

Developing an Expert System to Diagnose Malaria

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Abstract: *Malaria is a life-threatening disease spread to humans by some types of mosquitoes. It is mostly found in tropical countries. It is preventable and curable. The infection is caused by a parasite and does not spread from person to person. Symptoms can be mild or life-threatening. Mild symptoms are fever, chills and headache. Severe symptoms include fatigue, confusion, seizures, and difficulty breathing. Infants, children under 5 years, pregnant women, travellers and people with HIV or AIDS are at higher risk of severe infection. Discovering this disease is a good step for proper and correct treatment. Determining the treatment with high accuracy depends on the method used in the diagnosis. Correctly, expert systems can greatly help to avoid spreading this disease. The expert system diagnoses malaria disease correctly to facilitate doctors to find the correct treatment based on the appropriate diagnosis. Objectives: An expert system has been established based on CLIPS to diagnose malaria disease.*

Keywords: *Artificial intelligent, expert system, malaria disease, CLIPS.*

1. INTRODUCTION

Malaria, a mosquito-borne infectious disease caused by the Plasmodium parasite, continues to pose significant diagnostic challenges worldwide. This debilitating illness affects millions of people, particularly in tropical and subtropical regions, where the Anopheles mosquito thrives. The disease presents with symptoms such as fever, chills, headache, and fatigue. If left untreated, malaria can lead to severe complications and even death. However, accurately diagnosing malaria can be complex, hindering timely treatment and impeding efforts to control the disease effectively.

Malaria diagnosis traditionally relied on microscopic examination of blood samples to detect the presence of Plasmodium parasites. While this method remains important, it requires skilled technicians, well-equipped laboratories, and quality assurance measures. In resource limited settings, these requirements may not be readily available, leading to inadequate or delayed diagnosis.

2. EXPERT SYSTEM

An expert system has been established that diagnose malaria disease. The expert system helps doctors and facilitates the process of discovering diseases in a clear and good manner. The system also diagnose malaria diseases by showing a list of symptoms related to malaria disease. The expert system was programmed using the Clips language. The expert system diagnoses diseases related to malaria disease through a system that consists of some menus that facilitate its use by the user.

At first, a user interface will appear that contains four tasks. If the user clicks on the "Start" icon, the user will see an interface that contains a list of all the symptoms. The user will choose all the symptoms related to the disease he wants.

