EXPERT SYSTEM FOR LASSA FEVER DIAGNOSIS USING RULE BASED APPROACH

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ABSTRACT: Lassa fever is an acute viral haemorrhagic fever caused by the Lassa virus and first discovered in 1969 in Lassa, a town in Borno State, Nigeria though it has been in existence since 1950s. Lassa virus belong to a member of the Arenaviridae family, a single stranded Ribonucleic Acid virus (RNA), has characteristic similar to Ebola virus. Lassa fever has killed thousands of people in West Africa, most especially in Nigeria, many of whose lives could have been saved if rapid diagnostic test was available; people who could have received treatment early and also who could have been isolated early enough to reduce spread of Lassa fever. Recently many people have died in the rural areas due to late detection or delay access to proper medical attention. This is due to the fact that most medical centres equipped with handling Lassa fever cases are situated far away from the rural communities. Hence, it would be of great necessity to provide a computerized system that will provide a complementary medical service where the experts are not sufficient. Therefore, in this paper, a rule-based medical expert system is developed and tested to address the various challenges of the traditional method of diagnosing Lassa fever. This research work tried to replace the manual method of diagnosing the Lassa fever by Medical Expert, with an Expert System (ES) which is capable of correcting all the limitations associated with the manual method.
KEYWORDS: Expert System, Artificial Intelligence, Lassa Fever, Rule Based Expert System, Medical Expert System, Viral Hemorrhagic Fever.

1. INTRODUCTION

Expert Systems (ESs) are computer application that simulates the decision and actions of a person or an association that has specialist facts and experience in a particular field. It is a branch of computer science called Artificial Intelligent (AI), which has the ability to replicate human being action, reasoning and make judgment based on some facts and rules presented to it ([Dur94; GK12]). Nowadays application of expert systems have been widely considered in almost all the fields of man's expertise to support the users in taking decision; where human expatriation and multifaceted decision making is required, like medical diagnosis, expert decision making, policy making, estimating strategies, analysis and soon ([GK12]). Medical artificial intelligence is mostly concerned with the construction of AI programs that perform diagnosis and make therapy recommendations. Medical Expert Systems (MESs) are more likely to be found in clinical laboratories and educational settings, for clinical surveillance, or in data rich areas like the intensive care setting. The system performs excellently, if the systems are enriched with suitable rule, intelligent programs and do indeed offer significant benefits ([OC12]). MESs have been in full swing since early 70's when MYCIN was developed for diagnosis bacteria that causes severe infections ([Dur94]). There are lot of medical expert systems such as PUFF that was designed to diagnose lung disease; ANGY aids physicians to diagnose the narrowing of coronary vessels by identifying and isolating coronary vessels in angiograms; BABY aids clinicians to monitor patients in a Newborn Intensive Care Unit (NICU) ([GR91]). ESs can be categorised into two; those that are designed based on rules is known as *rule-based expert systems*, and those that are built on probabilistic graphical models are often called *probabilistic expert systems* or *normative systems*. Rule-based expert systems (RBESs), originating from the work of Buchanan and Shortliffe on the MYCIN system intend to capture human expertise in terms of rules of the form **if** *condition* **then** *action* ([BS84]). There is irresistible proof that showed rule based is capable of modelling human thought process ([NS72; AHJ15]). A set of rules can be employed to capture a human expert's related domain knowledge and can then be used to replicate the expert's problem solving in that domain. Probabilistic expert systems are derived from research at the intersection of statistics and AI. RBES includes both conventional techniques, such as database management systems (DBMSs), and artificial intelligence (AI) techniques such as knowledge-based systems (KBSs) ([RN02]). In MES, DBMSs are employed for storing, retrieving and generally manipulating patient data, whereas ESs are mainly applied on patient's data to perform diagnoses, since they are naturally represent the way experts reason and provide solution to problem at hand ([MKV09]). In this research work, RBES is used to diagnosis Lassa fever.

