Scientia Africana, Vol. 21 (No. 2), August, 2022. Pp 127-138 https://dx.doi.org/10.4314/sa.v21i2.13
© Faculty of Science, University of Port Harcourt, Printed in Nigeria ISSN 1118 – 1931

INTELLIGENT RULE-BASED SYSTEM FOR DIAGNOSING EYE DISEASES

[1]Kobani E. S. and [2]Okengwu U. A.
[1]Department of Computer Science, University of Port Harcourt, Choba, Rivers State
[2]Department of Computer Science, University of Port Harcourt, Choba, Rivers State
Email: ekobani@gmail.com ; ugochi.okengwu@uniport.edu.ng

Received: 03-03-2022
Accepted: 16-07-2022

ABSTRACT

This topic presents the development of an intelligent rule-based system for diagnosing multiple Eye diseases. The motivation behind this work was due to the inflexibility of the existing systems that are only able to diagnose a single type of eye disease. An expert system like the CASNET/GLAUCOMA or PADI-HAA was used to diagnose glaucoma. The stages used to develop our system includes modelling, Knowledge representation, Knowledge acquisition, Inference and System evaluation. This system was developed using HTML, CSS and JavaScript for the frontend and Node.JS for the backend. This system can diagnose eleven different eye diseases thereby solving the issue of the inflexibility of other expert systems.

Keywords: Diagnosis, Expert System, Eye, Knowledge-base, Inference engine, Symptoms

INTRODUCTION

For the last thirty years, the expert system has been the most popular and successful AI study (Wagner, 2017). In a variety of problem areas and domains, several methodologies, philosophies, and technologies have been developed. The expert system is a computer program that simulates the problem's human reasoning process, and then completes the representation of human knowledge by solving the problem using heuristic knowledge rather than precise matching, which correctly reflects most human knowledge. Rule-based diagnostic expert systems, model-based diagnostic expert systems, and online diagnostic expert systems are the most common forms of diagnostic expert systems. Forward reasoning (that is, the reasoning process that follows the rules from the original data to the conclusion), backward reasoning (that is, the process of inferring from the target to the data through hypothesis verification), and two-way reasoning are all part of the rule-based diagnostic expert system's inference strategy (Chen *et al*. 2019). Medical expert systems have distinguishing characteristics that set them apart from other medical software. One of these distinctions is that systems step-by-step emulate the inferences of a doctor to get accurate outcomes. A system expert is usually aware of sequential inferences. To provide correct findings, these expert systems require a huge number of rules and medical information (Mirmozaffari, 2019).

According to the article: Expert System for Early Diagnosis of Eye Diseases Affecting Malaysians (Ibrahim *et al*. 2001). "The employment of a computer software that could assist physicians and other health care providers in discharging their clinical roles in diagnosis, therapy, and prognosis has been driven by a growing demand for high-quality medical services combined with the explosive rise of medical knowledge."

In the ophthalmological knowledge area, only a few expert systems have been constructed, and the majority of them are several years old. A casual-associational network (CASNET) was employed by Rutgers researchers to construct an expert system for detecting and treating glaucoma. As a result, the program is known as CASNET/ GLAUCOMA.

The second, known as the OCULAR HERPES MODEL, is a rule-based expert system that assists in the selection of ocular herpes medications. The third, the Primary Eye Care system (PEC), is an expert system used by non-physician healthcare professionals to treat potentially blinding eye conditions. Its knowledge base is developed from the World Health Organization's Guide to Primary Eye Care. PADI-HAA is a fourth expert system that is also utilized for the diagnosis of Glaucoma. And finally, STRABDIAG is an expert system developed at the University of Rochester for the diagnosis of strabismus and related disorders. Each of these expert systems is restricted to the purpose they were each designed for (Madsen *et al*. 1990).

