An Expert System Generator Incorporating Machine Learning Techniques (EGIMLT)

by Jana Publication & Research

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Abstract

This article is a continuation of the GExpert+ project, an expert system generator, with a focus on promotingtraditionalAfricanknowledge in medicine. This knowledge, oftenpassed down orally and at risk of disappearing, requires modern tools to bepreserved and exploited. The main objective is to design an iconic expert system generatorincorporating machine learning techniques, calledKambiExpert (currentlyjust a prototype). This system features an interface based on images and icons, accessible even to illiterateusers, and the integration of a machine learning module enabling the continuousevolution of the knowledge base. The methodologyadoptedisbased on threestages:theoreticalresearch, prototype design and future experimentation.

Keywords: Expert system, knowledge extraction, artificial intelligence, machine learning, automaticlearning

1-Introduction

In Africa, manytraditionalmedicinepractitionerspossessvaluableknowledge about medicinal plants and naturaltreatments. Unfortunately, thisknowledgeisoftenkept secret and passed on onlyorally. Despite oral transmission, some are very reluctant and decide to keepitcloselyguarded [1]. When a healer dies without sharing theirknowledge, itdisappearsforever, makingitverydifficult for the youngergeneration to inherit the knowledge of theirancestors for the benefit of the population (the sick). It is in thiscontextthatresearchers have designed innovative digital tools, includingGExpert+ [1], an expert system generatorbased on iconicrepresentations. This approachaims to help traditionalpractitionerssafeguardtheirknowledge, as the use of icons breaks down the languagebarrier, unlikeothersystemsbased on textualrules. This makesitbeneficial for illiterate people. Althoughpowerful as a system, GExpert + can only process explicit knowledge and cannotlearn or adaptautonomouslybecauseitrequireshuman intervention (no integration of artificial intelligence such as machine learning, hence no automaticrecording of the knowledge base). Illiterateusersneed assistance to install the icons on their computers beforethey can use the system.

2- Expert system

An expert system (ES), alsoknown as an intelligent knowledge-based system, is a system thatsimulates the behaviour of an expert in a specificfield. Expert systems solve a user'sproblems in a mannersimilar to that of an expert. An expert system contains a knowledge base thatbringstogetherknownfacts and inferencerules, and an inference engine (a programme that uses knownfacts and rules to arrive at a solution)[6].

3- Knowledge extraction

Knowledge extraction is a way of transformingraw information intowell-organisedknowledge. It is a bit like sortingthrough a huge pile of documents, photos or data neatlyarranged in tables to keeponly the essentials. The ultimate goal is to presentthisknowledge in such a clearwaythat a computer can easilyread and use it. [7] Data miningaddresses an important challenge by improving data accessibility, givingusers more power over data without the need for IT resources. Every organisation manages disparate data sources, and all data is in differentformatsKnowledge extraction requires data, sowewillnowdiscuss how data isextracted. To extractknowledge, you first need to have data. This isprecisely the role of data extraction. Its job is to gather all the information, whereveritmaybe, and consolidate and convertitinto a single format. Once thisisdone, it places the data in a central location, much like a sharedlibrary, sothateveryone can easilyaccessitwhenevertheyneedit. [8]

4. State of the art

- **MYCIN**

According to ourresearch, MYCIN is one of the first expert systems in medicine. It wasdesigned by Edward H. Shortliffe, a physician and computer scientist, and Bruce G. Buchanan at Stanford University in the United States. MYCIN wasused to diagnose blood-relatedbacterial infections such as meningitisbased 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, itis an expert system generated by GExpert+ based on the use of iconsratherthantext to representfacts. It wasdesigned, implemented and used to create an expert system in the field of traditionalAfricanmedicine, whererepractitioners are oftenilliterate. Thanks to itsiconicinterfaceadapted to the knowledge of traditionalmedicine practice, this system allowsusers to beindependentbecausethey do not necessarilyneedintermediaries in the

process of managing and usingtheirownknowledge base. This assistance islimited to scanning the images and icons to beinstalled on their machine. Traditionalmedicinepractitioners can grantrights to queryotherusers. MedTrad+ certainlycannot replace a traditionalmedicinepractitioner, but it can beusedto:providemedical assistance to patients, learnherbalmedicine, and learntraditionalmedicine[3].

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

VetoMedis an icon-based expert system for traditionalveterinarymedicinegenerated 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 traditionalveterinarypharmacopoeia, whepractitioners are oftenilliterate. Thanks to itsicon-based interface adapted to illiterateusers, this system allowsany user to manage and use itsknowledge base without the need for an intermediary. The VetoMed expert system certainlycannot replace a traditionalpractitioner, but it can beused to providemedical assistance to patients, teachpharmacopoeia and teachtraditionalveterinarymedicine[4].