2. LASSA FEVER

Lassa fever is an acute viral haemorrhagic fever caused by the Lassa virus. The first case of Lassa fever was reported in the town of Lassa, in Borno State, Nigeria in the year 1969 ([F+70]). Lassa virus is a member of the Arenaviridae virus family, with characteristic similar to Ebola ([Don09]). Clinical records of Lassa fever had been known for over five decades, but there was not any report to connect it with a viral pathogen ([Wer04]). Lassa virus is spread from animals to human; hence, it is zoonotic. It spreads from rodents to human beings. This rodent is called Multimammate mouse (*Mastomys Natalensis*) ([RB03]). This is a common mouse in equatorial Africa, ubiquitous in human houses and eaten as a delicacy in some regions. In these rodents, infection is in a persistent asymptomatic state. Their excreta (urine and faeces) harbour this virus, which can be aerosolized. In severe cases, Lassa fever is characterized by weakened or tardy cellular immunity resulting in fulminant viremia ([PHE14]).
More than 300,000 people are infected yearly, with deaths in excess of 5,000 people per annual ([V+16]). It is quite rampant in West Africa where the Multimammate rat is commonly available, particularly countries like Guinea, Liberia, Nigeria and Sierra Leone. Although, some cases have been reported in the Central African Republic, Mali, Senegal and other neighbouring countries ([PHE14]). Its first confirmed case was reported in 2014 in Benin Republic, while Togo had its first confirmation in 2016.
About 80% of infected people with Lassa virus display no symptoms or they have symptoms that are closely related to other febrile illnesses making its treatment challenging in the first instance. Without prompt diagnosis and treatment, 1 in 5 infected people result in severe disease, where the virus damages some organs such as the liver, spleen and kidneys, according to Dr Formenty, expert in hemorrhagic fevers at WHO.
The prevention and control of Lassa fever is centred on vector control, hygiene, sanitation, quarantine affected people, disease surveillance and contact tracing. Also in case outbreaks, patience should be quarantined, treated and monitored before they are discharged. It is also important that cases of Lassa fever should be duely reported and effectively diagnosis and treated.

2.1 Causes

Human beings can be infected with Lassa virus from exposure to urine or faeces of infected Mastomys rats. The virus may also be spread among human beings through direct contact with the blood, urine, faeces, or other bodily fluids of infected person with Lassa fever. There hasn't being any epidemiological evidence supporting its spread between humans through airborne. Person-to-person transmission may occur in the community and health-care settings, where the virus may be spread as result of contaminated medical equipment, such as re-used needles and syrings. Lassa fever occurs across all age groups and both sexes. Although, people at greatest risk are those living in rural areas where rodents are usually found, filty environments especially in communities with poor sanitation or with crowded living conditions. Also, health workers may be at risk if caring for Lassa fever patients is in the absence of proper barrier nursing and infection prevention and control practices.

3. STATEMENT OF THE PROBLEM

Medical facilities should be handy at all times to the citizenries. But in most case, the people that suppose to access these facilities are far away from these facilities. Many patients have pass away both in the rural and urban regions as a result of late detection or delay access to proper medical attention. This is due to the fact that most medical centers furnished with equipment to handle Lassa fever cases are located at a distance from the communities.
In view of this, it would be of great inevitable to provide a computerized system that will serve as complementary medical service, such as medical disease diagnosis to proffer way out to the availability of medical health diagnosis where the experts are not sufficient, overcrowding of health facilities and covering long distance before patients can access medical facility. This proposed system will be able to diagnosis Lassa fever and identify the stages of the fever (Mild, Severe or Critical); and able to generate diagnosis report for printing.

4. RELATED WORKS

GIDEON was developed by specialists in infectious diseases and biostatistics, and computer scientists at University-based medical schools in the United States and Israel. GIDEON is an expert system to diagnosis and reference in the fields of tropical and infectious diseases, epidemiology, microbiology and antimicrobial chemotherapy. It was designed to diagnose most common infectious diseases based on symptoms, laboratory testing and dermatological profile. It aids in diagnosing infectious diseases, but difficult to maintain, manage and upgrade because it is not web-based. It also attempts to diagnose all infectious diseases which introduced certain complexities ([Gid12]).

The MYCIN Program for infectious diseases 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 identifies what bacterium caused the disease and then suggests antibiotic to give the patient. It is very helpful for physicians that lack expertise at certain diseases because it provides reason for suggesting diagnosis and recommending treatment. The setback of MYCIN is that runs on large time shared systems (slow response), and it is not suitable for the treatment of malaria ([BS84]).

EMERGE is an expert system that based on rule-based to diagnosis disease. It was designed to be used in an emergency room only. 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 so that the decision process may be more precise, the results more accurate, and the explanations better understood. Its setback is that it is difficult to maintain, manage and upgrade since it is not web-based, beside its restriction to emergency room usage ([HK92]).

YOUR DIAGNOSIS is an online medical diagnosis and symptoms analysis system. It asks several questions from user about body system and symptoms. Allergies, medications and immunizations are recorded as well as family history and past medical problems. It also does a complex analysis of all information gathered about symptoms and produces a list of all possible and probable medical diagnoses. It is online and can be interacted with in stages. All provided information can be securely stored as confidential personal health record for future retrieval. It also gives a confidential medical report, which could be printed or have emailed for personal usage. The setback of Your Diagnosis is its complexity in trying to diagnose and treat all the ailments in one sweep ([Yo12]).