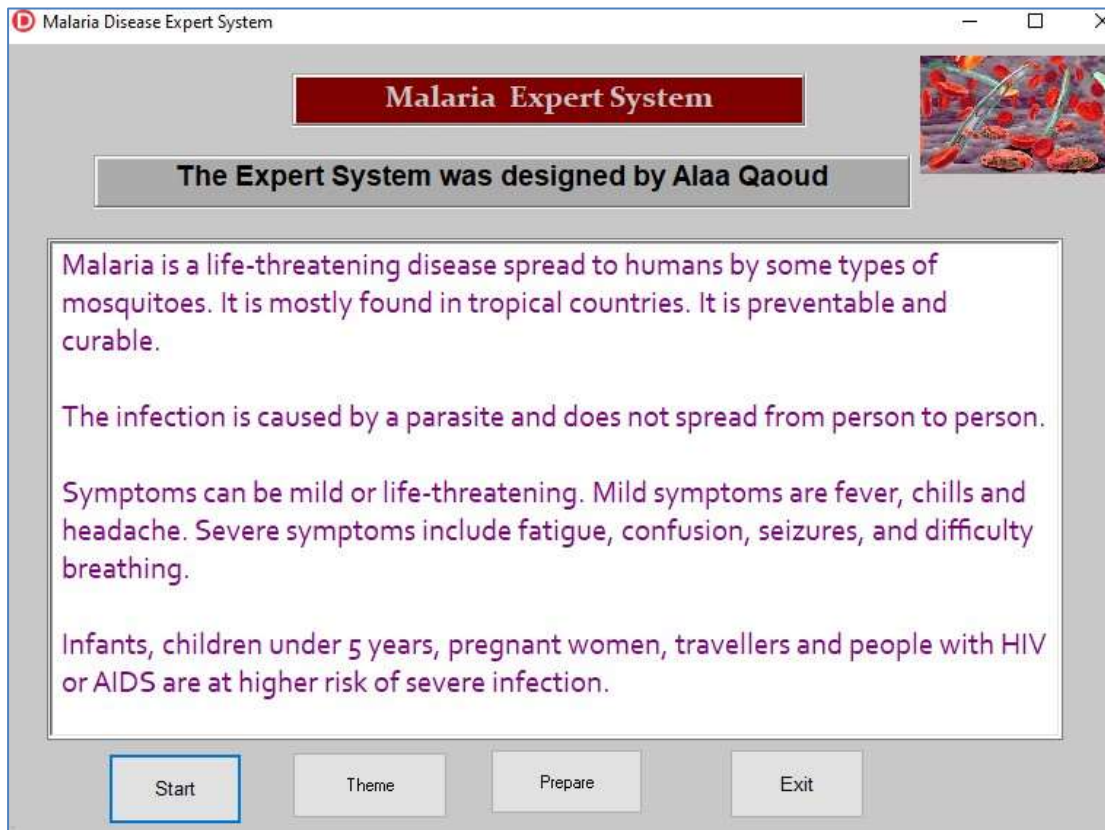


Figure 1: First destination

Then appear list about destination diagnosis to show the symptoms for the user to choose the symptoms that will be treatment

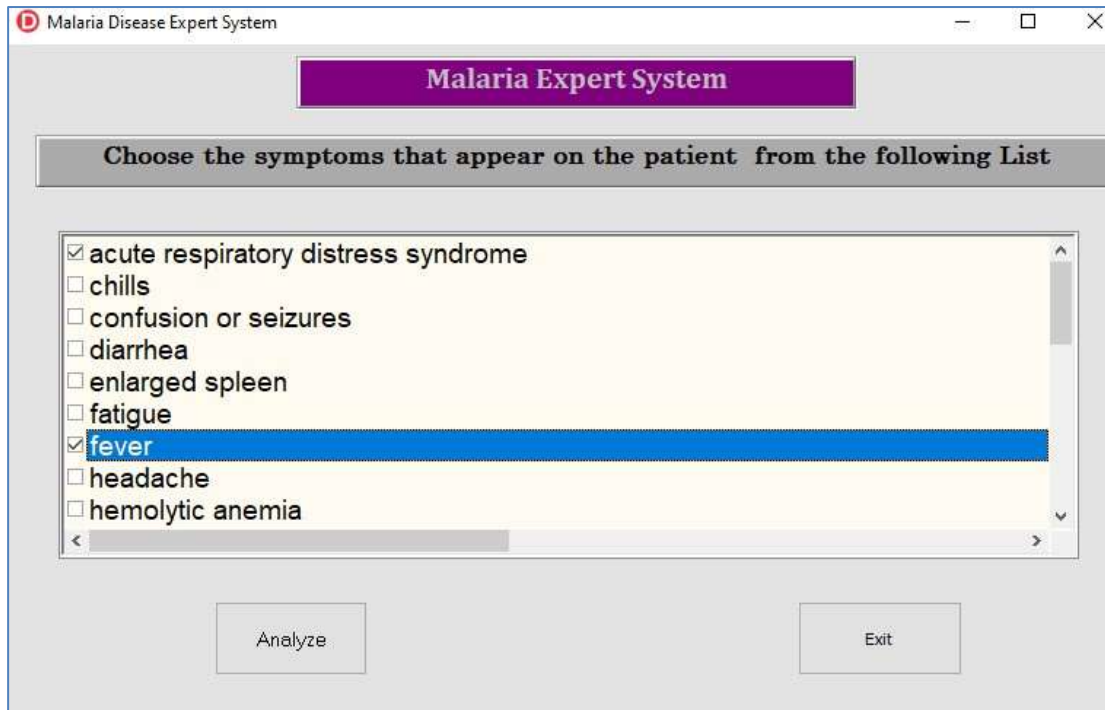


Figure 2: Symptom destination

Then appear list about destination analyze to show the symptoms for the user to show the Diagnosis.

