VISUAL MEDICAL DECISION-MAKING: BIPARTITE GRAPHS VS. INTERACTIVE TABLES

Hui Xia

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Department of Computer Science,
University of Ottawa
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Abstract

Most of the current medical diagnosis support systems are based on a textual design. In this thesis we present a model that uses a different design. It uses visualization to aid home diagnosis of common diseases in a user-friendly way. The model clearly displays the diagnostic results on the screen. A way of organizing the information into a picture of all symptoms, diseases, and the complex relationships between them (especially the combination of symptoms onto a single screen to give a global view) is presented.

The purpose of designing this model is to bring complicated medical knowledge to the ordinary user. We believe that the simplified and economic display can demystify medicine, and empower the user to take better care of himself. By this convenient software tool people can discover quickly at home whether their symptom is serious or not, and then decide whether it is necessary to see the doctor; also people can compare the diagnosis the model makes with the doctors'. This model does not recommend treatment or therapy.

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Chapter One

Introduction

Medicine today is big business. Of the 17 billion dollar Ontario budget, about 1/3 is devoted to health-related tasks, including doctors, nurses, paramedics, ambulance drivers, hospital administrators, editors of medical journals, manufacturers and distributors of drugs and medical instruments, lawyers, public health administrators, medical schools and medical researchers, insurance agents, and so on. With the development of high technology, computer support has penetrated nearly every aspect of medicine. One interesting topic is computerized medical diagnosis systems, and visual medical diagnosis systems is currently a growing topic.

1.1 The Needs for A Visual Assistant In Medical Diagnosis

Over the last 30 years it has been proved that computers can support diagnostic decision-making. However, there are many studies discussing the importance of whether these systems can be constructed pictorially. From a large amount of research over several decades, it has been clearly demonstrated that human observers are effective discriminators of visual textures. Human beings can process tremendous quantities of image information in parallel, detecting and tracking complex visual patterns with incredible speed [**AaR90**]. With developments in visualization technology software, there are many recent studies focusing on visualization in medical application. Visualization promises a powerful way of communication in medical diagnosis which can improve the process to better analyze the medical results and make better decisions. The model we present here uses visual tools to retrieve medical information, and explores the complex relationships in an user-friendly way.

1.2 What Is Lacking

Most existing artificial medical diagnosis decision systems do not have a help tool for finding all the common diseases in a visual way. Although artificial intelligence provides us with more sophisticated knowledge representation schemes, it does not provide for proper visualization of such knowledge. All artificial expert systems are devoted to assisting clinicians in making decisions and perhaps lowering medical costs. But few efforts have been made to help the patients understand their health situation. Many people can tell only the suffering they feel, and do not know the disease which causes the suffering; because most people cannot understand many complicated medical terms, the possibility of a single cause of several symptoms, and also because there does not exist a simple way to help them to learn the relationships between symptoms and diseases. So far no system on this particular subject helps the user in an effective way. With computers available at home, there is a need for a medical diagnosis tool to give the user the ability to learn, self-diagnoses, and care for himself. Our model is specifically designed for this need.

1.3 Objective

We believe that managing large quantities of information will be the key to effective computer use in the 1990s and that visual interfaces that recode the information in progressively more abstract and simpler representations will play a central role [**CRM 91**]. In the thesis, we attempt to design a new system using visualization techniques and database information based on a text-book in medical diagnosis.

The purpose of designing such a system is to develop a way of using computers to present textual knowledge in a visual display to provide the user with easier and faster knowledge access. This approach has three parts: one is to give a useful tool to the patient to assist in medical diagnosis; two is to use visualization techniques; three is to present all the data on one screen.

There are broad classes of computer approaches that have been and are being developed in medicine which classify several levels of care, ranging from self-care by the patient to expert consultation with the specialist physician depending on whether the system is built on patient-oriented or expert-oriented decision support. For an expert-oriented type, the physician is guided in the choice and interpretation of laboratory tests [**Wtb82**]. Our model is a patient-oriented type through which the patient is guided in sorting a mix of complaints into the appropriate consideration for further care.

There may be a question as to whether the model to be presented in later chapters is really a diagnosis tool. It depends on the definition of diagnosis. If the definition

is "deciding exactly which disease the patient has", then this model does not fit the definition. If diagnosis means presenting a short list (usually fewer than five) of possible diseases that the patient may have, then the model does diagnose. In this thesis, we use the loose definition.

1.4 Related Work

1.4.1 Background

The need to design appropriate environments is felt most in the area of health care. The environment can influence health outcomes by mitigating the impact of stress [**Ulr91**]. In computer applications the environment is the interaction between the human and computer. The traditional technique utilized by design interaction is textual format, such as medical history. Nowadays a visualization environment becomes the first consideration for the human-computer interface design with the advent of computers' modern display technology, which is an important application of Graphic User Interfaces (GUIs).

Visualization is a technology that uses computer graphics to help the users understand complex processes and obtain information from a data set. The focus of visualization is to represent patterns and understand any underlying relationships in the data. Whether the purpose of the visualization is for representation or communication, the better the mapping (between the data and the visual form) reflects the capabilities of the human vision, the better the chance that the information will be extracted and understood. Nowadays, visualization environment is adopted to evaluate and analyze data sets, especially large ones, in various applications.

Most of the advances in visualization have been in support of analyzing scientific, engineering, and similar physical data. Very little research has addressed the needs of a large population. This includes experts in finance, management of health care, educational assessment, and many other professions. There are large potential needs for visualization which may soon include almost everyone for shopping, communication, education, and so on.

Computer-graphics visualization has been successfully applied to large scientific datasets. Most of these datasets have a natural physical basis for visualization; for example in medicine, current research on visualization is focused on human anatomy and its inner structure in three-dimensions [**SHP93**][**PSR94**], such as the 3D geometry of the heart. It is also possible to apply visualization to non-scientific problems involving only abstract data, for example, analyzing financial data, or medical diagnosis data by providing visualization-based interaction with large, complex sets of information. Our model is based on this general concept of visualizing retrieved

information from abstract data in a medical diagnosis support system.

1.4.2 Current work

Graphs with hundreds of vertices and edges are common in applications. As long as relationships exist between any two objects, we could present them in a graph, such as network topology, using physical connection between nodes. Graphs can also present abstract level of datasets; in medicine, for example, the relationship between symptom and disease can be described in a graph. There are hundreds of algorithms for positioning nodes to produce an aesthetic and informative display [**EpR89**]. How can we display all the information associated with the vertices and edges (assuming that it can fit on one screen) and show the global structure of the graph? Researchers have observed that browsing a large layout by scrolling and arc traversing tends to obscure the global structure of the graph [**HCM89**].

The paper "Graphical Fisheye view" [**SmB94**] points out that the drawback of global structure is that the details are typically too small to be seen and alternatively zooming into a part of the graph and panning to other parts loses the overall structure of the graph even though it shows the local details clearly. This paper suggests a fisheye lens approach to viewing and browsing graphs. A fisheye view of a graph can enlarge the area of interest and show other areas successively smaller and in less detail. This local zooming and global structure is achieved by repositioning and resizing objects of the graph. We believe that a fisheye lens has all the advantages of the other approaches for viewing and browsing a graph without the drawbacks.

We are aware of certain research on graphical fisheye views. William Farrand's [**Fwa73**] doctoral dissertation is one of the earliest uses of fisheye views of information in a computer screen. In 1982, Spence and Apperley [**SrA82**] developed a technique called the bifocal display for visualizing office information. At CHI'91, Robertson, Mackinlay, and Card, presented two views of structured information that have fisheye properties. The perspective wall maps a large linear information base into a 3D visualization [**MRC91**]. There is one formal study that investigated the efficiency of using graphical fisheye views without hierarchy, and of clustering rather than scrolling a zoomed image, by Hollands, Carey, Matthews, and McCann [**HCM89**].

In this thesis, a model suggests a new way of viewing the global structure of a graph and all details, without loosing the overall structure of the graph. In this model all the edges which present the relationship between symptom and disease are erased. The relationships are hidden so that there are no crossing lines laid on the screen, which makes more space for the global view. The techniques used here are color coding and flashing lights.

Our contribution in viewing large datasets is to introduce layout considerations to

reach the global view and detailed view in medical diagnosis system. In other words, to design our particular model of user interface, the screen layout is the key.

1.5 Overview

The model we present is a visualization tool to support medical diagnosis. With the visualization a large amount of data and complex relationship can be easily studied and analyzed. The model saves us a tremendous amount of time spent on reading textbooks, reading the context, figuring out the relationships, and remembering all the necessary items; it gives us a chance to concentrate on decision-making.

This thesis comprises seven chapters. Chapter 2 is a literature review of computer-assisted clinic diagnosis in medicine, starting with the problems occurring in medical diagnosis, which leads to the matter of computational needs. A comparative survey of the major computer-aided medical diagnosis systems in artificial intelligence is exhibited. The purpose of surveying these systems is to provide a general background of medical diagnosis in computer-aided systems. With the advent of computer-display technology, visualization becomes an important subject which could dramatically change the computer-human interface (HCI). In order to realize the importance of visualization, the basic concept of HCI and visualized environment are addressed. Much visualization research has been done in medical diagnosis. Some visualization systems are viewed in this chapter in order to understand the purpose of our system.

Chapter 3 provides the data set description for the model design. It explains the importance of the data source. The more data we get, the more accurate the diagnosis is. It also describes how the data are organized and managed.

Chapter 4 describes the bipartite approach for the first model design. Along with that, it provides some graph theory, and introduces some problems in graphical presentation, such as how to view large datasets in a limited space. Problems in this first approach are also addressed.

Chapter 5 discusses the no-edges graph approach for the second model design. To simplify the graphical display, some techniques have been discussed, such as planarity graph, expanded vertex, etc. One of the current interesting techniques, fisheye view, is presented in this chapter. The chapter evaluates the fisheye view. It comes up with certain limitations in our case. The weaknesses and strengths of this model are listed and we explain why we finally gave up on this approach.

Chapter 6 is the description of the third approach. The model is for the home-based medical diagnosis assistant. In order to validate the system, the properties of this system are emphasized. We come up with six major properties. Finally the general features and color techniques are discussed.

Chapter 7 is a system implementation for the third approach. It provides some solutions for the problems of the second model design. The method of designing and validating the system is presented. This chapter also describes in detail how the system successfully combines the global view with local view, with color technique heavily involved, and how complex data are controlled in a two-dimensional matrix. The reason the Visual Basic language is chosen for the system and the advantages of Visual Basic are mentioned.

Chapter 8 is an evaluation of the third approach. Ten real user cases are provided. Through the experiment, easy use of the model is clearly explained, and problems are also discovered which lead to future work.

Chapter 9 is the conclusion. It summarizes the purpose of designing a visual tool for medical diagnosis, and it lists the advantages the system provides. There is a section in which some subjects have been discussed in detail, such as: weighted edges; the special advantages/disadvantages of the bipartite graph model over other systems built using neural-networks, and under which circumstances the database information should be migrated, etc. Several techniques in visualization are being compared. The last part suggests future work.

In the appendix A, all the data sets in the medical text book we used are listed in two different ways: table and graph.

Appendix B provides some additional information.

Chapter Two

Literature Background: Computer-Assisted Clinical Diagnoses

2.1 Problems in Medical Diagnosis

2.1.1 Differential diagnosis

Differential diagnosis is the process of considering the possible causes of the patient's complaint before making a diagnosis [**SBH88**]. When there are many possible causes of a symptom to consider (which is the usual case), then it is difficult to diagnose since you may also discover these symptoms in other diseases. To master differential diagnosis procedure requires skill. For example, for a simple "headache" symptom, there are 7 possible causes: nervous tension, migraine, cluster headache, high blood pressure, sinus infection, brain tumor and head trauma. To discover or rule out these diseases and to formulate a diagnostic hypothesis often seems excessively difficult, because some individuals who display a particular symptom don't have a particular disease, and some individuals who have a particular disease don't display all the symptoms. The more data one gets, the greater the chance of correct diagnosis, however to get all possible data is expensive.

Clinical decision making is extremely variable. There is abundant evidence that, in the care of patients with the same problem, clinicians differ radically in their decisions about ordering diagnostic tests, seeking consultation, recommending hospitalization, and prescribing treatment. Such variability in practice exists and is accepted, because it is rarely clear that one clinical strategy is superior to any of several others. Therefore it is rarely clear whether particular practices represent the right use of resources.

2.1.2 Medical knowledge changes

Nothing in the world can stay unchanged. This includes medicine. Compared with the 19th century, modern medicine has indeed changed a lot. For example, many child diseases have disappeared. On the other hand, there are also many new diseases discovered by new technology and more accurate devices, such as AIDS. In the book "Medicine in the Age of Computer"**[Fjg86]**, George J. Flynn writes:

> *"Furthermore, medical knowledge is far from complete. A disease that results in headaches, weakness, fatigue, and raised blood pressure was not identified and described until 1956, ..., but until it was recognized and described, physicians were unable to do anything for the victims, who just had to put up with an unexplainable medical problem that neither expert consultants nor general practitioners could do anything about. ... medical knowledge continues to increase, and some believe a relatively complete and comprehensive understanding of the human body will not be reached until about the year 2000."*

Much knowledge has been developed in recent decades and it is still believed to be only 80 percent complete. Since the knowledge base has grown, no one can be competent in all therapeutics. For instance, new drugs are being developed almost daily. Some replace the old drug; some have slightly different results and side effects. Other "new" drugs may be just old drugs with new names produced by more advanced manufacturing processes. Similarly new treatments and new surgery arise.

2.1.3 Specialist

As the knowledge base becomes large, it has led inevitably to specialization. The American Medical Association actually recognizes nineteen major specialties and at least thirty-two subspecialties, and about one-half of all doctors are specialists. The major reason for specialists is that some diseases are rare. If a symptom has many possible causes, the diagnosis depends on the physician's experience. A physician's diagnosis is based on his knowledge. If it is a common symptom, it will be easy to solve; if rare, he will be stuck, he may shift it to the specialist to solve. The specialist may handle the problem readily, perhaps using instantaneous pattern recognition because of his familiarity with similar problems, while the primary physician would find it difficult. However the results of specialization are not all good. Some young subspecialists are seldom willing to accept a patient with a symptom outside of their own narrow domain.

2.1.4 Massive knowledge base

If you look closely at all possible diseases in the medicine, you will find a large number. There are many common ones and many rare ones. In medical practice, the physician must know how to deal with this massive knowledge base, that is, to handle all the possibilities, particularly in complicated and rare cases. Generally in the hospital there is only a 5 or 10 percent chance that a complex problem can be treated, and there are many complicated and rare illness. So the real problem in a busy practice is that the rare and complex illness does not receive a correct diagnosis.

2.1.5 Human factors

Not only is the knowledge base large, a lot of doctors apparently make many mistakes in diagnosing disease. "Only 40 percent of all human ailments are found and labeled by doctors, and 60 percent are missed. Of those that are ostensibly found, half are diagnosed in error. Given an unknown ailment in the body of a patient, then, the chances of the American physician finding it and diagnosing it correctly are one in five!" **[Fjg86]**. That is, only 20 percent of unknown ailments are diagnosed correctly. Why does this happen? There could be many reasons: lack of experienced physicians, poor data gathering with respect to history and clinical examinations, missing or incomplete diagnostic knowledge, diagnostic carelessness and psychological factors for both the patient and doctor.

2.2 Computational Needs

From the previous section we know that there are many problems in medical diagnosis. The basic facts are that the human being is complicated, the amount of information that has been created about the human is large (especially the amount of medical information), and the population that stands to benefit from the application of that knowledge is enormous. No human brain can encompass it all. Moreover, most people need medical help of one sort or another, not just once or twice in their lifetime but many times; the older a person gets, the more likely he or she is to need medical help. As a result, the medical professor and the entire health industry is looking for help.

Computers are efficient. They deal with information, are ideally suited to deal with the complex problems of medicine and equally complex problem of delivery of medical care. The first use of computers in medicine was the application of business-type programs to the operation of large hospitals. Programs developed to help large corporations meet payrolls, to keep track of bills to be paid, to watch inventories,

and to calculate profits or losses [Led85], could be adopted without much trouble to perform similar jobs in hospitals. Most hospitals today and many individual doctor group practices have computerized many of their routine business functions. But medicine is more than the efficient administration of hospitals [Fjg86].

2.3 Computer-Based Application in Medical Diagnosis

When computers were first introduced into medicine, dramatic changes occurred. Computers have changed medicine more than any other aspect of our daily lives. They have changed medicine. The computer has become one of the physician's tools, helping him to work more efficiently and with fewer mistakes. They have provided new insights into the body through imaging techniques. Furthermore they not only watch patients and control liquid medicine; they also help in diagnosis [Jaj86].

Computer-based medical diagnosis system must enable a physician to perform his task better and more efficiently by providing better diagnoses or better suggestions for therapy than he has currently available from his stored knowledge, and by enabling him to reach a diagnosis or management plan faster.

2.3.1 The rise of artificial intelligence

When computers got larger and faster, and especially when programming got more sophisticated, the question arose as to whether computers could behave intelligently in the same way as humans do. This field of research started in the 1950s. The first attempts to write such programs for playing checkers and chess were made. At the end of the 1960s, a few researchers in artificial intelligence (AI) decided to try applying what had been learned to real problems. One of the areas that seemed especially promising was medicine, and for a number of reasons that are still true today. Medicine could provide difficult problems; the knowledge base is large and never stops growing; there did not seem to be enough specialists available, and the cost of medical care was increasing rapidly.

AI is concerned with programming computers to perform tasks that are presently done better by humans, because they involve higher mental processes such as perceptual learning and judgmental reasoning. It is about the simulation of human behavior.

The reason that many researchers work on artificial intelligence in medical diagnosis is that it presented precisely the types of problems that artificial intelligence should be good at. Particularly, it involves an increasing mass of information that physicians must wade through and apply to a diverse population of all ages; each person has a different genetic makeup, life experience, and medical history [Fjg86].

There are many problems in artificial intelligence, and one of the most important and difficult is the representation of knowledge. If you can express the knowledge in a mathematical equation, you can program it into a computer without great problems. If you can express the knowledge in terms of a statement of logical relationships, you can also program it easily. But how do you tell a computer that a patient feels good?

The patient can enter a number, such as 7. In this case, the knowledge representation problem has been solved by a transformation into a number, which the computer can work with.

2.3.2 Expert systems

The theory of expert systems emerged from the field of Artificial Intelligence. An expert system is an algorithm that mimics a human expert's ability to solve problems. The algorithm has several paths, it runs quickly, and it gives reasons for its decisions **[Jap86]**. An expert system seldom has absolute authority; usually it is subordinate to a human being.

Expert medical systems have existed for two decades. Most of them mimic doctors **[Anm87]**. They accept medical information about patients and furnish diagnoses with associated degrees of certainty. The systems' expertise comes from a large collection of many patients' symptoms and diseases. The probabilities attached to the diagnoses are also based on this large collection. Some systems give a diagnosis of only one disease; some give several, with probabilities attached; and some also suggest treatment or further tests.

Compared with a physician expert, computers' expert abilities are limited. For example, they cannot do a physical examination or perform a complex invasive procedure. But they can provide superb intellectual skills. They can process information to create knowledge, and they can organize knowledge to produce a differential diagnosis, to recommend a testing procedure, or to recommend treatments.

2.3.3 MYCIN system

The study of computer-based medical diagnosis started in 1970. Several major universities used artificial intelligence to solve medical problems. One of the application in expert systems is the well-known MYCIN system **[She76]**, which was developed at Stanford University. In MYCIN, the diagnosis is a major component.

MYCIN is an expert system designed to carry out medical diagnoses. Specifically, it is designed to work in blood and meningitis infections, making an appropriate diagnosis from evidence presented to it and recommending drug treatment. It consists of 450 rules developed with the help of the Infectious Diseases Group at Stanford. Its

most fundamental point and the one which can give rise to the most complications is the use of probabilities. Medical diagnosis is an inexact science. If a patient exhibits a particular set of symptoms then he may have a particular illness, but the connection is not guaranteed.

The way MYCIN tackles the problem is to assign a certainty factor to every one of its 450 rules. That is MYCIN contains a series of rules of the form IF ... THEN with certainty P. These certainty factors come from humans. When they suggested a rule they stated their degree of confidence in that rule on a scale from 1 to 10. Having set up these rules with their associated certainties, MYCIN works by backward chaining from a possible outcome to see if this outcome can be believed or not. Once it has established all of the items it needs about a particular outcome, it makes a judgment on that outcome on the basis of the certainty factors associated with the rules used.

Probably the most important point to note is that MYCIN does not come up with a diagnosis. What it does is to come up with a whole series of diagnoses each of which has some certainty score associated with it. Above a certain ad hoc value all of these diagnoses are accepted as being likely and the user is presented with a list of possibilities.

The next point to make about MYCIN is its use of English. When it wants information from the user it asks for it in English . When the user enters information he/she does so in a way which appears fairly natural and English-like. This sounds handy, but there is something more than that. There are two parts to the matter: the part that concerns user acceptance of the finished product and the part that concerns the actual implementation **[She76]**.

2.3.4 Neural network system

In the seventies and eighties, expert systems were developed as an aid to medical diagnosis. Despite some interesting and successful results, significant shortcomings were encountered, due to an inherent risk of errors, the complexity of the problems considered, and the difficulty of accessing the expert knowledge held by physicians. More recently , many techniques have been proposed in the field of Artificial Neural Networks allowing knowledge to be directly learned from experimental results and medical practice **[CAH93]**.

Neural network technology is a newcomer to many application areas. Its widespread use today is fraught with difficulties in achieving optimum performance, monitoring activity, and integrating networks into existing environments **[Ljg92]**.

Neural networks in computing resemble neural networks in the brain, that is, they consist of many simple junctions linked together **[Bhd62]**. They are multi-partite, that is, arranged in several layers **[Ljg92]**, and only junctions in adjacent layers are

connected. Two junctions in the same layer cannot be connected. The top layer is excited from a source outside the network, and the computer neural network is supposed to model the excitation in the bottom, or inner, layer [**Jap86**].

Recently activity in the field of artificial neural networks has increased exponentially. Artificial neurons are highly simplified representations of some of the functions of real, biological nerve cells or neurons.

One application of computer neural networks is in diagnosis of pulmonary disease, developed at the University of Patras, Greece [**ESE94**]. The system composes several large networks, and can diagnose 35 different pulmonary diseases. It accepts symptoms [**HrH93**], [**Lpr87**], [**SsT92**], [**Wbl90**] as input and groups the 35 possible diseases into 12 major classes. The system has three layers, each of which has a few levels.

So far results have shown an overall performance of nearly 85% success in diagnosing pulmonary diseases.

2.3.5 Fuzzy system

Fuzziness describes ambiguity. It measures the degree to which an event occurs. A fuzzy set (set-as-points) defines a point in a unit-hypercube, and a non-fuzzy set defines a vertex of the hypercube [**Kob92**]. Within the cube the distance between points can lead to measures of the size and fuzziness of a fuzzy set. A fuzzy system is a mapping between hypercubes. This level of abstraction provides an alternative to the propositional and predicate calculus reasoning techniques used in artificial-intelligence expert systems. It allows us to reason with sets instead of propositions.

For many different systems in decision support, it is observed that none of the existing systems examined is capable of providing a correct diagnosis in more than, on average, 70% of the cases [**TmM94**]. The diagnostic accuracy of such systems will have to be improved before any of them can be used in general practice. The difficulties with developing such systems are the blurred and vague symptoms, the lack of reliable expert knowledge (non-specific data, incomplete knowledge base, too great a reduction of the set of diagnoses concerned), as well as the great number of exceptions and rare diseases.

A fuzzy logic-based expert system for diagnostic decision support is presented in MEDUSA (a decision-support system for the diagnosis of acute abdominal pain) [**TmM94**]. This system uses fuzzy sets and fuzzy relations as a tool to describe uncertainty [**Sae79**]; that is MEDUSA's knowledge representation and diagnostic inference are based on fuzzy logic. The results of the diagnosis enable the physician to verify his diagnosis, particularly in special domains. There are five steps in this process. The first step is to examine the patient and verify the data collected from

the patient. The second step is to interpret the data at an abstract level. All possible symptoms are defined into certain degrees on the basis of their proper definitions. After these two steps are done, the third step is to draw all possible certain conclusions from the given symptoms. The fourth step is to evaluate hypothetical diagnoses which have been neither excluded nor established based on the known and uncertain medical relations. The fuzzy set and fuzzy relation are used in this step. The fifth step is for all the special cases.

MEDUSA was correct in 80% of the cases. However in about half of these cases, the correct diagnosis was suggested as only a possible diagnosis. To improve the diagnostic accuracy, we need optimization of weights within as well as the specification of the fuzzy sets and the enlargement of the special case library from the present 150 cases.

2.4 Major Approaches Among The Systems

Medical diagnosis systems share many similarities, and each takes a different approach. In the literature, a number of decision-making systems have been based upon decision trees, weighting algorithms, nonparametric testing, and so on. The classification used here includes: categorical approaches; probabilistic approaches; artificial intelligence approaches; and pattern recognition approaches.

Categorical approaches are referred to as deterministic. They provide unambiguous rules to action. They can be exemplified by unambiguous flow charts, diagnostic and treatment protocols, where no deviation from prescribed treatment is desired so that the number of potential variables may be reduced to manageable proportions. The decisions, once made, are unalterable, whereas the physician frequently reconsiders his diagnosis [**Wtb82**].

Probabilistic approaches may include statistical decision approaches, statistical inference, and other approaches. They assign degrees of probability to results. Greater deviations from normal generally reflect a higher probability of disease. Such an exercise must rely on the gathering of data about these probabilities from defined populations.

Artificial intelligence approaches have arisen out of attempts to model human thought processes or at least to simulate human behavior. They may also be said to be concerned with the strategies and tactics of problem solving in the face of uncertainty and complexity. Medicine abounds with such problems. Artificial intelligence techniques include deterministic and probabilistic inference. Their application in medicine led to the insight that humans are able to reach reasonable decisions in situations of uncertainty and complexity where traditional algorithmic or probabilistic techniques are inappropriate.

Pattern recognition approaches are pervasive throughout medicine. They may be involved in the first three classes [**PSS74**] (i.e., Categorical, Probabilistic and Artificial intelligence approaches). The physician is confronted with patterns from the time of his first encounter with the patient. Patterns often imply a parallel presentation of data, i.e., multiple data elements must be present in order to form a pattern. At the first encounter between physician and patient, there are many data elements presented in many different ways simultaneously. Some of these may be nonverbal, the appearance of anxiety, peculiarities of gait, pallor, and other items of the general appearance. Hence even before the physician acquires the patients' chief complaint he has already begun pattern-processing.

2.5 Visualization in Medical Diagnosis

There is a great deal of interest in applying visual processing and data visualization techniques in medicine. This interest is especially keen in surgery, planning radiotherapy, chemotherapy planning, and disease diagnosis. A number of visualization and image processing packages have been produced for the medical community and have been used widely, for brain, cardiac, and cranio-facial research.

2.5.1 Why visualization?

Vision is a basic activity of human beings in their daily lives. A person learns about his environment largely through his eyes, but the human visual system has its limitations and its quirks; an appreciation of these is an important prerequisite for making the most efficient use of our visual sense.

Several studies suggest that visualization can be defined as the substitution of preconscious visual competencies and machine computation for conscious thinking [**Gen93**]. In other words, visualization replaces ad hoc or improvised, consciously mediated processes with preconscious, hardwired processes resident in the physiology of the visual system.

At a 1986 National Science Foundation meeting someone prophesied that visualisation in computing would become a major field. It can see things that are normally invisible [**MDB87**]. Since then much research has been done in developing and applying visualization.

After about six years of research and development in the field of visualization, it was discovered how large data sets can be visualized in such a way that humans can detect patterns more readily than a direct analysis of the numbers would. Similarly, information visualization seeks to display structure relationships between documents

and their context that would be more difficult to detect by individual retrieval requests.

2.5.2 Fundamentals of human-computer interface (HCI)

Visualization in computing can be described as a kind of interface between human and computer. The computer has great abilities; it can store a vast amount of information. The computer also has some deficiencies; the most important one is the communication link between computer and human. Computers do not understand the natural language of humans and humans do not understand the natural languages of computers. The task of interface with a computer-based system is to provide communication between human and computer. In other words, users can input information to a computer system and get results back from the computer. With the spread of computer systems, nowadays people have routine almost daily interactions with computers. There is an increasing awareness that the design of a high-quality user interface in any interactive system is crucial for bringing many different computer applications to end-users **[Foj91]**. Ease of learning and speed of use typically must be combined in an attractively-designed interface which appeals to end-users. This is a complex job of requiring the skills of the computer scientist, application specialist, graphic designer, human factors expert, and psychologist.

The theory of human-computer interaction began about 1982, when the Gaithersburg Conference on Human Factors in Computing took place and personal computers became common. In the next decade much research and development was done on the subject of the human-computer interface. Now the theory is becoming organized **[DFA93]**.

Textual display interface

A person's interaction with the outside world occurs through information being received and sent: input and output. In an interaction with a computer the user receives information that is output by the computer, and responds by providing input to the computer; the user's output becomes the computer's input and vice versa. One of the major input devices to a computer is the typewriter-like keyboard by which user can type information into a computer and computer displays the text on the screen.

At first, most system interfaces were designed in this way. In other words, the communication is text-based. Text-based communication is familiar to most people, because people receive or send letters. However, there are several aspects to consider about text reading: reading is a process of extraction of information from text. This

process can be divided into several sub-processes: first, the user must be aware of the visual pattern of the words on the page before he can decode the meaning of these words. This process involves interpreting visual representation of the words into the word's meaning. For example, if we are reading the word "yellow", we come up immediately with the meaning of a certain kind of "colour" stored in our mind after we understand the visual pattern "yellow". Second, after validating the meaning of individual words in a sentence, the reader must begin to analyze the syntax which means the reader must follow grammar rules to find out the meaning of the word in the specific sentence in this language (since different languages have different syntax rules). The meaning of the sentence usually depends not only on the words, but also on the way they are combined.

As we have seen, the procedure of text reading is quite complex even though humans do not realize it; humans get used to it since we are able to learn.

Graphic display interface

Recently, there is much attention paid to the design and development of human-computer interface for acceptance, effectiveness and high-quality. Ease-of-use and ease-of-learning for the end-users are first considered. Traditional textual interfaces have long dominated computer behavior. But humans often prefer glancing at a graph to studying a table of numbers or string of letters, so we know that using graphic or visual interface would improve the interaction between humans and computers. Microsoft DOS and WINDOWS is a good example of these two different user-interface designs. McCormick, DeFanti, and Brown [**MDB87**] define visualization as the study of mechanisms in computers and in humans which allow them in concert to perceive, use, and communicate visual information. A number of psychological research papers prove that graphic display is better than text display, for the following reason:

- do the task faster;
- do the task with fewer errors (without worrying about spelling mistakes);
- do the task more easily;
- do the task more pleasantly.

Computer interfaces that help users to access and interpret information will typically enhance the quality of human-computer interaction. A user often experiences difficulties in accessing information through the computer because his knowledge of how to interact with the computer, such as using commands, is limited.

In order to provide a graphic user interface, a typical set of interaction techniques is used which includes a dialogue box, file-selection box, alert box, help box, list box, message box, choice buttons, toggle-button , fixed menu, pop-up menu, text input,

and scroll bar, etc. It avoids using a keyboard which is slow and is subject to many errors, especially if one is not a skilled typist. Furthermore, the information has to be entered in a very specific way.

2.5.3 The role of visualization in medicine

The role of computer-aided visualization in medicine is burgeoning [**Mct76**]. Visualization plays an essential role in the rapid recognition of abnormalities and their relation to anatomy. The demand for computer-assisted visualization is escalating. A big push forward in computer visualization came from magnetic resonance imaging. It typically requires data transformation, conversion and reformatting as preparation for effective visualization. More research needs to be done in how to visualize in the expert system. A picture is worth one million words in computed diagnostic images.

2.5.4 Visualization in computed diagnosis images

Visualization today is a well-understood technique to turn data into images [**Tla89**] [**MDM87**]. Visualization provides a way to understand and use vast quantities of data. Visualization of the human body and its inner structure has challenged artists and scientists for centuries. Imaging techniques now make possible the visualization of the heart beating inside the body. Now, instead of relying on indirect signals such as sound or electrical signals, the physician can observe the heart in action. This makes diagnosis faster and surer.

Visualization in radiological applications

For 500 years, since Leonardo da Vinci, drawings have been the main resource for learning anatomy because they allow the mixture of realism and abstraction suitable for didactic purposes. With the discovery of x-rays 100 years ago, it become possible to look into the living body [**RIR96**].

Since the 1970s computer tomography (CT) and magnetic resonance imaging (MRI) have made it possible to acquire image data in three dimensions; 3D computer graphics generated the first models of the living body. Multiparameter and multimodality tomographic imaging is becoming common [**PLS90**], for example in computer tomography (CT) and magnetic resonance (MR) diagnosis of liver cancer.

