Diagnosing Ankle Diseases Expert System

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Abstract: In recent years, technology has evolved significantly to intervene in the treatment of diseases through diagnosis online before going to the specialist doctor, where it become possible for the patient to know the name of his illness, the specialist doctor who can treat him and the multiple treatment methods through specially designed systems called expert systems.

The expert system is based on the principle of asking the user gradual questions about the symptoms he feels, leading him to the result of diagnosing the illness, dealing with it quickly, and tips for permanent treatment. These systems may also help both trainee physicians and physiotherapists.
This research paper is a living example of these effective applications, explaining in a simplified manner some of ankle diseases, how to deal with them and methods of physical therapy.
The ankle is a small region in the leg. It is two joints, the first consist of three bones (tibia, fibula and talus underneath) which is called true ankle joint. The other is called subtalar joint have two bones: talus on top and calcaneus on the bottom.
This tarsus between the end of the leg and the start of the foot facilitates the movement up-down and left-right with no problems in normal case, although, it needs a special case as Physiotherapist when gets injury.
We have identified seven ankle diseases: Ankle Sprain, Fracture (of Fibula), Rheumatoid Arthritis, Rheumatoid Fever, Gout, and Osteoarthritis (Degenerative Joint) using SL5 Object Expert System Language in the work of the expert system.

Keywords: Sprained ankle, ankle bones, ankle pain, expert system with applications, knowledge management, knowledge base tools, and knowledge based System

1. INTRODUCTION

The term Ankle represents the region of meeting between the leg and the foot. It is the point where bear the full weight of the human body. In medical terminology, ankle can refer broadly to the region to the talocrural joint [1].

As you can see at the picture below, the bones, which form the ankle, are (in the foot) talus is a foot bone sits above the heel bone, and (in the leg) tibia is the shinbone and fibula the thinner bone next to the shinbone [1, 2].

Side by side, the ligaments that strongly joint the bones together and allow the movement of the leg easily are four:

- **Deltoid ligament:** is a strong, flat, triangle band, which is composed of the anterior tibiotalar ligament, tibiocalcaneal ligament, posterior tibiotalar ligament and the tibionavicular ligament [3].
- The anterior talofibular ligament.
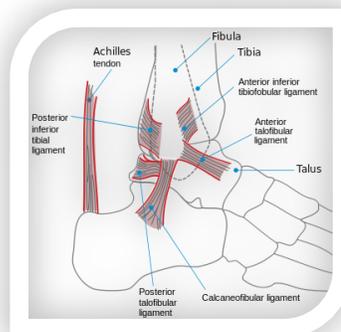- The posterior talofibular ligament.
- The calcaneofibular ligament.

Figure 1: Ankle graphic photo for the bone and ligaments [22]

From the above abstract details which describe the importance of the ankle, if one from those bones, joints or ligaments are damaged or suffered minor damage, that will cause pain and a true problem if it doesn't treat well.

From these disease are: Fracture, severe sprain, sprained ankle, Fracture of the fibula, Rheumatoid arthritis, Rheumatoid fever, Infected joint, Gout, Osteoarthritis, or Degenerative joint.

Until these days, there are no specialized doctors at ankle or foot problems [4], although the cases are patronized by Orthopedist hand by hand with Physiotherapist. As computer programmer specialists, we seek to integrate technology with field's life to have an easy more healthy living. In this manner, we develop an expert system for diagnosing ankle's injuries based on ask reasoning questions to guide you to the main problem. In addition, this application will help junior doctors on recognition the problems.

2. KNOWLEDGE-BASED SYSTEM:

Knowledge-based System -KBS- (or Expert System) is a computer system that emulated the decision-making ability of a human expert in a restricted domain [5,37-40].

The aim of the expert system is solve the problem by using the information provided by the end-user and processing it inside the application by if-conditions to obtain the result as new knowledge presented again to the user.

