Implementation Constraints and Opportunities in Developing Expert System Solutions for Diagnosis of Common Diseases Found in Taraba State

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ABSTRACT

Digital age has reform decision making especially in medical field through information and communication technology which become inevitable part of our lives. this paper illustrates the implementation constraint that encompasses developing Expert System for diagnosis of common diseases usually found in Taraba State. The paper, shows how fuzzy expert works through four distinct phases. It is discovered that the ratio of doctors to patients and the ratio of hospitals to doctors in Taraba is too low. Different literature that discussed how expert systems for diagnosing various diseases were reviewed; Interview, clinical observation, asking question and internet services were used as methodology for accomplishing this paper. Result were illustrated and finally conclusion was drowned which shows that e-medical solution for diagnosing disease would do well in Taraba because of the opportunities it offers but it loaded with challenges and implementation constraint.

Keywords: e-medical**,** fuzzy logic, expert system, medical diagnosis, healthcare, opportunities, challenges, fuzzy expert system.

1. Introduction

The ultimate dream in healthcare is to eradicate disease entirely. This dream might be possible one day with the assistance of artificial intelligence (AI), but we have a very long way to go and when we asked any person with experience and knowledge of artificial intelligence where he/she see the most potential for application of expert system of applied artificial intelligence, he/she would unanimously agree on healthcare. Technology has already been used to incrementally improve patient medical records, care delivery, diagnostic accuracy, and drug development, but with artificial intelligence we could achieve exponential breakthroughs.

Expert system is a branch of applied artificial intelligence that deals with designing and developing of software application which used to take an expert view in the absence of a human proficiency [3]. As human expertise in a domain is rarely and not able to be present everywhere and anytime, so in that cases application of expert system is helpful to solve the real world complex problem at the level of extra-ordinary human intelligence and expertise, as it is not possible that, everyone is expert in every field.

An expert system is an intelligent computer application that has been developed by expert engineer who has sophisticated knowledge in logical programming and talent in knowledge acquisition and analysis. This intelligent application can be web-based, desktop or mobile application and is characterized by high performance, understandable, reliable and is highly responsive. Expert system is usually developed with the data acquired by expert engineer from human expert who is versed and expert in a specific domain.

An expert system captures the knowledge of a human expert on a specific area. The vital idea behind these systems is just that expertise on an exact area is transferred from a human to a computer application. The excellence, effectiveness and quality of expert systems have increased in this digital era [3]. This type of applications is wonderful program with unique capacity such as predicting results, Justifying the conclusion, suggesting alternative options to a problem, although they are incapable of: substituting human decision makers, possessing human capabilities, producing accurate output for inadequate knowledge base or refining their own knowledge. Expert systems are applied in many different areas but medical field is a domain where expert system play a significant role across the world. In medical field, an expert system

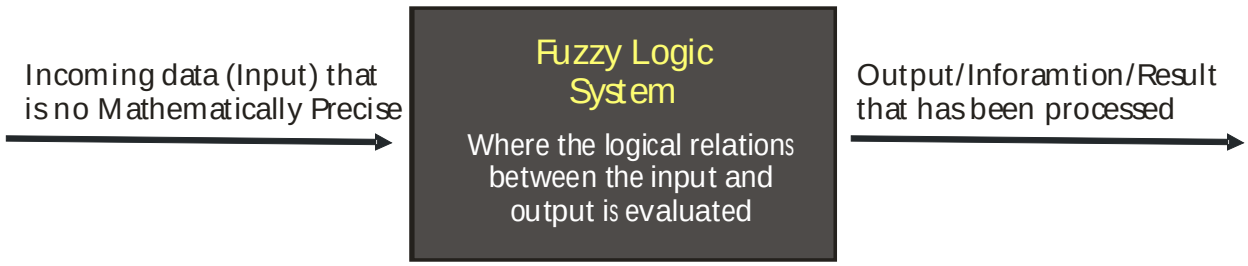
can diagnose diseases, instructing and assisting patient in decision making, explaining, interpreting patients input, deriving a solution to patient, advising, solve medical problem, as well as assisting doctors in diagnosis of disease of a patient, also help interpret medical test results [3]. The application can be used by both patient and doctors.

