NEAR EAST UNIVERSITY

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DIAGNOSTIC EXPERT SYSTEM FOR ABDOMINAL DISEASES

Graduation Project
COM-400

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ABSTRACT

Increasing the complexity of the technology process, the presence of difficult formalization and unpredictable information, the uncertainty of environment leads to non-adequate description of these processes by deterministic methods and so the development of system with low accuracy. The effective way to solve this problem is the use of artificial intelligence ideas, such as expert systems.

In this project the development of diagnostic expert system for abdominal diseases is considered. The state of art understanding of expert system for medical diagnosis problem is given. The structure of expert system and the functions of its main blocks are described. Models of knowledge representation, such as OAV triplets, semantic networks, predicate logics, frames, neural networks, and rule based model and their main properties are described. For development of expert system the rule based model representation of knowledge is chosen. Using knowledge of experienced specialists and different medical references the knowledge based is constructed. This knowledge base contains production rules. Premise part of the rules includes the input symptoms of abdominal diseases and the conclusion part includes diagnosis. The considered expert system is realized on the base of ESPLAN expert system shell. This system can be used as an assistant to the physicians in making decision, diagnosis, in treatment of diseases and teaching students.

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INTRODUCTION

There are some problems that are difficult to solve using conventional programming techniques. These problems are characterized ill-structured nature, and have unformalized or different formalized factors. One of efficient technology to solve these problems is construction of knowledge base systems, such as Expert Systems (ES's). ES may be considered as software, which operates on a sophisticated system like a human expert. In other words, ES are computerized program tools that mimic the judgment of human experts in a well-defined domain. Since 1970, a variety of ES have been applied successfully in different fields such as MYSIN and INTERNIST for medical diagnosis, DENDRAL and SECS for chemical analysis, XCON and XSEL for designing the system configuration of computer systems.

Considering the application of ES's, diagnosis of the system failure via observation occupies the most important field. Medical diagnosis is the most widely used among these.

This study has aimed to investigate the expert systems designed for medical area, and then, to show how simple expert system based on Bayes method can be designed.

Many expert systems are not complex or difficult to build. In a very simple case, consider a tree diagram on paper describing how to solve a problem. By making a selection at each branch point, the tree diagram can help someone make a decision. In a sense, it is a very simple expert system. This type of tree structured logic can easily be converted to a computerized system that is easier to use, faster and automated. More elaborate systems may include confidence factors allowing several possible solutions to be selected with different degrees of confidence.

Expert systems can explain why data is needed and how conclusions were reached. A system may be highly interactive (directly asking the user questions) or embedded where all input comes from another program. The range of problems that can be handled by expert systems is vast.

Expert systems can be developed with Expert System Shells. An expert system shell is a software programming environment which enables the construction of expert or knowledge based systems. Expert systems software can be developed for any problem that involves a selection from among a definable group of choices where the decision is based on logical steps. Any area where a person or group has special expertise needed by others is a possible area for an expert system. Expert systems can help automate anything from complex regulations to aiding customers in selecting from among a group of products, or diagnosing equipment problems.

Traditionally expert system development has been a major expense both in time and money. Getting even a single system built was a big project. The cost of system development prohibited building expert systems on more than a few projects. The key to implementing expert systems widely, effectively and at low cost is to have easy-to-use expert system development tools readily available to the experts. As more power is needed for certain applications, higher level tools can be used with advanced features to give you complete control over the inference engine, modularization of the knowledge base, flow of execution, the user interface and integration with other programs.

Medical diagnosis was one of the first knowledge areas to which ES technology was applied, but diagnosis of engineered systems quickly surpassed medical diagnosis. There are probably more diagnostic applications of ES than any other type. The diagnostic problem can be stated in the abstract as: given the evidence presenting itself, what is the underlying problem/reason/cause?

Aim of the project is the development of diagnostic expert system for abdominal diseases. Project consists of introduction, four chapter, conclusion and appendix.

In chapter one the review on Expert System for medical diagnosis problem is given, the application areas of Expert Systems, its advantages have been described.

In chapter two architecture of Expert System, its main block, their functions are presented. Forward and backward chaining mechanisms of inference engine are described.

In chapter three knowledge representations models in Expert Systems are given. The description OAV triplets, frames, neural networks, predicate logic, and rule based knowledge representation models are presented. The analysis of rule base system has been given.

In chapter four the development of diagnostic expert system for abdominal diseases is carried out. The different abdominal diseases are explained. The input symptoms of abdominal diseases and its output diagnosis and type of illness are defined. The knowledge base for severe abdominal diseases is constructed. Using ESPLAN Shell the development of Expert System is carried out.

Conclusion includes the important results obtained from the project.

CHAPTER ONE: A REVIEW ON DIAGNOSTIC EXPERT SYSTEM FOR ABDOMINAL DISEASES

1.1 Overview

This chapter is about state of art of medical expert systems. The fundamental principles of expert systems are introduced. The advantages and disadvantages of expert systems are discussed and the appropriate areas of application of expert systems are described. The relationship of expert systems to other methods of programming is discussed. The application of expert system to different industrial and nonindustrial fields is considered. Advantages of application and future works are described.

1.2 Expert Systems and its Application Areas

An expert system is a computer program designed to model the problem-solving ability of a human expert. An expert is someone who is skillful in solving a problem in an effective and efficient manner. An expert system is defined as a model and associated procedure that exhibits, within a specific domain, a degree of expertise in problem solving that is compatible to that of a human expert.

A doctor diagnosing diseases, a bank loan manager reviewing mortgage applications, or a technician repairing some system, May all is considered experts within their field. They are called experts when they exhibit reasoning abilities that are superior to others in their profession.

Consider the profession of police detective. For the most part, each individual who reaches the rank of police detective within a given police force has gone through essentially the same training and has faced similar experiences. However, some detectives will ultimately exhibit far more proficiency in their work than will the bulk of the detective force. These are the experts. Such experts exist in virtually all professions, and they often stand head and shoulder, in terms of their performance, above their colleagues. In all likelihood, one reason for their success is that they have been able to develop a set of heuristics, which permits them to solve problems faster, and generally better, than their fellow workers.

An expert system may completely fulfill a function that normally requires human expertise, or it may play the role of an assistant to a human decision maker. In other words, the client may interact with the program directly, or interact with a human expert who interacts with the program.

The first step in solving any problem is defining the problem area or domain to be solved. This consideration is just as true in artificial intelligence (AI) as in conventional programming. Today there are many real-world problems that are being solved by AI and many commercial applications of AI.

Although general solutions to classic AI problems such as natural language translation, speech understanding, and vision have not been found, restricting the problem domain may still produce a useful solution. For example, it is not difficult to build simple natural language systems if the input is restricted to sentences of the form noun, verb, and object. Currently, systems of this type work well in providing a user-friendly interface to many software products such as database systems and spreadsheets. In fact, the parsers associated with popular computer text-adventure games today exhibit an amazing degree of ability in understanding natural language.

As Figure 1.1 shows, AI has many areas of interest. The area of expert systems is a very successful approximate solution to the classic AI problem of programming intelligence. Professor Edward Feigenbaum of Stanford University, an early pioneer of expert systems technology, has defined an expert system as "an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solutions." [1]. That is, an expert system is a computer system that emulates the decision-making ability of a human expert. The term emulates means that the expert system is intended to act in all respects like a human expert. Emulation is much stronger than a simulation, which is only required to act like the real thing in some respects.

Although a general-purpose problem solver still eludes us, expert systems function well in their restricted domains. As proof of their success, you need only observe the many applications of expert systems today in business, medicine, science, and engineering, as well as all the books, journals, conferences, and products devoted to expert systems.

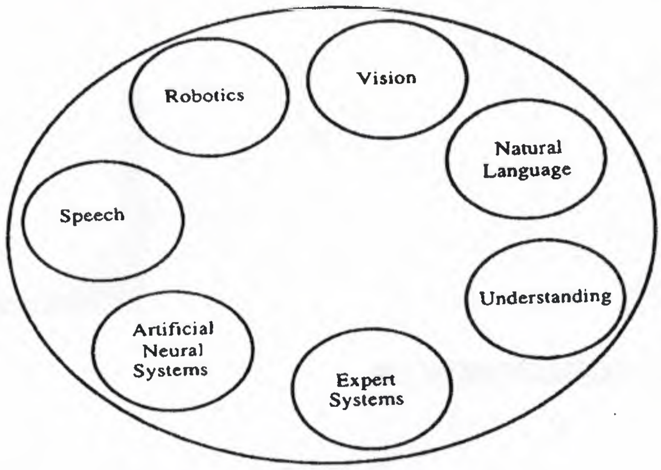

Figure 1.1 Some Areas of Artificial Intelligence

Expert systems are a branch of AI that makes extensive use of specialized knowledge to solve problems at the level of a human expert. An expert is a person who has expertise in a certain area. That is, the expert has knowledge or special skills that are not known or available to most people. An expert can solve problems that most people cannot solve or can solve them much more efficiently (but not as cheaply). When expert systems were first developed in the 1970s, they contained expert knowledge exclusively. However, the term expert system is often applied today to any system that uses expert system technology. This expert system technology may include special expert system languages, programs, and hardware designed to aid in the development and execution of expert systems.

The knowledge in expert systems may be either expertise or knowledge that is generally available from books, magazines, and knowledgeable persons. The terms expert system, knowledge-based system, or knowledge-based expert system are often used synonymously.

Figure 1.2 illustrates the basic concept of a knowledge-based expert system. The user supplies facts or other information to the expert system and receives expert advice or expertise in response. Internally, the expert system consists of two main components. The knowledge base contains the knowledge with which the inference engine draws conclusions. These conclusions are the expert system's responses to the user's queries for expertise.

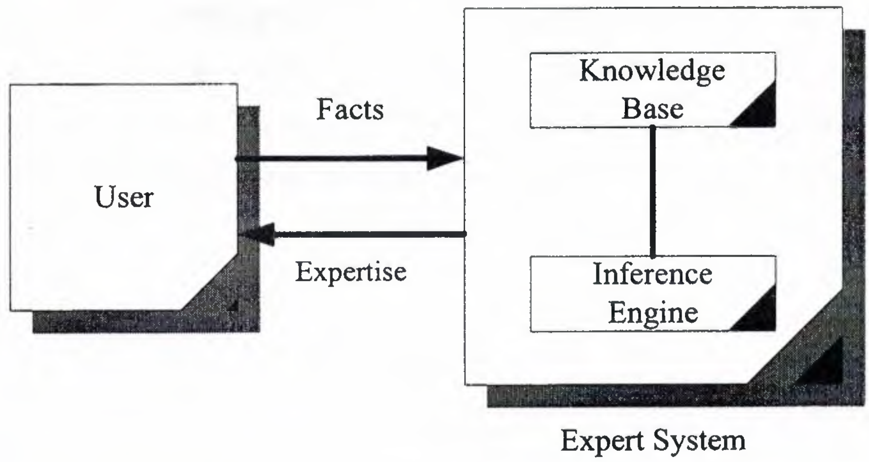

Figure 1.2 Basic Concept of an Expert System Function

Useful knowledge-based systems have also been designed to act as an intelligent assistant to a human expert. These intelligent assistants are designed with expert systems technology because of the development advantages. As more knowledge is added to the intelligent assistant, it acts more like an expert. Thus, developing an intelligent assistant may be a useful milestone in producing a complete expert system. In addition, it may free up more of the expert's time by speeding up the solution of problems. Intelligent tutors are another new application of artificial intelligence. Unlike the old computer-assisted in struction systems, the new systems can provide context-sensitive instruction [2].

An expert's knowledge is specific to one problem domain, as opposed to knowledge about general problem-solving techniques. Expertise in one problem domain does not automatically carry over to another.

The expert's knowledge about solving specific problems is called the knowledge domain of the expert. For example, a medical expert system designed to diagnose infectious diseases will have a great deal of knowledge about certain symptoms caused by infectious diseases. In this case, the knowledge domain is medicine and consists of knowledge about diseases, symptoms, and treatments. Figure 1.3 illustrates the relationship between the problem and knowledge domain. Notice that this knowledge domain is entirely included within the problem domain. The portion outside the knowledge domain symbolizes an area in which there is not knowledge about all the problems.

One medical expert system usually does not have knowledge about other branches of medicine such as surgery or pediatrics. Although its knowledge of infectious disease is equivalent to a human expert, the expert system would not know anything about other knowledge domains unless it was programmed with that domain knowledge.