Radiologists are now commonly faced with visual analysis of four or more images at each tomographic level. In order to see the combined information that these displays only crudely afford when viewed individually, there is a big need for integrated displays. Radiologists then can easily see shifts in polarity or large changes in the

contrast of a lesion; more subtle changes, such as in its shape or internal structure are very difficult to analyze and study. Moreover, some structures may not be visible clearly in any separate view, and may be visible only in some integrated display. To get beyond that limitation requires entirely new approaches to integration [**Led85**].

In this application, the values of the corresponding pixels in the images are represented in the integrated display by an icon with independently controllable visible qualities, each controlled by a different parameter. One specific approach to iconographic representation is to use color coding [**PmG88**] which is often used in image-based diagnosis. Color coding is the only approach to the integration of multiparameter images currently recognized. This technique can integrate three views into one. The gray-scale values of the pixels in the separate images control the color values of corresponding pixels in a single color picture. The detection and recognition of regions depends on sensing contrasts in color [**Leh91**].

Advanced technology for integrating multiparameter imagery is of great potential value in several areas of image-based medical diagnosis .

Visualization in surgical planning applications

As early as 1960s, when patient-monitoring devices were introduced to the operating theater, surgical treatment started to be assisted by computer and electronic technology [**RlR96**].

The widespread use of computer support in surgical interventions has become a recent phenomenon. Development began with the three-dimensional computer models generated from computed tomography and magnetic resonance imaging. Three-dimensional medical images provide a non-invasive visualization of internal organs. These 3D images can supplant the diagnostic information in the 2D cross-sectional images provided by X-ray computed tomography and magnetic resonance imaging. Bone was identified and visualized with early computer graphics shading methods based on a stack of consecutive cross-sectional pictures. In such a way, complex interior structures could be viewed for surgical planning and the results assessed post-operatively. This technique has become standard in several disciplines, for example, craniofacial surgery [**HPP96**].

Current developments in surgical visualization

It is said from radio broadcast that two new applications of visualization in surgery have been developed in 1995 in Halifax. One helps new surgeons gain experience without harming patients. The new surgeon dons a hood to obtain virtual reality. He sees a realistic model of the patients body and of the scalpel. He moves his hands to

perform the surgery. The computer displays a realistic result of his actions. In this way the surgeon can gain much experience rapidly, safely, and cheaply.

The second is surgery at a distance. Suppose that a patient in a hospital needs to have a difficult operation performed immediately, and no surgeon at the hospital can do the operation. Somewhere far away, there is a competent surgeon. He is connected to a video camera at the patient's hospital, and dons a virtual reality hood that controls a surgical robot at the patient's hospitai. By moving his hands, he controls the robot, and performs the operation by remote control.

Of course, surgery includes exploratory surgery, which is sometimes used to diagnose diseases. Suppose a patient has a liver problem, and the doctor doesn't know exactly what the disease is. A surgeon exposes the liver for visual examination, perhaps by remote control, as explained previously. From the visual examination the doctor diagnosis the disease.

2.6 Home-Based Diagnosis

Microprocessors can be used to automate the operation of diagnostic instruments to a level that allows their use by lay people at home. Self-diagnosis and monitoring at home are likely to change the relationship between the patient and the family doctor or the specialist in the near future. As the educated patient or his family takes over some of the monitoring and treatment functions of the physician and the nurse, the physician will stop controlling health care to the extent he does today. People will be performing more self-diagnosis, referring themselves to the physician when indicated by the logic of the computerized diagnostic devices [**Anm87**]. It's like the thermometer used to indicate fever. If you have it, then you visit a doctor.

Some recently developed software applications in medical area are home-based diagnosis. They provide a tool for the patient to solve simple diagnosis problem on his own.

Self-care application is growing along with concern for the rising cost of health care and increased patient assertiveness. Programs in this area include simple first-aid techniques and stress assessment. Software now assists consumers in assessing and treating their minor ailments. When the symptoms are more serious, the programs recommend that the patient go to a health professional for care. Most of this software warns that the programs are not intended to take the place of health practitioners, and if patients have any doubts at all, they should contact their physician.

According to the statistics about 90 percent of patients [**Fjg86**] who visit a doctor have relatively uncomplicated medical problems and are diagnosed relatively easily. Therefore, with a tool of home-based diagnosis, a user could get some advice from

it to get better health care. Home-based diagnosis could help to solve the following problems to some extent:

- too many doctors in some parts of the country, and too few in other parts;
- increasing demands by more and more patients for better medical care.
- the cost of medical care.

Therefore developments in medical technology, and the extension of health care to larger sectors of the population are necessary.

Chapter Three

Data Set Description

3.1 Data Source

Data collection is an important part of making the right decision in medical diagnosis. In a clinic, the physician makes his initial attempt at classification of the patient's problem from descriptors provided by the patient. If it is a problem the physician has never experienced before, he will be influenced by a variety of extraneous factors . An experienced physician may take steps to increase his confidence in the interpretation he has placed in a patient's response to his question by asking the same question in several different ways, each of which requires a different kind of response from the patient, i.e., true-false, or multiple-choice, to collect more data. Seldom is the answer to single question sufficient to establish with certainty the presence or absence of a particular disease.

"The Horse and Buggy Doctor" emphasized in 1938 [**Tbr73**] that

> *"Having acquired a patient, the first thing to do is obtain a history of his ailment. The securing of an adequate one is a work of art. It requires a knowledge of disease and of human nature. It is hard work and is time-consuming but it is necessary, because in many cases it is the most important factor in the whole procedure. A good history may even anticipate what the microscopic slide will show."*

The book "A Primer of Clinical Symptoms" by Robert B. Taylor [**Tbr73**] provides a working guide of formulating a realistic differential diagnosis in common clinical symptoms. The book covers 109 symptoms and 423 different diseases. Most patients encountered by the fledgling physician will offer one of the symptoms mentioned in this book as a chief complaint. That is where the work starts, i.e., the symptom is where the evaluation of disease must start. The details discussed in the following are based on Taylor's book.

3.2 Symptom and Disease

Symptom and disease are the basic elements in medical diagnosis. They have a very close relationship. Symptoms are usually important signals which present a warning of a possible serious illness. In other words, a symptom is caused by a disease. The complaints such as fever, indigestion, or weakness may produce physical discomfort. Some noticeable part of the symptom results from a hidden danger. Therefore symptoms are often important for finding out the diseases. The human body comes supplied with sensors, which provide information to the conscious levels of the central nervous system concerning the status of many internal organ system. Each organ of the body produces characteristic symptoms in the presence of illness. Recognition of a specific symptom helps direct attention to a particular organ of the body.

A symptom such as loss of appetite, insomnia, or skin infection could suggest the presence of a disease more serious than the symptom itself. Moreover a symptom can be caused by many different diseases. Symptoms are phenomena, while disease is the cause of sickness. That is very important. Prompt recognition and evaluation of medical symptoms allow the detection of disease while still in an early stage.

Various diseases have characteristic symptoms. Moreover, some illnesses cause symptoms or complaints affecting many parts of the body. A disease can cause many different type of symptoms. Because of this complex relationships, the decision about which is the real problem seems very difficult to make. Therefore the more symptoms you get, the more accurate the diagnosis.

3.3 Symptom Combinations

A symptom rarely occurs alone. A disease can cause many symptoms, and that is the usual case. Hence, careful evaluation usually reveals other associated symptoms. Although a single complaint can be treated as the main source of concern, with careful investigation, some other symptoms may be discovered. For instance, a single complaint such as tremor may lead, on close questioning, to loss of appetite. The purpose of history is to find more symptoms by asking many questions of the patient. The recognition of symptom patterns often allows the physician to diagnose a condition while he is taking a history because the presence or absence of other symptoms can aid in diagnosis. More accurate diagnosis is based on the observation of more symptoms.

3.4 Symptom Groups

Although many symptoms exist in the real medical world, and they all have different characters, they can be put in groups according to the character they share. For example, symptoms like fatigue, insomnia, weight loss, and loss of appetite, etc., may be the first symptoms of disease and occur in combination. Therefore these symptoms are categorized as "general complaints". Similarly, other symptom groups are formalized the same way. A particular group of symptoms characteristic of a disease is called a syndrome. The recognition of a specific group of symptoms can be an important diagnostic clue. There are 19 symptom groups in this workbook. These groups are:

1. *General complaints*
2. *Nervous system symptoms*
3. *Eye symptoms*
4. *Ear Symptoms*
5. *Nose and throat symptoms*
6. *Oral and dental symptoms*
7. *Neck symptoms*
8. *Heart symptoms*
9. *Lung symptoms*
10. *Breast symptoms*
11. *Stomach symptoms*
12. *Liver and gallbladder symptoms*
13. *Intestinal and rectal symptoms*
14. *Urinary symptoms*
15. *Female reproductive organ symptoms*
16. *Male reproductive organ symptoms*
17. *Skin symptoms*
18. *Muscle and joint symptoms*
19. *Emergency*

3.5 Disease Groups

Disease groups are different from symptom groups. A disease group is associated with each symptom. Each symptom has its own set of diseases; this set of diseases we call its disease group. However, a disease can cause different symptoms. There are many more disease groups than symptom groups, because there are more symptoms than symptom groups.

3.6 Connected Symptom Groups

All symptom groups can be divided into 17 subgroups by their connections: one large connected subgroup and 16 small connected subgroups. Fig. 3.1 shows a small group with only one symptom.

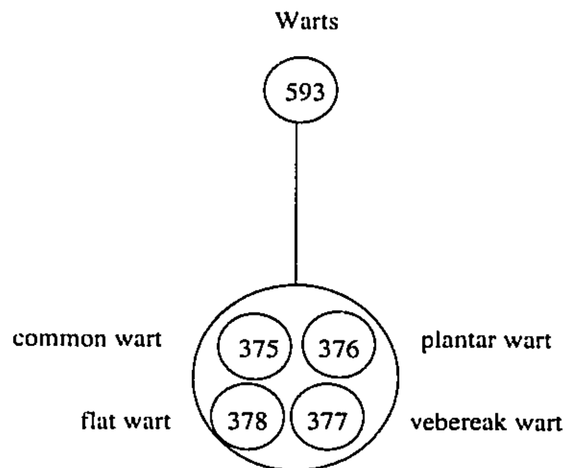

Figure 3.1: A small connected graph.

Here are four diseases: common wart, flat wart, plantar wart, vebereak wart; and these four diseases are related only to the symptom "Warts"; no one of these four disease is related to any other symptom. In other words, the symptom "Warts" is a common symptom for all these four diseases.

3.7 Data Structure

The relationship of system groups, symptoms, and diseases formalizes a three-layer data structure, illustrated in Fig. 3.2.

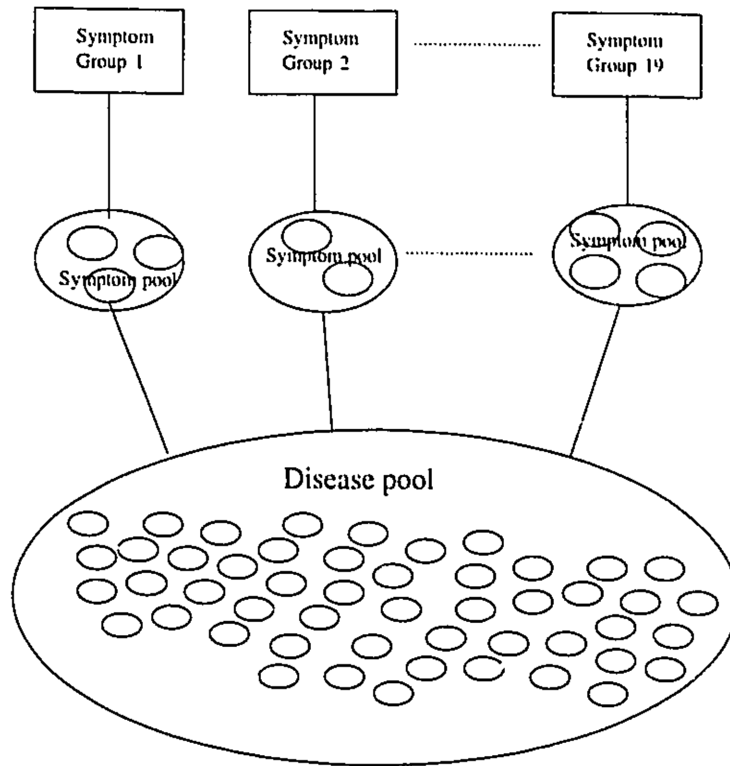

Figure 3.2: Data structure.

Each symptom group has its own set of symptoms, which can not be shared with other symptom groups. The relationship between symptom and disease is complex in that it is rarely one-to-one; each symptom is usually connected to several diseases and vice versa.

Each symptom can have diseases which are shared with other symptoms. The relationship is one-to-many, that is, some diseases can cause in many different symptoms which belong to different symptom groups.

We use the term "disease pool" or "symptom pool" to represent a large collection of diseases or symptoms, respectively.

Chapter Four

A First Approach: Bipartite Graph

4.1 Introduction

It has become clear in recent years that graph theory and computer science have much in common, and that each is capable of assisting significantly in the development of the other. Thus, graph theorists are finding that many of their problems can be solved, or their research furthered, by the use of computing techniques; while computer scientists are realizing that the language of graph theory is a convenient one in which to express many of the concepts with which they have to deal, and that standard results in graph theory are often very relevant to the problems they are concerned with.

There are a number of situations that can be represented by graphs, such as network topology in communication, and symptom-disease in medicine. The common feature in these two areas is that in each case we have a system of objects that are related in some way; that means we can represent the connections by means of graphs using vertices and edges.

Graph theory is widely used in computing because almost everything has a connection to some other thing. In medical diagnosis, the symptom-disease connection is a good example of the use of graph theory.

4.2 Graph Theory

Graph definition: A graph is a diagram consisting of points, called vertices, joined together by lines, called edges; each edge joins exactly two vertices [**Tvn81**].

Graph theory is a branch of mathematics which has applications in many areas: anthropology, architecture, biology, chemistry, computer science, economics, environmental conservation, psychology, telecommunications, etc. In a typical situation, a problem arising in the real world can be modeled using graphs.

Graph theory is primarily concerned with connections between objects. Graphs can be used to depict the relationships between certain objects: you simply represent the objects by vertices, and the relationships by edges joining the vertices. In order to investigate such relationships more deeply, we need to introduce the theory of graphs in some detail.

Graph

A graph is defined as a collection of points or vertices, some pairs of which are joined by lines or edges. The same pair of points may be joined by several lines, so a graph may have multiple lines or edges. A graph is connected if every pair of points in it is joined by at least one path, disconnected otherwise [**Tvn81**].

For example, a road map can be represented graphically by means of points and lines as in Fig. 4.1(a). The points P, Q, R, S and T are called vertices and the lines are called edges; the whole diagram is called a graph. The intersection of the lines PS and QT is not a vertex of the graph since it does not correspond to a cross-roads. The degree of a vertex is the number of edges which have that vertex as end-point, and corresponds in Fig. 4.1(b) to the number of roads at an intersection; thus the degree of the vertex Q is four [**Wjr79**].

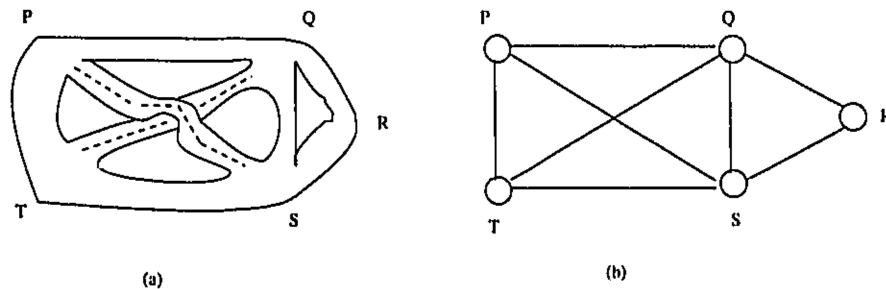

Figure 4.1: Road map.

Bipartite graph

A graph G is bipartite if its node set V can be partitioned into two subsets V_1 and V_2 such that every edge of G joins a node of V_1 with a node of V_2 [**BfH90**]. For example, the graph of Fig. 4.2 (a) can be redrawn in the form of Fig. 4.2 (b) to display the fact that it is bipartite. That is, the graph G consists of a set of vertices divided into two subsets of $\{t_1, u_1, v_1, w_1\}$ and $\{t_2, u_2, v_2, w_2\}$; the edges are from one subset to the other subset. The main feature of a bipartite graph is that there is

no edge entirely in one subset, which means there are edges only from one subset to another subset, as shown Fig. 4.2 (b).

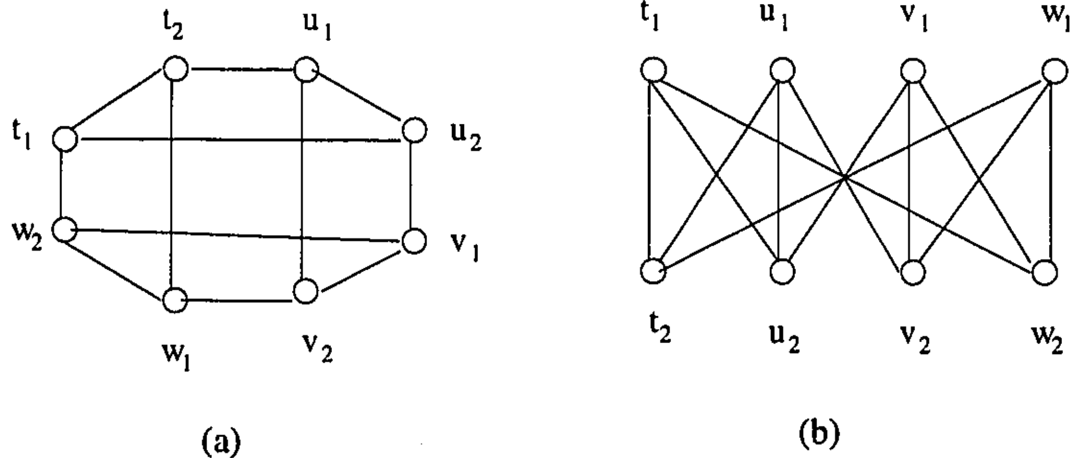

Figure 4.2: A bipartite graph.

4.3 Graph Theory Applied to Medicine

In medical diagnosis, the only basic elements to be considered are symptoms and diseases. The complex relationships of symptom-disease can be drawn graphically. For example, the symptom "Headache" has a connection to the diseases nervous tension, migraine, cluster headache, high blood pressure, sinus infection, brain tumor, and head trauma. To present this relationship we use a graph model; see Fig. 4.3.

In the graph we present each symptom and each disease as a vertex, and their relationship is presented as an edge. As we can see, this graph presentation is much simpler than the text explanation, which helps us to analyze it better. Furthermore, the symptom-disease graph can be drawn as a bipartite graph. For example, from the previous headache example, the disease "brain tumor" and "head trauma" also cause the "Coma" symptom which has 13 diseases, such as brain tumor, head trauma, stroke and uremia, etc. We notice that there is no direct edge (i.e., connection) between these two symptoms "headache" and "Coma". Therefore the graph can be drawn as a bipartite graph, see Fig. 4.4.

Because we do not consider symptom-to-symptom relationships or disease-to disease relationships (we consider only the symptom-to-disease relationship), if we draw a graph, we put all the symptoms in one set and all the diseases in another set. In

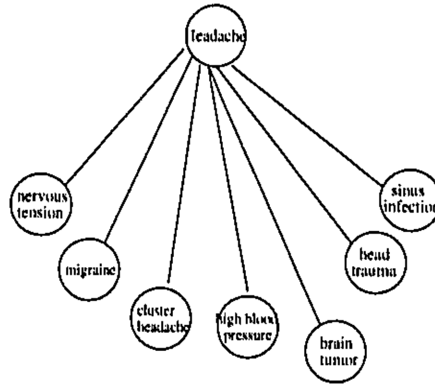

Figure 4.3: A graph of one symptom.

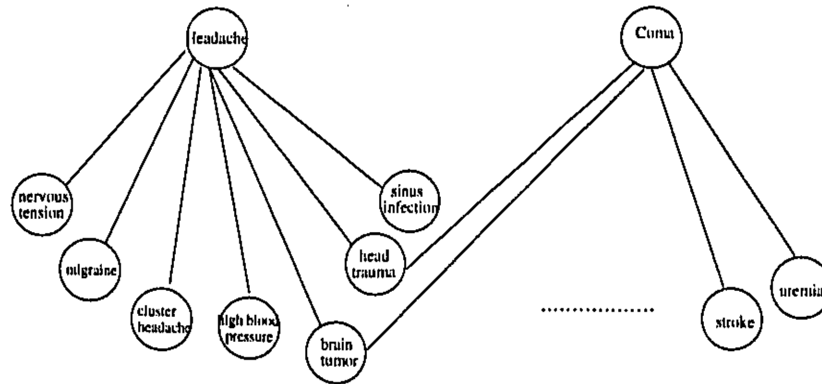

Figure 4.4: A graph of two symptoms.

medical diagnosis, we note carefully that some sufferers of a disease will not report this symptom and certainly that some reports of this symptom don't imply the disease, just that sufferers of this disease often report this symptom.

4.4 Problems in Graph Presentation

We know that graphs have the great advantage of simple, clear, and direct displays in explaining complicated data structures. This feature leads us to attempt to implement it in the medical symptom-disease data set. However, there are some limitations to be considered:

1. How to display a large data set in a limited space?

   In the previous section, we have seen that graphically displaying the two symptoms' structure "Headache" and "Coma" is quite clear. We clearly see not only

each symptom in relation to its diseases, we also see the connection between these two symptoms. It is important to be able to see all this structure in order to understand the details. The question is, if we have many symptoms, let's say hundreds, can we still display all the relations in the same clear manner? We may need many sheets of paper or many separate screens to present this clearly. Then the problem occurs: the global structure will be broken. If we don't want to look at papers or screens, can we have some techniques to present this on one screen? It is useful to display a global view in many areas, such as computer network topology. For this it is important to view the whole network structure in order to analyze the system. For medical diagnosis it is useful to see the whole data set.

2. How to study detail in a part of the data set?

   The use of graphs (vertices and edges) to present the relation between objects clearly on one screen is recommended only if the graph is small. Suppose we want to have a global view and somehow we do succeed in presenting hundreds of vertices and edges on a single screen in a very clustered way, which means crowding vertices next to each other closely and many lines jumping from one vertex to another. Then how can we get to know the details?

In order to better retrieve the information through graphs exhibiting, some techniques must be applied to simplify the graphs.

Planar graphs

A graph that can be drawn on a piece of paper without any crossings is called planar. A planar graph is one of the clear ways of presenting a graph. If many crossing lines can removed, a much clearer view of the relation can be provided. Various algorithms have been developed for deciding whether a graph is planar, and if not, to reduce to a minimum the number of crossings, but the algorithms become very complicated for large graphs. An important theorem by Kuratowski [**Tvn81**] states that any non-planar graph contains at least one subgraph homeomorphically equivalent to one or other of the graphs shown in Fig. 4.5(a) and Fig. 4.5(b), in these graphs at least one crossing is inevitable.

4.5 Bipartite Graph Presentation of Data Set

According to the discussing of graph presentation, there are two requirements considered as major.

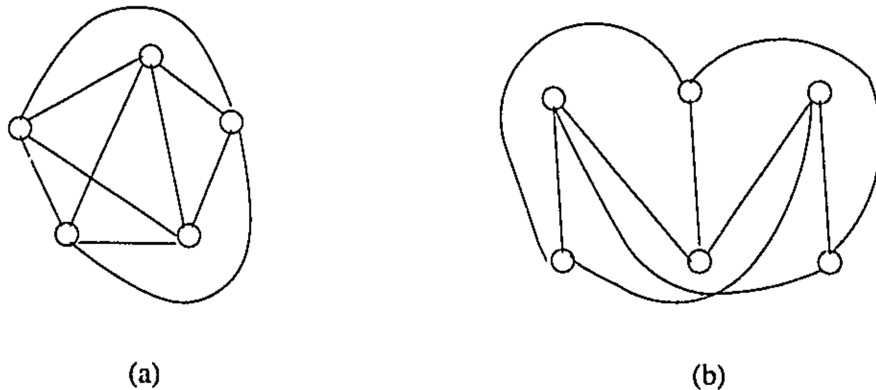

Figure 4.5: Non planar graph

1. Display all vertices and edges on one screen;
2. Minimize the number of crossing lines;

Why bipartite graph model?

- Advantages

1. easy to present the connections between any two objects;
2. graph is simple;
3. easy to draw the graph.

Numbered symptom and disease

Each symptom and disease are represented in the graph by a vertex in which there is a name corresponding to one symptom or disease, such as in Fig. 4.3. Considering the large amount of the space taken by providing each name of symptom and disease, we give them numbers. We assign the range from 500 to 609 to the symptoms, and from 0 to 423 to diseases. The complete data set with all numbers drawn as bipartite graph is displayed in Fig. 4.6. The linkages between each group (total 19 groups) are not presented. Because this network of group edges will be spread out and many lines will cross which makes the layout untidy.

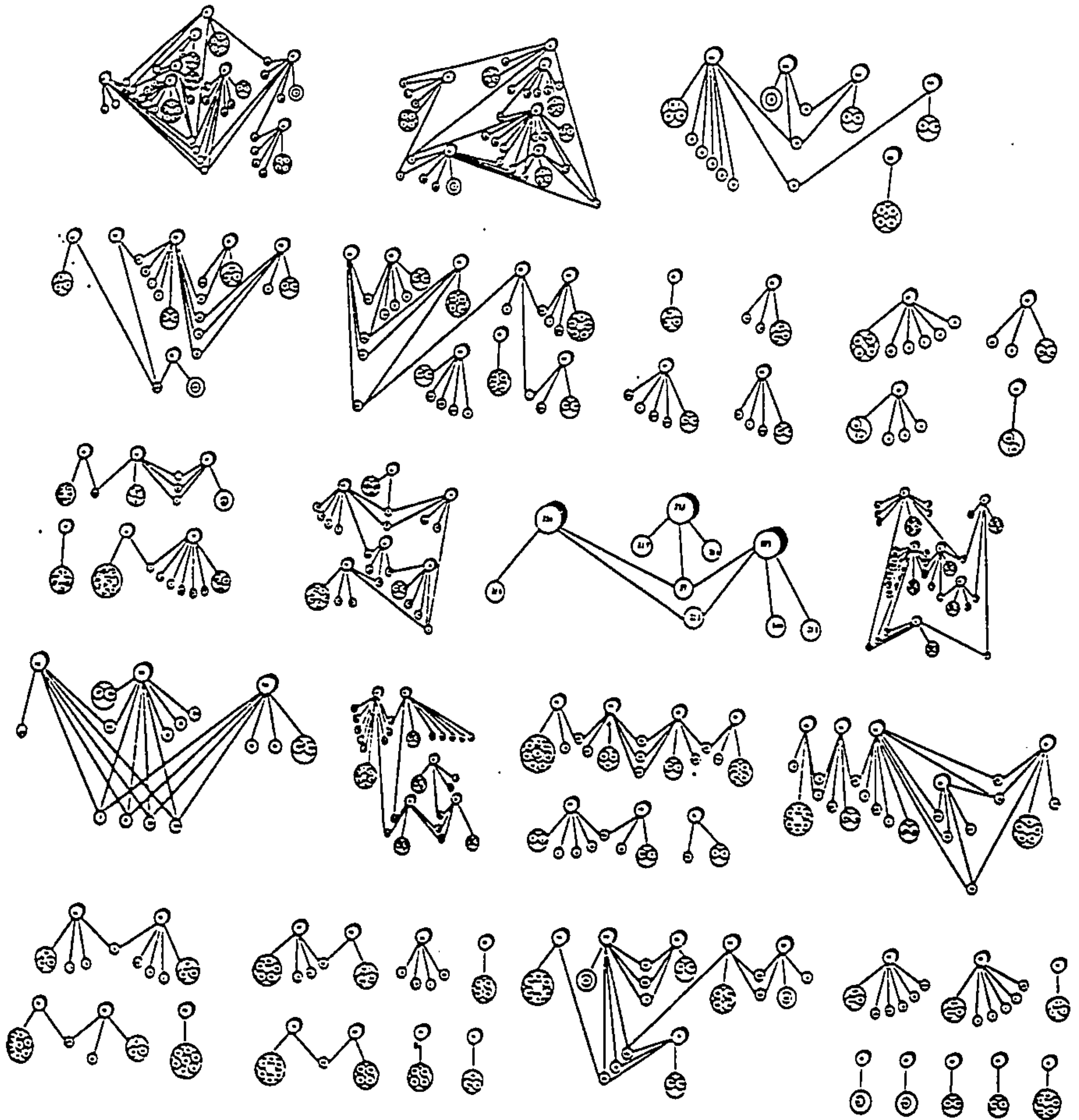

Figure 4.6: Bipartite graph model

Distance

Distance can be helpful for the decision maker. The distance between a symptom and a disease is the minimum length of the paths joining the two; this distance is always odd. The greater the distance between a symptom and disease, the less likely it is that a patient with that symptom has that disease. It is possible only if the symptom is spurious.

Minimized crossing line

The graphs of symptoms and diseases were designed manually and then put on the screen by a software package, Unix X-figure. An attempt was made to draw the graphs with minimum crossings by rearranging the vertices in the proper position so that the number of crossing lines can be reduced (see chapter 9).

Problems in this graphical display

Reader can see in this chapter that one idea we had at first was to present all the relations between symptoms and diseases in a graph; the relationship is graphical, after all. Of course, it would be convenient to have the graph occupy one page; one could just look at the graph and figure out which disease he had. Well, we drew the graph, figure 4.6. One look at the figure will explain why this approach was abandoned. The display is a mess; even scientists don't want to look at it, let alone doctors or patients. The numbers are too small to read, and the connection between symptom and disease is not at all clear. It would be of no use in diagnosis, even though most of the information is presented on one page. Therefore we need a better way.

Chapter Five

A Second Approach: No Edges

5.1 Introduction

We wrote that it is important for extracting information from the graph that the presentation be simple. The planar graph is simple. From Fig. 4.6, we can see that even though we attempt to draw this graph with big efforts of minimizing the crossing lines, there are still many necessary crossings (many external crossings between each subgraph) which is inevitably unavoidable. In the following we introduce some other methods that can improve the graphs' presentation.

5.2 Techniques

5.2.1 Tower vertex

Definition of tower vertex

If one vertex can present several vertices, we call this vertex as tower vertex.

The usability of tower vertex is that if several vertices share some features, we can then use one vertex to present them all.

Expanded tower vertex

If all vertices are visible in the tower vertex, we call this tower vertex as expanded tower vertex, for example a tower vertex in Fig. 5.1. Suppose all the symptoms and diseases are numbered.

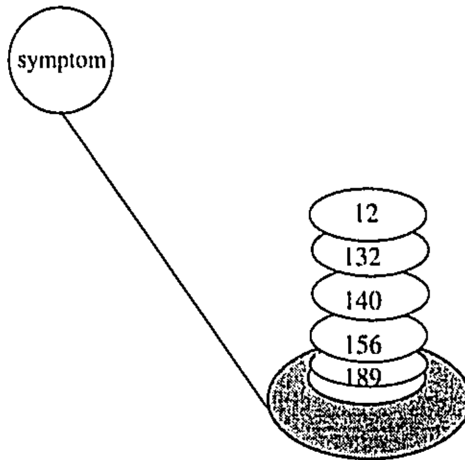

Figure 5.1: Expanded vertex.

In this example because a symptom is related to the five diseases: 12, 132, 140, 156, 189, the usual way of showing this would require 5 lines, one from the symptom to each disease. After using this expanded vertex method, 4 lines can omitted. This method can also be described as zooming.

Shrunken tower vertex

Alternatively, if "one vertex" presents a string of vertices which are clustered and not visible, then we call this "one vertex" is shrunken tower vertex. Fig. 5.2 as an example.

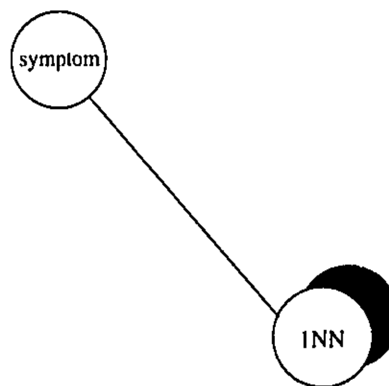

Figure 5.2: Clustered vertex.

The "1NN" presents a set of vertices labeled with first digit "1", and followed by any two digits "NN".

Combination use of expanded and shrunken tower vertex

We make the shrunken tower vertex with a shadow to indicate that there are more than one vertex hidden, and assign a number to it (where N means it can be any number). Fig. 5.3 shows how to use both expanded-tower vertex and shrunken-tower vertex together to simplify the graph drawing, i.e., reduce many lines.

