AN EXPERT SYSTEM PROTOTYPE TO DETERMINE OSTEOPOROSIS

AZLIYANA BT SULAIMAN

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DECLARATION

This is to certify that I am responsible for the work submitted in this project that original work is my own except as specified in the references and acknowledgements and that the original work contained herein have not been taken or done by unspecified sources or person.

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AZLIYANA SULAIMAN

2000556727

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ABSTRACT

By testing bone mineral density levels in high-risk patients, physicians are able to establish a diagnosis of osteoporosis, predict a patient's future fracture risk and monitor changes in bone mineral density due to medical problems or therapeutic interventions but the process in detecting osteoporosis are costly.

In order to reduce cost and time, this system will use the minimum of the requirement hardware and software. Patient can prevent form using long-term therapy if the can detect the bone mass in their body. This condition is associated with decreased bone mass in some patients.

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CHAPTER 1

INTRODUCTION

1.1 Background of the problem

Osteoporosis can be define as a condition characterized by the progressive loss of bone density and thinning of bone tissue which bones become extremely porous, subject to fracture, and heal slowly. Osteoporosis is the most common type of metabolic bone disease.

Osteoporosis occurs when the body fails to form enough new bone, or when too much old bone is reabsorbed by the body, or both. Calcium and phosphate are two minerals that are essential for normal bone formation. Throughout youth, the body uses these minerals to produce bones. If calcium intake is not sufficient, or if the body does not absorb enough calcium from the diet, bone production and bone tissues may suffer. While there are a number of causes of osteoporosis, hormone deficiencies (estrogen in women and androgen in men) are the leading cause.

Women, especially over the age of 60, are the most frequent sufferers of the disease. This is due to the loss of ovarian function and subsequent reduction in estrogen production that occurs at the time of menopause. Other causes include corticosteroid excess (from Cushing's syndrome or from prescribed exogenous steroids), hyperthyroidism, hyperparathyroidism, immobilization, bone malignancies, certain genetic disorders, and other miscellaneous problems such as low calcium in diet

Bone loss is a serious issue for a woman who are approaching menopause because a dramatic reduction in bone density can leads to osteoporosis. Adults should be aware with their bodies' need of calcium, vitamins, good nutrition and the right kind of exercise. Serious fractures may require hospitalization and major surgery. A serious fracture can impair a person's ability to walk and can cause severe back pain, loss of height, and deformity.

Osteoporosis affects more than 25 million Americans and most of them are women who passed menopause. The National Osteoporosis Foundations says that one in two women and one in eight men over 50 will have an osteoporosis related fracture in their lifetime. 33% of women over 65 will experience a fracture of the spine and as many as 20% of hip fracture patients die within 6 months from condition caused by lack of activity such as blood clots and pneumonia.

As women age, estrogen levels decrease and the risk of osteoporosis increases. Women who take birth controls pills during their reproductive years may reduce their risk of osteoporosis developing later in life, probably because of the estrogen that many oral contraceptives contain. Estrogen replacement therapy helps to protect women against bone loss.

Because it is hard to replace bone loss, determine and preventing is the main key. Treatment for osteoporosis focus on slowing down or stopping the demineralization process, preventing bone fractures by minimizing the risk of falls, and controlling pain associated with the disease.

Table 1.1: World Health Organization (WHO) classified these scores as standard deviation

Type	Measurement
1. Normal	T-score > than –1.0
2. Osteopenia	–2.5 < T-score < -1.0
3. Osteoporosis	T-score < than - 2.5
4. Established Osteoporosis	T-score < than - 2.5 in the presence of fragility fracture

1.2 Problem Description

There are treatments available as measurement and osteoporosis prevention, for example Bone Mineral Densitometry (BMD) the most widely used techniques is dual energy x-ray absorptiometry (DEXA), Quantitative Ultrasound, Dual Photon Absorptiometry (DPA), and Quantitative Computed Tomography (QCT).

Almost of this methods are using an x-ray images to measure bone density. The different techniques or an algorithm is needed to identify a poor quality x-ray images. Plain x-ray cannot detect mild bone loss. A bone must lose at least a quarter of its weight before a standard x-ray can detect the problem.

Quantitative Ultrasound technique is inability to measure density of bones most likely to fracture because of osteoporosis and limited usefulness for monitoring the effect of medication used to treat osteoporosis. Meanwhile, DEXA exposes the person to radioactive substance that is to produce the radiation. QCT is a type of CT Scan. It is expensive and results in a radiation exposure that is 20 to 200 times greater than the other techniques.

