REKABENTUK SISTEM PAKAR BAGI PULMONARI TUBERCULOSIS DENGAN PENINGKATAN IMEJ

Oleh

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ABSTRACT

An expert system is a system that is capable of emulating the human expert problem assessment ability. The expert system is a part of artificial intelligence or artificial intelligence technology research field that is design to assist problem solving and improve productivity. Knowledge extracted from texts, journals, experts or other sources are coded in apt forms for the system to use in its reasoning process.

The expert system develop allows for pulmonary tuberculosis infection forecast with the aid of image enhancement tools. The system design was develop by application of Borland C++ Version 6.0 software development tools. The expert system itself includes not only the disease infection certainty forecast but also disease explanation within the expert system main interface frame.

The main diagnosis means for detection of pulmonary tuberculosis is made by using chest x-ray images. These images loaded into the expert system mainframe will be inferred upon by the expert system client. Manipulation of the images by the client is done with the enhancement tools incorporated into the expert system. The whole software is devise with one main principle that is to have the system simple enough that even a first time user would be able to use it affectively.

ABSTRAK

Sistem pakar adalah suatu system yang mampu meniru cara pakar menganalisis masalah. Sistem pakar adalah sebahagian daripada cabangan kajian teknologi kepintaran buatan yang direkabentuk untuk membantu mengatasi masalah dan mempertingkatkan tahap produktiviti. Pengetahuan atau maklumat yang di ambil daripada buku teks, journal, para pakar, atau mana-mana sumber lain dikod ke dalam bentuk bersesuaian untuk digunakan dalam proses deduksi.

Sistem pakar yang dibina membolehkan jangkitan penyakit batuk kering atau *Tuberculosis* diramal dengan bantuan alat peningkatan imej. Sistem pakar ini, direkabentuk dengan aplikasi Borland C++ Bulder Versi 6.0. Sistem yang dibina ini bukan sahaja boleh meramal jangkitan tetapi turut memberi keterangan mengenai penyakit pada paparan tetingkat utama.

Alat bantu utama dalam mengesan penyakit batuk kering atau *Tuberculosis* ini adalah dengan menggunakan imej x-ray. Imej yang dimuat naik ke dalam tetingkap utama sistem pakar akan dirujuk oleh pengguna system. Manipulasi imej boleh dilakukan oleh pengguna dengan mengaplikasikan alat peningkatan imej. Sistem pakar ini dibina dengan berpegang kepada prinsip yang memerlukan sistem yang mudah agar pengguna kali pertama sistem turut boleh menggunakannya dengan efektif.

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CONTENT

Chapter 1

INTRODUCTION

1.1 Foreword

Every day more than 2000 people die from Tuberculosis infection in South East Asia and over 5000 a day worldwide. This means that in a year over 2 million will die from Tuberculosis infection. More than 100,000 from that amount are children and hundreds of thousands more children will become orphans due to this disease worldwide. According to the World Health Organization (WHO), Tuberculosis causes the highest death rates by infectious agents in the South East Asia region. The death rates by infectious agents are as given in figure 1.1.

