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An Online Doctor's and Patient help Desk Assistant for Early Diagnoses of Prostate Cancer in the Rural Areas of Bayelsa State

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ABSTRACT

The shortage and unavailability of medical practitioners particularly medical doctors in the world has created deficiency in the health sector, which is even more prevalent in the developing countries. This has made rural dwellers in developing countries to experience chronic diseases like prostate cancer, lung cancer, breast cancer and so on which leads to mortality and disabilities. Prostate cancer is a male disease that occurs in the malignant tumors of the prostate epithelium. In this paper, we present an online doctor's and patient help desk assistant for the diagnoses of prostate cancer at its early stage in the rural areas where there are no health professionals. The system offers medical assistance to patients by providing diagnostic information of their status based on a set of questions answered with respect to prostate cancer. The system is developed with Java Expert System Shell (JESS) alongside other web programming tools. The result from the system evaluation with 50 participants show greater than 95 percent accuracy on expert confirmation.

Keywords : Prostate Cancer, Expert System, JESS, Disease

I. INTRODUCTION

In recent years, the rising services provided by the Internet technology has paved way in providing different kinds of services to mankind which has been making life easier by the day. In same manner the computer technology also has gone through significant changes which has influenced many areas of humanity. One of this aspect of life that has been positively affected by the use and application of computer technology is the healthcare industry, where the application of specialized machines like surgical robots, wireless body area network for sensing and sending patient health information, and software. Some of such software are derived from a branch of artificial intelligence (AI) known as "Expert System or Rule-based System or Knowledge-based system" [11]. An expert system is an intelligent computer program which captures the knowledge of a human expert and applies the captured knowledge in solving real life problems in an automated fashion. The mode of operation of such systems simply displays an expertise level of operation specific to the subject matter. The main purpose of knowledge-based system is to make the knowledge of human expert and their experiences to be more commonly available, particularly in areas where there are no readily available experts. Particularly in our rural communities where dwellers experience high prevalence of chronic diseases, mortality, and disabilities due to limited access to professional health personnels', good health facilities, health campaign, and disease prevention programs ([18, 19]. One of such health challenges is the prostate cancer common among men above the age forty. In view of this, the study is aimed at designing an expert system for the diagnoses of prostate cancer from its early stage to the full-blown prostate cancer.

The prostate gland is a small walnut-shaped organ in the male reproductive system that is responsible in producing seminal fluids that sustain and transport sperm and surrounds the neck of a man's bladder and urethra [5]. It is located below the urinary bladder opposite the rectum. It is partly muscular and glandular, with ducts opening into the prostatic portion of the urethra. It consists of three zones: central, peripheral, and transitional. Up to 70 percent of prostate adenocarcinoma (cancer of the glandular epithelium) is found in the peripheral zone [9]. The prostate gland's primary function is to secrete a slightly alkaline fluid that forms part of the ejaculate, which nourishes sperm and aids its motility (See Figure 1 for sectional view of prostate glands).

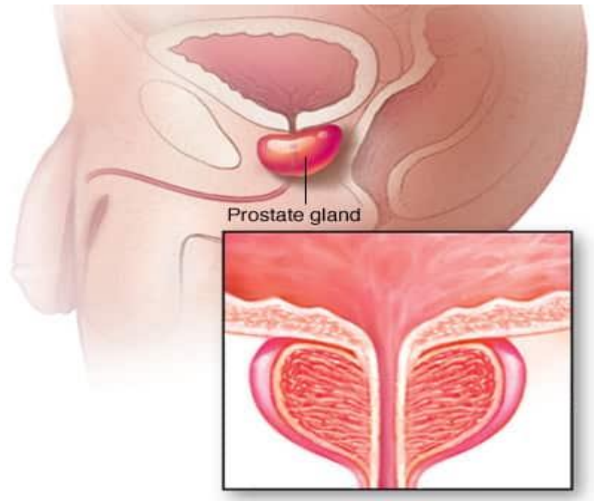

Figure 1 Sectional View of prostate gland

Prostate cancer is a male disease that occurs in the malignant tumors of the prostate epithelium [20]. The age of its onset is mainly 40 years and above of age, and the incidence rate increases with respect to age [28, 29]. The mortality rate is second only to lungs cancer [30]. Prostate cancer has become one of the most common cancers among men in the world especially in Europe and the United States [21, 22] with the incidence rate occurring more in African American men than any other racial group [31].

