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RESEARCH ARTICLE

AN EXPERT SYSTEM GENERATOR INCORPORATING MACHINE LEARNING TECHNIQUES (EGIMLT)

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Abstract

This article is a continuation of the GExpert+ project, an expert system generator, with a focus on promoting traditional African knowledge in medicine. This knowledge, often passed down orally and at risk of disappearing, requires modern tools to be preserved and exploited. The main objective is to design an iconic expert system generator incorporating machine learning techniques, called KambiExpert (currently just a prototype). This system features an interface based on images and icons, accessible even to illiterate users, and the integration of a machine learning module enabling the continuous evolution of the knowledge base. The methodology adopted is based on three stages: theoretical research, prototype design and future experimentation.

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Introduction:-

In Africa, many traditional medicine practitioners possess valuable knowledge about medicinal plants and natural treatments. Unfortunately, this knowledge is often kept secret and passed on only orally. Despite oral transmission, some are very reluctant and decide to keep it closely guarded [1]. When a healer dies without sharing their knowledge, it disappears forever, making it very difficult for the younger generation to inherit the knowledge of their ancestors for the benefit of the population (the sick). It is in this context that researchers have designed innovative digital tools, including GExpert+ [1], an expert system generator based on iconic representations. This approach aims to help traditional practitioners safeguard their knowledge, as the use of icons breaks down the language barrier, unlike other systems based on textual rules. This makes it beneficial for illiterate people. Although powerful as a system, GExpert + can only process explicit knowledge and cannot learn or adapt autonomously because it requires human intervention (no integration of artificial intelligence such as machine learning, hence no automatic recording of the knowledge base). Illiterate users need assistance to install the icons on their computers before they can use the system.

Expert system:-

An expert system (ES), also known as an intelligent knowledge-based system, is a system that simulates the behaviour of an expert in a specific field. Expert systems solve a user's problems in a manner similar to that of an expert. An expert system contains a knowledge base that brings together known facts and inference rules, and an inference engine (a programme that uses known facts and rules to arrive at a solution) [6].

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Knowledge extraction:-

Knowledge extraction is a way of transforming raw information into well-organised knowledge. It is a bit like sorting through a huge pile of documents, photos or data neatly arranged in tables to keep only the essentials. The ultimate goal is to present this knowledge in such a clear way that a computer can easily read and use it. [7] Data mining addresses an important challenge by improving data accessibility, giving users more power over data without the need for IT resources. Every organisation manages disparate data sources, and all data is in different formats. Knowledge extraction requires data, so we will now discuss how data is extracted. To extract knowledge, you first need to have data. This is precisely the role of data extraction. Its job is to gather all the information, wherever it may be, and consolidate and convert it into a single format. Once this is done, it places the data in a central location, much like a shared library, so that everyone can easily access it whenever they need it. [8]

**State of the art:-**

- **Mycin:-**

According to our research, MYCIN is one of the first expert systems in medicine. It was designed by Edward H. Shortliffe, a physician and computer scientist, and Bruce G. Buchanan at Stanford University in the United States. MYCIN was used to diagnose blood-related bacterial infections such as meningitis based on information entered by the user. This system was able to simulate the behaviour of a human expert. [2]

- **Medtrad+:-**

Designed by Konan M. BROU1, Ibrahim LOKPO1 and Bi Tra GOORE, it is an expert system generated by GExpert+ based on the use of icons rather than text to represent facts. It was designed, implemented and used to create an expert system in the field of traditional African medicine, where practitioners are often illiterate. Thanks to its iconic interface adapted to the knowledge of traditional medicine practice, this system allows users to be independent because they do not necessarily need intermediaries in the process of managing and using their own knowledge base. This assistance is limited to scanning the images and icons to be installed on their machine. Traditional medicine practitioners can grant rights to query other users. MedTrad+ certainly cannot replace a traditional medicine practitioner, but it can be used to: provide medical assistance to patients, learn herbal medicine, and learn traditional medicine [3].

