A MEDICAL EXPERT SYSTEM FOR MANAGING TROPICAL DISEASES

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Abstract
In this paper, we proposed a Medical Expert Solution (MES) system that diagnoses symptoms related to a given tropical disease, suggests the likely ailment, and advances possible treatment based on the MES diagnosis. The MES uses a knowledge base which comprises of two knowledge structures, namely symptom and diseases. The MES system has a user-friendly interface that makes it easy for user to supply or obtain information to/from the expert system during run-time. The various symptoms of tropical diseases are stored in the diagnostic centre and the patient selects signs and symptoms from a drop-down list. These data are then used by the expert system to perform the diagnosis. The MES inference engine uses a forward chaining mechanism to search the knowledge base for symptom of disease and its associated therapy which matches the query supplied by the patient. The implementation centered on a workflow activity chart and is divided into two levels for MES administrators and MES clients respectively. The MES would be useful for people who do not have access to medical facilities and also by those who need first-aid solution before seeing medical consultants. Thus, the MES will reduce physicians' workload during consultations and ease other problems associated with hospital consultations.

Keywords: Expert Systems, Knowledge Bases, Medical Diagnosis, Tropical Diseases

Introduction

In recent time, research efforts have been concentrated on medical expert systems as complementary solution to conventional technique for finding solution to medical problems. The increasing expectations of the highest quality health care and the rapid growth of more detailed medical knowledge leaves the physician without adequate time to address each case-file satisfactorily while at the same time struggling to keep up with the newest developments in his field. As a result, most medical decisions are made based on 'spontaneous' judgments of the case relying on the physician's unaided memory. Computer tools help to organize, store and retrieve appropriate medical knowledge needed by the practitioner in dealing with each difficult case and suggesting appropriate diagnostic, prognostic and therapeutic decisions and decision-making techniques (Szolovits, 1982). An expert system is a computer program that contains some of the subject-specific knowledge of one or more human experts which makes decisions or solves problems by using knowledge and analytical rules defined by experts in the field (See Figure 1 below). Human experts solve problems by using a combination of factual knowledge and reasoning ability. In an expert system, these two essentials are contained in two separate but related components, a knowledge-base and an inference engine. The knowledge-base provides specific facts and rules about the subject, and the inference engine provides the reasoning ability that enables the expert system to form conclusions. Expert Systems also provide additional tools in the form of user interfaces and explanation facilities. User interfaces, as with any application, enable people to form queries, provide information, and otherwise interact with the system. Explanation facilities, an intriguing part of expert systems, enable the systems to explain or justify their conclusions, and they also enable developers to check on the operation of the systems themselves (Alty J.L. and Coombs M.J, 1984; Harmon and Sawyer, 1990).

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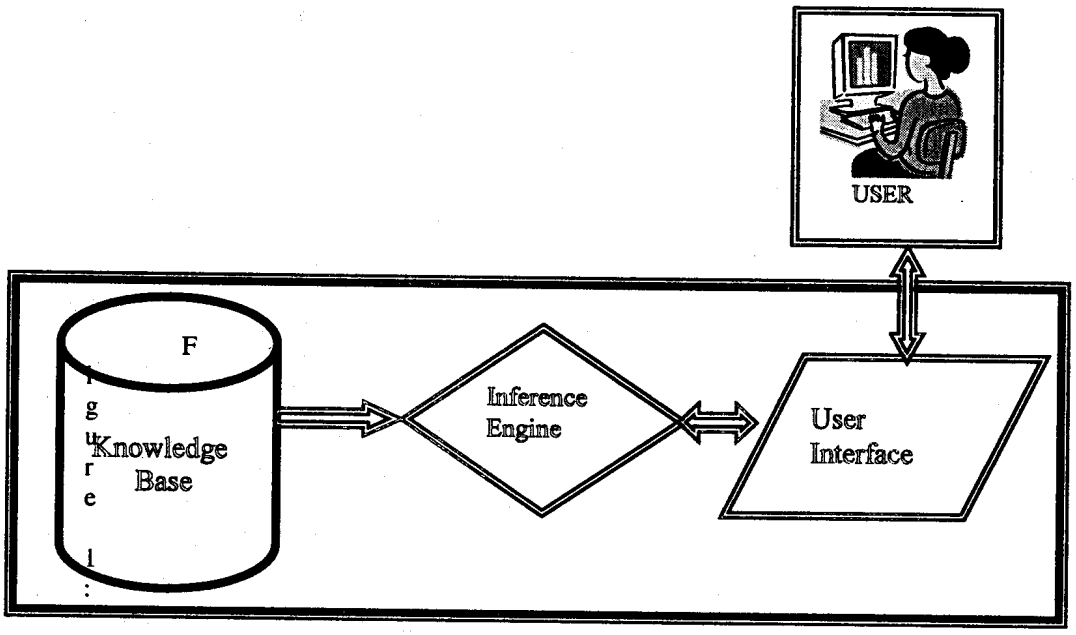