Many successful expert applications prove the validity of using technology in other fields like: Dendral (at chemical), Mycin (at medicine), Prospector (at geology) and Decision support system (at Business) [6,7]. Each one of these applications consists of main components as expert system, which described in details at the following:
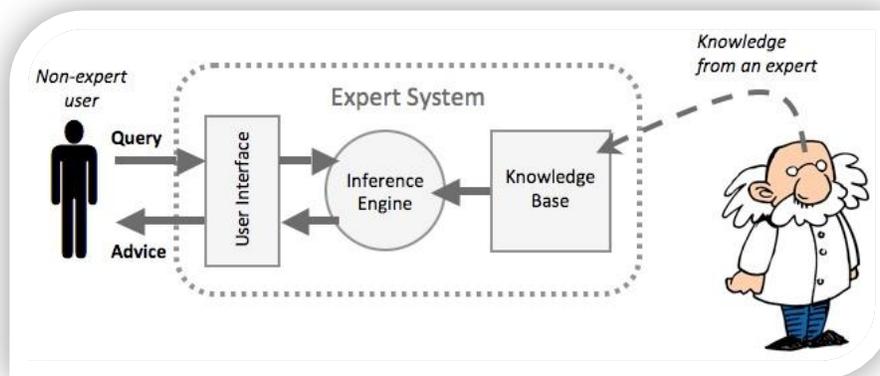

Figure 2: Knowledge Based System Structure [7]

❖ User Interface (UI): to facilitate exchanging the information and the facts between the user and the Inference engine.
❖ Inference Engine: mechanism to derive new knowledge from existing knowledge and information provided by the user, also, it contain "Agenda" to locate a goal and specific rules used to acquire new knowledge.
❖ Knowledge Based: contains whole rules and facts about a certain domain provided either directly from the environment or from the expert person (developer).
❖ Working Memory: Which store temporary information that entered from the end-user.

3. MATERIAL AND METHOD:

The tendered expert system diagnoses seven ankle diseases between fractures, sprain, types of arthritis, and joint problems. It depends on asking the patient a related yes/no questions about the symptoms felt by the injured. After the system finishes asking, it will show the diagnoses (the name of the illness) with recommendation and quick self-care.

The following figures show the program interfaces for the main page, symptoms question page and diagnosis and recommendation page.
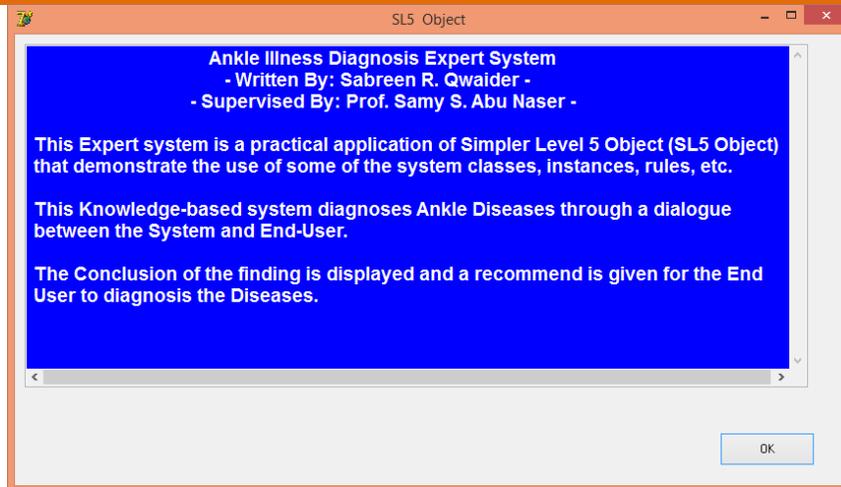
Figure 3: Main Expert System Interface
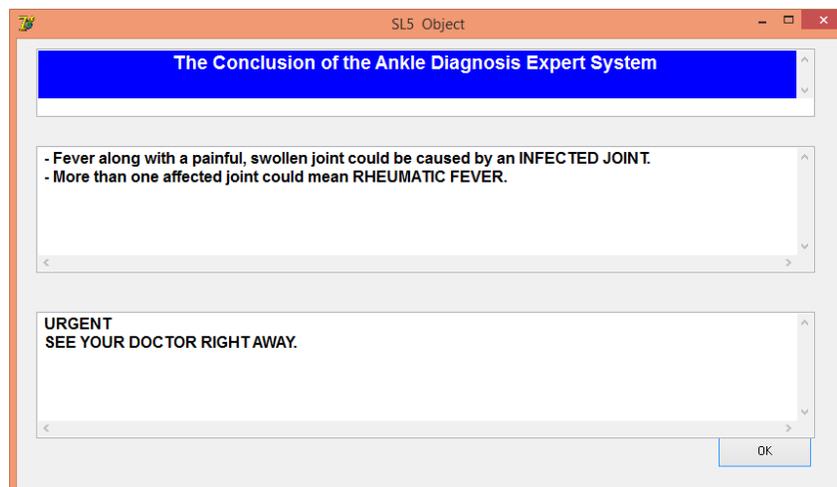
Figure 4: Yes/NO Question Screen

