

Application of Expert System for Diagnosis of Monkeypox

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Abstract: Monkeypox is a virus-borne disease that spreads from animals to humans and causes symptoms similar to those experienced in smallpox patients. The most important orthopoxvirus develops as Monkeypox. Natural hosts include vertebrates such as animals and humans, as well as arthropods. People can become infected with the Monkeypox virus by coming into touch with infected animals or humans (living or dead). An Expert System (ES) technique can be used to diagnose this condition. It (ES) is a computer program with a set of rules that evaluates data about a certain class or outcome. The increase rate of Monkeypox disease, limited or inadequate medical personnel in the local areas and inaccessibility to the medical facilities in getting medical services by the patients are the challenges; and these call for the design of the Expert System. This study is aimed to diagnose Monkeypox in order to complement the services of the medical personnel. The proposed system is based on Expert System that consists of User interface, Inference engine and Knowledge base. The signs and symptoms of Monkeypox disease are gathered from various Clinics and Hospitals, then built the Inference Engine where IF-THEN rules are domiciled to act intelligently on the symptoms and diagnose the degree of intensity of the disease (Monkeypox virus). The study is implemented using programming language tools: PHP, MySQL and Vue JS framework. This study could be deployed in the hospitals to complement the services of health workers especially where medical experts are not sufficient. This could also be used in a situation where patients are not having access to healthcare facilities to diagnose Monkeypox on time and early referral could be done on time to the appropriate healthcare centres.

Keywords: Expert System, Monkeypox, Inference Engine, Diagnosis

1. Introduction

Monkeypox is an infectious disease caused by the Monkeypox virus. Monkeypox virus (MPXV) is a member of the Orthopoxvirus subfamily. This virus creates a smallpox-like illness. It might cause a severe rash, swollen lymph nodes, fever, headache, muscle aches, back pain and low energy. The Monkeypox virus can be transmitted through touch, kissing, or sex, contaminated bedding, clothes, or needles, hunting, skinning, or cooking of animals, and respiratory droplets. Monkeypox symptoms normally last two to four weeks, but may continue longer in people with impaired immune systems [1].

People can be infected with the Monkeypox virus

via contact with the infected animals (Monkeypox, rabbits, hamsters and guinea pigs) or humans, contaminated materials with the virus [2-4].

Inaccessibility of health care facilities by people is a major problem as some people do not have access to the healthcare facilities due to distance challenge from these facilities. Moreso, in the few available facilities, qualified medical personnel are not always in the primary healthcare centres. These are the key issues that need urgent attention of Expert System.

An Expert System is a type of artificial intelligence program that simulates the knowledge and analytical abilities of one or more human experts. Artificial Intelligence is demonstrated by the ability to solve problems, make

decisions, and learn and understand. AI's basic include reasoning, knowledge, planning, learning, communication, vision, and the ability to move and manipulate objects [5].

An Expert System (ES) is a program that simulates the knowledge and analytical skills of human experts in a domain by using a set of rules to analyse information to solve problems [6]. An expert system which is software could be used to diagnose Monkey pox on the basis of the human expert in medical domain.

Expert System for diagnosis of MonkeyPox consists of three major components: User Interface, Inference Engine and Knowledge Base. The User interface communicates with the Expert System to find a solution. Inference Engine is the engine where inference rules derive a conclusion so that health workers can make decisions. The knowledge base stores factual and heuristic knowledge acquired from the medical experts.

In this era of technology, it would be of great necessity to provide a computerized system to complement the services of medical experts, such as medical disease diagnosis in places where accessibility is a problem as well as health care facilities where qualified experts are lacking, especially in Sub Saharan Africa. Hence, there is a need to design an expert system on the diagnosis of Monkey pox.

The proposed system employs the knowledge and skills of the medical experts to diagnose the degree or intensity of Monkeypox in the healthcare system. Hence, it is helpful in the diagnosis of Monkeypox where medical experts are not available especially in the primary healthcare system in developing countries. The objective of the study is to develop an Expert System for the diagnosis of Monkeypox.