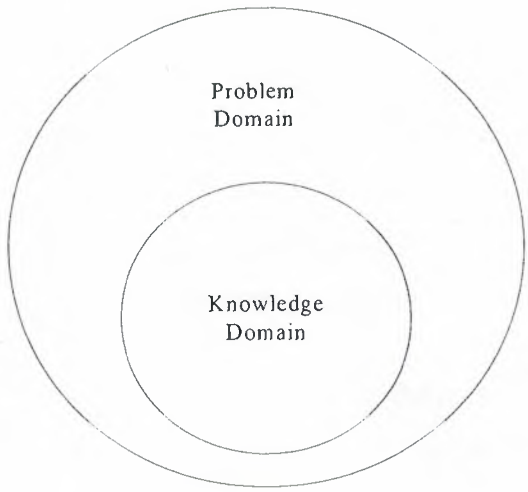

Figure 1.3 A Possible Problem and Knowledge Domain Relationship

In the knowledge domain that it knows about, the expert system reasons or makes inferences in the same way that a human expert would infer the solution of a problem. That is, given some facts, a conclusion that follows is inferred.

1.3 Application of Expert Systems for Solving Diagnostic Problems

The spectrum of applications of expert systems technology to industrial and commercial problems is so wide as to defy easy characterization. The applications find their way into most areas of knowledge work.

In [3] the Expert Systems DENDRAL is considered. Its purpose was the identification of the molecular structure of unknown compounds, a problem of considerable computational complexity. DENDRAL, unlike many of the early expert systems, found acceptance and is still in use by chemists all over the world in fact, for some tasks, DENDRAL is generally acknowledged as performing better than any human expert. DENDRAL utilizes production rules and was implemented in the LISP programming language. DENDRAL does not have an explanation facility. That is, it simply reaches a conclusion and this conclusion is presented to the user.

The HEARSAY-I and HEARSAY-II were developed at Carnegie-Mellon University. Specifically, the goal of the system was to have computer understand spoken input [4].

The input to the HEARSAY system is a speech waveform. From this waveform, a set of hypotheses about what may have been said is developed. A best guess from this set is then presented as the output.

One of the more innovative concepts developed by the HEARSAY project was that of the use of multiple knowledge bases. One important result of the HEARSAY project was the demonstration that an expert systems approach was superior to what had been the conventional approach to speech recognition. The conventional methodology relied upon statistical tools, that is, the analytical approach. Another result of HEARSAY was that it spawned several follow-on efforts dealing with the interpretation of several types of signals, in particular, acoustic signals such as those obtained through sonar contacts.

The goal of INTERNIST is to perform a diagnosis of the majority of diseases associated with the field of internal medicine [5]. This, in itself, is an ambitious endeavor as there are hundreds of such diseases. However, not only is INTERNIST/CADUCEUS intended to diagnose each disease, it is supposed to consider all the possible combination of diseases that might be present in the patient. It is estimated that the number of such combinations is on the order of 10 to the 40th power. Consequently, as in the case of DENDRAL, we are faced with a problem that exhibits combinatorial explosiveness; a problem for which the heuristic approach is most appropriate.

The MYCIN is the most widely known of all expert systems [6]. And this is despite the fact that it has never been put into actual practice. The particular role proposed for MYCIN was that of providing assistance to physicians in the diagnosis and treatment of meningitis and bactericidal infections. The knowledge base of MYCIN contains the heuristic rules used by physicians in the identification of certain infections. EMYCIN (for Empty MYCIN) is the name given to MYCIN when this specific knowledge base is removed. In many cases, one may collect a knowledge base associated with a different domain and insert this into EMYCIN, where the result is a new, working expert system.

The purpose of PUFF is to interpret measurements related to respiratory tests and to identify pulmonary disorders [7]. PUFF interfaces directly with the pulmonary test instruments used in such measurements. At the conclusion of the testing, PUFF presents the physician with its interpretation of the measurements, a diagnosis of the illness, and a proposed treatment scheme. PUFF is viewed as an ordinary piece of laboratory equipment, rather than as an intelligent competitor.

The XCON was developed for the configuration of VAX computers at the Digital Equipment Corporation (DEC) [8]. A VAX computer may be configured in an enormous number of ways, and DEC attempts to configure each computer according to the specific requirements of each customer. Such a problem might be thought of as a type of loading problem wherein a box is to be loaded with equipment to achieve a specific purpose. Of course, the combinatorial complexity of this problem is enormous and, as such, certain heuristic rules must be employed to reach an acceptable configuration within a reasonable time frame.

An Expert in the Maintenance of Diesel-Electric Locomotives system developed by the General Electric Company in the early 1980s [9]. The purpose of DELTA/CATS-l is to assist railroad personnel in the maintenance of General Electric's diesel-electric locomotives. The development effort began in 1981 and the first field prototype was completed in 1983. Over this period, the number of production rules increased from 45 to 1200. The system was originally developed in LISP and then converted to FORTH for increased transportability and speed of execution. Both forward and backward chaining is utilized. A particularly interesting feature of DELTA/CATS-l is its interface with visual support systems.

An Airline Gate Assignment and Tracking Expert System is being used by TWA to assist ground controllers in the assignment of gates to arriving and departing flights [10]. The knowledge base was acquired from an experienced ground controller who solved such problems on a daily basis. The gate assignment problem can become quite complex, and requires rapid solution during intervals of flight delays, bad weather, mechanical failures, and so forth. Optimization methods had been attempted but were simply unable to cope with the real-time demands of the problem. Thus GATES was developed, using PROLOG, and implemented on a personal computer. The system handles about 100 or more flights a day, have direct access to TWA's database, and can create gate assignments in about 30 seconds. Previously, the human experts had needed between 10 and 15 hours to prepare an assignment, and as much as an hour to modify the assignment each morning.

Medical Diagnostic Expert System using the massive knowledge base first developed for INTERNIST, QMR (quick, medical record) assists physicians in the diagnosis of an illness based upon the patient's symptoms, examination findings, and laboratory tests

[11]. QMR, which is resident at the University of Pittsburgh, incorporates over 4000 possible manifestations of diseases and is said to perform at a level comparable to practicing physicians.

The Chemical Bank does $750 billion a year in foreign exchange trading. This involves thousands of transactions a day with the paperwork resulting from such transactions weighing in at about 10 pounds per month. As such, the audit volume is well beyond the capabilities of unassisted human auditors. One particularly important type of audit is that of the recognition of irregular transactions. FXAA has been developed to provide [12] the necessary auditing assistance. FXAA is a rule-based expert system that has evidently made a major impact within Chemical Bank.

An Expert in Commodities Trading systems for stock and commodity trading, while it is still too early to assess the success or failure of these programs, they have attracted considerable attention, and customers [13]. Jonathan's Wave is just one of these, developed specifically for commodities futures and commodities futures options trading. Incorporated in the program are the knowledge bases of several approaches to commodities trading. Based upon their suggestions, and their past performance, the system determines the trades to be made. In this manner, the system acts somewhat as though it was using multiple experts to reach its conclusion.

The Insurance ExperTax is created to assist in the identification of tax planning and accrual issues. Through Insurance ExperTax, companies now have access to the knowledge and tax planning skills from across the country. Insurance ExperTax took more than a year to develop and consists of more than 3000 rules [14].

An Expert Scheduler for the Petrochemical Industry was developed to support of product scheduling at a major petrochemical firm's refinery [15]. The knowledge base in HESS was developed via the acquisition of heuristic rules from two refinery product schedulers. Their function was to determine what product, or products, to produce, at what time, and through which processors. Their performance was measured against the costs of production; production ruins (i.e., products that do not meet specifications and must be either recycled or downgraded), and lost customer sales. HESS was developed using the EXSYS expert system shell, and through a 12-month effort. HESS, which stands for hybrid expert system scheduler, consists of approximately 400 production rules and runs on an IBM PC or compatible. Not only does HESS accomplish the scheduling task previously done by the human expert, it does soon a much more consistent basis. Savings through the implementation of such a system, at a typical U.S. refinery, have been estimated (by refinery personnel) to be on the order of several million dollars each year. Despite this, the package has yet to be fully implemented as a result of the lack of access to the firm's databases.

An Expert in Poultry Farming system analyzes data from the poultry farm's environmental control system [16]. Using information on feed and water consumption, temperature, humidity, and ammonia levels, the system may be used to alert the farmer to any diseases the chickens have, or may get.

An Expert in Mine Safety replaces the limited number of human experts that assess the air quality of mining operations [17]. Based on the amount of coal and silica dust in the air, mining operations must be adjusted to ensure that safety requirements are satisfied. DustPro interfaces with monitoring systems (that monitor methane gas emissions and dust). It runs on a PC and takes about 15 minutes to reach a conclusion. The knowledge base' consists of roughly 200 rules.

An Expert in Security Classifications within the Department of Energy (DOE), there are more than 100 classification guides to nuclear weapon security data. One of the more onerous tasks within DOE is to attempt to correctly classify a given document through the use of these guides. Document classification determines who is permitted to view a document, and who is not-a potentially critical factor in national security. The knowledge base of this shell contains the rules from the classification guides that determine just how to classify a document (e.g., as confidential, secret, or top secret) and the system is being used to relieve the workload of the people previously assigned to this effort [18].

An Expert in Computer Program Assessment introduced an expert system for evaluation of C source codes [19]. Termed Code check, the package is a rule-based expert system that checks C source code for such things as complexity, formatting, and adherence to standards. A code that satisfies such checks is more likely to be maintainable and portable. Abraxas personnel note that the most common cause of hard to maintain software is the programmers' tendency to write overly complex code. Code check identifies those portions of the code that may be simplified. In addition, Code check evaluates the portability of the source code by comparing it with the numerous standards now existing for C programs and identifies any code that will not port between DOS, OS/2, UNIX, VMS and Macintosh.

Expert Systems for Faster, Fast Food Operations serve to reduce inventory, speed up service, and even act as training assistants [20]. Wendy's, for example, uses expert systems to plan faster and more efficient delivery of inventory-and plans to expand the package into a more far-reaching decision support system. McDonalds incorporates expert systems in its European operations that incidentally, are entirely PC-driven. Such packages provide valuable, timely assistance to managers who are neither familiar, nor entirely comfortable with the pace of activities in such operations. In a sector in which there exists such fierce competition, any improvement in cost reduction and enhanced operations can simply not afford to be overlooked.

In a few examples of expert systems, which are fairly representative of the bulk of applications thus far developed, are presented. That is, the majority of applications involve classification (diagnosis). For example, in the medical expert systems, we are given certain data (symptoms) with regard to a patient and attempt to diagnose the associated cause, disease. In maintenance applications, precisely the same type of problem faced. Here, the symptoms are the data on machinery performance while the diagnosis involves the identification of defective or failed components. Further, once a classification has been made, the specific class is matched to an associated treatment.

The remaining set of applications involves what is defined in this text as construction problems. XCON and HESS is representative of this type of application. Note that XCON attempts to construct a VAX computer, while HESS attempts to construct a schedule.

1.4 Advantages and Disadvantages of Expert Systems

Expert systems have a number of attractive features:

- Increased availability. Expertise is available on any suitable computer hardware. In a very real sense, an expert system is the mass production of expertise.

- Reduced cost. The cost of providing expertise per user is greatly lowered.

- Reduced danger. Expert systems can be used in environments that might be hazardous for a human.

• Permanence. The expertise is permanent. Unlike human experts, who may retire, quit, or die, the expert system's knowledge will last indefinitely.

• Multiple expertise's. The knowledge of multiple experts can be made available to work simultaneously and continuously on a problem at any time of day or night. The level of expertise combined from several experts may exceed that of a single human expert.

• Increased reliability. Expert systems increase confidence that the correct decision was made by providing a second opinion to a human expert or break a tie in case of disagreements by multiple human experts. Of course, this method probably won't work if the expert system was programmed by one of the experts. The expert system should always agree with the expert, unless a mistake was made by the expert. However, this may happen if the human expert was tired or under stress.

• Explanation. The expert system can explicitly explain in detail the reasoning that led to a conclusion. A human may be too tired, unwilling, or unable to do this all the time. This increases the confidence that the correct decision is made.

• Fast response. Fast or real-time response may be necessary for some applications. Depending on the software and hardware used, an expert system may respond faster and be more available than a human expert. Some emergency situations may require responses faster than a human and so a real-time expert system is a good choice [21].

• Steady, unemotional, and complete response at all times. This may be very important in real-time and emergency situations, when a human expert may not operate at peak efficiency because of stress or fatigue.

• Intelligent tutor. The expert system may act as an intelligent tutor by letting the student run sample programs and by explaining the system's reasoning.

• Intelligent database. Expert systems can be used to access a database in an intelligent manner [22].

The process of developing an expert system has an indirect benefit also since the knowledge of human experts must be put into an explicit form for entering into the computer. Because the knowledge is then explicitly known instead of being implicit in the expert's mind, it can be examined for correctness, consistency, and completeness.

The knowledge may then have to be adjusted or re-examined, which improves the quality of the knowledge.

