International Journal of Academic Information Systems Research (IJAISR)
ISSN: 2643-9026
Vol. 5 Issue 4, April - 2021, Pages: 59-66

An Expert System for Knee Problems Diagnosis

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***Abstract**: In fact, people get knee problems due to something such as sports, or fall. They usually have difficulty moving to the doctor. In this paper an expert system was designed to help users to correctly diagnose knee problems (Fractured in knee, torn ligament, Bursitis, Chondromalacia patellae, Torn cartilage, Rheumatoid arthritis and Rheumatic fever, Osteoarthritis, Baker's cyst, Osgood-Schlatter disease) with some information about the disease and self-care. CLIPS expert system language was used to design and implement this expert system.*

Keywords: Expert Systems, CLIPS, Knee Problems, Medical expert system

I. Introduction:

The knee is a modified hinge joint, which permits flexion and extension as well as slight internal and external rotation, the largest joint in the human body. The knee is vulnerable to injury and to the development of osteoarthritis. It is often termed a compound joint having tibiofemoral and patellofemoral components. (The fibular collateral ligament is often considered with tibiofemoral components.) [1]

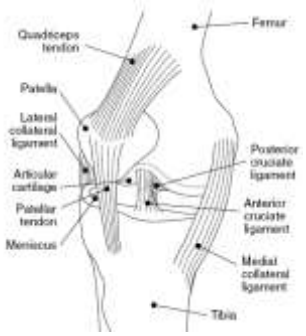

Figure 1 knee

II. Expert System

The Expert Systems (ES) are the computer applications developed to solve complex problems in a particular domain, at the level of extra-ordinary human intelligence and expertise, See figure 2 for details [2].

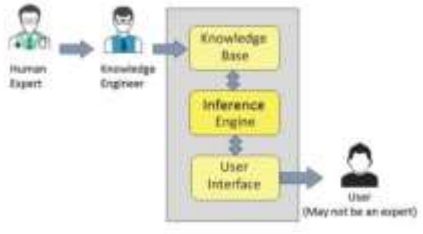

Figure 2 Main of ES Components

Knowledge Base

Contains facts, rules, and objects in domain-specific and high-quality knowledge. Knowledge is required to exhibit intelligence. The success of any ES majorly depends upon the collection of highly accurate and precise knowledge. Obtained from the human expert is prepared by acknowledge engineer as most human experts are not skilled at computer programming.

Inference Engine

Software that matches the users input with data contained in the knowledge base, the Inference Engine acquires and manipulates the knowledge from the knowledge base to arrive at a particular solution, adds new knowledge into the knowledge base if required. Resolves rules conflict when multiple rules are applicable to a particular case [3].

User Interface

Show questions to the user and accepts inputs from them; the user of the ES need not be necessarily an expert in Artificial Intelligence.

The propped Expert System for diagnosis knee problem, was designed and implemented using CLIPS.

III. Methods

After running the expert system, user will be answering the questions to answer yes or no only, so the system can then compare the answers with the facts and laws stored in Knowledge Base and give the user the correct Diagnosis and Self Care, Figure 3 shows the decision tree of the expert system for diagnosing the knee problems.

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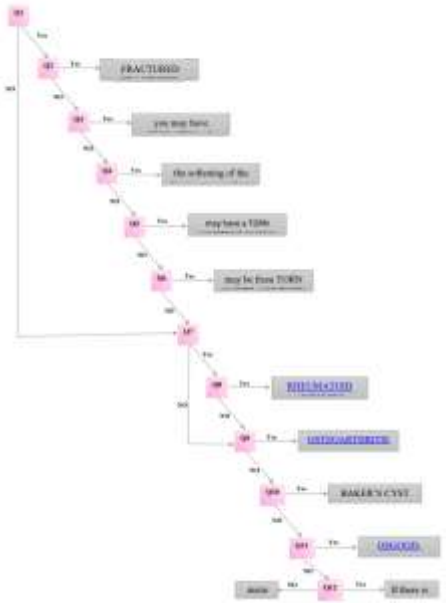

Figure 3 Decision tree of the expert system for diagnosing knee problems.