The Architecture of an Expert System

The process of checking a person's physiological conditions and determining the ailment such a person has in relation to the symptoms presented is referred to as diagnosis. Accordingly, diagnosis is a brief written medical conclusion of an existing disease described in medical terms, denoting the name of the disease and its form. Medical diagnostics is based on different methods of research and diseases' determination, and their severity with the purpose to select and carry out necessary treatment, and prevent the development of complications and recurring diseases. Diagnostic procedures involve interaction between the patient and the medical personnel in the form of 'question and answer'. This implies that a satisfactory patient-doctor relationship is needed, without which relevant information cannot be extracted. Therefore, the need of a human-computer interaction and the potentials of knowledge based systems are highly needed to allow us to represent aspects of a user's behavior, capabilities and characteristics which can then be incorporated into the construction of interactive interfaces. This will allow the interaction to be more flexible and usable.

An expert system for diagnosis and treatment of diseases such as malaria, ulcer, diarrhea, cholera, tuberculosis etc aimed at achieving the provision of an advice-giving system as pertained to complete diagnosis and treatment of some diseases. This work highlights the use and importance of computer-automated reasoning in diagnosing diseases and prescribing treatments. Succinctly, this work focused on the design of a system that provides information on some diseases, and also diagnoses diseases of patients based on information supplied to it. Specifically, the proposed system aims to:

i) Solve the problems encountered in areas where there are no medical experts or where medical experts are limited in number.
ii) Provide efficient information to assist experts in decision-making
iii) Provide consistent answers for repetitive decisions, processes and tasks
iv) Hold and maintain significant levels of information
v) Review transactions that human experts may overlook

The scope of this work is restricted to a medical expert system and it specializes in the diagnosis and therapy recommendation of tropical diseases.

The increasing expectations of the highest quality health care and the rapid growth of more detailed medical knowledge leaves the physician without adequate time to address each case-file satisfactorily while at the same time he struggles to keep abreast of the newest developments in his field. As a result, most medical decisions are made

based on 'spontaneous' judgments of the case relying on the physician's unaided memory. Only in rare cases can a literature search or other extended investigation be undertaken to assure the doctor (and the patient) that the latest knowledge is brought to bear on such particular cases. Continued training and recertification procedures ensure that the physician keeps up-to-date and relevant information constantly in mind, but there are fundamental limitations of human memory coupled with the growth of knowledge. Computer tools help to organize, store and retrieve appropriate medical knowledge needed by the practitioner in dealing with each difficult case and suggesting appropriate diagnostic, prognostic and therapeutic decisions and decision-making techniques.(Szolovits, 1982).

The application of artificial intelligence in medicine is primarily concerned with the design and implementation intelligent information systems that diagnose and make therapy recommendations. These systems are designed based on symbolic models of disease entities and their relationship to patient factors and clinical manifestations. Rogers et al. (1984) reported that based on application of expert systems in different areas of medicine, medical diagnosis remain the top priority of medical practitioners when compared to other areas such as clinical laboratories, clinical surveillance, and intensive care settings. What might have prompted researchers to explore into the possibility of using computers to solve medical problems might be connected to the urgent need to find a lasting solution to occurrences of epidemics where medical personnel were not enough and there was need of an assistant in form of an expert that could perform similar tasks as a human expert (Schwartz, W.B., 1970). In general, medical expert systems focus on the diagnostic aspect of consultation involving selection of a disease from a set where the symptoms have been presented to the system using various techniques. Some of these medical expert systems are:

1. The MYCIN Program for Infectious Diseases

MYCIN is one of the earliest medical expert systems to have been developed. It was designed to diagnose and prescribe treatment for infectious diseases particularly spinal meningitis and bacterial infections of the blood. It first decides what bacterium caused the disease and then based on this decision; it suggests what antibiotic to give the patient. It is very helpful for physicians that lack expertise at certain diseases.

2. PNEUMOCONIOSIS X-RAY Diagnosis Expert System

This was developed by Miriam Kubiska and Julie Herzner in 1992. This expert system incorporates the inference engine to examine the shadows on the x-ray. The shadows are used to determine the type and degree of pneumoconiosis (a lung disease). The system also includes three other modes: the knowledge base (which contains the data of X-ray representations of various stages of the disease), the explanation interface (which details the conclusions) and the knowledge acquisition mode (which allows experts to add or change information in the system).

3. XDIS

This is an expert system that was designed to assist physicians in making diagnosis. The system contains information of more than 300 internal diseases and pathologic syndromes most frequently met in general practice. For each set of symptoms entered for a case, the system gets the full list of possible diagnosis ranking from the most probable to the least probable. The time to work out a diagnosis is usually less than 10 minutes. XDIS helps make preliminary diagnosis on the first visit of a patient to the physician and at the same time decide on the necessity of referring the patient to a specialist and to select medical tests to make a more exact diagnosis.

