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Knowledge Based System for Diagnosing Fractures and Treatment

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Abstract*: The bones are the structure of the body that enable us to stand up straight, place of attachment of muscles thus permitting the course of the blood vessels, where the bone marrow and nerve protect the soft tissues, and bone is likewise an organ that humans need to lift and move weighty goods. The bone is an organ that we need to do daily activities, thus we cannot envision how disturbance when there is a damage that happens to our bones. Due to the complications in diagnosing fractures, I propose to design and development of an expert system to diagnose broken bones in humans using CLIPS and Delphi languages. The knowledge is going to be collected from human experts that specializes Broken Bone. The collected knowledge of experts who specializes in health issues, particularly regarding diseases of the bones (in this case is an expert in fractures) can be represented into the computer in the form of a program that can be used by many users and can be used to resolve problems experienced independently without the presence of a human expert directly so that we can get the diagnosis and treatment accurately and easily. The expert system was evaluated by a group of medical students in Al-Azhar University in Gaza and fractures specialists in the Faculty of Medicine in Al-Azhar University, and the their relevant comments and recommendations were used in the final development stage of the expert system. The final system was tested by 30 patients who had fractures of various types, and the results were compared with the specialists' diagnosis. The results of both methods were consistent.*

Keywords: Artificial Intelligence, Expert System, Rule-Based System, bones, fractures, diagnosis, CLIPS and Delphi.

1. Introduction

During the late nineteen sixties, scientists agreed to make computer programs more intelligent and called this field of computer science Artificial Intelligence (AI). They developed techniques to be used in specialized programs to overcome the difficulty of making the entire program for general purpose. The AI scientists focused on how to formulate the problem? And searched how to find a solution?

In the nineteen seventies, scientists developed special-purpose computer programs in specialized domains as they realized that the problem-solving power of a program comes from the knowledge it possesses calling it Expert Systems (ES) or for more specific applications as Rule-Based System (RBS).

The field of AI involves the creation of computer systems which shows behavior that, when observed within humans, can be deemed to show intelligence. AI researchers try to uncover the underlying theory of intelligence, to create a "science of intelligence" [1].

According to Webster's Dictionary, intelligence is defined as: the available ability to use one's existing knowledge, meet new situations, solve new problems, learn, foresee problems, use symbols and relationships, create new relationships, and think abstractly [2].

This definition shows the key elements of intelligent behavior: the ability to represent knowledge and use it in problem solving.

Computers were originally designed as digital processors, but computer scientists explored the ability of computers to deal with non-digital symbols.

Psychologists and AI researchers are concerned with developing computer systems that produce results that simulate human behavior and that we would normally associate with human intelligence.

The first AI application that was successfully implemented was Chess game which represents one of the fundamental principles of AI "the concept of intelligent search".

The most widely studied issues in AI research include:

a. What information a program should have and how to store the information in the computer.
b. How further conclusions can be drawn from the initial information.

Mathematical logic provides many powerful methods for both the representation of knowledge and ways of reasoning. Logic studies the relationship of implication between assumptions and conclusions and gives formalization to a systematic way of reasoning. Additionally, mathematical models representing real-world reasoning using fuzzy logic make it possible to simulate the way humans are perceived to reach conclusions when confronted with incomplete or imprecise initial information.

The field of artificial intelligence can be categorized into several sub-areas:

a. Pattern Matching: includes systems which can recognize objects by comparison with stored patterns kept within a database.
b. Natural Language Processing: includes systems using a grammar syntax and a dictionary with a semantics interpreter to analyze the meaning of a sentence.
c. Robotics: includes machines designed to carry out exhausting or dangerous tasks which humans can't or don't desire to perform.
d. Expert Systems: include computer programs applied to simulate reasoning processes requiring expert knowledge and experience. The systems consist of a database of data and knowledge and a system that controls the application of this knowledge to analyze the data. Interaction between expert systems and existing large databases is currently a very active area of research.

Interaction between these sub-areas is common as any automated system trying to simulate human performance must be able to behave intelligently in more than one specific sub-area. For example, most robotic systems use pattern matching as a means of analyzing visual data [1].
Artificial intelligence is generally divided into three phases:

a. Artificial Narrow Intelligence (ANI): is partial in scope with intelligence limited to only one useful domain.
b. Artificial General Intelligence (AGI): is at an advanced level and it contains more than a single domain like cognitive power, problem-solving and mental thinking, which is mostly equivalence with humans.
c. Artificial Super Intelligence (ASI): is the last phase of the intelligence explosion, in which AI surpasses human intelligence in all domains.

The transition from the first to the second phase has taken a long period, and nowadays we are on the point of completing the transition to the second phase, in which the intelligence of machines equals humans. The transition from the second to the third phase is aimed at early 2050 [3].

In the domain of AI, an Expert System (ES) is a computer system with the ability to imitate or replicate the tasks of human's intelligence by making decisions exactly as a skilled human expert does.

Human experts can solve problems at a high level as they exploit information about their area of proficiency. This information provided the basic for the design of programs with rule-based problem-solving proficiencies. An expert system uses clear data about an area in order to gain competence as a human expert. The clear information may be gained by questioning one or more experts in the area. The area expert systems are sub-areas of artificial intelligence which has reached great success in many domains. Nowadays expert systems are used in various topic areas such as medicine, chemistry, geology, law, politics, economics, and control systems. Any area in which decisions are to be made is a potential application of expert systems [4].

Expert systems are developed to deal with and solve difficult problems by cognitive thinking about knowledge, expressed mainly as If-Then rules through predictable procedural code. AI programs that achieve competency at expert level in solving problems in some task areas by conveying to encompass a certain level of knowledge about specific tasks are termed expert systems, knowledge-based systems or rule- based systems.

The Expert systems are frequently allocated for a program whose knowledge base has the knowledge used by human experts, in comparison to the knowledge acquired by non-expert and textbooks. In an expert system, the task domain is the area which human intellectual attempt to understand. Task means some goal-oriented, problem-solving activity and Domain means the exact area in which the task is being accomplished [5].
The expert system includes various applications such as knowledge domain which is used to discover faults in vehicles. It is also applied in finance and commerce to discover any possible fraud, doubtful transactions, stock market trading, and airline scheduling. Another application is a design domain where the camera lens is designed. It is also used in monitoring systems to equate data continuously with the experimental system or with prescribed behavior such as monitoring the traffic congestion problem. An additional application is Medical Domain for diagnosis systems to reduce the cause of disease from experimental data and conduction medical operations on humans [6].
The word "break" is commonly used by normal people(non-professional).
Amongst doctors, especially bone specialists, such as orthopedic surgeons, "break" is a much less common term when talking about bones.
A crack (not only a break) in the bone is also known as a fracture. Fractures can occur in any bone in the human body [1].
There are several different ways in which a bone can fracture; for example, a break to the bone that does not damage surrounding tissue or tear through the skin is known as a closed fracture [2].
On the other hand, one that damages surrounding skin and penetrates the skin is known as a compound fracture or an open fracture. Compound fractures are generally more serious than simple fractures, because, by definition, they are infected.
Most human bones are surprisingly strong and can generally stand up to fairly strong impacts or forces. However, if that force is too powerful, or there is something wrong with the bone, it can fracture [1].

The older we get, the less force our bones can withstand. Because children's bones are more elastic, when they do have fractures they tend to be different. Children also have growth plates at the end of their bones - areas of growing bone - which may sometimes be damaged [3].