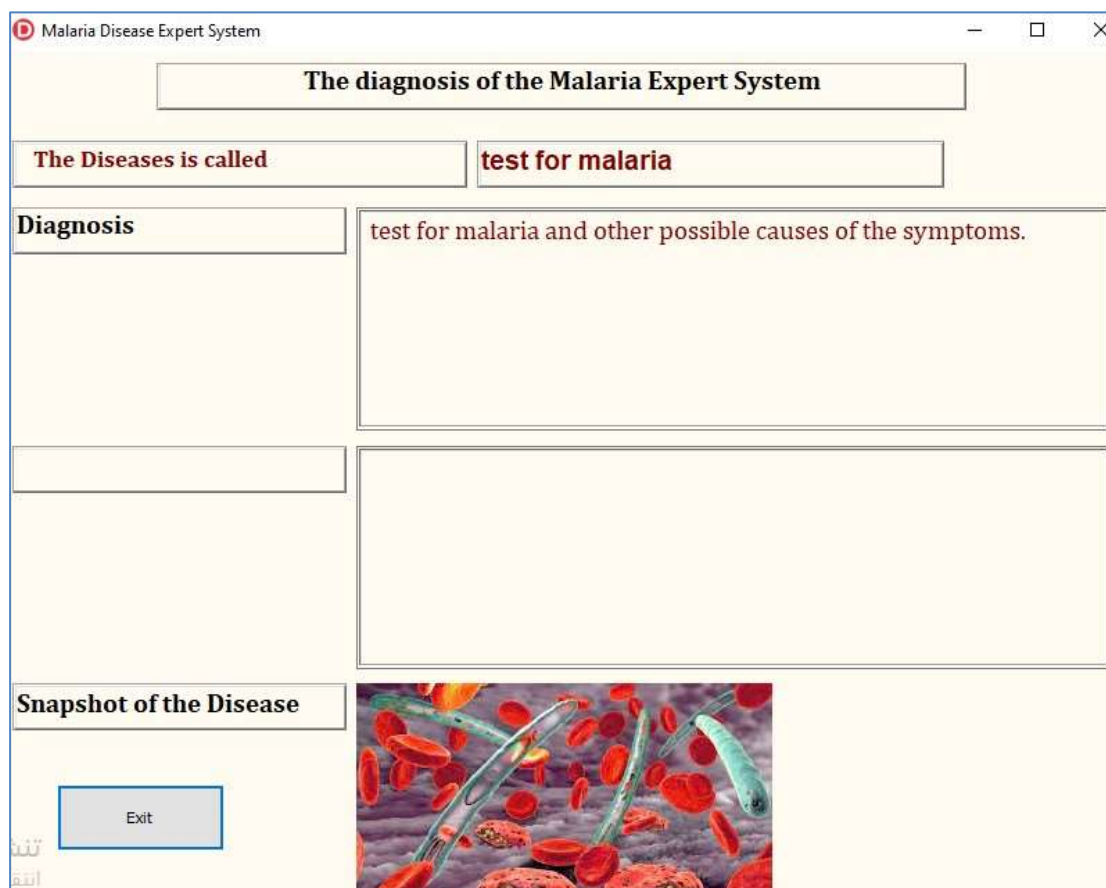


Figure 3: Destination analyze

3. LITERATURE REVIEW

Malaria, a significant global health concern, has motivated researchers to explore innovative solutions for its diagnosis, treatment, and management. In recent years, the development of expert systems specifically tailored for malaria has gained attention. This literature review aims to provide a comprehensive overview of the existing research on malaria expert systems, highlighting their advancements, challenges, and potential future directions.

Findings:

Malaria Expert System Architecture: Several studies proposed different architectures for malaria expert systems, ranging from rule-based systems to hybrid models combining rule based and machine learning approaches. The architectures aimed to incorporate various components such as knowledge representation, inference engines, and user interfaces to support accurate diagnosis, treatment recommendations, and monitoring of malaria patients.

Malaria Treatment and Management: Expert systems have been explored for providing treatment recommendations and management guidelines for malaria cases. These systems incorporate knowledge from clinical guidelines, drug resistance data, and patient-specific information to generate personalized treatment plans. The use of expert systems has shown potential in optimizing drug selection, dosage calculations, and monitoring adverse drug reactions.

Challenges and Limitations: Despite their potential, malaria expert systems face several challenges. The availability and quality of data, especially in resource-limited settings, can limit the performance and generalizability of these systems. Additionally, the interpretability and explain ability of expert system outputs remain important considerations, particularly in the context of clinical decision-making.

Impact on Malaria Control: Malaria expert systems hold the potential to enhance disease control efforts by supporting accurate diagnosis, personalized treatment, and surveillance. They can assist healthcare providers, particularly in resource-constrained settings, in making informed decisions, ultimately leading to improved patient outcomes and reduced morbidity and mortality.