4. EMERGE

This is another example of a diagnosis rule-based expert system. It was designed to be used in an emergency room. The system uses a form of production rules which incorporates weighing factors that are determined by a neural network. The neural network is composed of input and output blocks with a hidden layer block in between which communicates input to the output. The neural network learns from examples and then predicts an output based on this knowledge. This system also uses an IF-THEN-UNLESS statement instead of an IF-THEN statement. Because of this, the decision process may be more precise, the results more accurate and the explanations better understood.

Typical Tropical Diseases

Tropical diseases are infectious diseases that are prevalent in or unique to tropical and subtropical regions. These diseases are less prevalent in temperate climates, due in part to the occurrence of a cold season, which controls the insect population by forcing hibernation during the cold season. Insects such as mosquitoes and flies are by far the most common disease carrier or "vector". These insects may carry a parasite, bacterium or virus that is infectious to humans and animals. Most often disease is transmitted by an insect "bite", which causes transmission of the

infectious agent through subcutaneous blood exchange. Some typical tropical diseases as reported in David Werner (1993) include the followings among others Malaria, African trypanosomiasis, Dengue fever, Leishmaniasis, Schistosomiasis, Tuberculosis, Chagas disease, Leprosy, Lymphatic filariasis, Onchocerciasis, Trachoma, Ascariasis, Trichuriasis and Hookworm. Others include Human African trypanosomiasis, Dracunculiasis, Buruli ulcer, Treponematoses, Leptospirosis, Strongyloidiasis, Foodborne trematodiases, Neurocysticercosis and Scabies.

Methodology

The MES system comprises of two main sections, where the first section (*user interface*) is meant for information display and user interaction with the system while the second section (*expert system)* which comprises of the inference engine and the knowledge base, is where the diagnostic centre is situated. The MES was developed with the Microsoft Visual Basic.NET Interactive Development Environment (IDE). The processing mode is highly interactive and the processing algorithm which was used to achieve the required task is outlined below:

1) When the system is started, the Welcome Screen is displayed for 5 seconds.
2) The Login window will be displayed for the user to login to the system.
3) The user can login into the system as Admin or Client user.
4) If the user is an admin user, the Administrative User window will be displayed.
5) The admin user can then select a choice out of the three administrative choices, i.e. *'Add new disease', 'Edit disease' or 'Delete disease'*. Depending on the choice of admin user, the *'Add new disease', 'Edit disease' or 'Delete disease'* window will be displayed on the screen respectively.
6) Else If the user is a client user, the Client User window will be displayed.
7) The client user can then select a choice out of the two client choices, i.e. *'Search for a disease' or 'Diagnose a disease'*. Depending on the choice of client user, the *'Search for a disease' or 'Diagnose a disease'* window will be displayed on the screen respectively.
8) When the user finishes using the system, the user exits the system by closing the login window.

The graphical illustration of these procedures and the MES prototype is illustrated in the activity diagram in figure 2 and the conceptual diagram in figure 3 below.