Fracture types include the followings [3]:

- **A closed fracture:** is when the bone breaks but there is no puncture or open wound in the skin. An open fracture is one in which the bone breaks through the skin; it may then recede back into the wound and not be visible through the skin. This is an important difference from a closed fracture because with an open fracture there is a risk of a deep bone infection.
- **Open fracture:** (or so-called open fracture), which distinguishes this type is the injury of the skin around the broken bone, which leads to the appearance of the bone and makes the injury more susceptible to infections.
- **Compression fracture:** is defined as the exposure of the spinal bones formed by the spine to compression due to trauma or strong bodily injury in healthy people, or the lightest strength unit in the elderly or people with cancer or osteoporosis; where their bones are fragile and easy to break.
- **A comminuted fracture:** is a break or splinter of the bone into more than two fragments? Since considerable force and energy is required to fragment bone, fractures of this degree occur after high-impact trauma such as in vehicular accidents.
- **Fracture Avulsion:** An avulsion fracture is a bone fracture which occurs when a fragment of bone tears away from the main mass of bone as a result of physical trauma. This can occur at the ligament due to the application forces external to the body (such as a fall or pull) or at the tendon due to a muscular contraction that is stronger than the forces holding the bone together. Generally muscular avulsion is prevented due to the neurological limitations placed on muscle contractions. Highly trained athletes can overcome this neurological inhibition of strength and produce a much greater force output capable of breaking or avulsing a bone.
- **A pathologic fracture:** is a broken bone that's caused by a disease, rather than an injury Some conditions weaken your bones, which makes them more likely to break Everyday things, such as coughing, stepping out of a car, or bending over can fracture a bone that's been weakened by an illness.
- **Greenstick fracture:** occurs when a bone bends and breaks, but doesn't break into two separate pieces. It's called by this name because it looks similar to what happens when you try to break a "green" branch from a tree. It also goes by the term "partial fracture.
- **Hip Fracture:** A hip fracture is another term for a broken hip. It is a common injury in older women with underlying 'thinning' of the bones (osteoporosis).
- **Stress Fracture:** Stress fractures usually happen from repeating the same movement over and over (such as when someone trains for a sport). They also can happen from everyday activities in people whose bones are weak due to poor nutrition or a medical condition.
- **Fractured skull:** The skull can break, or fracture, if it is subject to a direct and forceful impact. The underlying cause of a skull fracture is a head trauma that is significant enough to break at least one bone. People with a skull fracture need treating as soon as possible.
- **Hairline fracture:** Hairline or stress fractures are tiny cracks on a bone that often develop in the foot or lower leg. It is common for hairline fractures to occur as a result of sports that involve repetitive jumping or running.
- **Hairline fractures** may also occur in the upper limb and are often related to falls or accidents.
- **Tibia fracture:** The shinbone or tibia is the long bone located in the lower leg between the knee and foot. Tibia fractures are common and usually caused by an injury or repetitive strain on the bone.
  A fracture is another word for a break. In some cases, the only symptom of a small fracture is a pain in the shin while walking. In more severe cases, the tibia bone may protrude through the skin.
- **Spiral fracture:** A spiral fracture is usually treated right away with surgery. After the surgery, a cast may be worn. A spiral fracture happens when a long bone is torn in half by a twisting force or impact.

Due to the difficulties in diagnosing fractures, we are proposing to design and develop an expert system to help in diagnosing broken bones in humans by using CLIPS and Delphi Languages. The knowledge will be solicited from human experts who is in the Broken Bones specialists, the knowledge of a human expert who specializes in health issues, particularly regarding diseases of the bones (in this case is an expert fractures) can be represented into the computer in the form of rules that can be used by many people and can be used to resolve problems experienced independently without the presence of an expert directly so that we can conclude the diagnosis and get the treatment.

2. Problem Statement

Diagnosing bones fractures is a very complicated process, so we propose to design and develop an expert system for diagnosing broken bones in humans using CLIPS and Delphi languages. This expert system aims to help determine the types of broken bones, based on the results of questions about the symptoms and bone fractures. This expert system can provide treatment and recommendations based on the result of the expert system.

3. Objectives of the study

The objectives of this study are:

- To make a diagnosis expert system for fractures with CLIPS and Delphi languages, in order to simplify the system user in diagnosing the disease fracture.
- With the expert system is expected to help determine the type of disease and broken bones fracture treatment method quickly and accurately.
- Assist and facilitate expert fractures in determining the type of bone disease experienced by patients based on their symptoms.

4. Literature Review

There are a lot of expert systems that help humans in health problems as follows:

1- A Ruled Based System for Ear Problem Diagnosis and Treatment [4]. This Ruled Based System for Ear problem diagnosis was implemented using SL5 Object language. In this ruled based system ear problems were classified into three main sets: a- Inflammation of the inner ear b- Middle ear problems c- External ear problems.

2- Lower Back Pain Expert System Diagnosis and Treatment [5]. This paper proposes an expert system that can be used to positively diagnose low back pain concentration. This system asks for the symptoms then lastly it can pick the illness producing these symptoms and recommends the appropriate treatment.

3- A Proposed Expert System for Foot Diseases Diagnosis [6]. This expert system diagnoses eighteen foot problems of all phases of the human life beginning with baby to the grownup by examining with yes/no questions. The expert system asks the end user to select the right answer in every screen. Latterly, the expert system provides the diagnosis and recommendation to the user.

4- Fuzzy MLP based expert system for medical diagnosis [7] A fuzzy MLP model, established by the knowledge engineer, was used as a connectionist expert system to diagnose hepatobiliary disorders. It has the ability use uncertainty in the input and the output. The input to the network is modeled in terms of linguistic pi-sets whose centers and radii along each feature axis are determined from the distribution of the training data. In case of partial inputs, the model can query the user for further important feature when needed. Explanation for an inferred decision can be developed in rule form.

5- A Knowledge Based System for Neck Pain Diagnosis [8]. The knowledge based system is can diagnose seven neck diseases of different phases of the human life beginning by asking the user many questions according to their pain symptoms. SL5 Object language, a rule-based language was used in designing and implementing the Knowledge Based System for neck diseases diagnosis.

6- A Proposed Rule Based System for Breasts Cancer Diagnosis [10]. This Rule Based System was developed to help people in preventing and early detecting breast cancer; since it is known that this disease does not have medication or cure yet. SL5 Object language was used in the designing of this ruled based system.

7- Development of a Medical Expert System as an Expert Knowledge Sharing Tool on Diagnosis and Treatment of Hypertension in Pregnancy [11]. This article presents the development a Medical Expert System for the diagnosis and treatment Hypertension in Pregnancy to be used in the Reproductive Health Division at Moi Teaching and Referral Hospital in Eldora, Kenya.

8- A Proposed Expert System for Skin Diseases Diagnosis [12]. An expert system for skin diseases diagnosis was developed using CLIPS Language Integrated Production System) to help user diagnose the following skin diseases (Psoriasis, Eczema, Ichthyosis, Acne, Meningitis, Measles, Scarlet Fever, Warts, Insect Bites and Stings) were presented, an overview about the skin diseases were displayed, the cause of diseases were outlined and the treatment of disease were given whenever possible.

9- Male Infertility Expert System Diagnoses and Treatment [13]. The researchers presented an expert system for male infertility diagnosis which helps men to explore everything related to the problems of infertility and infertility diseases such as: Azoospermia, O.T.A syndrome which mean oligo-terato-astheno spermia, Aspermia and Sexual transmitted disease. This expert system for male infertility diagnosis used 5th generation language called: SL5 Object language for its design and development.

10- An expert system for diagnosing eye diseases using clips [14]. This paper presented the design of an expert system that provides the patient with background for suitable diagnosis of a few of the eye diseases. CLIPS language was used as a tool for developing the expert system. A preliminary evaluation of the expert system was done and the outcome was positive.