Figure 5: Diagnosis and Recommendation Screen

4. BACKGROUND/LITERATURE REVIEW:

Expert Systems are a good decision-maker when there is a good knowledge existing inside it. The knowledge comes from the environment, expert person, and client feedback, too, which make it in a constant evolution to get client satisfaction.

Nowadays, there is a lot of knowledge-based system that treats a special problem or manages a certain domain; however, the most useful is system, which diagnosis patient diseases and give initial processing order, such as treating diseases in: infants and children, ear problems, low back pain, neck pain, foot and even breast cancer illness [4, 31-31-60]. Although there is no free, available expert system to help dealing with "Ankle Problems" in the right way, which provides in this paper.

5. KNOWLEDGE REPRESENTATION:

The major source of recognition disease's data is form Podiatric physician and specializes websites [2, 8].

The information has transformed to SL5 Object Expert System Language by syntax (rules, facts, and objects)[39]. Currently the application has converted seven diseases by eight Attributes and fifteen rules.

Ankle Fracture or Broken Ankle:

It refers to broken at one of the ankle joint bones, which may be Simple break in one bone, such it doesn't stop you from walking, or several fractures, which compelling you to be at bed for weeks. It may be caused by twisting or rolling the ankle, drop down the stairs, or being in an accident.

Although the main problem is that, the fracture cannot be diagnosis rather than sprain of the ankle a dislocation, or tendon injury without X-rays [9,10].
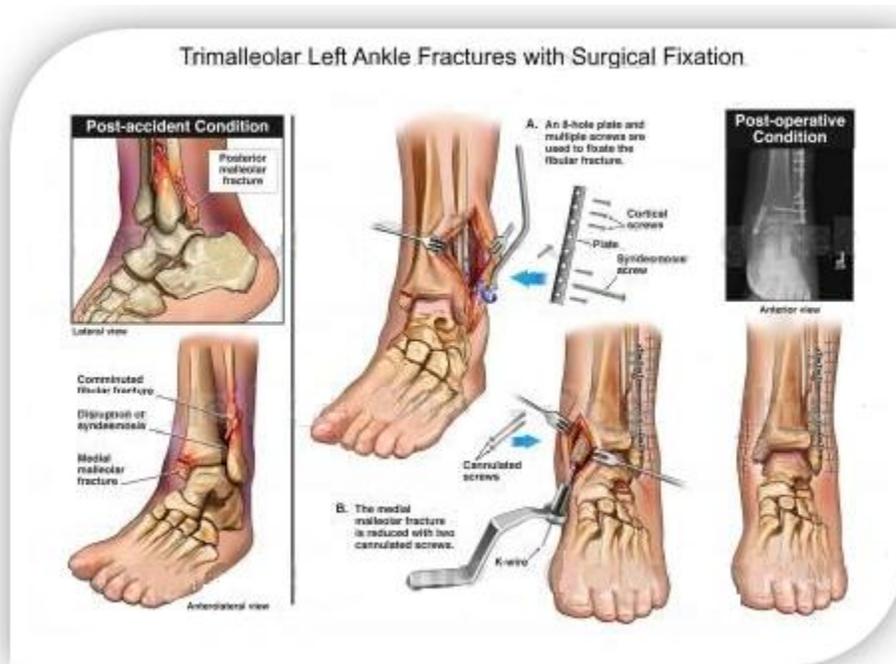
The next picture demonstrates the break position:

Figure 6: Ankle Fracture

Fracture of the Fibula:

It is a break of the small two outside bones. It may be complete or incomplete fracture on any part along of the bone. Although, the special two things of this type of a break are it is common, and almost it accompanied by ankle sprain that make the problem more complex [12].
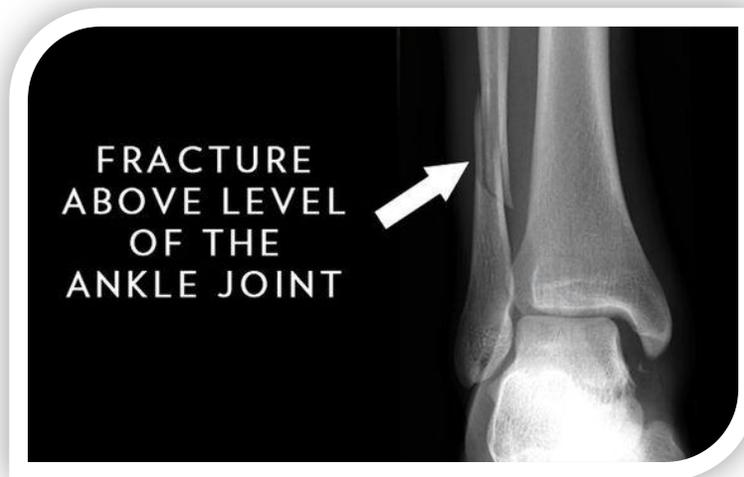
Figure 7: Fracture of the Fibula [27]

Ankle Sprain:

It refers to stretch or possibly torn of the ligament ankle. It has happened to soccer player when rapid shifting with foot planted [11]. Some states could be treated directly if it is simple and other will make more pain when put weight on the ankle while walking.

Figure 8: Ankle Sprain [23][23]

Rheumatic Fever:

R fever is an inflammation disease developed be insufficient treatment to strep throat or scarlet fever that attack humans' body after infection with streptococcus bacteria. The harm of R fever can damage heart valves and heart failure, although, the treatment reduces the pain and prevent its recurrence. [15]
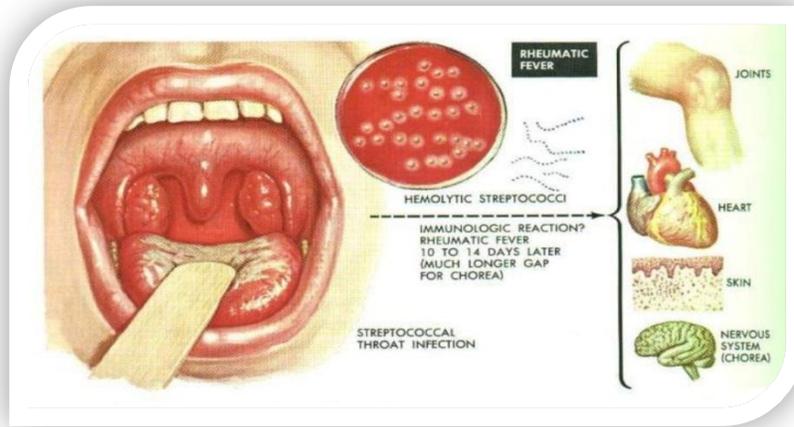
Figure 9: Rheumatic Fever [29]

Rheumatoid Arthritis (RA):

It is an autoimmune disease such the body's immune system attacking mistakenly the joints. The immune system that supposed to be the first defense line of any misters enters the body as bacteria or viruses, sudden attack the joints create inflammation, which effect at it and may cause swelling and pain in and around the joints. Even more, if the inflammation does not treat well and quick may affect the body's system as cardiovascular or respiratory systems [14]. The following picture evinces the effect of it.