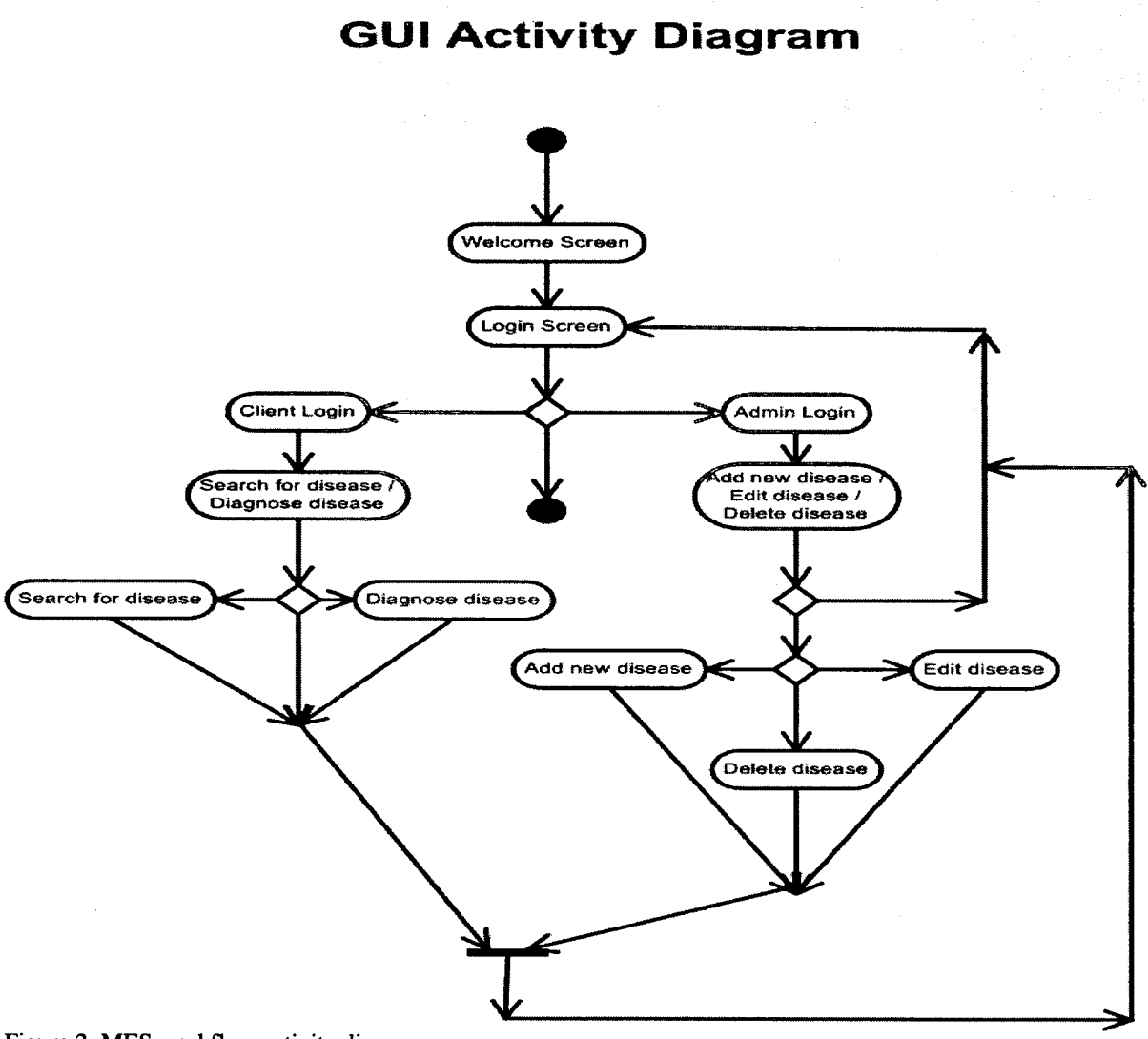


Figure 2: MES workflow activity diagram

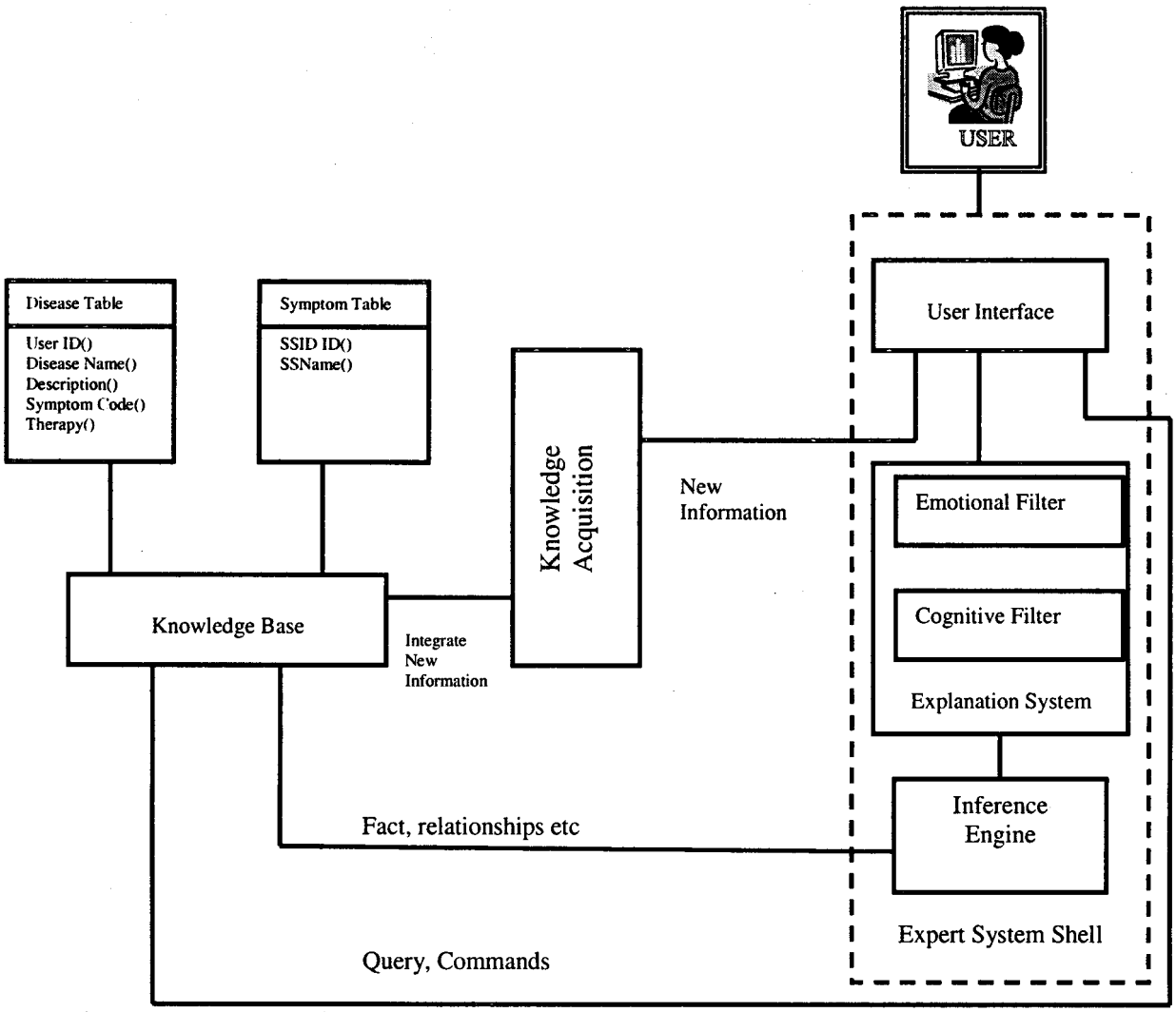


Figure 3: Conceptual Diagram of the Medical Expert System

(Adapted from: Akinyokun, O.C. and Anyiam, T.N. (2001). A Prototype of Knowledge Base System for Weather Monitoring and Forecasting. *International Journal of The Computer, The Internet and Management*. Vol. 9, No. 1.)

The MES User Interface

The MES system has a user-friendly interface that makes it easy for use. The entry of data is achieved via the keyboard and the mouse. Information from the patient serves as the source document. This information is supplied to the computer during run-time by the patient with aim of obtaining relevant feedback such as the ailment name, nature and the treatment that could be applied to cure the ailment.

MES Diagnostic Centre

The MES Diagnostic Centre consists of the knowledge base and the expert system shell (inference engine and decision support engine). The various symptoms of all diseases discussed in this domain are stored in the diagnostic centre and the patient selects signs and symptoms from a drop-down list. The responses at this stage will be used by the computer to perform the diagnosis. When the input regarding the symptoms has been processed, the result can be displayed on the screen.

The MES Knowledge Base

The MES knowledge base was designed with Microsoft Access by creating the following two tables namely;

1. **The Disease Table:** This table contains information about the diseases. The information contained here are diseaseId, diseaseName, description, symptomsCode, therapy. The structure is shown in Table 1 below

Table 1: Knowledge Structure for Handling Diseases

Disease				
diseaseID	**diseaseName**	**Description**	**symptomsCode**	**Therapy**
0	Malaria	Malaria is an infection of the blood that causes chills and high fever. It is spread by mosquitoes. The mosquito sucks up the malaria parasites in the blood of an infected person and injects them into the next person it bites.	0,1,2,3,	- chloroquine is usually effective. - fansidar or quinine may be needed where malaria is resistant to chloroquine