11- An Expert System for Mouth Problems in Infants and Children [15]. This expert system asks the user to answer the questions about the symptoms of the patient and end up with some information about the disease and some advices telling the user how to deal with the baby. SL5 Object expert system language was used to develop the expert system.
12- mMES: A Mobile Medical Expert System for Health Institutions in Ghana [17]. This study presents and suggests a Mobile Medical Expert System (mMES) by mobile devices and computing technology thus Medical Doctors in Ghana can accelerate diagnosis, check their own diagnosis, deliver advice on found diagnosis and offer advice on certain diseases when identified on a patient.
13- Medical Expert Systems-Knowledge Tools for Physicians [18]. In this study the author deliberates largely the expert system ONCOCIN. ONCOCIN is an advanced expert system for medical oncology that has been under improvement at Stanford University School of Medicine ever since 1979. It is intended for use after a diagnosis has been concluded, concentrating in its place on support with the management of patients with cancer who are getting chemotherapy.
14- Knowledge Based System for Long-term Abdominal Pain (Stomach Pain) Diagnosis and Treatment [19]. The authors proposed an expert system which was made to aid internist physicians in diagnosing numerous of the abdomen diseases for example: gastritis, hiatal hernia, ulcer or heartburn; the proposed expert system offers a summary about abdomen diseases are given, the cause of diseases are drew and the cure of disease when possible is shown up. Clips expert system language was used for developing this proposed expert system. The proposed abdomen diseases diagnosis expert system was assessed by medical students and they were content with its performance. The proposed expert system is very valuable for internist physician, patients with abdomen problem and newly graduated physician.
15- Knowledge Based System for Ankle Diseases Diagnosis [20]. The authors in this article have recognized seven ankle diseases: Ankle Sprain, Fracture (of Fibula), Rheumatoid Arthritis, Rheumatoid Fever, Gout, and Osteoarthritis (Degenerative Joint) and they developed the expert system for those ankle diseases using SL5 Object Expert System Language.
16- An Expert System for Diagnosing Shortness of Breath in Infants and Children [21]. In this article, the authors presented an expert system for aiding Respiratory physician, pediatrician, newly graduated physician, and children's parents in diagnosing infants and children patients with twelve various shortness of breath in infants and children diseases. They can get the diagnosis quicker and more exact than the traditional diagnosis. It is easy to use and has user friendly interface. The system was developed using SL5 Object expert system language.
17- Ear Diseases Diagnosis Expert System Using SL5 Object [27]. The authors in this article presented an expert system that swiftly diagnosis patient's condition and proposes a appropriate answer for the problem. It was developed using SL5 Object language. It was evaluated by a group of physician and found to be a beneficial tool that supports physicians and patients who are suffering from hearing senses problems.
18- An expert system for feeding problems in infants and children [28]. The authors in this article presented an expert system to diagnose feeding problems in infants and children. This expert system was found to be helpful methodology in addition to existing impartial ones. As far as the authors are aware, this expert system was the initial for attaining good performance in a real world application. It was developed to aid parents diagnose these problems and get a recommendation of how to deal with infants and children.
19- An expert system for men genital problems diagnosis and treatment [30]. The authors in this paper presented an expert system to assist men diagnose their genital problems and give them the suitable treatment. Genital problems and injuries usually occur through: recreational activities (such as: Basketball, Football, Hooky, Biking), work-related tasks (such as: contact to irritating chemicals), downhill drop, and sexual activities. SL5 Object expert system language was used to develop this expert system.
20- An expert system for nausea and vomiting problems in infants and children [29]. The authors in this article presented an expert system to aid users in getting the right diagnosis of problems of nausea and vomiting in infants and children (Gastro-esophageal reflux, Gastroenteritis, Systemic Infection, Bowel obstruction, Tumors, A bleeding disease, tonsillitis, and Hepatitis pharynx). Additionally, this expert system offers information about the disease and how to deal with it. SL5 Object expert system language was used to develop it.

4.1 Comments about Previous Studies

The previous studies aimed at solving problems like: Ear Problem Diagnosis and Treatment, Lower Back Pain Expert System Diagnosis and Treatment, A Proposed Expert System for Foot Diseases Diagnosis, Fuzzy MLP based expert system for medical diagnosis, A Knowledge Based System for Neck Pain Diagnosis, A Proposed Rule Based System for Breasts Cancer Diagnosis, Development of a Medical Expert System as an Expert Knowledge Sharing Tool on Diagnosis and Treatment of Hypertension in Pregnancy, A Proposed Expert System for Skin Diseases Diagnosis, Male Infertility Expert System Diagnoses and Treatment, An expert system for diagnosing eye diseases using clips, An Expert System for Mouth Problems in Infants and Children, An Expert System for Mouth Problems in Infants and Children, mMES: A Mobile Medical Expert System for Health Institutions in Ghana, Medical Expert Systems-Knowledge Tools for Physicians, Knowledge Based System for Long-term Abdominal Pain, Knowledge Based System for Ankle Diseases Diagnosis, An Expert System for Diagnosing Shortness of Breath

in Infants and Children, Ear Diseases Diagnosis Expert System Using SL5 Object, An expert system for feeding problems in infants and children, An expert system for men genital problems diagnosis and treatment, An expert system for nausea and vomiting problems in infants and children.

None of the previous studies aimed in diagnosing Fractures. So, we proposed to design and develop an expert system for diagnosing and treatment of fractures to help doctors, patients, and interested people in the field of fractures in diagnosing fractures.

5. Expert System

An expert is somebody who is able to do things in a better way through his training and knowledge while the individuals cannot. An Expert System (ES) is a computer program designed to act as an expert to provide a solution to a problem in a specific area.

The individuals participating in an expert system development are the Domain Expert, Knowledge Engineer and User. The Domain Expert, through his knowledge and training, presents the knowledge about a specific domain. The Knowledge Engineer represents it in an appropriate manner, through a suitable tool and makes an Expert System. The last User uses the system and solves the problem. The main task completely depends on the Knowledge Engineer who has to gain the knowledge from the expert and present it to the user in a simple understandable manner.

Expert systems are artificial intelligence applications which can accomplish countless services which earlier need human expertise. For example, they can exemplify approximate non-algorithmic expertise for answering certain forms of problems. In addition, they are used in diagnostic applications examining both people and machinery. They also play chess, make monetary preparation decisions, monitor real-time systems, and guarantee insurance policies [19].

In the universe of Artificial Intelligence, an "Expert System" is a computer system that imitates the tasks of human's intelligence. This chapter will outlines the architecture of an ES, comparison with conventional programming, some ES Tools, and CLIPS.

5.1 The Architecture of an Expert System

An expert system or Rule-Based System (RBS) is called a system, not a program as its building is a mixture of many elements that drive into the decision making i.e. goals, facts, rules, inference engine, etc. [19]. The basic Architecture of RBS is shown in Figure (1).

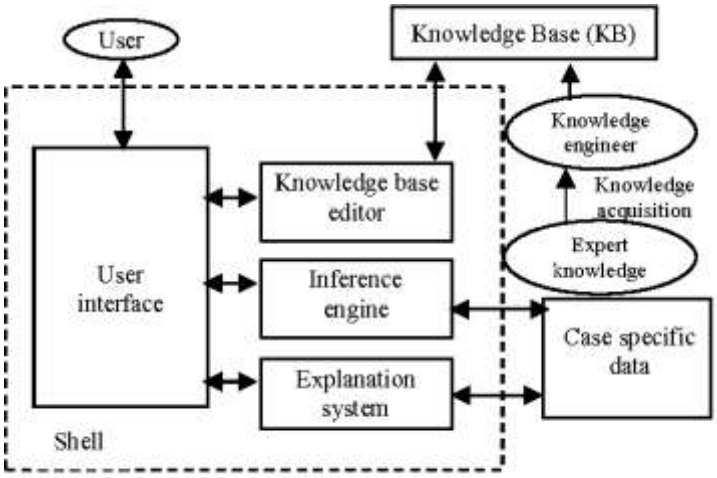

Figure 1: Expert System Architecture.

5.1.1 Knowledge Base

The knowledge base is the heart of the Expert System. Engineering problem solving uses heuristic knowledge as well as recognized scientific ideologies and computational algorithms. A heuristic knowledge aids one to limit how to proceed. The domain knowledge of an expert system is organized in the knowledge base and this module is so critical that the successful practice of the system depends on the excellence and dependability of the knowledge confined in it [3].

A knowledge base includes both declarative knowledge refers to facts or information stored in the memory, that is considered static in nature. Declarative Knowledge, also referred to as conceptual, propositional or descriptive knowledge, describes things, events, or processes, their attributes, and their relation to each other. And procedural knowledge that deals with the info about the sequence of action. There are various techniques of representation and organization of knowledge base. The most widely used techniques are:

a. Semantic Networks.
b. Frames.
c. Logic.
d. Rules.

The knowledge base is denoted in the technique of production rules, If-Then rules, which are very influential and frequently used technique for representing knowledge. For this reason, the Rules are used in this study to represent the Knowledge Base [5, 6].

5.1.2 Inference Engine

The inference engine, termed as control structure or the rule translator, is an extra component of the expert system that guides the implementation of the knowledge because gathering of the Expert knowledge in the knowledge base is not enough.
The inference engine chooses the kind of search to be used to solve the problem. In fact, the inference engine runs the expert system, defining which rule is to be useful, implementing the rules and defining when a suitable solution is reached. The kind of inference mechanism depends on equally the nature of the problem domain and the technique in which knowledge is represented in the knowledge base.
In an expert system, someone may starts with a preliminary state and tries to reach the goal state for the specific problem. The method of shifting over different solutions to proceed from the preliminary state to goal state is termed search and the field of all probable paths of search is the search space. There are 3 search methods broadly used in rule based systems which are "forward chaining, backward chaining, and hybrid chaining".