LITERATURE REVIEW

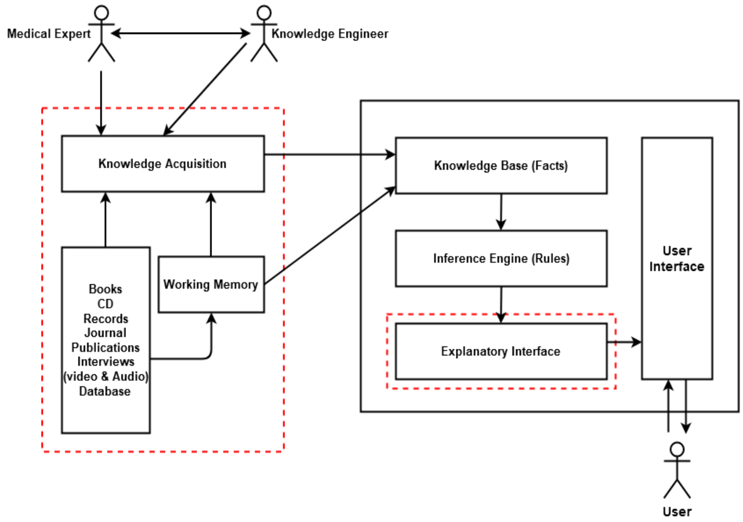
Expert systems that leverage human knowledge to solve problems that would ordinarily need human intellect are known as rule-based expert systems. Expert systems are interactive computer programs that include built-in judgment, experience, rules of thumb, intuition, and other expertise to deliver educated advice and solutions on a variety of topics (Maher *et al*. 1986). "A computer program that uses expert knowledge to achieve a level of performance comparable to that of highly competent experts," is known as an Expert system. As a result, expert systems are created to solve complex issues and explain the reasoning process, where information is represented symbolically rather than numerically (Minkarah *et al.* 1989).

The end-user is usually the non-expert, whereas the computer model is the expert. They can also play chess, make financial judgments, configure computers, monitor real-time systems, underwrite insurance policies, and execute a variety of other tasks that used to require a human skills. The user can interact with a computer to solve an issue using an expert system. This can happen because the expert system can store heuristic knowledge (Samy *et al*. 2008).

Major Components of an Expert System

The knowledge base and the inference (reasoning) engine are the two most important components of an expert system. The knowledge base contains well-known sets of data regarding the area in question. That data is gathered with the assistance of a subject matter expert in the field. The expert collaborates with a knowledge engineer who understands how to program data into the system. The engineer converts the expert's skills and experience into explicit knowledge, with the expert providing comments and feedback on the system's accuracy and behaviour (Lichy *et al*. 2015).

Scientia Africana, Vol. 21 (No. 2), August, 2022. Pp 127-138 https://dx.doi.org/10.4314/sa.v21i2.13
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*



Knowledge Base

This is the expert system's knowledge, coded in a format that the system can understand. It is created by a team of humans (for example, a knowledge engineer) and an automated learning system (for example, one that can learn from good examples of expert performance) (Buchanan *et al.* 1984). Semantic networks, conceptual graphs, frame object-oriented schemes, and Petri nets are examples of additional formalisms that can be used to express knowledge (Nikolopoulos, 1997). It is usually not difficult to elicit knowledge from an expert. The issue is eliciting the appropriate knowledge. Knowledge must be in a format that allows it to be applied to the problem in the appropriate manner and at the appropriate time. The initial stage is to specify the proper problem-solving approach for the task, as well as the types of knowledge roles that this method requires (Eshelman *et al*. 1986).

The building of a knowledge base is one of the most difficult aspects of developing expert systems. The system's rules, patterns, facts, data requirements, and other structures are kept in this section of the expert (Elsharif *et al*. 2018). A rule-based system is an expert system in which the knowledge base is simply supplied in the form of product rules (McLeod *et al.* 2007). Expert systems capture from people who are experts in a certain topic, as well as books, scientific journals, and other printed materials. The information is organized in a knowledge base and presented in a specified format. An expert system then uses this knowledge base to determine the reasoning behind its challenges. The expert system seeks to identify a suitable solution, which is good enough to allow a job to run even though it is not optimal (Sumartono *et al*. 2017).

Inference Engine

The inference engine is in charge of generating outcomes depending on the user's input and the knowledge base. A user interface allows the user to communicate with the expert system. The user can enter information about the problem and receive a solution, as well as the logic behind it. The rule-based system is the most common method of constructing expert systems. The inference engine's heuristics are represented as production rules, or simply Rules, in this case. A rule is made up of two parts: IF and THEN. The IF section specifies a collection of criteria that must be met in some logical order for the rule to be valid. When the rule's conditions are met, the THEN component of the rule executes a sequence of actions. Pattern matching is the process of matching known facts against rule condition patterns. The inference engine selects an applicable rule during execution time and then performs the actions of that rule (which may affect the list of applicable rules by adding or removing facts). If more than one rule applies, the inference engine chooses the one with the highest priority. After the chosen rule's acts have been completed, another appropriate rule is chosen. The engine repeats this operation until no valid rules remain (Lichy *et al*. 2015).

