modules.

4.2.3 System Testing

Before bringing the expert system prototype to use, it is of vital importance that the system is both comprehensive within its intended limit and fully correct. So, each routine must have been written according to specification and tested to complete satisfaction. Also, bug must have been removed completely and the program run produced exactly what is required of it.

4.3 The Expert System Implementation

The expert system was implemented on a stand-alone system, as a prototype. Based on the various interfaces below, a systematic step by step approach is demonstrated, starting from the paramedic logon form to the final disease diagnosis and treatment report form.

When a patient visits the medical diagnostic center, the administrator or paramedic starts up the expert software. The paramedic is presented with a login form, requesting a username and a password (figure 3).



Figure 3: The Paramedic logon form

After login, the next interface is the patient diagnosis main form which is presented in a menu form. Care should be taken to select the correct menus and toolbox. Below is a visual presentation of the expert system form and menus.

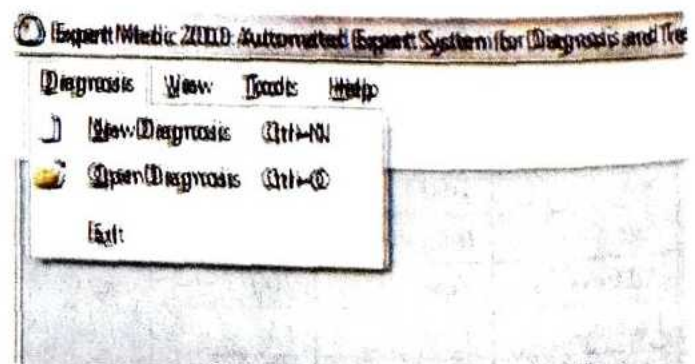


Figure 4: The Expert System Diagnostic menu

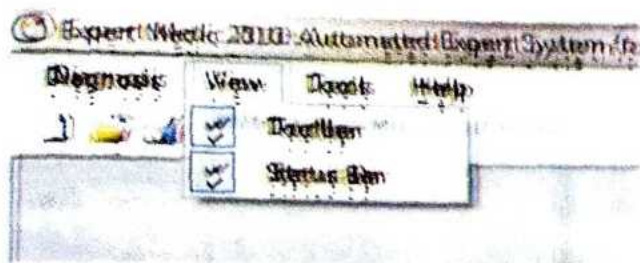


Figure 5: The Expert System View menu

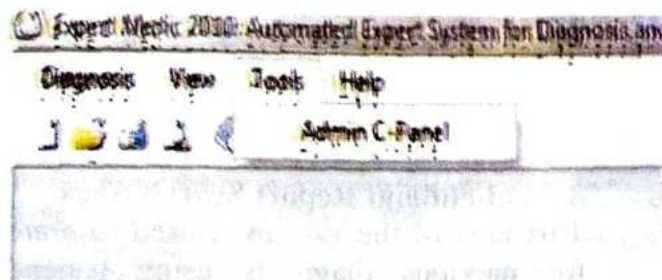


Figure 6: The Expert System Tools menu

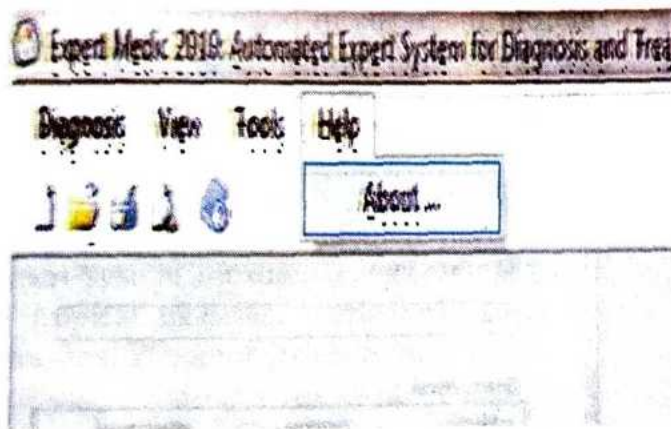


Figure 7: The Expert System Help menu

After logon, the paramedic must first register the patient. Registration is mandatory. During registration the following data are collected and stored in the database: i.) Surname, ii.) Other Names, iii.) Sex, iv.) Age, v.) Contact Address, vi.) Phone number.

Figure 8: Patient Registration form

After registration, the wizard automatically takes the paramedic to the questionnaire where the system will intuitively ask step by step questions which will be used to diagnose the patient. The paramedic will read and interpret each question to the patient as well as taking the patient's response and imputing same into the system.