1	Pneumonia	Pneumonia is an acute infection of the lungs. It often occurs after other respiratory illnesses or any very serious illness, especially in babies and old people. A person with AIDS may also develop	0,2,4,5,6,7,	- aspirin or acetaminophen to lower the temperature and lessen the pain - plenty of liquids - plenty of water to ease the cough and loosen the mucus

2. **The Symptoms Table:** This table contains information about symptoms. It contains SSID and SSName.

Table 2: Knowledge Structure for Symptoms

Symptoms	
SSID	**SSName**
0	Chills
1	Headache
2	Fever
3	High temperature
4	rapid, shallow breathing
5	Cough
6	chest pain
7	cold sores on face or lips
8	Thirst
9	little or no urine
10	sudden weight loss
11	dry mouth
12	sunken, tearless eyes

The MES Inference Engine

The MES inference engine uses a forward chaining mechanism described in Akinyokun & Anyiam (2001) to search the knowledge base for symptom of disease and its associated therapy which matches the query supplied by the patient. The following statements illustrate some of the forward chaining inference procedure:

IF diseaseID(i) = SSID(i) AND . . . AND SSID(n)
THEN write diseaseName( ), Description ( ) and Therapy ( )

For instance,

IF SSID(1) = 0 AND SSID(2) = 1 AND SSID(3) = 2 AND SSID(4) = 3
THEN diseaseName( ) = "Malaria", Description( ) = "An infection of the blood that causes chills and high fever", Therapy( ) = "Use Chloroquine or Fansidar"

IF SSID(1) = 0 AND SSID(2) = 2 AND SSID(3) = 4 AND SSID(4) = 5
SSID(5) = 6 AND SSID(6) = 7
THEN diseaseName( ) = "Pneumonia", Description( ) = "An acute infection of the lungs", Therapy( ) = "use aspirin or acetaminophen to lower the temperature and lessen the pain, plenty of liquids and drink plenty of water to ease the cough and loosen the mucus"

IF SSID(1) = 0 AND SSID(2) = 1 AND SSID(3) = 2 AND SSID(4) = 3
SSID (5) = 10 AND SSID (6) = 37
THEN diseaseName( ) = "Typhoid Fever", Description( ) = "An infection of the gut that affects the whole body", Therapy( ) = "seek medical help, use co-trimoxazole, lower the fever with cool and wet cloths, and take nutritious food and plenty of liquid"