Matching, selecting, and executing are the three major functions of the inference engine. It looks for a match in the rules on the rule based on the data from the inference engine (Al-Ajlan, 2015). Forward Chaining is a technique for locating feasible rules and firing their actions. The inference engine starts with a collection of known conditions and works its way to a conclusion. Backward chaining is another way that can be used. In this scenario, the inference engine starts with a known conclusion and looks for conditions that make that line of reasoning true (Fischer, 1999).

Knowledge Acquisition Facility

Knowledge Acquisition (KA) is a method of obtaining, building, and organizing knowledge from a single source, usually human specialists or experts, for use in software like expert systems.

Any expert system's accomplishments are mostly dependent on the quality, comprehensiveness, and accuracy of the material stored in the knowledge base. This allows you to learn more about the problem domain from the expert (Patel, 2013). The domain experts, current sources such as websites, catalogues, and maintenance guides, as well as information, all contribute to the knowledge base (Mostafa *et al*. 2018).

The acquisition of knowledge (KA) is an important stage in the development of an expert system It entails eliciting, analyzing, and interpreting the information that a human expert employs to solve a specific problem, and then converting that knowledge into a machine representation. The quality of the underlying representation of expert knowledge determines the power and utility of the final expert system, hence KA is crucial. It entails the following procedures: (a) using a strategy to obtain data from the expert (typically verbal). (b) Inferring what the expert's underlying knowledge and reasoning processes would be by interpreting these verbal inputs (more or less skillfully). (c) Using this interpretation to guide the creation of a model or language that accurately captures the expert's knowledge and performance (more or less). This dynamic model guides the interpretation of additional data.

Explanation Facility

One of the primary advantages of the expert system is that it can explain to the user how a result was reached. An expert system must be accountable to be trusted. It must be able to explain and justify its judgments in the same way that a human expert can. An explanation capability improves the transparency of an expert system. An explanation system can reassure the user that an expert system's counsel is appropriate if it is based on sound knowledge and reasoning procedures. In the field of expert systems, *Explanation* has evolved, researchers have learned that when designing a system, *Explanation* concerns must be considered, or the system would not produce good explanations (Swartout *et al.* 1993).

Scientia Africana, Vol. 21 (No. 2), August, 2022. Pp 127-138 *https://dx.doi.org/10.4314/sa.v21i2.13*
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

METHODOLOGY

It should be remembered that the main goal of this project is to create an eye diagnostic package/system capable of detecting and diagnosing eye illnesses as well as prescribing relevant treatments.

This information is gathered in two stages. The medical background of eye illnesses is recorded in the first step by conducting personal interviews with doctors and patients. In the second phase, a set of rules is established, including an IF component containing the symptoms and a THEN part containing the condition that should be recognized. The inference engine (forward reasoning) is a mechanism for selecting and firing rules. It is based on a pattern-matching algorithm whose primary goal is to link facts (input data) to relevant rules in the rule base. Finally, the inference engine generates results based on eye disorders. We have looked at the numerous ways that knowledge may be represented in a knowledge base previously. The usage of RULES is one of the methods described. The usage of RULES as a form of knowledge representation has been utilized in this study. This is based on the applicability and acceptance of diagnostic systems in development. It's worth noting that the designed system will be referred to as a Rule-based system. Because such systems are capable of collaborating with human users, the quality of help provided and how it is presented are critical considerations.

I. The Decision Table shows the Eye Diseases and their symptoms. This will help create the Production Rule which will serve as the building block for the knowledge base.

Table 1: Decision Table Showing the Eye Diseases and Their Symptoms.

