AN IMPLEMENTATION OF EXPERT SYSTEM FOR ORTHOPEDIC PATIENT DIAGNOSIS

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ABSTRACT

An expert system is computer-based and knowledge-based systems that utilize expert knowledge experience of a qualified person in a restricted area. In this work, the ES_Buider 3.0 tool was used to incorporate expert knowledge and expert system technologies. This expert system tool allows the creation of Internet accessible expert systems to address many problematic domains. The developed expert system is able to assist (a) orthopedic doctors, nurses, and students in dealing with diseases associated with symptoms, and (b) orthopedic patients in the form of first-aid diagnosis and provide a repository of information vis-à-vis multiple diseases.

Keywords: Artificial intelligence, expert system, orthopedic, knowledge base, inference engine.

I. INTRODUCTION

Artificial Intelligence (AI) is an artificial brain with the capability of behaving similar to humans. Expert system (ES) is one of the applications of AI. ES aim to solve problems, make decisions, and provide consultations that normally require a human expert. An ES can be defined as a set of programs that use human expertise as knowledge, which is stored, encoded in knowledge base, and manipulated to solve problems within a specialized domain [1]. From the 60's, ES have evolved towards new techniques and applications from first systems such as PROSPECTOR, MYCIN, or DENDRAL, to the modern decision support systems [9-11]. ES had been applied to multiple problem domains, such as medical diagnosis, industrial issues, business, applied mechanics, and materials, especially aeronautics [2-6, 12-15, 24-33]. For example, ES now help diagnose illnesses (like mental disorder, diabetes, and heart), classify diseases, unit the component problem, design and develop software, and utilize fuzzy expert system via video surveillance [12-13, 16-17].

Basically, there are two types of expert system, which are (i) conventional and (ii) fuzzy logic based system. Conventional expert systems are typically symbolic reasoning engines, while fuzzy expert systems are oriented towards numerical processing, which handles uncertain or imprecise information [1]. However, there are three main components of an ES (as shown in Figure 1 & 2), which are (a) the user interface, showing questions and acquires answers from the user, showing the conclusions, and describes reasoning, (b) the knowledge or rule base (KB or RB), comprising of the facts and rules signifying the domain of knowledge, where the knowledge from specialists is transformed by a knowledge engineer into a set of rules [7], and (c) the inference engine (IE), applies the rules in order to acquire a conclusion and defines the method of reasoning used by ES. There are two main approaches of speculation used by expert system with production rules, which are forward (deductive) and backward (inductive) chaining. Depending on the project of the expert system, the inference engine performs either forward or backward chaining, or a combination of both. In deductive IE, the system begins with facts provided by the user, and then draws conclusions from those facts; there is no goal to prove, while in inductive IE, the system begins with some given goals that they need to prove. Generally, there are four people that contributed to the development of ES, who are (a) the domain expert, whose information and skills has to be gained to design and construct the expert system, (b) the knowledge engineer, who performs knowledge acquisition or the elicitation process involving a range of interview and non-interview approaches to extract knowledge from domain experts, (c) the programmer, who stores and encodes the expert knowledge into the knowledge base, and (d) the user (client or end user). Figures 1, 2 and 3 described the components and overall process of accessing valuable information from expert system through the user interface. After collecting information from the medical expert, the knowledge engineer transformed and programmed all the gathered information in knowledge base (in the form of facts and rules). When the user asks any query, the inference engine matches the user query with the stored rules in knowledge base and gives feedback to the user with appropriate explanations. The process of building an expert system is known as knowledge engineering process. The main stages in the knowledge engineering process (dialog process) are shown in Figure 3. Referring to Figure 3, this process will iterate until

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the human expert finds the ES satisfactory for the envisaged purpose.