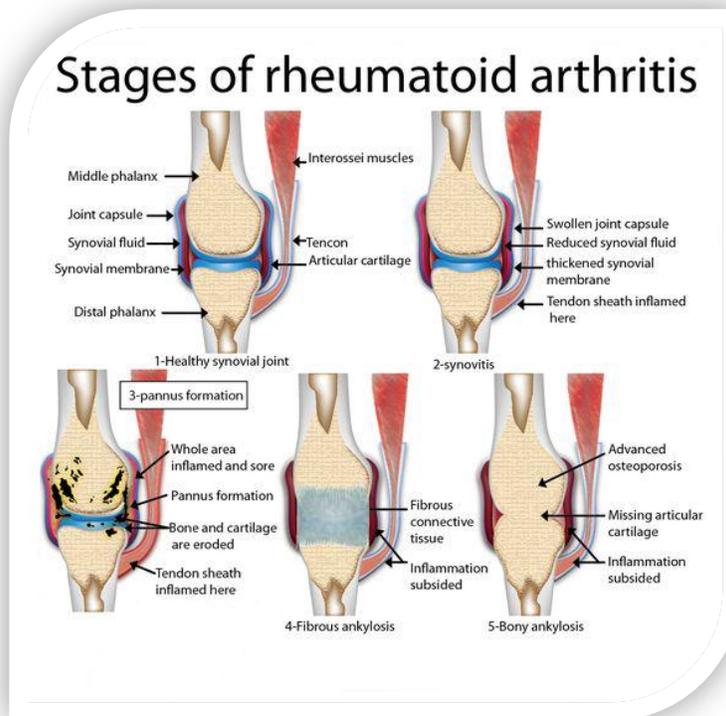This disease must discover early as doctors recommend depending on its fast and severe effect.

Figure 10: Rheumatoid Arthritis [28]

Gout:

It is an arthritis caused by form in joint needle-like crystal of uric acid. The normal percent of uric acid in blood does not doing anything, however if the percentage is abnormally getting up to build up crystal compounds in joints, it will cause painful arthritis, blockage of the kidney which lead to kidney failure.

Gout is the most frequent recorded medical illness throughout history [16, 17].

Figure 11: Gout illness [30]

Osteoarthritis (OA) or Degenerative Joint:

Degenerative Arthritis, arthritis, Osteoarthritis, or Degenerative Joint is the same meaning of one illness that is damaged the surface of the joints called cartilage covers the end of each bone, to become the joint movement not smoothly. When OA worsens over time, it may give rise to break down the bone and develop growths called spurs. Bits of bone or cartilage may chip off and float around in the joint [18, 19].
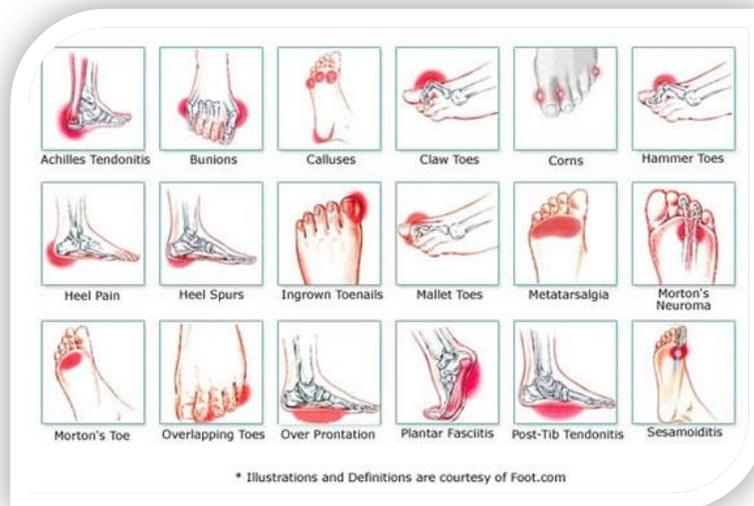

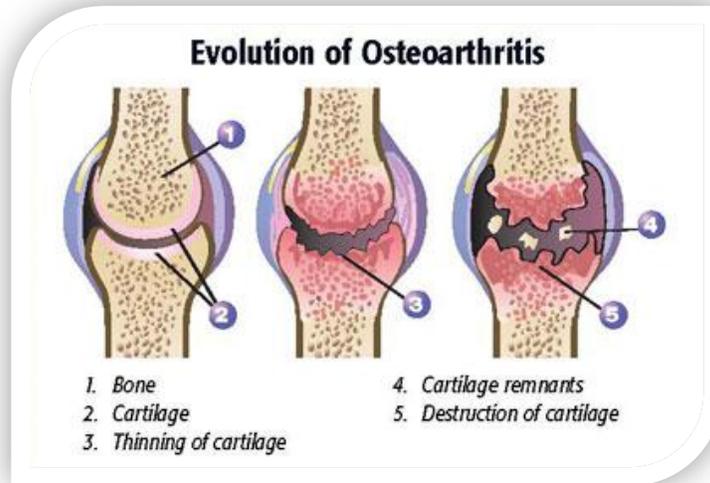**Figure 12:** Osteoarthritis (OA) at foot joints [24]