Symptoms/Eye Diseases	AMD	Amblyopia	Astigmatism	Blepharitis	Cataracts	Colour Blindness	Conjunctivitis	Diabetic Retinopathy	Dry Eye	Glaucoma	Retinal Detachment
Blood in Eye	No	No	No	Yes	No	No	Yes	No	No	Yes	No
Bloodshot Eye	No	No	No	Yes	No	No	Yes	No	No	Yes	No
Blurriness	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Burning Eyes	No	No	No	Yes	No	No	Yes	No	Yes	No	No
Colours (dull or faded)	No	No	No	No	Yes	Yes	No	No	No	No	No
Crusty Eyelid or Eyelashes	No	No	No	Yes	No	No	Yes	No	No	No	No
Dark Spots in Vision	Yes	No	No	No	No	No	No	No	No	No	No
Discharge From Eye	No	No	No	Yes	No	No	Yes	No	Yes	No	No
Distorted Vision	Yes	No	Yes	No	No	No	Yes	No	No	No	No
Double Vision	No	No	No	No	Yes	No	No	No	No	No	No
Dryness	No	No	No	Yes	No	No	No	No	Yes	No	No

Eyestrain	No	No	Yes	No	No	No	No	No	No	No	No
The feeling of Something in the Eye	No	No	No	No	No	No	Yes	No	No	No	No
Floaters in Vision	No	No	No	No	No	No	No	Yes	No	No	Yes
Grittiness	No	No	No	Yes	No	No	Yes	No	Yes	No	No
Halos Around Lights	No	No	No	No	Yes	No	No	No	No	Yes	No
Headache Behind Eye	No	No	No	No	No	No	No	No	No	Yes	No
Headache	No	No	Yes	No	No	No	No	No	No	Yes	No
Irritation	No	No	No	Yes	No	No	No	No	Yes	No	No
Itchiness	No	No	No	Yes	No	No	Yes	No	Yes	No	No
Light Sensitivity	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	No	No
Night Vision Problem	Yes	No	Yes	No	Yes	No	No	No	No	No	No
Pain Around Eye	No	No	No	No	No	No	No	No	No	Yes	No
Pain in Eye	No	No	No	No	No	No	Yes	No	No	Yes	No
Red Eye	No	No	No	Yes	No	No	Yes	No	Yes	Yes	No
Reduced Vision	No	Yes	No	No	Yes	No	No	Yes	No	Yes	No
Squinting	No	Yes	Yes	No	No	No	No	No	No	No	No
Starbursts Around Lights	No	No	No	No	Yes	No	No	No	No	Yes	Yes
Straight Lines (Bent or Wavy)	Yes	No	No	No	No	No	No	Yes	No	No	No
Swelling Around Eye	No	No	No	Yes	No	No	Yes	No	No	No	No
Tearing	No	No	No	No	No	No	Yes	No	Yes	No	No
Tunnel Vision	No	No	No	No	No	No	No	No	No	Yes	No
Vision Loss, Central	Yes	No	No	No	No	No	No	Yes	No	No	No
Vision Loss, General	No	Yes	No	No	No	No	No	Yes	No	Yes	No
Vision Loss, Peripheral (Side)	No	No	No	No	No	No	No	Yes	No	Yes	Yes

II. Production Rule represent knowledge in the form of:

IF (condition) THEN (conclusion or action).

Rule: AMD (Age-related Macular Degeneration)
IF

Blurriness, AND
Dark Spots in Vision, AND
Distorted Vision, AND
Light Sensitivity, AND
Night Vision Problem, AND
Straight lines (bent or wavy), AND
Vision loss (central)

THEN

The patient is suffering from AMD (Age-related Macular Degeneration)

Rule: Amblyopia

Scientia Africana, Vol. 21 (No. 2), August, 2022. Pp 127-138 https://dx.doi.org/10.4314/sa.v21i2.13
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

IF
Reduced Vision, AND
Squinting, AND
Vision loss (general)
THEN
The patient is suffering from Amblyopia

Rule: Astigmatism
IF
Blurriness, AND
Distorted Vision, AND
Eye Strain, AND
Headache, AND
Night vision problem, AND
Squinting
THEN
The Patient is suffering from Astigmatism

Rule: Blepharitis
IF
Blood in the eye, AND
Bloodshot eye, AND
Burning eyes, AND
Crusty eyelid or eyelashes, AND
Discharge from eye, AND
Dryness, AND
Grittiness, AND
Irritation, AND
Itchiness, AND
Light sensitivity, AND
Red-eye, AND
Swelling around eye
THEN
This patient is suffering from Blepharitis

Rule: Cataracts
IF
Blurriness, AND
Colours (dull or faded), AND
Double vision, AND
Halos around light, AND
Light sensitivity, AND
Night vision problem, AND
Reduced vision, AND
Starbursts around lights
THEN
This patient is suffering from Cataracts