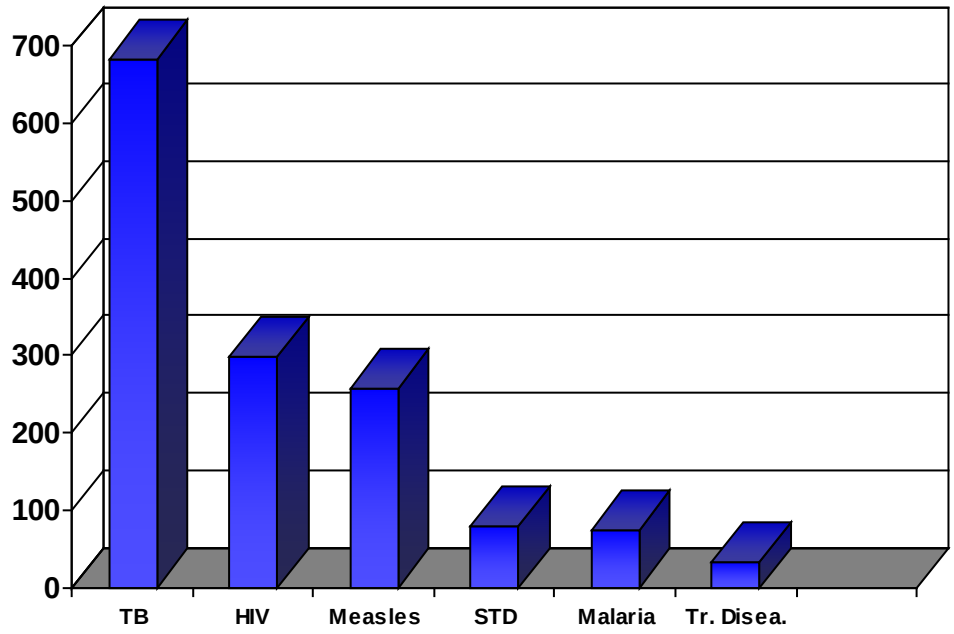

Figure 1.1 Death Rates by Infectious Disease in South East Asia Region

The percentage of Tuberculosis infection in South East Asia is 38% thus making this region death rate from Tuberculosis the highest in the world. Within South East Asia, more than 95% of cases are found in India, Indonesia, Bangladesh, Thailand, and Myanmar. Figure 1.2 gives Tuberculosis infection percentages worldwide. The second highest area for tuberculosis infection is in the West Pacific Region that accounts for 25%. The Percentages are further elaborated in the table 1.1.

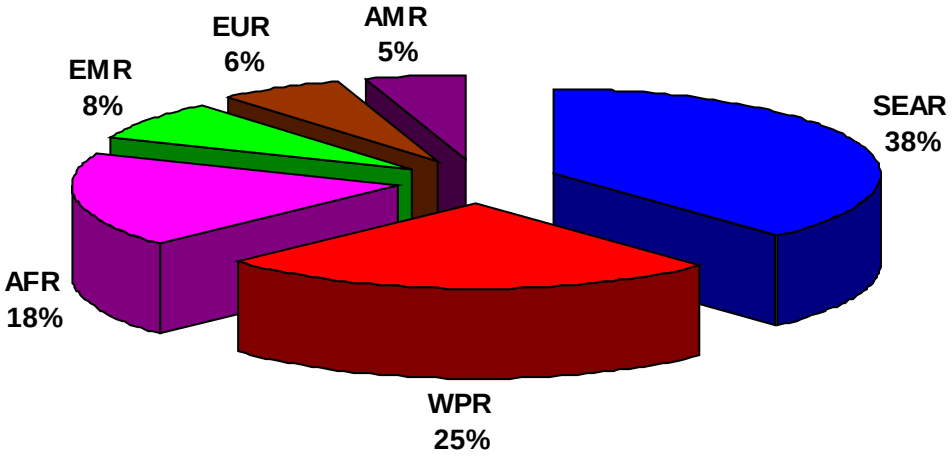

Figure 1.2 Tuberculosis Infection Percentages Worldwide.

Table 1.1 Tuberculosis Percentage Detail

Region	Percentage
South East Asia	38
West Pacific	25
Africa	18
East Mediterranean	8
Europe	6
America	5

Tuberculosis can occur in any part of the body, however most cases of infection occur only in the lungs. Pulmonary Tuberculosis accounts for more than half of the worldwide Tuberculosis infection rates. Due to this factor, the expert system built is design to combat Pulmonary Tuberculosis specifically.

The project develop is entitle Expert System for Pulmonary Tuberculosis with Image Enhancement. The system is design to aid doctors and medical students diagnose Pulmonary Tuberculosis with differential diagnosis and chest x-ray images. The system is completed with image enhancement tools to allow for chest x-ray image manipulation by the system client.

The system development involves both research into the disease medical background and implementation of the knowledge to structure to form the expert system. This is done with the application of the Borland C++ Builder Version 6.0

software. With the completion of the expert system, integration with image enhancement tools was executed.