In developing countries like Nigeria with poor health record keeping capabilities [26] lacks the ability to deliver vivid information about prostate cancer incidence cases. However, in recent times it has been observed that there is an increase in the incidence cases in Nigeria which is due to recent improvement in health data collection and diagnosed cases of the disease with better diagnostic equipment's like PET, MRI and CT scans as well as required reagents for testing and confirmation from other urinary tract infections [10]. Prostate cancer cases have risen to as high as 9 in 100,000 becoming the 6th highest form of neoplasm in general and 3rd highest in males [7]. In this regard prostate cancer is of high medical prevalence, thus, calls for urgent research geared towards rapid and efficient diagnostic technique and holistic therapeutic management, especially one that is affordable and less traumatic. To the best of researchers' knowledge there have been no doctor's help desk assistant for the diagnosis of prostate cancer. This research seeks to design an online doctor's and patient help desk assistance for the diagnosis of prostate cancer at its early stage in the rural areas where there are no health professionals.

II. RELATED WORKS

The development of Artificial Intelligence (AI) has provided insight into how to analyze real life problems and the subsequent development of general search strategies for problem solving [2]. However, the field of AI is surrounded with several uncertainties about the exact nature of AI and its consequence. Most AI researchers regard AI as a multi-disciplinary field. Artificial Intelligence comprises of interesting subfields such as expert systems, machine learning, natural language processing, robotics and so on. The design of computer systems that use symbolic knowledge to simulate behavior of human experts is referred to as Expert System. Other areas which have led to advances in Expert System development include cognitive psychology, symbolic computing, and interactive programming [4]. One of the early Expert System was the MYCIN which was developed at the Stanford University in the mid-1970s. MYCIN provides consultative advice about bacterial infections in the blood and meningitis [15].

Expert Systems have two integral components: a knowledge base and a mechanism for drawing inferences. Both need to be represented within the computer. Expert System have usually been designed using programming languages like LISP (List Processing), a language specifically designed for symbolic and list manipulation, or PROLOG (Programming in Logic), a language which facilitates specification of facts and inferences that may be drawn from it. LISP and PROLOG are referred to as Artificial Intelligence languages [14]. These naturally lend themselves to the design of knowledge-based systems. Often designers of knowledge-based systems may also want access to a prepackaged code that facilitates the programming task. Packages which allow access to such a code are called programming environments. INTERLISP, a version of LISP which contains different prepackaged routines, is an example of programming environment. [23] review in their work how they implemented KL-one using INTERLISP. However, if rapid development of ES is to take place, the designer must have access to Knowledge Engineering Tools or Shells. Shells are packages that contain elementary constructs for modelling, specific strategies for representing knowledge, inference, and control. The extent to which a shell facilitates development of a knowledge system will depend on how closely and accurately the problem domain can be modelled by the constructs available in the shell.

III. PROBLEM STATEMENT

Prostate cancer is the single most common cancer in men and remains a significant public health problem with considerable social and economic consequences [16] with increasing incidence and morbidity among black African ancestry [31, 12, 8]. Screening is the presumptive identification of unrecognized disease or defects by means of tests, examinations, or other procedures that can be applied rapidly. Common screening techniques for prostate cancer include the digital rectal examination (DRE) and assessment of serum Prostate-Specific Antigen (PSA). DRE is the oldest and cheapest. It was the first and only diagnostic tool used for detection of prostate cancer until the mid-1980 before the discovery of PSA. However, this test has considerable inter examiner variability and most cancers detected by means of digital rectal examination are at an advanced stage [25].

The adoption of technologies like expert system in the medical field is important especially in pre-treatment activities like diagnosing diseases before medical consultation to actual treatment by a specialist. Moreover, patients need to wait for a long period for diseases to be diagnosed by specialist and even when the treatment is prescribed, it may be too late, and patient would have suffered severe pains or in certain cases lead to mortality which can ordinarily be avoided. Computer technologies such as expert system can solve the above problems with the aim of conducting earlier diagnosis of the diseases for patients, identify disease symptom and provide immediate response to save patients' life [3]. In addition, if further examination of the disease after the Expert System diagnoses turns to be positive, that means the patient consulting an Expert System before consulting a specialist for treatment becomes more effective in saving time and life.

IV. METHODOLOGY

Generally, our approach takes in a set of 19 'yes' or 'no' answers as input from a patient and match them against prostate cancer facts and rules defined in the knowledge base to reason with to arrive at a prostate cancer suspected or prostate cancer negative decision (see the set of 18 Yes or No question in Table 1) [24, 27]. Here, a "yes" answer from a patient confirms the captured fact. For example, a "yes" answer to question 2 and 9 in Table 1 captures the information in Prolog form as *Urination(patient, frequent)* and *Ejaculation(painful)* respectively, while a "no" answer eliminate such facts from the working memory in order to retrieve more precise facts from the patient.