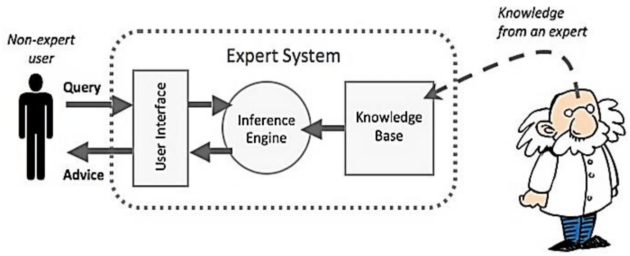


Figure 1: Interaction between expert system and user [23].

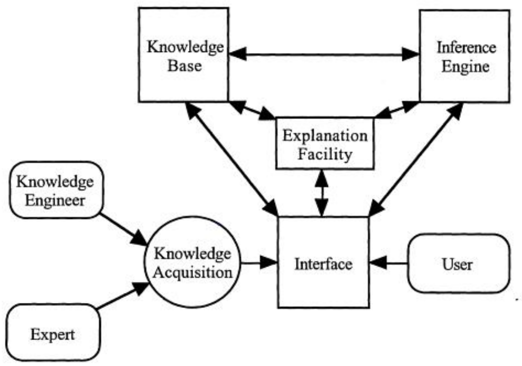


Figure 2: Architecture of expert system development and operational environment [8].

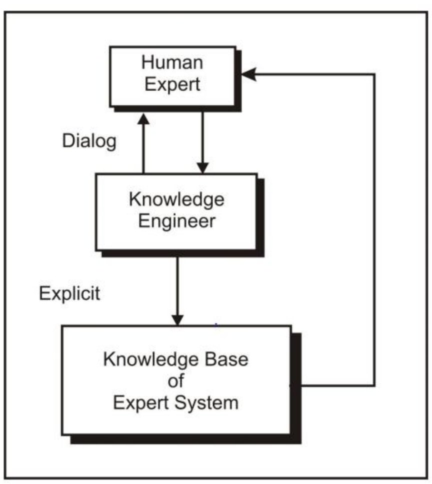


Figure 3: Knowledge engineering process [22].

Expert systems have some advantages over humans, some of them being the fact that they can possess knowledge from multiple experts, can be used in any risky environment where humans cannot work, is cheaper, permanent, unemotional, and respond relatively quickly. However, the development process of an expert system is quite a time consuming process, and it needs to be applied in an organized manner. This paper deals with the development of an expert system that (a) solve real world orthopedic problems, (b) comprises the expert knowledge of skillful human; this proficient knowledge is in a form that others may use to solve complications in a particular domain, (c) brings the user with diagnosed diseases via consultation, and (d) can enlighten the diagnoses it provides, and why it is asking particular questions. This paper is subdivided into five sections. The first section of this paper discussed the expert system, while the second describes the notion of the orthopedic field. The third section describes the expert system shell, while the fourth details its implementation. The final section concludes the paper.

II. AN OVERVIEW

A. ORTHOPEDIC FIELD

Orthopedic is a medical domain that focuses on the diagnosis, care, and treatment of patients with disorders of the ligaments, bones, nerves, joints, muscles, tendons, and skin [18]. These elements create a musculoskeletal system that helps us stand, sit, move, play, and work. Doctors who specialize in this domain are called orthopedic surgeons. Orthopedic specialists are involved in all aspects of heath care pertaining to the musculoskeletal system. They use medical, physical, and rehabilitative methods, as well as surgery. Orthopedic surgery addresses and attempts to correct problems associated with the skeleton and its corresponding attachments, ligaments, and tendons. It may also include some problems associated with the nervous system, such as those resulting from spinal injuries. These problems can occur at birth, via injury, or as the result of aging. They may be acute, as in an accident or injury, or chronic, as in many problems related to aging.