XDIS is an expert system that was designed to help physicians in diagnosis. The system holds information of more than three hundred (300) internal diseases and pathologic syndromes most frequently encountered in general practice. For each set of symptoms entered for a case, the system produces the full list of possible diagnosis ranking from the most probable to the least probable. The time spend to display the result of a diagnosis is usually less than ten (10) minutes. XDIS assists in making preliminary diagnosis on the first visit of a patient to the physician and at the same time, decides on the need to refer the patient to a specialist and to select medical tests to make a more exact diagnosis. Its setback is that it gives probable list of diagnosis, not exact diagnosis ([Afr12]).

Djam et al. ([D+11]) designed an expert system called fuzzy expert system for the management of malaria (FESMM). Their research work offers a complementary decision support platform for medical practitioners in malaria prevalent areas. About 35 malaria patients were sampled and their results are computed in the range of predefined limit by the signs monitored via a multi-parameter heart screen. Intelligent systems techniques are applied in the data acquisition and processing (such as sorting, transforming, among others) it into valuable information. The system was used to conduct pre-diagnosis and gives alert signs to the medical staff.

Senthil ([Sen11]), designed Fuzzy Expert System for Diabetes dignosis using Fuzzy Verdict Mechanism. The researcher proposes a fuzzy expert system framework which builds huge scale of knowledge based system for effective diabetes disease dignosis. The knowledge is designed using the fuzzification to transform crisp values into fuzzy values by employing the fuzzy verdict mechanism to diagnosis diabetes.

5. METHODOLOGY

The aim of this research is to automate the manual method of diagnosing Lassa fever by Medical Expert, with an ES which has ability to correct some of the limitations associated with the manual method ([D+11]). A rule-based ES is a system that comprises set of rules that is employed to define certain patterns. Data for this system are collected through the observation and available medical record; evaluate using these rules. If the rules are reasonably well structured, the pattern can be easily identified, and a problem related to that pattern is recommended. These rules are specific and do not concern with the ambiguity and the impreciseness of humanoid perceived data; cognitive and real world knowledge that characterized by incompleteness, erroneousness, and contradiction. The rule-based technique apply IF-THEN form of rules. **IF-THEN** rule has the following form: *IF there is action THEN there must be reaction*.

5.1 Research Design

Rule-based system basically has four modules ([AHJ15]) that consist of the following:

1. A knowledge based which specify the rules to follow by the system.

2. An inference engine or semantic reasoner, that can deduces information or trigger an actions as a result of the input data supply (that is, user symptoms) and the knowledge base defined. The interpreter performs a production system program by implementing the following match-resolve-act cycle:
   i. **Match Phase:** At this stage, the antecedent productions rule (left hand side) are compared against the data in storage (temporary working memory). With this, conflict set of results are generateded, which consists of all instance of satisfied productions. An instance of a production is a list of working memory components that matches with the antecedent production.
   ii. **Conflict-Resolution Phase:** At this stage, one of the instance of productions in the conflict set is selected for execution. If there is no production match, the interpreter terminates.
   iii. **Act Phase:** At this stage, the effects of the production chosen in the conflict-resolution phase execute and the execution may alter the contents of the working memory. At the end of this phase, the execution transfer control to the first stage.
3. Temporary working memory.
4. User Interface (Front-end): means of communicating with the system (through which the user can interact with the system).

5.2 Proposed System Model

Generally, patients visit the hospitals to complain of their diseases and Lassa Fever Diagnosis System (LFDS) user interviews the patients concerning their diseases and searches the symptoms in database. If symptoms match what is in the database, then the user gives the prescription to the patient. The proposed framework for the LFDS is adopted from our previous work ([AHJ15]) as shown in Figure 1. In this figure, the various components that make up a complete rule-based expert system are presented.

5.3 Knowledge Acquisition Process

The knowledge base acts as the brain capacity of the ESs as all the essential facts for constructing the rules are contained in the knowledge base. This knowledge is main source of rules for the ESs. The most main source of knowledge acquisition for the LFDS was consultation with general physician doctors, Internet medical website, medical books, research papers and journals. The knowledge based made up of acquiring the symptoms of the diseases ([ESL84; RS12; AHJ15]). The knowledge is represented in the form of rules.