Figure 13: Degenerative Joint at joint between two bones [25]
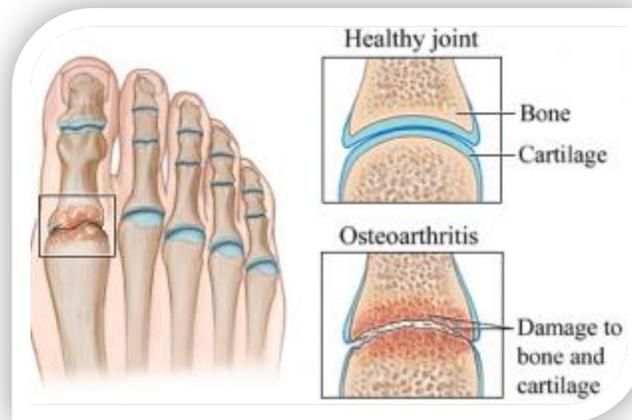
Figure 14: Health joint and Osteoarthritis at joint [26]

6. DECISION TREE FOR THE KBS ANKLE ILLNESSES DIAGNOSIS:

Decision tree is a decision support tool illustrate graph as tree its branches contain every possibility, resource, cost or event related to the subject [13].

Our decision tree, as you can see at Figure3 based its branches on expected symptoms as Yes/No questions. The end-user (patent) answers the first question (the root of the tree), which will transfer him to another question (from the leaves question at the branches of the tree), and continue this operation until get complete information about his status, then shows the result. The result contents are the diagnosis of the symptoms and self-caring as a quick treatment or urgent message to go to the doctor when the state is danger.
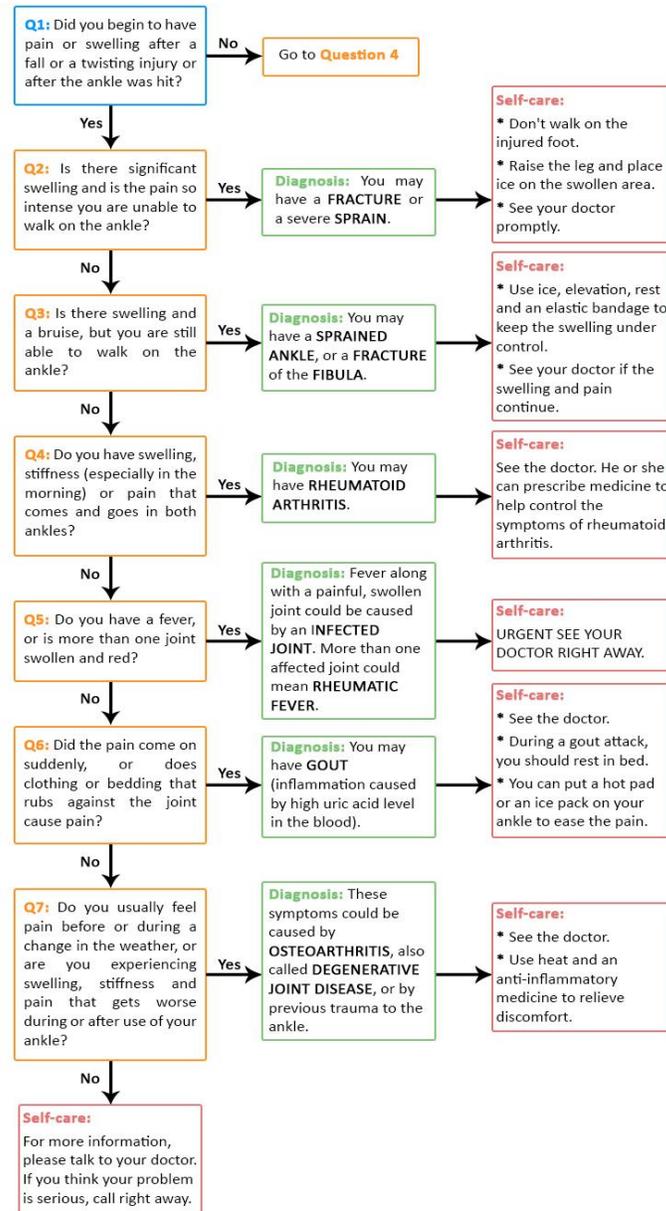
Figure 15: Decision Tree to diagnose ankle diseases by Sabreen Qwaider.