There are some disadvantages of ES;

- There is no learning.
- It is not adaptive.
- It has not friendly GUI.
- Difficulty in engineering, especially acquiring the expertise.
- Mistrust by user.
- Effective only for narrow specific areas (areas of expertise).

1.5 Future Expert Systems

Most of the expert systems that have thus far been discussed in the literature are essentially stand-alone systems. However, in the very near future it is likely that a large portion of the expert systems that are developed will be embedded systems, that is, systems that form only part of the overall software package.

Another form of the embedded expert system is that of the so-called intelligent interface. Intelligent interfaces shall rely, more and more; on expert systems to be better achieve user friendliness in software. Such a system will immediately determine whether or not the user is a novice or expert, and its tailor actions accordingly. That is, the novice user will require more help, support, and guidance, while the more experienced user will need but minimal assistance.

Another trend that we expect to continue is the increased development expert systems-expert systems having 200 or fewer rules. This particular prediction is, however, somewhat, at odds with a commonly held belief of the AI community. A view may have made sense some years ago when expert systems development was somewhat of a trial and error process, and when much of the software for support had to be developed by one, and in a difficult language such as LISP, and with the support of expensive LISP machines. However, with the advent of powerful, inexpensive expert shells-and with implementation on the personal computer-the development of small expert systems is highly cost effective.

1.6 Summary

In this chapter we have reviewed the problems and developments that have led to expert systems. The problems for which expert systems are used are generally not solvable by conventional programs. Because of expert systems are knowledge-based systems, they can be effectively used for real-world problems that are ill-structured and difficult to solve by other means.

The advantages and disadvantages of expert systems were also discussed in the context of selecting an appropriate problem domain for an expert system application. Criteria for selecting appropriate applications were given.

CHAPTER TWO: ARCHITECTURE OF EXPERT SYSTEMS

2.1 Overview

Most expert systems are developed via specialized software tools called shells. These shells come equipped with an inference mechanism (backward chaining, forward chaining, or both), and require knowledge to be entered according to a specified format. They typically come with a number of other features, such as tools for writing hypertext, for constructing friendly user interfaces, for manipulating lists, strings, and objects, and for interfacing with external programs and databases. These shells qualify as languages, although certainly with a narrower range of application than most programming languages.

The structure of Expert systems and the functions of its main blocks are described. The inference engine mechanisms - forward and backward chaining mechanisms have been described.

2.2 The Structure of Expert System

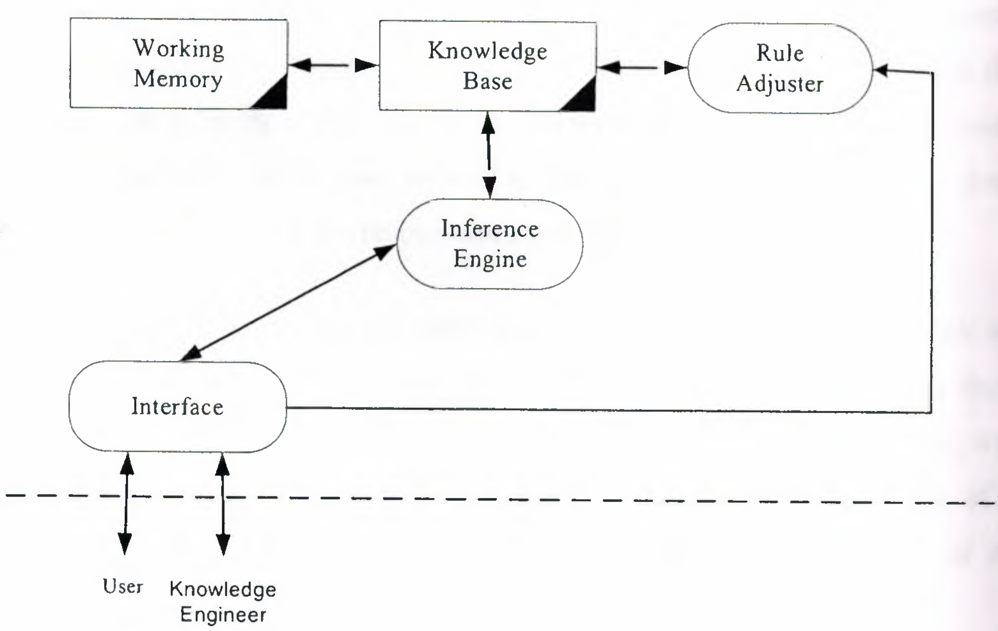

Figure 2.1 A genetic expert system.

One of possible representation of an expert system is given Figure 2.1. The components above the dashed line are those within the computer [23]. Below this line, access capabilities for two types of human users are noted. The first is that individual designated as the knowledge engineer. The knowledge engineer is also interface between human expert and the expert system. That is, the knowledge engineer somehow must capture the expertise of the human expert and in a format that may be stored in the knowledge base-and will be used by the expert system. In the ideal expert system, there would be no need for a knowledge engineer. The domain expert would interact directly with the expert system and would replace knowledge engineer in the figure 2.1. As discussed, the knowledge engineer is the person responsible for placing into the expert system's knowledge base; the portion of the expert system shown at the top of figure 2.1 He or she accomplishes this through the interface and rule adjuster.

The second type of individual with access to the expert system is designated; in figure 2.1 as simply the user. The designation refers to anyone who will be using the expert system as a decision making aid. And the successful knowledge engineer must always keep in the mind that the expert system is ultimately intended for the benefit of the user, not for that of the knowledge engineer or the domain expert.

The interface handles all input to the computer and controls and formats all outputs. The interface would handle such scores. A well-designed interface would be one that exhibits ease of use, even for the novice user. The interface also handles all communication with the knowledge engineer during the development of expert system's knowledge base. Another property that sometimes exhibited in expert system is that of explanation. That is, some expert system have limited ability to explain the reasons for the any questions asked of the user, as well as the rationale for the conclusion reached. Again this function would be the responsibility of the interface.

The inference engine serves as the inference and control mechanism for the expert system and, as such, is an essential part of the expert system as well as a major factor in the determination of the effectiveness and efficiency of such systems. Inference, in turn, is the process of drawing a conclusion by means of a set of rules, for a specific of facts, for a given situation. Inference is thus the knowledge processing element of expert systems.

The interface engine is employed during a consultation session. During consultation, it performs two primary tasks. First, it examines the status of the knowledge base and working memory so as to determine what facts are known at any given time, and what facts are known at any time, and to add any new facts that become available. Second, it provides for the control of the session by determining the order in which inferences are procedures and heuristic programming. In particular note that the knowledge base is separated from the inference engine. In other words, and unlike algorithms and heuristic programming, an expert system separates heuristic rules from the solution procedure. The knowledge base contains a description of "what we know". The inference engine contains a description of "what we do" to actually develop the situation. While the knowledge base changes from domain to domain, the inference engine remains the same.

2.3 Forward & Backward Chaining In Inference Engine

The inference engine is the generic control mechanism [24] that applies the axiomatic knowledge present in the knowledge base to the task-specific data to arrive at some conclusion. This is the second key component of all expert systems. Having a knowledge base alone is not of much use if there are no facilities for navigating through and manipulating the knowledge to deduce something from it.

As a knowledge base is usually very large, it is necessary to have inference mechanisms that search through the database and deduce results in an organized manner. A few techniques for drawing inferences from a knowledge base are described here.

2.3.1. Forward Chaining

Consider the following set of rules

Rule 1: IF **A** and **C**	THEN **F**
Rule 2: IF **A** and **E**	THEN **G**
Rule 3: IF **B**	THEN **E**
Rule 4: IF **G**	THEN **D**

Suppose it needs to be proved that **D** is true, given **A** and **B** is true. Start with Rule 1 and go on down till a rule that "fires" is found. In this case, Rule 3 is the only one that fires in the first iteration. At the end of the first iteration, it can be concluded that **A**, **B** and **E** are true. This information is used in the second iteration. This time Rule 2 fires adding the information that **G** is true. This extra information causes Rule 4 to fire, proving that **D** is true.

This is the method of forward chaining, where one proceeds from a given situation toward a desired goal, adding new assertions along the way. In expert systems, this strategy is especially appropriate in situations where data are expensive to collect, but few in quantity.

2.3.2 Backward Chaining

In this method, one starts with the desired goal, and then attempts to find evidence for providing the goal. Returning to the previous example, the strategy to prove that **D** is true would be as follows.

First, find a rule that proves **D.** Rule 4 does so. This provides a sub-goal to prove that **G** is true. Now Rule 2 comes into play, and as it is already known that **A** is true, the new sub-goal is to show that **E** is true. Here, Rule 3 provides the next sub-goal of providing that **B** is true. But the fact that **B** is true is one of the given assertions. Therefore, **E** is true, which implies that **G** is true, which in turn implies that **D** is true.

Backward chaining is useful in situations where the quantity of data is potentially very large and where some specific characteristic of the system under consideration is of interest. Typical situations are various problems of diagnosis, such as medical diagnosis or fault - finding in electrical equipment.

2.4 Summary

The inference engine contains, like the knowledge base, a set of rules. However, the rules in the inference engine are those used specifically to control the inference process, the process of determining a conclusion from the knowledge base, give a certain set of facts.

The brief introduction to algorithms for backward, forward and even mixed modes of chaining is given. The algorithms presented were purposely designed for manual use, and these methods are used to solve the problems at the end of the chapter.

CHAPTER THREE: KNOWLEDGE REPRESENTATION

3.1 Overview

"Knowledge is power". The knowledge that is contained within an expert system consists of priori knowledge: the facts and rules that are known about a specific domain prior to any consultation session with the expert system. Inferred knowledge: the facts and rules concerning a specific case that are derived during, and at the conclusion of, a consultation with the expert system.

In this chapter, the representation of these types of knowledge, and particular knowledge of the first type within the digital computer will be considered. In particular, our attention will be focused on the use of rule base for the representation of expert knowledge.

The knowledge is contained within ES is the expert system's knowledge base and working memory knowledge base. The knowledge within the knowledge base is that of the first type, a priori facts and rules about the specific domain. The knowledge within the working memory is dynamic as it changes for each problem addressed and is of the second type, that is, inferred knowledge about the particular problem under consideration.

In this section, briefly described will be the pertinent features of such modes of knowledge representation as OAV (object-attribute-value) triplets, semantic networks, frames, logic programming, and neural networks. To being, OAV triplets will be addressed. Not only are they a mode of knowledge representation in themselves, they also form the building blocks of virtually any other approach to knowledge representation.

Knowledge-based expert systems, or simply expert systems, use human knowledge to solve problems that normally would require human intelligence. These expert systems represent the expertise knowledge as data or rules within the computer. These rules and data can be called upon when needed to solve problems. Conventional computer programs perform tasks using conventional decision-making logic containing little knowledge other than the basic algorithm for solving that specific problem and the necessary boundary conditions. This program knowledge is often embedded as part of the programming code, so that as the knowledge changes, the program has to be changed and then rebuilt. Knowledge-based systems collect the small fragments of human know-how into a knowledge-base which is used to reason through a problem, using the knowledge that is appropriate. A different problem, within the domain of the knowledge-base, can be solved using the same program without reprogramming. The ability of these systems to explain the reasoning process through back-traces and to handle levels of confidence and uncertainty provides an additional feature that conventional programming doesn't handle.

3.2 OAV Triplets

Object-attribute-value triplets provide a particularly convenient way in which to represent certain facts within a knowledge base and may be extended to provide the basis for the representation of heuristic rules. Each OAV triplet is concerned with some specific entity, or object. For example, our object of interest might be an illness of human. Associated with every object is a set of attributes that serve to characterize that object. Using the illness of human as an example (i.e., as the object), some of its attributes include the following:

- Type of human
- Temperature of human (e.g., high or normal)
- Type of illness (e.g., Acute Adrenal Crisis)

For each attribute, there is an associated value, or set of values. Notice in particular that values in OAV triplets may be numeric or symbolic. We may list these facts as shown below:

If temperature is 39°C the illness is Acute Adrenal Crisis.

- Type of human = Child
- Temperatures of human= 39°C
- Type of illness = Acute Adrenal Crisis

Observe that, in this list, the object itself (child) is never explicitly stated. Actually, the above statements represent AV (attribute-value) pairs. However, associated with any AV pair is some object. Thus, any AV pair implies an OAV triplet.

