

# An Expert System for Ankle Problems

Basel Y. Elhabil and Samy S. Abu-Naser

Faculty of Engineering & Information Technology,  
Department of Information Technology  
Al-Azhar University, Gaza, Palestine

**Abstract**— Anatomy of the anterior compartment includes the tibia and the fibula. It also includes the tibialis anterior tendon, the extensor hallucis longus tendon and the extensor digitorum longus tendons. The anterior tibial artery and the deep peroneal nerve and finally the superior and inferior extensor retinaculum. In this paper an expert system was designed to help users to correctly diagnose ankle problems. There are many structures present at the anterior aspect of the ankle; these structures are often susceptible to injury common injuries and conditions around the anterior ankle. Clips expert system language was used to design and implement this expert system.

**Keywords**— Artificial Intelligence; Expert Systems; Ankle problems; anterior compartment

## I. INTRODUCTION

The first condition is enter lateral and pinched 'men painful limitation a full range of ankle motion due to soft tissue or osseous pathology soft tissue thickening commonly seen in athletes with prior trauma that extends into the ankle joint. This type of impingement may also be bony tibial bone spur. Impinging on the tailless can become a source of chronic ankle pain and limitation of ankle motion and athletes an osseous or bony spur on the anterior lip of the tibia contacting the talus during dorsiflexion. The second condition is arthritis of the ankle joint commonly the result of a prior injury or inflammation to the ankle joint. It can usually be diagnosed with an examination and x-ray. The third condition is osteochondritis dissecans of the tailless chip type fracture that usually occurs with severe ankle sprains and causes pain swelling and stiffness of the ankle joint. X-rays CT scan or MRI are commonly used for diagnosis. The final condition is tibialis anterior tendonitis. This is an overused condition common in runners and it usually accompanies anterior shin splints if this tendon is strained pain and tenderness will be felt upon active dorsiflexion or when the tendon is touched.

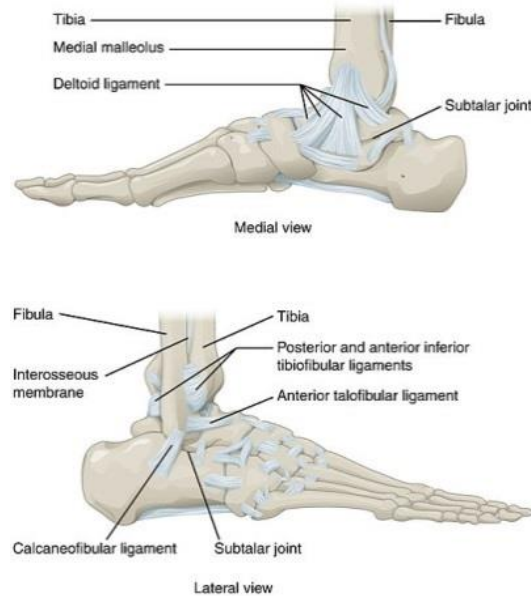


Fig. 1 Ankle joint

## II. EXPERT SYSTEM LANGUAGE

Expert system is a computer system that emulates the decision-making ability of a human expert. Expert systems are designed to solve complex problems by reasoning through bodies of knowledge represented mainly as if-then rules the typical expert system consists of

1. Interface is the system that allows a non-expert user to query or question the expert system and to receive advice the user interface is designed to be a simple to use as possible on the other hand the inference engine may also include abilities for

explanation so that it can explain to a user the chain of reasoning used to arrive at a particular conclusion by tracing back over the firing of rules that resulted.

2. Knowledge base: knowledge base, which is a collection of facts created from information provided by human experts. It is a database designed in a way to allow the storage and retrieval requirements of the expert systems next rules base. It is a set of rules for making deductions from the data this is made up of a series of inference rules represented mainly as if-then rules this inference rules which closely follow human reasoning are used by the inference engine to draw conclusions.

3. An inference engine which acts like the search engine that applies inference rules in examining the knowledge base for information that meshes the users query it attends to drive answers from the knowledgebase using a form of reasoning.