7. SYSTEM EVALUATION:

At this preliminary evaluation, my brother Eng. Mohammed Qwaider as Technology Expert, and patients have bruises or trauma at the ankle, have tested this Knowledge based system. They have felt familiar and comfortable with its interfaces, easy usage and simplicity of information.

8. CONCLUSION:

This paper demonstrates simply a new expert system to diagnose ankle disease easily by presenting screens to help end user. This knowledge-based system was developed using SL5 Expert System Language, will help both Podiatric physician and end user who do not know much about the diseases but have a serious urgent case to do Band Aid.

The system currently covers the following seven illnesses for ankle pain: Ankle Fracture, Fracture of fibula, Ankle Sprain, Rheumatoid Arthritis, Rheumatic Fever, Gout, and Osteoarthritis.

9. FUTURE WORK:

This application is expected to be more intuitive and useful as part of an integrated expert system that contains a diagnosis of whole the anticipated problems in the body parts from head to foot.

10. EXPERT SYSTEM SOURCE CODE:

```
! A Knowledge Based System for Ankle Diagnosis
! Written By: Sabreen R. Qwaider
! Supervised By: Samy Abu Naser


ATTRIBUTE Did you begin to have pain or swelling after a twisting or hit on the ankle COMPOUND Yes, No
ATTRIBUTE Is there significant swelling and the pain so intense you are unable to walk COMPOUND Yes, No
ATTRIBUTE Is there swelling and a bruise but you are still able to walk on the ankle COMPOUND Yes, No
ATTRIBUTE Do you have swelling or stiffness or pain that comes and goes in both ankles COMPOUND Yes, No
ATTRIBUTE Do you have a fever or is more than one joint swollen and red COMPOUND Yes, No
ATTRIBUTE Did the pain come on suddenly or through rub bedding with joint COMPOUND Yes, No
ATTRIBUTE Do you feel pain or suffer swelling during a change in the weather or using the ankle COMPOUND Yes, No
ATTRIBUTE start SIMPLE

INSTANCE the domain ISA domain
  WITH start := TRUE

INSTANCE the application ISA application
 WITH title display := introduction
 WITH conclusion display :=  Conc
 WITH compound query text := "
 *
of
 *"
INSTANCE introduction ISA display
  WITH wait := TRUE
  WITH delay changes := FALSE
  WITH items [1 ] := textbox 1

INSTANCE textbox 1 ISA textbox
  WITH location := 10,10,800,350
  WITH pen color := 255,255,255
  WITH fill color := 000,000,255
  WITH justify IS left
  WITH font := "Arial"
  WITH font style IS bold
  WITH font size := 14
  WITH text :="
                  Ankle Illness Diagnosis Expert System
                   - Written By: Sabreen R. Qwaider -
                  - Supervised By: Prof. Samy S. Abu Naser -


This Expert system is a practical application of Simpler Level 5 Object (SL5 Object)
that demonstrate the use of some of the system classes, instances, rules, etc.
This Knowledge-based system diagnoses Ankle Diseases through a dialogue
between the System and End-User.
The Conclusion of the finding is displayed and a recommend is given for the End
User to diagnosis the Diseases. "
```

```
INSTANCE Conc ISA display
  WITH wait := TRUE
  WITH delay changes := FALSE
  WITH items [1] := title textbox
  WITH items [2 ] := diagnosis textbox
  WITH items [3 ] := recommend textbox

INSTANCE title textbox ISA textbox
  WITH location := 20,10,800,70
  WITH pen color := 255,255,255
  WITH fill color := 255,000,000
  WITH justify IS center
  WITH font := "Arial"
  WITH font style IS bold
  WITH font size := 14
  WITH text := " The Conclusion of the Ankle Diagnosis Expert System "

INSTANCE diagnosis textbox ISA textbox
  WITH location := 20,110,800,130
  WITH pen color := 0,0,0
  WITH fill color := 255,255,255
  WITH justify IS left
  WITH font := "Arial"
WITH font style IS bold
  WITH font size := 12
  WITH text :=" --===--"

INSTANCE recommend textbox ISA textbox
  WITH location := 20,280,800,130
  WITH pen color := 0,0,0
  WITH fill color := 255,255,255
  WITH justify IS left
  WITH font := "Arial"
  WITH font style IS bold
  WITH font size := 12
  WITH text :=" --===--"

RULE R0
IF start
THEN ASK Did you begin to have pain or swelling after a twisting or hit on the ankle

RULE R1
IF Did you begin to have pain or swelling after a twisting or hit on the ankle IS Yes
THEN ASK Is there significant swelling and the pain so intense you are unable to walk

RULE R1a
IF Did you begin to have pain or swelling after a twisting or hit on the ankle IS No
THEN ASK Do you have swelling or stiffness or pain that comes and goes in both ankles

RULE R2
IF Is there significant swelling and the pain so intense you are unable to walk IS Yes
THEN text OF diagnosis textbox := " You may have a FRACTURE or a severe SPRAIN. "
AND text OF recommend textbox := "
- Don't walk on the injured foot.
- Raise the leg and place ice on the swollen area.
- See your doctor promptly. "
```