- **VetoMed : un système expert à base d'icônes pour la médecine vétérinaire traditionnelle:-**

VetoMed is an icon-based expert system for traditional veterinary medicine generated by GExpert+. Developed by Professors Konan Marcellin BROU, N'Guessan Clément BOGUI, Tra BI GOORE and Ibrahim LOKPO, the VetoMed expert system plays an important role in the field of traditional veterinary pharmacopoeia, where practitioners are often illiterate. Thanks to its icon-based interface adapted to illiterate users, this system allows any

user to manage and use its knowledge base without the need for an intermediary. The VetoMed expert system certainly cannot replace a traditional practitioner, but it can be used to provide medical assistance to patients, teach pharmacopoeia and teach traditional veterinary medicine [4].

• GExpert+:-

GExpert is a rank 0+ expert system generator (GSE) developed by Prof. Konan M. BROU, Ibrahim LOKPO, Tra GOORE BI and Michel BABRI. It is a system based on the use of icons to represent facts in an expert system and in a web environment, thus facilitating its use by practitioners. Despite its ease of use, the system requires some initial assistance (such as scanning the icons or installing them on the machine), which can limit practitioners' complete autonomy. GExpert+ remains a basic system because it does not automatically evolve with new knowledge, meaning there is no self-learning. It remains an assistance and learning tool, not an autonomous or complete intelligence. [1] We note that, although many expert systems have attempted to integrate traditional medicine, very few take into account the specificities of the target audience : the illiterate. KambiExpert positions itself as an innovative response to these challenges by integrating the achievements of previous projects while surpassing them technically and socially.

Proposed approach:-

An expert system generator (ESG) is a development tool (inference engine + management utility) used to build a knowledge base and exploit it. There are many ESGs, but they are not intended for non-literate users. This is because the knowledge acquisition modules of these ESGs use icon-based knowledge representation formalisms and have fixed knowledge. Illiterate users need assistance in installing images or icons in order to use the system. Our approach consists of presenting a grid of images and icons already in the system to facilitate use and integrate machine learning for automatic learning based on new information entered into the system.

Mathematical Modelling:-

5.1.1 Inputs

$X \in \mathbb{R}^n$: symptom vectors

$M \in \{m_1, m_2, \dots, m_k\}$: set of diseases.

$P \in \mathbb{R}^p$: plant vector

R : set of knowledge base rules

T : set of treatments

Deduction (Expert):-

$$MEX = f_{EX}(X, R) \quad (1)$$

User Module:-

$$MU = f_U(X, R_u) \quad (2)$$

Machine Learning Prediction:-

$$MML = f_{ML}(X, P; \theta) \quad (3)$$

$$\text{Percentage} = \frac{\text{Number of correct cases}}{\text{Total number of cases}} \times 100$$

Taking into account (1), (2) and (3), we have :

$$M_{\text{final}} = \alpha MEX + \beta MU + \gamma MML \text{ with } \alpha + \beta + \gamma = 1$$

M_{final} : is the result of the diagnosis or the disease predicted by the system

The coefficients α , β and γ are weightings introduced into the objective function to combine the three sources of knowledge (expert knowledge, user knowledge and machine learning).