Table 1: Rule-Base for the Proposed LFDS

1. IF (Slight Fever) THEN LASSA FEVER Mild
2. IF (Head Ache) THEN LASSA Fever Mild
3. IF (Weakness) THEN LASSA Fever Mild
4. IF (Bleeding Gum) THEN LASSA Fever Severe
5. IF (Bleeding Eyes) THEN LASSA Fever Severe
6. IF (Bleeding Nose) THEN LASSA Fever Severe
7. IF (Nausea and Vomiting) THEN LASSA Fever Severe
8. IF (Facial and Neck Swollen) THEN LASSA Fever Severe
9. IF (Diarrhoea) THEN LASSA Fever Severe
10. F IF (Chest Pain) THEN LASSA Fever Severe
11. IF (Sore Throat) THEN LASSA Fever Severe
12. IF (Back Ache) THEN LASSA Fever Severe
13. IF (Deafness) THEN LASSA Fever Critical
14. IF (Convulsion) THEN LASSA Fever Critical
15. IF (Tremor) THEN LASSA Fever Critical
16. IF (Stroke) THEN LASSA Fever Critical
17. IF (Thirst) THEN LASSA Fever Critical
18. IF (Drowsiness) THEN LASSA Fever Critical
19. IF (Poor Appetite) THEN LASSA Fever Critical

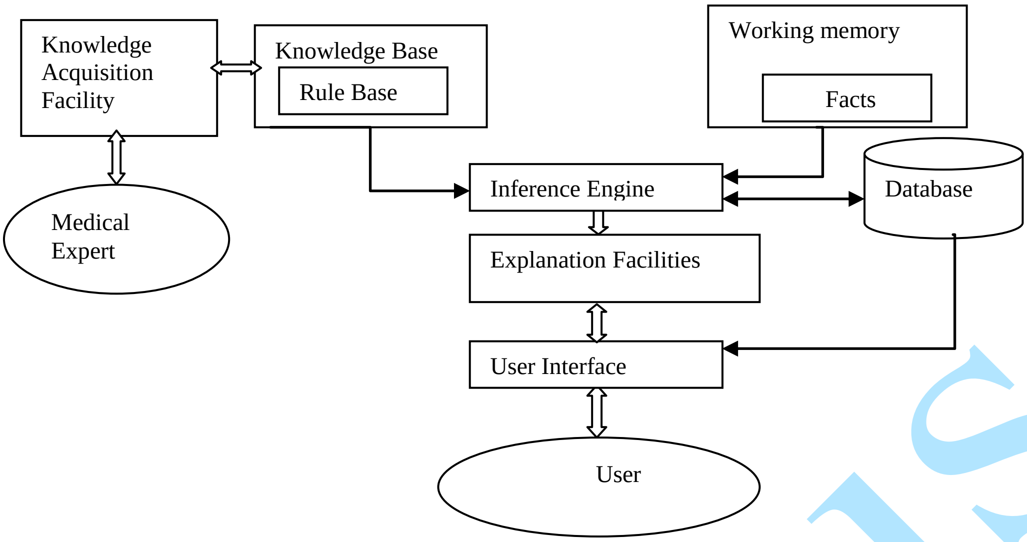

Figure 1: Proposed framework for LFDS (Adewole, Hambali & Jimoh, 2015)

6. RESULTS AND DISCUSSION

The proposed LFDS first require user to supply username and password in order to access the facilities provided by the system as shown in Figure 2. Once a valid username and password are supplied, the registration interface shown in Figure 3 is displayed. This interface is used to capture all patients' records.

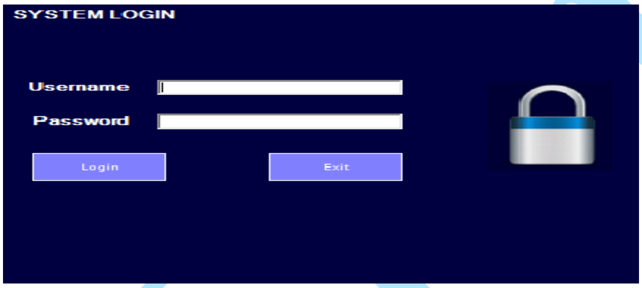

Figure 2: Login Page

Patient Registration Page: This page enables patients to register, before carrying out diagnosis.

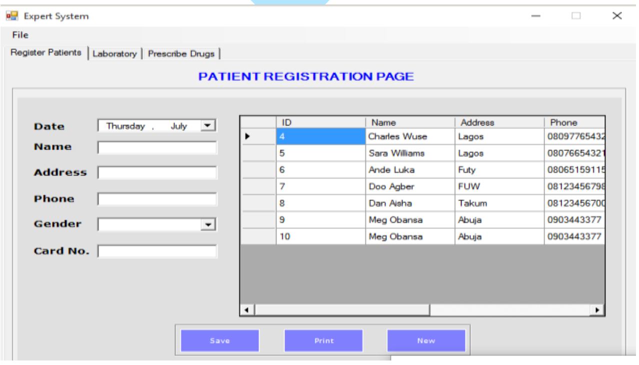

Figure 3: Patient Registration Page

After registration, the patient proceeds to diagnosis centre where he/she will supply several symptoms and the LFDS will diagnose the patient without waste of time. The interface for diagnosis centre is shown in Figure 4.