Rule: Color Blindness
IF
Colours (dull or faded), AND
Light sensitivity
THEN
This patient is suffering from Color Blindness

Rule: Conjunctivitis
IF
Blood in the eye, AND
Bloodshot eye, AND
Blurriness, AND
Burning eyes, AND
Crusty eyelid or eyelashes, AND
Discharge from eye, AND
Distorted vision, AND
Feeling of something in the eye, AND
Grittiness, AND
Itchiness, AND
Light sensitivity, AND
Pain in the eye, AND
Red-eye, AND
Swelling around the eye, AND
Tearing
THEN
This patient is suffering from Conjunctivitis

Rule: Diabetic Retinopathy
IF
Blurriness, AND
Floaters in vision, AND
Reduced vision, AND
Straight lines (bent or wavy), AND
Vision loss (central), AND
Vision loss (general), AND
Vision loss (peripheral)
THEN
This patient is suffering from Diabetic Retinopathy

Rule: Dry Eye
IF
Blurriness, AND
Burning eyes, AND
Discharge from eye, AND
Dryness, AND
Grittiness, AND
Irritation, AND
Itchiness, AND
Light sensitivity, AND
Red-eye, AND
Tearing
THEN
This patient is suffering from Dry Eye

Rule: Glaucoma

IF

Blood in the eye, AND
Bloodshot eye, AND
Blurriness, AND
Halos around the eye, AND
Headache behind the eye, AND
Headache, AND
Pain around the eye, AND
Pain in the eye, AND
Red-eye, AND
Reduced vision, AND
Starbursts around light, AND
Tunnel vision, AND
Vision loss (general), AND
Vision loss (peripheral)

THEN

This patient is suffering from Glaucoma

Rule: Retinal Detachment

IF

Blurriness, AND
Floaters in vision, AND
Starbursts around light, AND
Vision loss (peripheral)

THEN

This patient is suffering from Retinal Detachment

OUTPUT AND RESULTS

The output for this system could be seen below. Figure 2 shows the Welcome UI introducing the user to the system. Here instructions on what is required of the user are stated.

Figure 3 shows the UI requesting the name of the user so that the user's name will be attached to the result of the system for record purposes.

Then, Figures 4 to 12 show the question UIs prompting the user to give a YES or NO answer to various questions related to symptoms the user is experiencing or suffering from. The answers to these questions will serve as the bases for the result in Figure 13.

And Finally, Figure 13 shows the Result UI with the name of the user and finally the final diagnosis of the eye disease the patient is suffering from.