2. Fuzzy Expert System

One of the most important applications of fuzzy logic is Fuzzy Expert System. In the world of medicine fuzzy logic play an utmost role for effective diagnosis of diseases because Fuzzy Logic (FL) is conceptually simple and easy to understand and the precise concepts behind fuzzy logic are very easy [3]. Fuzzy Logic (FL) is a method of reasoning that resembles human reasoning. The approach of FL imitates the way of decision making in humans that involves all intermediate possibilities between digital values YES and NO. The conventional logic block that a computer can understand takes precise input and produces a definite output as TRUE or FALSE, which is equivalent to human's YES or NO [4]. The inventor of fuzzy logic, Lofty Zadeh, observed that unlike computers, the human decision making includes a range of possibilities between YES and NO, such as: Certainly, Yes, Possibly Yes, Cannot Say, Possibly No or and Certainly No. [4]. The fuzzy logic works on the levels of possibilities of input to achieve the definite output.

Fuzzy expert system is a knowledge based system where fuzzy logic is used as a tool for developing relations between input and output data. Fuzzy Logic Systems (FLS) produce acceptable but definite output in response to incomplete, ambiguous, distorted, or inaccurate (fuzzy) input.

Figure 1: Illustrates the fuzzy logic system architecture accepting crisp data and providing result



How the system work: The System work in four distinct phases:

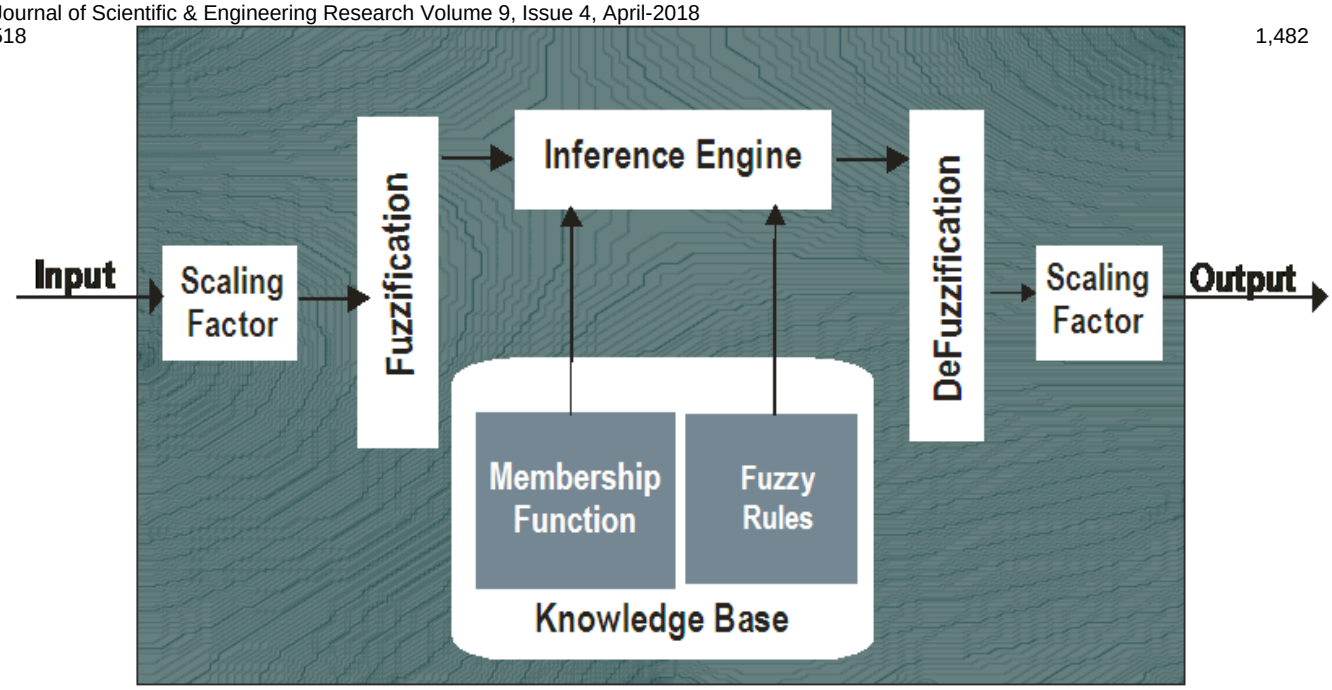
PHASE 1 Fuzzificaztion- in this stage, a process of transforming crisp values into grades of membership for linguistic terms of fuzzy sets takes place. The membership function is used to associate a grade to each linguistic term. [1][3]