Table 1. The set of 18 Yes or No questions

#	Questions
1.	How old are you?
2.	Do you urinate frequently?
3.	Do you have hesitant in urination?
4.	Do you have painful or burning urination?
5.	Difficulties in having an erection?
6.	Difficulty starting or holding back urination?
7.	Weak, dribbling, or interrupted flow of urine?
8.	A decrease in amount of fluid ejaculated ?
9.	Painful ejaculation?
10.	Blood in the urine or semen?
11.	Pressure in the urine or Semen?
12.	Pressure or pain in the rectum?
13.	Pain or Stiffness in the lower back hips, or thighs?
14.	Are you taking pills to lower your blood sugar?
15.	Have you ever taken any of the following medication: * Proscar *Propecia *Viagra * Androgen Supplement (Such as DHEA, Androstenedione, Norandrostentone) Body Building or Performance enhancing agents ?
16.	During a typical night, do you wake up to urinate more than four (4) times?
17.	Are you circumcised?
18.	Did a doctor ever tell you that you had an enlarged prostate or benign prostatic hypertrophy?
19.	Has anyone in your family or related to you by blood told you they have cancer (Prostrate Cancer)?

Our methodology for developing the Prostrate Cancer Diagnosing System (PCDS) involved three steps. The first step determines the demand for the system based on literature reviews and the usefulness of the requirements by a questionnaire survey among human experts in the health sector. Secondly, PCDS was constructed, and the general knowledge representation, which include the structures of different plans of the system and the system computerization. Lastly, is the verification, validation and evaluation of the PCDS (see Figure 2. For System construction flow).

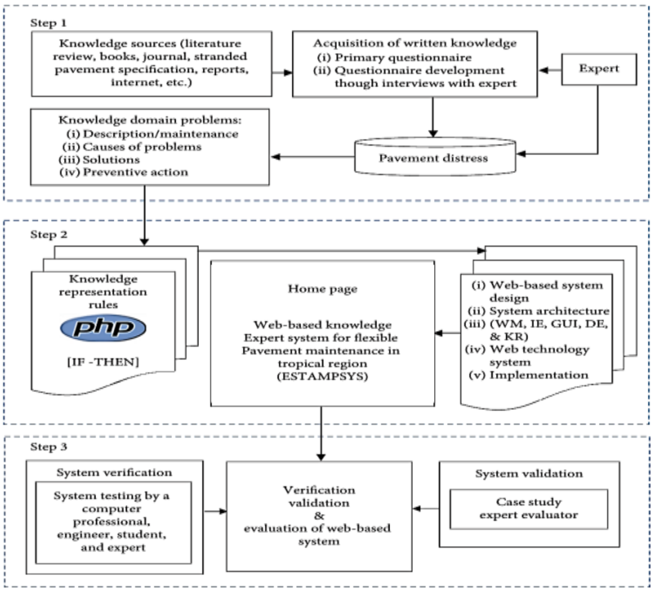

Figure 2. System construction flow

Knowledge Acquisition

The medical diagnosis expert system internal structure comprises of a knowledge base which contains prostate cancer symptoms information. The knowledge base gives the context of the problem domain and what is generally considered to be a set of useful facts [13]. Facts about prostate cancer symptoms were collated and extracted from domain experts, textbooks, and scholarly journal publications as well as web pages which were used to build the prostate cancer knowledge base [17, 6, 8, 7]. Knowledge elicitation from a set of medical practitioners (Doctors and Nurses) was done through interviews and collection of expert reports. For interviews, we adopted both unstructured and open-ended interview. The unstructured interview was to enable domain expert to introduce relevant concepts, vocabularies, and ideas. Whereas the open-ended interview was to enable researchers to ask specific questions with respect to certain aspect of the domain for clarification and understanding. The facts extracted from textbooks, journal articles and web pages were matched against facts collected from medical practitioners for correlation. This was an important activity in the research in that, medical practitioners possesses both factual and heuristic knowledge. Facts were extracted in the form of triples which were presented in the form of prolog syntax like *pain(patient, lower-pelvic), loss(patient, weight), loss(patient, appetite)* and so on.

The rule base applied in this research is the IF-THEN rules [1]. These rules are the primary structure of the reasoning component of the expert system. Rules define the kind of action to be taking if certain conditions are satisfied. Basically, these rules contain two parts which are the premises and conclusion, such as IF (premises) THEN (conclusion). Rules are fired in forward chaining form if the premises are satisfied. Some of the rules defined in this research contains multiple premises which are joined together by the 'AND' logical operator. For example,

$$IF\ pain(p, lower\_pelvic) \wedge urination(p, frequent) \wedge come\_with(urine, blood) \wedge urine\_flow(weak) \wedge urine\_flow(painful) \rightarrow suspected(urology\_problem)$$

From the above rule, the following *Pain(p, lower-pelvic), Urination(p, frequent), come_with(urine, blood), Urine-flow(weak), Urine-flow(painful))* are different premises that need to be satisfied for a medical professional to suspect urological problem. The beauty of this rule is that the different premises as identified here are connected by the 'AND' logic operator which constitute the IF part of the rule while *suspected(urology_problem)* is the conclusion. This explains that if a patient possesses these premises during medical examination the patient is suspected of having urological problem.