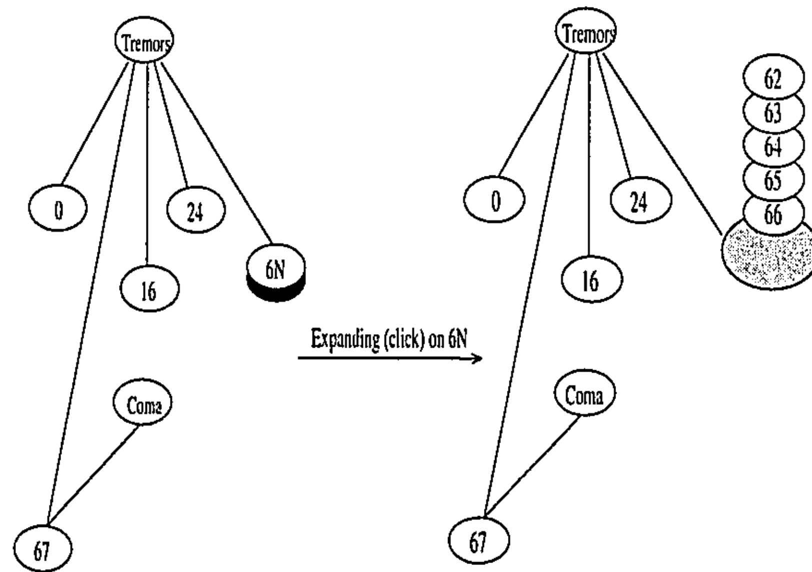

Figure 5.3: A graph of expanded and clustered vertex.

5.2.2 Fictitious vertex

Suppose there exists an intersection connected with all the vertices. It can be added to the graph and called a fictitious vertex to simplify the graph structure, see Fig. 5.4.

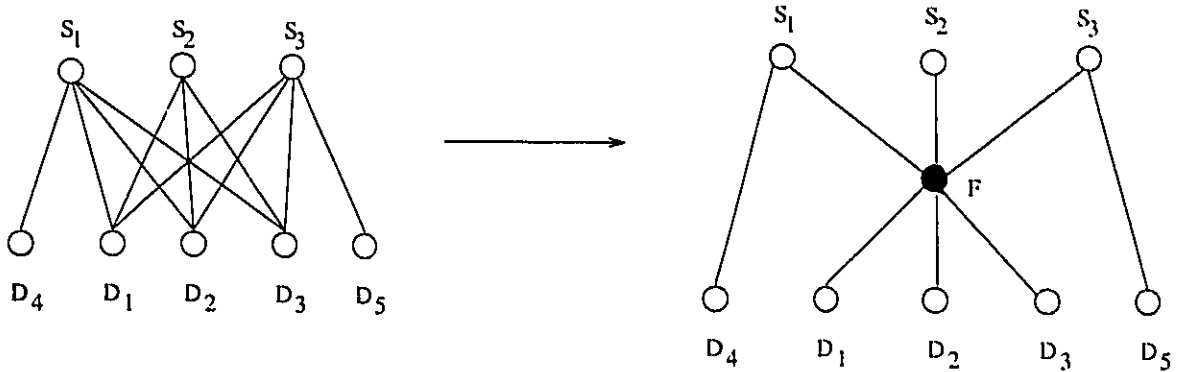

Figure 5.4: Fictitious vertex.

Although there is an additional vertex which is fictitious, it reduces the number of lines to each disease vertex.

5.3 Graphical View

In section 5.2, we considered only the question of how to simplify the graph drawing in order to accommodate more elements in the graph in a limited space. In this section, we introduce some methods of how to view a large amount of data in a limited space.

5.3.1 Hierarchical view

Visualization is a widely acknowledged discipline to explore vast amount of numerical data by interactive analysis. If we want a global structure display, including large labeled graphs, then an effective presentation must be given to those situations in which the amount of information to be presented exceeds the amount of space provided. Traditional solutions for solving the navigation and information quantity problems incorporate hierarchical menu facilities, windowing techniques, and scroll/zoom features.

Hierarchical view provides some features as following:

1. clarity and displayability;
2. facility of analysis and study;
3. ease of processing, correction;
4. decomposability, including the facility for concurrent execution of operation, distributed processing for concurrent design by different specialists, etc., [**Lsm93**].

5.3.2 Fisheye view

People naturally perceive the world using both local detail and global context. Biologically, our eyes let us see detail for only a small focused region. Yet we remain constantly aware of the global context through our peripheral vision and by glancing around. We rely heavily on global context to orient ourselves and to understand local detail; indeed, tunnel vision (which can be simulated by holding a paper tube to ones eye) is considered a serious handicap.

Most computers naturally encourage tunnel vision interfaces, for they supply users with very small screens to view large complex information spaces. Interfaces can minimize the tunnel vision effect through several fundamental strategies.

First, traditional graphical systems supplied pan and zoom capabilities, where users can pan or scroll a window across a virtual canvas, and they can adjust the scale of their view (and the entire space) through zooming. The problem is when users zoom out for orientation, there is not enough detail to do any work. When they zoom in to see detail, the context is lost.

Second, multiple windows may be provided, each with a pan and zoom capability. While reasonable for small information spaces, the many windows required by large spaces often lead to excessive screen clutter and window overlap.

Third is the map view strategy, where one window shows a large detailed view. The overview contains a rectangle which can be moved and resized, and its contents are shown at a large scale in the large view. Map views suffer from the extra space required for the overview, and from forcing the viewer to mentally integrate detail and context.

In this section we introduce the well-known fisheye view on graphical presentations. As we mentioned before, there are two problems to be considered in the graphical presentation of large data sets. One is the global problem, the other is the local problem. In order to display all the vertices and edges on one screen to show the global structure, they must be typically too small to see: see Fig. 5.5 [**SmB94**]. Alternatively, zooming into part of the graph, to see the local details will lose the overall structure of the graph.

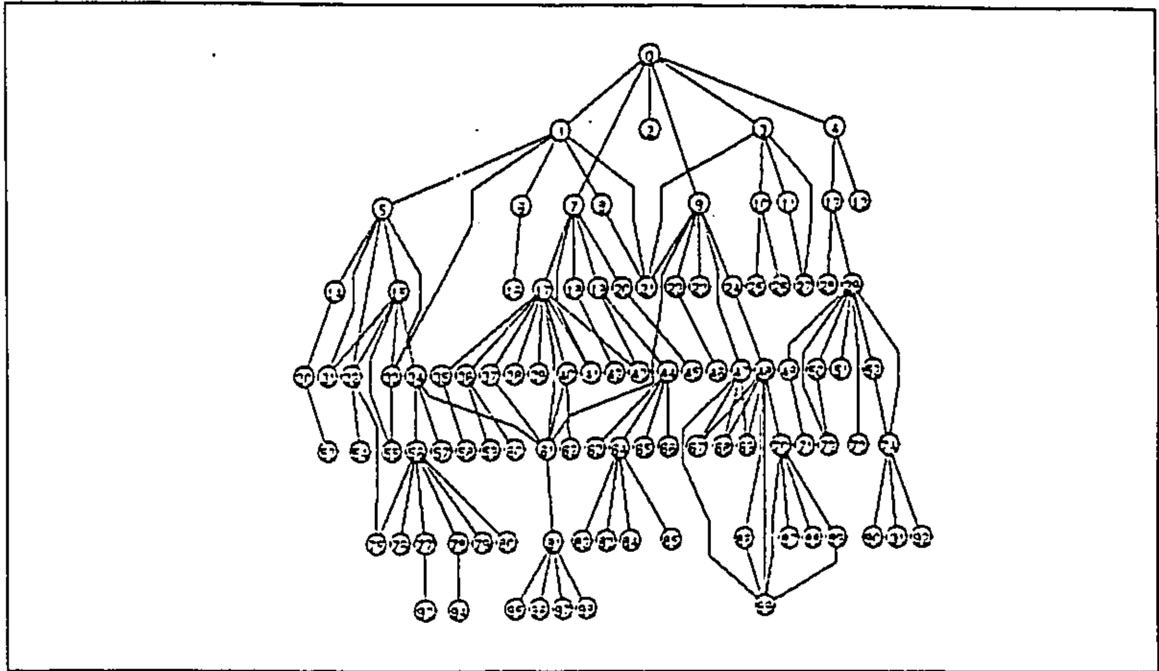

Figure 5.5: A global view.

How to overcome these two problems? Using two pictures, one of the entire graph and the other of a zoomed portion, gives one the advantage of seeing both local detail and overall structure and has the drawback of requiring extra screen space and forcing the viewer to mentally integrate the views. The multiple-view approach also has the drawback that parts of the graph adjacent to the enlarged area are not visible at all in the enlarged views.

Recent advances in computer-based information visualization have acknowledged the importance of balancing local detail with global context in a single view by providing fisheye views of the data space **[Fgw86][HMM89]**. This technique presents information related to points of interest (focus points) in great detail; less relevant information is presented as an abstraction. In this manner the user is provided detailed information concerning a specific item of interest; and the global aspects are not eliminated from the users view. The motivation for incorporating fisheye presentations in a computer interface is to provide users with a balance between local detail and global context; see Fig. 5.6 **[SmB94]**.

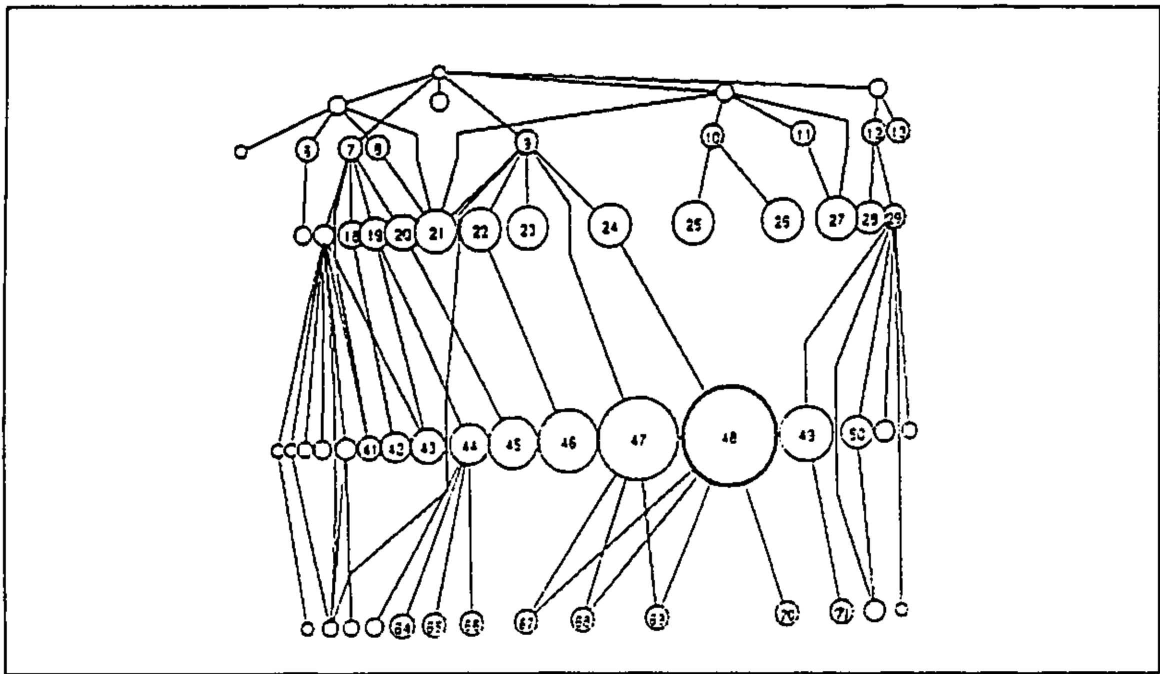

Figure 5.6: Fisheye local view.

Fig. 5.5 is a graph with 100 vertices and 124 edges. All edges point downward. Fig. 5.6 is a graphical fisheye view of Fig. 5.5. The focus is the vertex labeled 48. A viewer can select the focus by clicking with a mouse. The advantage of a fisheye view is to have smooth integration of local detail and global context by repositioning and resizing elements of the graph. A fisheye lens seems to have all the advantages of the other approaches for viewing and browsing a graph without any of the drawbacks.

There are two methods for viewing hierarchically clustered diagram. Traditional full-zoom techniques provide details of only the current level of the hierarchy. In contrast, fisheye views (generated by the variable zoom algorithm) provide information about higher levels as well.

5.4 Screen Layout

It is obvious that if the graph is drawn as Fig. 4.6 (in Chapter 4), we then would read no details, we couldn't even read the numbers on each vertex. If we are looking for a certain vertex, for example, label 48, how do we search for this vertex? Zooming each vertex by fisheye view will be time-consuming. Diagram usability depends on the ease of finding a diagram element when needed. Therefore how to read, and how the information can be extracted, are the critical issues.

The screen layout we present here (Fig. 5.7), is designed by the methods of expanded vertex and clustered vertex, as well as color techniques.

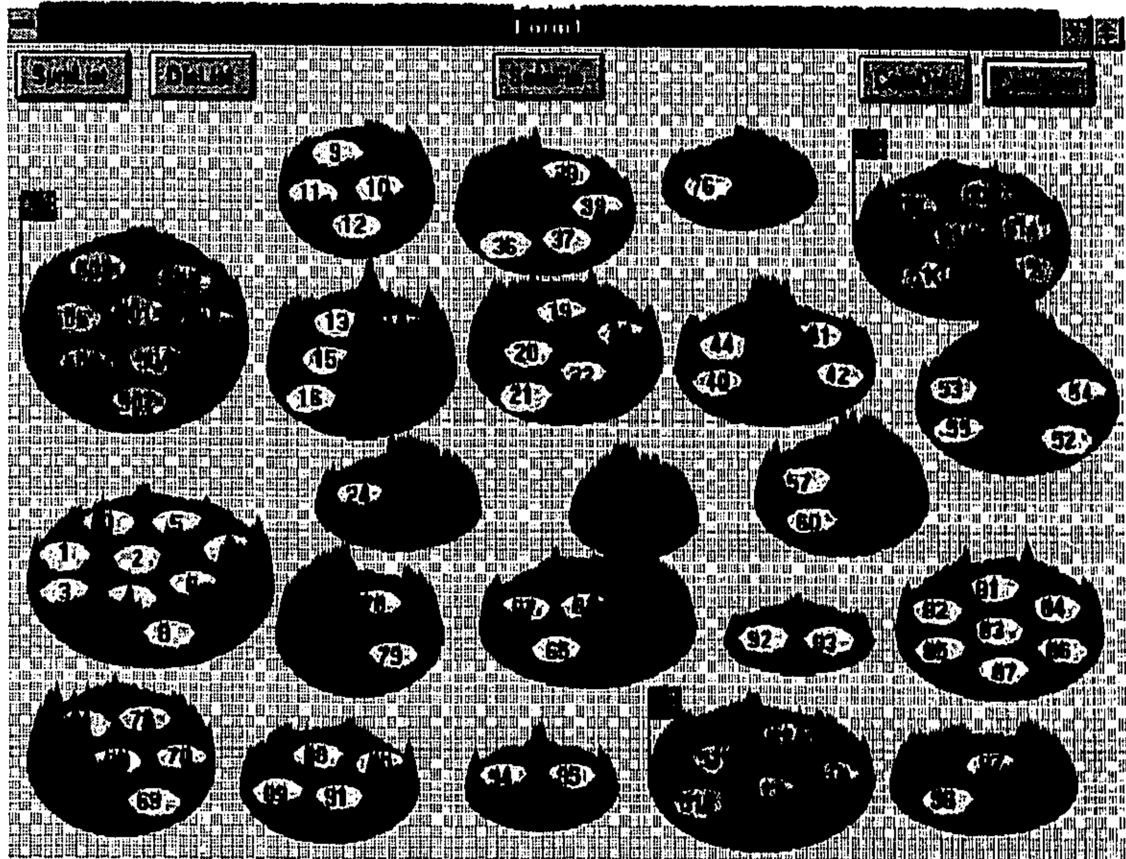

Figure 5.7: Screen layout.

There are three symptom groups displayed, each one with a flag (in order to distinguish the disease group). The disease groups have no flag. The vertex which has a number followed by dash "-", for example "1-" means it is a clustered vertex. So when we click on this vertex, i.e., zoom in on this vertex, it will be expanded so all the vertices of diseases will pop up. See Fig. 5.8.

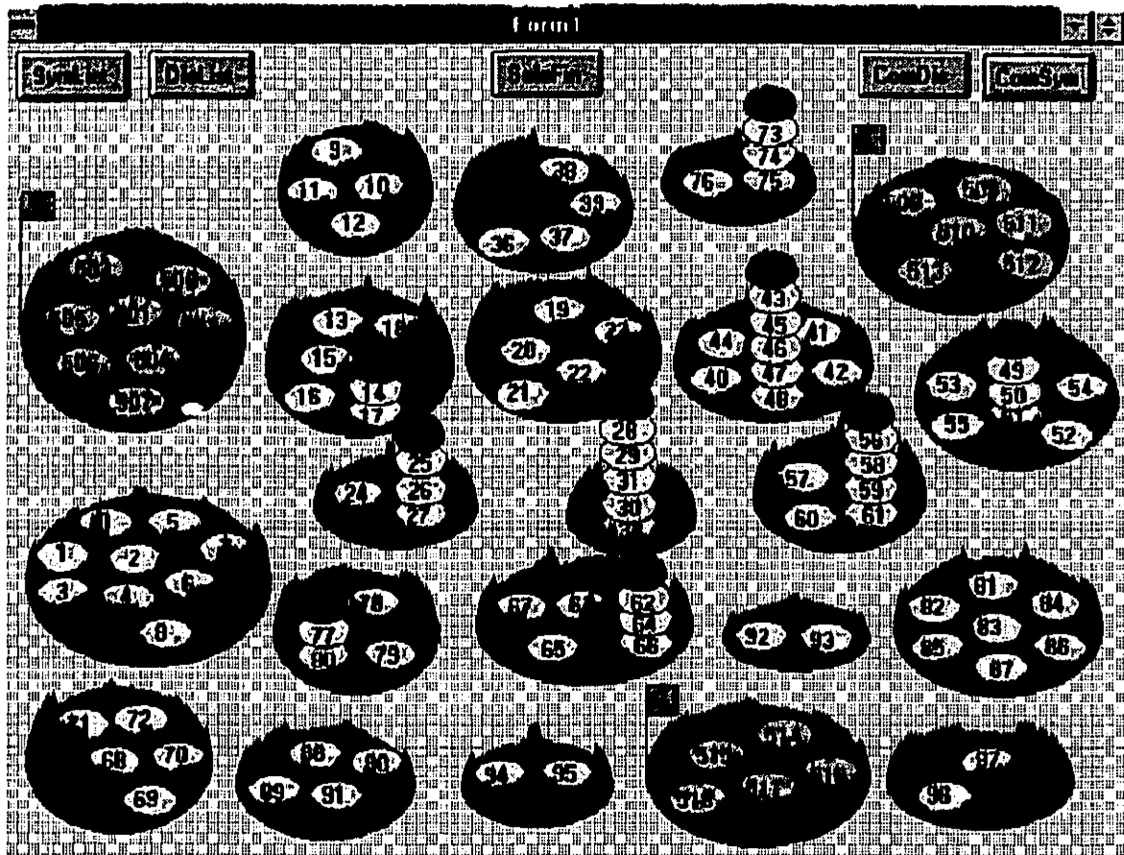

Figure 5.8: Display expanded vertices.

Some diseases have only one symptom. In this case, it is simpler to collect all such diseases having the same unique symptom into one big super disease, called a tower vertex. Such tower vertices are presented in the graph in a different way from ordinary diseases; they have a different color, and they have a number followed by a dash. The user can discover the ordinary diseases that have been collected into a tower vertex by clicking on the tower.

Functionality of the prototype

There are five buttons on a single screen:

1. SymList

   This button is used for displaying the symptom list. Because all the vertices are numbered, before we look for a certain symptom, we must know the corresponding number. This button provides the number. This symptom list is sorted by name. If you know the name of the symptom, it will not be difficult to find the number corresponding to it. Once you click on this button, the list box will pop up, and you can move around the window in case this list box overlaps some vertices you are interested in. See Fig. 5.9 at right lower corner box.

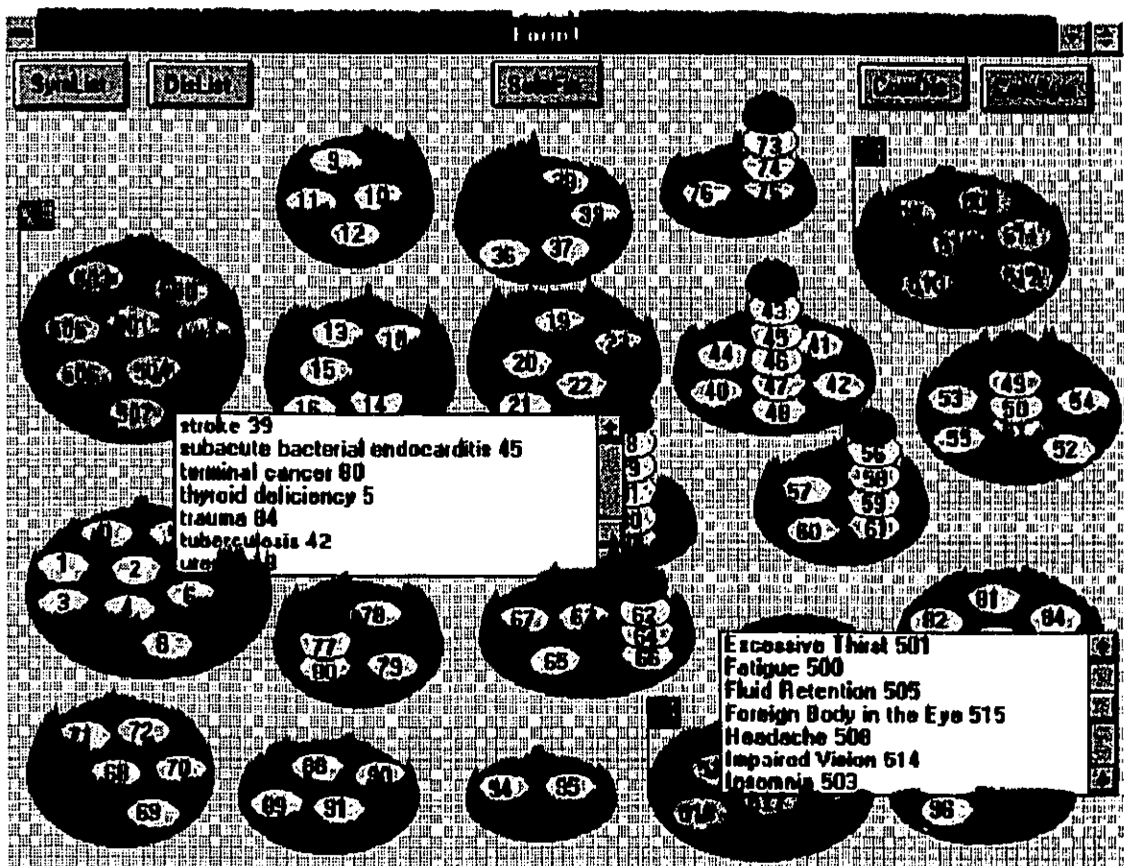

Figure 5.9: Display names and numbers of symptom and disease.

2. DisList

   This buttons' function is similar to the SymList, providing the disease list. This list is also sorted by name, see Fig. 5.9 (in the previous page) at left middle.

3. ComDis

   This buttons' function is to select the working mode, meaning that we want to display the list of the common diseases for the symptoms. See Fig. 5.10.

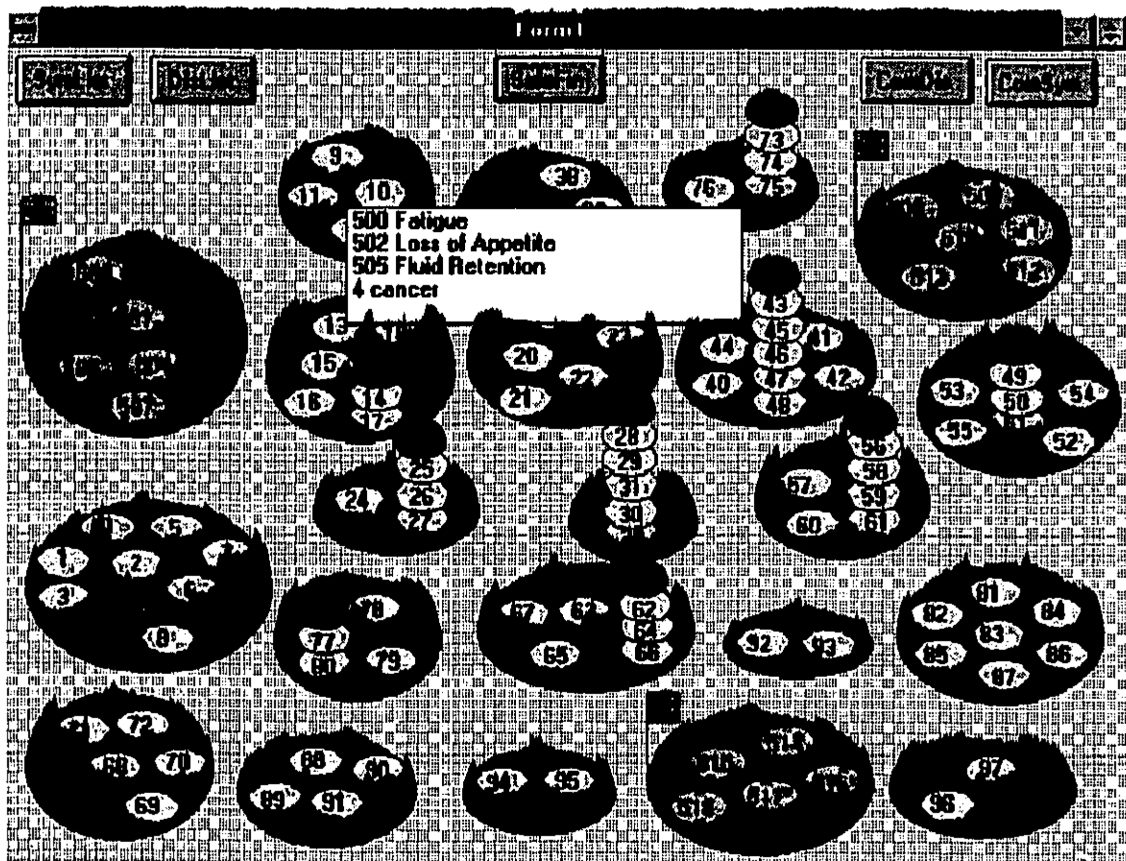

Figure 5.10: Display result of common diseases.

In the result box we see that the selected symptoms are: Fatigue, Loss of appetite, and Fluid Retention; the common disease is "cancer".

4. ComSym

   This button is similar as the ComDis. The difference is that we want to display the common symptoms for the selected diseases. Same procudure as the ComDis, but instead of ComDis button by using ComSym. See Fig. 5.11.

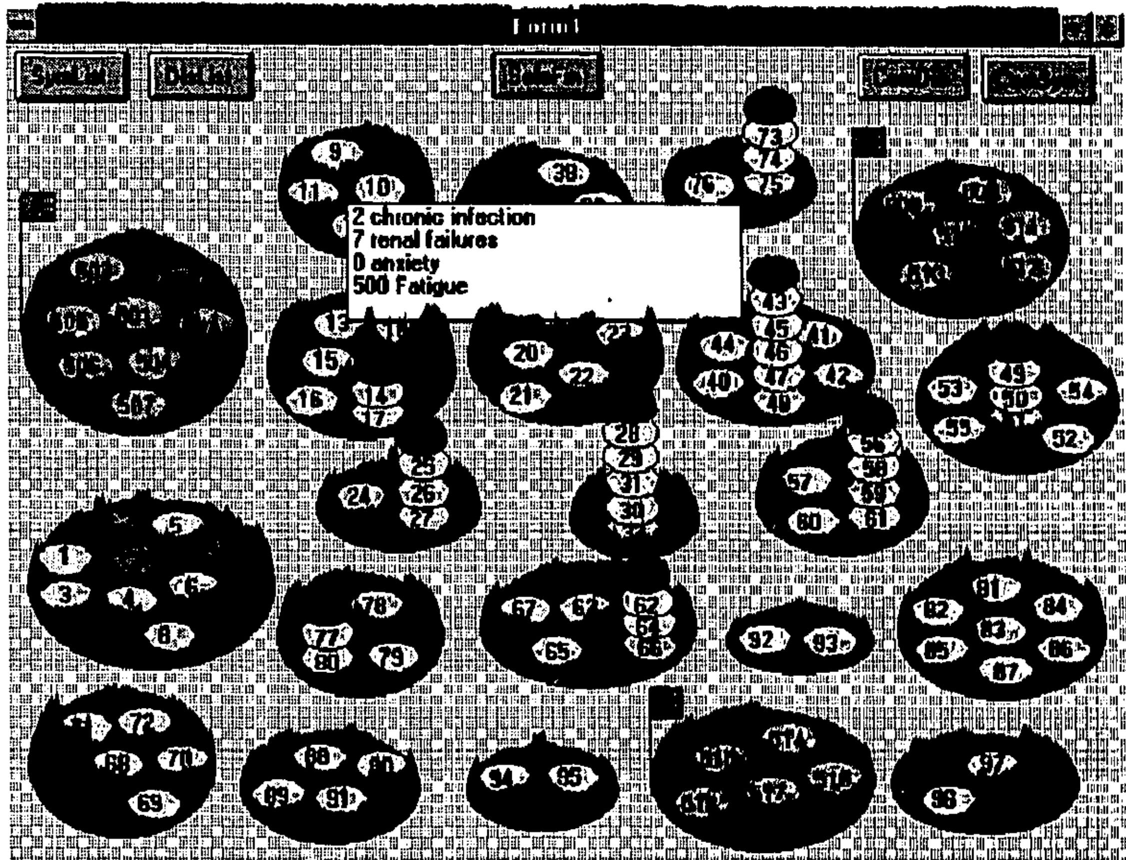

Figure 5.11: Display result of common symptoms.

   In the result box it shows the selected disease: chronic infection, renal failures, and anxiety; the common symptom is "Fatigue".

5. SeleFin

   This button is used to finish the selection for symptoms or diseases, and to display the common list of disease or symptoms found for the selected symptoms or diseases.

Experiment of the prototype

There are some advantages in this prototype:

1. Graphic interface

   The interaction with computer is only through the function buttons and numbered vertices.

2. Multiple functionality

   Two functions can be chosen. One is common disease selection and another one is common symptom selection through the working modes "ComDis" and "ComSym".

3. No edges displayed

   On the screen layout, there are no multiple edges or crossing edges, which makes the screen clearer.

4. Zooming function

   A zooming function is presented in this model by providing the clustered vertices and Expanded vertices.

5. Coloring

   Humans are sensitive to color, so it can be important to use color in the graph to attract attention. In this model no edges appear, because we believe that there is no need to present the edges if we can not read them clearly. Instead of presenting the edges, we use color to present only the relation we are interested in, such as common diseases and common symptoms, which are presented in different colors.

   We use color not only to distinguish the selected vertex and common vertex, we use it also in the shrunken and expanded tower vertex, i.e., the shrunken vertices are presented in brown.

There are some drawbacks and limitations to this prototype:

1. Limited display

   There are only three symptom groups presented on one screen and 19 symptom groups are required.

2. Interaction insufficient

   Before selecting any vertex, we must know the number. This number must be found through the list box help. The way of using the numbers is not convenient, and lowers the speed in accessing the information.

Chapter Six

Matrix Table – A Third Approach

6.1 Introduction

From the literature review in Chapter 2, we have seen that a large amount of research work has been done in the medical field. Many different types of systems are developed based on many sophisticated methodologies. The reason for this is that medicine is an important part of any social structure. Health care influences society not just by affecting the number of its healthy individuals but also by changing the way the people think and behave. Therefore health care plays a major role in our society.

As almost everyone needs help for health care, there are not enough physicians, and some physicians have not enough skills to deal with all the medical problems. Therefore if we have a tool to help physicians or patients, it will be a significant change in our society. That is why when people found out that a computer is an ideal tool for handling such large and complex problems in medicine, they were just thrilled. It turns out that there are lots of things in medicine that a computer can do, such as keeping patient records in hospitals and other health care centers (since computers have the capacity to store vast quantities of data which can be recalled in a few seconds); or patient history taken by computer-controlled interview; or computer-assisted diagnosis, which is the most extensive use of computers.

