Early Zika Virus Detection System Using Rules Based Technique

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Abstract: Zika's virus is a disease caused by mosquitoes and is spread out very fast around the world. Therefore, it is need an effective mechanism for detecting early stage symptoms or signs of Zika's disease. In this study, a prototype system was developed using rules based techniques. The rules are used based on Zika symptoms and the history that the users have visited in the risk area. This system responds very fast either positive or negative symptoms of the disease and also contains the steps for preventive the disease. If the feedbacks shown the positive for Zika virus, the users are strongly advised to Hospital or Health Center for make a blood test or urine test for the validation. In addition, this system can be used at all times and anywhere.

Key words: Zika virus • Rule based technique • Zika symptoms • Detection system • Expert system

INTRODUCTION

The Zika virus was first identified in 1947 in the Zika Forest at Uganda, Afrika. It is identified during the program for monitoring wild yellow fever [1-4]. This virus is arbovirus of the genus Flavivirus in the family Flaviviridae and most closely related to the spondweni virus such as dengue, yellow fever, West Nile fever, Japanese Encephalitis and Chikungunya virus [5]. In 1954, the first case of Zika isolation in human has occurred during an epidemic of jaundice in Nigeria [6] and the next outbreaks of the disease were first notified in the Pacific regions in 2007 and 2013, respectively in the Yap Island and French Polynesia, Brazil and Colombia (Amerika) and Cape Verde (Africa) in 2015 [2-4,7].

Since then it has been observed, the epidemic has spread into most American countries and also to other continents including the Southeast Asia. This virus is spreading in Malaysia because of the Aedes (Aedes Aegypti and Aedes Albopictus) mosquitoes found locally that have connection to the Zika virus [8]. In addition, Chikungunya and dengue viruses can simultaneously distribute as is the case of Pacific [8] and Latin America [9] and this can also occur in Malaysia due to having similar climate and environments [10]. Realizing Zika can spread throughout the country, the Malaysian Ministry of Health has issued warnings and guidelines to all hospitals on how to handle Zika cases. Detailed and specific guidelines for healthcare providers, including the management of pregnant women and infants with suspected Zika are also available from the Centres for Disease Control and Prevention.

In light of that, there is a need to have a system for detecting the symptoms of Zika infection at the early stage. It is important to initiate public awareness of the symptoms such that everyone can take an appropriate action if they suspected of has been infected by this virus. The system can be used to diagnose the person having the Zika symptoms and for confirmation and further treatment, the system can recommend the person to any hospital.

There are many expert systems that use rules based techniques in supporting the diagnosis of disease a such as asthma, asthma, heart diseases, sleep disorder, diabetes, cerebral palsy, and neuromuscular disorder. In [11], the authors applied of a rule based expert system for cerebral palsy diagnosis which ends up classifying the symptom as mild, moderate or severe. During the implementation, a few most classical symptoms of cerebral palsy is taken and assigned a weightage to each symptom according to the feedback given by the user. The expert system offers great deal of support for the medical professionals in making decision and it is very beneficial for the parents having children with cerebral palsy in taking appropriate actions to manage the disease.
Moreover, a rule-based expert system was also used for diagnosis all types of diabetes [12]. The authors claimed the findings showed the expert system has been used effectively in many parts of medical science and health care. In particular, in terms of the number of diabetic patients worldwide, expert systems can be very helpful to patients. In many cases, the patient is unaware that he has a disease and not knowing how to control it. The condition may be worse if the patient does not have access to the doctor as needed. Therefore, the system provides the necessary information and instruction regarding the diagnosis and treatments. As this expert system gathers its knowledge from some physicians, this system has far a broader knowledge and as such can be very helpful to diabetes patients.

Meanwhile, researchers in [13] produced an expert system for waterborne diseases. This research captures waterborne diseases such as cholera, typhoid, malaria, chikungunya, tuberculosis and dengue. Confusion can occur as symptoms of this infection overlapping with each other; therefore an initial diagnosis is essential for the medical professional to effectively treat for patients. The expert system that was developed would facilitate this process by providing inference based on symptoms collected and acting as a tool of assistance for the medical experts in identifying the disease based on the symptoms specified by the patients.