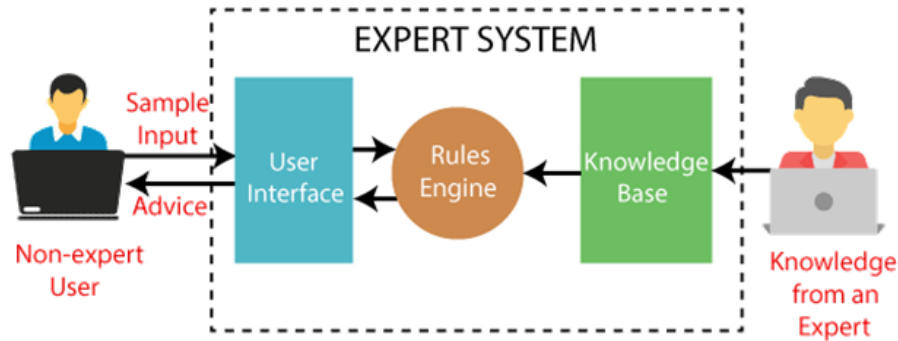
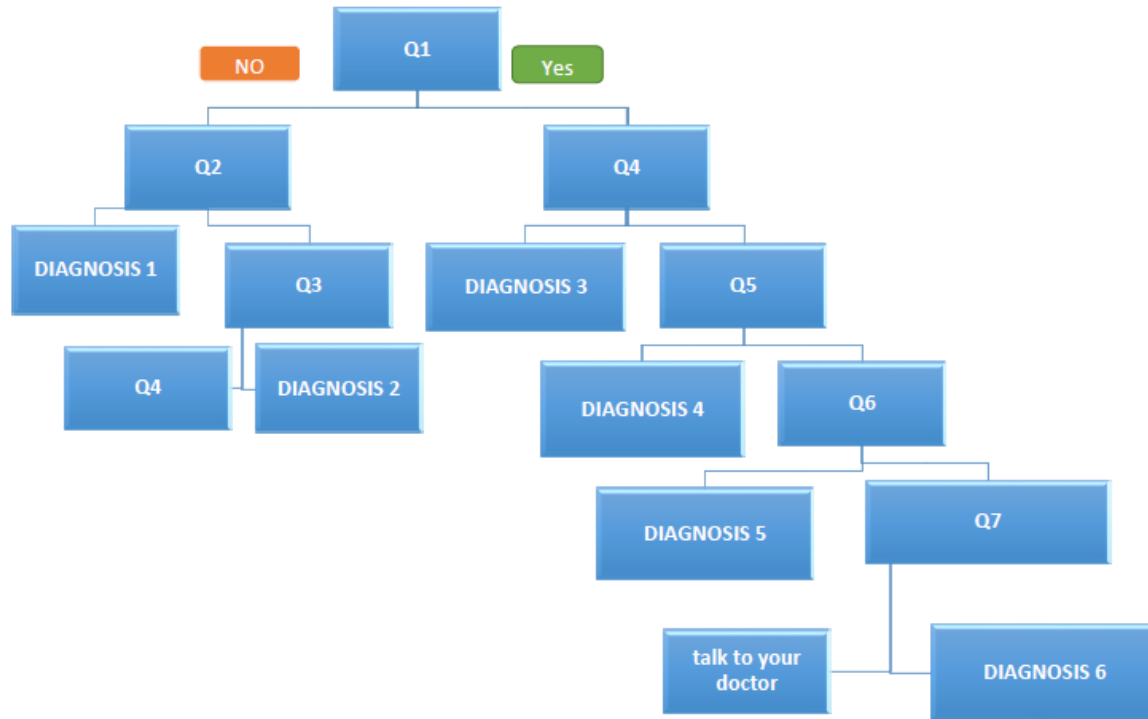


Fig. 2: Components of an expert system

The proposed Expert System for Ankle problems diagnosis was designed and implemented using, Clips expert system language.

### III. MATERIALS AND METHODS

The proposed expert system will ask the user to answer the questions about the symptoms of the patient and end up with the diagnosis; accordingly, the expert system shows the user some information about the disease and some recommendation telling the Patient how to deal with the baby. Figure 3 shows the decision tree of the expert system for diagnosing the ankle problems.



**Fig. 3:** Decision tree of the expert system.

- Q1 Did you begin to have pain and/or swelling after the ankle was hit or after a fall or a twisting injury?  
 Q2 Is the ankle significantly swollen, and is the pain so intense that you can't put weight on that foot?  
 Q3 Is the ankle swollen and bruised, and can you still put weight on that foot?  
 Q4 Do you have swelling, stiffness (especially in the morning), and/or pain that comes and goes in both ankles?  
 Q5 Do you have a fever, and is one or more of your joints painful, swollen, and red?  
 Q6 Did the pain start suddenly, and is it painful when clothing or bedding rubs against your ankle?  
 Q7 Do you usually feel pain before or during a change in the weather, and/or are you experiencing swelling, stiffness, and pain that gets worse during or after you use your ankle?