Computer-aided diagnostic support with systematic feedback improves the quality of diagnoses and can substantially reduce the number of serious mistakes in treatment. That is why in the past, many different systems for decision support have been developed. However, most systems do not pay much attention to visualization in diagnosis, only in the surgical area. Our application is one of these developments, which is focused on:

• Source representation
how source data can be represented in a structure that can be visualized by a computer;

• Information generation
How can the data structures generate information about an individual case?

• User interaction
How can the system optimize the interface design in the most friendly environment?

6.2 Purpose

The purpose of this system design is to provide an easy-to-use home tool to bring complicated medical knowledge from the medical book to the ordinary user by computer visualization.

6.3 Scope of The Model

The model is specially designed for the home-based medical assistant, which gives the end-user the following abilities.

1. self-diagnosis;
2. self-learning;
3. self-assessment;
4. self-care.

6.4 Design Goals

The principle goals are ease of understanding, and ease of use.

6.4.1 Ease of understanding

Since the key point of visualization is to facilitate human understanding, the visual display should be as intuitive and meaningful as possible. Graphical elements symbolizing data attributes should be effective and expressive. Display techniques should take advantage of well-known metaphors from daily life. They should use existing conventions to support the human visual system.

6.4.2 Ease of use

High-level graphical interfaces should significantly increase the ease of use of visualization software. Nowadays interactive, mouse and menu-oriented user-interfaces allow the user to interact and dynamically change the graphical representations of data and programs. No typing is involved, and user should be able to operate the system without being helped.

6.5 General Outlines of The Tool

The aim of this study is to develop a new tool to be used in medical diagnosis. It should enable the user to make some decisions or learn some information from the existing medical database; moreover it should offer a visualization environment through the whole procedure. The following properties should hold:

1. Efficient display of human body

   In the first approach, the user interface design is not efficient, since every time you want to select some symptoms or diseases, you must know their numbers. Therefore you must open list box (textual style) to read through and get the information you want. Obviously it is quite inconvenient. Although the screen shows the visual graphics, it is too abstract to understand and to operate. Therefore we must design an efficient interface.

   The human body is a complex structure; it has many parts, here we say groups, which can be completely different. To describe this could take many pages. For visualization purposes it is not feasible to use words for displaying the complicated human body structure. A picture is worth one million words. A computed diagnostic image in two dimensions displays almost all the important parts of human body.

2. Efficient input

   Because the graphics provide the intuitive perception, the user should provide the proper input by just clicking the mouse for the specific part of the body without knowing the particular medical name. Traditionally the input is done by typing information into the computer system, then the system processes the result and gives it to the user. It is less convenient for the user to do the typing, unless the user is a typist or knows exactly what he or she is typing. We need to design a user interface which uses only a mouse to point out the part of the body, which means that two-dimensional body needs to be mouse sensitive.

3. Efficient system response

   Efficient interaction between system and user is the first priority for system design. In order to comply with this principle, the system response for the input in graphic style provides an intuitive and direct feedback. The techniques used here can be list box, color highlight and color flash to make the user pay more attention.

4. Efficient display of multiple selection

   In the first approach the system provides only the common diseases or common symptoms. It will often be the case that there is no common disease for selected symptoms or common symptom for selected diseases, if you select more than two symptoms or diseases. However, there may be a common disease, near-common disease or common symptom, near-common symptom between two sub-symptoms or sub-diseases. For example, if you select three symptoms in the general complaint group: fatigue, weight loss, and excessive thirst, there is no common diseases causing them, but there are common diseases for two symptoms: fatigue and weight loss. These two symptoms share two diseases: cancer, and renal failure. This information is important in medical diagnosis. Consider how physician diagnose: actually it is a mapping process, which means they search the database built from studying and working, to find out which have common causes between these symptoms if there are more than one. If they find common diseases, then the diagnosis procedure would be easy; if not (in most cases), the physician often searches near-common diseases, to determine which symptoms are really present. Therefore it is necessary to simulate the diagnosis in a clear way.

   Another point of designing such a system is that if the system has no reaction (if the system could not find a common disease), the user will become suspicious about the system. If the system provides all the information, the user may have confidence.

5. Efficient displays of all the information

   We mentioned before that the diagram of vertices and edges can be used to display all the relationships between any two nodes or objects, however it is hard to display them on one screen for a large amount of data. We know the usability of a diagram relies on the ease of finding a diagram element when needed. Computer graphics are powerful. If the system can use graphics to display all the information that a diagram has, it will be simpler and clearer, because the graphics will replace the puzzled image of vertices and edges.

6. Efficient output

   The results we get from the system should be displayed visually. The system is concerned not only with visual input but also with visual output, which is an important point for final decision-making. Most systems are not concerned much with visual output, using text-list output only. Therefore it is worthwhile to experiment with visual output.

7. Efficient method for information processing

   In Chapter 3, we wrote that the data come from a medical book. In the system design we must provide a efficient method to process all this medical information in a way that is fast enough to produce all information. Since we only have two data classes to consider, symptom and disease, a two-dimensional data matrix should be considered.

8. Efficient language

   Choosing the right language is important for the system design. Since our system is visual, visual language facilitates our implementation. Currently C++ and Visual Basic are the most popular visual languages. For ease of use, ease of manipulation, ease of learning, and for small projects, Visual Basic should be chosen.

6.5.1 Principle of user interaction design

According the experience of the first approach, to design a effective user interface, following principles should be taken into account:

1. Maximize the amount of display area allocated to all necessary objects;

2. View the relation of symptom-disease;

3. Maximize clarity of layout.

6.5.2 Color techniques

Color may be used to achieve the following goals:

1. reveal connections between any two objects (by mapping relations to colors);

2. highlight areas of interest;

3. emphasize body patterns; and

4. make the course of computation visible (for instance, by mapping any interconnection in color).

6.5.3 System description

The system can be divided into three main parts, as shown in Fig. 6.1.

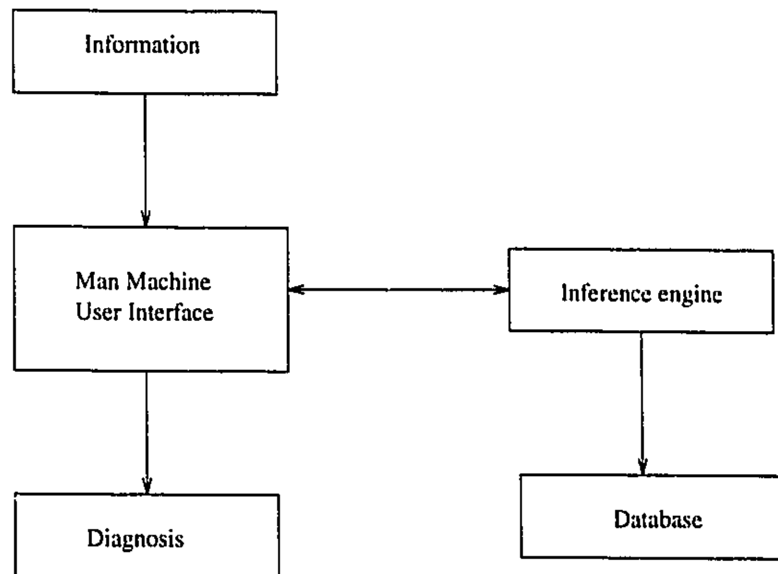

Figure 6.1: System description.

1. Man-machine user interface

   The man-machine user interface is essentially the human body image. The system accepts information from the user and outputs a diagnosis under the management of the database.

2. Inference engine

   The inference engine uses the table-lookup method to seek the value for expressions within the database.

3. Database

   The program flow is largely governed by logic programmed in the database. After receiving information from the user, the system analyzes the information and makes a relevant diagnosis based on the pre-existing database.

6.6 Hardware Requirement

The application should be able to run on the PC under Windows, at 386 system or higher.

Chapter Seven

Implementation of Matrix Table

7.1 Introduction

It is now universally accepted that graphics should play a significant role in human-computer communication. The application of graphics has already proved successful in many fields. People are very subjective when selecting images, menu design or computer interfaces.

Computer interfaces that facilitate users' abilities to access and interpret information will enhance the quality of human-computer interaction. A user often experiences difficulties in accessing and interpreting information, because his knowledge of both the underlying structure and the relationships between information is limited. Traditional solutions for solving the navigation and information quantity problems described above incorporate hierarchical menu facilities, windowing techniques, and scroll/zoom features.

In our model we use a combination of two-dimensional image and coloring techniques to present an amount of information which exceeds the amount of space provided by the screen. The model is carefully designed under a certain condition, that is, the problem domain or the database is collected from a medical workbook "*A Primer Of Clinical Symptoms*" **[Tbr73]**. It has 200 pages which covers most of the general cases. It is a good medical book for case study and model building. This model implementation is based on the design description of the previous section.

A little hierarchy is used in the presentation of the screens: the first step is the display of the human body; then come the symptom groups; then the individual symptoms; and finally the table of diseases.

The actual system is implemented on two screens. The first screen is the human body picture that provides the input. The second screen is actually the result picture, representing the relationship symptoms-diseases. The simple look and simple procedure is the primary design goal.

7.2 Major Considerations

Implementation is based on following major considerations:

1. Global view:

   In order to have a global view, the question is how to show much information on a limited space and still understand the structure? There are 109 symptoms and 423 diseases, so the total will have 532 objects.

2. No typing request:

   In order to provide user-friendly environment, how to get rid of keyboard input?

3. Labeling problem

   From the viewpoint of the user, labeling all the symptom and disease names on the screen will be intuitive, but it takes too much space, it would surely be messy, and be hard to read. How should we present all this labeling information?

4. Displaying

   According to the data set structure in Chapter 3, there are three data classes; one is the symptom groups, another one is symptoms, the third one is diseases. How can we display these three different data classes graphically?

7.3 Solution in Implementation

In order to solve the problem, this model is implemented in the following way:

1. The first screen layout is used to provide the efficient input and present all the symptom groups;

2. The second screen is used to present the global structure of all diseases and corresponding symptoms;

3. Common diseases are displayed on the second screen with flashing lights.

7.4 Screen Layout

7.4.1 First screen

The first screen this model provides is a two-dimensional human body, as Fig. 7.1.

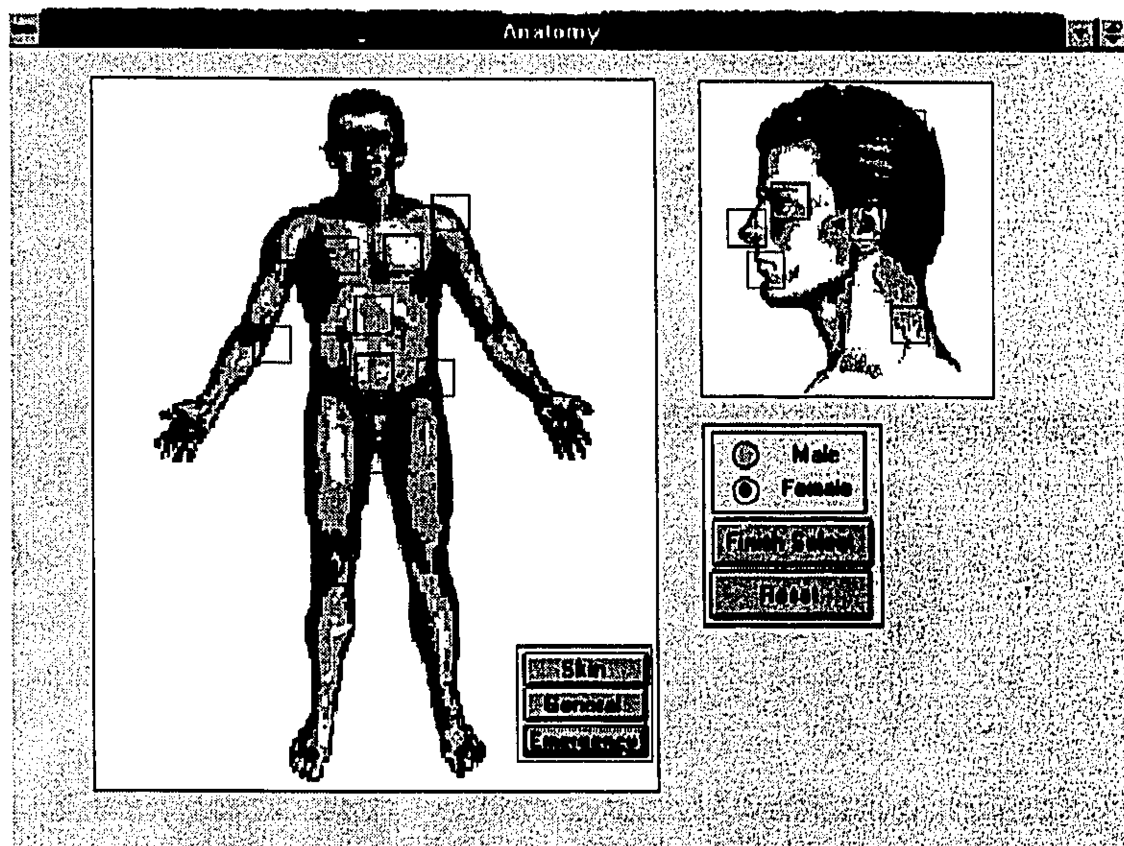

Figure 7.1: Anatomy of male.

We did not design this human body picture. The picture actually is a snapshot from the software called "Home Health Advisor". For our purpose, we need this picture only to display the symptom groups on the human body, instead of using words to explain.

We take this picture as background and then associate each symptom group to a certain part of the body by drawing a square on it to indicate the available symptom group, which is mouse sensitive. For example, if you click on the heart part of the body, the system will know that you selected the heart symptoms group. There are eight symptom groups on the main body:

1. *Muscle and joint symptoms*
2. *Lung symptoms*
3. *Heart symptoms*
4. *Stomach symptoms*
5. *Liver and gallbladder symptoms*
6. *Intestinal and rectal symptoms*
7. *Urinary symptoms*
8. *Male reproductive organ symptoms, or female reproductive organ symptoms*

There are six symptom groups related to the human head, however in the picture the size of human head is not big enough to put six squares on it. We enlarged the head on the screen and put it separately. These six symptom groups are:

1. *Nervous system symptoms*
2. *Eye symptoms*
3. *Ear symptoms*
4. *Nose and throat symptoms*
5. *Oral and dental symptoms*
6. *Neck symptoms*

There are another three symptom groups for which it is difficult to find the right position on the body picture. We put them in command buttons beside the body. Once these command buttons have been clicked, the system will acknowledge our selection. These three symptom groups are:

1. *Skin symptoms*
2. *General complaints symptoms*
3. *Emergency symptoms*

There are another two symptom groups on the female body.

1. *Breast symptoms*
2. *Female reproductive organ symptoms*

Function buttons

There are three function buttons on the first screen:

• "Male" and "Female" buttons offers the choice of male or female. The default picture is male body. If you click on the female button, the screen will bring up the female body picture. See Fig. 7.2.

• "Finish Select' button is used when the selection of symptom group is complete, to tell the system to process the user input provided.

• "Reset" is used to bring the program to the beginning. Therefore if user clicks on some symptom groups by mistake, or user wants to start a new selection, clicking on this button will clear all selected groups and start over again.

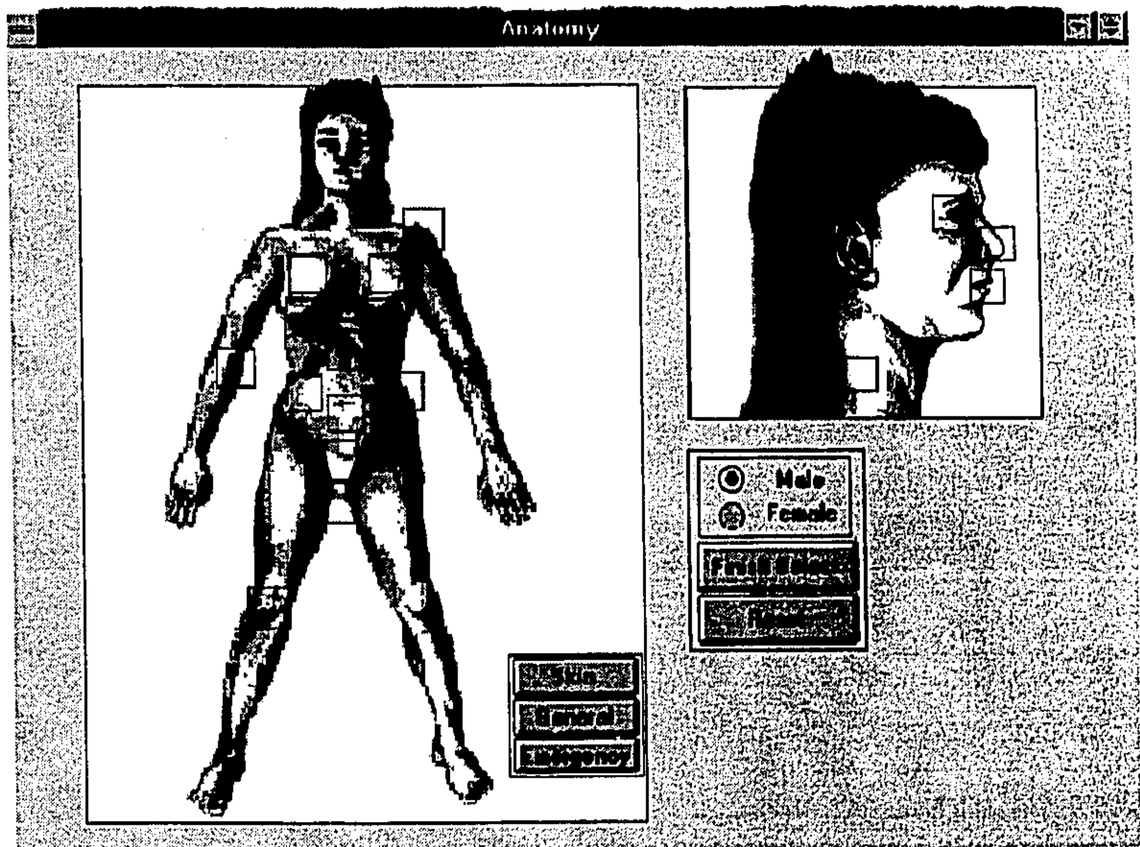

Figure 7.2: Anatomy of female.

System reaction

It is important to realize how the system will affect the user understanding. Suppose you click on the body part from the first screen, the system should tell you that it acknowledges your input. If system shows nothing, you probably wonder if you did the input correctly. Thus we use color. If the user clicks on a certain part of the body, this part of the body will be colored with yellow to distinguish the selected part from the background (except for the three special command buttons of symptom groups which are not represented on the human body).

7.4.2 Second screen

The second screen shows the symptom groups chosen from first screen and has a matrix of 423 disease cells; see Fig. 7.3.

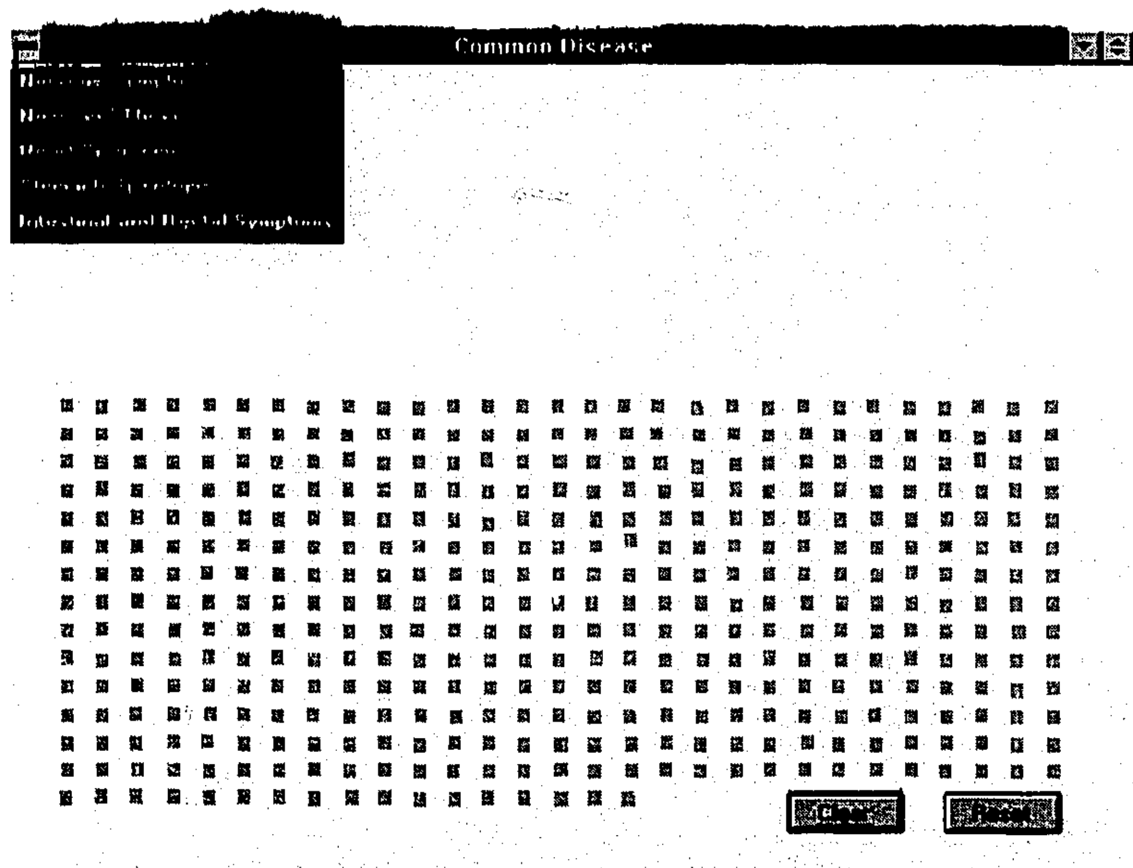

Figure 7.3: Display symptom groups.

The cell will flash if the disease corresponds to the symptoms chosen. Cells flash in different colors for different symptoms.

There are two steps involved in the second screen display.

- Step one:

Each symptom group contains its own symptoms. To choose the symptoms, you need to click on its certain group. The additional list box will show up next to the symptom groups' list box, as shown on Fig. 7.4

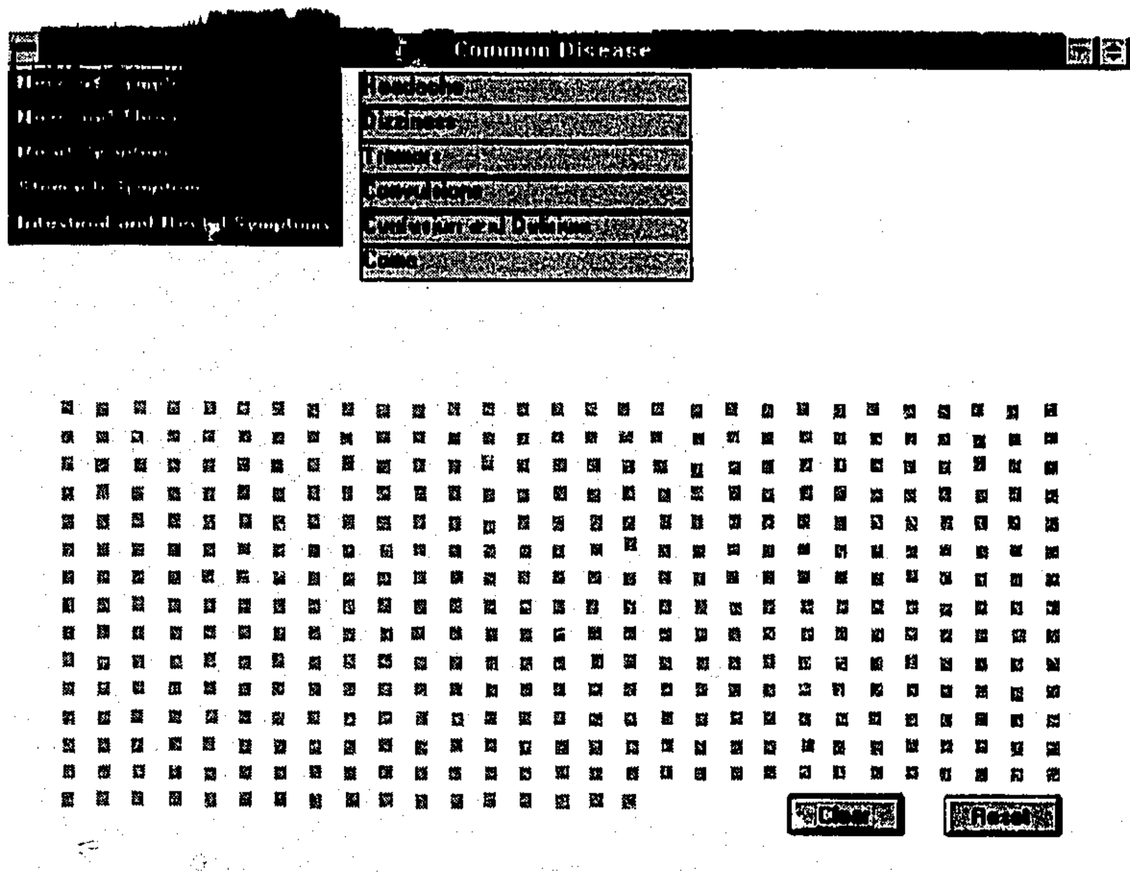

Figure 7.4: Display symptoms in selected symptom groups.

• Step two:

From symptoms displayed, the user can decide which symptom he/she has. Once one symptom is selected, it will be held on the right upper corner, displayed in a certain color, and the rest of the symptoms will disappear to save screen space. Once the symptom is selected, and it is held on the right upper corner, then in the disease pool, some corresponding diseases will be lit up. See Fig. 7.5.

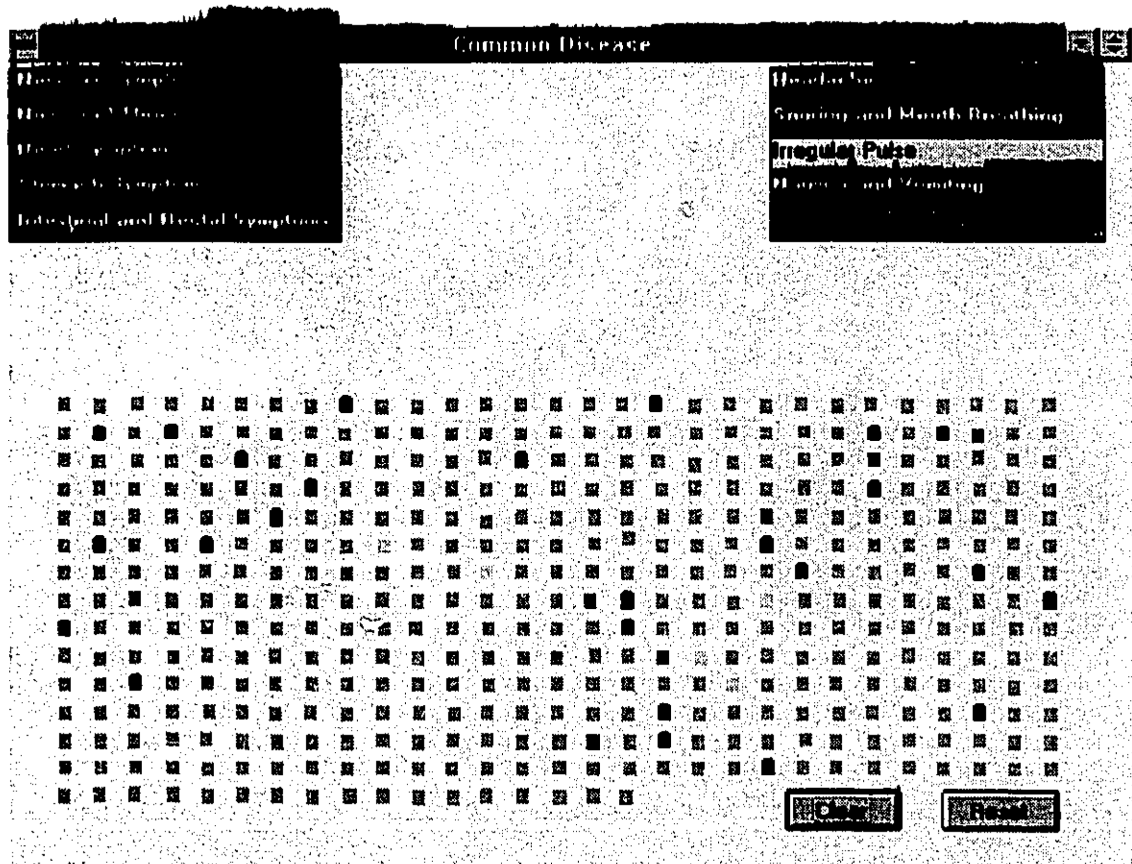

Figure 7.5: Displaying selected symptoms.

Color usage

In order to distinguish the symptoms selected each time, the system uses color coding. The rule is as follows: first selected symptom, red; second selected symptom, yellow; third, blue; fourth, green; fifth, black. At the time we select a symptom, the corresponding diseases from the disease pool are lit up in the same color order as selected symptoms to indicate that the symptom and disease correspond. Thus it is easy to tell which symptom has which disease.

Final result

The final result will be presented in the disease pool by color flashing if there is any common disease or near-common disease. As we wrote before, each symptom has its own diseases which are colored the same. However, since diseases can be shared by many other symptoms, there is a possibility that the same disease will be colored in two, or three, or four, even five different colors depending on how many symptoms are selected and if any common or near-common diseases exist. Therefore from the different lights, we can tell immediately which symptoms have a common disease or a near-common disease.

Labeling

The final information accessed is the disease name corresponding to the disease cell; see Fig. 7.6 in next page.

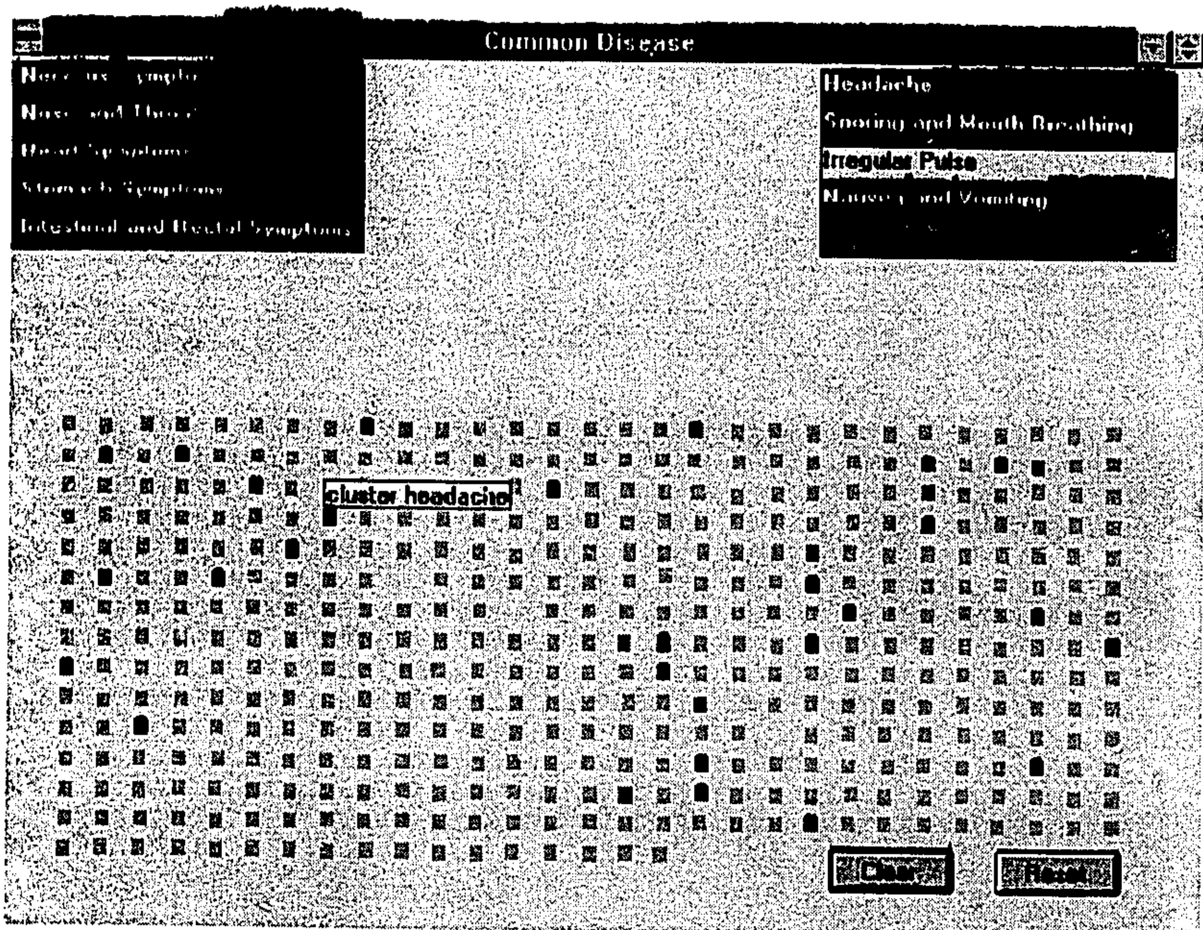

Figure 7.6: Displaying common diseases' name.