In this paper, we propose an expert system based on rule-based technique for early detection of symptoms in a Zika-related patient. This application can be used to assist medical officers in isolating Zika patients in case of outbreak. With vast and comprehensive knowledge about Zika, it will be able to provide an efficient and fast diagnosis together with a precise result.

The rest of the paper is organized as follow, the overview of the Zika disease and the development of the system is provided in the Materials and Methods section. The result of this project in the form of system user interface and successful test are given in Result and Discussion section. Finally, the Conclusion section summarizes the finding of this paper.

**MATERIALS AND METHODS**

In this section, we discuss the building block of our expert system. The architecture of rule-based expert system is consolidated in the system development known as expert system development methodology and is shown as in Figure 1. The rule-based system is one part of an intelligence system [14], it consists of knowledge base, database, inference engine, explanation subsystem and user interface [15]. The whole process is divided into six phases, the detailed explanation of each part will be discussed together in the system development. The first three phases will be discussed in this section, followed by the next two in the next section and the last phase is shown only for completion.

Phase 1 involves with carrying out an initial planning that includes identifying the issues and defining the problem. Although it may need to be adapted at a later stage, a good working definition makes it possible to describe the problem to others who may become involved in the problem solving process.

Phase 2 is where the requirement for the system is gathered. After having analysed the problem domain in term of users or stakeholders involvement in the surrounding of the system and the diseases of the Zika virus, the necessary knowledge was acquired from

![Fig. 1: The Steps of rule-based expert system development methodology.](image-url)
various sources. In this system there are several types of users involved whether directly and indirectly. Example of direct source are patients, and the medical staffs (clerks, nurses, lab staffs, doctors and others). In our case, we interviewed the experts from the Student Health Center, Unisza Kampus Tembila, Terengganu, reading journal articles, website, textbook and others. Some of the knowledge needs for a refinement because difference knowledge and opinion are prevailed from one expert to another or from different sources. Accordingly, this information are used to develop the system efficiently and effectively.

Likewise, the information of the Zika virus is obtained from the various sources and if needed the information will be discussing with the experts. The expert is responsible for reviewing the information collected such that they are accurate and correct. The most crucial information is the virus-causing Zika disease and the way they are transmitted. The spread of Zika virus among humans can occur in several ways. They are either through mosquito bite (Aedes albopictus and aegypti) [8], perinatal transmission (include trans placental, delivery and breastfeeding) [16], sexual intercourse (presence in semen) [17] and blood transfusion [18] which can be simplified into an illustration as in Figure 2 [19].

<table>
<thead>
<tr>
<th>Table 1: Symptoms/Signs of Zika Disease</th>
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<tr>
<td>Number</td>
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There are several signs or symptoms if this disease infects the human. The incubation period (the time from exposure to symptoms) of Zika virus is not clear, but is likely to be a few days. The symptoms are similar to other arbovirus infections such as dengue, and include fever, skin rashes, conjunctivitis, muscle pain, joint pain and headache. These symptoms are usually mild and last for 2 to 7 days. The symptoms of Zika virus can be simplified as in Table 1 [20-24].

In addition, Figure 3 illustrates the familiar location in human body for where the virus is normally affected [25]. Nevertheless, to confirm this virus infected the human, the patient must visit the doctor and run through a check to identify the symptoms, most notably any recent travel experience followed by a blood or urine test. The countries that are frequently exposed to the risk are Argentina, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador,
Phase 3 involves the analysis and design of the system. This results in the construction of the knowledge base system based on top of knowledge gathered into a database and rules in a form of programming language. The knowledge is transformed into the rules based in a form IF-THEN rules. Rules are made to be accurate by getting assistance from the medical experts. After that, it will go through a process of coding the rules using some programming tools. The aim of the resulting system shows all the rules in the knowledge base are evaluated until the possible outcome appears. The general form of rules adopted in this paper can be described as following.