4. KNOWLEDGE REPRESENTATION

There are nineteen procedures to be diagnosed through symptoms that are displayed using CLIPS expert system language:

1. Test for malaria using a blood smear or rapid diagnostic test (RDT) if you have the following symptoms: fever AND chills AND headache AND muscle pain AND fatigue.
2. Test for malaria along with other possible causes of the symptoms if you have the following symptoms: fever AND sweating AND diarrhea AND vomiting.
3. Test for malaria and consider treatment even if the test is negative if you have the following symptoms: fever AND enlarged spleen.
4. Test for malaria immediately, even if other symptoms are not present if you have the following symptoms: recent travel to a malaria-endemic area AND fever.
5. Test for malaria as a possible cause if you have the following symptoms: persistent fever despite treatment for suspected bacterial infection.
6. Test for malaria immediately as it can be particularly dangerous for both the mother and the baby if you have the following symptoms: pregnant woman AND fever.
7. Test for malaria and consider treatment even if the test is negative, if you have the following symptoms: unexplained fever AND history of previous malaria infection.
8. Test for malaria and other possible causes of the symptoms if you have the following symptoms: fever AND jaundice.
9. Test for malaria and other possible causes of the symptoms if you have the following symptoms: fever AND confusion or seizures.
10. Test for malaria and other possible causes of the symptoms if you have the following symptoms: fever AND hemolytic anemia.
11. Test for malaria and other possible causes of the symptoms if you have the following symptoms: fever AND thrombocytopenia.
12. Test for malaria and other possible causes of the symptoms if you have the following symptoms: fever AND acute respiratory distress syndrome (ARDS).
13. Test for malaria and other possible causes of the symptoms if you have the following symptoms: fever AND renal failure.
14. Test for malaria and other possible causes of the symptoms if you have the following symptoms: fever AND hypoglycemia.
15. Test for malaria and consider treatment even if the test is negative, if you have the following symptoms: fever AND history of exposure to malaria-infected blood or needles.
16. Test for malaria and consider treatment even if the test is negative, if you have the following symptoms: fever AND history of receiving blood transfusion or organ transplant in a malaria-endemic area.
17. Test for malaria and consider alternative treatments or confirmatory testing if you have the following symptoms: fever AND recent use of antimalarial medication.
18. Test for malaria and other possible causes of the symptoms if you have the following symptoms: fever AND suspected or confirmed co-infection with another vectorborne disease (e.g., dengue, Zika, or chikungunya).
19. Test for malaria and other possible causes of the symptoms if you have the following symptoms: fever AND suspected or confirmed bacterial co-infection (e.g., typhoid fever or bacterial sepsis).