5.1.2.1 Forward Chaining

Forward chaining, termed a data driven search, is a basic technique in the inference engine. In this technique, the search proceeds in the forward direction and depends on the production rules, IF P THEN Q (certainty factor), in which: P (antecedent) represents facts; Q (consequent) represents a conclusion. The meaning is: if the fact P is satisfied, the conclusion Q will be derived. It is useful when goal conditions are minor in number when related to the initial state. Antecedent part is checked first and then goes to consequent part. In an expert system, a forward-chaining rule exposes certain facts in the database and takes an action because of them. The forward chaining technique sounds more desirable as it proceeds on the basis of available information. This is true especially at the beginning of inference process, when the input basic information leads to some fast intermediate conclusion especially when there are several goals [20].

5.1.2.2 Backward Chaining

Backward chaining is a basic technique in the inference engine. It is termed a goal driven or ambitious search. A system supposed to perform backward chaining when it backs a goal state or suggestion by examining known information's in the framework. It searches in the state space working from goal state to the preliminary state by the application of inverse operators. It may be better to start with the goal to work back towards the controller state when there are rare goal states and many preliminary states [20].

5.12.3 Hybrid Chaining

Hybrid chaining is a technique used in the inference engine. It uses both chaining techniques (Forward and Backward) to provide more advantages comparatively with those utilizing a single technique. This has proven to have an important increase on the performance and accuracy of the inference engine. Using hybrid chaining technique is desirable when using one chaining technique (Forward or Backward) doesn't lead to the desired results due to incomplete or unsupportive facts [3].

5.1.3 Working Space

The working space or working memory is the dynamic part of an expert system's memory. It includes the problem description and the problem status of the expert system. It aims at gathering symbols or reliable information that reflects the present condition of the problem which includes the data gathered during problem implementation.

5.1.4 Knowledge Acquisition

Knowledge acquisition is the process of extracting, organizing, and constructing knowledge into rules from a single source, typically human expert, so it might be used in software such as an expert system. The type of knowledge used by experts to solve problems is often subjective, partly judgmental and ill-defined. In most cases, it is not formulated in a way that is easy to translate into a computer program. The difficult task of extracting the expert's understanding of a problem and representing it as facts and relations in an expert system is often performed by a knowledge engineer. Accomplishments of any expert system mainly depends on the superiority, comprehensiveness, and accurateness of the data stored in the knowledge base [21].

5.1.5 User Interface

User interface is a vital component in the ES. It creates communication between the ES and the knowledge engineer, the domain expert, and the user.

5.1.6 Explanation Facility

The Expert System has the ability to describe to the user what steps were involved in the process to arrive to a conclusion and this is one of the key benefits of the expert system.

5.2 Comparison between Expert Systems and Conventional Programs

Expert systems are distinguished from conventional programs by their approach of development. Most software engineers traditionally have chosen a top-down approach to software development. This approach requires a view of the overall structure of the problem and an awareness of the relationships among the various modules. In case of having insufficient level of knowledge, the top-down approach is less effective for development. In this case, using expert systems is the best as they can deal with such cases. A summary of the basic distinctions between conventional programs and expert systems is outlined in Table (1).

Table 1: Comparison between conventional programs and expert systems.

Conventional Programs	Expert Systems
Suitable for top-down development approach.	Suitable for bottom-up development approach.
Provides only answers.	May provide explanation for their reasoning.
May be difficult to use and understand.	Transparency of knowledge representation and dialogue.
Generates results that are certain.	May produce uncertain results.
Produces unique solution.	May produce several solutions.
May be difficult to modify.	Incremental growth capability.
Combination of information and control.	Separation of knowledge and control.
Requires complete set of data.	Can function with incomplete set of data
Uses algorithms.	Uses heuristics.

5.3 Some Expert System Tools

a. Prolog: A logic programming language associated with AI and computational linguistics that practices backward chaining. It was designed primarily to deal with symbols rather than numeric data by Alian Colmerauer and Robert Kowalski and the first Prolog system was developed by Alian Colmerauer with Philippe Roussel [19, 22].
b. OPS5: Official Production System is the first AI language used for Rule-Based System. It was developed by Charles Forgy [23].

c. Mycin: A medical expert shell for knowledge representation, reasoning, and description. It was one of the first expert systems to perform with a human expert and to provide users with complete explanation of its logical reasoning. It was developed by Edward Shortliffe under the direction of Bruce G. Buchanan, Stanley Cohen [24, 25].

d. Mole: A knowledge acquisition tool for obtaining and maintaining domain knowledge and generating expert systems that do heuristic classification [26].

e. Esplan: An expert system shell that includes required components to process the fuzzy explanation of antecedents and consequents in production rule. [27].

f. SL5 Object: The Simpler Level 5 Object is an ES Language. Architecturally, SL5 Object is an RBS executing a rule-based program; thus, the SL5 Object language is a declarative language, which means the program is made up of a set of statements about the world, rather than a list of commands to execute. The SL5 Object engine is implemented in Delphi Embarcadero RAD Studio XE6. It was developed by Prof. Dr. Samy S. Abu Naser [28, 29].

g. CLIPS: C-Language Integrated Production System is a common language for constructing expert systems. It was developed at NASA Johnson Space Center.

5.4 C-Language Integrated Production System Tool

The researcher selected The C-Language Integrated Production System (CLIPS) to implement the Rule-Based part of the control smart traffic light system for several reasons. First, the data-driven nature of forms processing are suitable for the inference engine technique of CLIPS which mainly depends on a forward-chaining technique. Second, CLIPS operates in more than one operating system such as Windows and Macintosh and most users use this operating system. Third, the availability of CLIPS source code provides the ability to use it for specific needs. Forth, CLIPS is available to knowledge engineers at no cost. In addition, CLIPS has been linked to a high level programming language (Delphi), developed by Prof. Dr. Samy Abu Naser, which provides a more user friendly interface [5, 30].
CLIPS is a multi-paradigm programming language that provides support for rule based, object-oriented, and procedural programming. It supports only forward chaining rule and it does not support backward chaining. The inference and representation capabilities provided by the rule-based programming language of CLIPS are similar to, but more powerful than, those of OPS5 [5, 31, 32].

The basic components of CLIPS represent the ES architecture as shown in Figure (2).

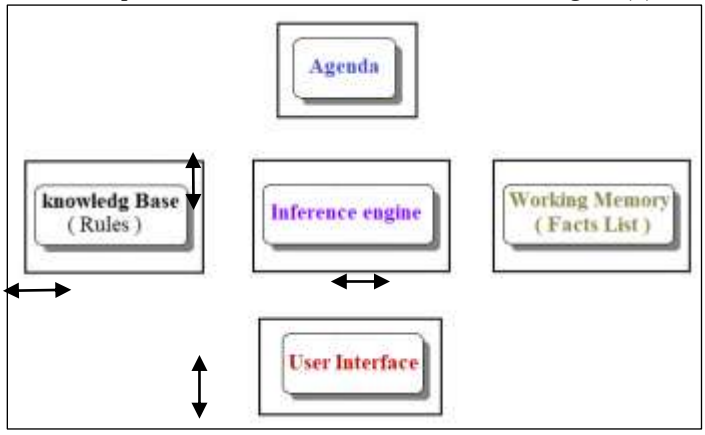

Figure 2: CLIPS Basic Components.

a. User Interface: The mechanism which facilitates communication between the user and the expert system.
b. Working memory: A fact-list for data. It represents the initial state of the problem from which inferences are derived.
c. Knowledge-base: Contains all the rules used by the expert system. In the CLIPS syntax, these rules and the associated dialogue can be expressed mainly as If-Then rules. It can turn the problem state into a solution.
d. Inference engine: Makes inferences by deciding which rules are satisfied by facts, prioritizes the satisfied rules, and executes the rule with the highest priority. It matches the facts against the rules to see what rules are applicable. It internally uses the Rete Algorithm for pattern-matching [33]. The algorithm was developed to efficiently apply many rules to many facts, in a knowledge base. It is used to execute the actions associated with the winning rule.
e. Agenda: A list with the highest priority created by the inference engine of instances of rules whose patterns are satisfied by facts in the fact list.

6. Bone Fractures

6.1 Definition of Fracture

A fracture is the medical term for a broken bone. Fractures are common; the average person has two during a lifetime. They occur when the physical force exerted on the bone is stronger than the bone itself [31]. A person risk of fracture depends, in part, on his age. Broken bones are very common in children, although children's fractures are generally less complicated than fractures in adults. As a person age, his bones become more brittle and is more likely to suffer fractures from falls that would not occur when he was young.