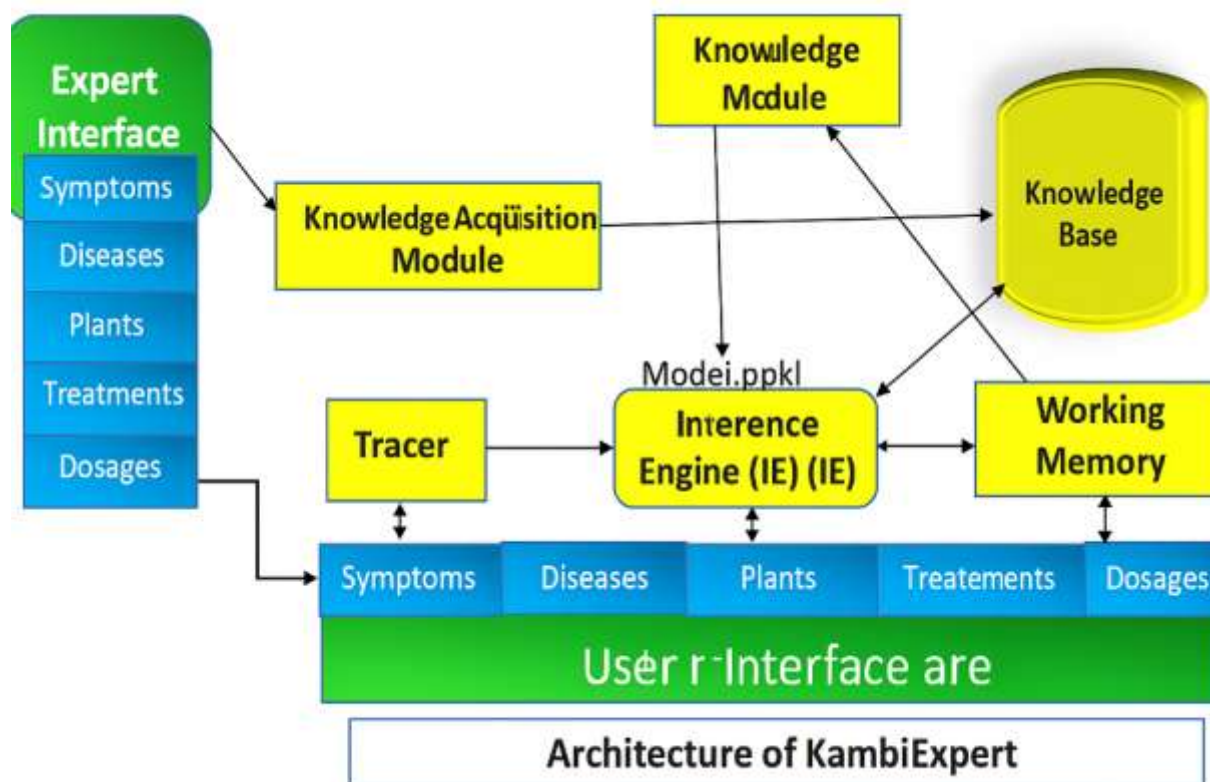
- α represents the importance given to expert knowledge (rules of traditional practitioners).
- β represents the importance of user knowledge (user feedback).
- γ represents the importance of machine learning (automatic predictions from model training).

Thus, the coefficients allow the combination of the three components to be adjusted in order to obtain a more robust and representative final diagnosis

$$C = \alpha CEX + \beta CU + \gamma Cml$$

C : is an evaluation function that measures the quality or performance of the diagnosis obtained.

KambiExpert Architecture:-



The expert system is built around eight components. The Expert Interface allows experts to enter and formalise traditional knowledge. This data passes through the Acquisition Module, which standardises it and integrates it into the Knowledge Base, the heart of the system where symptoms, diseases, plants, treatments and dosages are stored. Model Training applies machine learning to create a prediction model and refine accuracy. The Inference Engine uses this model and the rules in the database to reason and propose diagnoses, drawing on the Working Memory, which temporarily stores data and results. The Tracker justifies conclusions to enhance transparency. Finally, the User Interface makes information and results accessible, with an iconic design that is suitable even for illiterate people.

Problem resolution:-

To resolve the problem of designing an iconic, self-learning expert system generator, we developed and simulated an innovative hybrid architecture in Python. This approach adaptively merges three distinct sources of knowledge:

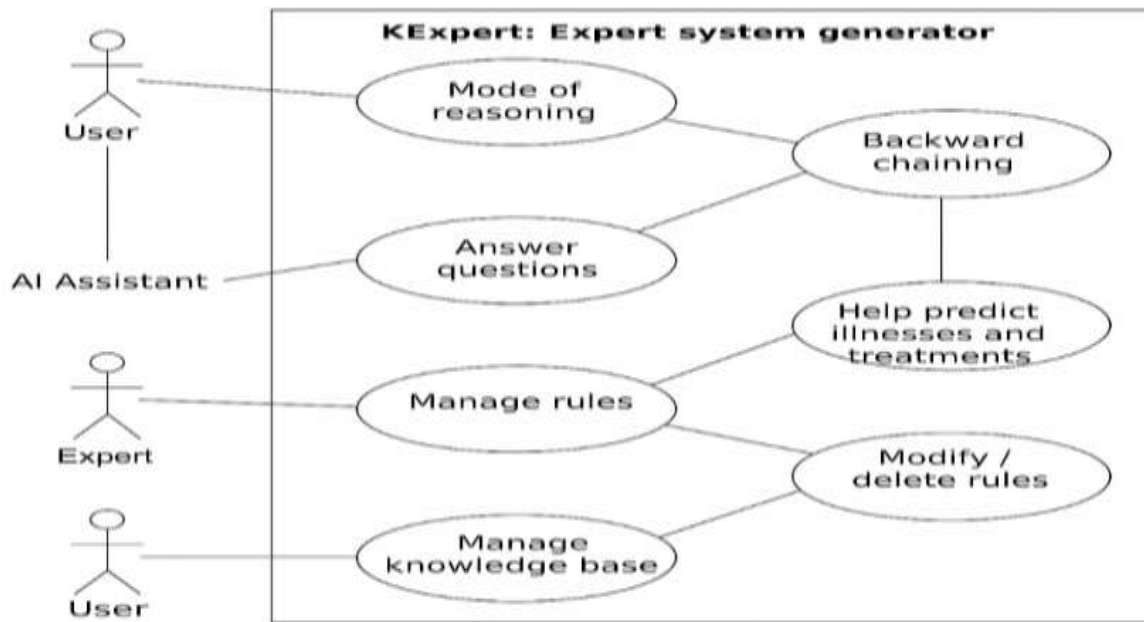
- Expert knowledge: rules defined by traditional practitioners
- User knowledge: feedback from end users
- Machine learning: automatic learning from accumulated data