DIAGNOSIS 1: You may have a FRACTURE or a severe SPRAIN.

SELF CARE: See your doctor promptly. Don't put weight on the injured ankle. Raise the ankle above your heart while sitting or lying down. Use a compression wrap to help control swelling. Place an ice pack wrapped in a thin, damp cloth on the swollen area. You can also consider using a soft compression brace and crutches.  
 "

DIAGNOSIS 2: You may have a SPRAINED ANKLE or a FRACTURE OF THE FIBULA.

SELF CARE: Raise the ankle above your heart while sitting or lying down. Use a compression wrap to help control swelling. Place an ice pack wrapped in a thin, damp cloth on the swollen area. You can also consider using a soft compression brace and crutches. See your doctor if the swelling and pain continue."

DIAGNOSIS 3: You may have RHEUMATOID ARTHRITIS or OSTEOARTHRITIS (also called DEGENERATIVE JOINT DISEASE).

SELF CARE: See your doctor. He or she can treat the symptoms of rheumatoid arthritis or osteoarthritis with a combination of therapies."

DIAGNOSIS 4: Fever and a painful, red, swollen joint may be caused by an INFECTED JOINT (also called SEPTIC ARTHRITIS). More than one affected joint may be caused by RHEUMATIC FEVER.

SELF CARE: URGENT SEE YOUR DOCTOR RIGHT AWAY."

DIAGNOSIS 5: You may have GOUT (swelling and pain caused by too much uric acid in your body).

SELF CARE: See your doctor. During a gout attack (also called a flare), rest in bed until the pain eases up. Apply an ice pack wrapped in a thin, damp cloth to your ankle. Drink extra water to help flush uric acid from your body. Avoid alcohol and high-fat foods. They can trigger gout attacks."

DIAGNOSIS 6: These symptoms may be caused by OSTEOARTHRITIS (also called DEGENERATIVE JOINT DISEASE). Previous surgery or trauma to the ankle can also cause these symptoms.

SELF CARE: See your doctor. If you have osteoarthritis, he or she can treat your symptoms with a combination of therapies. Relieve your symptoms by applying a heating pad or an ice pack wrapped in a thin, damp cloth to your ankle. Use nonsteroidal anti-inflammatory drugs (NSAIDs) to ease the pain.

#### IV. BACKGROUND

Anatomy of the medial ankle includes the tibia, the tibialis posterior tendon, the flexor digitorum longus tendon and the flexor pollicis longus tendon. Here you can see the posterior tibial artery and nerve and its calcaneal branches as well as the flexor retinaculum the Achilles tendon and the bursa. There are many structures present at the medial aspect of the ankle. These structures are often susceptible to injury common injuries and conditions around the medial ankle:

The first condition is posterior tibial tendinitis or rupture posterior tibial tendon problems can occur from overuse activities degeneration or trauma. The posterior tibial tendon is one of the major supporting structures of the foot the tendon helps to keep the arch of the foot in its normal position. When there's insufficiency or rupture of the tendon, the arch begins to sag and a flat foot deformity can occur with associated tight Achilles tendon. Your tibial tendon rupture occurs distal to the medial malleolus. This area is hypo vascular clinical presentation painful swelling on the poster medial aspect of the ankle; unable to perform a single leg toe raise, too many toes flat foot and fixed deformity of the hind foot. There are four stages of posterior tibial tendon rupture in rupture of the posterior tibial tendon could be missed.

The second condition is tarsal tunnel syndrome. Tarsal tunnel syndrome is compression of the tibial nerve in the tarsal tunnel; the flexor retinaculum covers the nerve. Tarsal tunnel syndrome is similar to compression of the median nerve in the carpal tunnel causes include ganglia accessory muscles or soft tissue mass. Differential diagnosis may include a herniated disc stress fracture or plantar fasciitis. Clinical findings of tarsal tunnel syndrome include pain on the medial side of the foot and pain is worse with dorsiflexion due to tension of the nerve parathesia and numbness of the foot positive tunnel sign behind the medial malleolus and EMG usually not helpful.