PHASE 2 Inferences. It simulates the human reasoning process by making fuzzy inference on the inputs and IF-THEN rules. A fuzzy inference system (FIS) is a system that uses fuzzy set theory to map inputs to outputs. The truth-value for the basis of each rule is computed, and applied to the conclusion part of each rule. [3] This results in one fuzzy subset to be assigned to each output variable for each rule. [3]

PHASE 3 Composition- All the fuzzy subsets assigned to each output variable are combined to form a single fuzzy subset for each output variable. There are two methods for composition 1. MAX composition- in which, the combined output fuzzy subset is constructed by taking the point wise maximum over all the fuzzy subsets assigned to variable by the inference rule. 2. SUM composition- in which, the combined output fuzzy subset is constructed by taking the point wise sum over all the fuzzy subsets assigned to the output variables by the inference rule. [3]

PHASE 4 Defuzzification- Is the process of converting the fuzzy output set to a crisp value. It transforms the fuzzy set obtained by the inference engine into a crisp value. There are more defuzzification methods in which Two of the more common techniques are the CENTROID and MAXIMUM methods. [1][3]

Figure 2: Shows the anatomy of the Expert System for Diagnosis of common diseases



3. Problem Statement

Despite the opportunities and solutions an expert system promises in medical domain, to doctors and patients, there has been challenges and constraint involves in the implementation of such system to improve or replace the existing system and to assist both doctors and patient in diagnosis of common diseases found in Taraba State.

Both public and private hospitals in area of Taraba does not seems to embrace innovation that would improve the clinicians' operation in all aspect of the healthcare services efficiently. This is because of the ignorance at the part of government unaware what the new system can offer, so government does not want to invest in such and the hospitals staff does not seem to accept such system thinking it will replace their job and afraid they will lose their job thereby not well-coming the idea of implementing such type of system. At the part of private owned hospital, implementing such type of system will cost them huge amount of money and their goal always is to minimize cost to maximize profit being unaware the benefit of the new expert system.

The ratio of Doctors to Patient in Taraba state is too low, when this system is achieved, these imbalances would be addressed. But the constraint here most of the patient and doctors are computer illiterate and cannot be able to operate the system. Long distance which is proximity to hospitals is also an issue, for some patient to reach hospitals or clinics to get doctors services is too far, but with this program that can also be used on mobile phones, patient can quickly access

the system anywhere, anytime, answer some diagnosis questions through his/her mobile phones and get the results instantly, this would even remove the cost of traveling. But the challenge here most of the patient are poor cannot afford smart mobile phone and internet service does not reach everywhere within Taraba State. [5] [6]

More to that, the issue of consultancy services especially with the private hospitals is too high, with the implementation of this system, problem would be solved but private hospitals clinical operation remains as existed so the charges remain high.

Manual way of diagnosing patient which is time consuming, involve poor data record keeping and low performance is also an issue, robust expert system is of high performance, faster, efficient and reliable because is not only going to diagnose but also will serve as repository where patients record can be stored for future references. patient medical history can be forwarded to another doctor electronically. Patient records as soft data can also be used for datamining to produce some interesting insight that would provide some fantastic solutions to some problem (diseases) but implementation to replace the existing manual system is not encouraging. [5] [6]

There are many well-known challenges to implementing machine learning and A.I. in healthcare. The first is the lack of "curated data sets," which are required to train A.I. via supervised learning. "Curated data sets that are robust and have both the breadth and depth for training in a particular application are essential, but frequently hard to access due to privacy concerns, record identification concerns, and HIPAA (Health Insurance Portability and Accountability)," explains Dr. Robert Mittendorff of Norwest Venture Partners [7].