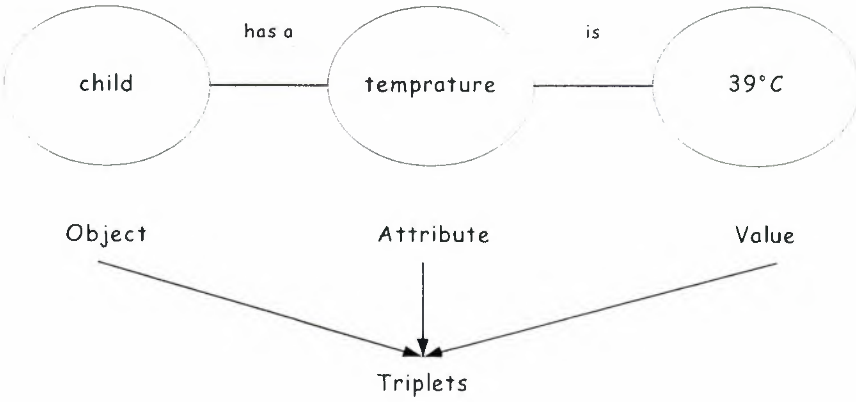

Figure 3.1 AOV triplets

3.3 Semantic Networks

A semantic network may be thought of as a network that is composed of multiple OAV triplets in network form. However, rather than pertaining to just one attribute for a single object, semantic networks may be used to represent several objects, and several attributes per object. Taking medical illustration, we might develop a partial semantic network as illustrated in figure 3.2. Here, the Gastritis is a special type of Abdominal Diseases. Further, since the Gastritis is an Abdominal Diseases, it inherits the properties associated with Gastritis in general. Such an inheritance property can prove to be of considerable value in the reduction of memory storage requirements. That is, since Gastritis is an Abdominal Diseases, there is no need to store, at the Gastritis node, the fact that it cans chronic gastritis, acute gastritis, and gastric ulcer. Thus, the semantic network scheme provides for a convenient approach for the representation of associations between entities. We might also note that the OAV triplet is actually just a restricted subset of semantic networks wherein the only relationships that may be used are those of "is-a" and "has-a." OAV nodes, in turn, may be any of three types: objects, attributes, or values.

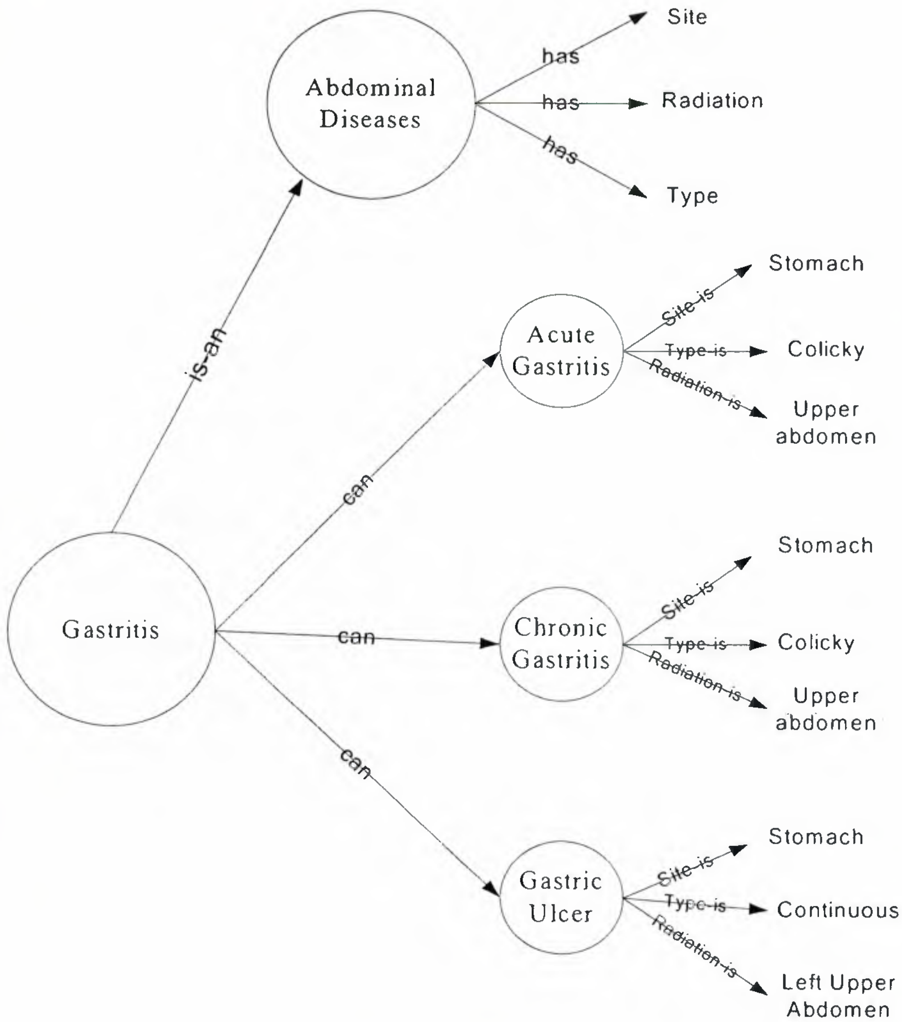

Figure 3.2 Semantic Networks

3.4 Frames

While semantic networks provide a relatively versatile means for knowledge representation, the use of frames represents an alternative approach that serves to capture most of the features of the semantic network while providing certain additional aspects. In fact, we may think of a semantic network as being a subset of the concept of frames.

The employment of frames represents a particularly robust way in which to present knowledge. A frame contains an object plus slots for any and all information related to the object. The contents of such slots are typically the attributes, and attribute values, of the particular object. However, in addition to storing values for each attribute, slots may contain default values, pointers to other frames, and sets of rules or procedures that may be implemented.

The primary drawback to the use of frames is, ironically, caused by the very robustness of such a mode of representation. As a result, to obtain any reasonable proficiency in the use of frame-based tools in expert systems, a lengthy training period is required. Despite such drawbacks, frames can prove quite useful, if not essential, in the design of large-scale, complex expert systems-particularly those involving a large amount of a priori facts (i.e., data) and multiple objects. While frames are not focused on in this text, it is strongly encouraged that the serious student investigates this topic-after he or she has attained a reasonable level of competence in the use of rule bases.

3.5 Representation via Logic Statements

The most common form of logic is that known as prepositional logic. A proposition, in turn, is a statement that may be either true or false. Propositions may be linked together with various operators (termed logical connectives) such as AND, OR, NOT, and EQUIVALENT. Linked propositions are termed compound statements.

Predicate calculus represents an extension of prepositional logic. The fundamental elements of predicate calculus are the object and the predicate. A predicate is simply a statement about the object, or a relationship that the object possesses. Predicates may address more than one object and may be combined by use of logical connectives.

One major advantage of the use of logic for knowledge representation is that logic-based languages, such as PROLOG, do exist. However, such languages have been criticized for a certain lack of flexibility a criticism that is becoming less valid with recent enhancements to their procedures. A more immediate and pragmatic drawback of the use of logic for knowledge representation is the fact that one must learn some logic programming language (e.g. PROLOG) in order to develop expert systems.

3.6 Neural Networks

Obviously, somehow, some way, the human brain stores knowledge. What is not so obvious is the precise manner in which this is accomplished. Neural networks represent mankind's attempt to replicate, in hardware, theories pertaining to the brain. Specifically, it is thought that knowledge is stored in neurons (or, actually, in the connections between neurons). Figure 3.3 depicts a simplified representation of only two neurons within the neural network of the human brain.

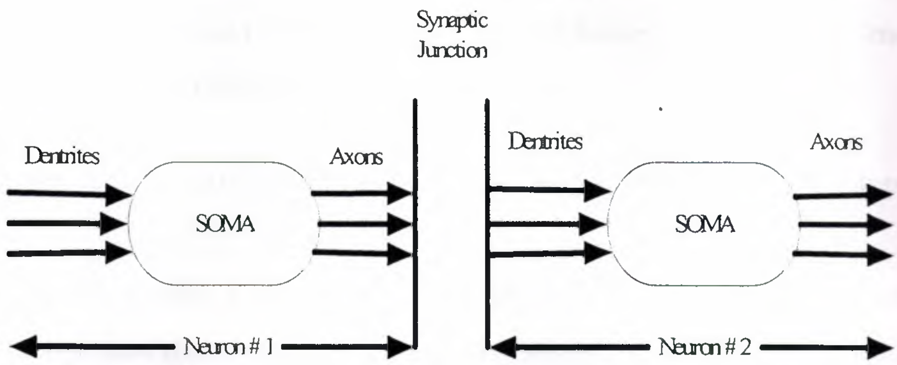

Figure 3.3 A portion of a neural network.

In the human brain there are more than 10 billion neurons, and each neuron is connected to one or more other neurons, resulting in a massively interconnected network. At each neuron, impulses are received by the dendrites and transmitted by the axons. If the output of the axon is at a high-enough level, the signal will jump the synaptic junction and trigger the connected neuron. It is believed that the weightings on each neuron-to-neuron interconnection, which in turn influence the level of strength of the interconnecting impulses, might then represent knowledge.

The attempts to duplicate the neural network structure of the brain have been, at best, extremely modest. Typically, electronic amplifiers are used to represent the neurons and resistors to correspond to the interconnecting weights. And existing systems have but a few layers of relatively few neurons. Despite this, neural networks can be used to accomplish some intriguing tasks, including some success in speech recognition. In particular, they provide a robust approach to the general problem of pattern recognition. Probably the biggest single disadvantage of the neural network approach to knowledge representation is the fact that any knowledge that exists is almost totally opaque.

3.7 Representation via Rule-Based Systems

The most popular mode of knowledge representation within expert systems, at least at this time, is the mode obtained through the use of rules, or rule-based systems. Alternatively, such rules are referred to as IF-THEN, or production rules. We have selected rule-based expert systems as our approach to knowledge representation for a number of reasons, including their popularity and widespread use. However, it should be stressed that this decision does not imply that rule-based systems are necessarily the best approach or, in particular, the best approach for every situation. There are those who present quite persuasive arguments for other approaches in particular for the employment of frame-based representation [24]. Choice of rule-based knowledge representation has been made for the following reasons:

- The majority of existing expert system is development packages employ rule bases.
- Rule-based expert systems development packages are normally much less expensive than those employing alternative modes of representation.
- The widespread availability of rule-based expert systems shells permits the knowledge engineer to focus his or her attention on the most critical phase of the development of an expert system, that is, on the knowledge base.
- Rules represent a particularly natural mode of knowledge representation. Consequently, the time required to learn how to develop rule bases is minimized.
- The learning curve for rule-based expert systems is much steeper than for any alternative mode of representation.
- Rules are transparent, and are certainly far more transparent than the modes of knowledge representation employed by rule-based systems two major competitors: frames and neural networks.
- Rule bases can be relatively easily modified. In particular, additions, deletions, and revisions to rule bases are relatively straightforward processes. And this is particularly so in the case of well-designed bases.
- Rule-based expert systems can be employed to mimic most features of frame based representation schemes.
- Validation of the content of rule-based systems is a relatively simple process. Similar validation of frames or neural networks, on the other hand, is normally difficult to impossible.

3.7.1 Production Rules: An Overview

Rule-based modes of knowledge representation employ what are termed production rules or, for short, simply rules. Such rules are typically of the IF- THEN variety. However, in some instances this is extended to include IF-THEN-ELSE rules. For example, let's consider simple IF- THEN-ELSE rule about abdominal disease as shown below:

Rule 1: *If* the child fever is 39°C or more

Then the diagnosis of the child disease is Acute Adrenal Crisis

Else, the diagnosis of the child disease is not Acute Adrenal Crisis

Which is equivalent to two IF-THEN rules or,

Rule 1a: *If* the child fever is 39°C or more

Then the diagnosis of the child disease is Acute Adrenal Crisis

Rule 1b: *If* the child fever is less than 39°C

Then the diagnosis of the child disease is not Acute Adrenal Crisis

For clarity of presentation, we shall focus primarily on just IF- THEN rules. In fact, it is generally advisable to avoid the use of ELSE statements in rule-based expert systems. This is true for three reasons. First, a number of commercial expert systems development packages simply do not permit the use of IF- THEN-ELSE rules. Second, validation of such rules is considerably more difficult than for their IF- THEN equivalents. Third, when encountered in the inference process, such rules will tend to always reach a conclusion. This can result in some unanticipated results. Thus, whenever one comes upon such a rule, we strongly advise the formation of the corresponding two equivalent rules. An alternate designation for IF- THEN rules is that of condition-action or premise-conclusion statements. The reason for this terminology should be obvious from the above example. That is, given the condition that a child has a fever of 39°C or more, we take the action of admitting the child to our diagnosis program. Production rules also contain OAV triplets. Returning again to our previous example and, specifically, to rule 1a, we may note that there is one OAV triplet implied in the IF, or premise, portion of the rule:

Object = child

Attribute = fever

Value = 39°C or more

And another OAV triplet is implied in the THEN, or conclusion, portion:

Object = child

Attribute = Acute Adrenal Crisis

Value = yes (i.e., the value to be assigned)

It is particularly important to notice the distinction between the values listed in a rule premise and those listed in a conclusion. In a rule premise, we are testing the value in the statement with any value provided. For example, in the premise to the above rule, we would test the child's actual fever value against the value of 39°C (or more). However, in the conclusion, we are assigning a value to an attribute. Referring again to the above rule, if the child fever is 39°C or more, we may then assign the value of yes to the attribute Acute Adrenal Crisis.