Every disease cell has its name; this is pre-assigned in the system design stage. The user can click on any disease cell to see the disease name; instead of displaying all disease names on the screen statically, blocking the view, we let the user use the mouse to click and hold on a certain disease cell to display the label. Once the mouse is released, the label will disappear.

Cell flashing

In order to improve the display of diseases, we randomly arrange the disease cells so that it is unlikely that several adjacent cells will flash, which provides better information visualization.

Summary

In summary, there are six steps involved.

- From the first screen:

1. Choose gender;
2. Choose symptom groups;
3. Finish selection by clicking on "Finish Select" button;

- From the second screen:

1. Choose particular symptoms.
2. Watch lights flash. This indicates diseases associated with selected symptoms. The diseases with the most colors are the most probable diseases.
3. Read the disease name by clicking and holding mouse on the corresponding disease cell.

7.5 Complex Data Set Management

7.5.1 Symptom-disease matrix

The data set is made up of symptoms and diseases. These data sets are the core of the system. In the program these data sets are arranged in a two-dimensional array. Each row holds disease elements, each column holds symptom elements. This makes the data a matrix. All the computations use this matrix.

To interpret every cell of the matrix with its meaningful name, there is a table in which each number has the corresponding name of the disease or symptom. The system uses this table to do the translation for the user interface. For more details, there is code available.

7.5.2 Calculation in common-disease

In this two-dimensional matrix, each cell of the matrix represents the relation of symptom-disease which can be described here by a pair of disease and symptom, that is for each symptom if there are diseases related, set all these row cells to 1; 0 otherwise. These are predefined in the program according to the primer; see Table 7.1.

Table 7.1: Matrix table.

	S_1	S_2	S_3
D_1	1	1	1
D_2	1	1	1
D_3	1	1	1
D_4	1	0	0
D_5	0	0	1

Once this matrix is built, then we can search each column to see if there are any "1"s; if yes, then the rows are the diseases which cause that symptom. In the system, we actually use this method to compute the common disease. For example, if symptoms S_1 and S_3 are selected, then from these two columns we go through all the disease rows to check if it has "1" in both columns; if yes, then the row number, that is disease number, will be the common disease for S_1 and S_3. Here each row number corresponds to the disease number.

7.6 Program Description

The program can be described in several procedures.

Symptom group procedure

First the body diagrams are displayed on the screen with indicated symptom groups. When the user clicks on the body part, the program calls up the appropriated symptom group. There are two tasks in this procedure:

1. color the selected symptom groups on the body part in yellow;
2. wait for the next selection.

Finish selection procedure

Once finished with the selection of the symptom groups, and the "Finish Select" button is activated, then the program goes into the following stages:

1. brings up a second screen (which overlaps the first screen), displaying the disease pool and selected symptom groups in the left upper corner. The selected

symptom group is presented in the list-box individually (each list box has the number for the selected symptom group);

2. wait for the next action.

Symptom group list-box procedure

When the list-box (which contains one symptom group) is invoked, it will do the following tasks:

1. display all the symptoms of that group next to the symptom list-box; there can be several list boxes;
2. waits for selection of the symptoms.

Symptom list-box procedure

From the symptoms provided on the screen, the user can choose symptoms he has. Once one symptom is chosen, the system list-box will take action as follows:

1. place the selected symptom in a "selected symptom list-box" on the right upper corner;
2. light up that selected symptom in some color;
3. dismiss all the symptom list-boxes on the screen;
4. look up the symptom-disease matrix table, to find out if any diseases correspond to that symptom; if yes, color all these diseases in the same color as the symptom;
5. return to the stage of symptom group list-box again to repeat steps from 1.

Control of flashing lights

The program obtains the common and near-common diseases from the disease-symptom matrix by going down the columns corresponding to the symptoms selected. Each row having a one in the column selected, corresponds to a disease having that symptom. Those diseases having some or all of the symptoms are copied from the matrix. Then each disease (more properly the cell corresponding to that disease) having symptom one, flashes red. Each disease having symptom two, flashes yellow. Clearly each disease having both symptoms flashes twice, and so on. The common diseases, if any, will flash in five different colors. Once all symptoms have been run through, the program repeats the flashing routine. The routine repeats, so to identify the common and near-common disease is easy, by mere inspection.

Summary

As the user chooses the first symptom, the program colors the cells (of the matrix) corresponding to the disease having THAT symptom red; if a second symptom is chosen, the cells corresponding to those diseases having the second symptom and not the first are colored yellow, and those diseases having both symptoms flash red and then yellow. For the third symptom, the new color is blue. The absolutely common disease flashes all three colors, and the near-common diseases flash with their appropriate two colors. For the fourth symptom, the new color is green, and finally for the fifth symptom, the color is black. In each case, the near-common diseases flash with their respective colors.

7.7 Visual Language

As the distribution of personal computers and the personal workstations grows, the majority of computer users now do not know how to program. They buy computers with packaged software and are not able to modify the software even to make small changes. Easy-to-use software actually makes the user-programmer gap worse since more people will be able to use the software (since it is easy to use), but the internal program code is now much more complicated (due to the extra code to handle the user interface). Therefore, systems are moving in the direction of providing end-user programming. It is well known that conventional programming languages are difficult to learn and use [**GlF84**], requiring skills that many people do not have. In an attempt to make the programming task easier, recent research has been directed towards using graphics. This has been called Visual Programming or Graphical Programming. Some Visual Programming systems have successfully demonstrated that non-programmers can create fairly complex programs with little training [**Hcd84**].

Another motivation for using graphics is that it tends to be a higher-level description of the desired actions (often de-emphasizing issues of syntax and providing a higher level of abstraction) and may therefore make the programming task easier even for professional programmers. This may be especially true during debugging, where graphics can be used to present much more information about the program state, such as current variables and data structures, than is possible with purely textual displays.

Visual Basic is one of the best programming tools ever created for the PC. It is the stuff of programmers dreams, especially Windows programmers whose programs are usually difficult, time-consuming, and hard to debug. Writing the actual code usually takes many more hours, including time for experimentation and fixing problems. Graphical User Interfaces - GUIs- definitely are the wave of the future.

Even the most elementary Windows application, which might do nothing more than pop an window on the screen, can take about five pages of C code and four separate files (although it is getting better now with C++). The enormous complexity of writing an actual, useful application often slows development speed down to a snails' pace.

Visual Basic changes this picture entirely. Finally it adds the programming tools that have been lacking for so long in Windows. The ideas are simple. If you want a window of a certain size, you simply draw it that size. If you want a text box at a particular point in your window, simply select the correct tool and draw the text box there. That is useful because, at last, the aid of the computer is being enlisted in the Window programming process. You can draw just about anything list boxes, buttons, combo boxes, anywhere you need it. When you are finished, you write a few (often a very few) lines of Basic code to make things work, and Visual Basic creates the working .Exe file for you. From the Windows programmers point of view, this package is nothing short of astonishing.

If there are much more diseases to be presented on one screen, new solutions should be considered.

Chapter Eight

Evaluation of Matrix-Table Model

As we mentioned before, the purpose of designing a visual tool in medical diagnosis is to provide an easy-to-use home tool to bring complicated medical knowledge from the book to the ordinary user by computer visualization. Through the model the user can get medical knowledge much more easily, and quickly – in only a few minutes all the causes of the user's symptoms can be displayed on the screen, which is impossible through reading medical books. Therefore the user can do self-assessment or self-diagnosis to discover quickly at home whether his symptom is serious or not, and then decide whether it is necessary to see the doctor; people will not panic, at least, if they manage to rule out certain serious diseases; the user can also check (through the model) the diagnosis that the doctor provided to see whether it is right; or the user can gain more medical knowledge by choosing interesting symptoms and seeing the possible causes in order to take better care of himself in the future. Many useful points can be made here especially for the layman. The model empowers individuals to understand their own condition. Of course all definitive diagnoses should be carried out by a licensed medical practitioner.

8.1 Purpose of Evaluation:

The matrix-table model can be referred to as Home Health Care (HHC). Evaluation of this model is important, through which the following aspects can be verified.

1. How useful is this HHC tool at the ordinary user level?
2. How close a diagnosis can the HHC provide to a real medical diagnosis?
3. How much useful information can the user obtain from this tool for learning?
4. How does visualization help the user gain information better?
5. How does the result match our original design goal?

8.2 Function of The Model

In order to understand this HHC, it is necessary to clarify its functionality.

1. HHC is not a doctor, and does not provide a final diagnosis, in the sense of saying to the user "you have this disease and no other";
2. HHC provides only a set of possible causes of the symptoms which include common diseases or near-common diseases, if any;
3. All diseases have the same weight;
4. All the causes in this HHC model are for information only;
5. There is no treatment or therapy provided.

8.3 User Study

We have 10 real cases. Each individual was selected among the author's friends. Nine of these case studies are based on information provided in interviews with the patients. The tenth is based on a friend's recollection of the late patient. For each case we compare the doctors' diagnosis with the common diseases or near-common diseases, if any, provided by this HHC. This is to show how close the doctors' and model's diagnoses are. This is based on the following assumptions.

Assumptions:

1. User symptom does not match the model's symptom.

   If the symptoms the user provided are not in the model database, the symptom will be replaced by the closest symptom in the model if there is one; it will be omitted otherwise.

2. All symptoms have the same weight in the model.

   A diagnosis from a doctor perhaps will rule out some of the symptoms (which are not important) by close questioning or lab testing. The model does not provide this function, it treats all symptoms reported as present. Since the common diseases the model provides are for all the symptoms, therefore some near-common diseases are likely to agree with the diagnosis from the doctor.

3. Different names for the same disease.

   Sometimes the model and the doctor arrive at what appear to be different diseases; it's really the same disease under two different names. We treat this as agreement.

4. Information display.

   In the figures we display only the disease name that agrees most closely with the doctors' diagnosis, if indeed any disease agrees with the diagnosis.

5. User symptoms different from model symptoms.

   In each real case we list symptoms in two different ways, one for the user's symptoms and another for model's symptoms. Sometimes the two lists of symptoms, i.e., User and Model, disagree. Why? One reason may be that the user symptoms are provided in the patient's own words; the model symptoms are medical terms, for one thing, and also are fixed in the computer and cannot be altered. When we use different wording for the symptoms, the two wordings are equivalent.

Case 1:

Patient profile:

Age: 52. Gender: male. Build: skinny, tall. Health background: good. Qualification: Economist.

Doctor:

- User symptoms:
  Double vision, Fatigue, Headache, Loss of appetite, Mood swings;
- Diagnosis: torn retina in the right eye (by lab test);
- Treatment: operation.

HHC:

- Model symptoms:
  Impaired vision (substituted for double vision), Pain in the eye, Headache, Fatigue;
- Diagnosis:
  - There is no common disease for these symptoms;
  - There is a near-common disease: glaucoma for symptoms "Impaired vision" and "Pain in the eye";
  - For the symptom "Impaired vision", one of the diseases is "retinal

detachment".

Torn retina and retinal detachment may be similar.

Outcome: Patient's right eye was operated on and is now blind.

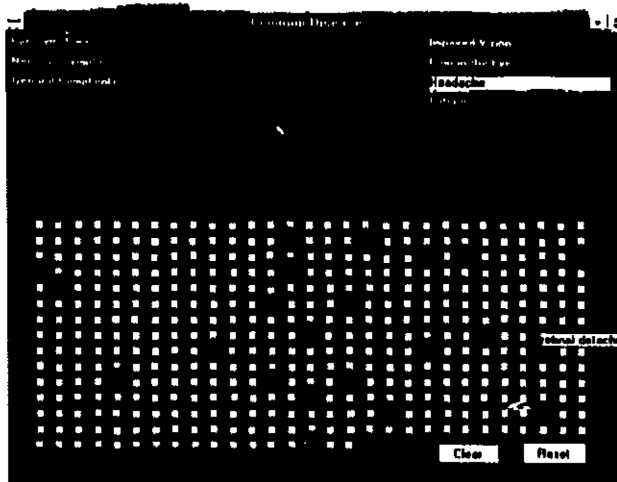

Figure 8.1: Case 1.

Remark:

The doctors' diagnosis is based on ultrasound and direct examination in order to rule out other related diseases.

In real medical practice, among the many symptoms the user presents, there must be some major symptom which causes the other minor symptoms. For the doctor it is easy to figure this out by questioning or lab tests. Lab testing is a very important tool in real differential diagnosis, since if the doctor faces many possible diseases, he must have a way to rule out some diseases. But our model's diagnosis is based on all the symptoms the user presents, even if he exaggerates or omits some symptoms.

Case 2:

Patient profile:

Age: 40. Gender: male. Build: skinny, average height. Health background: good. Qualification: Computer programmer.

Doctor:

- User symptoms:
  Itchy skin, Scaling skin patches, Insomnia, Fatigue, Red spots on the skin;
- Diagnosis: eczema;
- Treatment: medicine.

HHC:

- Model symptoms:
  Itching, Scaling skin patches, Fatigue, Insomnia;
- Diagnosis:
  - There is no common disease for these symptoms;
  - There is a near-common diseases: eczema for the symptoms "Itchy skin" and "Scaling skin patches".

If the symptoms "Fatigue" and "Insomnia" are considered unimportant, then both diagnoses are the same.

Outcome: Patient was cured.

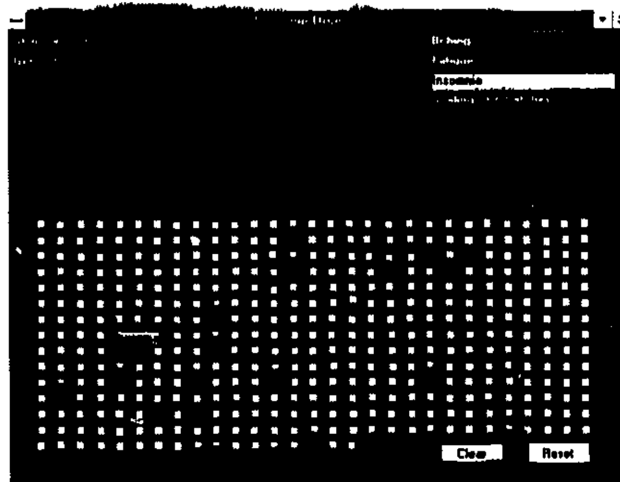

Figure 8.2: Case 2.

Remark:

It is obvious that the doctors' final decision is based on extensive questioning. In future our model can be improved by presenting pop-up questions (what symptoms are related to the diseases the model produced?) to the user in order to eliminate other unimportant symptoms.

Suppose a user selects a set of symptoms that have no common disease and several near-common diseases. A future version of the model could ask questions of the user, such as "Do you have such and such a symptom?" (this symptom was not mentioned by the user). If he says "yes", then we can change the set of symptoms and perhaps obtain a common disease. If he says "no", we can eliminate some of the near-common diseases, and the set of near-common diseases will be smaller; thus we will have greater confidence in the model's diagnosis.

Case 3:

Patient profile:

Age: 33. Gender: female. Build: skinny, height. Health background: good. Qualification: System analyst.

Doctor:

- User symptoms:
  Ringing in the ear, Fatigue, Dizziness, Loss of appetite, Thirsty;
- Diagnosis: anxiety;
- Treatment: none.

HHC:

- Model symptoms:
  Ringing in the ear, Fatigue, Loss of appetite, Dizziness, Excessive thirst;
- Diagnosis:
  - There is no common disease for these five symptoms;
  - There is a near-common diseases: anemia for symptoms "Ringing in the ear", "Fatigue", and "Dizziness";
  - There are four near-common diseases: anxiety, depression, cancer and acute illness for symptoms "Fatigue" and "Loss of appetite".

Outcome: Patient still has this problem sometimes.

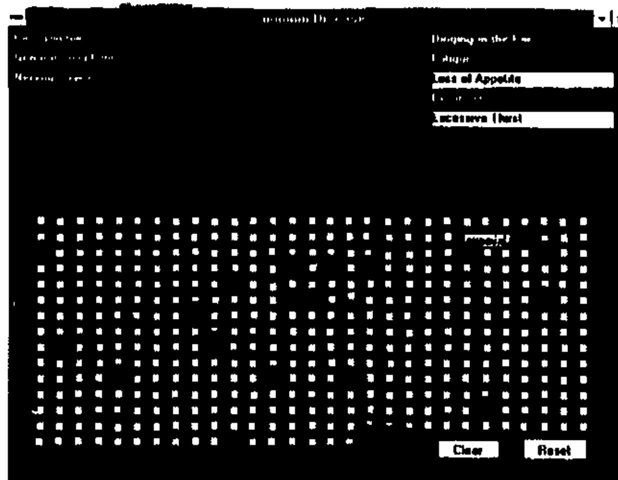

Figure 8.3: Case 3.

Remark:

The model provides four near-common diseases for the combined symptoms, but does not tell the patient which one he/she has. Our model does not make a final diagnosis for the user, the model just gives the patient a general idea of what illness he/she might have. If the patient thinks that some of the diseases are serious, then the patient can see the doctor. By that time the patient knows about all the possible diseases, so that if the doctors' diagnosis is one of the disease the patient is familiar with, the patient will feel safe; if the disease is not provided by the model, then the user can question the doctor, because sometimes the doctor makes wrong diagnoses. After using HHC, the patient at least knows what the doctor is doing.

Case 4:

Patient profile:

Age: 55. Gender: male. Build: skinny, tall. Health background: good. Qualification: Statistician.

Doctor:

- User symptoms: Back pain, Fatigue, Insomnia;
- Diagnosis: torn muscle;
- Treatment: none.

HHC:

- Model symptoms: Low back pain, Fatigue, Insomnia;
- Diagnosis:
  - There is no common disease for these three symptoms;
  - There are two near-common diseases: anxiety and depression for symptoms "Fatigue" and "Insomnia";
  - For the symptom "Low back pain", one of the diseases is low back strain.

A doctor may rule out symptoms "Fatigue" and "Insomnia", and treat symptom "Back Pain" as the main symptom.

Outcome: Patient still has this problem. The doctor said "I think you tore a muscle and it healed imperfectly. It's permanent. Put up with it."

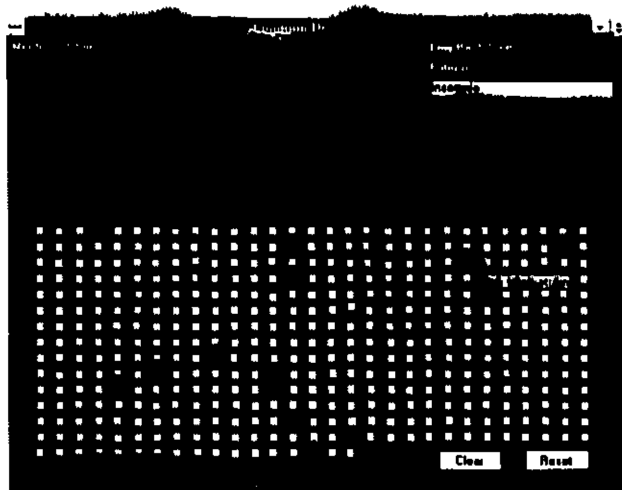

Figure 8.4: Case 4.

Remark:

In this case the doctors' diagnosis is determined by probing the patient's back and making the patient bend over; that is physical testing. He also asked some questions such as "How long have you had this symptom?". This is important for ruling out a slipped disk.

The doctor can perform simple physical tests immediately and thereby eliminate many diseases. Our model can do no such physical testing. This is one reason why no computer model can replace the doctor.

case 5:

Patient profile:

Age: 30. Gender: female. Build: average. Health background: good. Qualification: Hardware designer.

Doctor:

- User symptoms: Runny nose, Sore throat, Fever, Fatigue, Loss of appetite;
- Diagnosis: flu;
- Treatment: medicine.

HHC:

- Model symptoms:
  Nasal congestion (replaces runny nose), Sore throat, Acute fever, Fatigue, Loss of appetite;
- Diagnosis:
  - There is no common disease or near-common diseases for these symptoms;
  - There is one disease: "virus infection" for the symptom "Sore throat".

Virus infection may be a synonym for flu.

Outcome:

Patient is cured now.

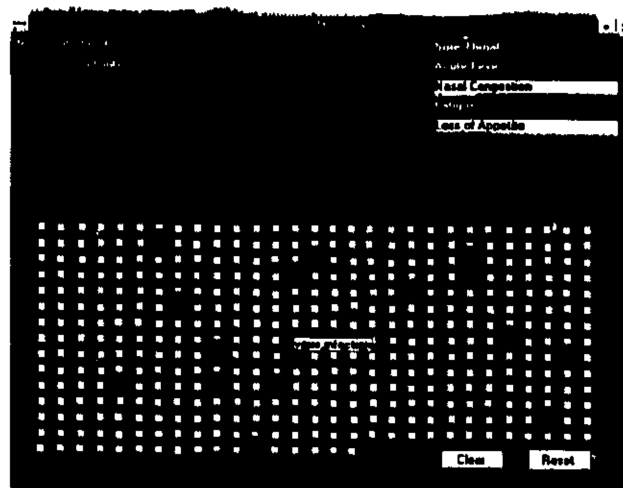

Figure 8.5: Case 5.

Remark:

The primer does not use the word "flu". This is a problem, as a certain symptom or disease may have different names. This will be a problem in any computer medical model that does not check all possible names. In this case model correctness is hard to decide.

Case 6:

Patient profile:

Age: 41. Gender: female. Build: skinny, average height. Health background: weak. Qualification: Movie producer.

Doctor:

- User symptoms: Red eyes, Itchy eyes. Fatigue, Runny nose;
- Diagnosis: allergy;
- Treatment: medicine.

HHC:

- Model symptoms:
  Red eyes, Pain in the eye (instead of itchy eye), Fatigue, Nasal congestion (instead of runny nose);
- Diagnosis:
  - There is no common disease for these four symptoms;
  - There are two near-common diseases: glaucoma and conjunctivitis for the symptoms "Red eye" and "Pain in the eye";
  - There is one disease: allergy for the symptom "Nasal congestion".

Outcome: Patient was cured.

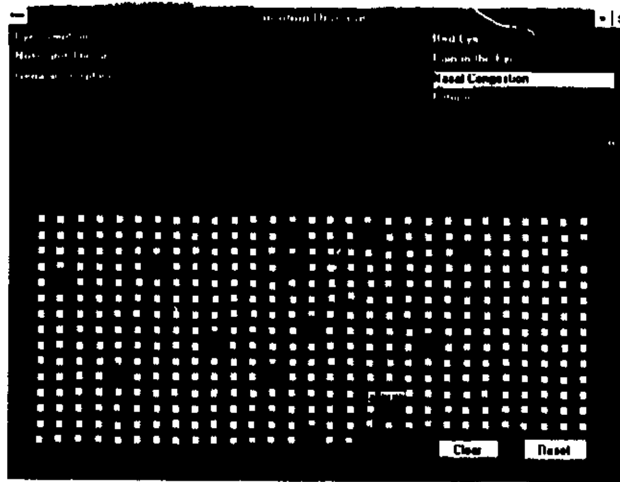

Figure 8.6: Case 6

Remark:

The doctor took the "Runny nose" symptom as the major one. The doctor eliminated two near-common diseases by examination and close questioning. Presumably other symptoms are present and unreported by the user. This case illustrates the value of a real doctor; he frequently asks for other symptoms that the patient has not mentioned. The model assumes that the patient tells all.

This suggests some future work: for every common or near-common disease, the HHC would respond by asking the user about other symptoms; therefore the list of causes of the symptoms can be narrowed down.

Case 7:

Patient profile:

Age: 28. Gender: female. Build: average height. Health background: good. Qualification: System engineer.

Doctor:

- User symptoms: Headache, Dizziness, Insomnia, No appetite, Fatigue;
- Diagnosis: depression;
- Treatment: none.

HHC:

- Model symptoms: Headache, Dizziness, Insomnia, Loss of appetite, Fatigue;
- Diagnosis:
  - There is no common disease for these symptoms;
  - There is a near-common disease: depression, for symptoms "Fatigue" and "Loss of appetite";

In this case, the model's diagnosis completely matches the doctors' diagnosis

Outcome:

Patient still has this problem sometimes.

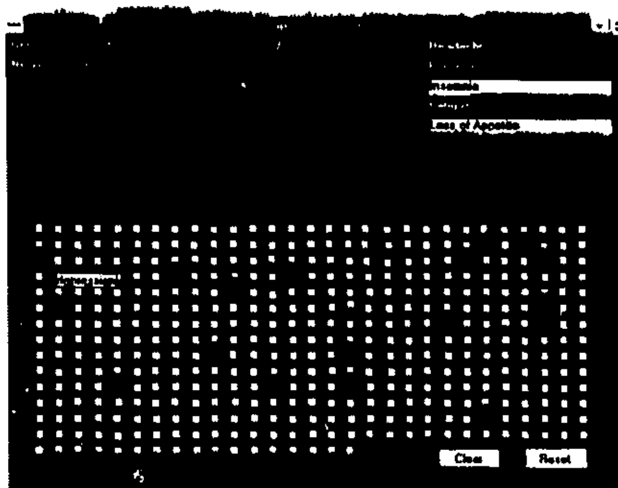

Figure 8.7: Case 7.

Remark:

In the list of near-common diseases provided by the model, if the disease having most of the symptoms agrees with the doctors' diagnoses, then we say that the two diagnosis are identical.

Case 8:

Patient profile:

Age: 55. Gender: female. Build: a bit fat, average height. Health background: good. Qualification: Remote sensing scientist.

Doctor:

- User symptoms:
  Frequent urination, Painful urination, Incontinence of urine, Insomnia;
- Diagnosis: infection;
- Treatment: medicine.

HHC:

- Model symptoms:
  Frequent urination, Painful urination, Incontinence of urine, Insomnia;
- Diagnosis:
  - There is no common disease for these symptoms;
  - There are four near-common diseases: urinary tract infection, bladder stone, prostate infection, and urethritis for symptoms "Frequent urination" and "Painful urination".

The doctor eliminated two diseases: bladder stone, urethritis by a urine test; and eliminated "prostate infection" disease by observing that the patient is female.

Outcome: Patient was cured.

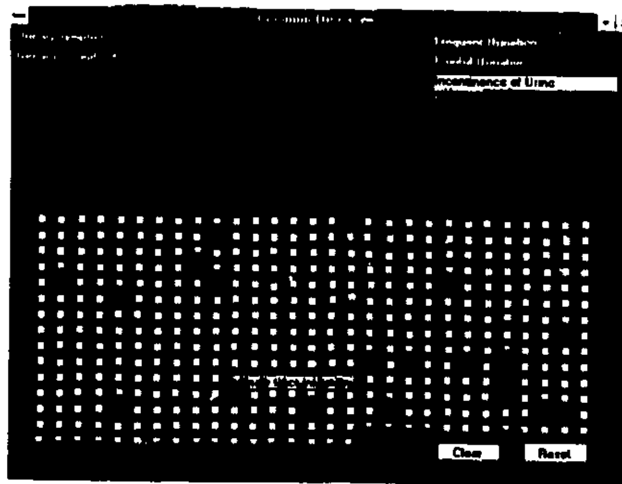

Figure 8.8: Case 8.

Remark:

Many diseases are shared by women and men; some are not, such as "prostate disease" and "pregnancy". The model merely goes from symptom to disease without considering the sex of the patient, since the model follows the primer in this regard.

In future the model should automatically eliminate diseases that do not occur in patients of this sex. The way to do this is to check the diseases after they have been identified and before they are displayed on the screen. If this disease cannot occur in this patient, eliminate the disease from the list.

Case 9:

Patient profile:

Age: 7. Gender: female. Build: average. Health background: good. Qualification: Pupil.

Doctor:

- User symptoms: Sharp upper abdominal pain, Upset stomach;
- Diagnosis: appendicitis;
- Treatment: operation.

HHC:

- Model symptoms: Upper abdominal pain, Dyspepsia;
- Diagnosis:

– There is no common disease for these two symptoms;
– There is one disease: appendicitis for the symptom "Upper abdominal pain".

Outcome:

Patient was operated on, and cured.

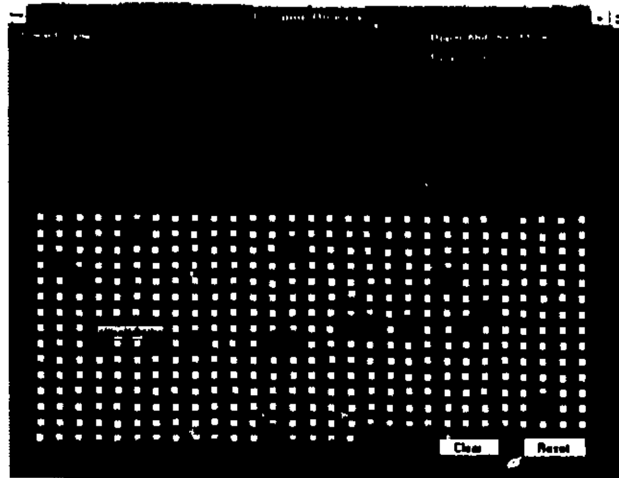

Figure 8.9: Case 9.

Remark:

Doctors' diagnosis "appendicitis" also is based on touching the patient to get a feeling about what the real problem is. For the HHC model there is no such action.

Case 10:

Patient profile:

Age: 33. Gender: male. Build: skinny, average. Health background: good. Qualification: Electronical engineer.

Doctor:

- User symptoms:
  Fatigue, Loss of appetite, Weight loss, Pain in the upper right side;
- Diagnosis: cancer of liver;
- Treatment: operation.

HHC:

- Model symptoms:
  Fatigue, Loss of appetite, Weight loss, Pain in the right upper quadrant;
- Diagnosis:
  - There is no common disease for these symptoms;
  - There is a near-common disease: cancer for the three symptoms "Fatigue", "Weight loss" and "Loss of appetite"
  - There is a near-common diseases, cancer of the liver for the two symptoms "Pain in the right quadrant" and "Loss of appetite".

Presumably the doctor discounted some symptoms, perhaps from questioning the patient closely or some lab testing.

Outcome: Patient was operated on and now is dead.

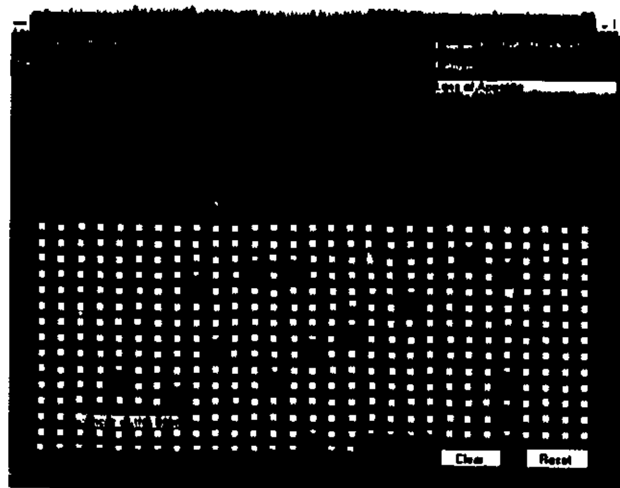

Figure 8.10: Case 10.

Remark:

If the patient had used this model as soon as he discovered these symptoms, he might have visited the doctor immediately. His disease might have been detected earlier; the operation might have been performed earlier. The patient might be alive now.

8.4 Correctness of The HHC Model

The program has been run many times with no problem; the code is straightforward. Some experiments have been performed to see whether the program would give the same diagnosis as a doctor would. This is done with real users. First the user runs the program, and then compares the diagnoses from the doctor and HHC. If they differ, how would we measure the distance between the two diagnoses?

The question of whether it gives the same diagnosis as doctor would has been addressed indirectly, through a conversation with a doctor.

What is the degree of accuracy of the HHC model? Before making any judgment, we first need to define accuracy.

8.4.1 Criterion

If the doctor's diagnosis agrees with one of the HHC's diseases at the top of the list of common and near-common diseases and this HHC's disease is based on at least two symptoms, then we say that the program is accurate; otherwise we say that it is inaccurate. We do not call it accurate if the HHC disease is based on only one symptom because from one symptom one can diagnose many diseases, maybe fifty, so by chance it is fairly likely that coincidence with the doctor's diagnosis would occur.

8.4.2 Degree of accuracy in the ten real cases

From the criterion of accuracy given, we can easily check the accuracy of each case. Following is the table of results.

Table 8.1: Accuracy in the ten real cases.