There are many types of fractures, but the main categories are: displaced, non-displaced, open, and closed. Displaced and non-displaced fractures refer to the alignment of the fractured bone.
In a displaced fracture, the bone snaps into two or more parts and moves so that the two ends are not lined up straight. If the bone is in many pieces, it is called a comminuted fracture. In a non-displaced fracture, the bone cracks either part or all of the way through, but does move and maintains its proper alignment.
A closed fracture is when the bone breaks but there is no puncture or open wound in the skin. An open fracture is one in which the bone breaks through the skin; it may then recede back into the wound and not be visible through the skin. This is an important difference from a closed fracture because with an open fracture there is a risk of a deep bone infection[31].

6.2 Types of Fractures

6.2.1 Closed Fractures

A fracture in which the skin remains intact with no penetration or protrusion of bone.
Symptoms of Close fracture
Severe pain: Swelling of the affected area (the area around the affected part). Changing the shape of the injured organ (the organ takes a shape other than its normal shape has a twisted shape in position or an abnormal angle of the broken organ). Abnormal movement in the affected organ (with the possibility of hearing a crack in the place of the fracture when moving the fracture place by hand, and often do not resort to this, because it may cause rupture in the tissue surrounding the fracture and the severity of pain may lead to fainting of the injured).

Treatment of Close Fractures
Relax the victim and take the appropriate position to start the ambulance procedures.
Do not give the patient anything through the mouth in the event of fractures, which require surgery.
The bleeding associated with the fracture (if any) should be controlled and not washed or examined, but it should be covered with a clean, sterile bandage to stop the bleeding.
Failure to move the patient with an injury to the spine for fear of rupture of surrounding tissue, this would cause paralysis, and if it must be moved it is done by three or four people.
In the case of a fracture of the joints should not place the organ in the form of a straight line.
Do not attempt to return the broken bone to its normal position.
The twisted organ is attached to a compressive ligament to prevent it from moving, or involuntarily using it in anything that can cause pain.
Monitoring the patient's vital signs. Pain may be given to the patient, such as ibuprofen. Until the ambulance arrives or takes the injured to the hospital [32].

6.2.2 Open fracture

What distinguishes this type is the injury of the skin around the broken bone, which leads to the appearance of the bone and makes the injury more susceptible to infections.

Symptoms of open fracture

An open fracture is a broken bone that penetrates the skin. This is an important distinction because when a broken bone penetrates the skin there is a need for immediate treatment, and an operation is often required to clean the area of the fracture. Furthermore, because of the risk of infection, there are more often problems associated with healing when a fracture is open to the skin.

Open fractures are typically caused by high-energy injuries such as car crashes, falls, or sports injuries. Joe Thiemann, a professional football player, famously ended his career with an open fracture that occurred on national television.

Pain, swelling, bruising, discolored skin around the affected area, angulation - the affected area may be bent at an unusual angle, the patient is unable to put weight on the injured area the patient cannot move the affected area the affected bone or joint may have a grating sensation. The severity of an open fracture is generally classified according to a system called the Gustilo-Anderson open fracture classification system. This classification system gives information about the likelihood of infection and the anticipated time for healing of an open fracture.

Treatment of Open Fractures

Open fractures require urgent surgery to clean the area of injury. Due to broken skin, debris and infection can move to the place of fracture, leading to a higher rate of bone injury. Once the injury is established, solving the problem can be a difficult one.

The timing of surgery is a topic of discussion, as traditional orthopedic surgeons recommended surgery within six hours of injury. Recently, some data supported surgery with slightly less urgency, but within 24 hours of injury.

In addition to surgical disinfection of the wound, treatment should include appropriate antibiotics and fixation of the fracture. Patients should receive tetanus vaccine if they are not up to date or unaware of their vaccination status.

Fixed osteoarthritis treatment often requires many surgeries, long-term antibiotic treatment and long-term problems. Therefore, every effort is made to prevent this potential problem with early treatment. Despite this early treatment, patients with open fracture are still prone to bone infections [33].

6.2.3 Compression fracture

It is defined as the exposure of the spinal bones formed by the spine to compression due to trauma or strong bodily injury in healthy people, or the lightest strength unit in the elderly or people with cancer or osteoporosis; where their bones are fragile and easy to break.

Symptoms of compression fracture

Compression fractures may or may not cause symptoms. If compression fractures cause symptoms, these may include: pain in back, arms, or legs numbness and/or weakness in arms or legs (if the fracture has affected the spinal cord and/or surrounding nerves in the spine) over an extended period, patients may notice a loss of height. A compression fracture that occurs suddenly can be very painful, but a compression fracture that occurs gradually may cause pain only gradually.

Treatment of Compression Fractures

For the most part, no operative treatments are recommended for compression fracture. These treatments include pain medications and modified physical activity. The doctor may recommend wearing a brace that helps support the back and prevents bending forward, and therefore removes pressure from the fractured vertebrae.

Vertebral fractures typically take about three months to fully heal. The doctor will order X-rays monthly to see how the fracture is healing.

If the fracture is caused by osteoporosis, treatment of the osteoporosis can help prevent additional fractures. Treatment may include calcium and vitamin D supplements, bisphosphonates, and weight bearing exercises.

Surgery may be necessary if the spine appears to be unstable. The surgeon may perform a vertebroplasty or a kyphoplasty. During these surgical procedures, the surgeon injects a cement mixture into the fractured bone to stabilize the fracture, treat pain, and prevent a spinal deformity from progressing.

In some cases, the surgeon may need to perform a spinal stabilization and fusion surgery to support the spine until the bone heals. During these procedures, the surgeon places a bone graft across the area of instability, allowing the vertebrae to fuse (grow together). The surgeon secures the spine with an internal fixation implant, using screws and rods, to hold the vertebrae in place while the bone heals [34].

6.2.4 A comminuted fracture

It is a break or splinter of the bone into more than two fragments? Since considerable force and energy is required to fragment bone, fractures of this degree occur after high-impact trauma such as in vehicular accidents.

Symptoms of comminuted fracture

Many fractures are very painful and may prevent you from moving the injured area. Other common symptoms include: Swelling and tenderness around the injury, Bruising, Deformity — a limb may look "out of place" or a part of the bone may puncture through the skin.

Treatment of comminuted Fractures

- **Cast Immobilization**: A plaster or fiberglass cast is the most common type of fracture treatment, because most broken bones can heal successfully once they have been repositioned and a cast has been applied to keep the broken ends in proper position while they heal.
- **Functional Cast or Brace**: The cast or brace allows limited or "controlled" movement of nearby joints. This treatment is desirable for some, but not all, fractures.
- **Traction**: Traction is usually used to align a bone or bones by a gentle, steady pulling action.
- **External Fixation:** In this type of operation, metal pins or screws are placed into the broken bone above and below the fracture site. The pins or screws are connected to a metal bar outside the skin. This device is a stabilizing frame that holds the bones in the proper position while they heal. In cases where the skin and other soft tissues around the fracture are badly damaged, an external fixator may be applied until surgery can be tolerated [35].

6.2.5 Fracture Avulsion

An avulsion fracture is a bone fracture which occurs when a fragment of bone tears away from the main mass of bone as a result of physical trauma. This can occur at the ligament due to the application forces external to the body (such as a fall or pull) or at the tendon due to a muscular contraction that is stronger than the forces holding the bone together. Generally muscular avulsion is prevented due to the neurological limitations placed on muscle contractions. Highly trained athletes can overcome this neurological inhibition of strength and produce a much greater force output capable of breaking or avulsing a bone.

Symptoms of Avulsion fracture

The symptoms of an avulsion fracture include: intense and sudden pain where the trauma occurred, swelling, bruising, trouble moving the bone or joint, pain when trying to move

Treatment of Avulsion Fractures

If a fragment of bone has been pulled more than a few centimeters away from where it usually sits, then surgery may be needed. Most of the time, however, avulsion fractures do not require surgery.

Avulsion fractures are typically treated by:

- resting the affected area
- applying ice packs
- doing exercises to strengthen muscles, improve movement, and help the bone heal
- These steps help the affected bone return to its normal position naturally [36].

6.2.6 Pathologic fracture

It is a broken bone that's caused by a disease, rather than an injury Some conditions weaken your bones, which makes them more likely to break Everyday things, such as coughing, stepping out of a car, or bending over can fracture a bone that's been weakened by an illness.

Symptoms of pathologic fracture

Pathologic fractures don’t always have symptoms. When they do, they share the same symptoms as an injury-related fracture. These include: mild to severe pain near the broken bone, bruising, tenderness, and swelling near the broken bone numbness, tingling, or weakness near the broken bone in some cases, it may be hard to tell the difference between symptoms of a pathologic fracture and those of the underlying condition affecting your bones.