During the treatment, correct positioning is important for an accurate BMD measurement. If the scan is not done with the bone in proper position, the result may be inaccurate. A previous bone fracture can cause false highly BMD results. Metal objects (such as button, zip, jewelry) that interfere with the scan also affect the results.

BMD also needs experts to utilize the machines to categorize patients as normal, osteopenia, osteoporosis and established osteoporosis problem. However, to build examination table or purchased the machines of BMD are costly. A small medical center (clinic) is not willing to pay a big amount of money to have a BMD.

1.3 Problem Scope

These silence disease always ignored by senior generation because the symptoms are not appeared directly. The machine that measured bone density can easily give inaccurate reading because of variations in the measurement or the patient. If the patient moves an arm or hip from one measurement to the next, the reading can be slightly different, and nobody knows if the difference is because of the machine or a drug therapy.

1.4 Problem Significance

In this part will explain the existing problem significance. Patients can't move especially their upper body during the bone density test. The machine can't capture accurate images then produce inaccurate x-ray images. The images may overlap or may appear different than patient's body.

BMD machine are costly, only medical center like hospital are willing to purchased it. Beside the BMD machine only specific for bone measurement like osteoporosis and fractures.

An expert physician is needed to use the machine and explained all the information to assure the test not more than twice. This situation would produce inaccurate records.

1.5 Potential Benefits

By developing an expert system, inaccurate report can be reduce because the result using an expert system can be compare with bone density test to produce an accurate reports. Although physicians or doctors are not around, allowed users such as nurses also accepted to use an expert system to determine osteoporosis. Patients are not necessary to wait until physicians or doctors to give the result. Unconfident patients are allowed to ask a doctors or experts.

As we know, technologies will update every day. It is also occur to an expert system because physicians and doctors also allowed to added, updated and deleted the information on this expert system. Beside use to determine the osteoporosis, physicians and doctors are exposing the information on osteoporosis to others.

Beside update the information about osteoporosis, an expert system also updated to new version with new function. For example, an expert system will evolve into intranet expert system in the hospitals and clinics. This new expert system will expose to other than osteoporosis experts.

CHAPTER 2

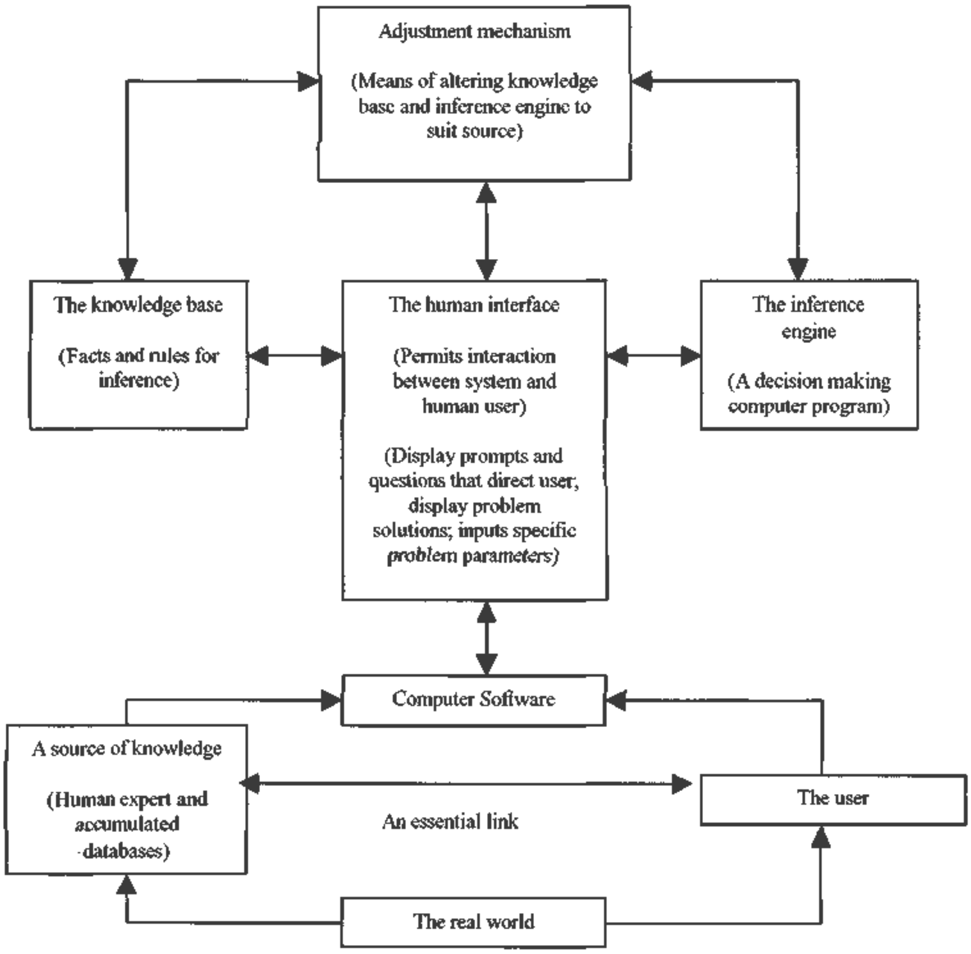
LITERATURE REVIEW

2.1 Detailed description of the problem

An expert is a person with a high degree of knowledge about or skill in a certain subject. A system is a group of interacting, interrelated, or interdependent elements forming or regarded as forming a collective entity.