We started with a baseline of 1,600 patient diagnoses:-

Sequence diagram:-



Use case diagram:-



Use Case Diagram

Results and Discussion:-

We used data for malaria diagnosis [5] to demonstrate the performance of our system by combining several data sources: user knowledge, expert knowledge, and machine learning.

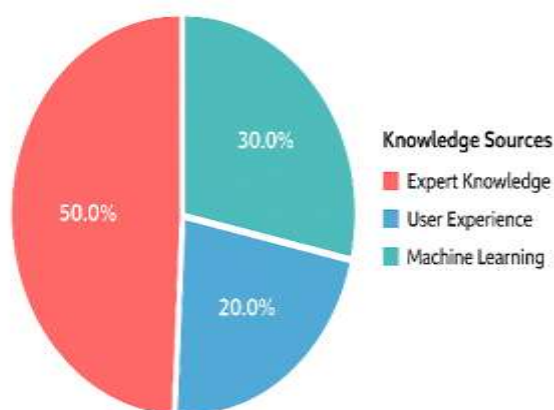
Symptom and diagnosis tables:-

The Fever and Chills columns use binary coding, where 1 means present and 0 means absent. The Diagnosis (y) column contains 1 if the patient has malaria and 0 if not.

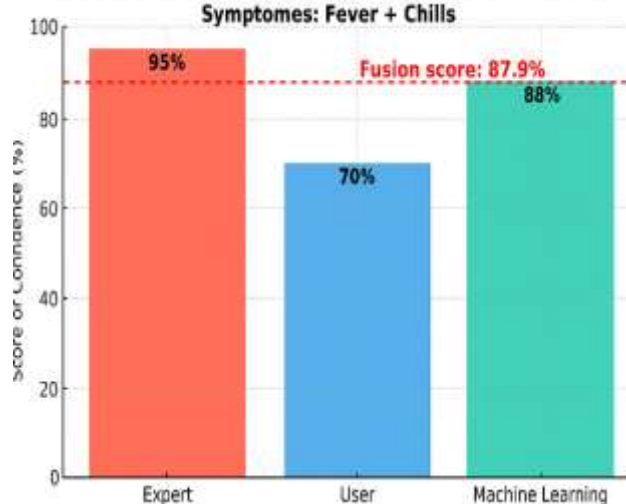
Patient	Fever	Chills	Diagnosis
1	1	1	1(malaria)
2	1	0	0 (No)
3	0	1	0 (No)
4	1	1	1(malaria)
--			
1600	0	0	0 (No)

Source	Correct cases	Total	Percentage
User	1120	1600	70%
Expert	1520	1600	95%
Machine Learning	1408	1600	88%
Overall score	—	—	87,9%