Doctor	*HHC* 5 − *common* − *disease*	*HHC* 4 − *common* − *disease*	*HHC* 3 − *common* − *disease*	*HHC* 2 − *common* − *disease*	*HHC* *accuracy*
********	**********************	****************	*******************	******************	*********
1. torn retina	—	none	none	glaucoma	inaccurate
2. eczema	—	none	none	eczema	accurate
3. anemia	none	none	anemia	anxiety, depression, cancer, acute illness	accurate
4. torn muscle	—	—	none	anxiety, depression	inaccurate
5. flu	none	none	none	none	inaccurate
6. allergy	—	none	none	glaucoma, conjunctivitis	inaccurate
7. depression	none	none	none	depression	accurate
8. infection	none	none	none	urinary tract infection, bladder stone, urethritis, prostate infection	accurate
9. appendicitis	—	—	—	none	inaccurate
10. cancer of liver	—	—	cancer	cancer of liver	accurate

Remark:

Observe that there is agreement at the level of pairs of symptoms. According to the table, we can see that the accuracy rate is 5 out of 10.

8.4.3 Testing of the model's correctness

One question is whether the model indicates the same disease as the primer, i.e., whether the information was entered into the model correctly. The way to test this is click on each symptom separately and see if the correct disease flashes. This involves about 100 trials, perhaps a reasonable task.

The best way to test the model for "correctness" would be to collect a random sample of patient records from private practice doctors and emergency wards. For each report, enter the patient symptoms in the program and obtain the list of common and near-common diseases. Compare these with the doctor's diagnosis. If the program produces a common or near-common disease that agrees with the doctor's diagnosis, score one for agreement; otherwise score zero. When a zero is recorded, it is not clear who is right. One would need to check that the model agrees with the medical textbook primer. If it does, then the primer and the doctor disagree, perhaps because the doctor judged many of the patient symptoms to be spurious and/or assumed that some symptoms were present that were not reported. The model does not make this assumption; it would be dangerous for the model to do so; it may be dangerous for the doctor to do this. It is possible that the doctor made a mistake, in the sense that if reminded about the symptoms related to the disease diagnosed, he will change his mind and diagnose some other disease.

We did not do the correctness by the patient records through the private practice, because medical records are generally unavailable to the public (they are confidential). However we collected ten anecdotes from friends and performed the same operations as mentioned previously. The danger in what we did is that the patient may not now report his symptoms faithfully: he may have forgotten some of the symptoms, he may have forgotten the doctor's questioning which caused the patient to change his symptoms, or he may be dead. Thus our correctness score may be inaccurate.

Chapter Nine

Conclusion

9.1 Summary

Through the literature review in Chapter 2 we know that data visualization has received a great deal of attention. Furthermore, the need for better visualization tools is widely recognized [**Bvr92**], [**Tbj92**]. One of the main reasons for better visualization tools is the limitation of the human cognitive process.

Our project demonstrated that good design principles of visualization and simplicity have produced a highly usable diagnosis interface for adults. This thesis has emphasized the necessity of visualizing the information to produce an interface design that is appropriate to the user.

The design principles can be summarized as follows:

- Make it simple so that ordinary people can use it easily;
- No typing request;
- Use pictures of the human body;
- Use flashing colored lights.

The tool has been designed and the tool has also been used by some people.

This thesis describes a visual technique for medical diagnosis. The key ideas are:

1. visual representation;
2. coloring of the result;
3. direct manipulation;
4. relationships between problems.

The visual representation is achieved by displaying the human body in two-dimensions, and by graphically placing the disease cells on the screen. The color of each disease is determined the symptom. With the color presentation it is easy to

find particular problems without becoming lost in the global structure. Using direct manipulation techniques we interact with the display to find interesting patterns. With our graphical tools the relationships are obvious.

We summarize the methods used in this model as follows:

- Display an entire disease set on a single screen;
- Color code each disease according to the selected symptom;
- Provide interactive user-interface;
- Enable an analyst to read the results.

This program was an experiment to see if it is possible to use visual display for the medical diagnosis. We did not intend to produce a commercial product at this early stage; we want to lay the groundwork for someone else.

9.2 Advantages

Fundamental achievements have been made in visualization of information in medical knowledge, interactive diagrammatic user interfaces. We know of no other research addressing the same goals.

The new tool provides several major advantages over the conventional assistant in medical diagnosis:

1. Easy access

   The system can be easily accessed by the user who has no computer knowledge. The operation is simple. All the user needs to know is how to use the mouse.

2. User-friendly interface

   The model provides an attractive graphic interface by displaying the human body on the screen; it lets users have an intuitive sense of symptom groups applied to different parts of body, even if the person has little medical knowledge or a poor English background (especially foreigners), since it requires no typing.

3. Global view

   The model is implemented globally which brings all information on to one screen.

4. Multiple-symptom diagnosis

   The greatest advantage in this model is the automatic diagnosis of multiple symptoms. This gives the user information about all possible causes.

It seems to be superior to all known techniques, because it allows a look between the pages.

9.3 User Opinion

In order to verify the performance of the tool, we have made evaluation experiments on end users, one physician, and general users. Results obtained from the HHC model correlates well with their opinion.

•User 1:

She is a clinical physician. She has more than 20 years experience in medical practice. Her opinion on this tool is: it is impressive, especially the user interface. But if this system is designed for the physician, it is too simple, since physicians make diagnoses based not only on the conventional symptom-disease relationship, but also the history of the patient, obtained by the closely questioning the patient. It is important to note that the same disease may cause different symptoms in different people according to sex, race and age. This tool can be helpful for the medical student, especially the beginner.

• User 2:

He is a economist. He works for the federal government. He thinks that the system has the advantage of being pictorial instead of textual; no typing is required; it can contain many pages of disease-symptom relationships without the user's needing to read them. It never gets tired or inefficient as doctors sometimes do; it gives its conclusions instantly. One weakness is that the program considers neither the length of time over which the symptom has been present, nor whether the symptom has become more severe over time.

• User 3:

He is a engineer. He has been working for a private company for many years, and he offered to test this application. He found it very useful for users lacking medical and computer knowledge. It prevents misinterpreting the symptoms, by simplicity and ingenuity of the design. Unfortunately the system doesn't cover real situations concerning symptoms and diseases and it is not open to the user to improve it with new knowledge.

Our experience of the tool has been positive. However the present system is still in an early stage and has limitations. In its present form, it does not provide history-taking strategies or treatment options. It also recognizes only the most common symptoms. Database expansion has no automatic methodology.

9.4 Discussion

We have discussed the general notion of medical diagnosis and visualization. Graphs and fisheye view were briefly reviewed. A new implementation has been introduced, which employs both color and zooming perception. The need for a thorough performance evaluation to determine the efficacy of such displays has been emphasized. More displays need to be developed using a large variety of options, such as help menu display, treatment suggestion display, etc.

There are many interesting questions about the model. Some are subject to the principle of system design, some are related to system evaluation. To clarify them is important, in order to understand our system better.

9.4.1 Weighted edges

Almost all diagnosis systems use weighted edges, or probabilities, in diagnosis, to save time and money. However, this is not a very safe idea for some unusual cases. It amounts to using a doctor's previous experience with all his patients. His present patient may be a different race, and may have a very different constitution from all of his previous patients.

Weighted edges is a safe practice in deciding which lab tests to perform. Suppose we have taken all of the patient's symptoms, and we conclude that he has one of five possible diseases. To isolate his disease, we need lab tests. Suppose that different lab tests isolate different diseases. Which lab test should be ordered first? With weighted edges we should first order the test that isolates the probable disease, or excludes the rare disease. This criterion seems not to be used in North America; instead the cheap lab test are ordered first and the expensive ones later, if they are needed.

The system presented in this thesis uses unweighted, or equally weighted, edges. This is a safe way to diagnose diseases. Suppose we want to extend this system to a weighted edges system. The key to the system presented here is the disease-symptom matrix, consisting of ones and zeros. In a weighted-edge approach, these numbers would be replaced by numbers between zero and unity. The trouble is, which number? It could be the conditional probability of having this symptom, given that the patient has this disease, or the conditional probability of having this disease, given that the patient has this symptom. Really, two matrices are necessary: one for diagnosis, proceeding from symptom to disease (the usual case for practicing doctors), the subject of this thesis; and the other for proceeding from disease to symptom (post-mortem examination or autopsy, or questioning a death certificate, when foul play is suspected).

Consider the case of proceeding from symptom to disease. We want conditional

probabilities of having certain diseases, given that the patient has certain symptoms. These probabilities can be collected experimentally, using the combined experience of many doctors and hospitals. The trouble is that the probabilities will depend strongly on the patients race, age, sex, and genes. Suppose we have these probabilities. Then a certain collection of symptoms will produce a set of diseases with certain probabilities.

9.4.2 Special advantages/disadvantages of the matrix table approach

- Advantages:

1. The computation involved is simple (matching zeros and ones) and fast.
2. It is easy to check whether a symptom and disease are related; just see whether there is a one in the appropriate cell. Furthermore, calculations about common and near-common diseases can be easily done by matrix arithmetic.
3. It is easy to multiply matrices and hard to multiply graphs.

- Disadvantages:

1. If the matrix is entered manually, there is a great danger of a typing error. It would be safer to have an automatic entry feature.
2. It is hard to see relationships, like common diseases or the odd distances between symptoms and diseases.

9.4.3 What is the advantage/disadvantage of a bipartite graph model?

- Advantage

  The advantage of the bipartite graph model is that the bipartite graph is simple, much simpler than most neural networks. It is easy to discover the diameter, and easy to check whether two symptoms are related, even if the relationship is distant.

- Disadvantage
  It is hard to multiply graphs.

9.4.4 Database management support

If we consider more diseases and symptoms, the matrix of symptom-disease will of course be larger. We may need a bigger, faster computer. If we need to constantly enter new diseases or symptoms, that is updating the matrix table, it is necessary to introduce data warehouse management techniques into the present system; or to link the present matrix table to an easily updateable database, if so, a special link program should be created for this task.

Because medical knowledge is continually changing and expanding, it is unrealistic to design a system which must cover the whole field in order to function at all.

9.5 Major Differences between The Second and Third Approach

The second and third approaches have some major differences which are explained in the following.

When a patient provides a list of symptoms, it often happens that there is no common disease having all these symptoms. The explanation is that some of the reported symptoms are spurious. Our first model suffered from this problem: many times it reported that there was no disease. Sick people don't like to hear that they are healthy. To deal with this problem the second model displays, as well as "absolutely common" diseases (diseases having all of the reported symptoms), some of the "near-common" diseases (diseases having almost all, or some, of the reported symptoms). Thus patients see which disease they probably have. Instead of an absolute diagnosis ("you have this disease and nothing else"), patients have a starting point from which work. Doctors routinely do this identification of near-common disease mentally.

9.6 The Choice of Method

Why didn't we use artificial intelligence in our model? It would have required a complicated program, and it would have given its conclusions in probabilistic terms. The latter fact would confuse the ordinary user; few people are comfortable with statements like "you have brain cancer with probability 0.01". Should he worry or not? In our model, it is clear; if brain cancer is on the list of common or near-common diseases, he should worry.

9.7 Future Work

Initial trials on this system have shown sufficient promise for it to be further developed as a medical diagnosis aid.

The possible future work can be put into three categories:

1. More features

   The system can be built to have more functions, such as, from diseases to get all possible symptoms. We also can build an on-line help feature for explaining the meaning of common diseases since most users are not physicians, and are unfamiliar with technical medical words; also we can provide treatment suggestions. Afterwards it will become a complete information system.

2. Limited space and time response

   If more objects are to be displayed on the system, there will be a memory problem. This is because on each screen Visual Basic can handle only about 500 objects. In future, we should not draw a graph using the default scheme that Visual Basic provides, instead we should use a function to draw the graph; this may solve the problems of running out of memory, and of slowly flashing lights.

3. Data updating

   The data from the text workbook needs to be supplemented by current experiments. The system should be capable of updating the database.

   In our system if we want to insert a new disease, we must add a row to the disease-symptom matrix, i.e., change the code in the program. It would be desirable to be able to add new diseases at run-time, by answering questions. That is, at the first step, a human body is displayed, and somewhere on the screen there is a button saying "Add new disease". If we click on this button and type in the name of the new disease and its symptoms, the program will add another row to the symptom-disease matrix automatically.

4. Search common symptoms

   In this model a search from disease to symptom would be very useful. Consider how a physician diagnoses: First, the physician asks the patient for the symptoms, then he tries to figure out which diseases are related to these symptoms; sometimes he finds many diseases related to some of the symptoms; in order to confirm this conclusion, the physician usually will ask the patient about symptoms he might have; since some symptoms may not be reported, laboratory

tests are sometimes needed. This suggests that if we find some diseases from which we could get more information about symptoms, it will help us to get the right diagnosis.

5. Check diseases for gender

   As we mentioned in Chapter 8, there is a problem in the model; the diseases are displayed without considering the patient's sex, since some diseases occur in only one sex. The model should have the ability to check if the diseases are sex-related.

6. Consistency in the disease's name

   In the experiment we found that certain diseases actually have slightly different names which causes difficulties for the model in making correct diagnoses. In future, we should check all the disease names and put similar names into one name.

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Appendix

A. Data set

In this appendix we list all the data sets from the medical textbook we used in two different display: table and graph. The contexts are identical. In the table each symptom and disease are assigned numbers which correspond to the numbers in the graph display.

The data sets are grouped into 19 symptom groups according to the book. The symptom groups are:

1. *General Complaints*
2. *Nervous System Symptoms*
3. *Eye Symptoms*
4. *Ear Symptoms*
5. *Nose and Throat Symptoms*
6. *Oral and Dental Symptoms*
7. *Neck Symptoms*
8. *Heart Symptoms*
9. *Lung Symptoms*
10. *Breast Symptoms*
11. *Stomach Symptoms*
12. *Liver and Gallbladder Symptoms*
13. *Intestinal and Rectal Symptoms*
14. *Urinary Symptoms*
15. *Female Reproductive Organ Symptoms*
16. *Male Reproductive Organ Symptoms*
17. *Skin Symptoms*
18. *Muscle and Joint Symptoms*
19. *Emergency*

Each group of symptoms contains many different individual symptoms and each symptom contains its related diseases. Following are the graphs for each symptom group with only numbers for both symptoms and diseases, and tables explaining the numbers.

Table 9.1: Symptoms 500, 501, 502, 503, 504, 505, 506, 507

Fatigue(500)	*ExcessiveThirst*(501)	*LossofAppetite*(502)	*Insomnia*(503)
anxiety(0)	diabetes mellitus(9)	anxiety(0)	anxiety(0)
depression(1)	diabetes insipidus(10)	depression(1)	depression(1)
chronic infection(2)	dehydration(11)	infectious hepatitis(13)	chronic illness(19)
anemia(3)	psychogenic polydipsia(12)	cirrhosis(14)	urinary tract disease(20)
cancer(4)		cancer of the liver(15)	congestive heart failure(21)
thyroid deficiency(5)		alcoholism(16)	hiatus hernia(22)
acute illness(6)		drug abuse(17)	drug reaction(23)
renal failure(7)		cancer(4)	
cirrhosis of the liver(8)		acute illness(6)	
		uremia(18)	

WeightLoss(504)	*FluidRetention*(505)	*AcuteFever*(506)	*ProlongedandRecurrentFever*(507)
diabetes mellitus(9)	birth control pills(28)	acute viral infection(33)	cancer(4)
cancer(4)	excessive salt intake(29)	acute bacterial infection(34)	leukemia(40)
overactive thyroid(24)	hot weather(30)	rheumatic fever(35)	lymphoma(41)
renal failure(7)	congestive heart failure(21)	phlebitis(36)	tuberculosis(42)
emotions(25)	protein deficiency(31)	heart attack(37)	hidden abscess(43)
infectious disease(26)	malnutrition(32)	pulmonary infarction(38)	infectious mononucleosis(44)
chronic gastrointestinal tract disease(27)	cancer(4)	drug reaction(23)	subacute bacterial endocarditis(45)
	renal failure(7)	stroke(39)	brucellosis(46)
	cirrhosis of the liver(8)		salmonellosis(47)
			chronic phlebitis(48)
			chronic infection(2)

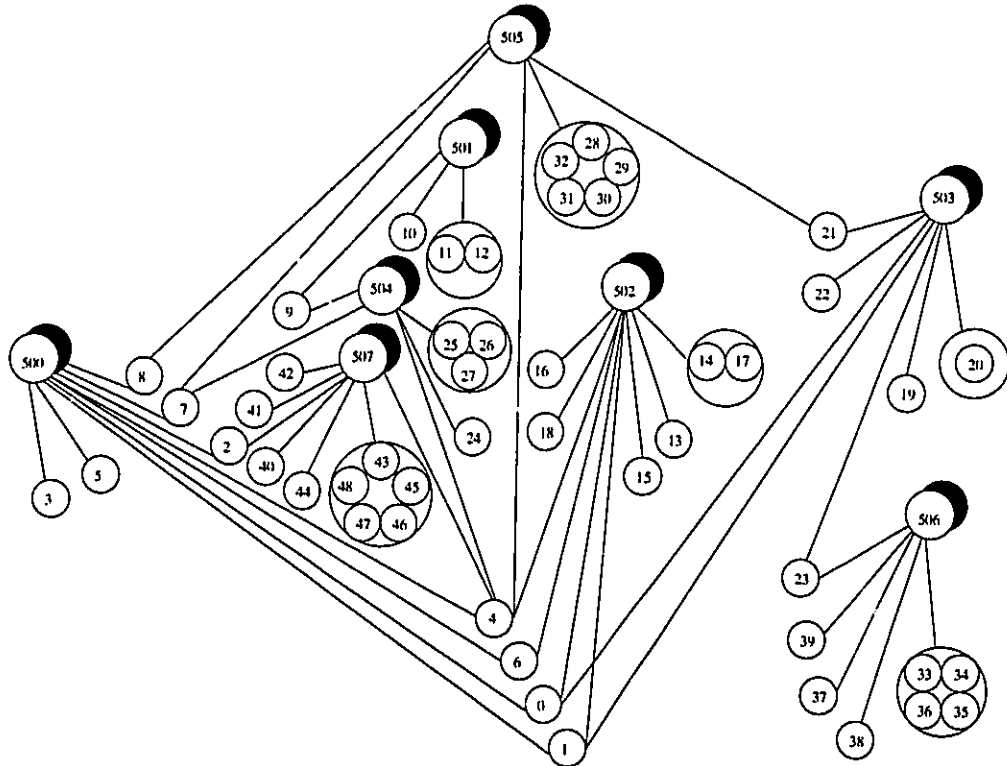


Figure 9.1: General complaints

Table 9.2: Symptoms 508, 509, 510, 511, 512, 513,

Headache(508)	*Dizziness*(509)	*Tremors*(510)
*************	**************	***********
nervous tension(49)	postural hypotension(56)	arteriosclerosis(62)
migraine(50)	infection(57)	neuritis(63)
cluster headache(51)	high blood pressure(52)	parkinson's disease(64)
high blood pressure(52)	cerebral arteriosclerosis(58)	anxiety(0)
sinus infection(53)	psychosomatic disease(59)	multiple sclerosis(65)
brain tumor(54)	anemia((3)	overactive thyroid(24)
head trauma(55)	low blood sugar(60)	alcoholism(16)
	middle or inner ear disease(61)	heavy metal poisoning(66)
		drug overdosage(67)
Convulsions(511)	*ConfusionandDelirium*(512)	*Coma*(513)
***************	*****************************	*********
fever(68)	intoxication due to alcohol or drugs(73)	meningitis(70)
epilepsy(69)	psychosis(74)	encephalitis(76)
stroke(39)	hardening of arteries to the brain(75)	brain abscess(71)
meningitis(70)	meningitis(70)	head trauma(55)
brain abscess(71)	encephalitis(76)	drug overdose(77)
brain tumor(54)	brain abscess(71)	diabetes(78)
head trauma(55)	brain tumor(54)	stroke(39)
alcohol or drug withdrawal(72)		pneumonia(79)
low blood sugar(60)		uremia(18)
		congestive heart failure(21)
		brain tumor(54)
		cirrhosis of the liver(8)
		terminal cancer(80)

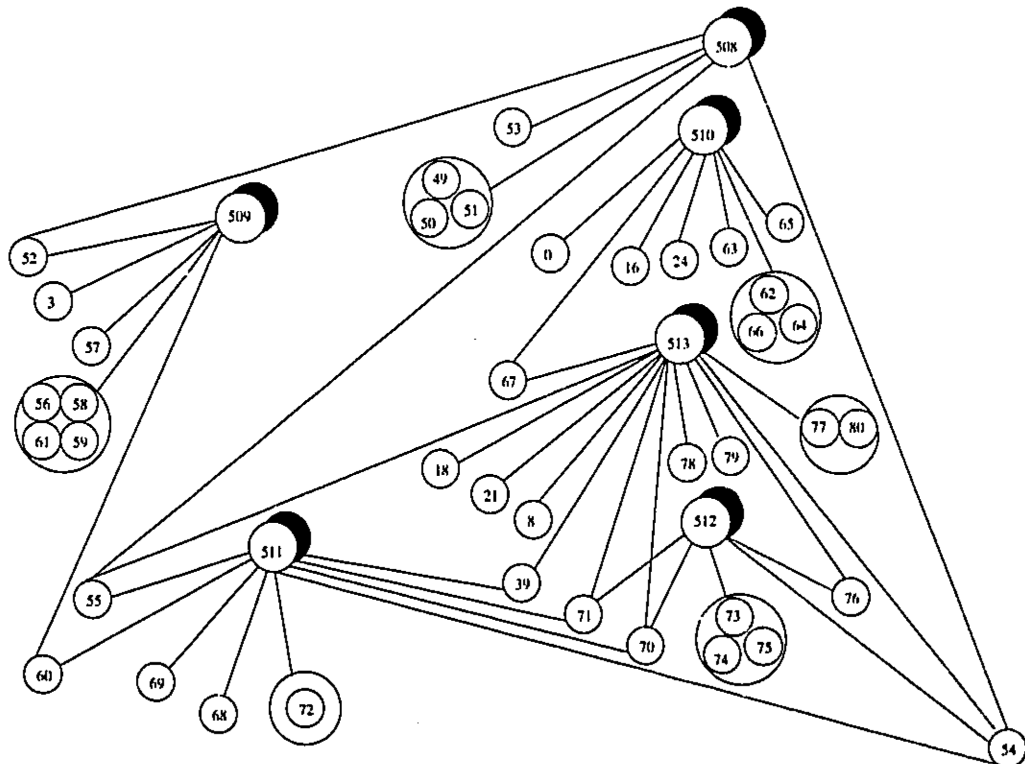


Figure 9.2: Nervous system symptoms.

Table 9.3: Symptoms 514, 515, 516, 517, 518,

ImpairedVision(514)	*ForeignBodyintheEye*(515)	*RedEye*(516)	*PainintheEye*(517)	*SpotsbeforetheEye*(518)
********************	**************************	*************	******************	**********************
refractive error(81)	dust(88)	conjunctivitis(92)	eye strain(94)	vitreous floaters(96)
infection(57)	eyelash(89)	iritis and uveitis(93)	glaucoma(86)	retinal detachment(85)
cataracts(82)	iron or steel (90)	glaucoma(86)	iritis(95)	cataract(97)
senile macular degeneration(83)	acid or alkali(91)		conjunctivitis(92)	
trauma(84)				
retinal detachment(85)				
glaucoma(86)				
hypertension(87)				
diabetes(78)				
drug reaction(23)				

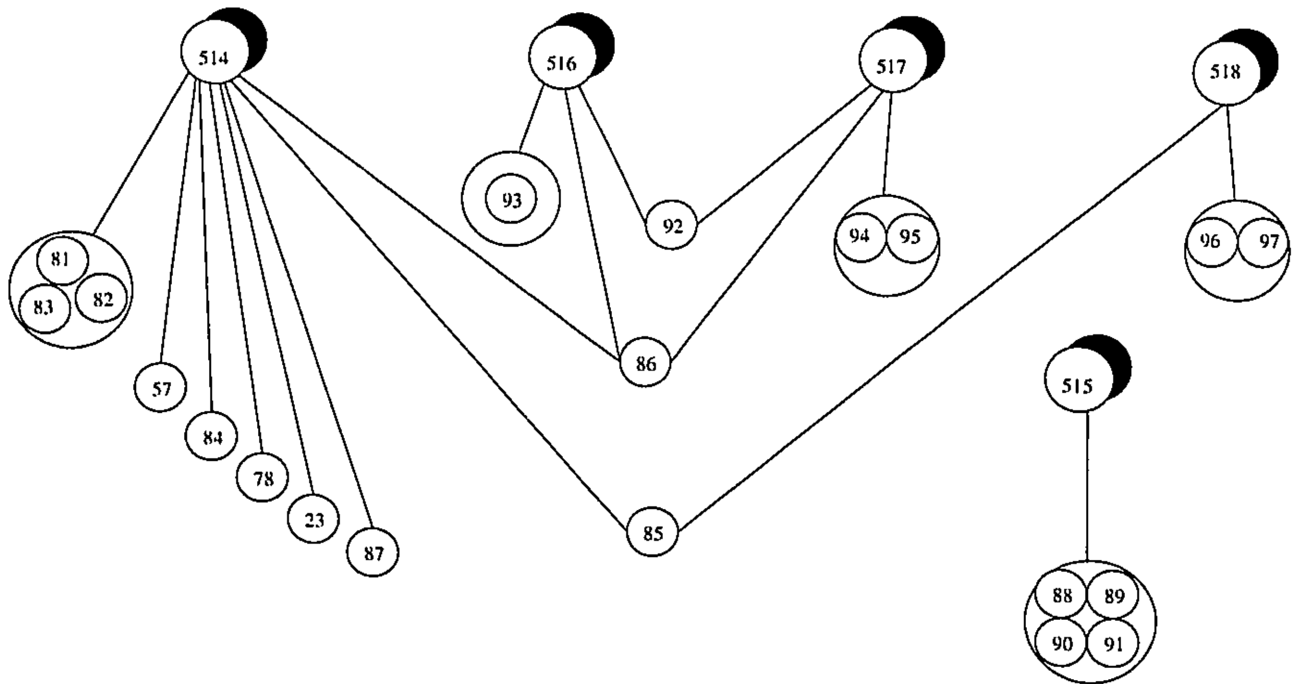


Figure 9.3: Eye symptoms.

Table 9.4: Symptoms 519, 520, 521, 522, 523, 524,

BlockedEar(519)	*Earache*(520)	*TheDrainingEar*(521)
***************	************	**********************
ear wax(98)	ear canal infection(100)	ear canal infection(100)
water in the ear(99)	middle ear infection(102)	middle ear infection with perforation of the eardrum(103)
ear canal infection(100)		
RingingintheEar(522)	*Vertigo*(523)	*HearingLoss*(524)
*********************	***********	******************
acoustic trauma(104)	labyrinthitis(109)	congenital(111)
drug toxicity(105)	meniere's disease(106)	ear infection
high blood pressure(52)	hypertension(87)	acoustic trauma(104)
anemia(3)	brain tumor(54)	otosclerosis(113)
middle ear infection(102)	drug toxicity(105)	presbycusis(114)
meniere's disease(106)	alcohol(110)	
brain tumor(54)		
hallucinations(107)		
epilepsy(69)		

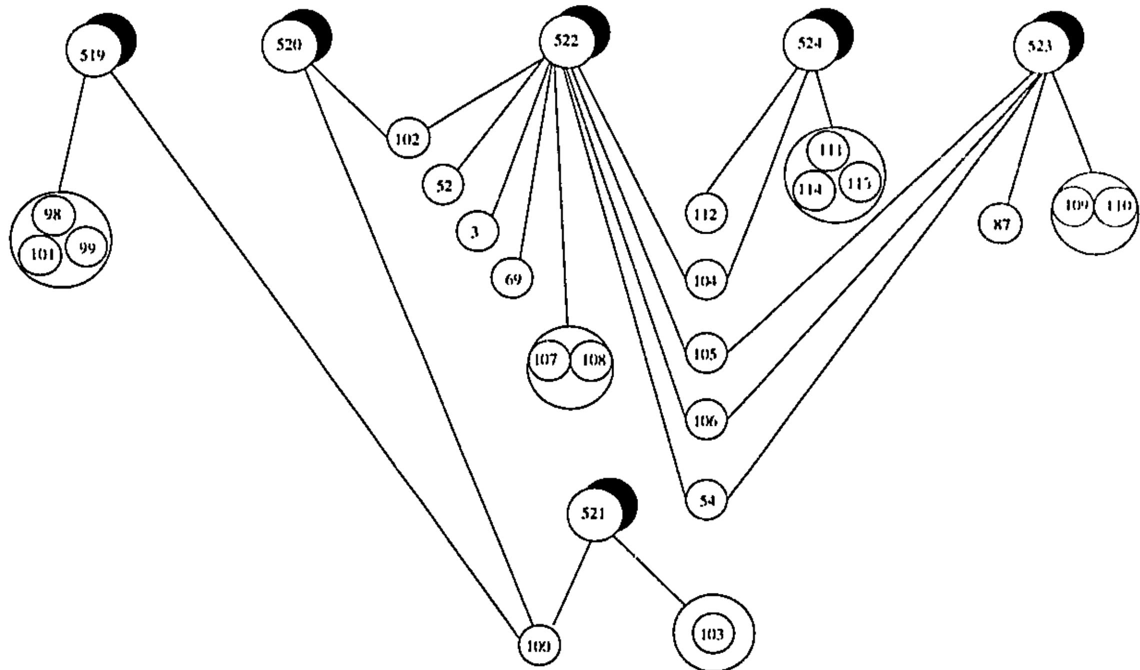


Figure 9.4: Ear symptoms.

Table 9.5: Symptoms 525, 526, 527, 528, 529, 530, 531, 532.

NasalCongestion(525)	*SnoringandMouthBreathing*(526)	*Nosebleed*(527)	*ChronicNasalCongestion*(528)
common cold(115)	enlarged adenoids(119)	allergy(116)	foreign body(125)
allergy(116)	deviated septum(118)	common cold(115)	nasal polyp(117)
nasal polyp(117)	nasal polyp(117)	trauma(84)	infection(57)
deviated septum(118)	allergy(116)	high blood pressure(52)	cancer(4)
	poorly fitting dentures(120)	leukkemia(40)	
	dental malocclusion(121)	platelet deficiency(123)	
	enlarged uvula (122)	anticoagulant overdosage(124)	
SoreThroat(529)	*WhitePatchintheThroat*(530)	*Hoarseness*(531)	*DifficultSwallowing*(532)
virus infection(126)	aphthous ulcer(131)	laryngitis(134)	anxiety(0)
streptococcal infection(127)	oral candidiasis(132)	vocal nodule(135)	cancer of the throat(138)
peritonsillar abscess(128)	leukoplakia(133)	cancer of the larynx(136)	cancer of the esophagus(139)
infectious mononucleosis(44)	cancer(4)	enlarged thyroid(137)	diverticulum of the throat(140)
tobacco(129)			esophageal web or stricture(141)
nocturnal mouth breathing(130)			foreign body(125)
			reflux of stomach acid(142)
			achalasia(143)

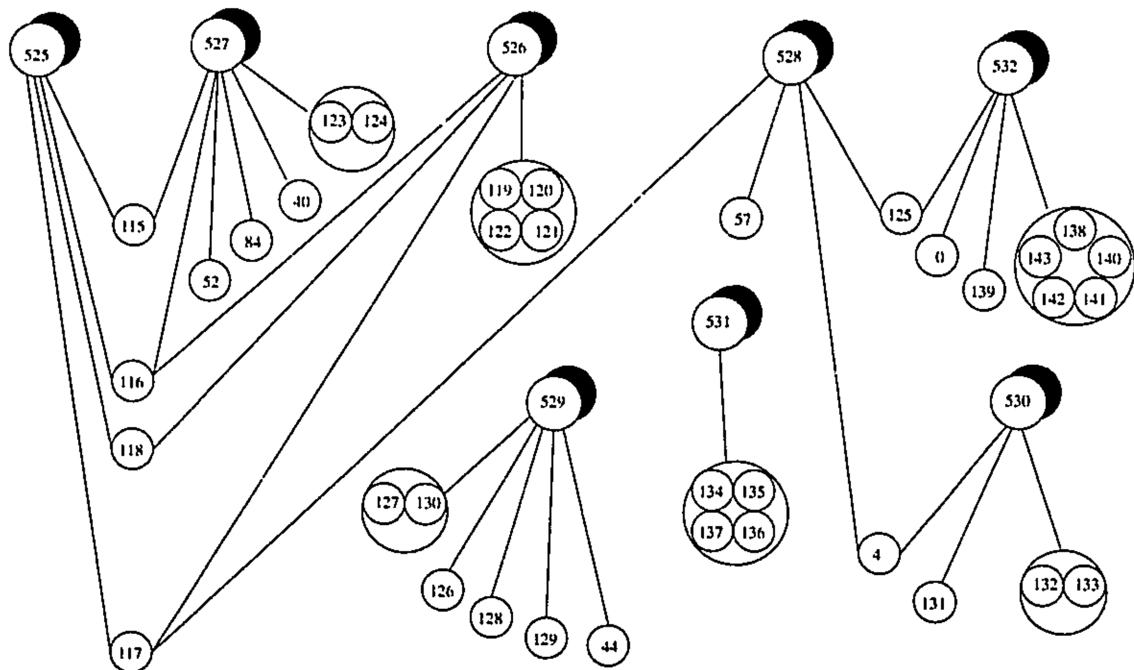


Figure 9.5: Nose and throat symptoms.