This chapter will explain similar study or research on expert system to diagnosis osteoporosis. A literature review is up to date research, and as a guidance to build a good project. Initially this requires identifying potential relevant material screening of the material by using the abstract, title, keyword and authors of the articles or the researcher of the project.

Figure 2.1: General model of an expert system



An expert system is an artificial intelligent technique in which to accomplish a particular task in encoded a priori from human expert. There are two type of expert system; first, the knowledge base and second, the cause.

The, knowledge base represents the expert's domain knowledge and must be encoded as efficiently as possible due to the size of the database. Meanwhile, the cause exploits the knowledge in the rules in order to apply that knowledge to a particular problem.

A medical expert system designed to diagnosis infection diseases will have a great deal of knowledge about certain symptoms caused by infectious diseases. In this case, expert system will discover or consists of knowledge about disease, symptoms, and treatments.

Medical expert systems have evolved to provide physicians with both structured questions and structured responses within medical domains of specialized knowledge or experience. The structure is embodied in the program on the advice of one more medical experts, who also suggest the optimal questions to consider, and provide the most accurate conclusions to be drawn from the answers the physician choose. In software programs, these decision sequences are represented in clauses of the form: "If…, Then…, Else…", with final else having positive value in the closed system of the program. Although the physician is free to select any one of the choices offered in each clause, the physician is limited to the choices offered by the expert in writing the program.

The program is thus limited by the fixed input from the expert at the particular time of formulation. If the physician has new questions or new data, a medical expert system program will not be able to accommodate the physician. It is for this basic reason that open system programs have been developed to meet the new needs of the user, with the contrast being paraphrased as "Expert System are by expert".

The phase of clinical care. The clinical care of a particular patient often proceeds in distinct phases, such as diagnosis before therapy, or prevention of disease before onset of disease, or rehabilitation of the patient after therapy of the patient. The analysis of queuing and renewal within human system has permitted the identification of both decision elements and potential decisions in a least 10 such distinct phases of clinical care.

PXDES, which is pneumoconiosis, a lung disease needs an X-ray diagnosis. This expert system incorporates the inference engine to examine the shadows on the X-ray. The shadows are used to determine the type and the degree of pneumoconiosis. This system also includes three other modes: the knowledge base, the explanation interface, and the knowledge acquisition modes.

The knowledge base mode contains the data of X-ray representations of various stages of the disease. These elements are in the form of fuzzy production rules discussed in the previous paragraphs. The explanation interface details the conclusions, and the knowledge acquisition mode allows medical experts to add or change information in the system.

Another example of a diagnosis rule-based expert system is EMERGE designed to be used in an emergency room. This system uses a form of production rules, which incorporates weighing factors, which are determined by a neural network. The neural network is composed of input and output blocks with a hidden layer block in between which communicates input to the output. The neural network learns from examples then predicts an output based on this knowledge.

This system also uses an IF-THEN-UNLESS statement instead of an IF-THEN statement. Because of this, the decision process may be more precise, the results may be more accurate and the explanations may be better understood. A specific example from EMERGE using the IF-THEN and the IF-THEN-UNLESS indicates that the latter case is more compact and less complicated.

IF-THEN
IF forced volume *capacity* is *high* (.625)
AND Bronchoscope results are positive (.250)
AND local symptoms are present (.125)
THEN surgery is probably necessary
IF Metastasis is present (.500)
OR Contraindications to surgery exist (.500)
THEN surgery is probably not appropriate

The IF-THEN-UNLESS rule that allows for fewer rules, permitting a more rapid search. The logical operators, AND and OR, used in both these methods give their corresponding rules different weighing factors and can be seen in the parenthesis next to each statement in the IF-THEN case. The threshold value for OR is lower than that for AND. Thus, for each additional AND you have a lower weighing factor but for each OR, the weighing factor is divided evenly. It can be seen from the example above that the weighing factors must add up to one.