2. Related Work

There are many researchers who have worked on the prevalence and morbidity of Monkeypox virus. Likewise, some authors looked at the various ways of diagnosing Monkeypox disease using Neuro-Fuzzy and Expert Systems as described below:

Studies show that there is an increased weighted average median age of Monkeypox infection in Africa, and it is between 4 and 5 years respectively. The people who have not received Smallpox vaccine are more susceptible to Monkeypox [7]. It was also reported that the prevalence of Monkeypox happened among men between age 32 and 43 years [8].

It was discovered in West Africa (Nigeria) that the outbreak of Monkeypox occurred in rural communities where young males trap and play with rodents [9]. The incubation period of this disease (Monkeypox) lasts between 5 and 21 days before flu-like prodromal symptoms appear such as fever, chills, weakness, malaise, headache, lymphadenopathy [3]. Records show that United Kingdom (UK), diagnosed about four people who had travel-associated Monkeypox (MPX) according to European Centre for Disease Control in 2022 [10]. Another case of MPX happened in USA in 2003 when infected rats were imported unintentionally [11]. Centres for Disease Control (CDC) in 2022 [12] reported that more than 12, 261 people have been affected by the disease (MPX) from more than 76 countries.

Boghuma K. et. al. [13] reviewed the multi-country outbreak of Monkeypox that occurred outside Africa. The authors targeted their study to let the professionals be familiar with the various clinical presentations and management of Monkeypox infection.

Lum, F. M. et. al. [14] presented their study by considering the epidemiology of Monkeypox in non-endemic regions where 48,000 cases were recorded. They discussed the clinical, epidemiological and immunological features of Monkeypox virus (MPXV) infections.

Amenu, O. and Assefa, A. [15] developed an expert system tailored for diagnosing diseases associated with MonkeyPox outbreaks. Their study not only addressed diagnostic solutions but also proposed treatment strategies of Monkeypox.

In a study by Tom, J. J. and Anebo, N. P [16], a neuro-fuzzy based model was devised for diagnosis of Monkeypox virus with a differentiation from other pox families. The study was implemented using neuro-fuzzy model.

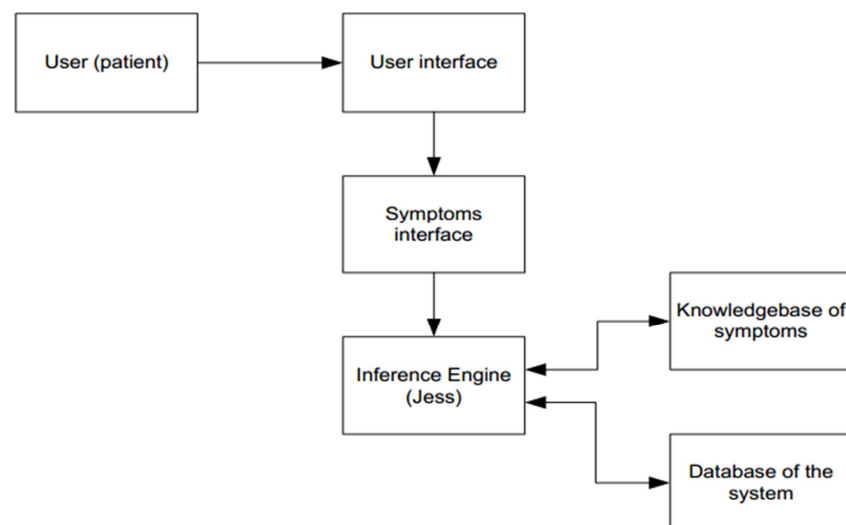


Figure 1. Expert System for Monkeypox Diagnosis (ESMD).

3. Methodology

The proposed system in Figure 1 contains various components which are User Interface, Inference Engine and Knowledge Base. The User Interface is the medium where system interacts with a user via input means. Interface allows interaction. User as a patient is an entity and the system can be considered as an entity. The interface allows users to interact with the system. This interface contains possible signs and symptoms of patients with Monkeypox collected from various healthcare centres. Monkeypox symptoms include fever, chills, swollen lymph nodes, exhaustion, muscle aches and backache, headache, respiratory symptoms (e.g., sore throat, nasal congestion, or cough) etc.