- **GExpert+**

GExpertis 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 representfacts in an expert system and in a web environment, thusfacilitatingits use by practitioners. Despiteitsease of use, the system requiressome initial assistance (such as scanning the icons or installingthem on the machine), which can limitpractitioners' completeautonomy. GExpert+ remains a basic system becauseitdoes not automaticallyevolvewith new knowledge, meaningthereis no self-learning. It remains an assistance and learningtool, not an autonomous or complete intelligence. [1]We note that, althoughmany expert systems have attempted to integratetraditionalmedicine, very few takeintoaccount the specificities of the target audience: the illiterate. KambiExpert positions itself as an innovative response to these challenges by integrating the achievements of previousprojectswhilesurpassingthemtechnically and socially.

5- Proposedapproach

An expert system generator (ESG) is a developmenttool (inference engine + management utility) used to build a knowledge base and exploit it. There are manyESGs, but they are not intended for non-literateusers. This isbecause the knowledge acquisition modules of theseESGs use icon-basedknowledgerepresentationformalisms and have fixedknowledge. Illiterateusersneed assistance in installing images or icons in order to use the system. Our approachconsists of presenting a grid of images and iconsalready in the system to facilitate use and integrate machine learning for automaticlearningbased on new information enteredinto the system.

5- MathematicalModelling

5.1.1 Inputs

X ∈ℝn:symptomvectors

M ∈ {m1, m2, …, mk}: set of diseases.

P ∈ℝp: plant vector

R: set of knowledge base rules

T: set of treatments

5.1.2- Deduction (Expert)

MEX = fEX (X, R) **(1)**

5.1.3- User Module

MU = fU (X, Ru) **(2)**

5.1.4- Machine Learning Prediction

MML = fML (X, P ; θ) **(3)**

$$\text{Percentage} = \frac{Number\ of\ correct\ cases}{\text{Nombre de cas totaTotal number of caseslTotal number of cases}} \times 100$$

Takingintoaccount (1), (2) and (3), we have:

Mfinal = αMEX + βMU + γMMLwith α+β+γ=1

Mfinal:is the result of the diagnosisor the diseasepredicted by the system

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

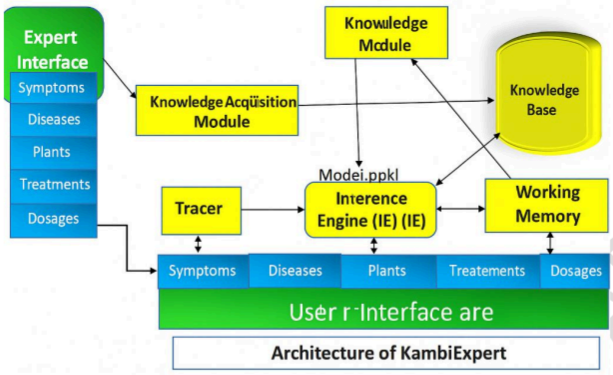
- αrepresents the importance given to expert knowledge (rules of traditionalpractitioners).
- βrepresents the importance of user knowledge (user feedback).
- γrepresents the importance of machine learning (automaticpredictionsfrom model training).

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

C= αCEX + βCU + γCml

C: is an evaluationfunctionthatmeasures the quality or performance of the diagnosisobtained.

KambiExpert Architecture



Architecture of KambiExpert

The expert system isbuiltaroundeight components. The Expert Interface allows experts to enter and formalise traditionalknowledge. This data passes through the Acquisition Module, which standardises it and integratesitinto the Knowledge Base, the heart of the system wheresymptoms, diseases, plants, treatments and dosages are stored. Model Training applies machine learning to create a prediction model and refineaccuracy. The Inference Engine uses this model and the rules in the database to reason and propose diagnoses, drawing on the Working Memory, whichtemporarily stores data and results. The Tracker justifies conclusions to enhancetransparency. Finally, the User Interface makes information and results accessible, with an iconic design thatissuitableeven for illiterate people.