We should also realize that there might be several premise and conclusion statements within a single rule. Each of these is termed clauses (i.e., premise clauses and conclusion clauses). While premise clauses may be connected by AND as well as OR operators, the conclusion clauses may only be connected by AND statements. That is, all of the conclusion clauses in a production rule must be true. Clauses connected by AND operators are denoted as conjunctive clauses. Those connected by OR operators are termed disjunctive clauses. Premise of a rule, refers to the complete set of premise clauses-in whatever manner they may be connected. The same is true of a reference to the conclusion of a rule, except that in this case the only acceptable statements are either a single conclusion clause or a set of conjunctive clauses.

3.7.2 Attribute- Value Pair Properties

As noted, each premise and conclusion clause contains attributes and values. Further, there must be an associated object, either implied or explicit. Consider, for example, the rule shown below:

Rule 1: *If* child fever is equals or exceeds 39°C

Then diagnosis the disease is Acute Adrenal Crisis

In this rule, the attribute for the premise clause is fever point average, and the value to be tested against is 39°C or more. The object has not been specified, but is implied by the rule and/or the particular situation under consideration. That is, the implied object for the premise clause is a child. The same object just happens to be implied in the conclusion to this rule. When clauses contain only attributes and values, as in the case of the rule under discussion, they are sometimes called attribute-value, or AV, pairs. In the conclusion clause, the attribute-value pair is accept and into diagnosis program. Actually, this is a poor choice of wording for this conclusion. A better conclusion clause might be: ''then, child's fever is yes." While the English may not be quite as natural as before, this restatement permits us to more clearly isolate the attribute and the value. In the restatement, the attribute is clearly child's fever while the value to be assigned is yes. In general, rules should be written so that identification of the attribute and value is straightforward-while the rules remain intelligible. The AV pair is the fundamental building block of a premise or conclusion, and thus the fundamental building block of a production rule. Associated with, each AV pair is a set of properties. The most typical of these is summarized below:

Name: The name of the attribute is simply the wording selected to identify the attribute of the (explicit or implicit) object associated with the clause under consideration. For example, some of the attributes symptoms of a disease are; site, radiation, type, severity, onset and duration, aggravating factors, etc,

Type: Attribute values may be either numeric or symbolic. For example, the temperature of a patient may be given in degrees Fahrenheit-a numeric value. Alternatively, we might specify the temperature values to be symbolic, such as high or normal. Yet another set of symbolic values would be yes and no, for example, such as with respect to the presence or absence of some feature.

Prompt: Associated with certain attributes are user prompts, or queries. When necessary, the user replies to this prompt with a value for the attribute under consideration. Specifically, the only attributes that should normally be provided with prompts are:

- Attributes that appear in a premise statement and never appear in any conclusion statement of the rule set
- Attributes for which the user can conceivably provide a response

Legal Values: Associated with every attribute is a set of legal, or acceptable, values. For example, the legal values for a person's weight would simply be the set of nonnegative real numbers. If the user replies with a no legal value, this is detected and the user may be asked to reply again. In the case of expert systems that provide menu-driven prompts, the set of legal values is simply presented to the user and he or she can only select from that list.

Specified Values: Specified values indicate the actual set of values that are either to be tested against (i.e., in a premise clause) or that will be, or have been, assigned (i.e., in a conclusion clause). More specifically, we are concerned with whether or not multiple specifications are permitted. Multiple values may also be allowed (where, again, this is dependent upon the particular software package employed) for attributes that appear in conclusion clauses. In other words, it may be permitted to assign (i.e., conclude) multiple values to the attribute in a conclusion clause.

Confidence Factors: If the expert systems development package permits we may deal with uncertainty in either conclusions (i.e., the conclusion attribute values assigned) or premises (i.e., the premise attribute values used). In order to clarify the above discussion, let us examine rule 1, as presented earlier and restated below:

Rule 1: *If* child's fever exceeds 39°C

Then child's fever is yes

Referring to the AV pair of the premise of this rule, the associated properties are

- Name: child's fever
- Type: numeric
- Prompt: "What is the fever for this child?"
- Legal values: all numbers from 0 to 45 (i.e., where A = 45)
- Specified values: single (i.e., a given child has only a single fever)
- Confidence factors: none

If we examine the conclusion clause of this rule, the properties of the AV pair are

- Name: child's fever
- Type: symbolic
- Prompt: none (recall that no prompts need be provided for attributes that appear in conclusion clauses)
- Legal values: yes or no
- Specified values: single (i.e., the child is either accepted or rejected)
- Confidence factors: none

3.7.3 Clause Properties

As we have discussed, there are two types of clauses: premise clauses and conclusion clauses. Other properties associated with clauses are summarized in the list below:

- Single versus multiple (or compound) clauses
- Conjunctive versus disjunctive (multiple) clauses

- Free (premise) clauses
- Specified (premise) clauses (i.e., specified true or specified false)

Let us examine each of these properties in turn. First, a premise or conclusion may consist of a single clause or a set of clauses. In the latter instance, we are said to have multiple clauses. Multiple clauses, in turn, may be either conjunctive clauses (each clause connected by the AND operator) or disjunctive (each clause connected by the OR operator). However, recall that disjunctive clauses are not permitted in the conclusion of a rule. Also, note that the premise of a rule may be quite complex.

Another property of a clause is that associated with premise clauses only. This is the property of being either free or specified, and if specified, of being either true or false. If the value of a premise clause attribute is not yet known, that clause is designated as a free clause. Note most carefully that we have drawn a distinction between not yet known and unknown. We shall describe the implications of this distinction in the material to follow. If a clause is not free then such a clause is either true or false .To illustrates these notions, consider the following simple premise clause shown below:

If A = X

Now A must be some attribute for the object about which the clause is concerned. X is then one possible (legal) value for this attribute, and we must test this clause to see if a does indeed equal X. if we do not know the value for A, and have yet to seek this value, the clause is free. However, if we do know the value for A, and this value is indeed X, then the clause is true. Otherwise, the clause is false. The properties of free, true, or false would seem to be straightforward. And indeed they are; however a certain degree of confusion may occur when one employs unknown as an attribute value. Note carefully that we must differentiate between unknown and not yet known. Not yet known means that the value for a respective attribute has not yet been determined. Thus, the associated clause is free.

Unknown, however, can be employed in one of two ways. First, it may simply be a legal value for a given attribute. This means is that the premise clause is true, and the rule is triggered. The second manner in which unknown may be employed is slightly more complex, and a function of the specific mode of inference used by the software package. In this case, a value of unknown is assigned to an attribute whenever its value cannot be determined from the inference procedure.

3.7.4 Rule Properties

As with AV pairs and clauses, there are certain important rule properties. Some of the more typical rule properties include

Name: Each rule should have a distinct, as well as descriptive name. Specifically, rather than just labeling a rule by a number or letter (e.g., rule 1, rule A, and so on), it is best to label the rule with a name that serves to concisely describe the contents and/or purpose of that rule.

Premise: Every rule consists of one or more premise clauses. The complete set of premise clauses is termed the rule premise. A rule premise may consist of conjunctive or disjunctive clauses. When we refer to the status of a rule premise, realize that this is a function of the status of the collection of individual premise clauses.

Intermediate conclusions and conclusions: Every rule consists of one or more conclusion clauses. In the case of multiple conclusion clauses, the clauses must be conjunctive. There are, in turn, two types of rule conclusions: Intermediate conclusions and (final) conclusions. An intermediate conclusion is one that is the conclusion clause of one rule while also serving as a premise clause for another. A (final) conclusion clause is one that does not appear as a premise clause for any other rule.

Notes and reference: It is essential that a rule base be documented. While you, the developer, may know the reason and source of the rules, others will not. Further, with the passage of time, even the developer will find it difficult to recall the origin and specifics of each rule. Many development packages permit the inclusion of notes and references, and this is a feature that should most definitely be employed in any actual knowledge-base development.

(Rule) Confidence factors: When uncertainty is employed, we may associate confidence factors with each rule. The confidence factor of a rule's conclusion is a function of the confidence factors of the rule and the rule premise.

Priority and cost: In some development packages, we are permitted to assign a priority and/or cost to each rule. Such properties are normally employed as a means to decide, during the inference procedure, the specific rule to be dealt with at a particular instance. Typically, the procedure will select the rule with the highest priority or the lowest cost.

Chaining preferences: The inference process involves a search procedure. In some cases, the search moves in a forward direction-from premise (or facts) to conclusions. In others, the search moves backward-from a hypothesized conclusion to the premises necessary to infer that conclusion. However, in addition to such normal modes of search, or chaining, some development packages permit the employment of a mixture of search methods. In Such instances, we might label rules according to their preferred or default method of chaining, either backward or forward.

Rule status: During consultation, the status of each clause and rule is subject to change. Keeping track of such changes is an essential part of the inference process. We need to become acquainted with the terminology used. A summary of this terminology and associated definitions is provided below:

- The premise of a rule is true whenever a test has been made and it has been determined that the premise has been satisfied.
- The premise of a rule is false whenever a test has been made and it has been determined that the premise has not been satisfied.
- If the premise of a rule is true then that rule said to be triggered.
- If the premise of a rule is false then that rule may be discarded or, in some cases, made inactive.
- If a rule is fired then this implies that the action implied by the conclusion clause(s) is taken. The values associated with each attribute of the conclusion clauses for this rule have to be assigned.
- A rule that has been fired is no longer active. It is either discarded or, in some cases, made inactive.
- If a rule is to be fired, that rule must first have been triggered.
- If a rule has been neither fired nor discarded, that rule is designated as being active.

3.7.5 Rule Conversion: Disjunctive Clauses

While such conversations are not necessary in the general methodology of expert systems, they often make easier for the beginner to follow the inference process of an expert system when manual demonstrations are employed. Further some expert systems development packages do not permit the use of disjunctive premise clauses. However, such a conversion does result in an enlargement of the number of rules necessary to represent the knowledge base of an expert system. Despite this the beginner may be well advised to consider such a conversion –as well as determine the restrictions of the software that is to be used.

3.8 Summary

In this chapter, the knowledge representation techniques have been described. After a brief introduction to alternative modes of representation, we addressed the rule-based mode of knowledge representation. Here, the topics of concepts, terminology, and guidelines for rule base development were covered in some detail. However, as emphasized repeatedly, the development of the knowledge base is the most important task that the knowledge engineer performs.

Actually, the development of any real world expert system, the process of knowledge acquisition and knowledge representation go hand in hand. That is, we acquire some knowledge and then represent these heuristics by our specific choice of knowledge representation. Thus, and in an incremental manner, we gradually develop the complete knowledge base.

CHEPTER 4: DEVELOPMENT OF DIAGNOSTIC EXPERT SYSTEM FOR ABDOMINAL DISEASES

4.1 Overview

In this chapter, we consider the implementation of diagnostic expert system for abdominal diseases. To develop expert system for this problem we collect knowledge from experienced specialist and different references. On the base of collected information we have created knowledge base for diagnosis of abdominal diseases. Using ESPLAN the implementation of diagnostic expert system for abdominal diseases has been created.

4.2 Analysis of Abdominal Diseases

The establishment of proper medical diagnosis can be difficult for number of reasons, which may depend on the analysis of sources with different nature. Besides, the recognition of the difference between learned factual medical information and ability to apply this knowledge to solve clinical problem is another possible obstacle for right decision.

Each disease is characterized by number of input signs. In many cases the values of these signs are described by linguistic terms. ES computer program has been applied to solve these problems. ES has medical information, covering the description of possible diseases. After analyzing of input signs of diseases these ES make appropriate diagnosis.

4.2.1 Abdominal Pains

Abdominal pains of organic origin fall into two classes:

1. *Visceral Pains,* due to increased tension on the splanchnic nerve endings in the muscular wall of the affected viscus. This pain is deeply situated, some-times colicky in type, and is found most commonly in obstructive lesions of the intestines and bile ducts. A similar pain is found in obstruction of other tubes, particularly the ureter in cases of renal colic. When an organ is inflament, the threshold to visceral pain is lowered, and it may then be induced by a variety of stimuli.