The user enters the symptoms, from this phase; it passes to the Inference Engine. The Inference Engine is made up of the efficient procedures and rules. The rules are used to deduce a correct solution. The inference engine serves as the brain of the expert system. It holds the logic for output interpretation. It interprets and evaluates the facts in the knowledge base in order to provide an answer.

The Knowledge Base is another component of Expert System where factual and Heuristic knowledge are stored. It contains facts about Monkeypox disease which could be symptoms. It contains all known answers about the solution. It is otherwise regarded as an organized collection of facts about the system's domain.

The Logic representation of diagnosis of Monkeypox is represented as follows:

If X is the Universe of discourse and its elements are denoted as x , in contrast with crisp set, then the logic set A of X has characteristics function associated to it. The logic set is represented by a membership function, defined as follows:

$$\mu_A: X \rightarrow [0,1]$$

$$\mu_A(X) = 1 \text{ if } x \text{ is totally in } A$$

$$\mu_A(X) = 0 \text{ if } x \text{ is not in } A$$

Where X is the disease and A is the text object (patient)

For the Diagnosis (D_x) i.e. the degree of intensity of diagnosis of Monkeypox, a patient (A) could have:

$$\mu: D \rightarrow [1:3]$$

$$\mu A(D_{x(mild)}) = 1 \text{ if } d_x \text{ is mild in } A$$

$$\mu A(D_{x(moderate)}) = 2 \text{ if } d_x \text{ is moderate in } A$$

$$\mu A(D_{x(severe)}) = 3 \text{ if } d_x \text{ is severe in } A$$

$$\mu A(D_{x(absence)}) = 0 \text{ if } d_x \text{ is when the symptoms are absent in } A$$

$\mu_A(X)$ expresses to which the value x belongs to the set A . The value 0 corresponds to the absolute non-membership and the value 1 corresponds to the absolute membership. The membership is defined by the availability of symptoms as related to Monkeypox.

A logic membership function (X) μ_A indicates the degree of belonging to some element x (symptoms) of the universe of discourse X (Monkeypox). It maps each element of X (symptoms) to the Diagnosis of a membership grade between 1, 2 and 3 where 1 represents Mild, 2 indicates Moderate and 3 represents Severe. All these values show the degree of

intensity of the Diagnosis of the Monkeypox disease that a patient could have.

The Logic Flow of the Expert System is described below:

Figure 2 shows the logic flow of the Expert System for diagnosis of Monkeypox as follows.

Step 1: Input signs and symptoms of patient complaint into the system.

Where x =number of signs and symptoms

X indicates the degree of the symptoms that show

$$x(\text{present/yes}) = 1, x(\text{Absent/no}) = 0$$

Step 2: Search the knowledge-base for the disease, which has the signs and symptoms identified.

Step 3: Get the weighing factors (wf) (the associated degree of intensity).

$$wf = 1, 2, 3$$

Where 1 = Mild, 2 = Moderate, 3 = Severe

Step 4: Logic rules using the mathematical calculations as represented above

Step 5: Map inputs into their respective weighing factors to determine their degree of membership.

Step 6: Determine the rule base evaluating (non-minimum values).

Step 7: Determine the firing strength of the rules R .

Step 8: Calculate the degree of truth R , of each rules by evaluating the non-zero minimum value.

Step 9: Compute the intensity of the disease.

Step 10: Output diagnosis

IF-THEN flow of the system is represented below

001: IF skin rash = 1 and fever = 1 and lymphadenopathy = 1 and chill = 1 and fatigue = 1 and headache = 1 and sore throat = 1 and backache = 1 and cough = 1 and nausea = 1 THEN Monkeypox = severe

002: IF skin rash = 1 and fever = 1 and lymphadenopathy = 1 and chill = 0 and fatigue = 1 and headache = 0 and sore throat = 1 and backache = 0 and cough = 0 and nausea = 1 THEN Monkeypox = moderate

003: IF skin rash = 1 and fever = 0 and lymphadenopathy = 1 and chill = 1 and fatigue = 0 and headache = 1 and sore throat = 1 and backache = 0 and cough = 1 and nausea = 0 THEN Monkeypox = moderate