Treatment of pathologic Fractures

The goals of treatment are pain relief, reversal or stabilization of neurological deficits, and stabilization of the spine. For the most part, no operative treatments are recommended for less severe pathologic fractures. These include taking pain medications, limiting physical activity, and wearing a brace. The brace helps support the back and prevents bending forward, which removes pressure from the fractured vertebrae.

If the fracture is caused by osteoporosis, treatment of the osteoporosis can help prevent additional fractures. Treatment may include calcium and vitamin D supplements, bisphosphonates, and weight bearing exercise.

If the fracture is caused by metastatic cancer, treatment options vary by case. Nonsurgical option for pain relief is radiation therapy or injection of bone cement. Radiation is applied to the area of involvement in the hopes of shrinking the tumor and removing pressure from the nerves. The surgeon may perform a vertebroplasty or a kyphoplasty. During these procedures, the surgeon injects a cement mixture into the fractured bone to stabilize the fracture, treat pain, and prevent a spinal deformity from progressing.

Spine surgery is considered if the spine appears to be unstable or if there is significant compression of the neural elements.
In some cases, the surgeon may need to remove diseased bone to relieve pressure on the spinal cord and nerves. Such procedures may also require a spinal fusion to stabilize the spine until it heals. During a spinal fusion, the surgeon may place a bone graft across the area of instability, allowing the vertebrae to fuse (grow together). The surgeon may also need to perform an internal fixation, using screws and rods, to hold the vertebrae in place while the bone heals [37].

6.2.7 Greenstick fracture

Occurs when a bone bends and breaks, but doesn't break into two separate pieces. It's called by this name because it looks similar to what happens when you try to break a "green" branch from a tree. It also goes by the term "partial fracture."

Symptoms of greenstick fracture

The symptoms of a greenstick fracture vary depending on the severity of the fracture. You may only develop a bruise or general tenderness in more mild fractures.
In other cases, there might be an obvious bend in the limb or fractured area, accompanied by swelling and pain. Symptoms also depend on the location of the injury. For example, if the injury occurs in your finger, you might not be able to move the finger for a period of time. Alternatively, a fracture in your arm might be painful with swelling and tenderness while you maintain mobility.

Treatment of greenstick Fractures

- Closed reduction with cast.
- Open reduction with percutaneous pinning.
- Time in the cast varies 3-8 weeks with fracture type [38].

6.2.8 Hip Fracture

A hip fracture is another term for a broken hip. It is a common injury in older women with underlying 'thinning' of the bones (osteoporosis).

Hip fracture symptoms

If you break (fracture) your hip you will feel a lot of pain around the injured hip. Typically, this is most pronounced over the outer upper thigh or in the groin. You will be unable to move your hip, stand or walk. The affected leg often looks shorter and is turned outwards compared to the other leg. You may also feel light-headed, both due to pain and also because broken bones may bleed internally and this can cause your blood pressure to fall.

Hip fracture treatment

Most people who have a broken (fractured) hip need surgery to fix the break in the bone. The type of surgery will depend on where you have broken your hip bone (whether you have an extracapsular or extracapsular fracture) and also any underlying health problems that you may have. You should discuss the options available with the surgeon who is performing your operation. Current guidelines from the National Institute for Health and Care Excellence (NICE) recommend that surgery should be performed, if possible, on the day of, or the day after, admission to hospital. The guidelines also say that adequate pain relief before and after surgery is essential. You will normally be given a painkiller such as paracetamol regularly and stronger painkillers if this is not enough to control your pain. (However, non-steroidal anti-inflammatory medicines are not recommended, as they may increase the bleeding associated with the fracture.) Another option is an injection to block a nerve in order to relieve pain experienced from that nerve [39].

6.2.9 Stress Fracture

A stress fracture is a tiny crack in a bone. Stress fractures usually happen from repeating the same movement over and over (such as when someone trains for a sport). They also can happen from everyday activities in people whose bones are weak due to poor nutrition or a medical condition.

Symptoms of a Stress Fracture

Symptoms of stress fracture include: pain when exercising that may or may not go away after rest, tenderness, mild swelling and redness, the lower leg and the foot are the most common areas to get a stress fracture. But they also can happen in other areas, such as the arm, spine, or ribs.

Treatment of Stress Fractures

The most important parts of recovering from a stress fracture are:

- resting the injured area
- taking a break from sports
- Sometimes a stress fracture will need a cast, splint, or brace. Rarely, surgery is needed.

If you have pain from a stress fracture, you can: Place a cold compress or ice wrapped in a towel on the area for about 15 minutes three times a day.

Take pain medicine as recommended by the health care provider.
Nutritional or psychological counseling can help if a stress fracture happens because of poor nutrition or an eating disorder [40].

6.2.10 Fractured skull

The skull can break, or fracture, if it is subject to a direct and forceful impact. The underlying cause of a skull fracture is a head trauma that is significant enough to break at least one bone. People with a skull fracture need treating as soon as possible.

Symptoms of fractured skull
The symptoms of a skull fracture may include: a headache or pain at the point of impact, a bump or bruise, bleeding from a wound, bleeding from the ears, nose, or eyes, clear fluid leaking from the ears or nose, bruising behind the ears or under the eyes, feeling drowsy, confused, or irritable, loss of speech or slurred speech, difficulty swallowing, loss of balance, impaired vision, changes in the pupils, such as becoming dilated or not reacting to light, convulsions, becoming unconscious, feeling sick or vomiting, a stiff neck, swelling, difficulty breathing, numbness or paralysis, a slow pulse, ringing in the ears or difficulty hearing, facial weakness, loss of bowel or bladder control[41].

6.2.11 Hairline fracture

Hairline or stress fractures are tiny cracks on a bone that often develop in the foot or lower leg. It is common for hairline fractures to occur as a result of sports that involve repetitive jumping or running.
Hairline fractures may also occur in the upper limb and are often related to falls or accidents.

Hairline fractures usually develop gradually as a result of overuse, as opposed to larger bone fractures or breaks that are mostly caused by acute traumas, such as a fall. While hairline fractures may heal with sufficient rest, they can be painful and last several weeks.

Anyone who engages in regular physical activity can develop a hairline fracture, especially if the activity involves repetitive movements that put a strain on a bone or a group of bones. The most common treatment approach is rest.

Symptoms hairline fracture
Symptoms are different from those of a more severe fracture or break when a person often feels a sharp pain immediately.

The pain from a hairline fracture will intensify when the person engages in activities that put a strain on the injured bone. This can inhibit a person's mobility, which means they will be restricted as to how much weight they can put on the affected area.
Other symptoms may include**:** swelling, bruising, tenderness, powered by Rubicon Project.

Treatment of hairline fracture
The majority of hairline fractures will heal by themselves if the person refrains from activities that put a strain on the affected area.
For the first 24 to 48 hours, a person can help the healing process by elevating the affected area and applying ice where possible.
As the swelling decreases and the pain subsides over the first 2 weeks, it is helpful to reintroduce weight-bearing activities gradually.
Staying active helps to stimulate the recovery process, so non-weight bearing activities, such as swimming or cycling, are also encouraged. However, it is essential to avoid high-impact sports or activities that can worsen the injury during the recovery period.
A complete recovery will typically take between 6 to 8 weeks, after which full mobility should be restored.
In some cases, a doctor may recommend protective footwear, a splint, or the use of crutches to minimize strain placed on the fractured bone during movement. In rare cases, a hairline fracture can be severe enough to warrant surgery if it does not heal on its own.

6.2.12 Tibia fracture

The shinbone or tibia is the long bone located in the lower leg between the knee and foot. Tibia fractures are common and usually caused by an injury or repetitive strain on the bone.
A fracture is another word for a break. In some cases, the only symptom of a small fracture is a pain in the shin while walking. In more severe cases, the tibia bone may protrude through the skin.
The recovery and healing time for tibia fractures differs and depends on the type and severity of the fracture. Fractures can be treated by a medical professional, and at-home exercises can speed up a person's recovery.
The tibia is the larger bone in the lower leg. It plays a key role in supporting a person's body weight.
According to the American Academy of Orthopedic Surgeons, the tibia is the most common long bone in the body to fracture. A tibia fracture refers to any crack or breaks in the tibia bone.

The tibia is one of two bones that make up the lower leg, the other being the fibula. The tibia is the larger of these two bones.
The tibia plays a key role in body mechanics, as it is:

- the larger of the two lower leg bones
- responsible for supporting most of the body weight
- vital for proper knee and ankle joint mechanics
- A fractured tibia often occurs with other kinds of tissue damage to the nearby muscles or ligaments. It should always be checked out by a medical professional.