2. *Referred Pains,* probably due in many cases to the irritative effects of inflammatory, haemorrhagic or neoplastic diseases of the abdominal viscera upon the parietal peritoneum. The parietal peritoneum in contact with the viscus receives its nerve supply from the same segments of the spinal cord as the overlying parts of the abdominal wall. This explains why pain and tenderness are experienced in many cases over the viscus, although the pain is referred. In other cases, as in the instance of shouldertip pain, the area of skin is situated remotely from the irritatedperitoneum. Here irritation of the peritoneum (or pleura) covering the central portions of the diaphragm, which receives its nerve supply from the phrenic nerve, causes the pain to be felt in an area supplied by other somatic nerves arising at the same level, over the tip of the shoulder. The pain of peritoneal irritation is mainly associated with deep tenderness and often with muscular rigidity. More constant than visceral pain, it is usually stabbing, cutting or burning in character.

An accurate description by the patient of his/her pain is of the greatest value in the diagnosis of digestive diseases. Special features of abdominal pains are [25];

1. *The situation.* From the preceding sections it follows that when pain is due to peritoneal irritation it is usually experienced over the affected viscus, but when truly visceral it may be more vaguely situated; in the case of gastrointestinal pain it is usually central. Visceral pain, as already pointed out, depends for its position on the embryological origin of the viscus.
2. *The character.* This includes the severity, which varies form the slight discomfort of gastric flatulence to the organizing pain of a perforated ulcer. The description of the type of pain – 'griping', 'gnawing', 'stabbing', 'cutting' and so forth – depends a good deal upon the intelligence and descriptive ability pf the patient; so too much stress cannot be laid upon it as a point in diagnosis. The distinction between visceral and somatic pain may be recognized from the patient's description.
3. *Conditions aggravating the pain.* Abdominal pains so frequently arises from the stomach, intestines or organs which modify the function of these that it naturally bears a close relationship to meals. Inquiry should be made whether the pain occurs after meals; if so for how long and whether it is relieved by taking more food. The patient should also be asked whether any particular kind of food disagrees with him and precipitates pain.

4. *Conditions relieving the pain.* The effect of starvation should be noted, or whether abstention from particular foods gives relief. Relief given by medicines, particularly antacids, may also be diagnostic. Comfort produced by evacuation of the bladder or rectum may suggest these organs as the source of pain.
5. *Duration.* If the pain comes on after meals, the patient should be asked whether it disappears before the next meal or whether it is continuous. In apparently continuous pain there are often spells which patient is comparatively comfortable. Intervals of freedom from the attacks of pain should be also noted. It is characteristic, for example, in gastric and duodenal ulcer to find periods of some weeks in which the patient is entirely free from discomfort. On the contrary, pain due to gastric and other visceral carcinomas often starts gradually and becomes more severe and continuous as time goes on. Pain of short duration is more likely to be due to obstructive causes such as renal or biliary colic than to inflammation or neoplasm.
6. *Associated phenomena.* Indications of the severity of the pain and its reflex effects are often seen in the association of vomiting, sweating and collapse. Severe pain, especially due to peptic ulcer, may wake the patient at night. It should be noted whether vomiting gives relief from the pain, a common history in cases of gastric diseases. The association of constipation or diarrhoea with abdominal pain should focus attention on the intestinal tract. Fever suggests an inflammatory lesion such as appendicitis, cholecystitis or cholangitis complicating bile duct obstruction by stone. The combination of fever with rigors, jaundice and abdominal pain is characteristic of ascending cholangitis usually caused by a bile duct stone.

4.2.2 Vomiting

Vomiting is another symptom common to so many diseases of the digestive and other systems that it is convenient to describe it before proceeding further [26]. It is a reflex act induced through the vomiting centre of the medulla and may be caused by central or peripheral stimulation. Central stimulation of the vomiting centre may occur from external causes such as disgustingsmels or sights or from increased intracranial pressure as in cerebral tumour. It may arise reflexly from labyrinthine disturbances, e.g. in seasickness and Meniere's disease. It is also a fairly constant symptom in the early months of pregnancy and may arise from metabolic cases such as uraemia and hypercalcaemia.

However, in this document we are concerned with vomiting due to primary disorders of the digestive system. It is common as ulcer or cancer, in reflex disturbance of the stomach from disease of the pylorus or small intestine is obstructed. In pyloric stenosis there may be food remnants recognizable as several days old and in intestinal obstruction the vomitus may be faeculent due to bacterial invasion.

Special feature of vomiting are;

1. *The relationship of the vomiting to any pain.* Note whether the pain precedes or follows the vomiting and at what interval.
2. *The time of day at which vomiting occurs.* In cases of pyloric stenosis, each meal adds to the gastric contents, and vomiting may not occur until the latter part of the day when a large quantity has accumulated. The vomiting of pregnancy and alcoholic gastritis occur characteristically in the mornings.
3. *The presence or absence of nausea.* Nausea generally precedes vomiting due to diseases of the digestive system, but in cases of increased intracranial pressure is often absent.

Characteristic of some diseases are reference on tables 4.1, 4.2, 4.3, 4.5, 4.5.

	Perforation	Appendicitis	Acute haemorrhagic pancreatitis	Gallbladder colic	Renal colic	Large-bowel obstruction (complete)	Small-bowel obstruction
site	Epigastric	Umbilical	Epigastrium or right hypochond-rium	Right hypochond-rium and epigastrium	Loin	Hypogast-ric	Umblical
Radiation	Whole abdomen and left shoulder	Right iliac fossa later	Back and whole abdomen	Right scapula	Towards groin	Flanks	Nil
Type	Sharp	Colicky, becoming constant	Constant	Colicky or continuous	Colicky	Colicky	Colicky
Severity	Very	Severe	Very severe	Very severe severe	Very severe	Severe	Severe
Onset and duration	Instantaneo us and persistent	Fairly rapid onset, many hours	Sudden and persistent hours	Sudden, lasting hours	Sudden, minutes to	Slow onset, lasting days	Fairly rapid onset, hours to days
Aggravating factors	Movement	Walking causing movement of the iliopsoas behind inflamed viscus	Nil	Nil	Jolting	Nil	Nil
Relieving factors	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Associated symptoms	Shock and vomiting	Vomiting, fever	Vomiting and shock	Vomiting and sometimes fevers with rigors	Vomitin g, frequen cy, haema-turia	Constipatio n. Vomiting at a late stage	Vomiting
Pyhsical signs	Board-like rigidity	Tenderness and guarding in right iliac fossa	Abdomen rigid after initial softness	Tenderness in right hypochondri um Transient jaundice	Nil	Flank distension, increased bowel sounds. Rectum ballooned and empty	Central distension. Bowel sounds increased Rectum ballooned and empty
Investiga-tions	Air under diaphragm seen on radiograph	Nil	Increased serum and urinary amylase	Cholecysto-gram or ultrasound may show calculus	Radiogr aph may show calculus	Intestinal fluid levels on radiograph	Intestinal fluid levels on radiograph

Table 4.1 Analysis of severe abdominal pain

4.3 Type of Severe Abdominal Pains

4.3.1 Diagnosis of the Appendicitis

The appendix is a small, tube-like structure attached to the first part of the large intestine, also called the colon. The appendix is located in the lower right portion of the abdomen. It has no known function. Removal of the appendix appears to cause no change in digestive function.

Appendicitis is an inflammation of the appendix. Once it starts, there is no effective medical therapy, so appendicitis is considered a medical emergency. When treated promptly, most patients recover without difficulty. Appendicitis is the most common acute surgical emergency of the abdomen. Anyone can get appendicitis, but it occurs most often between the ages of 10 and 30.

Symptoms: Symptoms of appendicitis may include: pain in the abdomen, first around the belly button, then moving to the lower right area, loss of appetite, nausea, vomiting, constipation or diarrhea, inability to pass gas, low fever that begins after other symptoms and abdominal swelling.

Diagnosis: Asking questions to learn the history of symptoms and a careful physical examination are key in the diagnosis of appendicitis. The doctor will ask many questions much like a reporter trying to understand the nature, timing, location, pattern, and severity of pain and symptoms. Any previous medical conditions and surgeries, family history, medications, and allergies are important information to the doctor. Use of alcohol, tobacco, and any other drugs should also be mentioned. This information is considered confidential and cannot be shared without the permission of the patient.

Before beginning a physical examination, a nurse or doctor will usually measure vital signs: temperature, pulse rate, breathing rate, and blood pressure. Usually the physical examination proceeds from head to toe. Many conditions such as pneumonia or heart disease can cause abdominal pain. Generalized symptoms such as fever, rash, or swelling of the lymph nodes may point to diseases that wouldn't require surgery.

Examination of the abdomen helps narrow the diagnosis. Location of the pain and tenderness is important. Pain is a symptom described by a patient; tenderness is the response to being touched. Two signs, called peritoneal signs, suggest that the lining of the abdomen is inflamed and surgery may be needed: rebound tenderness and guarding. Rebound tenderness is when the doctor presses on a part of the abdomen and the patient feels more tenderness when the pressure is released than when it is applied. Guarding refers to the tensing of muscles in response to touch. The doctor may also move the patient's legs to test for pain on flexion of the hip, pain on internal rotation of the hip, or pain on the right side when pressing on the left. These are valuable indicators of inflammation but not all patients have them.

4.3.2 Diagnosis of Diseases of the Pancreas

Pancreatitis: In acute pancreatitis there is intense agonizing upper abdominal pain with shock due to extravasation of blood and pancreatic secretions into the peritoneal cavity. An abdominal catastrophe is confirmed by the findings of severe tenderness and muscular rigidity and the diagnosis suggested by a raised serum amylase.

Chronic pancreatitis is nearly always alcoholinduced. The cardinal features are pain, exocrine insufficiency and endocrine insufficiency. The pain may be particularly severe and unrelenting, situated in the central abdomen, often radiating through to the back and eased by leaning forward.

Special Investigations: Diseases of the pancreas, especially alcogolic chronic pancreatitis, are sometimes associated with calcification and this can be demonstrated in a plain radiograph of the abdomen. A barium meal may reveal widening of the duodenal loop in cause of carcinoma of the head of the pancreas. Other techniques for delineating the physical control of the pancreas include the use of ultra-sound, computerized pixel tomography and celiac axis angiography. The anatomy of the pancreatic duct system can be he demonstrated by annulations of the ampulla's of Vater and introduction of contrast medium at the time of fibreoptic duodenoscopy. In the disease of the pancreas, there may be a deficiency of enzymes in the bowel as a result of obstruction to the pancreatic duct or an excess of enzymes, e.g. amylase or lipase, in the blood and urine due to leakage from pancreatic cells. A lack of lipase in the bowel leads to steatorrhoea due to excess of neutral fats in the stool, while lack of trypsin causes deficient protein digestion with the appearance in the stool of striated muscle fibers. Normally only small amounts of pancreatic digestive enzymes find their way into the bloodstream and appear in the urine, pancreatic secretion can also be obtained for analysis by aspirating the duodenal contents after the injection of a pancreatic stimulant.

4.3.3 Diagnosis of Diseases of the Gallbladder and Bile Ducts

Cholecystitis: Inflammation of the gallbladder commonly results from gallstones, and its symptoms are often combined with those due to calculi. Occasionally acute cholectstitis may occur without stones-acute acalculous cholecystitis. This is usually a surgical emergency terminating in gallbladder gangrene, and may be a complication of severe burns or follow major surgery.

Pain in the right hypochondrium and at the inferior angle of the right scapula is common. If the patient takes a slow, deep breath whilst the examiner's fingers are pressed firmly but gently over the right hypochondrium, there may be momentary interruption of breathing because of pain. Acute cholecystitis is accompanied by constitutional disturbances such as fever and leucocytosis, and on palpation there may be marked tenderness and guarding. The significance of the classical gallbladder symptoms of fat intolerance, flatulent dyspepsia and abdominal discomfort is now doubtful.

In acute cases greater constitutional disturbances such as pyrexia and leucocytosis are present together with more pronounced tenderness and guarding.

Gallstones: There may produce the symptoms of cholecystitis just described. If a stone lodges in the neck of the gallbladder or passes into the cystic or common guile duct, a characteristic attack of biliary colic results. Obstruction of the common bile duct gives rise to jaundice. Although gallbladder carcinoma is rare, when it is seen it is almost always in a gallbladder containing calculi.

Special Investigations: The diagnosis of calculus gallbladder disease is made either by ultrasonography or cholecystography. About 20 percent of calculi are calcified and will therefore show up on a plain abdominal radiograghy. If a stone is occluding the cystic duct, contrast material in bile cannot enter the gallbladder and it will be reported on oral cholecystography to be 'non-funtioning'. Other causes of failing to opacity the gallbladder are poor hepatic function or jaundice and failure to swallow or absorb the cholecystogram tablets.