1.2 Disease Diagnosis and Scope

Diagnosis of Pulmonary Tuberculosis requires detection of tuberculosis, screening for tuberculosis infection and confirmation of the infection. Detection of tuberculosis can be done by doing (a) Medical history check-up and (b) Physical examination of the patient. Screening for tuberculosis involves (a) Chest radiographic findings and (b) Mantoux Tuberculin Skin Test results. However due to the fact that chest x-rays is more reliable as a diagnosis tool for Pulmonary Tuberculosis rather than Mantoux Tuberculin Skin Test where sometimes false negative or false positive result is generated the Expert System develop encompasses only chest x-ray for disease forecasting.

Lastly, the final factor in Pulmonary Tuberculosis diagnosis is confirmation of Tuberculosis infection by bacteriological testing. However, system constructed entails only two levels of diagnosis which is detection of tuberculosis infection and screening of tuberculosis infection exclusive of bacteriological testing.

1.3 Project Development

Following the distribution of dissertation titles, an in depth research on the Expert System and development methods were done. Previous dissertation significant to the title and system models was taken as development references. The dissertation denoted [20] and [14] in the references index was primary source for system guide.

The next step in project development is to learn how to develop user system interface and inference engine for the expert system by application of Borland C++ Builder Version 6.0. The main reference for this portion is denoted [16] in the reference index. In this step C++ programming structure and syntax was emphasis upon and a programming study phase was allotted within the whole project development period.

The third step in the project development was to obtain information regarding Pulmonary Tuberculosis for inference engine knowledge database. The system database was design with input from texts, journals, experts or other sources. The texts and

medical journals used are listed within the reference index. The extracted knowledge was than tabulated and certainty level for expert system forecasting was set.

The following step in the project development is the actual Expert System construction. A structuralized question set was made, completed with answers and explanations sets. The tabulated certainty level mentioned earlier was place into the forecasting calculation algorithm to allow certainty computation by the Expert System.

The final phase of the project develop is the integration of enhancement tool into the software design. The enhancement tools chosen for integration were based upon usefulness in assisting chest x-ray image diagnosis and tool application simplicity features.

1.4 Project Objective

The main objective of developing the expert system is to develop an expert system that could aid physicians diagnose for Pulmonary Tuberculosis. The system is hoped to be able to simplify tuberculosis diagnosis of patients. The system develop could be set as a reference so that important symptoms are not forgotten.

To increase productivity and to help train more experts in the field the system could be applied as a teaching tool. The software itself is very simple to use and thus one does not need to take any formal lessons for the application. To further aid diagnosis, image enhancement done by the software will allow physician to have clearer x-ray images. With contrast manipulation, physician would be able to view images that might have been difficult to diagnose before.

1.5 Project Overview

As a whole, the purpose of Chapter 1 is to give an overall view of the project developed. This chapter will outline the project development and objectives. The subsequent Chapter 2 will elaborate on the Expert System develop and system application in diagnosing of Pulmonary Tuberculosis. This chapter contains a few examples of other Expert System found. Disease information and database structure formation and integration into the expert system are detailed into Chapter 3. This chapter also contains the system decision tree. Chapter 4 will comprise of the

methodology of the research and certainty classification explanations. The following Chapter 5 will explain about the enhancement techniques integrated into the Expert System. Chapter 6 will discuss the Expert System analysis conclusion and image enhancement techniques aiding diagnosis will also be shown. Chapter 7 will deal with project conclusion and overall view of the project. This chapter also includes improvements suggestions for the Expert System developed.

Chapter 2

The Expert System

2.1 Introduction

An expert system is a system that is capable of emulating the human expert problem assessment ability. An expert system includes structuralize rules sets that concludes new information with the present knowledge database and inputs given. An expert system endeavors to imitate human capability within certain set boundaries or narrow region of operation. With the properly set algorithm, the system is able to solve problems within a specified domain. The extent of quality for deduction or end results depends entirely on the rules and information acquired from the texts, journals or human experts.