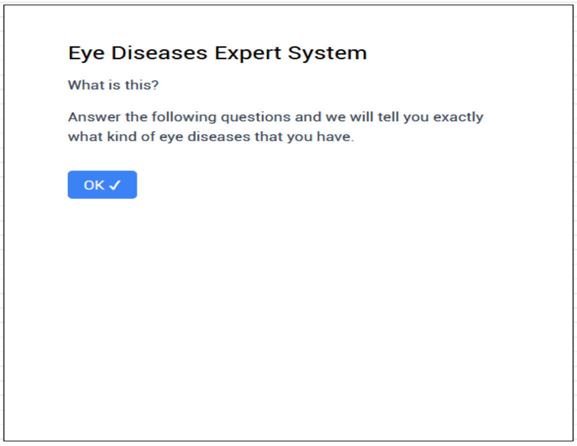


Figure 2: The Welcome user interface for the system

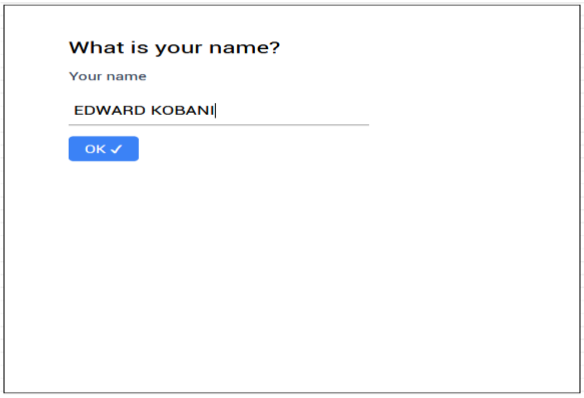


Figure 3: UI requesting user's name

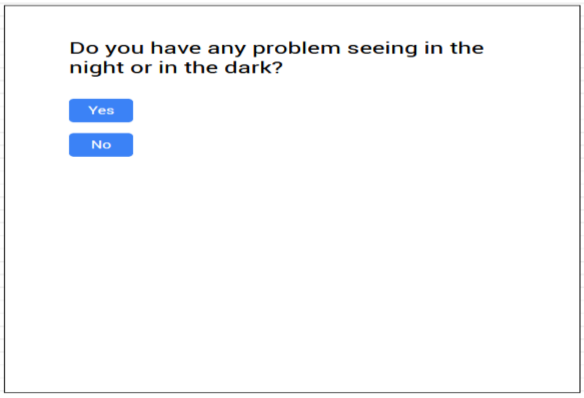


Figure 4: The "Night vision" question UI

Scientia Africana, Vol. 21 (No. 2), August, 2022. Pp 127-138 https://dx.doi.org/10.4314/sa.v21i2.13
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