IF SSID(1) = 1 AND SSID(2) = 13 AND SSID(3) = 14
THEN diseaseName( ) = "Migraine", Description( ) = "A severe throbbing headache often on one side of the head only", Therapy( ) = "take 2 aspirins with a cup of strong coffee or strong black tea, obtain pills of ergotamine with caffeine (Cafergot) and lie down in a dark, quiet place"

IF SSID(1) = 1 AND SSID(2) = 2 AND SSID(3) = 35
THEN diseaseName( ) = "Meningitis", Description( ) = "A serious infection of the brain, more common in children. It may begin as a complication of another illness such as measles, mumps, whooping cough, or an ear infection", Therapy( ) = "get medical help fast , (EVERY MINUTE COUNTS) and inject 500mg of ampicillin, every 4 hours (EMERGENCY ONLY)"

IF SSID(1) = 16 AND SSID(2) = 17
THEN diseaseName( ) = "Sinusitis", Description( ) = "an acute or chronic (long-term) inflammation of the sinuses or hollows in the bone that open into the nose", Therapy( ) = "drink a lot of water, sniff a little salt water into the nose, put hot compresses on the face and use decongestant nose drops"

Implementation

The MES System was designed in such a way that would allow a user access to the module which is relevant to his need. There are two broad groups of users were captured and these are administrators and clients (users).

1. **Administrators**: These are people who have the permission to update and edit the content of the MES knowledge base system. Adding, editing or deletion of entry can be performed based on new information which may be obtained from medical research outputs. If the user logs in as an administrator, he can add a new disease, edit a disease or delete a disease from the database (see figure 4 below).

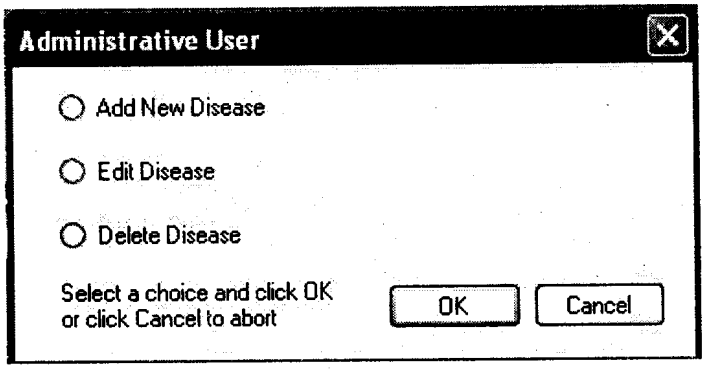


Figure 4: Administrative Home Interface

The Add New Disease form in figure 5 enables the user to add a new disease into the database. The user can also add new symptoms or use existing symptoms.

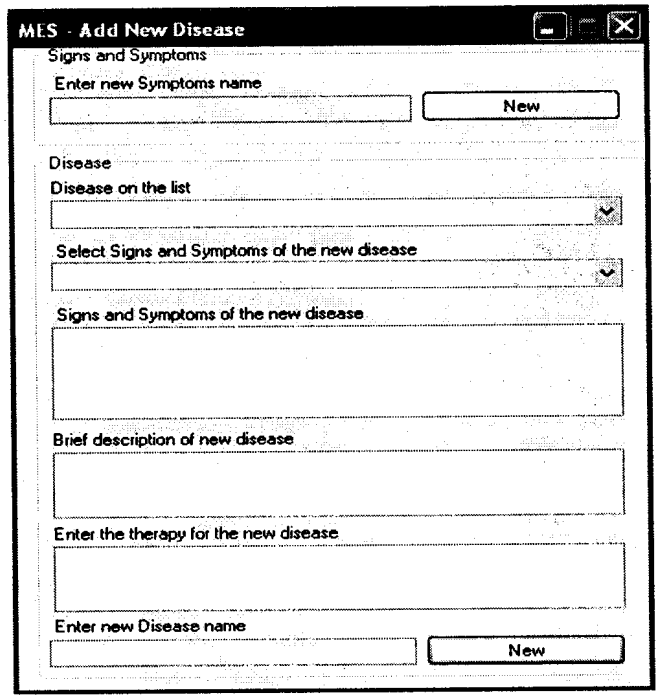


Figure 5: Add New Diseases

When there is new information about a disease which necessitates the knowledge base to be updated, the administrator makes use of the Edit Disease form in figure 6 which enables the administrative user to edit information about an already existing disease.