The third condition is flexor pollicis tendonitis which is pain swelling and weakness posterior to the medial malleolus dorsiflexion of the big toe may be reduced when the ankle is placed in dorsiflexion triggering and pain along the tendon sheath may also occur with toe flexion. This often occurs in activities such as ballet dancing in which plantar flexion is necessary. The final condition is rupture of the deltoid ligament. The deltoid ligaments are the primary stabilizers of the ankle joint and provide support to prevent the ankle from averting. An isolated version sprain with tear of the deltoid ligaments is a rare injury. The tibia, the fibula, the talus, the calcaneus (Achilles) tendon, sural nerve, small saphenous vein, the tibial nerve and the posterior tibial artery and vein followed by the flexor hallucis longus tendon and the retro calcaneal Bursa. There are many structures present at the posterior aspect of the ankle. These structures are often susceptible to injury; common injuries and conditions around the posterior ankle:

- ✚ The first type is posterior ankle and pigment Oz trigonal posterior talor and pin Djimon of the Austral gonna or large process of the talus; non-united piece of accessory bone seen posterior to the talus. This condition is common among athletes such as ballet dancers. Posterior ankle and pigment is associated with tenderness and the post a lateral aspect of the ankle posterior to the peroneal tendon especially with passive plantar flexion. It may also be seen in association with flexor hallucis longus tenosynovitis.
  
- ✚ The second type is flexor pollicis longus tenosynovitis. This condition is associated with ballet dancing in which extreme plantar flexion is necessary. There may also be swelling and pain posterior to the medial malleolus. There is also triggering with toe flexion dorsiflexion of the big toe is last when the ankle is dorsiflexed. However, there is a risk of infection skin and wound complications with surgery. The bony structures of the ankle consist the tibia, fibula, the talus and the calcaneus ligaments of the ankle include the syndesmosis

anterior tibia, fibula ligament and the posterior tibial fibula ligament. Ligaments around the ankle include the anterior talofibular ligament, a calcaneofibular ligament and the posterior talofibular ligament. Here you can see the peroneal tendons which run behind the fibula within the lateral compartment of the ankle. The peroneus brevis tendon, the peroneus longus tendon, and the Achilles tendon air2 bursae located near the insertion of the Achilles tendon into the calcaneus. The superior and inferior retinaculum are two bands would support the tendons of the peroneus longus and brevis muscles and finally the sural nerve passes along the lateral ankle.

- ✚ The third type is peroneal tendon subluxation. The shape of the retromalleolar groove also plays a significant role in maintaining tendon stability and varies between individuals.
- ✚ The fourth type is a rupture peroneus longus tendon. Here you can see the austere Neum is displaced proximally. The fifth type is perineal tendinitis. The sixth pipe is fractured to the anterior process of the calcaneus vii type is fracture to the lateral process of the tailless and the last type is achilles tendonitis.

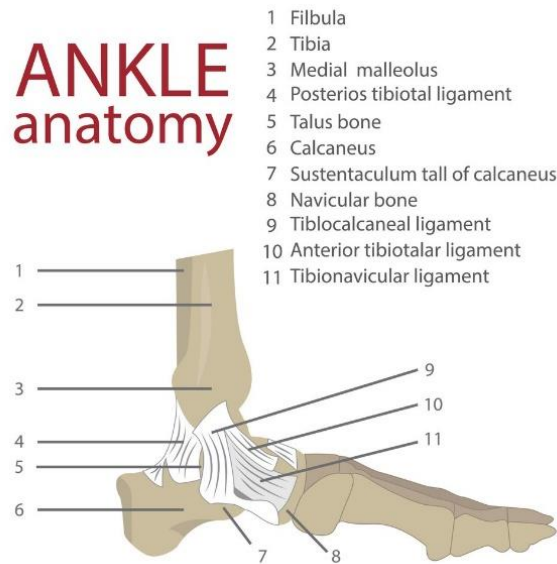


Fig 4: Ankle Anatomy

These bones include:

- ☒ The tibia (main lower leg bone)
- ☒ The fibula (smaller lower leg bone)
- ☒ The talus (top of the ankle joint).

Broken or Fractured Ankle Symptoms

- ☒ Pain (sharp in nature)
- ☒ Swelling
- ☒ Difficulty walking or weight bearing
- ☒ Bruising or discoloration
- ☒ Obvious deformities of the bones
- ☒ You hear a popping noise
- ☒ Examination by a Physician

A sprained ankle involves stretching or tearing one or more of the ligaments surrounding the ankle joint. The ligaments of the ankle attach bone to bone and provide stability. The severity of the sprain will lead to different treatment paths.