Treatment
Person with broken leg lying on hospital bed with brace and bandages. A cast, brace, or splint may be used to treat a tibia fracture if surgery is not appropriate. Treatment of a tibia fracture depends on several factors, including a person's overall health at the time of the injury, the cause and severity of the injury, and the presence or extent of damage to the soft tissues that surround the tibia.
In severe cases, surgery may be necessary to make sure the bone heals properly. A surgeon may place metal screws and plates on the bone to hold it in the right place, allowing it to heal with minimal long-term damage.
The surgeon may also use rods placed inside the tibia or pins placed through the bones above and below the fracture. They will attach these to a rigid frame called an external fixator to hold the bone in place.
Where surgery is not necessary or is not possible, for instance, due to a person's health, a doctor may use the following treatments for a fractured tibia:
A splint or cast to hold the bone in place, stop it from moving and allow it to heal. A splint can be removed easily and so it is a more flexible treatment option than surgical ones. A traction or functional brace, which is used in cases of less severe breaks to hold the bone in place while it heals.
In many cases, a person with a tibia fracture will require physical therapy and crutches or a walker to help them get back on their feet [42].

6.2.13 Spiral fracture

Patient with broken leg in cast on crutches, with doctor in hospital. A spiral fracture is usually treated right away with surgery. After the surgery, a cast may be worn. A spiral fracture happens when a long bone is torn in half by a twisting force or impact.
The long bones are the bones of the body that are longer than they are wide. Most spiral fractures involve the long bones of the legs, such as the femur, tibia, and fibula.
The injury can also involve the long bones of the arms, including the humerus, ulna, and radius.
Spiral fractures are usually serious injuries and carry the risk of complications.
When long bones are broken on an angle, they often separate into two parts that do not align and have rough, uneven edges. This fracture can make it difficult to put the bone back together.
Spiral fractures are sometimes called torsion or twisting fractures.

Causes of spiral fractures include:
Skiing or snowboarding injuries, when the leg is twisted by being stuck in a ski or snowboarding boot while the rest of the leg continues to move. Soccer injuries, especially when two players run into one another and become entangled or twisted. American football injuries, especially when one player runs into another, one player is held or restrained by another, or a player twists to get free. Wrestling injuries to the legs or arms caused by twists. Motor vehicle and motorcycle accidents. Bicycle accidents, typically those involving a motor vehicle as well. Falling after trying to compensate for a loss in balance by putting out an arm or quickly repositioning the leg.
Child abuse, if a child's arm or leg has been jerked aggressively. Falling down the stairs or a slope with fixed obstacles, such as rocks or trees that can twist an arm or leg away from the rest of the body. Physical violence, when a person's arm or leg has been twisted forcibly. Machinery injuries that involve someone's limbs.

Symptoms associated with the injury include:
Fainting or losing consciousness. inability to put weight on the affected bone. loss of feeling and control in the lower leg or arm, especially in the feet and hands. Bone tenting, where the fractured bone is ready to break through the skin. Inability to straighten or fully extend the leg or arm. Signs of bruising. Inflammation or redness and swelling. Loss of pulse in the ankle or wrist.

Treatment spiral fractures
Treatment for a spiral fracture depends on the severity of the breakage and damage to the surrounding tissues and blood vessels. Immediately after the injury takes place, it is important to make sure no weight is put on the fracture. If possible, it should be splinted to prevent further damage. The affected limb should be elevated to heart level and iced to reduce blood flow and limit inflammation. Ice should be applied for no longer than 10 minutes at a time.

Acetaminophen is the only over-the-counter medication recommended during initial treatment for a fracture. Anti-inflammatory medications weaken the blood's ability to clot and may make internal bleeding worse.
A person should not eat or drink anything immediately after the fracture, as surgery may be required [43].

7. Proposed System Design and Methodology

7.1 Knowledge Acquisition

The knowledge acquisition stage was done through collecting the data from specialized doctors in the field of fractures, and studying the related scientific resources.

7.2 Knowledge Representation

The proposed system is forward rule-based system; therefore, for knowledge representation, we used rules in the form of IF…THEN, where IF identifies the situation, and THEN provides the suggestion. In other words, experts' knowledge was transferred into rules. After collecting the symptoms of the diseases, we grouped them into symptoms groups as shown table 1 and detail symptoms are shown in table 2, and the diseases covered in our system are shown in Table 3.

Table 2: Group Symptoms

Label	Symptoms Groups
SG1	G01, G02, G03, G04, G07, G09, G10, G20
SG2	G01, G02, G03, G06, G07, G11, G20
SG3	G01, G02, G03, G07, G14, G15, G18, G25
SG4	G01, G02, G03, G04, G07, G14, G18
SG5	G01, G02, G07, G09, G25, G31,
SG6	G01, G02, G03, G06, G07, G09, G12, G14, G15, G19
SG7	G01, G02, G03, G04, G09, G19, G29, G30
SG8	G02, G03, G04, G17, G18
SG9	G01, G02, G03, G07, G19, G20
SG10	G01, G02, G09, G12, G13, G18, G21, G22, G23, G24, G25
SG11	G01, G02, G03, G07, G09, G14, G19
SG12	G01, G06, G07, G09, G12, G13, G14, G26, G27, G28
SG13	G01, G02, G03, G04, G07, G09, G12, G20, G23, G29, G30, G31

Table 3: Symptoms Details

Label	Symptoms Details
G01	Swelling
G02	Pain
G03	Half pain
G04	Dysfunction
G05	Excessive muscle contraction
G06	Bone ends visible
G07	Transformation
G08	The sound of crunching on broken bones
G09	Bruised
G10	Cannot be bent at the joints / The joint is locked
G11	Shock body
G12	Numb / Decreased sensation
G13	Breaks in the skin accompanied by bleeding
G14	Osteoporosis
G15	Cancer
G16	Fragments of bone
G17	light-headed
G18	blood pressure to fall
G19	Tenderness

G20	Redness
G21	Convulsions
G22	difficulty breathing
G23	slow pulse
G24	impaired vision
G25	loss of balance
G26	Nerve damage
G27	Muscle damage
G28	Blood vessel damage
G29	Fainting
G30	Losing consciousness
G31	Bone tenting

Table 4: Labeling Diagnosis

Label	Disease Name
D1	Closed Fractures
D2	Open Fractures (Compound)
D3	Compression Fractures
D4	Comminuted Fractures
D5	Fractures Avulsion
D6	Pathologic Fractures
D7	Greenstick Fractures
D8	Hip Fracture
D9	Stress Fracture
D10	Fractured skull
D11	Hairline fracture
D12	Tibia fracture
D13	Spiral fracture

7.3 Expert System Tool design

The researcher designed the Fracture Expert System (FES) using mainly CLIPS and Delphi languages. FES diagnoses and analyzes the patient symptoms to detect if he/she has one of the categories of fractures. Once the type of fracture is detected, FES gives some information about the diagnosis, treatment, and a snapshot of the fracture.

FES was built using a Delphi graphical user interface and CLIPS expert System language. After starting the FES, the patient is given a list of symptoms about 13 types of fractures. The patient selects the symptoms and these symptoms are sent to CLIPS expert system via both way link. The CLIPS part analyze the symptoms it receives from the Delphi Interface and decides the type of fracture the patient has and send the results back to Delphi interface. The Delphi Interface receives the type of fracture and displays the results in a nice graphical interface for the patient.

The main interface of FES shown in Figure (3) includes the name of the expert system, an overview about it, and the main buttons: Start, Theme, Prepare, and Exit. When the user clicks the Start button, the FES begins the process of diagnosis and analysis. A new interface will appear which includes a list of the possible symptoms as shown in Figure (4). Once the user select the symptoms that appear on the patient from the symptoms list, the user should click the Analyze button so the expert system can diagnose the disease and the result of the diagnosis is displayed on the screen in a nice format (as shown in Figure (5), Figure (6), Figure(7).

When the user clicks the theme button, a new interface will appear. Through this interface, the user can edit the text of overview, change the font type, font color, font size and background color as shown in Figure (8) and Figure (9). When the user clicks the prepare button, the user enter data related to each disease such as symptoms, diagnosis, treatment, and an image of the disease(as shown in Figure 10). When the user clicks the exit button, the whole process will stop and the FES will close all the interfaces.