2.2 Expert System Objectives

The development of the expert system is done with certain aims or goals. The develop expert system objectives are:

a. To reduce human negligence in Pulmonary Tuberculosis disease diagnosis.
b. For compilation of many human expert knowledge and experiences into a single system database.
c. Improvement of productivity in diagnosis by aiding the experts with the system structured question set.
d. To help train medical students diagnose the disease and to further train more experts in the system domain.
e. To function in a substitution capacity when a human expert is unavailable, this is for cases such as the absence of experts in remote regions.
f. Providing necessary expertise on projects that does not attract or retain expert interest.
g. To provide expertise to many when human expert services are too expensive to be attain.

2.3 Distinctive features of the Expert System

The expert system has a few very distinctive features that discern the system from the typical knowledgebase system readily available. The basic features are:

a. Ability of system to forecast or deduce the answers to certain specific problems.
b. An expert system would explain the reasoning behind the output or forecast made.
c. The database set is maintained separately from the program control.
d. Specific region or domain of operation.
e. Maintains two separate entities between the knowledgebase and the reasoning mechanism.

2.4 Expert System Architecture

The model expert system develop is based on five core components. The core components are the user interface, the expert system database, knowledge attainment engine, deduction or inference engine and explanation subsystem. The details of each segment will be explained in the following sub segments. The atypical model of the expert system architecture is as shown in figure 2.1.

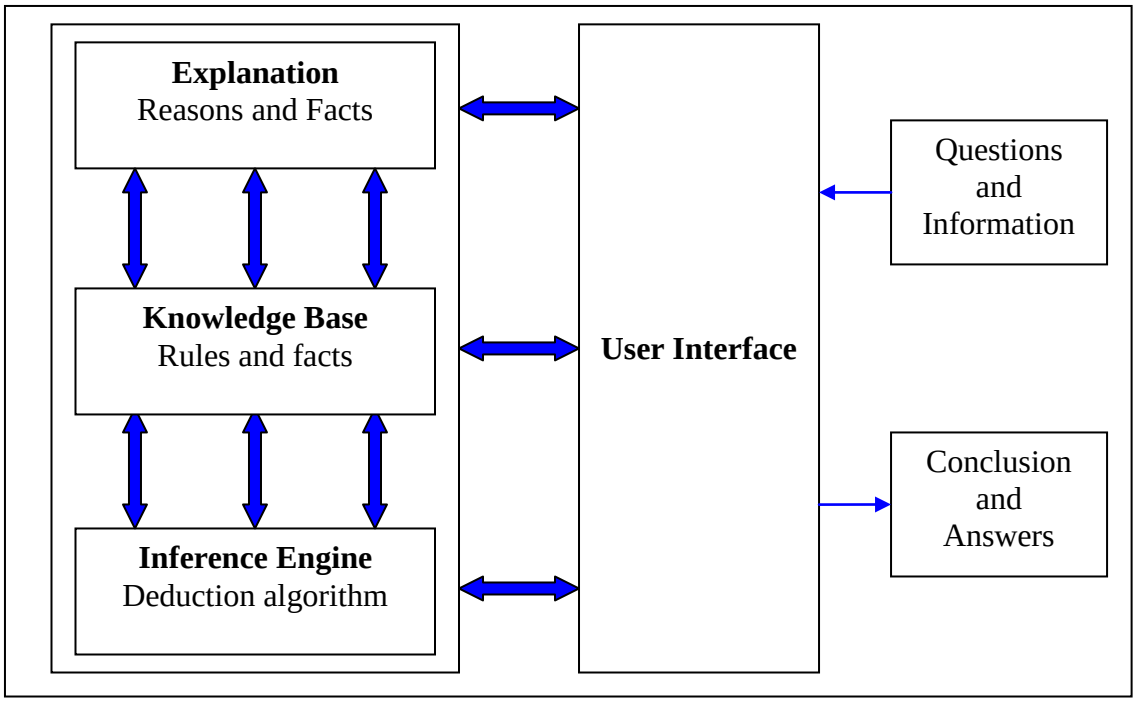

Figure 2.1 Architecture of an Expert System for Pulmonary Tuberculosis

2.4.1 User Interface

User Interface allows for the communication and interaction between client and expert system. This segment of the system enables user to key in information for expert system forecasting. The interface develop are included in appendix A.