4. Objectives of the Study

- To illustrate the challenges and constraint that involve in the implementation of expert system capable of diagnosis of common diseases found in Taraba State.
- To show the benefit and opportunities expert system promise to medical domain.
- To provide easy possible solution to doctors and patients that can assist human effort in healthcare.

- To sensitize Public and Private hospitals to embrace innovation that improve clinical operation and enhances healthcare service delivery
- To encourage public and private hospital in Taraba state to implement expert system that would undoubtedly increase efficiency in their medical operation

5 Literature Review

Fuzzy expert system for diagnosing malaria; the system have algorithm of ten steps how the program diagnosis a patient with malaria by imputing sign and symptoms, search the knowledge base for the disease, get the weighing factor (associate degree) which may be either Low (1), average (2), high (3) or very high (4), and then apply the fuzzy rule, then map the fuzzy inputs into their respective weighing factors to determine their degree of membership, after which the system will determined the rule base evaluating, after that it will determined the firing (conclusion) strength of the rules, at this step it will Calculate the degree of truth R, of each rules by evaluating the nonzero Minimum value, it will then compute the intensity of the disease and finally display the output of fuzzy diagnosis [1]

An expert system can be designing to have a fuzzy rule based inference system to determine and identify lung cancer [2]. Their system accepts the symptom as input and provides the confirmed disease and stage as the output. The system can be calculating the membership function for both input as well as the output variable [2]. They said a feature of fuzzy logic toolbox is used to implement the proposed system and is used as the medical diagnosis model for providing treatments to the patients as well as it can be used to assist the doctors [2].

Implementing and integrating technology has indeed been a burden for many clinicians and practitioners. Dr. Jose I. Almeida is a pioneer in endovascular venous surgery who has practiced for over 20 years. He adopted electronic health records (EHR) ahead of the curve, yet has not seen many of the promised benefits. “We implemented our first EMR System eight years ago hoping it would improve efficiencies. We are now on our fourth system, and remain disappointed,” complains Dr. Almeida. “Right now, it’s been more of a hassle than a time-saver, and has actually disrupted the doctor/patient relationship by forcing a screen between physicians and their patients.” [4]

While data problems in healthcare abound, another major challenge is designing technical solutions that can be smoothly implemented and integrated into clinician practices and patient

care. "Behavioural change is the blockbuster drug of digital health," claims Dr. Mittendorff, but changing habits is much easier said than done. The wrong solution or rollout can even harm the healthcare industry. [4]

Artificial intelligence can not only improve care delivery, but also assist in clinician decision-making and operational efficiency, amplifying the impact of each individual practitioner. Analytics MD employs AI and ML to streamline hospital operations in emergency rooms, operating rooms, and in-patient wards, while predictive companies like Cyft and Health Reveal analyse disparate data sources to accurately triage and apply interventions to the highest risk patients. [4] Many patients with chronic diseases like diabetes visit doctors and hospitals numerous times, costing themselves, insurance providers, and the medical system a substantial amount of money. Cyft builds sophisticated models that identify patients with a preventable re-admission and matches them to appropriate intervention programs. [4]

Rule based expert system for *Diagnosis of Neuromuscular Diseases* which they implemented using Java Expert System Shell (JESS), Their system makes use of backward chaining for the inference engine and uses the RETE algorithm to search the knowledge base. The system has a graphical user interface where the user finds two windows, where one is an interactive window and other is the recommendation window [4]. The user is presented with a series of questionnaire in the interactive window which the user has the option to answer in yes or no. [8]

We achieved System Design and Implementation by using Iterative design approach to develop the expert system for diagnosis of HIV AIDS. They choose the approach because it involves the domain experts (health care workers) and it allows correction of the system to be made early in the process. [9]

In designing and implementing our expert system, we adopted some steps in the diagnosis and treatment of hepatitis B. The steps include: analysis of current system, identifying the problem of the current system, analysis of the proposed system, system design, which is classified under Structured Systems Analysis and Design Methodology (SSADM). [6]. they design their expert-system shell that provides customizable inference engines and knowledge base that contains rules that are of the form "IF condition THEN action". [10]

Effective medical diagnosis involves series of steps that must be carefully followed to guarantee accurate results. This is highly essential, because it must do with human life. [7] Because of the flaws associated with the orthodox approach to TF diagnosis in developing countries, many lives have been lost while several others have experienced serious deterioration in their health status. [11] Hence, healthcare organizations in developing countries are expected to provide new and improved patient care capabilities at a reduced cost.