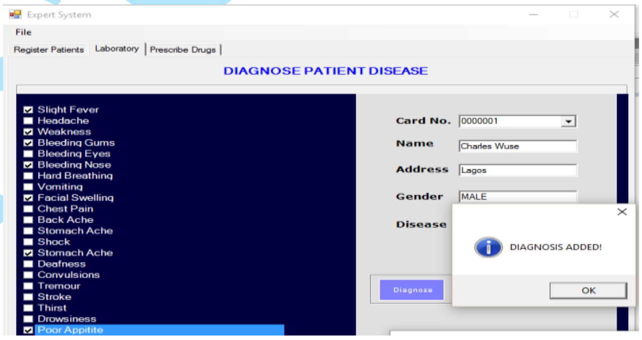

Figure 4: Diagnosis Centre for the proposed LFDS

Figure 5 shows interface that can be used to generate different reports including drug prescription.

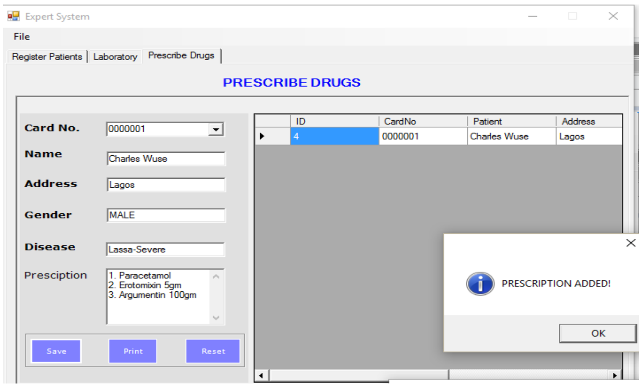

Figure 5: Drug Prescription Page for LFDS

Print Page: This is the page that enables the user to select the number of rows, columns and the title of the report to be printed.

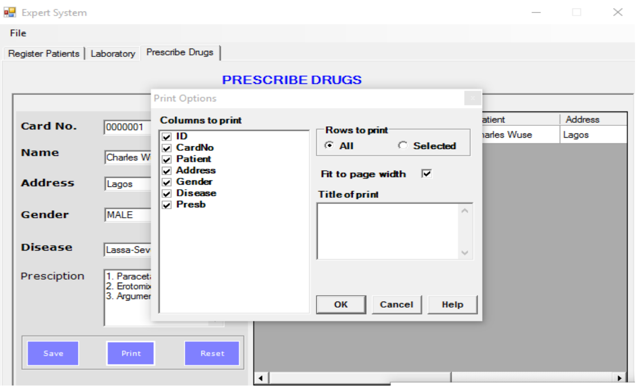

Figure 6: Print Options format Specification for LFDS

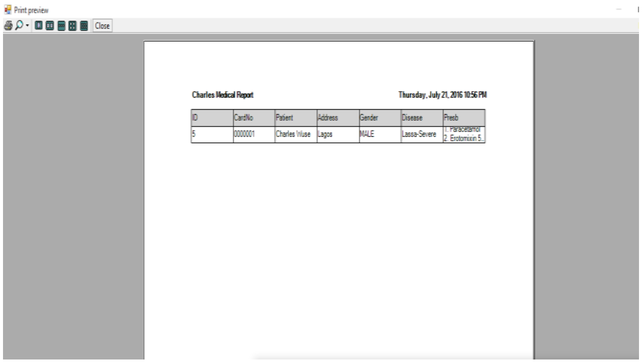

Figure 7: Report Generating Format

CONCLUSION

Expert systems have been found to be very expedient in our today's world driven by technology. When expert's knowledge is extracted and stored, such knowledge can be used to replace the expert in case of demise or absence. Medical diagnosis have greater part of the advantages of expert system, knowing that only a few specialties available in the medical field. The knowledge of such specialist can be replicated and made use of in times extreme necessity. In this paper, a rule-based medical expert system is developed and tested to address the various challenges of the traditional method of diagnosing Lassa fever. The researchers hope that the Medical Experts will find the proposed system useful and as a tool that can assist them to reduce queue and provide accurate diagnosis of Lassa fever.

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