2.2 Definition of pertinent technical terminologies.

The technical accuracy and precision of BMD measurement technologies are barely satisfactory for clinical use and require rigorous quality assurance. Independent standards of bone mass are used to determine accuracy and precision error rates. Accuracy refers to the degree, which BMD measurements represent the true BMD value of the site being measured. BMD accuracy studies measure the BMD of a cadaverous bone then reducing the bone to ash to remove the carbon thereby leaving the true value of the remaining minerals.

Error for dual-energy x-ray absorptiometry (DEXA), for example, can be as high as 8% in routine clinical use. This means that the true value of a woman's bone mineral density could be 8% higher or lower than the value reported to her. If diagnostic and treatment thresholds are used, then this amount of error can affect classification.

2.3 Different methodologies/approach to solve the same problem.

Various technologies have been developed which aim to measure BMD. Below are summary of the technical features of available BMD measurement technologies. A brief overview of each technology is also provided:

i. *DEXA (dual-energy x-ray absorptiometry)* - The bone mineral density (BMD) measurement technology currently in use in BC is dualenergy x-ray absorptiometry (DXA or DEXA) supplied by Hologic™ or Lunar™ corporations. It uses low energy radiation to estimate the amount of mineral per volume of bone. DEXA is essentially a refinement of earlier DPA technology, using x-ray rather than an isotope source for better image quality. DEXA can be used for lumbar spine, femur or total body images.

ii. *Ultrasound* - Ultrasound provides a measure of BMD through transmission velocity and attenuation of ultrasound in bone. It is limited to bone with minimal overlying soft tissue such as the calcareous and patella. Ultrasound is being hailed as a screening test because it is less costly and time consuming per test, more portable, and can be operated with less training than a DEXA machine; however, it is experimental because the technical accuracy and precision are not known.

iii. *DPA (dual-photon absorptiometry)* - This technique appeared in the mid 1970s. It uses a radionuclide source (153Gd) with emissions at two energy levels, which enables scanning of the lumbar spine, femur or total body. It is no longer being manufactured.

iv. *SPA (single photon absorptiometry)* - SPA was the first commercially available technique for the non-invasive measurement of BMD. It uses a radionuclide source (usually 125I) and measurements are limited to peripheral skeletal sites (distal radius and calcareous).

v. *QCT (quantitative computed tomography)* - QCT can be performed using most commercial CT scanners and uses radiographs to generate cross-sectional images of selected vertebrae; however, this is rarely done clinically. Generally the midlines of three or four lumbar vertebral bodies are scanned.

vi. *Plain film x-rays* - Conventional x-rays identify marked BMD loss exceeding 30%. Measuring the thickness of cortical bone and comparing that with normal controls obtain an estimate of BMD. Technical aspects may falsely amplify or mask bone changes.

Table 2.1: Features of available bone mineral density measurement technologies (Source: Erlichman and Holohan, 1996).

Technique	Site	Scan Time (minute)	Accuracy error*	Precision error*	Advantages	Disadvantages
DEXA	Spine, Hip	5 – 10	3 – 9%	0.5 – 3%	~ no isotopes ~ relatively higher precision ~ low radiation ~ multiples sites possible	~ uncertain accuracy in living bodies ~ relatively high cost ~ influence by osteoarthrosis and aortic calcification at lumbar sites
Ultrasound	Heel	5	Unknown	Unknown	~ no radiation ~ low cost ~ portability	~ not validated using studies of compression strength and ash weight
DPA	Spine, Hip	20 – 40	3 - 10%	2 – 5%	~ first technology to allow evaluation of axial sites as well as the whole body	~ no longer being manufactured ~ annual isotope replacement (cost, availability problems) ~ poorer precision and accuracy than SPA ~ unable to differentiate trabecular and cortical bone
SPA	Forearm, Heel	5 – 15	3 - 8%	2 – 5%	~ low radiation ~ high accuracy ~ high precision ~ low cost ~ portability	~ restricted to appendicular sites ~ isotope half-life short
QCT	Spine	5 – 30	5 - 15%	2 – 6%	~ gives true density values ~ high resolution	~ comparatively high radiation ~ high cost ~ high accuracy error ~ precision error (spine)

Table 2.2: WHO standard deviation for osteoporosis level

Normal	A value for BMD or bone mineral content (BMC) within 1 standard deviation (SD) of the young adult reference mean.
Low Bone Mass (Osteopenia)	A value for BMD or BMC more than 1 SD below the young adult mean but less than 2.5 SD below this value.
Osteoporosis	A value for BMD or BMC 2.5 SD or more below the young adult mean.
Sereve Osteoporosis	A value for BMD or BMC more than 2.5 SD below the young adult mean in the presence of one or more fragility fractures.