IV. BACKGROUND

Many expert systems have been designed[8-28] to help facilitating diagnosing and managing a lot of diseases and medical problems which considered as a part of applying Artificial Intelligence and computer science in order to help doctors, hospitals and health care facilities decision making to enable them to offer their health services in the right way. Some of them are listed below.

An Expert System for teeth and gums[8], Rickets Expert System Diagnoses and Treatment[9], Knowledge management in ESMDA: Expert System for medical diagnostic assistance [11], Kidney Expert System Diseases and Symptoms [12], An Expert System for Depression Diagnosis [14], Knowledge based System for Diabetes Diagnosis Using SL5 Object [17], Polymyalgia Rheumatic Expert System [18], Silicosis Expert System Diagnosis and Treatment [19[,endocrine diagnosis and treatments using JESS [20], Expert System for Arthritis Diseases Diagnosis Using SL5 Object[21], Hepatitis Expert System Diagnosis Using Sl5 Object[22], Seventh Nerve Inflammation (Bell's palsy) Disease[26], Long-term Abdominal Pain (Stomach Pain)[27], Hair Loss Diagnosis and Treatment[28].

Our expert system here is offering an easy way, helping people to know how to diagnose and deal with knee problems. We give a description and Diagnosis for 10 Problems of knee afflicting people around the world (Fractured in knee, torn ligament, Bursitis, Chondromalacia patellae, Torn cartilage, Rheumatoid arthritis and Rheumatic fever, Osteoarthritis, Baker's cyst, Osgood-Schlatter disease) [5].

- **Fractured in knee.**

The knee is the meeting place for four leg bones: the kneecap (patella), the thighbone (femur), the shinbone (tibia) and the calf bone (fibula). Damage to any of these bones can result in a fracture. Doctors categorize fractures in several different ways. In a non-displaced fracture, the broken pieces remain in contact with each other, or just a fraction apart, leaving most of the bone intact and in its correct position. In a displaced fracture, the pieces break and are no longer properly aligned. A comminuted fracture is where the bone breaks into many pieces. Open or closed fractures denote whether the bone has broken through the surface of the skin (open) or not (closed) [6] .

Figure 4 Fractured in knee.

- **Torn ligament**

When ligaments are damaged, the knee joint may become unstable. Ligament damage often happens from a sports injury. A torn ligament severely limits knee movement. This results in the inability to pivot, turn, or twist the leg. Surgery is a choice to repair a torn ligament if other medical treatment is not effective[7].

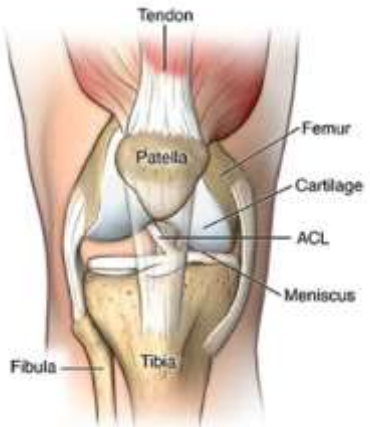

Figure 5 Torn ligament

- **Bursitis**

Knee bursitis is inflammation of a small fluid-filled sac (bursa) situated near your knee joint. Bursae reduce friction and cushion pressure points between your bones and the tendons, muscles, and skin near your joints. Any of the bursa in your knee can become inflamed, but knee bursitis most

commonly occurs over the kneecap or on the inner side of your knee below the joint. Knee bursitis causes pain and can limit your mobility. Treatment for knee bursitis often includes a combination of self-care practices and doctor-administered treatments to alleviate pain and inflammation [6].

Figure 6 Bursitis

- **Chondromalacia Patella**

Chondromalacia patella (knee pain) is the softening and breakdown of the tissue (cartilage) on the underside of the kneecap (patella). Pain results when the knee and the thigh bone (femur) rub together.

Figure 7 chondromalacia patella

- **Torn cartilage**

Torn meniscus is one of the most common knee injuries. Any activity that causes you to forcefully twist or rotate your knee, especially when putting your full weight on it, can lead to a torn meniscus. Each of your knees has two C-shaped pieces of cartilage that act like a cushion between your shinbone and your thighbone (menisci). A torn meniscus causes pain, swelling and stiffness. You also might feel a block to knee motion and have trouble extending your knee fully. Conservative treatment — such as rest, ice and medication — is sometimes enough to relieve the pain of a torn meniscus and give the injury time to heal on its own. In other cases, however, a torn meniscus requires surgical repair.