A fuzzy expert system for determining the possibility of diagnosing prostate cancer, which can be used by the specialist doctors for treatment and by the students for learning the scope [12]. They said, this system can be developed further with increasing the knowledge rules from one side and with adding the neural network to the system from the other side. [12]

Expert system can be developed; after selecting the domain they want to build expert system, you will precede to knowledge acquisition which involves the acquisition of knowledge from human experts, books, or documents [9]. They formally confirmed that knowledge acquisition is the bottleneck in Expert System development today. [13] Acquired knowledge is organized and be ready for use, in an activity called knowledge representation. This activity involves preparing and encoding of knowledge in the knowledge base. [13]

Fuzzy Expert System for Heart Disease Diagnosis; the system simulates the manner of expert-doctor. They designed the system in a way that patient can use it himself. This fuzzy expert system that deals with diagnosis has been implemented. Experimental results showed that this system did quite better than non-expert urologist and about 94 % as a well as the expert did. [14]

fuzzy diagnosis system, certain inputs are inserted into the system, and then they are converted to fuzzy and understandable values for the system by means of a fuzzifier and entered to fuzzy inference engine as inputs. Fuzzy inference function used inputs parallel with designed rule base [11]. Using these rules, membership inputs (with their specified values) to each rule is determined. Finally, the fuzzy outputs become certain outputs by defuzzifier and they are displayed as system outputs. [15]

6. Methodology

The methodology adopted in this paper is scrutinizing how the existing system works, identifying the flaws of the existing system, analyzing the opportunities of the proposed system and then identify the implementation constraints of the proposed system. Data are collected after interview with some doctors from federal medical center and specialist hospitals, some clinics including Taraba state university clinic, nurses within Taraba state, Federal University Wukari's clinic. Internet service, observation and view/opinion of people was also used to gather some vital information in respect to this paper.

7.0 Results

7.1 **How Existing Medical Diagnosis Works*:*** it is observed that, traditional method of diagnosing patient take place when a patient brought him/herself to the hospital, a file would be opened for him/her, the file would contain her/his personal record after which a number would be given to him/her on a small card which she/he will be using when follow-up. The patient will then join the queue waiting to consult with doctor that is available, depending on the time consume, on consulting with doctor when his/her turn is here, the doctor will ask the patient several questions which may include:

- What is happening to you?
- How long is that happening?
- What have you done or what medications have you been taking?
- Which hospital did you visit? Etc.

Having asked such kind of medical questions, if it is necessary, the doctor will physically check/observed/diagnose the patient physiology by way of opening the patient mouth, nose, ears, eyes or touch wherever necessary to be able to properly diagnose and come up with possible better solution to the patient. When the doctor ascertains the possible illness of the said patient, he will then use his expertise to either:

- prescribed drugs that may heal the illness
- ask the patient to undergo medical-laboratory test which may be:
    - Blood test
    - Saliva, Urine analysis, stool culture
    - Throat swap, skin culture etc.
- ask the patient to have his part of the body that is ill ultra-sound (scan) or X-rayed

- Or the doctor may refer the patient to a hospital that he feels they will provide him/her with best treatment.

7.2 Flaws of the Existing System:

- The entire operation and process is time consuming
- Performance of the existing system of patient diagnosis is too low
- Inefficiency in the public hospital's operations
- Consultation fees is too high at private hospital
- Long distance for some patient to get doctors attention, they must cover long distance
- Poor Patient medical record keeping
- Unfairness and favoritism in managing patient
- NHIS (National Health Insurance Scheme) is not balance, it is only the employed patient with federal government that benefit from the scheme
- The ratio of doctors to patient in Taraba State is to low
- The ratio of hospital to patient in Taraba State is also too low

7.3Analysis of the Implementation Constraint of the Proposed System:

The system is not automatically or totally going to replaced medical practitioners function/job rather it will provide an improved solution that will bridge the gap or mitigate the flaws of the existing method of medical diagnosis of patient by doctors. However, the proposed system entails some constraints that are analyzed as follows:

- Taraba state in brief: Location of Taraba State in Nigeria Coordinates: 8°00′N, 10°30′E, 8.000°N 10.500°ECoordinates: 8°00′N 10°30′E8.000°N 10.500°E. **Total Area of Taraba State is** 54,473 km^2 (21,032 sq mi) and the **Area rank is** 3rd of 36. **According to** 1991 **population** census, Taraba population Total is 1,480,590. It is e**stimated in** (2005) that the population is amount to 2,688,944. It is ranked 30^{th} of 36 states with density of 27/km^2 (70/sq mi). The **GDP (PPP)** as at year 2007, the total is $3.40 billion while **Per capita** is $1,446 [14].

- Ratio of doctors to patient in Taraba State as critically observed is too low therefore the expert system (e-medical solution) is needed to be implemented to supplement the gap, however there is digital divide amongst the citizens of Taraba, that shows:

- there are some with digital knowledge while others none
- There are some with financial means to afford the device to access the system while others none
- Within Taraba state, there are some areas where internet/mobile services are available while some other location the services are not available.
- Per digital divide, some devices have features to utilize such system while some devices owned by some Tarabans does not have such features to benefit from the proposed system.

· Illiteracy is also an implementation constraint to this promising system; considering the estimated population of 1,480,590 in 1991, in 2005 after 14 years the population is increased by 1,208,354 to make 2,688,944, it is deduced that after each year, the population is increased by 86311, therefore by this year 2015, Ten (10) years is added from 2005, so the population is going to be 86311 X 10 = 863110 + 2,688,944 = 3, 552, 054. The ratio of illiterate to literate in Taraba State is 60:40 therefore, the percentage of illiterate to literate is 60/100 x 3552054 = 2,131232.4. The result show that, the population of illiterate is higher than literate. The benefit of the system would not going to be fair or favorable given the illiterate are high than literate and that could only mean majority of the patient are illiterate and this is one of the challenges of implementing such system [14]

· **Region:** Taraba state has 16 distinct local government as a region, the development/advancement of each region varies inversely, some region like Jalingo, Wukari, Bali, Takum, Ussa, Ardo-Kola Local government developed more than other local governments, therefore such variation in development will hinder the smooth and fair of this solution when implemented because the region that advanced and equipped with digital knowledge, skills, experiences, interest and infrastructures will welcome the new system with full-force than other region that are not.

· **Development tools:** the programming languages that are used to create and developed computer software are the development tools, the most common ones that are using to developed expert system comprises of:

- Java programming language
- Visual Prolog (visual programming in Logic)

- Window Prolog
- Visual studio
- Mysql or Oracle for developing database (Knowledge base)

The choice of perfect developments tools that would match the implementation of e-medical solution constraint the implementation itself because as one tool suite the development of one expert system, that does not mean it will be suitable in developing every kind of expert system. For example, if you developed Loan Expert System with visual studio perfectly, it may not be suitable to developed car electrical system diagnosis expert system because of the linguistic variables that each system requires.

- **Available Hospitals and Clinics**: the number of available hospital and clinics available in Taraba State are 41, and, if desktop application is to be developed and run in the hospitals, it would not going to be enough considering the ratio of possible patient per day (PPPD) to the installed system to the doctors, this is also a challenge.

8. Conclusion:

Conclusively, Successful healthcare innovation will only happen with strong collaboration between entrepreneurs, investors, healthcare providers, patients and policy developers. If the stars align, humanity stands to derive enormous benefit from the application of A.I. and inch closer to our dream of perfect health and a world without disease. This paper tried to present detailed explanations that showcase the implementation constraint that may hinder the development of fuzzy expert system for diagnosis of various diseases commonly found in Taraba State. Having done that, we came out with the conclusion that expert system as e-medical solutions can do well in Taraba State if implemented given the benefit the system can provides and despite the development challenges surround the implementation processes. It can help junior doctors and clinicians in managing common diseases diagnosis and decision-making process. It can also help patient to use their mobile phone, installed the program, access and answer some diagnosis question, get result and advises to their ailment [3]

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