- ☒ Ankle Sprain Symptoms
- ☒ Swelling

- Pain (sharp in nature)
- Discoloration
- May appear deformed because of swelling
- Walking or weight bearing will be difficult

## V. CONCLUSION

In this paper, a proposed expert system was designed and developed using clips expert systems language in order to help physicians and parents in diagnosing the ankle problems in an easier and more precise way than before. This expert system is simple, fast and easy to use.

## VI. FUTURE WORK

The expert systems will be used with electronic medical record systems and this allows for automated updates to be made to the patient's files, so that it's very clear and smooth about what the patient is there for and what their patient history has been without all the paperwork that will be required to go through. If it wasn't all an electron medical record system and this way the system can send out warnings on a patient and this would be based on the patient's past treatment medical history. This is basically all to try to keep the patient as safe as you can possibly keep them why should medical expert systems be you and this is because they have been proven to increase the quality of care delivered by medical personnel.

## VII. EXPERT SYSTEM IN CLIPS LANGUAGE:

```
;;;=====
;;; Health Expert System
;;; Done By Basel Habil for Pro.Dr.Samy Abu-Nasser
;;; This expert system diagnoses
;;; ankle-problems
;;;
;;; https://familydoctor.org/your-health-resources/health-tools/symptom-checker/
;;;
;;; To execute: load, reset then run.
;;;=====
```

```
;;*****
;;* DEFFUNCTIONS *
;;*****
```

```
(deffunction ask-question (?question $?allowed-values)
  (printout t ?question)
  (bind ?answer (read))
  (if (lexemep ?answer)
      then (bind ?answer (lowercase ?answer)))
  (while (not (member$ ?answer ?allowed-values)) do
    (printout t ?question)
    (bind ?answer (read))
    (if (lexemep ?answer)
        then (bind ?answer (lowercase ?answer))))
  ?answer)
```

```
(deffunction yes-or-no-p (?question)
  (bind ?response (ask-question ?question yes no y n))
  (if (or (eq ?response yes) (eq ?response y))
      then yes
      else no))
```

```
;;*****
;;* QUERY RULES *
;;*****
```

;;\*\*\*\*\*

```
(defrule determine-pain-state ""  
  (not (f1 ?))  
  (not (r1 ?))  
  (not (r2 ?))  
  =>  
  (assert (f1 (yes-or-no-p "Q1 Did you begin to have pain and/or swelling after the ankle was hit or after a fall or a twisting injury (yes/no)? "))))
```

```
(defrule determine-swelling-stiffness1 ""  
  (f1 no)  
  (not (r1 ?))  
  (not (r2 ?))  
  =>  
  (assert (f4 (yes-or-no-p "Q4 Do you have swelling, stiffness (especially in the morning), and/or pain that comes and goes in both ankles (yes/no)? "))))
```

```
(defrule determine-significantly-swollen ""  
  (f1 yes)  
  (not (r1 ?))  
  (not (r2 ?))  
  =>  
  (assert (f2 (yes-or-no-p "Q2 Is the ankle significantly swollen, and is the pain so intense that you can't put weight on that foot (yes/no)? "))))
```

```
(defrule determine-swollen-and-bruised ""  
  (f2 no)  
  (not (r1 ?))  
  (not (r2 ?))  
  =>  
  (assert (f3 (yes-or-no-p "Q3 Is the ankle swollen and bruised, and can you still put weight on that foot (yes/no)? "))))
```

```
(defrule determine-swelling-stiffness2 ""  
  (f3 no)  
  (not (r1 ?))  
  (not (r2 ?))  
  =>  
  (assert (f4 (yes-or-no-p "Q4 Do you have swelling, stiffness (especially in the morning), and/or pain that comes and goes in both ankles (yes/no)? "))))
```

```
(defrule fever ""  
  (f4 no)  
  (not (r1 ?))  
  (not (r2 ?))  
  =>  
  (assert (f5 (yes-or-no-p "Q5 Do you have a fever, and is one or more of your joints painful, swollen, and red (yes/no)? "))))
```

```
(defrule suddenly ""  
  (f5 no)  
  (not (r1 ?))  
  (not (r2 ?))  
  =>
```

(assert (f6 (yes-or-no-p "Q6 Did the pain start suddenly, and is it painful when clothing or bedding rubs against your ankle (yes/no)? "))))

(defrule usually-feel ""

(f6 no)

(not (r1 ?))

(not (r2 ?))

=>

(assert (f7 (yes-or-no-p "Q7 Do you usually feel pain before or during a change in the weather, and/or are you experiencing swelling, stiffness, and pain that gets worse during or after you use your ankle (yes/no)? "))))

...\*\*\*\*\*  
;;;  
;;\* DIAGNOSIS RULES \*  
...\*\*\*\*\*  
;;;

(defrule FRACTURE ""

(f2 yes)

(not (r1 ?))