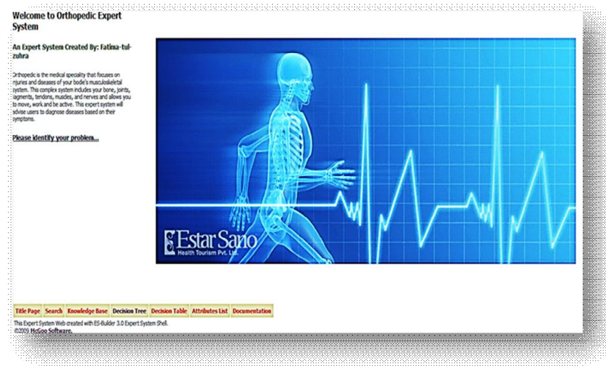
Orthopedic surgeons treat an extensive range of problems, ranging from dislocations and fractures, sciatica and low back pain, tendon injuries and ligament, bone tumors, osteoporosis and arthritis, and clubfoot [20]. Orthopedic specialists treat peoples of all age groups [21], such as (a) newborns and children with deformities, such as congenital dislocation of the hip, scoliosis, and club foot [19], (b) young people who need joint preserving surgery, such as osteotomy or arthroscopic surgery, and (c) older people with irreversible degenerative joint problems, such as joints replacement.

B. EXPERT SYSTEM SHELL

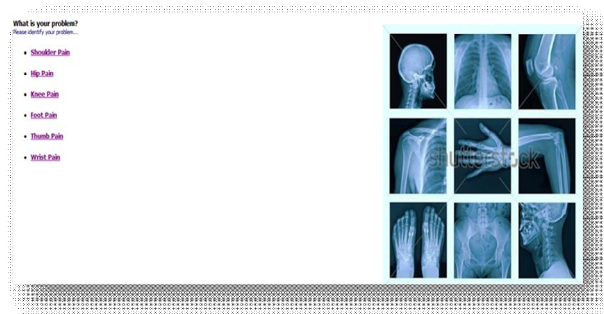
Most ES are developed using an expert system called 'shell'. An ES shell is a development tool that permits the entry of expert knowledge, and delivers the reasoning capability and user interface. An ES shell possesses a vacant inference engine, knowledge base, and a user interface. There are many tools available in the market. The ES_Buider 3.0 is user friendly, motivating, and compatible with Microsoft Windows from 98 to XP. It is used to create an ES that may be retrieved dynamically as web pages, and incorporated as a knowledge base into any website. It allows the user to generate complex, limitless decision tree, and it can be easily verified at every phase of the data entry. The purpose of the ES-Builder program is to promote expert system designers by providing a simple interface to implement prototypical ES that may have been pre-designed using appropriate design procedure. This type of ES was developed using a procedure of deductive reasoning. Thus, the expert system delivers an interface to test a series of attributes, which through the process of deduction, permits the user to arrive at a conclusion that is logically correct, based on the values selected by the user for each attribute. Built-in exporting functions include the flexibility to create web pages for (a) searching the expert system, (b) displaying the knowledge base, decision tree, and decision table, and (c) listing the attributes and values.

III. IMPLEMENTATION OF EXPERT SYSTEM

The development process of ES is time consuming. Taking this into account, this work has implemented an ES using an ES _builder expert system shell to diagnose orthopedic diseases. It consists of four phases, such as (i) domain selection, (ii) knowledge acquisition, (iii) knowledge representation, and (iv) system validation. Figure 4 (a&b) shows the output interfaces of the developed ES, where users can access the valuable information regarding a particular disease based on their symptoms. The development cycle of an expert system is shown in Figure 5. Referring to Figure 5, after selecting the orthopedic domain, knowledge was acquired by interviewing an orthopedic surgeon. The knowledge is all about the different patient's problems, such as shoulders, knees, hips, feet, thumbs, and wrists. The knowledge base is incomplete, and has six different problem areas and 370 rules with certain orthopedic diseases, but it could be updated with new symptoms and diseases. After obtaining knowledge from experts, it should be encoded and stored in the knowledge base, and transformed into one or more knowledge representation techniques. The knowledge base consists of the most widely used form of knowledge representation, such as (a) decision tree, which is a graphical depiction of the knowledge, and (b) production rules. Figure 6 represents the projected decision tree consists of some problem areas and symptoms along their specified diseases.