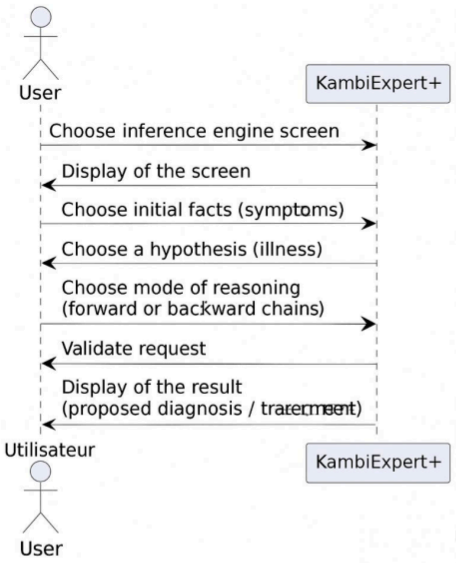
6-Problemresolution

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

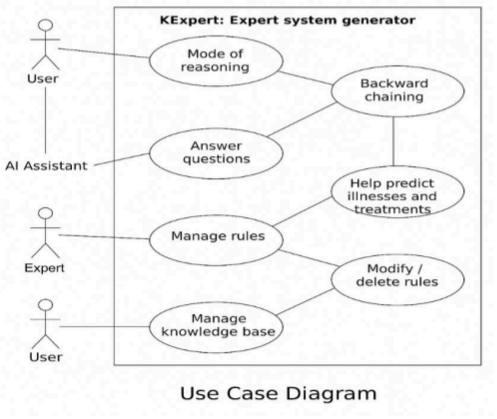
- Expert knowledge:rulesdefined by traditionalpractitioners
- User knowledge: feedback from end users
- Machine learning:automaticlearningfromaccumulated data

Westartedwith a baseline of 1,600 patient diagnoses.

Sequencediagram



6.2 Use case diagram



7- Results and Discussion

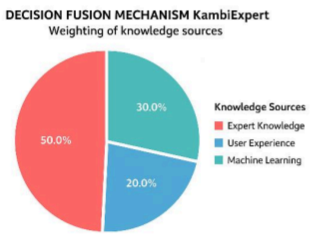
Weused data for malaria diagnosis [5] to demonstrate the performance of our system by combiningseveral data sources: user knowledge, expert knowledge, and machine learning.

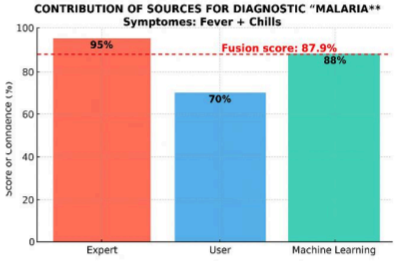
Symptom and diagnosis tables

The Fever and Chillscolumns use binarycoding, where 1 meanspresent and 0 means absent. The Diagnosis (y) columncontains 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%**

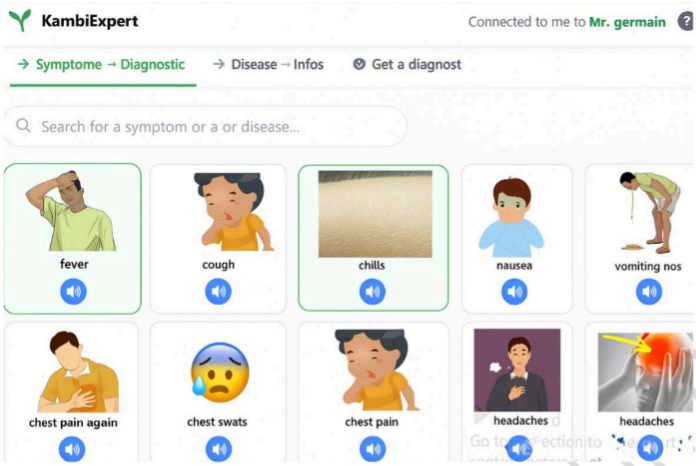




Weighting of knowledge sources

The simulation resultsconfirmthat the proposedapproachisbothfeasible and relevant. By combininghuman expertise, user feedback and machine learning, the hybrid system developedprovides diagnoses that are both more reliable and adaptive. The tests carried out not onlyvalidate the designed architecture, but alsodemonstratethatKambiExpertrepresents a significantadvance over existing solutions, particularly in terms of itsease of use, scalability and continuouslearningcapabilities.

Design of ourKambiExpert system



8- Conclusion and outlook

At the end of ourwork, we can saythatwe have achievedourgoal: to design KambiExpert, an expert system generatorthatiseasy to use, even for traditionalpractitionerswhocannotread or write. The ideawas to find a way to preserve and promotetraditionalmedicalknowledge, whichisoftentransmittedonly by word of mouth and is at risk of disappearing.

Our system offerstwo major innovations:
An iconic and audio interface thatmakes the tool accessible to all, and the integration of machine learning, whichallows the system to learn and improveits suggestions over time. KambiExpertistherefore a practical and modern tool, capable of linkingtechnologywith tradition. Our system isstill a prototype and needs to bedesigned. However, italreadyrepresents a significantstepforward, as it shows thatitis possible to preserve and pass on the knowledge of traditionalpractitionersthrough digital technology.
In short, thisproject opens up a new way of thinking about the future of traditionalmedicine and itsrole in oursocieties.
Althoughour system is effective, itneeds to beimproved for better use:

1- Develop a web application:becausewhatcurrentlyexistsisonly a simple prototype.

2- Integrate an intelligent audio system:add an AI assistant capable of communicatingverballywith the user. This willallowpractitioners to communicatedirectlywith the system usingtheirvoice and receive audible responses.

3- Offer audio in local languages:when the user clicks on an audio icon (e.g. for a symptom or a plant), theywillbe able to hear the namepronounced in their native language. This featurewillenhance the cultural and linguisticaccessibility 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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