2.4.2 Expert System Database

The database contains high level knowledge on the subject domain of the expert system. This portion of the system will determine the quality of the expert system developed. The content separately stored from the inference engine mechanism.

2.4.3 Knowledge Attainment Engine

Knowledge attainment engine uses the input information from the system client to deduce new information or conclusion.

2.4.4 Deduction or Inference Engine

Deduction or inference engine refers to the structuralized mechanism for output processing. The effectiveness of the system depends upon the efficiency of the inference engine.

2.4.5 Explanation Subsystem

Explanation segment is available to provide explanation for the questions and the answers given by the system client. This is to help user understand the reasoning behind expert system deduction.

2.5 Additional Features of the Expert System Design

The model expert system for Pulmonary Tuberculosis is further improved upon by addition of Image enhancement to the five core components of the expert system model in figure 2.1. The new improve system architecture is as shown in figure 2.2. The image enhancement tools are linked to the user interface. The image enhancements tools that are included in the expert system are contrast stretching, partial contrast stretching, linear stretching, dark and bright contrast stretching, contrast harmonic mean and adaptive local contrast. These enhancement tools will be explained in greater detail in Chapter 5.

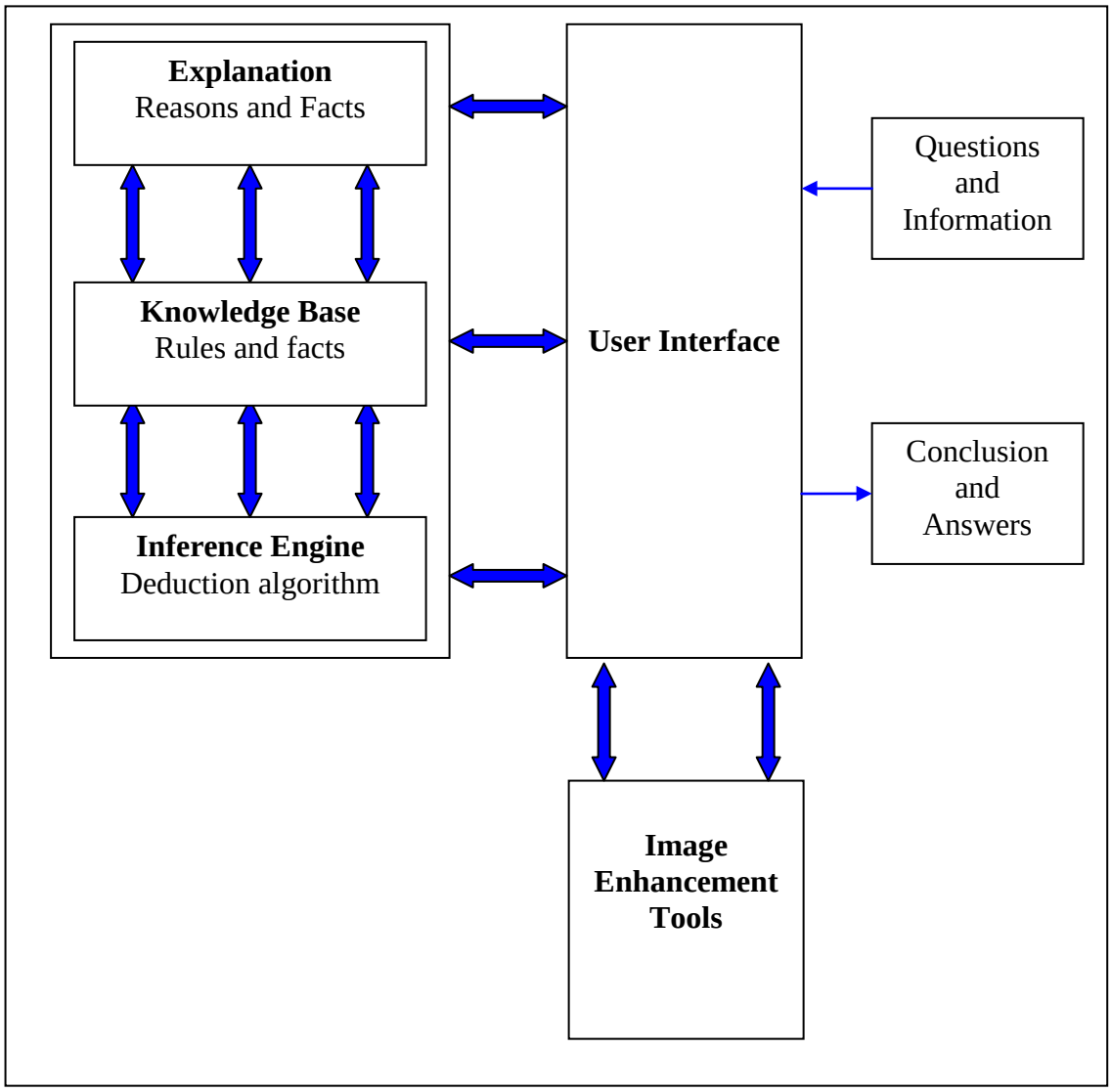

Figure 2.1 Architecture of the Expert System for Pulmonary Tuberculosis with Image Enhancement

2.6 Application of the Expert System in Medicine (System Examples)

The ability of the expert system to aid with multiple task and processes has allowed for rapid growth in the system development. Application of expert system in medicine is vast and encompasses wide ranging fields of medical studies. Some of the application system examples available are as listed in the following sub segments.

2.6.1 SYNDROC

SYNDROC is an acronym for Syndrome Diagnostic Expert System. SYNDROC applies for pseudo-Bayesian and heuristics approach to the system diagnostic forecasting system. SYNDROCS attained 78% of agreement between SYNDROC and a clinical geneticist [7].

2.6.2 OMIM

OMIM is an acronym for Online Mendelian Inheritance In Man. This system is used for syndrome diagnosis. OMIM uses a general search engine and allows clinician to enter patient's clinical traits and a list of match diagnosis will be displayed according to the index relevance [7].