Figure 8 Torn cartilage

- **Rheumatoid arthritis and Rheumatic fever**

Rheumatic fever is an inflammatory disease that can develop when strep throat or scarlet fever isn't properly treated. Strep throat and scarlet fever are caused by an infection with streptococcus (strep-toe-KOK-us) bacteria. Rheumatic fever most often affects children who are between 5 and 15 years old, though it can develop in younger children and adults. Rheumatic fever can cause permanent damage to the heart, including damaged heart valves and heart failure. Treatments can reduce damage from inflammation, lessen pain and other symptoms, and prevent the recurrence of rheumatic fever.

Figure 9 Rheumatoid arthritis and Rheumatic fever

- **Osteoarthritis, Baker's cyst**

The knee is filled with synovial fluid, which reduces friction between the bones of the knee joint while you move. Sometimes this fluid accumulates in the back of your knee. A Baker's cyst or popliteal cyst is a fluid-filled swelling that

develops behind the knee. This causes stiffness, tightness, and pain behind your knee. It is commonly seen in women and people aged over 40. A Baker's cyst may not cause any pain and may go unnoticed. You may, however, experience symptoms such as swelling behind your knee and leg, stiffness, and pain behind the knee towards the upper calf (especially when you bend your knee or straighten it completely). Pain can become severe when you flex your knee and when you are active. Sometimes the cyst can rupture, and the fluid can drain into the tissues of the lower leg, causing swelling and redness.

Figure 10 Osteoarthritis,Baker's cyst

- **Osgood-Schlatter disease**

Osgood-Schlatter disease is a condition that causes pain and swelling below the knee joint, where the patellar tendon attaches to the top of the shinbone (tibia), a spot called the tibial tuberosity. There may also be inflammation of the patellar tendon, which stretches over the kneecap. Osgood-Schlatter disease is most commonly found in young athletes who play sports that require a lot of jumping and/or running.

Figure 11 Osgood-Schlatter disease

V. Conclusions and future work

In this paper, a proposed expert system was designed and developed using CLIPS expert system language in order to help doctors, people and players to find out the cause of their knee problems, quickly and easily. This expert system is simple, fast and easy to use. We are planning to add more knee problems and creating a mobile app for diagnosing advanced knee problems to provide correct diagnosis and self-care.