(a)



(b)

Figure 4(a-b): Developed orthopedic expert system where users can search any disease by identifying their problems.

Whereas the Figure 7 shows a knowledgebase consists of production rules. The production rule is typically expressed as IF (condition or premise), THEN (action or conclusion) keywords, and could have more than one condition. Conditions can be merged by OR and AND keywords. Once knowledge (initial facts) has been symbolized in some form, the inference engine will use this knowledge to draw conclusions (new facts). The ES_Buider shell has produced conclusions using the forward chaining method, where the system begins with facts provided by the user, then draws conclusions from those facts. All initial and new facts are stored in the working memory. Finally, in order to validate the ES, (a) the user is asked to answer problem-related questions, if a certain symptom appears, then the ES diagnoses the name of the disease, and post it on the screen with some satisfactory explanation, and (b) the diagnosis presented by the system was compared to the diagnosis presented by domain experts.

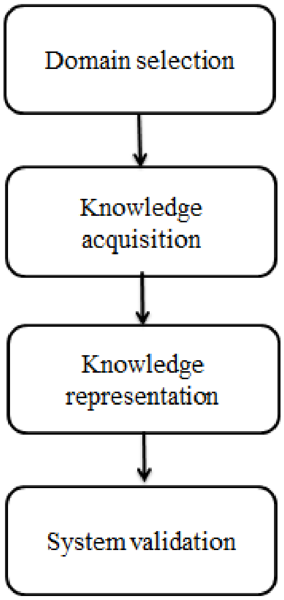


Figure 5: Expert system development cycle.

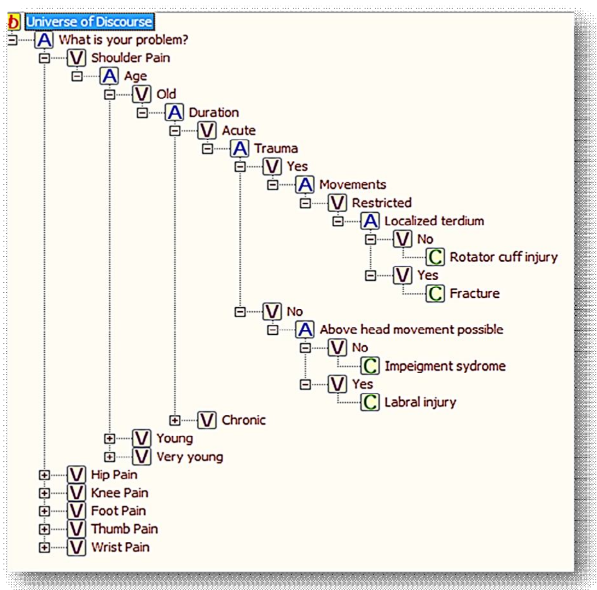


Figure 6: Decision tree of expert system.

Production rules in knowledge base

Rule 1:
IF patient has shoulder pain
AND if age is old
AND if duration is acute
AND if trauma
AND if movement restricted
AND if no localized terdium
THEN **rotator cuff injury**.

Rule 2:
IF patient has shoulder pain
AND if age is old
AND if duration is acute
AND if trauma
AND if movement restricted
AND if localized terdium
THEN **fracture**.

Rule 3:
IF patient has shoulder pain
AND if age is old
AND if duration is chronic
AND if normal movement
AND if range of movements restricted movement
THEN **adhesive capsulitis**.

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Rule n

Figure 7: Samples of production rules in knowledge base of expert system.

IV. CONCLUSION

This paper proposed an ES that diagnoses orthopedic diseases with reasonable explanation based on their respective symptoms. The information obtained from the expert system is similar to the information specified by a skilled doctor in a particular domain. The used information in the knowledge base is incomplete, but could be updated with new symptoms and diseases.

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