Table 9.6: Symptoms 533, 534, 535, 536.

Toothache(533)	*BleedingGums(534)*	*SoreTongue(535)*	*UlceroftheMouthandTongue(536)*
*************	****************	**************	*******************************
dental caries(144)	pyorrhea(147)	tobacco smoking(129)	aphthous ulcer(131)
pulpitis(145)	gingivitis(148)	hot or spicy foods(151)	herpes simplex cold sore(155)
dental abscess(146)	leukemia(40)	food allergy(152)	erythema multiforme(156)
	pregnancy(149)	vitamin deficiency(153)	cancer(4)
	diphenylhydantoin reaction(150)	anemia(3)	syphilis(157)
		antibiotic reaction(154)	

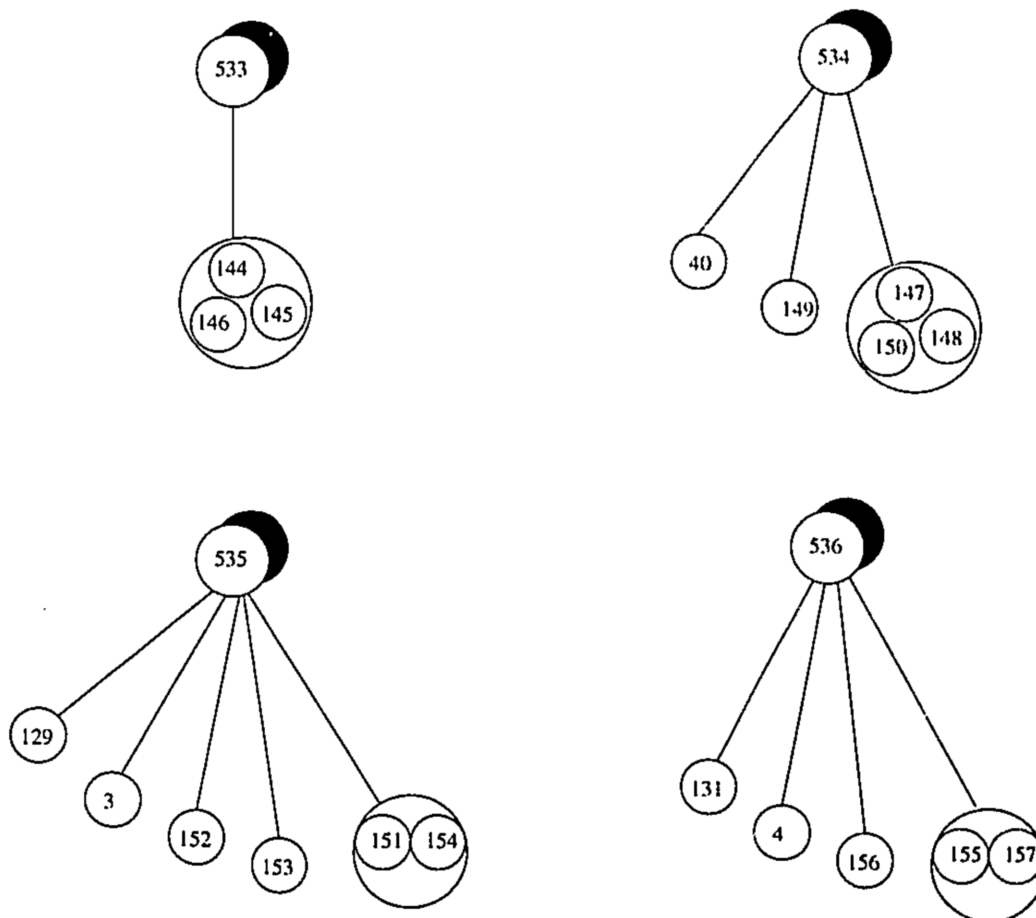


Figure 9.6: Oral and dental symptoms.

Table 9.7: Symptoms 537, 538, 539, 540

EnlargedGlandsintheNeck(537)	*StiffNeck*(538)	*EnlargedThyroid*(539)	*LumpintheThyroid*(540)
********************************	***************	*********************	************************
sore throat(158)	cervical sprain(162)	underactive thyroid(164)	enlarged nodule of functioning thyroid tissue(167)
ear infection(112)	arthritis of the vertebrae(163)	iodine deficiency(165)	cancer of the thyroid(168)
sinus infection(53)	stroke(39)	overactive thyroid(24)	
abscessed lymph gland(159)	meningitis(70)	thyroiditis(166)	
cancer(4)	encephalitis(76)		
leukemia(40)			
lymphoma(41)			
metastatic cancer(160)			
developmental cyst(161)			

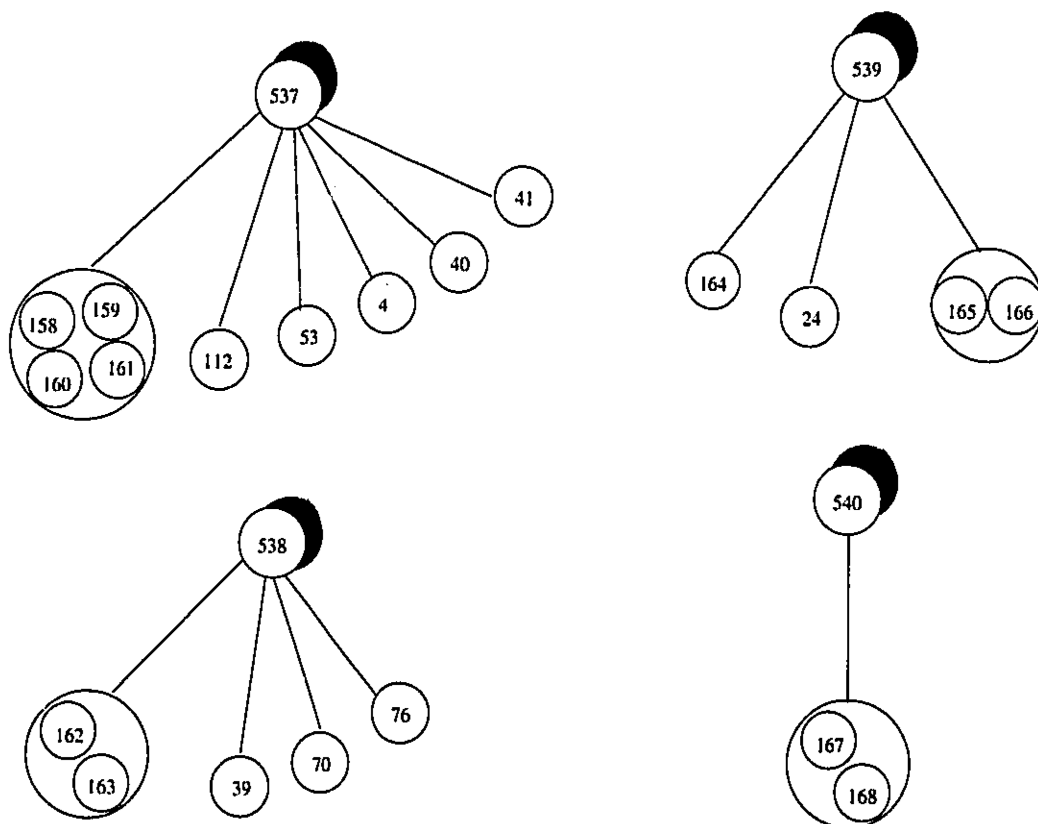


Figure 9.7: Neck symptoms.

Table 9.8: Symptoms 541, 542, 543, 544, 545, 546

ChestPain(541)	*Palpitation*(542)	*RapidHeartbeat*(543)
**************	***************	*****************
heart attack(37)	anxiety(0)	anxiety(0)
angina pectoris(169)	tobacco(177)	paroxysmal atrial tachycardia(181)
muscle strain(170)	coffee(178)	drug reactions
pericarditis(171)	medication(179)	overactive thyroid(24)
pulmonary embolism(172)	cardiac neurosis(180)	
dissecting aneurysm(173)	paroxysmal atrial tachycardia(181)	
indigestion(174)	overactive thyroid(24)	
intestinal gas(175)		
gall bladder attack(176)		
IrregularPulse(544)	*HeartMurmur*(545)	*ShortnessofBreath*(546)
*****************	***************	***********************
premature contractions(183)	innocent murmur(187)	congestive heart failure(21)
caffeine and tobacco(184)	congenital heart disease(188)	pneumonia(79)
medication(179)	rheumatic heart disease(189)	bronchitis(192)
fibrillation(185)	calcified heart valves(190)	asthma(193)
sinus arrhythmia(186)	weakened heart valves due to heart attack(191)	

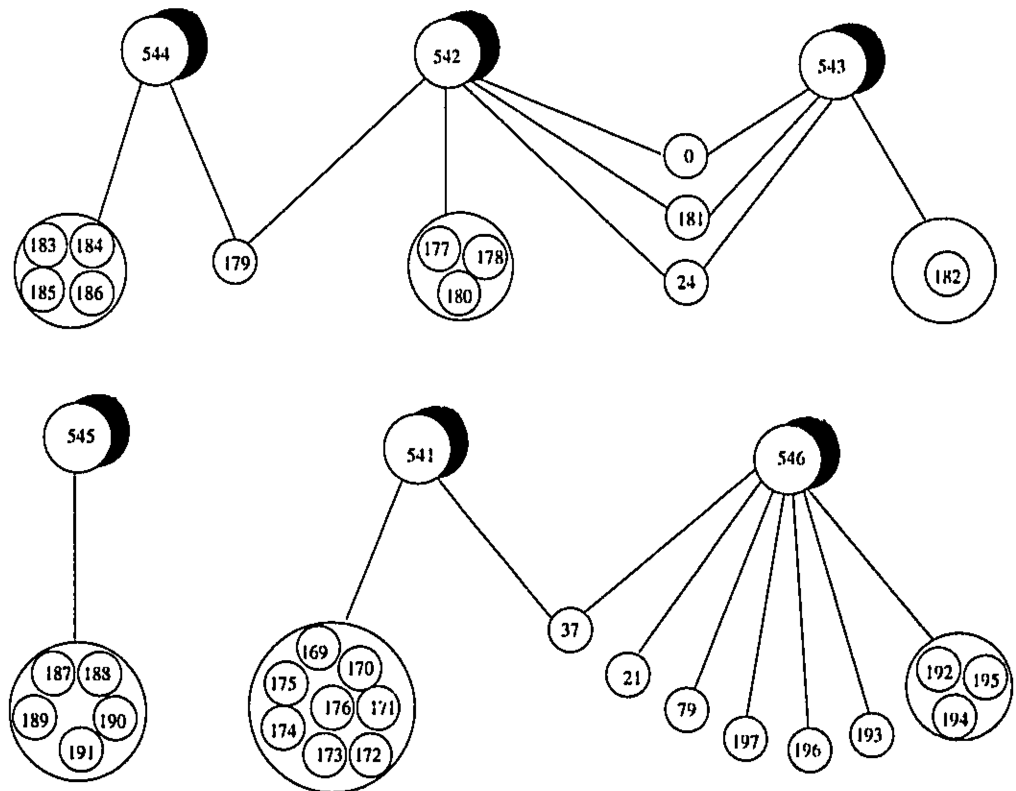


Figure 9.8: Heart symptoms.

Table 9.9: Symptoms 547, 548, 549, 550, 551, 552,

AcuteCough(547)	*Wheezing*(548)	*PainfulBreathing*(549)
***************	***********8	********************
acute bronchitis(198)	asthma(193)	pleurisy(202)
pneumonia(79)	asthmatic bronchitis(201)	pneumothorax(203)
croup(199)	emphysema(194)	injury of the chest wall(204)
pulmonary infarction(38)	foreign body aspiration(200)	pneumonia(79)
trauma(84)		
foreign body aspiration(200)		
heart attack(37)		

ChronicCough(550)	*CoughingUpBlood*(551)	*ShortnessofBreath*(552)
*****************	*********************	************************
excessive tobacco smoking(205)	Lung cancer(21)	pulmonary emphysema(211)
industrial fumes(206)	pneumonia(79)	congestive heart failure(21)
allergy(116)	congestive heart failure(21)	asthma(193)
chronic bronchitis(207)	pulmonary infarction(38)	hyperventilation(196)
postnasal discharge(208)	tuberculosis(42)	diabetic acidosis(197)
sinus infection(53)		anemia(3)
emphysema(194)		advanced cancer of the lung(212)
cancer of the lung(209)		
congestive heart failure(21)		

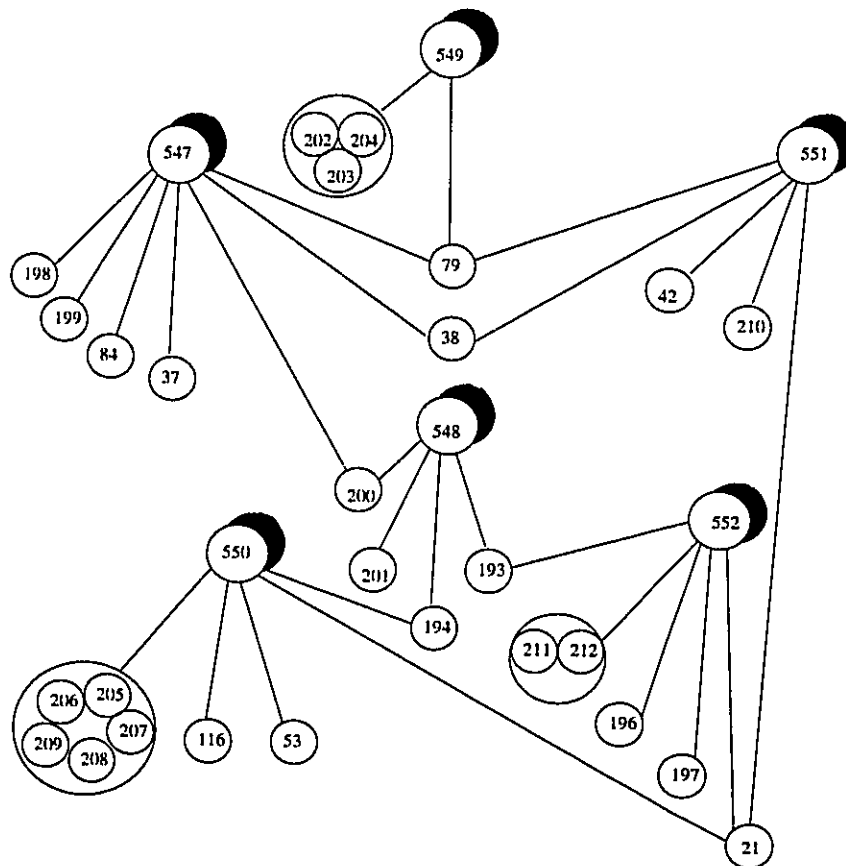


Figure 9.9: Lung symptoms.

Table 9.10: Symptoms 553, 554, 555

PainfulBreast(553)	*NippleDischarge*(554)	*LumpintheBreast*(555)
*****************	******************	**********************
cyclic menstrual changes(213)	infection(57)	breast cyst(214)
pregnancy(149)	papilloma(216)	fibroadenoma(217)
infection(57)	breast cancer(215)	breast cancer(215)
breast cyst(214)		
breast cancer(215)		

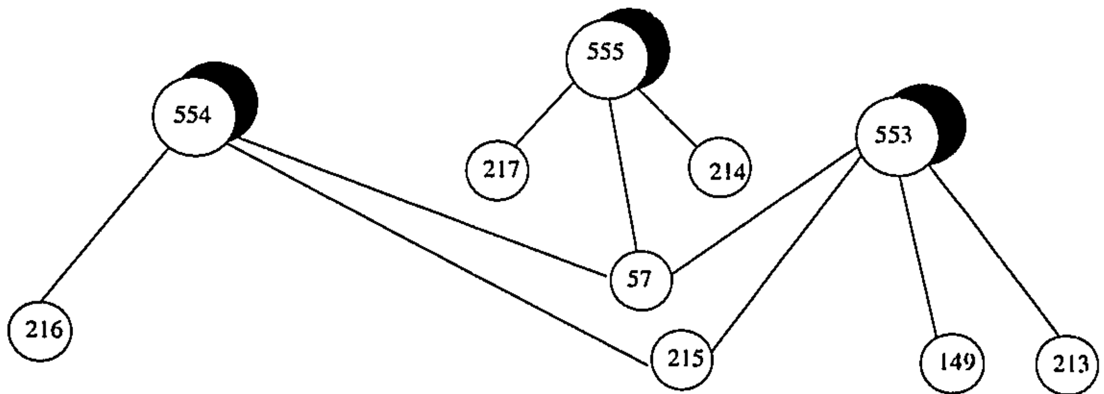


Figure 9.10: Breast symptoms.

Table 9.11: Symptoms 556, 557, 558, 559, 560, 561.

Dyspepsia(556)	*Belching*(557)	*NauseaandVomiting*(558)
*************	***********	**********************
gastritis(218)	air swallowing	viral gastroenteritis(227)
peptic ulcer(219)	stomach distention(224)	medication(179)
carcinoma of the stomach(220)	alcohol(110)	alcohol(110)
hiatus hernia(22)	chronic gallbladder disease(225)	narcotic drugs(228)
gallbladder disease(221)	cancer of the stomach(226)	infectious hepatitis(13)
abdominal epilepsy(222)	cancer of the esophahus(139)	acute appendicitis(229)
	hiatus hernia(22)	gallbladder disease(221)
		peptic ulcer(219)
		chronic ear(230)
		nose and throat infection(231)
		emotional(232)
		pregnancy(149)

VomitingBlood(559)	*UpperAbdominalPain*(560)	*Hiccups*(561)
****************	***********************	*******
bleeding peptic ulcer(233)	virus infection(126)	overfilling of the stomach
cancer of the stomach(226)	gallbladder disease(221)	highly seasoned foods
acute gastritis(234)	appendicitis(235)	alcohol(110)
alcoholism(16)	penetration of peptic ulcer(236)	uremia(18)
cirrhosis of the liver(8)	pancreatitis(237)	cirrhosis of the liver(8)
	cancer of the pancreas(238)	virus infection(126)
	pneumonia(79)	anxiety(0)
	uremia(18)	
	diabetic acidosis(197)	
	sickle cell anemia(239)	
	lymph node inflammation(240)	
	drug reaction(23)	
	abdominal epilepsy(222)	
	porphyria(241)	

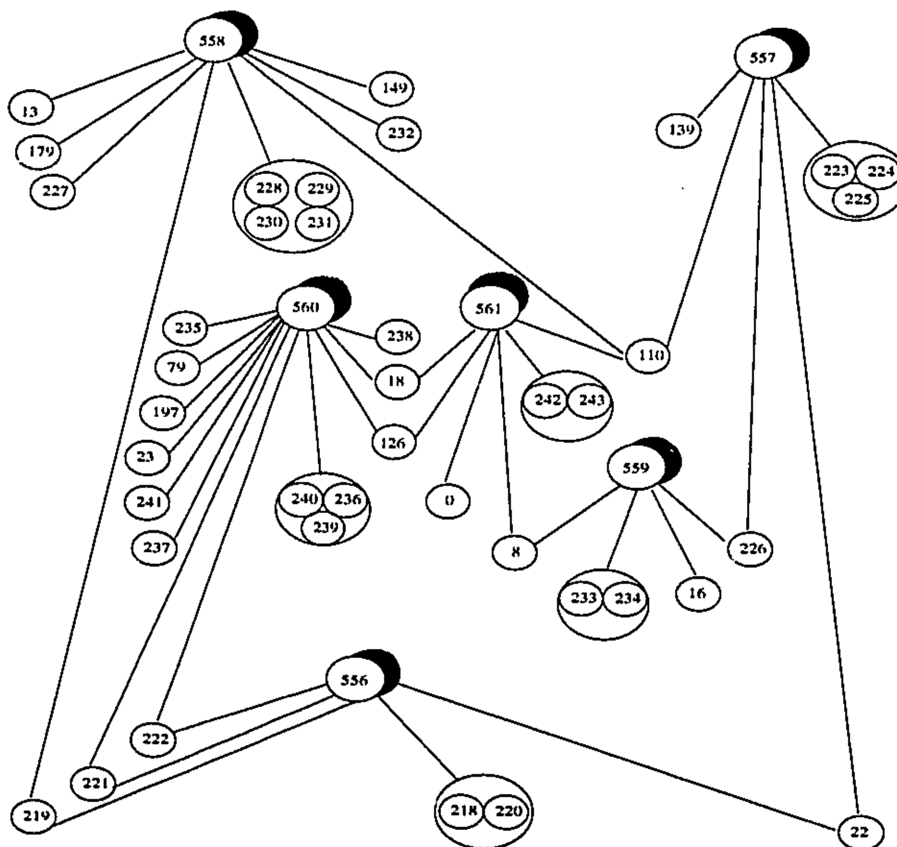


Figure 9.11: Stomach symptoms.

Table 9.12: Symptoms 562, 563, 564.

PainintheRightUpperQuadrant(562)	*Jaundice*(563)	*EnlargedLiver*(564)
*********************************	***********	****************
gallstones(244)	hepatitis(245)	cancer of the liver(15)
hepatitis(245)	gallstones(244)	chronic congestive heart failure(249)
cancer of the liver(15)	cancer of the liver(15)	cirrhosis of the liver(8)
cirrhosis of the liver(8)	cirrhosis of the liver(8)	hepatitis(245)
peptic ulcer(219)	liver abscess(246)	liver abscess(246)
liver abscess(246)	infectious mononucleosis(44)	leukemia(40)
	hemolytic anemia(247)	lymphoma(41)
	cancer of the pancreas(238)	hodgkin's disease(250)
	chemical toxicity(248)	
	drug reaction(23)	

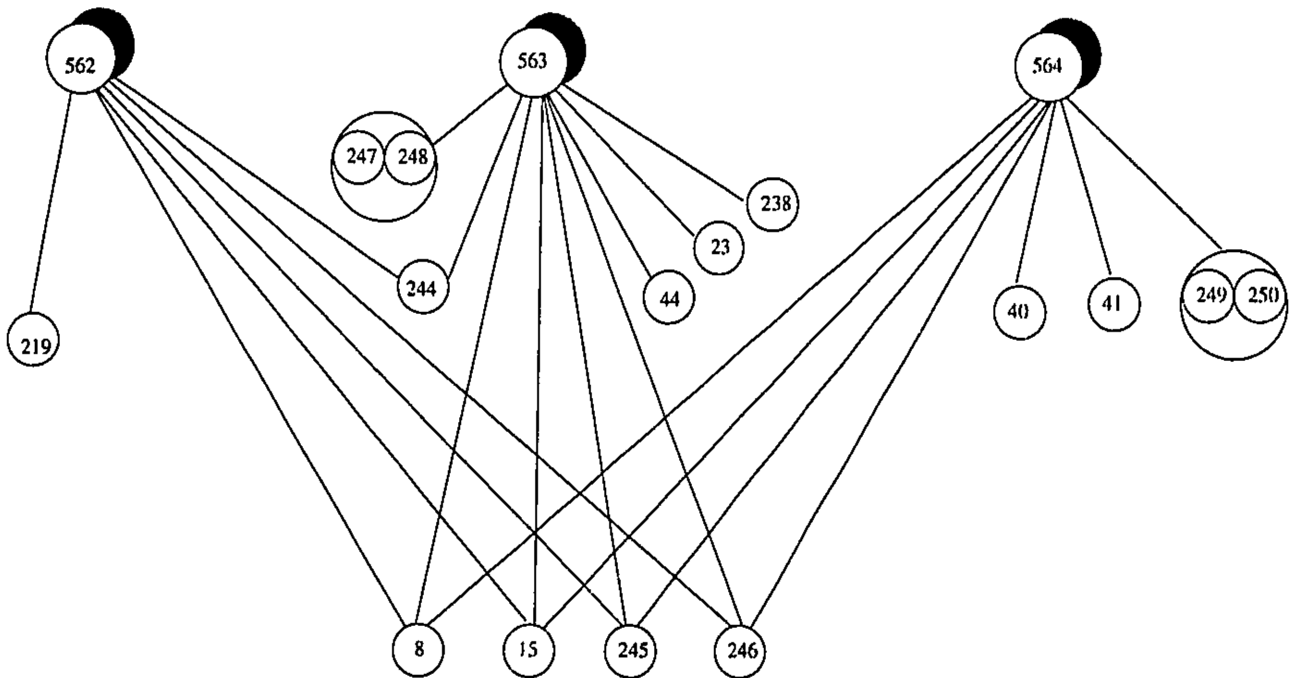


Figure 9.12: Liver and gallbladder symptoms.

Table 9.13: Symptoms 565, 566, 567, 568, 569.

Constipation(565)	*LowerAbdominalPain*(566)	*Diarrhea*(567)
******************	**************************	**************
"sluggish bowel"(251)	intestinal virus(257)	viral gastroenteritis(227)
inactivity(252)	diverticulitis(258)	food poisoning(267)
medication(179)	appendicitis(235)	ulcerative colitis(268)
cancer of the bowel(253)	intestinal obstruction(259)	food allergy(152)
rectal fissure(254)	gallbladder disease or peptic ulcer(260)	cancer of the large intestine(269)
cryptitis(255)	colitis(261)	vitamin deficiency(153)
psychic depression(256)	regional enteritis(262)	regional enteritis(262)
	kidney stone(263)	pancreatitis(237)
	blood clot in the artery(264)	overactive thyroid(24)
	pancreatitis(237)	
	ovarian cyst(265)	
	fallopian tube infection(266)	
	cancer(4)	
	diabetes(78)	
	abdominal epilepsy(222)	
	porphyria(241)	
BloodintheFeces(568)	*RectalIrritation*(569)	
************************	************************	
hemorrhoids(270)	hemorrhoids(270)	
rectal fissure(254)	thrombosed hemorrhoid(274)	
cancer of the rectum(271)	cryptitis(255)	
ulcerative colitis(268)	rectal fissure(254)	
rectal polyp(272)	pruritus ani(275)	
diverticulitis(258)		
peptic ulcer with massive hemorrhage(273)		

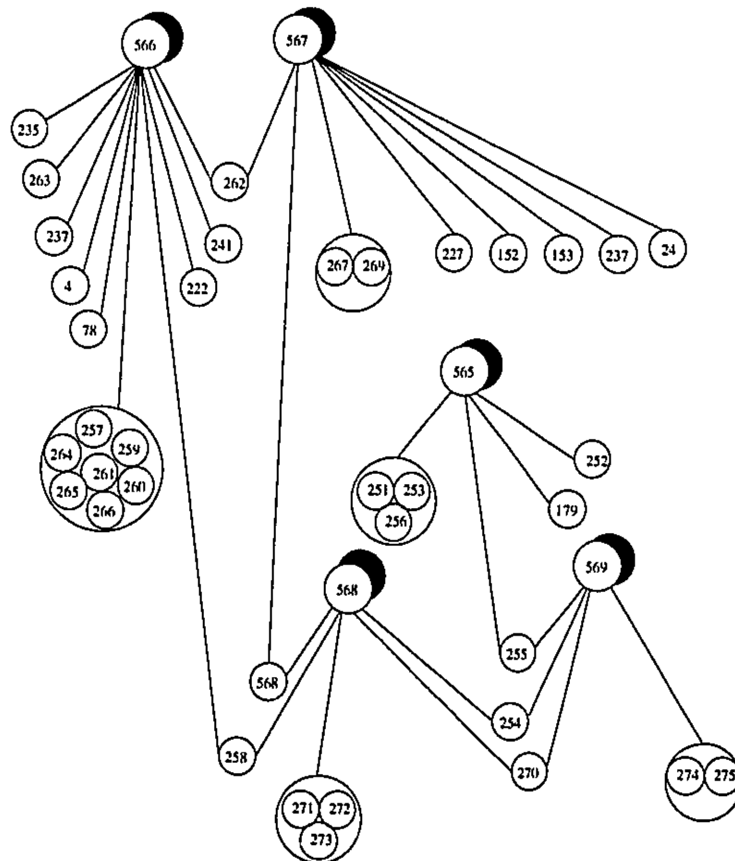


Figure 9.13: Intestinal and rectal symptoms.

Table 9.14: Symptoms 570, 571, 572, 573, 574

FrequentUrination(570)	*PainfulUrination*(571)	*BloodintheUrine*(572)
************************	************************	************************
urinary tract infection(267)	urinary tract infection(276)	urinary tract infection(276)
prostate infection(277)	prostate infection(277)	cancer of the bladder(281)
diabetes mellitus(9)	urethritis(333)	cancer of the kidney(285)
enlargement of the prostate(278)	vaginal infection(284)	glomerulonephritis(286)
bladder stone(279)	bladder stone(279)	kidney stone(263)
chemical irritation of the bladder(280)		bacterial endocarditis(287)
diabetes insipidus(10)		prostate infection(277)
cancer of the bladder(281)		tuberculosis of the urinary tract(288)
pregnancy(149)		bladder papilloma(289)
excessive fluid intake(282)		
urethritis(283)		
IncontinenceofUrine(573)	*InabilitytoUrinate*(574)	
************************	************************	
weakness of vaginal supporting tissues(290)	enlargement of the prostate(278)	
prostatic enlargement(291)	reaction to medication(297)	
bladder or prostate infection(292)	inactivity(252)	
diabetic neuropathy((293)	neuropathy(298)	
multiple sclerosis(65)	stroke(39)	
stroke(39)	coma(296)	
surgical complications(294)		
severe dysentery(295)		
coma(296)		

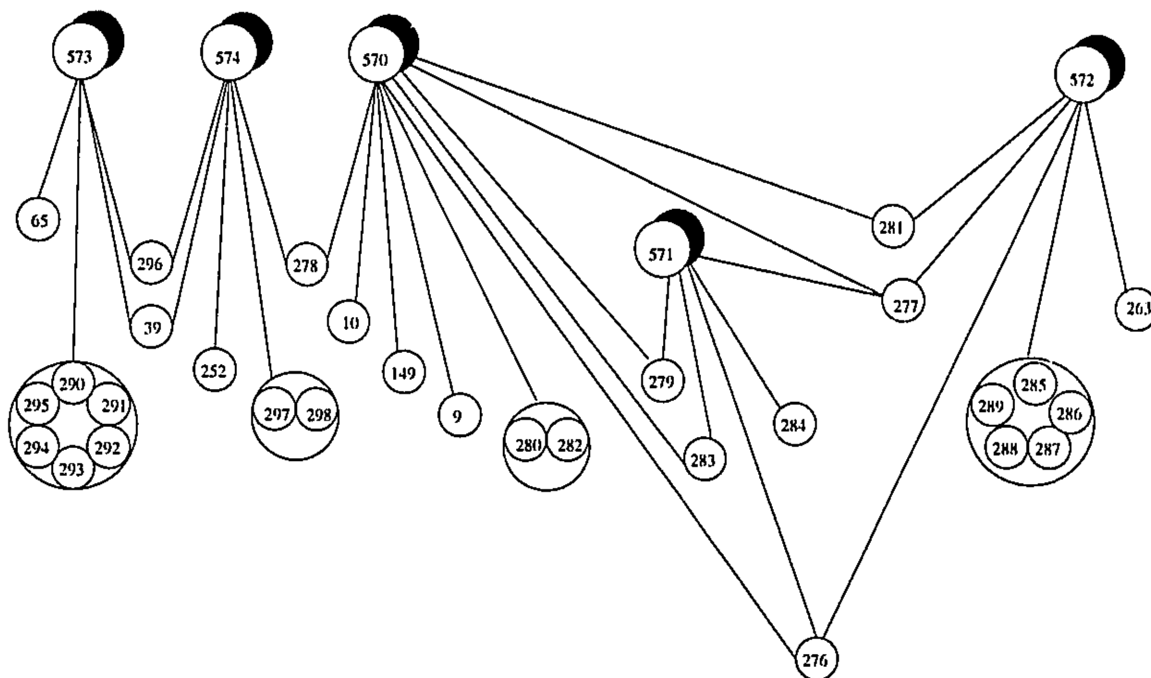


Figure 9.14: Urinary symptoms.

Table 9.15: Symptoms 575, 576, 577, 578, 579, 580, 581.