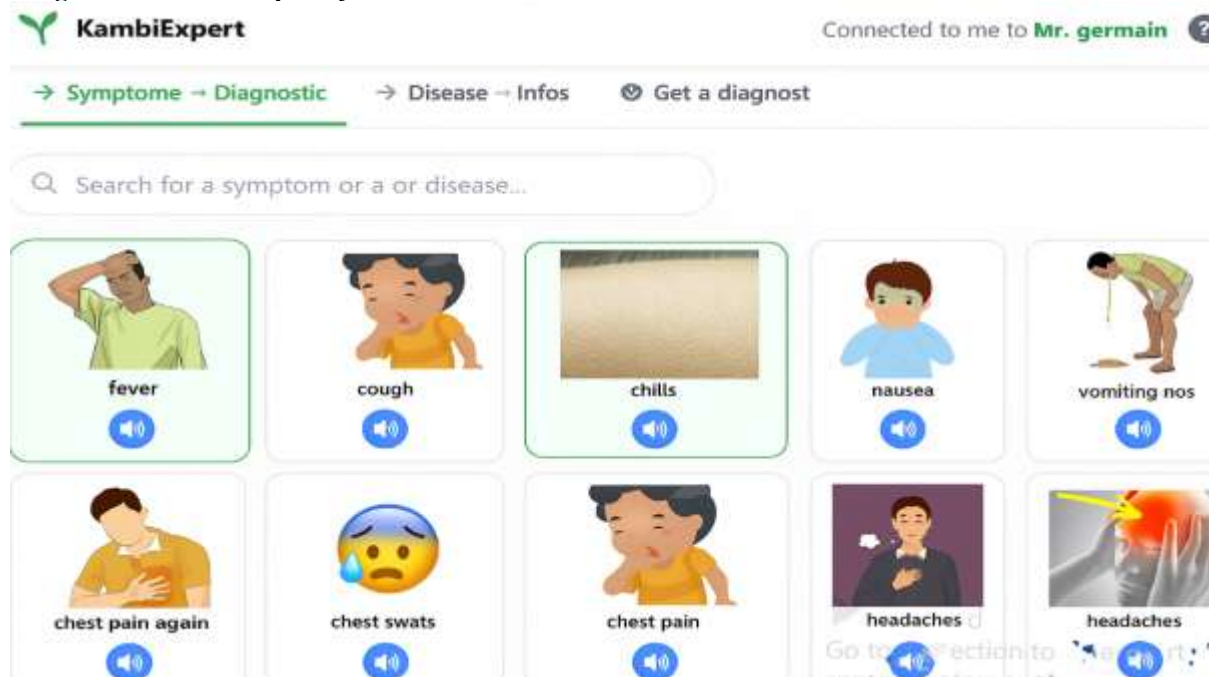
DECISION FUSION MECHANISM KambiExpert
Weighting of knowledge sources



CONTRIBUTION OF SOURCES FOR DIAGNOSTIC "MALARIA"**
Symptoms: Fever + Chills

**Weighting of knowledge sources:-**

The simulation results confirm that the proposed approach is both feasible and relevant. By combining human expertise, user feedback and machine learning, the hybrid system developed provides diagnoses that are both more reliable and adaptive. The tests carried out not only validate the designed architecture, but also demonstrate that KambiExpert represents a significant advance over existing solutions, particularly in terms of its ease of use, scalability and continuous learning capabilities.

Design of our KambiExpert system:-**Conclusion and outlook:-**

At the end of our work, we can say that we have achieved our goal: to design KambiExpert, an expert system generator that is easy to use, even for traditional practitioners who cannot read or write. The idea was to find a way to preserve and promote traditional medical knowledge, which is often transmitted only by word of mouth and is at risk of disappearing.

Our system offers two major innovations :

An iconic and audio interface that makes the tool accessible to all, and the integration of machine learning, which allows the system to learn and improve its suggestions over time. KambiExpert is therefore a practical and modern tool, capable of linking technology with tradition. Our system is still a prototype and needs to be designed. However, it already represents a significant step forward, as it shows that it is possible to preserve and pass on the knowledge of traditional practitioners through digital technology. In short, this project opens up a new way of thinking about the future of traditional medicine and its role in our societies. Although our system is effective, it needs to be improved for better use :

Develop a web application : because what currently exists is only a simple prototype.

Integrate an intelligent audio system: add an AI assistant capable of communicating verbally with the user. This will allow practitioners to communicate directly with the system using their voice and receive audible responses.

Offer audio in local languages: when the user clicks on an audio icon (e.g. for a symptom or a plant), they will be able to hear the name pronounced in their native language. This feature will enhance the cultural and linguistic accessibility of the system.

Conflict of interest: The authors declare no conflict of interest with respect to the publication of this article

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