The bile ducts may be seen on ultrasound or CT scan but direct cholangiography is often necessary, and three methods are available. Intravenous cholangiography rarely gives a clear diagnosis, and is unsuccessful if there is more than minimal jaundice.

Endoscopic retrograde cholangiography (ERCP) and *percutaneous cholangiography* (PTC) give excellent visualization of the biliary system, although PTC may be difficult if the ducts are not dilated.

	Acute Pancreatitis	Chronic Pancreatitis	Gallstone	Acute appendicit-is	Acute Cholecystit-is	Abdominal Aortic Aneurysm	Ectopic Pregnancy
Site	Epigastrium RUQ	Upper abdomen	Middle of the upper abdomen	Lower-right abdomen	Epigastric	Lower-back abdomen	Lower abdomen
Radiation	Back abdomen	Back abdomen	Back between the shoulder	Right scapula	Right scapular	Groin, buttocks	Shoulder
Type	Constants	Continuous	Colicky	Sharp	Continuous	Continuous	Sharp
Severity	Severe	Scarring and pain	Increase rapidly	More severe	Severe	Severe	Severe
Onset and duration	Persistent lasting for days	Last from hours to days	Last from 30 minutes to several hours	Occurs within several hours	Occurs within minutes following meals	Persistent or sudden	Sudden
Aggravating factors	When food is eaten	Eating a high carbohydrate, alcoholism, low-fat diet	Fatty or greasy foods	Walking or coughing	After eating or drinking or fluids greasy foods	Nil	Nil
Relieving factors	Nil	Nil	Nil	Lying with knees pulled up to abdomen	Nil	Nil	Nil
Associated symptoms	Nausea, vomiting, fever,	Nausea or vomiting	Nausea and vomiting	Nausea or vomiting	Nausea, vomiting, heartburn	Rapid pulse, shock and skin	Nausea
Physical Signs	Abdominal distension or rigidity	Serum amylase fecal fat test	Nil	Rebound tenderness	Jaundice	Nil	Nil
Investigations	Abdominal ultrasound to look for gallstone	Abdominal ultrasound	Abdominal ultrasound	CBC shows increased white blood cell count	CBC shows infection by an elevated white blood cell count	Abdominal X-ray	Pregnancy test

Table 4.2 Analysis of abdominal pain

4.4 Types of Abdominal Pains

4.4.1 Diagnosis of the Acute Pancreatitis

Some people have more than one attack and recover completely after each, but acute pancreatitis can be a severe, life-threatening illness with many complications. About 80,000 cases occur in the United States each year [27]; some 20 percent of them are severe. Acute pancreatitis occurs more often in men than women.

Acute pancreatitis is usually caused by gallstones or by drinking too much alcohol, but these aren't the only causes. If alcohol use and gallstones are ruled out, other possible causes of pancreatitis should be carefully examined so that appropriate treatment if available can begin.

Symptoms: Acute pancreatitis usually begins with pain in the upper abdomen that may last for a few days. The pain may be severe and may become constant-just in the abdomen or it may reach to the back and other areas. It may be sudden and intense or begin as a mild pain that gets worse when food is eaten. Someone with acute pancreatitis often looks and feels very sick. Other symptoms may include; swollen and tender abdomen, nausea, vomiting, fever, rapid pulse.

Severe cases may cause dehydration and low blood pressure. The heart, lungs, or kidneys may fail. If bleeding occurs in the pancreas, shock and sometimes even death follow.

Diagnosis: Besides asking about a person's medical history and doing a physical exam, a doctor will order a blood test to diagnose acute pancreatitis. During acute attacks, the blood contains at least three times more amylase and lipase than usual. Amylase and lipase are digestive enzymes formed in the pancreas. Changes may also occur in blood levels of glucose, calcium, magnesium, sodium, potassium, and bicarbonate. After the pancreas improves, these levels usually return to normal.

A doctor may also order an abdominal ultrasound to look for gallstones and a CAT scan to look for inflammation or destruction of the pancreas. CAT scans are also useful in locating pseudocysts.

4.4.2 Diagnosis of the Chronic Pancreatitis

Alternative names: chronic relapsing pancreatitis. Definition of these daisies is a persistent inflammation of the pancreas, an elongated, tapered gland that is located behind the stomach and secretes digestive enzymes and the hormones insulin and glucagons.

Symptoms: Abdominal pain, greatest in the upper abdomen, may be in the middle of the upper abdomen, may last from hours to days, eventually may be continuous, may be worse by eating or drinking, may be worse from alcohol, may radiate to the back, nausea , vomiting, weight loss, fatty stools.

Signs and tests: Serum lipase may be elevated, serum amylase may be elevated, serum trypsinogen may be low and fecal fat test shows fatty stools.

4.4.3 Diagnosis of the Gallstones and Gallbladder Disease

Alternative names are Cholecystitis, Choledocholithiasis, Common Bile Duct Stones, and Lithotripsy.

Diagnosis: The diagnostic challenge posed by gallstones is to be sure that abdominal pain is caused by stones and not by some other condition. Ultrasound or other imaging techniques usually detect gallstones readily. Nevertheless, because gallstones are common and most cause no symptoms, simply finding a stone does not necessarily explain a patient's pain, which may be caused by numerous other ailments.

4.4.4 Diagnosis of the Acute Appendicitis

Alternative name is appendicitis. It is a sudden inflammation of the appendix. The appendix is a narrow, small, finger-shaped tube that branches off the large intestine.

Symptoms: Abdominal pain; pain may begin in the upper-middle abdomen (epigastric), then develop to sharp localized pain, pain may shift from the epigastric area to become most intense in the lower right side of the abdomen ("typical" presentation), tenderness of this area is common, pain initially may be vague, but getting increasingly more severe, point tenderness, abdominal pain may be worse when walking or coughing, nausea and vomiting, fever usually occurs within several hours, the patient may prefer to lie with knees pulled up to abdomen to relieve muscletension on the abdomen.

Signs and tests: Appendicitis may be strongly suspected based on the following tests:

An abdominal sonography may show appendicitis. A CBC shows increased white blood cell count. An abdominal X-ray may or may not show signs of appendicitis. The diagnosis may be confirmed by the surgeon during an exploratory laparotomy.

4.4.5 Diagnosis of the Acute Cholecystitis

A sudden inflammation of the gallbladder that causes severe abdominal pain.

Symptoms: Abdominal fullness, gaseous, abdominal pain; severe, located on the right side (right upper quadrant) or in the upper middle of the abdomen (epigastric), may subside over 12 to 18 hours in uncomplicated cases, recurrent or with similar pain in past, occurs within minutes following meals, during deep inspiration, radiating to back or below the right shoulder blade (right scapular area), worsened after eating or drinking greasy (high fat) foods or fluids, fever, nausea, vomiting, jaundice, yellow color of the skin, heartburn, chills and shaking, chest pain under the breastbone.

Signs and tests: Examination of the abdomen by touch (palpation) reveals tenderness. Tests that detect the presence of gallstones or inflammation include are: Abdominal ultrasound, abdominal CT scan, abdominal X-ray, oral cholecystogram, gall bladder radionuclide scan. A CBC shows infection by an elevated white blood cell count.

	Choledec-holithiasis (Bile Calculus)	Chronic Gastritis	Functional Bowel	Mesenteric Artery Ischemia	Kidney Infection (Pyelonephritis)	Gastric Ulcer	Pacreatitic Cancer (Carcinoma)
site	Middle of the upper abdomen	Upper abdomen	Abdomen	Abdomen	Abdomen	Stomach	Pancreatitis
Radiation	Right shoulder	Nil	Back between the shoulder	Abdomen	Back abdomen	Left upper abdomen	Upper abdomen
Type	Sharp	Colic	Intermittent	Sharp	Occurs occasion ally	Continuous	Continuous
Severity	Recurrent	Nil	Severe	Severe	Severe	Intense	Severe
Onset and duration	Occurs within minutes following meals	Sudden	Nil	Sudden	Persist for more than 2 days	Occurs 2 to 3 hours after a meal	Intermittent
Aggravating factors	Eating fatty or greasy foods	After eating	After eating	After eating	Nil	Not eating	Nil
Relieving factors	Nil	Nil	Bowel movement	Nil		Antacids or milk	
Associated symptoms	Nausea, vomiting, fever, Loss of appatite	Nausea and vomiting	Nausea and vomiting	Vomiting and diarrhea	Vomiting, fever, nausea, heartburn	Nausea, vomiting, fever	Vomiting, diarrhea
Physical Signs	Jaundice	Nil	Nil	Jaundice	Jaundice	Pale	Jaundice
Investiga-tions	Abdominal ultrasound	EGD and biobsy showing gastritis	Test usually reveal no abnormalities	ACT scan may show abnormalitie s of the vesseli and the intestine	CBC shows infection by an elevante d white blood cell count	Voiding Cystourethro -gram	Abdominal CT scan

Table 4.3 Analysis of abdominal pain

4.5 Types of Abdominal Pains

4.5.1 Diagnosis of the Choledocholithiasis

Alternative names are Gallstone in the bile duct, Bile duct stone, Bile calculus, and Biliary calculus.

Symptoms: Abdominal pain in the upper right quadrant or the middle of the upper abdomen, may radiate to the right shoulder, may be sharp or cramping or dull, may be recurrent, may radiate to the back, Made worse by eating fatty or greasy foods, Occurs within minutes following meals, nausea, vomiting, fever, jaundice, loss of appetite.

Signs and tests: Tests that show the location of stones in the bile duct include the following: ERCP (endoscopic retrograde cholangiography), abdominal CT scan, abdominal ultrasound, percutaneous transhepatic cholangiogram (PTCA).

4.5.2 Diagnosis of the Gastritis – Chronic

Alternative names are chronic gastritis.

Symptoms: Upper abdominal pain, possibly aggravated by eating, abdominal indigestion, loss of appetite, nausea, vomiting, vomiting blood or coffee-ground like material, dark stools [28].

Signs and tests: EGD (esophagogastroduodenoscopy) and biopsy showing gastritis, CBC showing anemia, and a guaiac stool test.

4.5.3 Diagnosis of the Irritable Bowel Syndrome (Functional Bowel)

Alternative names are Pylorospasm, Nervous indigestion, Spastic colon, Intestinal neurosis, Functional colitis, Irritable colon, Mucous colitis, Laxative colitis, and Functional dyspepsia.

Symptoms: Diarrhea alternating with constipation for 6 months or more, abdominal pain, following meals, relieved by bowel movement, intermittent, abdominal tenderness abdominal fullness, gas, bloating, abdominal distention, nausea, vomiting, loss of appetite, emotional distress, depression.

Signs and tests: Tests usually reveal no abnormalities. Not all patients require endoscope, especially if symptoms begin early in life and have been stable. Patients who have irritable bowel symptoms beginning later in life usually require endoscope. Patients over age 50 should be screened for colon cancer. Younger patients with persistent diarrhea may require endoscope to rule out inflammatory bowel disease, which is an autoimmune disorder and is not the same as irritable bowel syndrome.

4.5.4 Diagnosis of the Mesenteric Artery Ischemia

Alternative names are Mesenteric Vascular Disease.

Symptoms: Chronic mesenteric ischemia caused by atherosclerosis is commonly associated with chronic abdominal pain after eating, and occasionally, diarrhea. Acute mesenteric ischemia due to an embolus is frequently associated with sudden onset severe abdominal pain, vomiting, and diarrhea.

Signs and tests: Laboratory tests may show an elevated white blood cell (WBC) count and acidosis in the case of acute mesenteric ischemia. A CT scan may show abnormalities of the vessels and the intestine. A mesenteric angiogram, a test in which dye is injected into the arteries of the intestine and x-rayed, is usually done. This can reveal the location of the blockage in the artery.

4.5.5 Diagnosis of the Kidney Infection (Pyelonephritis)

Pyelonephritis is an infection of the kidney and the ducts that carry urine away from the kidney (ureters). Alternative names are Urinary tract infection – complicated, Infection-kidney, complicated urinary tract infection, and Pyelonephritis.

Symptoms: Flank pain or back pain, severe abdominal pain (occurs occasionally), fever, higher than 102 degrees fahrenheit, persists for more than 2 days, chills with shaking, warm skin, flushed or reddened skin, moist skin (diaphoresis), vomiting, nausea, fatigue, general ill feeling, urination, painful, urinary frequency/urgency, increased, need to urinate at night (nocturia) , cloudy or abnormal urine color, blood in the urine, foul or strong urine odor, mental changes or confusion .

Signs and tests: A urinalysis commonly reveals white blood cells (WBCs) and/or red blood cells (RBCs). A urine culture or urine culture (catheterized specimen) may reveal bacteria in the urine. A blood culture may show an infection. An intravenous pyelogram (IVP) or CT scan of the abdomen may show enlarged kidney(s) with poor flow of dye through the kidneys. (IVP and CT scan of the abdomen can also indicate underlying disorders.