System Development

The various modules of the system are integrated into a single user-friendly web interface. Though, the symbolic programming languages are the commonly used tools for development of an expert systems; Programming languages like PROLOG and LISP are used in the development of Expert Systems as logical inferences can be easily implemented. However, recent times have experienced the use of high-level programming languages like java and its extension capabilities in Expert System development. The Java Expert System Shell (JESS) was used alongside other programming tools like Hypertext Pre-Processor (PHP), Hypertext Mark-up Language (HTML), Java Script (JS) and Cascading Style Sheet (CSS) to design the system. JESS is the rule-based engine for the Java language platform which was developed in the Sandia National Laboratory by Ernest Friedman-Hill. It possesses some inbuilt intrinsic functions of the C Language Integrated Production System (CLIPS). Here, JESS was used to develop the different modules of the doctor's assistant expert system while the other programming tools were used to build the web-based user interface (see desktop and mobile user interface of the system in Figure 3 and 4).

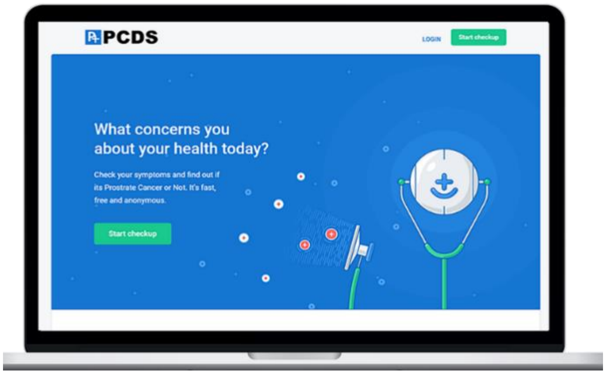

Figure 3. Desktop view

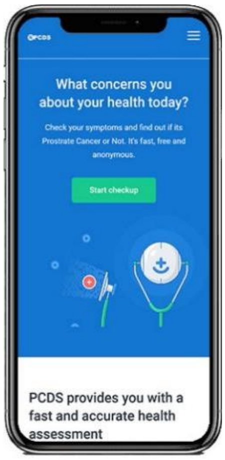

Figure 4. Mobile view

System Evaluation

For system evaluation, we evaluated the system in two ways: task-based and patient based Yes or No questions. The essence is that in error analysis, we can trace the system problem to a particular part of the system development life cycle and revised that component for further testing, while the 19 Yes or No patient questions may not be all the possible exact and direct questions a medical doctor may use for prostate cancer patient; they were evaluated by domain experts (medical doctors) for correctness and certified fit for use. The task-based evaluation was carried out on a set of 50 patient who visited the Amassoma General Hospital in Bayelsa State of Nigeria for consultation to assess the performance of the system. Out of the 50 patients, the results of 49 were prostate cancer negative while one was positive (see sample system output in Figure 5). To ascertain the correctness of the system output, both the questions and answers of each participant and their respective system outputs were taken to our team of medical doctors for certification. The doctors evaluated the system output to be correct. For live testing, visit https://wisdomomote.000webhostapp.com

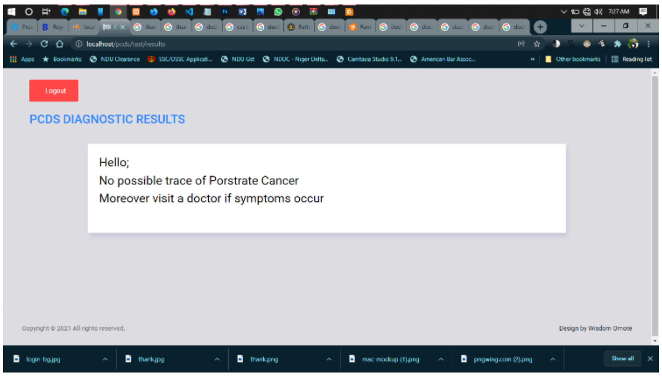

Figure 5. Sample System Output

V. CONCLUSION

This paper presents an online doctor's help desk assistant for the diagnoses of prostate cancer at its early stage where there are no health professionals. Rural dwellers can get diagnoses faster with the help of this system and more quickly than the traditional approach. This system does not require intensive training to use and moreover frees participants from the hurdle of moving from the rural areas to urban areas to see a physician. The system was evaluated and appears to be functional based on physicians' confirmation. However, our system is limited in certain areas such as does not address medication information, full fledge diagnoses and referrals information. In future, we will develop the system to address issues related to medication and referrals as well as professional advice on things to avoid as we age.

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