2.6.3 MYCIN

MYCIN is used to diagnosis patient with blood disease infection that causes meningitis. Meningitis is a deadly disease that needs to be treated quickly. MYCIN is a very effective system that is commonly used as a system reference model. This system was built at Stanford University [14].

2.6.4 LDDB

LDDB is an acronym for London Dysmorphology Database. The database includes index of syndrome names, a list of signs, short descriptive abstract and literature references. The LDDB allows users to group syndromes by syndrome family. The drawback of the expert system is that it does not include Cytogenetic diagnosis [7].

2.7 Conclusion

This chapter elaborates on the fundamentals aspects of the expert system. The chapter outlines the develop system internal architecture and the system development objectives. The chapter also outlines the distinctive features of the system in comparison with a knowledge base system. Included as well in the chapter, are a few well known expert systems. The next chapter will elaborate on Pulmonary Tuberculosis disease background and database structure formation.

Chapter 3

PULMONARY TUBERCULOSIS

3.1 Introduction

Tuberculosis is a communicable disease caused by Mycobacterium tuberculosis, or the tubercle bacillus. It is spread primarily by tiny airborne particles (droplet nuclei) expelled by a person who has infectious tuberculosis. If another person inhales air containing these droplet nuclei, transmission may occur. Some bacilli reach the alveoli, where they are ingested by macrophages. Infection begins with the multiplication of tubercle bacilli within these alveolar macrophages. Some of the bacilli spread through the bloodstream when the macrophages die. However, the immune system response usually contains the bacilli and prevents the development of disease. Although tuberculosis can occur in almost any anatomical site or as disseminated disease, the majority of tuberculosis cases are pulmonary.

Pulmonary Tuberculosis diagnosis requires three evaluation steps. The steps would be detection of tuberculosis, screening of tuberculosis and confirmation of infection. As stated earlier in Chapter 1 the scope of the project encompasses only detection and screening process of Pulmonary Tuberculosis. The screening of Pulmonary Tuberculosis is done with the application of chest x-ray. The following segments in this chapter would further elaborate in detail about Pulmonary Tuberculosis and the diagnosis decision tree structure.