	Cholangiocarcinoma (Bile duct cancer)	Chronic Renal failure	**Low Back Pain & Herniated Disk**	**Diverticulitis**	**Acute Adrenal Crisis**	**Acute Unilateral Obstructive uropathy**	**Amebic Liver Abscess**
site	Right upper abdomen	Back Abdomen	Back Abdomen	Left-lower abdomen	Abdomen	Lower quadrant	Right upper abdomen
Radiation	Back abdomen	Nil	Gluteal area	Nil	Nil	Groin, genitals, thigh	Abdomen
Type	Continuous	Sharp	Sharp	Continuous	Sharp	Colicky	Continuous
Severity	Severe	Very severe	Severe	Nil	Severe	Severe	Intense
Onset and duration	Slowly	slowly	Periodic	Nil	Sudden	Periodic and changing intensity over minutes or spasmodic	Stabbing
Aggravating factors	Nil	Nil	Nerve root irritated in anyone place	Nil	Nil	Nil	Nil
Relieving factors	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Associated symptoms	Fever, weight loss, itching	Excessive thirst, loss of appatite, blood in the vomiting	Nil	Nausea and vomiting, fever, chills	High fever, fatique, vomiting, headache, nausea, shacking chills	Nausea, vomiting, fever, Blood in the urine	Weight loss, chills, sweating, loss of appatite
Physical Signs	Progressive jaundice	Blood pressure	Blood pressure may be high, with mild to severe bypertension	Nil	The baseline cortisol level is low	High blood pressure that has increased recently	Jaundice
Investigations	Abdominal ultrasound	Renal ultrasound X-ray	Blood test or X-ray	Elevated white blood cell count	ACTH stimulation test shows low corticol	Abdominal ultrasoun	Liver scan

Table 4.4 Analysis of abdominal pain

4.6 Types of Abdominal Pains

4.6.1 Diagnosis of the Cholangiocarcinoma

Alternative name is Bile duct cancer.

Symptoms: Stools, clay colored, progressive jaundice, itching, right upper abdominal pain that may radiate to the back, loss of appetite, weight loss, fever, chills.

Signs and tests: Tests that show tumor or obstruction in the bile duct [29]:

ERCP (endoscopic retrograde cholangiopancreatography), percutaneous transhepatic cholangiogram (PTCA), abdominal CT scan, abdominal ultrasound, CT scan directed biopsy, cytology (examination of the cells obtained from either a CT biopsy or ERCP) that shows cholangiocarcinoma.

4.6.2 Diagnosis of the Chronic Renal Failure

Alternative name are kidney failure – chronic, renal failure – chronic, chronic renal insufficiency, CRF, and chronic kidney failure.

A gradual and progressive loss of the ability of the kidneys to excrete wastes, concentrates urine, and conserves electrolytes.

Symptoms: Unintentional weight loss, nausea, vomiting, general ill feeling, fatigue headache, frequent hiccups, generalized itching (pruritus) are initial symptoms. Later symptoms are increased or decreased urine output, need to urinate at night, easy bruising or bleeding, may have blood in the vomit or in stools, decreased alertness, drowsiness, somnolence, lethargy, confusion, delirium, coma, muscle twitching or cramps, seizures, increased skin pigmentation-skin may appear yellow or brown uremic frost-deposits of white crystals in and on the skin, decreased sensation in the hands, feet, or other areas.

Signs and tests: Blood pressure may be high, with mild to severe hypertension. A neurologic examination may show polyneuropathy. Abnormal heart or lung sounds may be heard with a stethoscope. A urinalysis may show protein or other abnormalities. An abnormal urinalysis may occur 6 months to 10 or more years before symptoms appear.

Creatinine levels progressively increase, BUN is progressively increased, Creatinine clearance progressively decreases, Potassium test may show elevated levels, Arterial blood gas and blood chemistry analysis may show metabolic acidosis.

4.6.3 Diagnosis of the Diverticulitis

Alternative name is diverticulosis.

Symptoms: Abdominal pain, tenderness in the left side of lower abdomen, When infection is present: fever, nausea, vomiting, chills, cramping, constipation.

4.6.4 Diagnosis of the Acute Adrenal Crisis

Acute adrenal crisis is a life-threatening state caused by insufficient levels of cortisol, which is a hormone produced and released by the adrenal gland.

Alternative names are Adrenal crisis, Addisonian crisis, acute adrenal insufficiency.

Symptoms: Headache, profound weakness, fatigue, slow, sluggish, lethargic movement, nausea, vomiting, low blood pressure, dehydration, high fever, shaking chills, confusion or coma, darkening of the skin (see skin, abnormally dark or light), rapid heart rate, joint pain, abdominal pain, unintentional weight loss, rapid respiratory rate (see tachypnea), unusual and excessive sweating on face and/or palms, skin rash or lesion may be present, flank pain, loss of appetite.

Signs and tests: An ACTH (cortrosyn) stimulation test shows low cortisol, the baseline cortisol level is low, fasting blood sugar may be low, Serum potassium is elevated (usually primary adrenal insufficiency), and Serum sodium is decreased (usually primary adrenal insufficiency).

	Cardiac Tamponade	Gastritis	Acute Gastritis
site	Abdomen	Stomach	Stomach
Radiation	Neck, shoulder abdomen	Upper Abdomen	Upper Abdominal
Type	Sharp	Constant	Colicky
Severity	Stabbing	Small pain	Severe
Onset and duration	Sudden	Periodic	Periodic
Aggravating factors	Deep breathing Or Coughing	Not eating	Strees
Relieving factors	Sitting or leaning forward	Milk	Nil
Associated symptoms	Pulse, weak or absent, drowsines, dizziness,	Abdominal indigestion	Nausea Vomiting blood
Physical Signs	Blood pressure low	Nil	Hiccups
Investiga-tions	Echocardio-gram	Gastrocopy	Gastrocopy shows gastritis

Table 4.5 Analysis of abdominal pain

4.7 Types of Abdominal Pains

4.7.1 Diagnosis of the Cardiac Tamponade

Compression of the heart caused by blood or fluid accumulation in the space between the myocardium (the muscle of the heart) and the pericardium.

Alternative names are Tamponade, and Pericardial Tamponade [30].

Symptoms: Anxiety, restlessness, sometimes discomfort is relieved by sitting upright or leaning forward, difficulty breathing, rapid breathing, fainting, light-headedness, chest pain, radiating to the neck, shoulder, back or abdomen, sharp, stabbing, worsened by deep breathing or coughing, swelling of the abdomen or other areas, skin pale, gray or blue, palpitations.

4.7.2 Diagnosis of the Gastritis

The term "gastritis" is commonly used by doctors and the public alike to explain the brief episodes of transient upper abdominal pain, nausea and vomiting which frequently affect much of the population. Gastritis, however, is usually not the cause of these upsets and, in its strictest sense, gastritis is a diagnosis made by a pathologist when he sees evidence of inflammation and damage to the stomach lining in a biopsy specimen taken at endoscopy. True gastritis may be of acute onset in which case symptoms are common, or else it may be a chronic, often silent problem.

4.7.3 Diagnosis of the Acute Gastritis

Causes, symptoms and treatment: Acute gastritis may produce no symptoms but can be associated with short-lived dyspepsia, lack of appetite, nausea or vomiting. It can occasionally be severe enough to cause gastrointestinal bleeding with melena or hematemesis. The most common cause is ingestion of aspirin or other non-steroidal anti-imflammatory drugs (NSAIDs). It can also occur during the early stages of infection with the bacteria, Helicobacter pylori "HP." Most cases resolve by themselves, but endoscopy and biopsy may be required to exclude other conditions such as peptic ulcer disease or cancer. At endoscopy the inner lining of the stomach (mucosa) may appear swollen, reddened and inflamed. There may be small, shallow erosions (breaks in the surface lining) or even tiny areas of bleeding from the mucosa. These changes are usually confined to the stomach rather than the duodenum. Other tests, such as blood tests, x-rays and scans are usually not necessary for diagnosis unless an alternative condition is suspected during investigation. Often no specific therapy is required but short courses of antacids, acid suppressing drugs or drugs for nausea may be necessary. Aspirin or NSAIDs should be stopped if possible.

4.8 Development of Diagnostic Expert System for Abdominal Diseases

Analysis of severe abdominal pains demonstrates that depend on input values of symptoms the different diagnosis can be obtained. These relations can be obtained from experienced specialist (medic ions). Using their experience and knowledge in this field we can a quite and collect knowledge base. This is one of main step of creating of expert systems for medical diagnosis.

Diagnostic expert systems for medical diagnosis contain databases that include information about patient and historical instances of disease for given patient. KB of expert system is constructed using these databases and make diagnosis for given illness. After that, it gives recommendations on how to treat the disease. The KB of ES is constructed by using "If – Then" rules that have form "If A Then B", where A is premise and B is conclusion parts of the rule. Premise of ES includes information, related to the patient with abdominal diseases, such as site of pain, radiation, type, severity, Onset and duration of pain, aggravating factors, relieving factors, associated symptoms, physical signs, and investigations. Most of the values of these parameters are characterized by symbolic information. In the knowledge base rules the inputs are the symptoms characterizing patient illnesses and output are diagnosis for given rule. The fragment of the rule base is presented in Figure 4.1.

rule 1:
If site is Epigastric
and radiation is Whole Abdomen and left Shoulder
and type is harp
and severity is Very
and Onset and Duration is Instantaneous and Persistent
and Aggravating Factors is Movement
and Relieving Factors is Nil
and Associated Symptoms is Shock and Vomiting
and Physical Signs is Board-like Rigidity
and Investigations is Air Under Diaphragm seen on radiograph
Then The diagnosis of the disease is Perforation

rule 2:
If site is Umbilical
and radiation is Right iliac Fossa Later
and type is Colicky, Becoming Constant
and severity is Severe
and Onset and Duration is Fairly Rapid Onset, Many Hours
and Aggravating Factors is Walking Causing Movement of the iliopsoas Behind Inflament Viscus
and Relieving Factors is Nil
and Associated Symptoms is Vomiting, Fever
and Physical Signs is Tenderness and Guarding in Right iliac Fossa
and Investigations is Nil
Then The diagnosis of the disease is Appendicitis

rule 3:
If site is Epigastrium or Right Hypochondrium
and radiation is Back and Whole Abdomen
and type is Constant
and severity is Very Severe
and Onset and Duration is Sudden and Persistent Hours
and Aggravating Factors is Nil
and Relieving Factors is Nil
and Associated Symptoms is Vomiting and Shock
and Physical Signs is Abdomen Rigid After Initial Softness
and Investigations is Increased Serum and Urinary Amylase
Then The diagnosis of the disease is Acute Haemorrhagic Pancreatitis

Figure 4.1 Fragment of rule base

The input of KB factors describes the current condition of the patient. In each rule for the given input parameters values the corresponding diagnosis has been made. Using knowledge of experienced specialists the knowledge base for medical diagnosis of the abdominal diseases has been constructed. After constructing knowledge base the realization of expert system is performed in the shell of ESPLAN. During consultation session the input data obtained from the patient that describes current condition of symptoms is given to the ES input. Using these inputs ES make diagnosis of illness and some recommendation for its treatment. Because of KB is constructed on the base of knowledge of many expert specialists the described approach allows more accurately make diagnosis of daisies and right treatment of illness. The obtained results satisfy the efficiency of applied methodology.

4.6 Summary

Analysis of severe abdominal pain is given, the main symptoms are defined. Using these systems the knowledge base is created. Knowledge base has if-then form and contains 56 rules. Using Expert System Shell the realization of diagnostic expert system for abdominal diseases is carried out.

CONCLUSION

In practice some industrial and nonindustrial processes are characterized by hard formalized factors and unpredictable information, in addition to uncertainty of environment. Analysis of these processes shows that the uses of traditional technology for control these processes leads to non-adequate their description. To solve this problem the development of expert system is considered within this project.

The application fields of some expert systems used in medical diagnosis have been considered. In addition to this, the design and working principles of expert system developed for medical diagnosis of diseases has been given. The architecture of an expert system for medical diagnostic is presented. The functions of its main blocks are described. To construct an expert system for diagnosis of abdominal diseases the knowledge base is created. The knowledge base includes production rules. It is acquired from the experienced specialist and medical references. Premise parts of the rules include the main input characteristics of diseases, whereas the conclusion parts are the diagnosis of illness.

The realization of the expert system is performed using expert system shell ESPLAN. This system can be used as an assistant to the physicians in making decision, diagnosis, in treatment of diseases and teaching students. Developed system gives the diagnosis with the certain confidence. The system can help to physicians to put preliminary diagnosis. The obtained results satisfy the efficiency of the applied methodology.

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