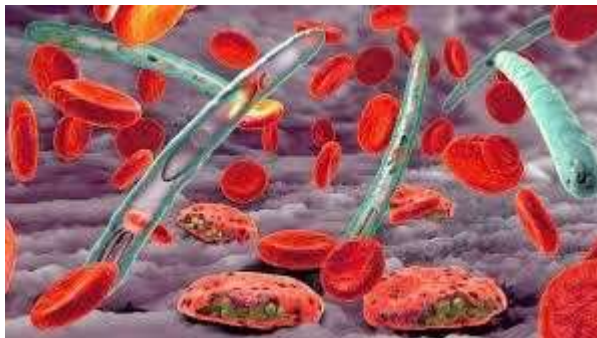


Figure 4: Malaria Parasite Life Cycle

5. EXPERT SYSTEM SOURCE CODE

```
(defrule disease1
(fever)
(chills)
(headache)
(muscle pain)
(fatigue)
(not (disease identified)) =>
(assert (disease identified))
(printout fdatao "1" crlf )
)

(defrule disease2
(fever)
(sweating)
(vomiting)
(diarrhea)
(not (disease identified)) =>
(assert (disease identified))
(printout fdatao "2" crlf )
)

(defrule disease3
(fever)
(enlarged spleen)
(not (disease identified)) =>
(assert (disease identified))
(printout fdatao "3" crlf )
)

(defrule disease4
(recent travel to a malaria-endemic area)
(fever)
(not (disease identified)) =>
(assert (disease identified))
(printout fdatao "4" crlf )
)

(defrule disease5
(persistent fever despite treatment for suspected bacterial infection)
(not (disease identified)) =>
(assert (disease identified))
(printout fdatao "5" crlf )
)

(defrule disease6
(pregnant woman)
(fever)
(not (disease identified)) =>
(assert (disease identified))
(printout fdatao "6" crlf )
)
```

```
(defrule disease7
(unexplained fever)
(history of previous malaria infection)
(not (disease identified)) =>
(assert (disease identified))
(printout fdatao "7" crlf )
)
```

```
(defrule disease8
( fever)
(jaundice)
(not (disease identified)) =>
(assert (disease identified))
(printout fdatao "8" crlf )
)
```

```
(defrule disease9
( fever)
(confusion or seizures)
(not (disease identified))
=>
(assert (disease identified))
(printout fdatao "9" crlf )
)
```

```
(defrule disease10
( fever)
(hemolytic anemia)
(not (disease identified)) =>
(assert (disease identified))
(printout fdatao "10" crlf )
)
```

```
(defrule disease11
( fever)
(thrombocytopenia)
(not (disease identified)) =>
(assert (disease identified))
(printout fdatao "11" crlf )
)
```

```
(defrule disease12
( fever)
(acute respiratory distress syndrome)
(not (disease identified)) =>
(assert (disease identified))
(printout fdatao "12" crlf )
)
```

```
(defrule disease13
( fever)
(renal failure)
```

```
(not (disease identified)) =>  
(assert (disease identified))  
(printout fdatao "13" crlf )  
)
```

```
(defrule disease14  
(fever)  
(hypoglycemia)  
(not (disease identified)) =>  
(assert (disease identified))  
(printout fdatao "14" crlf )  
)
```

```
(defrule disease15  
(fever)  
(history of exposure to malaria-infected blood or needles)  
(not (disease identified)) =>  
(assert (disease identified))  
(printout fdatao "15" crlf )  
)
```

```
(defrule disease16  
(fever)  
(history of receiving blood transfusion or organ transplant in a malaria-endemic area)  
(not (disease identified)) =>  
(assert (disease identified))  
(printout fdatao "16" crlf )  
)
```

```
(defrule disease17  
(fever)  
(recent use of antimalarial medication)  
(not (disease identified)) =>  
(assert (disease identified))  
(printout fdatao "17" crlf )  
)
```

```
(defrule disease18  
(fever)  
(suspected or confirmed co-infection with another vector-borne disease, e.g., dengue, Zika, or chikungunya)  
(not (disease identified)) =>  
(assert (disease identified))  
(printout fdatao "18" crlf )  
)
```

```
(defrule disease19  
(fever)  
(suspected or confirmed bacterial co-infection, e.g., typhoid fever or bacterial sepsis)  
(not (disease identified)) =>  
(assert (disease identified))  
(printout fdatao "19" crlf )  
)
```



```
(defrule endline
(disease identified) =>
  (close fdatao)
)
```

```
(defrule readdata
(declare (salience 1000))
(initial-fact)
?fx <- (initial-fact)
=>
(retract ?fx)
(open "data.txt" fdata "r") (open "result.txt" fdatao "w")
```

```
(bind ?symptom1 (readline fdata))
(bind ?symptom2 (readline fdata))
(bind ?symptom3 (readline fdata))
(bind ?symptom4 (readline fdata))
(bind ?symptom5 (readline fdata))
(bind ?symptom6 (readline fdata))
(bind ?symptom7 (readline fdata))
(bind ?symptom8 (readline fdata))
(bind ?symptom9 (readline fdata))
(bind ?symptom10 (readline fdata))
(bind ?symptom11 (readline fdata))
(bind ?symptom12 (readline fdata))
(bind ?symptom13 (readline fdata))
(bind ?symptom14 (readline fdata))
```

```
(assert-string (str-cat "(" ?symptom1 "))")
(assert-string (str-cat "(" ?symptom2 "))")
(assert-string (str-cat "(" ?symptom3 "))")
(assert-string (str-cat "(" ?symptom4 "))")
(assert-string (str-cat "(" ?symptom5 "))")
(assert-string (str-cat "(" ?symptom6 "))")
(assert-string (str-cat "(" ?symptom7 "))")
(assert-string (str-cat "(" ?symptom8 "))")
(assert-string (str-cat "(" ?symptom9 "))")
(assert-string (str-cat "(" ?symptom10 "))")
(assert-string (str-cat "(" ?symptom11 "))")
(assert-string (str-cat "(" ?symptom12 "))")
(assert-string (str-cat "(" ?symptom13 "))")
(assert-string (str-cat "(" ?symptom14 "))")
```

```
(close fdata)
)
```

6. CONCLUSION:

Finally, an expert system was established that diagnoses malaria disease, and this disease offers different procedures depending on the symptoms, which are: test for malaria using a blood smear or rapid diagnostic test, test for malaria immediately even if other symptoms are not present, test for malaria as a possible cause, test for malaria and consider alternative treatments or confirmatory testing. This expert system diagnoses this disease in the right and appropriate way and the procedures to be followed that helps doctors to find the appropriate treatment for this disease.

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