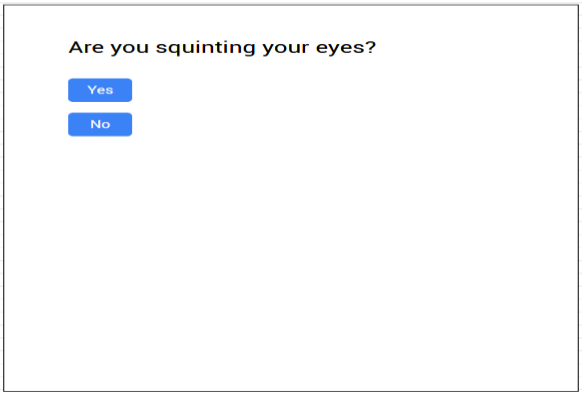


Figure 5: The "squinting eye" question UI

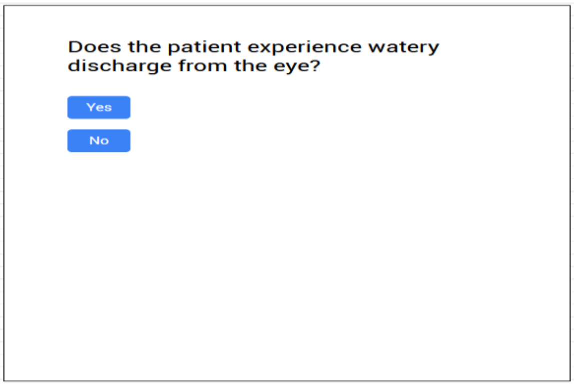


Figure 6: The "watery discharge" question UI

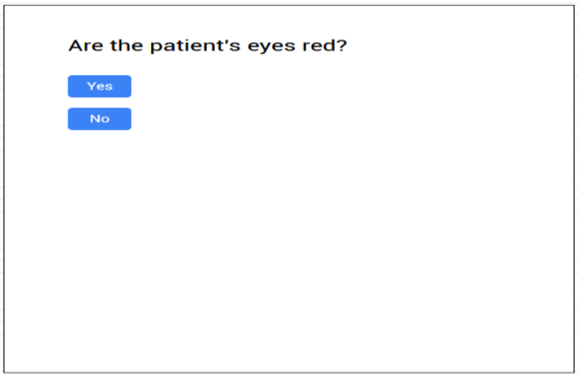


Figure 7: The "red-eye" question UI

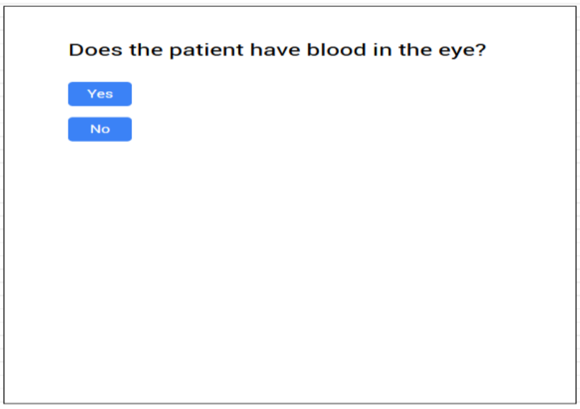


Figure 8: The "blood in eye" question UI

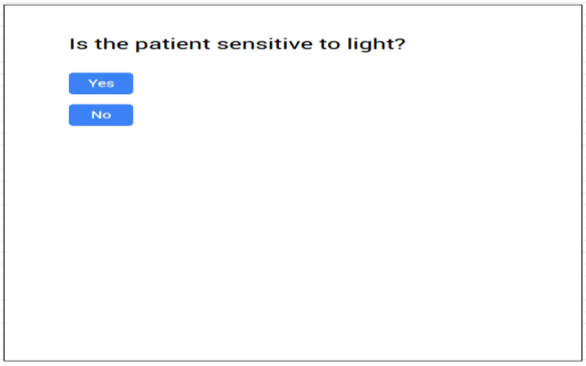


Figure 9: The "light sensitivity" question UI

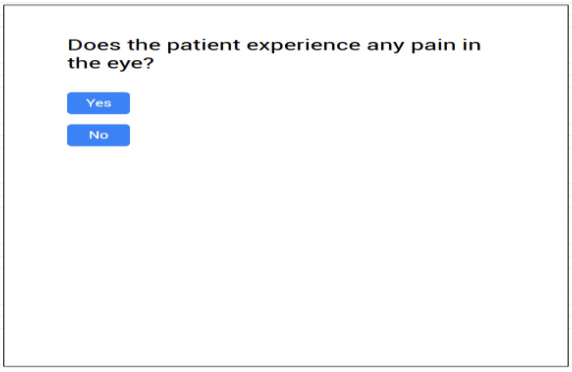


Figure 10: The "pain in eye" question UI

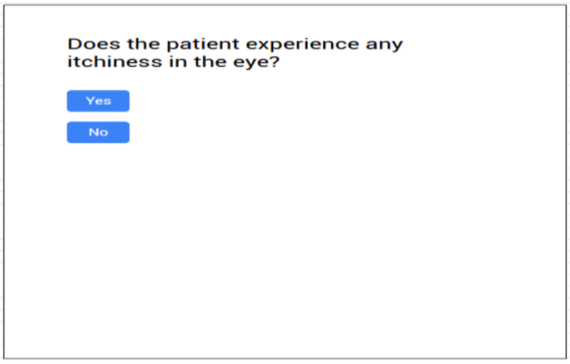


Figure 11: The "eye itchiness" question UI

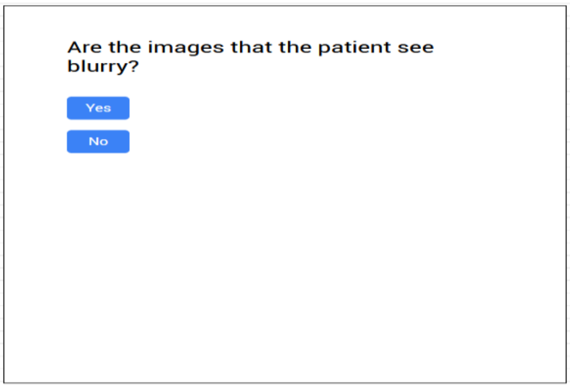


Figure 12: The "blurry vision" question UI

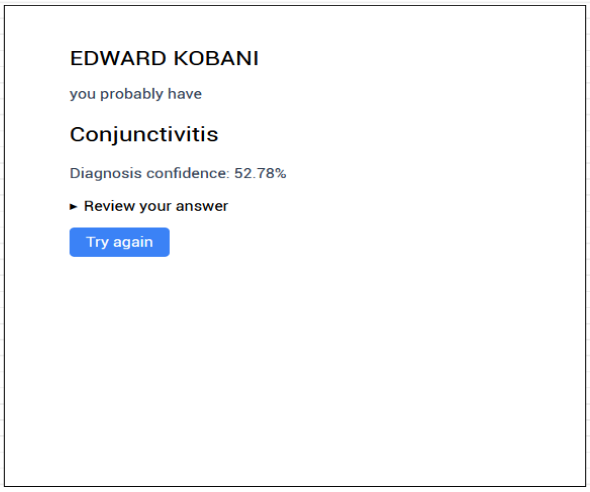


Figure 13: The result UI showing the specific Eye disease

CONCLUSION

During the diagnosis and/or treatment of patients, many ophthalmologists study medical textbooks. In the absence of the ophthalmologist, the medical assistant employing the diagnostic system will be able to confidently attend to booked patients. Though it is not the solution to every problem that an organization faces, an expert system component is ideal for assisting a decision-maker in an area where expertise is necessary. Expert systems should be developed with caution, especially if sensitive or strategic applications are involved. To represent the assumptions, facts, and reasoning involved in simple problem scenarios, hundreds of rules may be required. As a result, expert systems may be challenging to design and maintain cost-effectively. The costs of wasted expert time, hardware, and software resources for knowledge engineers may be too high to offset the gains predicted from particular applications. It is theoretically conceivable to create a successful expert system that can be utilized for ocular (eye) diagnosis in real life, but it is difficult to do so in practice.