VI. Expert System Source Code:

```
(deffunction ask-question (?question $?allowed-values)
   (printout t ?question)
   (bind ?answer (read))
   (if (lexemep ?answer)
      then (bind ?answer (lowcase ?answer)))
   (while (not (member ?answer ?allowed-values)) do
     (printout t ?question)
     (bind ?answer (read))
     (if (lexemep ?answer)
        then (bind ?answer (lowcase ?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 TRUE
      else FALSE))
(defrule system-banner ""
  (declare (salience 10))
  =>
  (printout t crlf crlf)
  (printout t "        The knee Expert System")
  (printout t crlf crlf))
(defrule print-diagnosis""
  (declare (salience 10))
  (diagnosis ?item1)
  (recommend ?item2)
  =>
  (printout t crlf crlf)
  (printout t " Diagnosis: "  ?item1)
  (printout t crlf crlf)
  (printout t " recommendation:"  ?item2)
  (printout t crlf crlf)
)
(defrule Q1 ""
(not (diagnosis ?))
(not (recommend ?))
(not (Q1 ?))
  =>
   (if (yes-or-no-p "Q1:Did your knee pain or swelling begin
after a fall, twisting injury, or after your knee was hit by an
object or person? ")
      then (assert (Q1 yes))
      else  (assert (Q1 no))
  )
)
(defrule Q2 ""
(not (diagnosis ?))
(not (recommend ?))
(not (Q2 ?))
(Q1 yes)
 =>
   (if (yes-or-no-p "Q2: Is your knee deformed? ")
```

```
      then (assert (Q2 yes))
      else  (assert (Q2 no))
   )
)
(defrule Q2yes ""
(not (diagnosis ?))
(not (recommend ?))
(Q1 yes)
(Q2 yes)
  =>
(assert (diagnosis  "Your knee may be FRACTURED and/or you may have seriously TORN some LIGAMENTS   (tissue connecting bones to each other) in the internal part of the knee."))
(assert (recommend "See your doctor or go to the emergency room right away."))
)


(defrule Q2no
(not (diagnosis ?))
(not (recommend ?))
(Q1 yes)
(Q2 no)
  =>
  (if  (yes-or-no-p  "Q3:Is your kneecap swollen, tender, and warm, and do you have pain with activity?")
      then (assert (Q3 yes))
      else  (assert (Q3 no))
)
)
(defrule Q3yes ""
(not (diagnosis ?))
(not (recommend ?))
(Q3 yes)
  =>
  (assert (diagnosis  "If you fell hard on your kneecap/patella it may be FRACTURED. Otherwise, it may be bruised or you may have PREPATELLAR BURSITIS, an irritation of a small lubricating sac (called bursa) in front of the kneecap."))
  (assert (recommend "See your doctor. Stretching and applying ice, as well as compression sleeves or wraps, may help with the discomfort and swelling."))
)

(defrule Q3no
(not (diagnosis ?))
(not (recommend ?))
(Q3 no)
  =>
  (if  (yes-or-no-p  "Q4:Is your knee tender and swollen, and does the pain get worse after sitting for a long time or after using the stairs?")
      then (assert (Q4 yes))
      else  (assert (Q4 no))
)
)
(defrule Q4yes ""
(not (diagnosis ?))
(not (recommend ?))
(Q4 yes)
  =>
  (assert (diagnosis  "Your symptoms may be from TORN CARTILAGE/MENISCUS, a TORN LIGAMENT (tissue connecting bones to each other), or CHONDROMALACIA PATELLAE, the softening of the ligament or cartilage underneath the kneecap"))
  (assert (recommend "See your doctor. Rest and anti-inflammatory medicine, as well as a compression sleeve or wrap, may help relieve the pain. Physical therapy, stretching, and strengthening exercises can also help."))
)
(defrule Q4no
(not (diagnosis ?))
(not (recommend ?))
(Q4 no)
  =>
  (if  (yes-or-no-p  "Q5:Do you have a sharp pain behind your knee and is it painful to extend (stretch out straight) your leg?")
      then (assert (Q5 yes))
      else  (assert (Q5 no))
)
)
(defrule Q5yes ""
(not (diagnosis ?))
(not (recommend ?))
(Q5 yes)
  =>
  (assert (diagnosis  "You may have a TORN HAMSTRING MUSCLE."))
  (assert (recommend "Apply ice to the area and use an anti-inflammatory medicine. You may also wrap your thigh with an elastic bandage or compression sleeve. Keep the injured leg elevated above the level of your heart. See your doctor if there's excessive swelling or pain, or the pain does not improve with simple rest."))
)
(defrule Q5no
(not (diagnosis ?))
(not (recommend ?))
(Q5 no)
  =>
  (if  (yes-or-no-p  "Q6:Do you still have a grinding feeling in your joint or does it ever lock (i.e., you can't flex or extend the joint or it is stuck in one of those positions), even after your knee pain is better?")
      then (assert (Q6 yes))
      else  (assert (Q6 no))
)
)
(defrule Q6yes ""
(not (diagnosis ?))
```

```
(not (recommend ?))
(Q6 yes)
  =>