The Next button is used to navigate the question forward and the previous button is used to navigate the question backwards. Each question is stored as current question, and open selection of the next question, the current question set as the previous question and can be accessed by the previous button.

The system manages all questions keeping on track of the disease in consideration. The questions are queued serially and are selectively displayed on the questioner area.

Figure 9: Patient Questionnaire form

From the form above, answers are multi-choice questions with a:

1. 'YES'
2. 'NO'
3. 'NOT SURE'

A 'YES' will add a count to the symptom collection, and a 'NO' will not be counted. A 'NOT SURE' will cause the question to be skipped or repeated in a different statement format. Each question point to a particular symptom and is used as a counter for that symptom.

4.4 Expert Administrative Area

This area of the system is used by the consulting expert to deploy diseases and symptoms, to manage paramedics and software users and so on. When one logs in, in the case of an expert, the expert clicks on the TOOLS menu, and then clicks on ADMIN C-PANEL, see menu figure 10.

Below are the visual dumps of the screen used by the expert.

Figure 10: Paramedic management form

Figure 11: Disease management form

Figure 12: Symptoms management form

Figure 13: Questionnaire management form

4.5 Patient and Report Search Area

This area of the system is used to search for previous diagnosis using patient's Surname or other names. When an old patient repeats, a paramedic can reference the old diagnosis in order to have a clear view of the medical possibilities and tendencies.

Figure 14: Report Search form 1

Figure 15: Report search form 2

4.6 Diagnostic Report Output Form

At the end of every diagnosis, a report is automatically generated and can be printed for issuance to the patient. It is usually stored in the database for future reference.

Below is a typical output report form for a diagnosis.

Figure 16: Report Output form

5.0 Conclusion

This thesis presents the use of expert systems in health care. The idea is to use expert systems to provide support in common clinical problems like diagnosis and treatment of tropical diseases. It is most useful in rural areas where there is a vast shortage of health personnel. This study is a prototype implementation of an expert system for diagnosis and treatment of tropical diseases, particularly malaria parasites. The knowledge domain is got by extensive consultations with knowledge experts in the field of medicine and literature review. Expert systems exercise information technology to acquire and utilize human expertise. They can be beneficial to organizations that have clear objectives, rules, and procedures by providing answers to repetitive decision-making processes and tasks. They can also reduce employment costs, centralize the decision making process, create efficiency and reduce time needed to solve complex problems. However, the weaknesses of these systems should never be overlooked such as the limited knowledge domain compared to human experts.

References

- [1] Russell, S. and Norvig, P. (2004). *Artificial Intelligence: A Modern Approach* (2nd Ed.). Prentice Hall, Inc.
- [2] McCulloch, W.S. and Pitts, W. (1943). A logical calculus of the ideas

immanent in nervous activity. *Bulletin of mathematics and Biophysics*.

- [3] Turing, A.M. (1950). Computing machinery and intelligence. *Mind: A Quarterly review of Psychology And Philosophy*.
- [4] Feigenbaum, E.A., Edward A., McCorduck, P and Nii, H.P. (1988). *The Rise of the Expert Company: How Visionary Companies are Using Artificial Intelligence to Achieve Higher Productivity and Profits*. New York: ASM Press.
- [5] Segal, E. (2001). *Information processing and computer simulation*. In Psy 416: Reasoning and Problem Solving. Department of Psychology, University at Buffalo, State University of New York. www.cas.buffalo.edu/classes/psy/segal/416f2001/Information/Information.htm.c2s2.htm
- [6] Newell, A. and Simon, H A. (1963). GPS, A program that simulates human thought. In Billing H., editor, *Lernende Automaten* Oldenbourg KG, Munich, Germany.
- [7] Coiera, E. (2003) *A Guide to Health Informatics*. (2nd ed.) Oxford: Arnold/Hodder and Stoughton Educational.
- [8] Takai-Igarashi, T., Nadaoka, Y., and Kaminuma, T. (1998). A Database for Cell Signalling Networks. *J. Comp. Biol.*
- [9] Meyer, F., Goesmann, A., McHardy, A.C., Bartels, D., Bekel, T., Clausen, J., Kalinowski, Linke, B., Rupp, O., Giegerich, R., and Puhler, A. (2003). GenDB-an open source genome annotation system for prokaryote genomes. *Nucleic Acids Research*.
- [10] Kolchanov, N.A., Nedosekina, E.A., Ananko, E. A., Likhoshvai, V. A., Podkolodny, L., Ratushny, A.V., Stepanenko, I.L., Podkolodnaya, O.A., Ignatieva, E.V. and Matushkin, Y.G. (2002). *GeneNet database: description and modeling of gene networks*. In *Silico Biol.*