004: IF skin rash = 1 and fever = 0 and lymphadenopathy = 1 and chill = 0 and fatigue = 0 and headache = 0 and backache = 0 and cough = 0 and nausea = 1 THEN Monkeypox = mild

005: IF skin rash = 1 and fever = 0 and lymphadenopathy = 1 and chill = 0 and fatigue = 0 and headache = 1 and backache = 0 and nausea = 0 THEN Monkeypox = Mild

006: IF skin rash = 1 and fever = 1 and lymphadenopathy = 1 and chill = 0 and fatigue = 0 and headache = 1 and backache = 0 and nausea = 1 and dehydration = 1 and sepsis = 1 and immunocompromise = 1 and pneumonia = 1 THEN Monkeypox = Severe

007: IF skin rash = 1 and fever = 1 and lymphadenopathy = 1 and chill = 1 and fatigue = 0 and headache = 1 and backache = 0 and nausea = 1 and dehydration = 1 and sepsis = 1 and extreme-of-ages = 1 and pneumonia = 1 THEN

Monkeypox = Severe

008: IF skin rash = 1 and fever = 1 and lymphadenopathy = 1 and chill = 1 and fatigue = 1 and headache = 1 and backache = 1 and nausea = 1 and dehydration = 1 and sepsis = 1 and convulsion = 1 and immunocompromise = 1 and pneumonia = 1 THEN Monkeypox = Severe

009: IF skin rash = 1 and fever = 0 and lymphadenopathy = 1 and fatigue = 1 and headache = 0 and backache = 1 and nausea = 0 and dehydration = 1 and pneumonia = 0 THEN Monkeypox = moderate

010: IF skin rash = 1 and fever = 0 and lymphadenopathy = 1 and chill = 0 and fatigue = 0 and headache = 0 and sore throat = 1 and backache = 0 and cough = 0 and nausea = 0 THEN Monkeypox = mild

011: IF skin rash = 1 and fever = 1 and lymphadenopathy = 1 and chill = 0 and fatigue = 0 and headache = 1 and backache = 0 and nausea = 1 and dehydration = 1 and sepsis = 1 and immunocompromise = 1 and pregnancy = 1 and pneumonia = 1 THEN Monkeypox = Severe

012: IF skin rash = 0 and fever = 0 and lymphadenopathy = 0 and chill = 0 and fatigue = 0 and headache = 0 and sore

throat = 0 and backache = 0 and cough = 0 and nausea = 0 THEN Monkeypox = Absent.

4. Implementation

The implementation of the study was done using programming language tools such as PHP, MySQL and Vue JS framework. The following are the interfaces from the implementation.

4.1. Patient Dashboard Interface

This interface shows all elements such as registered patients, undiagnosed and diagnosed patients with system users menu. It enables the system administrator to have full access and control of the Expert System. The registered patients are the patients already registered in the hospital, the diagnosed patients are those patients already attended to; the undiagnosed patients are the patients waiting to be diagnosed, and users are all active people using the system as presented in Figure 2.

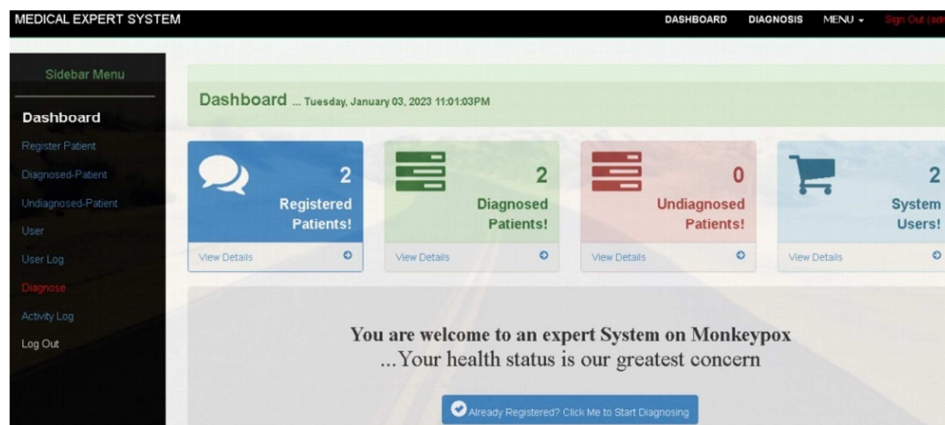


Figure 2. Patient Interface.