  (assert (diagnosis  "This may be from TORN
CARTILAGE/TORN MENISCUS."))
  (assert (recommend "Use an anti-inflammatory medicine
and rest your knee. If you keep experiencing pain or if your
knee becomes swollen, see your doctor. Stretching and
strengthening exercises can also help with healing."))
)
(defrule Q6no-Q1no
(not (diagnosis ?))
(not (recommend ?))
(or (Q6 no)
     (Q1 no))
  =>
  (if  (yes-or-no-p  "Q7:: Is your knee swollen and/or red?")
     then (assert (Q7 yes))
     else  (assert (Q7 no))
)
)
(defrule Q7yes ""
(not (diagnosis ?))
(not (recommend ?))
(Q7 yes)
  =>
 (if  (yes-or-no-p  "Q8:Do you have a fever along with
swollen and/or red joints?")
     then (assert (Q8 yes))
     else  (assert (Q8 no))
))
(defrule Q7no
(not (diagnosis ?))
(not (recommend ?))
(Q7 no)
  =>
  (if  (yes-or-no-p  "Q9:Has your knee become tender over
many months or years and does the pain get worse when the
weather changes?")
     then (assert (Q9 yes))
     else  (assert (Q9 no))
))
(defrule Q8yes ""
(not (diagnosis ?))
(not (recommend ?))

(Q8 yes)
  =>
  (assert (diagnosis   "You may have RHEUMATOID
ARTHRITIS, but you may also have a more serious
problem, such as RHEUMATIC FEVER or a SEPTICE
JOINT INFECTION."))
  (assert (recommend "See your doctor as soon as possible.
Your doctor will be able to tell what's causing your
symptoms, and may refer you for or perform a joint
aspiration (removing fluid from your knee joint)."))
)
(defrule Q8no
(not (diagnosis ?))
(not (recommend ?))
(Q8 no)
  =>
  (if  (yes-or-no-p  "Q9:Has your knee become tender over
many months or years and does the pain get worse when the
weather changes?")
     then (assert (Q9 yes))
     else  (assert (Q9 no))
)
)
(defrule Q9yes ""
(not (diagnosis ?))
(not (recommend ?))
(Q9 yes)
  =>
  (assert (diagnosis  "Chronic pain and stiffness may be
caused by OSTEOARTHRITIS, which can develop over
time or can be the result of previous surgeries or trauma."))
  (assert (recommend "Try an anti-inflammatory medicine.
Applying heat to tender joints may also help relieve the pain.
Regular physical activity can also improve symptoms. If
your symptoms worsen or don't improve, see your doctor."))
)
(defrule Q9no
(not (diagnosis ?))
(not (recommend ?))
(Q9 no)
  =>
  (if  (yes-or-no-p  "Q10:Is the back of your knee swollen or
tender?")
     then (assert (Q10 yes))
     else  (assert (Q10 no))
)
)
(defrule Q10yes ""
(not (diagnosis ?))
(not (recommend ?))
(Q10 yes)
  =>
  (assert (diagnosis  "The swelling may be from a BAKER'S
CYST, which often occurs following a small tear of your
CARTILAGE/MENISCUS, or can result from
ARTHRITIS."))
  (assert (recommend "Try an anti-inflammatory medicine.
You can also use a compressive wrap, bandage, or sleeve.
Exercises for strengthening and stretching can also be
helpful. If your symptoms worsen or don't improve, see your
doctor"))
)
(defrule Q10no
(not (diagnosis ?))
(not (recommend ?))
(Q10 no)
  =>
```

```
 (if  (yes-or-no-p  "Q11:Are you between 12 and 18 years,
and do you have a pain on the front of your knee below your
kneecap that gets worse with activities like running or
jumping?")
     then (assert (Q11 yes))
     else  (assert (Q11 no))
)
)
(defrule q11yes ""
(not (diagnosis ?))
(not (recommend ?))
(Q11 yes)
 =>
 (assert (diagnosis  "You may have OSGOOD-
SCHLATTER DISEASE (also known as TIBIAL
APOPHYSITIS)."))
 (assert (recommend "Apply ice to the affected area and rest
your leg. You can also use a compressive wrap, bandage, or
sleeve. Exercises for strengthening and stretching can also
be helpful. See your doctor if your pain is severe or if the
swelling is excessive"))
)

(defrule Q11no
(not (diagnosis ?))
(not (recommend ?))
(Q11 no)
 =>
 (if  (yes-or-no-p  "Q12:Are you younger than 18 years, and
do you have knee pain?")
     then (assert (Q12 yes))
     else  (assert (Q12 no))
)
)
(defrule q12yes ""
(not (diagnosis ?))
(not (recommend ?))
(Q12 yes)
 =>
 (assert (diagnosis  "If there is no discernible issue at the
knee, you may have a hip problem that feels like knee
pain."))
 (assert (recommend "See your doctor."))
)
(defrule q12no ""
(not (diagnosis ?))
(not (recommend ?))
(Q12 no)
 =>
 (assert (diagnosis  "Unknown "))
 (assert (recommend "For more information, please talk to
your doctor. If you think your problem is serious, call your
doctor right away."))
)
```

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