RULE R2a
IF Is there significant swelling and the pain so intense you are unable to walk IS No
THEN ASK Is there swelling and a bruise but you are still able to walk on the ankle

RULE R3
IF Is there swelling and a bruise but you are still able to walk on the ankle IS Yes
THEN text OF diagnosis textbox := " You may have a SPRAINED ANKLE or a FRACTURE of the FIBULA. "
AND text OF recommend textbox := "
- Use ice, elevation, rest and an elastic bandage to keep the swelling under control.
- See your doctor if the swelling and pain continue. "

RULE R3a
IF Is there swelling and a bruise but you are still able to walk on the ankle IS No
THEN ASK Do you have swelling or stiffness or pain that comes and goes in both ankles

RULE R4
IF Do you have swelling or stiffness or pain that comes and goes in both ankles IS Yes
THEN text OF diagnosis textbox := " You may have RHEUMATOID ARTHRITIS. "
AND text OF recommend textbox := "
- See your doctor.
- He or she can prescribe medicine to help control the symptoms of rheumatoid arthritis. "

RULE R4a
IF Do you have swelling or stiffness or pain that comes and goes in both ankles IS No
THEN ASK Do you have a fever or is more than one joint swollen and red

RULE R5
IF Do you have a fever or is more than one joint swollen and red IS Yes
THEN text OF diagnosis textbox := "
- Fever along with a painful, swollen joint could be caused by an INFECTED JOINT.
- More than one affected joint could mean RHEUMATIC FEVER. "
AND text OF recommend textbox := "
URGENT
SEE YOUR DOCTOR RIGHT AWAY. "

RULE R5a
IF Do you have a fever or is more than one joint swollen and red IS No
THEN ASK Did the pain come on suddenly or through rub bedding with joint

RULE R6
IF Did the pain come on suddenly or through rub bedding with joint IS Yes
THEN text OF diagnosis textbox := "
You may have GOUT
(inflammation caused by high uric acid level in the blood). "
AND text OF recommend textbox := "
- See your doctor.
- During a gout attack, you should rest in bed.
- You can put a hot pad or an ice pack on your ankle to ease the pain. "

RULE R6a
IF Did the pain come on suddenly or through rub bedding with joint IS No
THEN ASK Do you feel pain or suffer swelling during a change in the weather or using the ankle

RULE R7
IF Do you feel pain or suffer swelling during a change in the weather or using the ankle IS Yes

THEN text OF diagnosis textbox := "
These symptoms could be caused by OSTEOARTHRITIS,
also called DEGENERATIVE JOINT DISEASE,
or by previous trauma to the ankle. "
AND text OF recommend textbox := "
- Use heat and an anti-inflammatory medicine to relieve discomfort.
- See your doctor. "
RULE R7a
IF Do you feel pain or suffer swelling during a change in the weather or using the ankle IS No
THEN text OF diagnosis textbox := " For more information, please talk to your doctor. "
AND text OF recommend textbox := " If you think your problem is serious, call right away. "
END

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