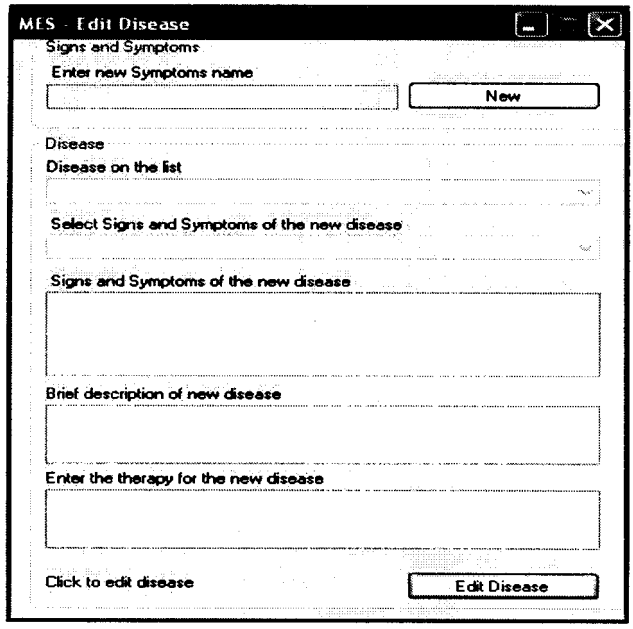


Figure 6: Edit Disease

The Delete Disease Form in figure 7 provides the platform for the administrator to delete a disease from the database.

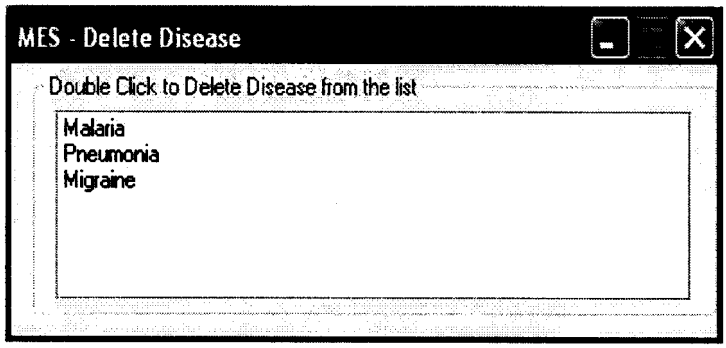


Figure 7: Delete Disease

2. **Clients:** These are people who seek medical information and/or assistance concerning an ailment. If the user logs in as a client, he can search for a disease and diagnose a disease in the Client User window (see figure 8).

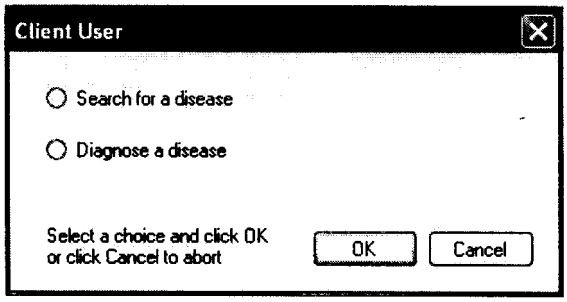
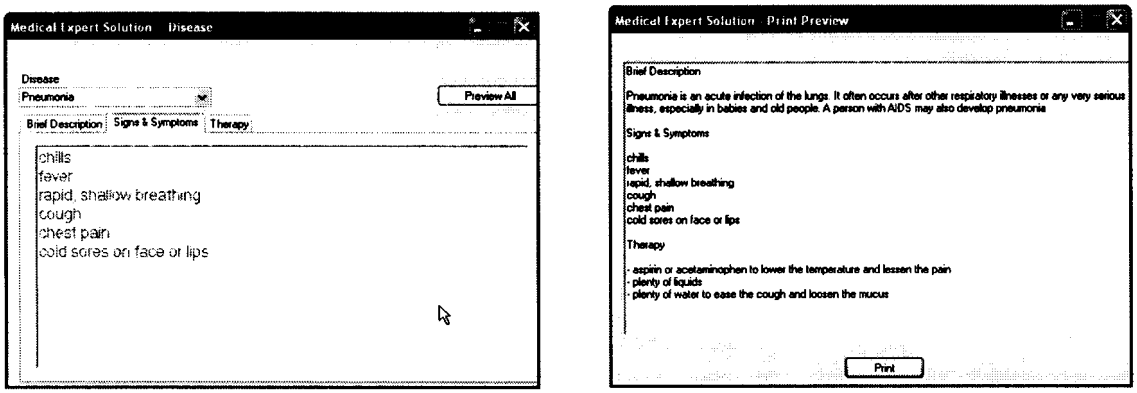


Figure 8: User's Log-in Interface

The Search Disease Form

Here, the user searches for a disease by clicking the drop down arrow while the form displays a description about the disease, signs and symptoms of the disease and the therapy for the disease depending on which view that is desired by the user. For instance in figure 9a below, the user's display preference is "Signs & Symptoms", while the disease chosen is "Pneumonia". To preview and/or print the three options at once (figure 9b), the user clicks on the "Preview All" button in figure 9a.