\[
\text{IF } y_1 \text{ AND } y_2 \text{ AND.. } y_n \text{ THEN } z_1 \text{ OR } z_2
\]

The rules are usually expressed in two parts which is IF part called antecedent or premise (or condition) and the THEN part is called consequent or conclusion (or action) [26]. If the rules is of multiple structure (usually combination of rules using AND and OR operator), it can be decomposed into much simple rules [27]. Example of simple and multiple rules are as follows:

- IF condition THEN action
- IF condition 1 OR condition 2.. OR conditionN THEN action
- IF condition 1 AND a condition 2.. AND conditionN THEN action.

In this research, the proposed system uses backward chaining method (goal driven reasoning) as its inference mechanism. Here is how it works, suppose a person is suspected of Zika virus, the rules for Zika disease will be:

**If the patient**
- Answer (fever =yes)
- Answer (skin rash =yes)
- Answer (join pain =yes)
- Answer (Conductivities (red eyes) =yes)
- Answer (Muscle pain =yes)
- Answer (Headache =yes)
- Answer (travel the risk area =yes)

**Then**
- The patient is early suspected Zika disease and need for further treatment at the Hospital

Likewise, this is an example of no early Zika disease infection from a person that has gone through the checking by our expert system.

**If the patient**
- Answer (fever =No)
- Answer (skin rash =No)
- Answer (join pain =yes)
- Answer (Conductivities (red eyes) =yes)
- Answer (Muscle pain =yes)
- Answer (Headache =yes)
- Answer (travel the risk area =yes)

**Then**
- The patient is not suspected OF Zika disease but need to further treatment at the Hospital

The database is an important part in the development of rules based system. It is used for storing all information needed for the Zika diseases. For this purpose, the MySQL is used as part of the database and and PHP language as a tool for implementation. Example information included in the database are the symptoms of Zika disease, the ways to protect outbreak of Zika, patient information, blood test and the information the person who charge the blood test.
Fig. 4: The inference process Early Zika Detection Diseases Using Rule Based

The inference process manipulates the knowledge base to deduce information requested by the user and carries out the reasoning required by the expert system to reach a solution. It links the rules given in the knowledge base with the facts store in the database. For example, if a patient only have Zika symptoms like fever and skin rash while not others, the system concludes the patients is not early suspected of the Zika virus because the symptoms shown does not match all Zika symptoms. However, the system suggests the patient to go to hospital for further treatment because this symptoms may be related to others diseases such as aedes or chingkunya. The system inference prosess is shown in Figure 4.

RESULTS AND DISCUSSION

This section describes the content of Phase 4 and Phase 5 from expert system development methodology. In general, different functional of interface is designed for different users. In this system the type of the users are patients, medical experts and the staffs at the hospital. The users must first be registered and then are allowed to use the system according to the functionality of the type users. Normally, the flow of the system starts when a patient register and check the symptoms, and the expert (system) identify if he is suspected with Zika disease or not. If positive (yes) the patient is highly suggested to go to hospital for blood or urine test. The system then captures the result from the blood testing and the final results can be accessed by the patient through the system. Some screen layouts for a few processes is shown in Figure 5, Figure 6(a) and 6(b), and Figure 7.

System testing and validation was also performed to test if the functionality abides the initial requirement specification set by the users. This stage is important to ensure the prototype or the system free from errors before releasing for use. The errors such as logic errors,
Fig. 6(a): Test Zika Disease form

Fig. 6(b): Test Zika Disease form

Fig. 7: Manage the risk area form
debugging, successful link between the module or menu, rules checking and sample field are all tested. The validation concern with diagnostic result so as to closely match the views of human experts.

CONCLUSION

This paper presented a rule based technique for early Zika detection system. The system diagnose the symptoms of Zika disease in a patient for early confirmation. The proposed system offers assistants to the patients to know more about the disease, how to treat and prevent the virus from spreading. It also gives an awareness to users for early Zika disease detection.

REFERENCES