4.2. List of Patients Interface

This interface contains the information of all registered patients in the hospital. It shows the Patient ID, full name,

gender, address and mobile number of the patients. It enables proper update and deletion of patient's record as appropriate as shown in Figure 3.

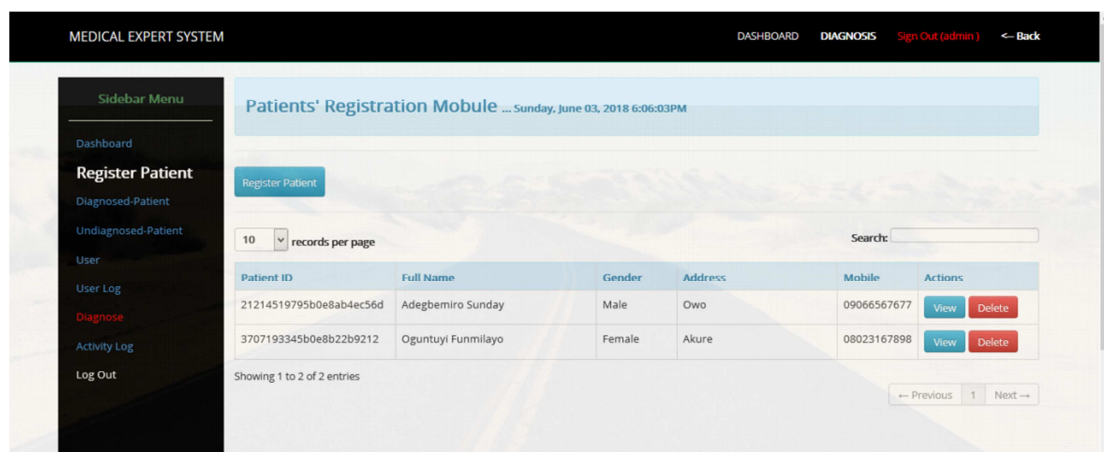


Figure 3. List of Patient.

4.3. Diagnosis Stages

This interface contains predefined questions to determine the diagnosis result. It has seven stages in all. Stage one contains the patient information, stage two contains the

agreement note, stage three to six contain symptoms of Monkeypox while the completion stage is the final phase where the diagnosis process is completed as shown in Figure 4.

Figure 4. Diagnosis Stages.

4.4. Diagnosis Interface

Stage three to six of the system contains the symptoms of Monkeypox. These series of symptoms described enable the Expert System to determine the output of the diagnosis as presented in Figure 5.

Figure 5. Diagnosis Interface.

5. Conclusion

Expert systems have emerged as invaluable assets in our technology-driven world. The extraction and storage of expert knowledge within these systems offer a means to mitigate potential setbacks, such as the absence of experts due to various circumstances.

Considering the recent surge in Monkeypox disease outbreaks across Africa, substantial efforts have been exerted to combat the ailment. The healthcare sector, primarily through medical professionals like doctors, nurses, and anatomists, has deployed medical equipment for diagnosing and treating Monkeypox disease. Nonetheless, challenges persist, notably the unfortunate loss of medical experts in developing regions and the scarcity of available professionals. Consequently, rural communities suffer from limited access to quality healthcare services.

Given the aforementioned challenges, the imperative arises to counteract them with an alternative solution that replicates the services provided by human experts. This underscores the necessity for a medical diagnostic expert system capable of emulating the diagnostic and treatment skills of medical practitioners. By harnessing the power of computers, this system can deliver the same level of service even in the absence of experts.

The expert system has been meticulously designed as a web-based platform, facilitating remote and convenient access for users. This approach seeks to overcome the challenges faced by patients.

Importantly, the medical diagnostic expert system for various Monkeypox complications has been developed with the intention to aid patients and support doctors rather than replace them. Its role is to augment healthcare efforts, ensuring that both patients and medical professionals' benefit from its capabilities.

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