MenstrualCramps(575)	*VaginalDischarge*(576)	*IrregularMenstrualPeriods*(577)	
**********************	**********************	**********************************	
fluid retention(299)	trichomoniasis(304)	dysfunctional uterine bleeding(311)	
emotional(232)	moniliasis(305)	postadolescence(312)	
pelvic infection(300)	cervicitis(306)	menopause(313)	
endometriosis(301)	gonorrhea(307)	acute illness(6)	
uterine fibroids(302)	cancer of the cervix(308)	overactive thyroid(24)	
imperforate hymen(303)	cancer of the uterus(309)	underactive thyroid(164)	
	senile vaginitis(310)		
VaginalBleeding(578)	*HotFlushes*(579)	*Infertility*(580)	*Frigidity*(581)
*********************	*****************	******************	****************
pregnancy(149)	menopause(313)	poor timing of sexual relations(318)	emotional(232)
uterine fibroids(302)	carcinoid tumor(316)	infrequent intercourse(319)	poor sexual technique(326)
cervical polyp(314)	acute anxiety(317)	toofrequent intercourse(320)	painful sexual relations(327)
cervical infection(315)	fever(68)	fallopian tube blockage(321)	
senile vaginitis(310)		fibroid uterus(322)	
cancer of the cervix(308)		failure of ovulation(323)	
cancer of the uterus(309)		infection of the cervix(324)	
		gonorrhea(307)	
		diabetes(78)	
		thyroid dificiency(325)	

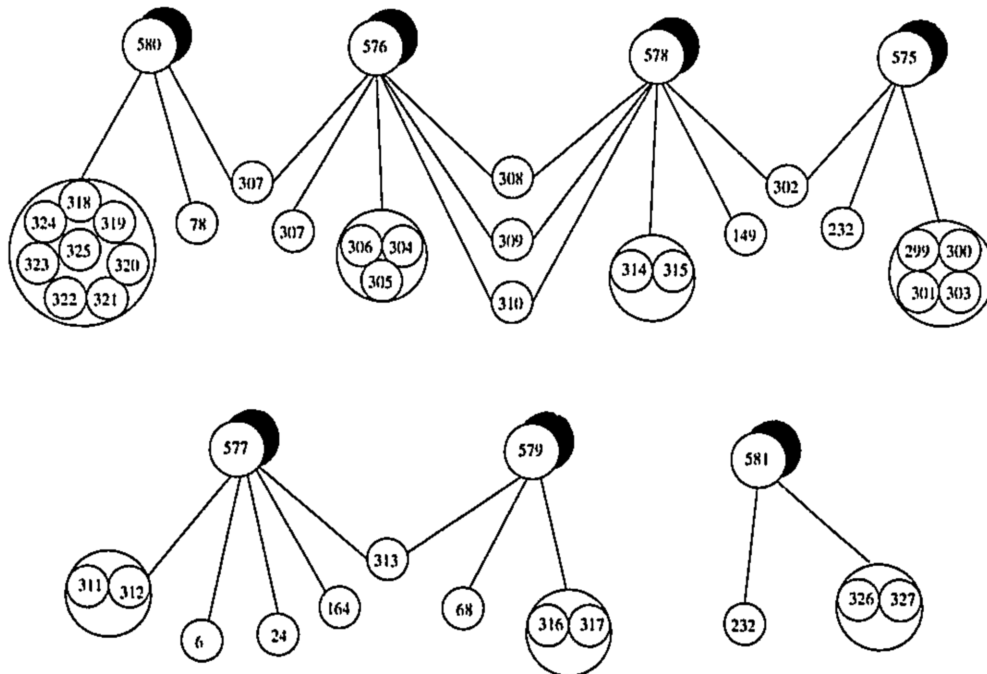


Figure 9.15: Female reproductive organ symptoms.

Table 9.16: Symptoms 582, 583, 584, 585, 586.

UrinaryHesitancy(582)	*DischargefromthePenis*(583)	*LumpintheScreen*(584)
***********************	******************************	************************
enlarged prostate(328)	nonspecific urethritis(331)	inguinal hernia(334)
urethral stricture(329)	reiter's syndrome(332)	hydrocele(335)
bladder stone(279)	gonorrhea(307)	spermatocele(336)
cancer of the prostate(330)	prostate infection(277)	varicocele(337)
drug reaction(23)	trichomonas(333)	epididymitis(338)
diabetes(78)		torsion of the testicle(339)
multiplesclerosis(65)		cancer of the testicle(340)
Sterility(585)	*Impotence*(586)	
***************	***************	
poor vaginal penetration(341)	emotional(232)	
infrequent sexual relations(342)	fatigue(348)	
too frequent sexual relations(343)	chronic illness(19)	
low sperm count(344)	multiple sclerosis(65)	
mumps orchitis(345)	diabetes mellitus(9)	
blocked seminal tract(346)	prostate srugery(349)	
prostate infection(277)	lerich's syndrome(350)	
seminal vesicle infection(347)		

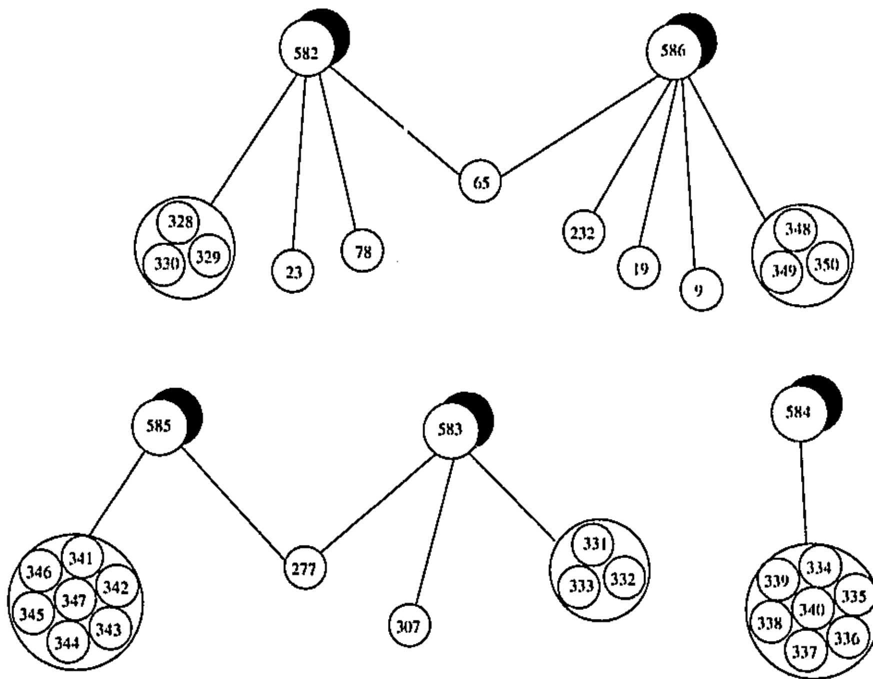


Figure 9.16: Male reproductive organ symptoms.

Table 9.17: Symptoms 587, 588, 589, 590, 591, 592, 593, 594.

Itching(587)	*Hives*(588)	*SkinInfection*(589)	*ScalingSkinPatches*(590)
*************	***********	********************	************************
eczema(351)	drug reaction(23)	impetigo(357)	psoriasis(362)
hives(352)	food allergy(152)	boils(358)	pityriasis rosea(363)
contact rash(353)	anxiety(0)	fungus infection(359)	eczema(351)
chickenpox(354)	erythema multiforme(156)	herpes simplex(360)	keratosis of the skin(364)
insect bites(355)		herpes zoster(361)	
diabetes(78)			
leukemia(40)			
hodgkin's disease			
SkinUlcers(591)	*LossofPigment*(592)	*Warts*(593)	*Moles*(594)
****************	*********************	***********	**********
impaired arterial blood	vitiligo(371)	common warts((375)	benign nevus(379)
supply to the leg(365)		planter wart(376)	junctional nevus(380)
varicose veins of the leg(366)	deep skin burn(372)	venereal wart(377)	malignant melanoma(381)
infected laceration(367)	deep skin infection((373)	flat wart(378)	
cancer of the skin(368)	tinea versicolor(374)		
fungus infection(359)			
anthrax(369)			
pemphigus(370)			

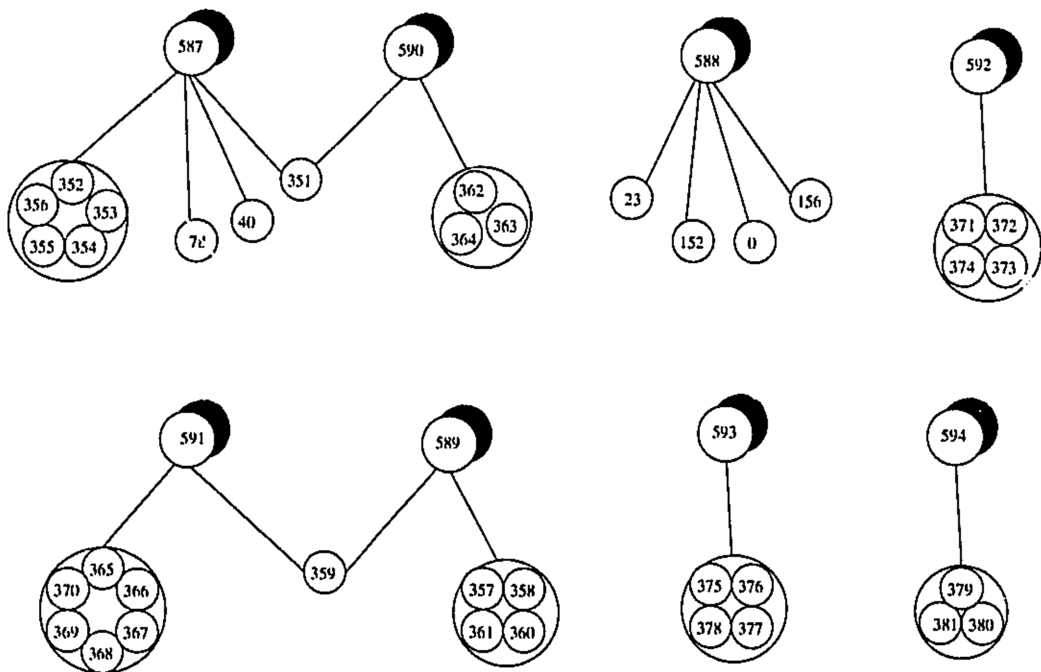


Figure 9.17: Skin symptoms.

Table 9.18: Symptoms 595, 596, 597, 598, 599, 600.

PainfulJoints(595)	*PainfulShoulder*(596)	*PainfulElbow*(597)
********************	********************	********************
osteoarthritis(382)	bursitis(389)	tennis player's elbow(393)
rheumatoid arthritis(383)	radiculitis(390)	Bursitis(389)
gout(384)	Heart attack(37)	Radiculitis(390)
joint infection(385)	gallbladder attack(391)	Arthritis(394)
psoriatic arthritis(386)	trauma or arthritis(392)	Gout(384)
acute febrile illness(387)		Heart attack((37)
inflamed biceps tendon(388)		Trauma(84)
PainfulWrist(598)	*LowBackPain*(599)	*PainDowntheLeg*(600)
**************	********************	************************
tenosynovitis(395)	low back strain(397)	nerve root pressure(402)
ganglion(396)	sciatica(398)	neuritis(63)
arthritis(394)	arthritis(394)	metastatic cancer(160)
gout(384)	metastatic cancer(160)	multiple myeloma(399)
trauma(84)	multiple myeloma(399)	
	compression fracture of a vertebra(400)	
	vertebral infection(401)	

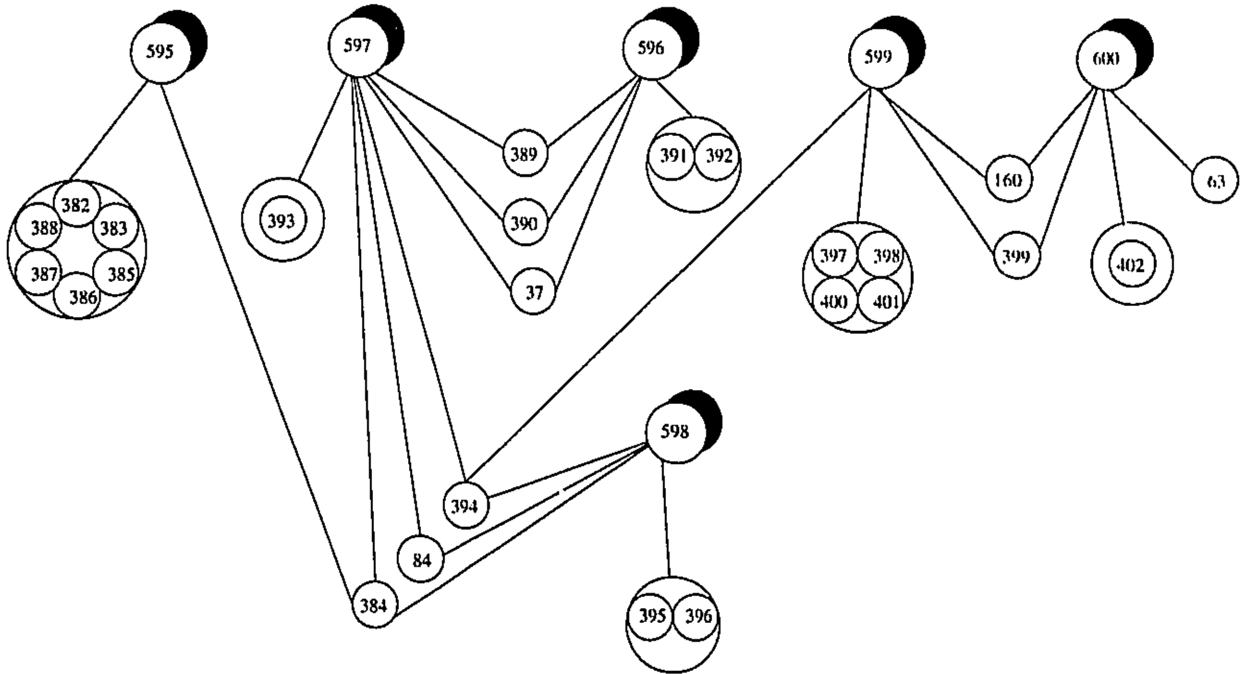


Figure 9.18: Muscle and joint symptoms.

Table 9.19: Symptoms 601, 602, 603, 604, 605, 606, 607, 608.

Choking(601)	*Fainting*(602)	*Burns*(603)	*Abrasion*(604)
**************	**************	************	**************
croup(199)	emotional(232)	first-degree brun(409)	superficial scraping of the skin(412)
foreign body in the throat(403)	acute illness(6)	second-degree burn(410)	
allergic swelling of the throat(404)	rapid heartbeat(406)	third-degree burn(411)	
trauma(84)	slow heartbeat(407)		
epilepsy(69)	anemia(3)		
nasal polyp(117)	stroke(39)		
tonsillitis(405)	convulsive seizure(408)		
peritonsillar abscess(128)	low blood sugar(60)		
Contusion(605)	*Lacerations*(606)	*HeadTrauma*(607)	*MultipleInjuries*(608)
***************	******************	********************	************************
a bruise with swelling of the tissues(413)	sharp trauma(414)	with or without loss of consciousness(416)	assure airway(418)
	blunt trauma(415)	with or without skull fracture(417)	stop bleeding(419)
			treat shock(420)
			splint fractures(421)
			definitive diagmosis and treatment of lesser injuries(422)

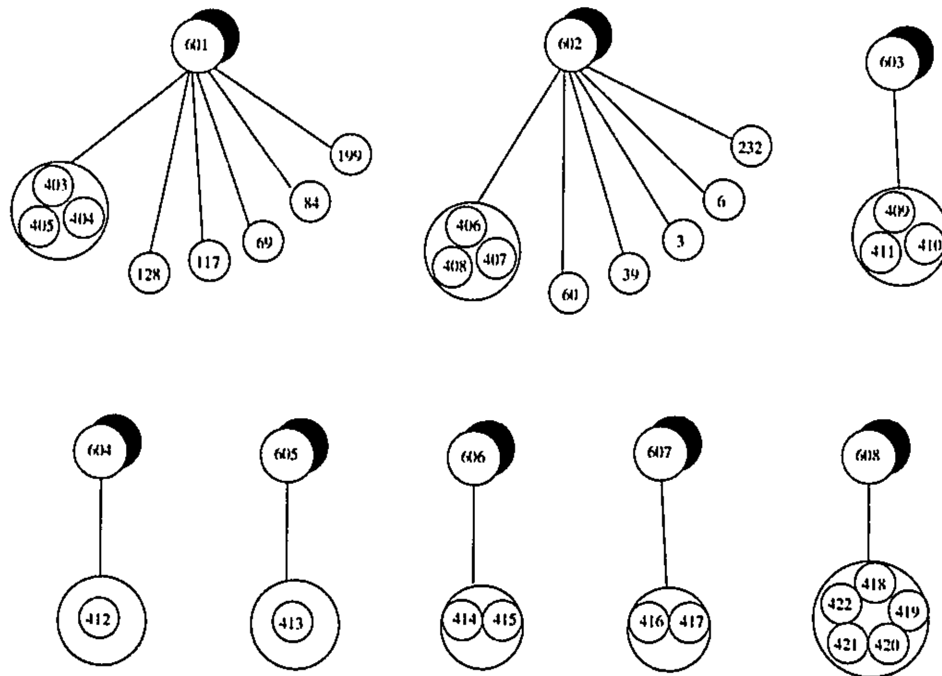
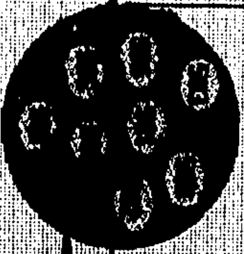
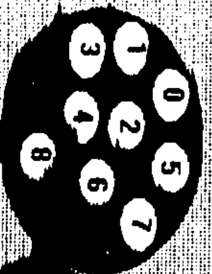


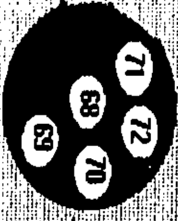
Figure 9.19: Emergency.

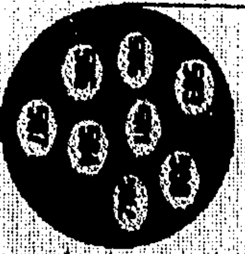
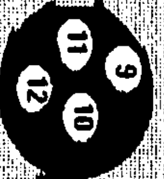
B. *Visual Tool for Medical Diagnosis* Diskette

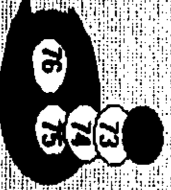
Visual Tool for Medical Diagnosis version 1.0 diskette will run under DOS or WINDOWS on a PC 386 or higher version. Available on request.

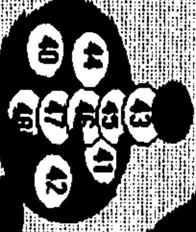


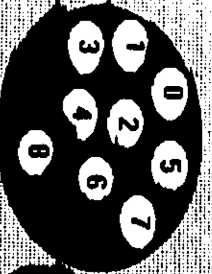
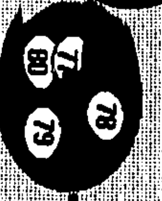


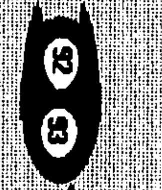
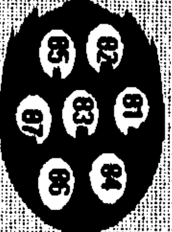
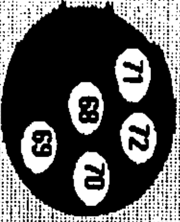
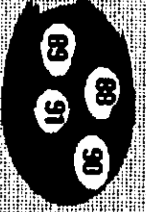


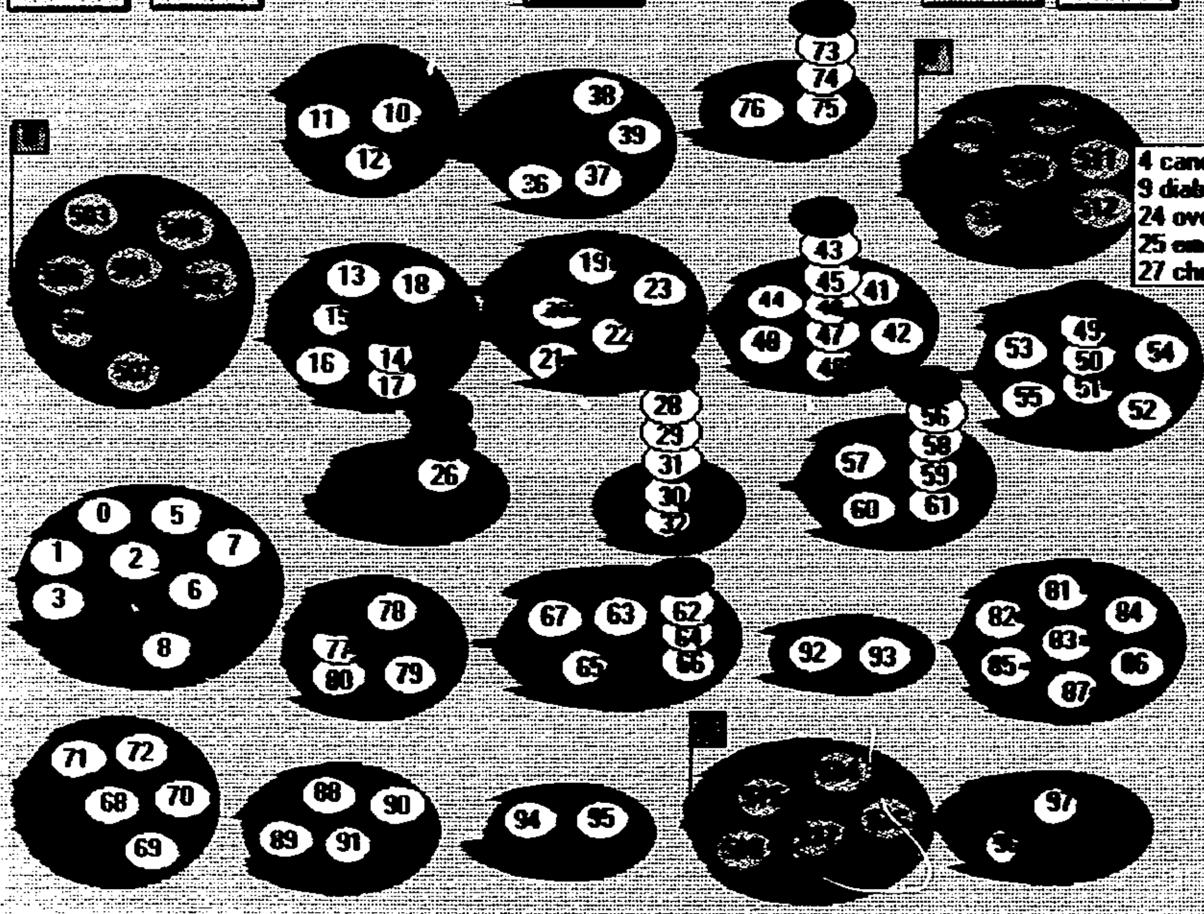





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DisList
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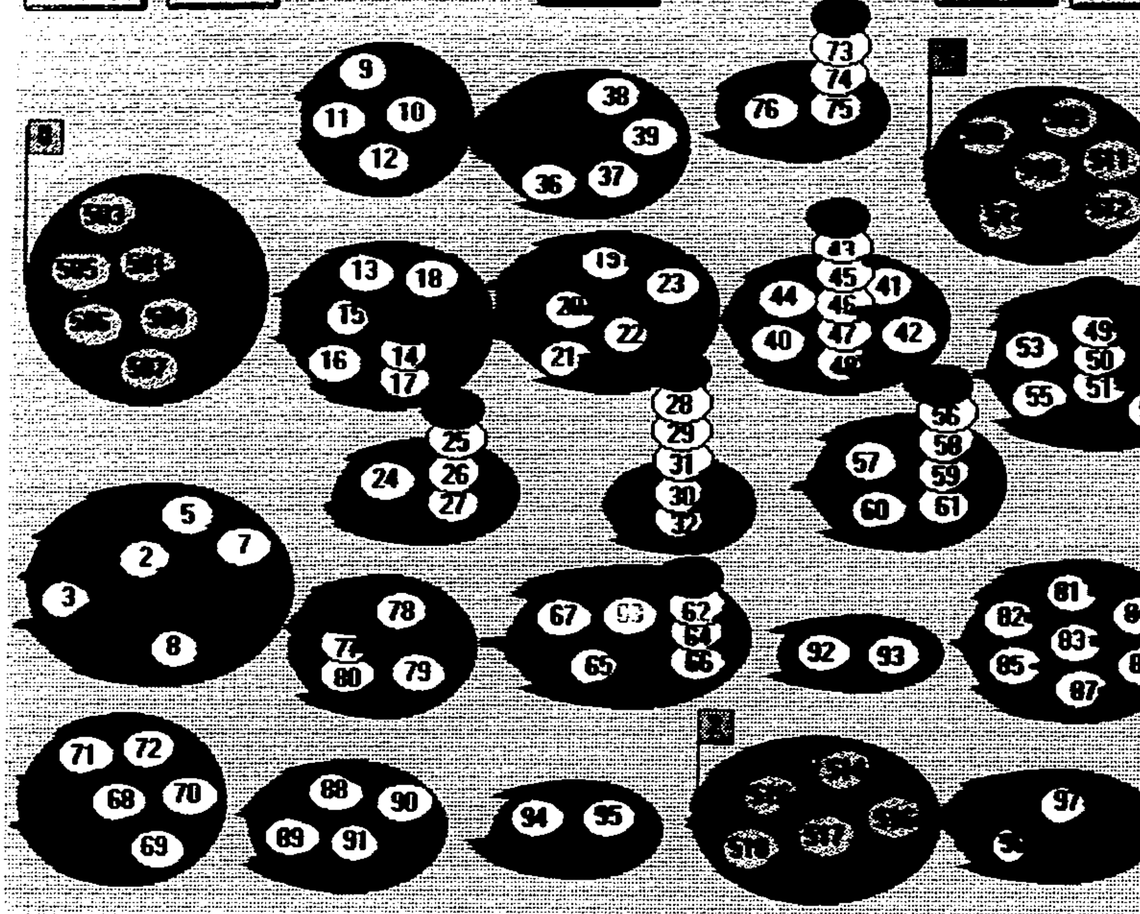
9 diabetes mellitus
24 overactive thyroid
25 emotions
27 chronic gastrointestinal tract di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DisList
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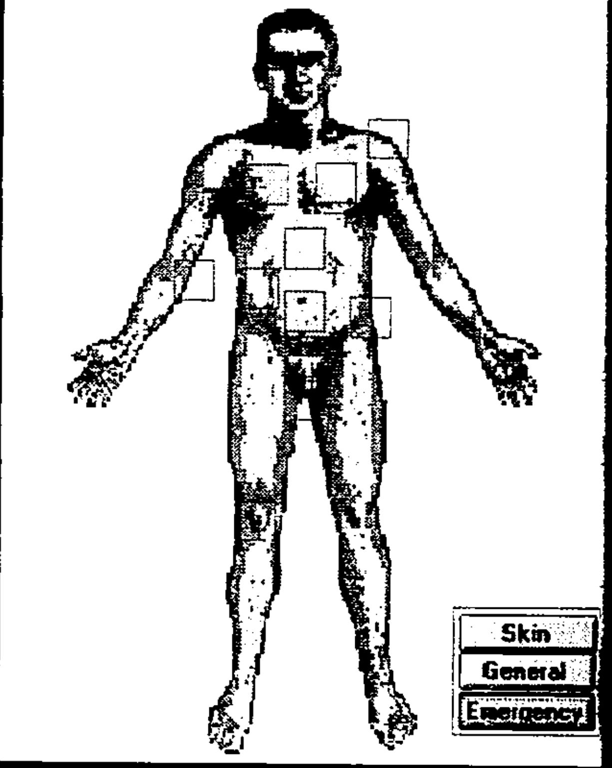
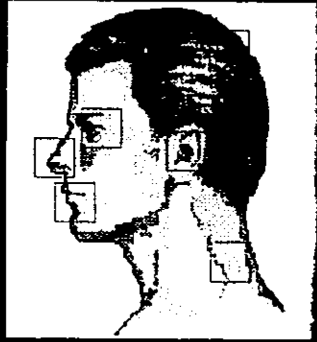
4 cancer

Anatom





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Reset

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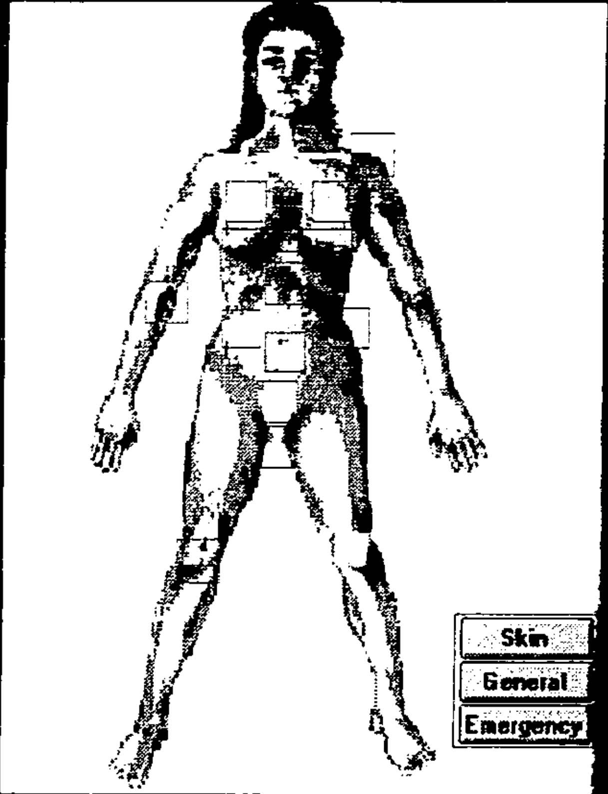

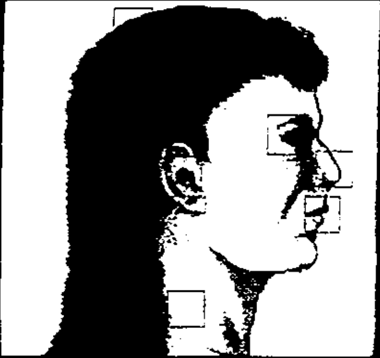

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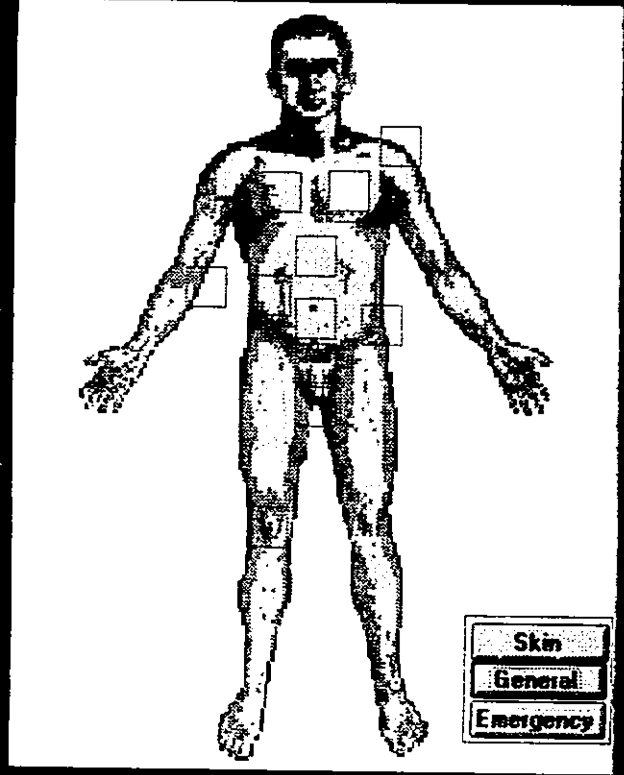

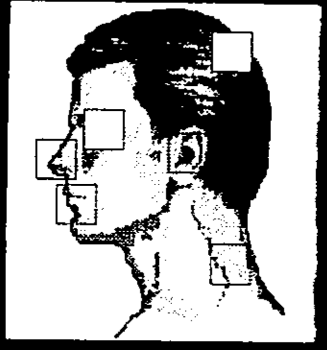

Finish Select

Reset

Common Disease

Nervous symptoms

Eye Symptoms

Heart Symptom:

Genaral Complaint:

Clear

Reset

Common Diseas

Nervous symptom
Eye Symptoms
Heart Symptom
Genaral Complaint

Headache
Dizziness
Tremors
Convulsions
Confusion and Delirium
Coma

Clear
Reset

Common Disease

Nervous symptoms

Eye Symptoms

Heart Symptoms

Genaral Complaint:

Dizziness

Impaired Visio

Rapid Heartbeat

Insomn

Clear

Reset

Common Diseas

Nervous symptom:

Eye Symptom.

Heart Symptom

Genaral Complaint

Dizziness

Impaired Visio

Rapid Heartbeat

Insom

infection

Clear

Reset