REFERENCES

Al-Ajlan, A. (2015). The Comparison between Forward and Backward Chaining, International Journal of Machine Learning and Computing, 5 (2). 106-113

Buchanan, B. G., Shortliffe, E. H. (1984). Rule-Based Expert Systems: The MYCIN Experiments of the Stanford Heuristic Programming Project. Addison-Wesley, First Edition. 149-150

Chen, C., Zhang, L., Zhang J. (2019) Application of Fault Diagnosis Expert System for Unmanned Vehicle Safety, IOP Conference Series: Materials Science and Engineering 608 (2019) 012015, 1-6

Elsharif, A. A., Abu-Naser, S. S. (2018). An Expert System for Diagnosing Sugarcane Diseases, International Journal of Academic Engineering Research (IJAER), 3(3), 19-27

Eshelman, L., McDennott, J. (1986). MOLE: A Knowledge Acquisition Tool that Uses its Head. In Proceedings of the Fifth National Conference on Artificial Intelligence. Philadelphia, Pennsylvania. AAAI-86 Proceedings. 950-955

Fischer, S. R. (1999), A History of Language, Reaktion Books, First Edition (December 1999) ISBN 1-86189-080-X.

Ibrahim, F., Ali, J. B., Jaais, A. F., Taib, M. (2001). Expert System for Early Diagnosis of Eye Diseases Infecting the Malaysian Population, IEEE Catalogue 0-7803-7101-1/01/2001, 430-432

Lichy, K., Ziemecki A. (2015), Expert Systems in Medical Rescue. Information Systems in Management, 4 (2) 110-122

Scientia Africana, Vol. 21 (No. 2), August, 2022. Pp 127-138 *https://dx.doi.org/10.4314/sa.v21i2.13*
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

Madsen, E. M. (1990), Expert Systems in Optometry. Pacific University, College of Optometry. 1315, 9-11

Maher, M. L., Longinos, P. (1986), Development of an Expert System Shell for Engineering Design. Department of Civil Engineering Carnegie-Mellon University Pittsburgh, PA 15213. September 1986

McLeod, R., Schell, G. P. (2007). Management information systems. USA: Pearson/Prentice Hall.

Minkarah, I., Ahmed, I. (1989). Expert Systems as Construction Management Tools, Journal of Management in Engineering, 5(2).

Mirmozaffari, M. (2019), "Presenting a Medical Expert System for Diagnosis and Treatment of Nephrolithiasis". EJMED, European Journal of Medical and Health Sciences 1(1), May 2019.

Mostafa, S. A., Mustapha, A., Hazeem, A. A., Khaleefah, S. H., & Mohammed, M. A. (2018), An Agent-Based Inference Engine for Efficient and Reliable Automated Car Failure Diagnosis Assistance. Vol. 6, 8322-8331. March 12, 2018.

Nikolopoulos, C. (1997). Expert Systems: Introduction to First and Second Generation and Hybrid Knowledge Base Systems. CRC Press.

Patel, T. (2013). Knowledge Models, current Knowledge Acquisition Techniques and Developments. Oriental Journal of Computer Science and Technology, 6(4), 467-472.

Samy, S. A. and Abu, Z. O. (2008). An Expert System for Diagnosing Eye Diseases using CLIPS. Journal of Theoretical and Applied Information Technology 4(10), 923-930, January 2008.

Sumartono, I., D. Arisandi, Siahaan, A. P. U., and Mesran, (2017), Expert System of Catfish Disease Determinants Using Certainty Factor Method. International Journal Recent Trends Eng. Res. 3(8), 202–209, Aug. 2017.

Swartout, W. R., Moore, J. D. (1993), Explanation in Second Generation Expert Systems in Second Generation, Heidelberg. 543-585

Wagner, W. P. (2017), Trends in Expert System Development: A Longitudinal Content Analysis of Over Thirty Years of Expert System Case Studies. Expert System Application. 2017, 76, 85–96