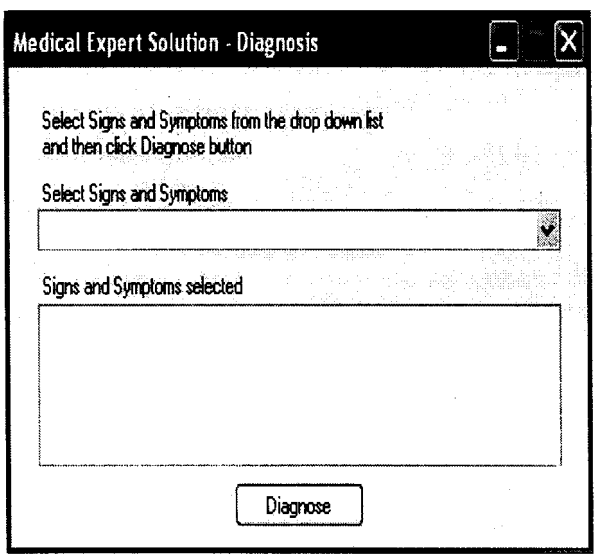


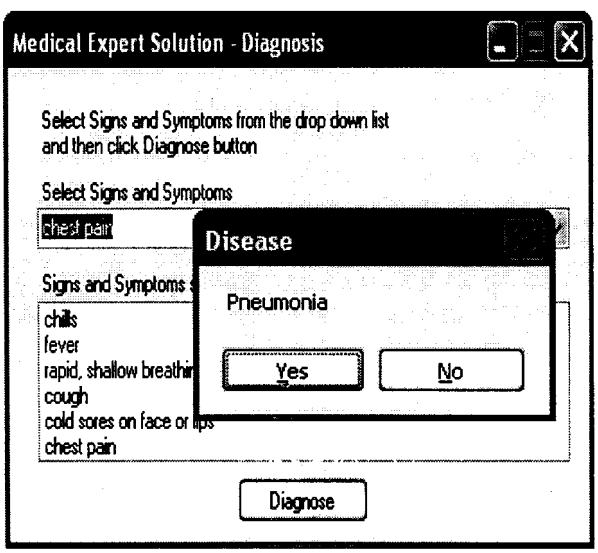
(a) (b)

Figure 9: The Search Disease Form

The Diagnosis Form

Here, the user selects signs and symptoms from a drop-down list (see figure 10) and the program uses the symptoms selected to diagnose a disease, and the result of the diagnosis, the symptoms, and the therapy can be printed out as illustrated in figure 11.





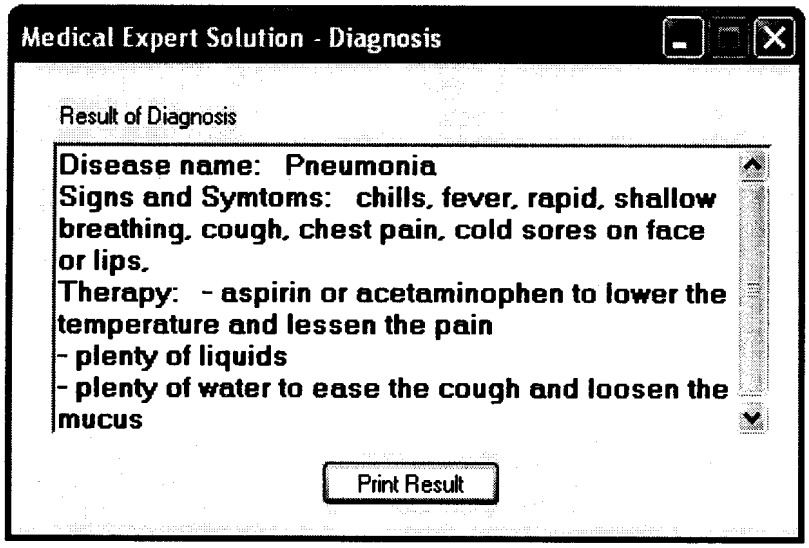


Figure 11: The Diagnosis Form

Conclusion

The main objective of the proposed system is to develop an effective and efficient strategy to diagnose various types of diseases in the domain of this project and to recommend the necessary therapy for the patient through the use of a computer. It also contains various diseases, their symptoms and their therapy.

The program is designed to handle the patient's condition by querying the patient on the type of symptoms it has. The patient will supply the vital and required information to the system. The computer system will, through the information supplied, state the type of disease the patient has or suffers from and prescribe drugs to the patient for treatment. Medicine is complex and there is countless number of diseases with their own different symptoms which makes it difficult sometimes to determine exactly what is wrong with a patient. Artificial intelligence, as a branch of computer science, has offered itself as a useful device for man survival. Making use of medical expert solution to assist physicians in diagnosing diseases will enable them to attend to as many patients as possible within a short period of time. Also, it enables patients to diagnose diseases themselves, when they cannot get the help of a physician.

The *Medical Expert Solution* can be implemented practically by both physicians and patients. The system will be of great assistance to certain situations such as where there are epidemics and war where services of medical personnel are limited. The design and interface of the system makes it flexible, friendly and usable for people without much background in computer operations. Furthermore, implementation of the MES will reduce doctors' workload during consultations and ease other problems associated with hospital consultations.

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