(not (r2 ?))

=>

(assert (r1 "DIAGNOSIS: You may have a FRACTURE or a severe."))

(assert (r2 "SELF CARE See your doctor promptly. Don't put weight on the injured ankle. Raise the ankle above your heart while sitting or lying down. Use a compression wrap to help control swelling. Place an ice pack wrapped in a thin, damp cloth on the swollen area. You can also consider using a soft compression brace and crutches."))

(defrule SPRAINED ""

(f3 yes)

(not (r1 ?))

(not (r2 ?))

=>

(assert (r1 "DIAGNOSIS: You may have a SPRAINED ANKLE or a FRACTURE OF THE FIBULA."))

(assert (r2 "SELF CARE Raise the ankle above your heart while sitting or lying down. Use a compression wrap to help control swelling. Place an ice pack wrapped in a thin, damp cloth on the swollen area. You can also consider using a soft compression brace and crutches. See your doctor if the swelling and pain continue."))

(defrule RHEUMATOID ""

(f4 yes)

(not (r1 ?))

(not (r2 ?))

=>

(assert (r1 "DIAGNOSIS: You may have RHEUMATOID ARTHRITIS or OSTEOARTHRITIS (also called DEGENERATIVE JOINT DISEASE)."))

(assert (r2 "SELF CARE: See your doctor. He or she can treat the symptoms of rheumatoid arthritis or osteoarthritis with a combination of therapies."))

(defrule INFECTED ""

(f5 yes)

(not (r1 ?))

(not (r2 ?))

=>

(assert (r1 "DIAGNOSIS: Fever and a painful, red, swollen joint may be caused by an INFECTED JOINT (also called SEPTIC ARTHRITIS). More than one affected joint may be caused by RHEUMATIC FEVER."))

(assert (r2 "SELF CARE: URGENT SEE YOUR DOCTOR RIGHT AWAY."))

(defrule GOUT ""

(f6 yes)

(not (r1 ?))



```
(not (r2 ?))  
=>  
(assert (r1 "DIAGNOSIS: You may have GOUT (swelling and pain caused by too much uric acid in your body)."))  
(assert (r2 "SELF CARE: See your doctor. During a gout attack (also called a flare), rest in bed until the pain eases up.  
Apply an ice pack wrapped in a thin, damp cloth to your ankle. Drink extra water to help flush uric acid from your body.  
Avoid alcohol and high-fat foods. They can trigger gout attacks.")))
```

```
(defrule OSTEOARTHRITIS ""  
(f7 yes)  
(not (r1 ?))  
(not (r2 ?))  
=>  
(assert (r1 "DIAGNOSIS: These symptoms may be caused by OSTEOARTHRITIS (also called DEGENERATIVE  
JOINT DISEASE). Previous surgery or trauma to the ankle can also cause these symptoms."))  
(assert (r2 "SELF CARE: See your doctor. If you have osteoarthritis, he or she can treat your symptoms with a  
combination of therapies. Relieve your symptoms by applying a heating pad or an ice pack wrapped in a thin, damp cloth  
to your ankle. Use nonsteroidal anti-inflammatory drugs (NSAIDs) to ease the pain.")))
```

```
(defrule CARE ""  
(f7 No)  
(not (r1 ?))  
(not (r2 ?))  
=>  
(assert (r1 "DIAGNOSIS: Unknown"))  
(assert (r2 "SELF CARE For more information, please talk to your doctor. If you think your problem is serious, call  
right away.")))
```

```
;;*****  
;;* STARTUP AND CONCLUSION RULES *  
;;*****
```

```
(defrule system-banner ""  
(declare (salience 10))  
=>  
(printout t crlf crlf)  
(printout t "The Ankle Problems Expert System")  
(printout t crlf crlf)  
(printout t "Done By Basel Habil for Pro.Dr.Samy Abu-Nasser")  
(printout t crlf crlf))
```

```
(defrule print-r""  
(declare (salience 10))  
(r1 ?item1)  
(r2 ?item2)  
=>  
(printout t crlf crlf)  
(printout t "Suggested:")  
(printout t crlf crlf)  
(format t " %s%n%n%n" ?item1)  
  
(printout t "Suggested:")  
(printout t crlf crlf)  
(format t " %s%n%n%n" ?item2))
```

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