Figure 3: Main interface of Fracture Diseases Expert System

Figure 4: Show Basic Data for Fracture Diseases Expert System

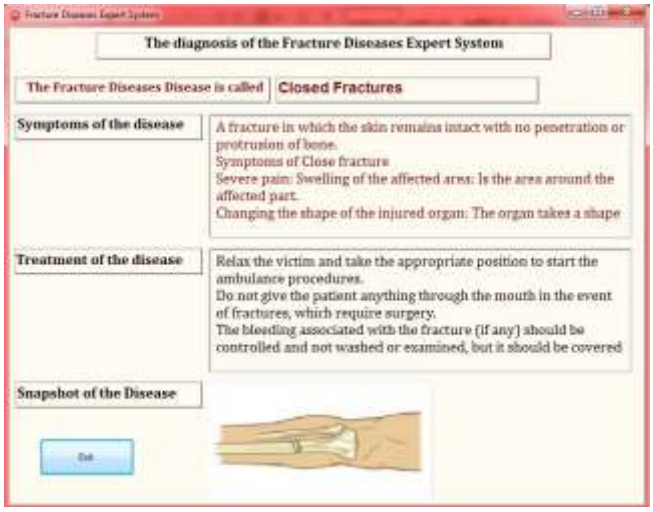

Figure 5: Show closed fracture disease

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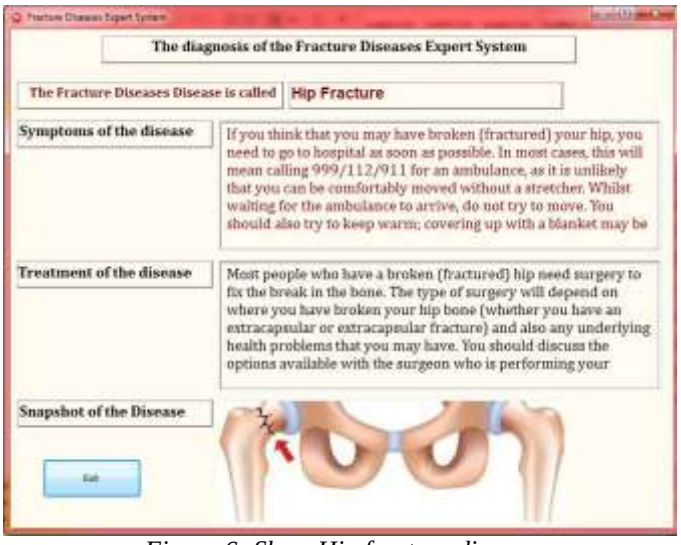

Figure 6: Show Hip fracture disease

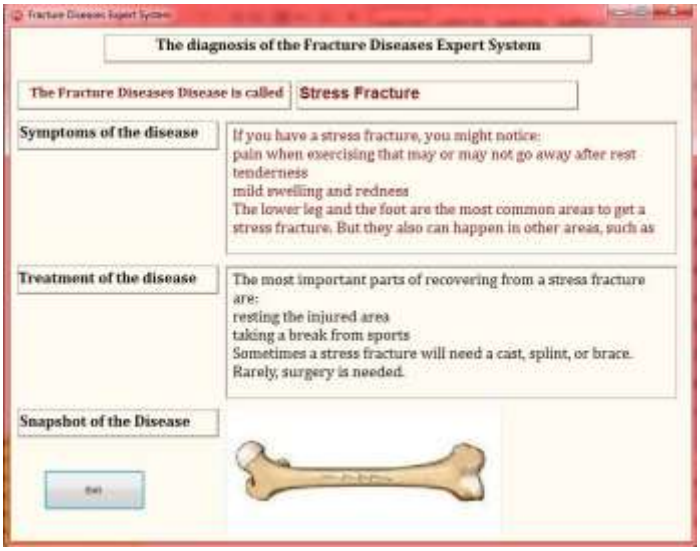

Figure 7: Show Stress fracture disease

Figure 8: Show Basic Data for Fracture Diseases Expert System

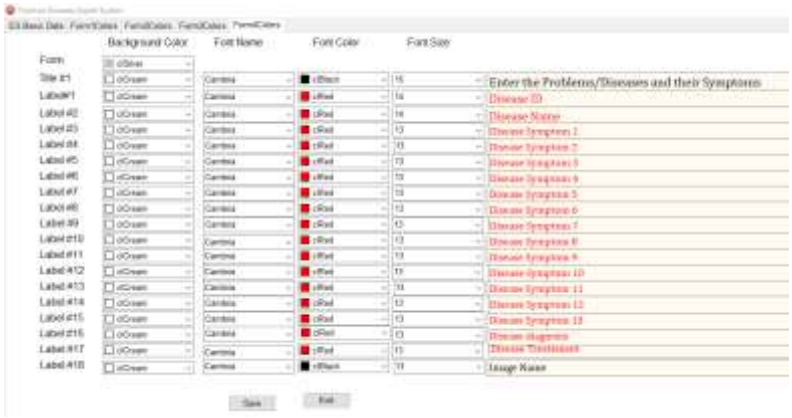

Figure 9: The user can edit the text of overview, change the font type, font color, font size and background color

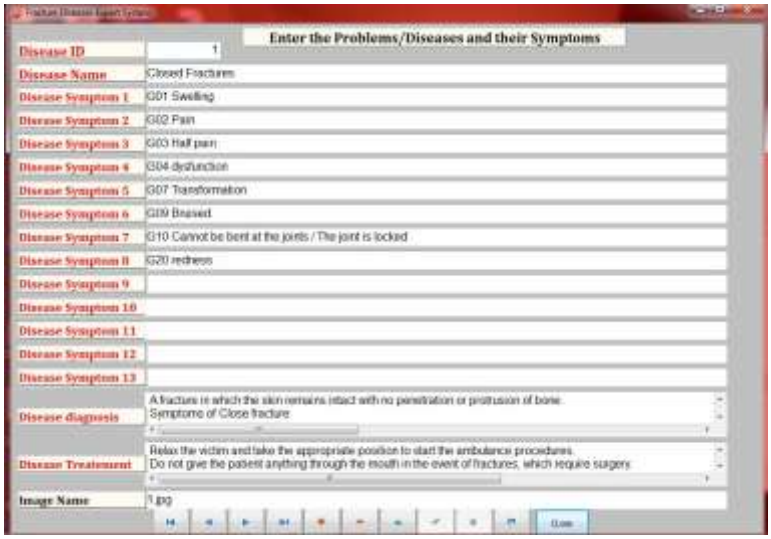

Figure 10*: Show the interface for adding the data about each diseases*

7.4 Testing and Validation

During the system development, all rules, paths, and relationships between the attributes were tested, and the necessary changes were made. Then the system was evaluated by a group of medical students in Al-Azhar University in Gaza and fractures specialists in the faculty of Medicine in the same university, and the relevant comments and recommendations were used in the final development stage. The final system was tested by 30 patients who had fractures of various types, and the results were compared with the specialists' diagnosis. The results of both methods were consistent.

8. Conclusion

The bones are the structure of the body that enable us to stand up straight, place of attachment of muscles thus permitting the course of the blood vessels, where the bone marrow and nerve protect the soft tissues, and bone is likewise an organ that humans need to lift and move weighty goods. The bone is an organ that we need to do daily activities, thus we cannot envision how disturbance when there is a damage that happens to our bones.

In the Palestinian society we are exposed to a lot of fractures or broken bones. Due to the complications in diagnosing fractures, I proposed the design and development of an expert system for diagnosing broken bones in humans using CLIPS and Delphi languages. The knowledge of fractures and broken bones were collected from human experts that are specialized in broken bones. The collected knowledge of experts particularly regarding diseases of the bones (in this case is an expert fractures) were represented into the computer in the form of an expert system that can be used by many users and can be used to resolve problems experienced independently without the presence of a human expert directly so that we can get the diagnosis and treatment accurately and easily.

The expert system was evaluated by a group of medical students in Al-Azhar University in Gaza and fractures specialists in the Faculty of Medicine in the same university, and the their relevant comments and recommendations were used in the final

development stage. The final system was tested by 30 patients who had fractures of various types, and the results were compared with the specialists' diagnosis. The results of both methods were consistent.

9. Future Work

In the future work, we are going to enhance the performance of the expert system design as to add more type of bone diseases and convert the system to be mobile app. to make it accessible to any user at any time.
Furthermore, we are going to enhance the user interface to be more users friendly by adding new icons, adding special sound and image icons, in general work to improve the performance of this expert system.

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