3.2 Pulmonary Tuberculosis Detection

Everyone is susceptible to tuberculosis infection however whether this person is at high risk depends upon the few factors listed in the following sub segments. Tuberculosis infection is more commonly found among certain groups and in certain settings. Detection of pulmonary Tuberculosis involves (a) Medical history check-up and (b) Physical examination of the patient.

3.2.1 Medical History Check-Up

Medical history check-up entails pertinent detail about the patient. The following are the details that the expert system must consider to enable effective diagnosis to be done.

1. Close contacts of a person with active tuberculosis
2. Foreign-born persons from countries where tuberculosis is very common
3. High-risk groups
    a. The homeless
    b. Inmates of jails and prisons
    c. Residents of long term care facilities (for example, nursing homes)
    d. Previously-infected persons of all ages (PPD reactors)
    e. Some ethnic groups, notably African American and Native Americans have higher rates
    f. HIV-infected and other immune compromised persons
    g. Substance use (alcohol abuse, injection drug use, other drug abuse)

3.2.2 Physical Examination of the Patient

Physical Examination of the Patient entails pertinent detail about the patient. The following are the details that the expert system must consider to enable effective diagnosis to be done. In most cases of pulmonary tuberculosis the infected patient would have the following symptoms:

1. Chest symptoms
    a. Cough, prolonged for three or more weeks.
    b. Sputum production (represents lung damage).
    c. Chest pain.
    d. Coughing any blood or blood-tinged sputum.
2. General symptoms and signs
    a. Fever.
    b. Chills or night sweats.
    c. Fatigue and weakness.
    d. Loss of appetite and weight loss.

3.3 Pulmonary Tuberculosis Screening

Pulmonary Tuberculosis screening involves chest x-ray radiographic findings. These radiographic finding will later on be use by the expert system to forecast infection. Pulmonary Tuberculosis is classified into three types. Details of Pulmonary Tuberculosis classification types are given in the following sub segments.

3.3.1 Primary Tuberculosis

Basically, the two features for Primary Tuberculosis infection are the lung lesions and the glandular components. Each characteristic are as noted in the subsequent sub segment.

3.3.1.1 The Lung Lesion

Primary tuberculous infection is often in the chest. This usually results in a lesion in the lungs. Characteristics of the lungs lesions are as follows:

a. Appearance of an area of consolidation (pneumonia).
b. No particular site of election (occurring in any parts of the lungs).
c. Lesion may be of any size involving up to a whole lobe.
d. Single or multiple bilateral foci (lesion)
e. Homogeneous consolidation rather than patchy.
f. Mostly caseation however cavitation still occurs rarely.

3.3.1.2 The Glandular Component

Characteristics of the glandular components in concurrence to Primary Tuberculosis infection are as follows:

a. Massive or moderate enlargement of mediastinal glands nearest the lesion or all gland groups.
b. If segmental bronchus is occluded segmental consolidation will result. Most common cause for segmental lesion for children.
c. Healing usually complete without any fibrosis and the lungs undamaged apart from the calcified foci.

d. Immunosuppress patient primary infection may progress to adult reinfection type without intermission causing consolidation to cavitate and give rise to spread throughout the lungs or a generalized miliary dissemination all over the body.

3.3.2 Chronic Pulmonary Tuberculosis

Chronic pulmonary tuberculosis is a form of pneumonia. The radiographic appearances are basically consolidation. Features that help to distinguished chronic pulmonary tuberculosis from other types of pneumonia will be explained in detail in the following sub segment.

3.3.2.1 Situation

In most cases the disease is usually located in the upper or lower lobes and rarely occurs in elsewhere. Chronic Pulmonary Tuberculosis is commonly bilateral, affecting either both apices or one apex and the opposite midzone.

3.3.2.2 Consolidation

There are three types of consolidation the first type of consolidation is seen as mostly mottling with the individual shadow being from 1-5mm in diameter. The consolidation has hazy and indistinct shadow outline. Shadow tend to remain discrete and not coalesce even when disease are spreading.

The second type of consolidation is a less common type. It may present as isolated larger opacities, roughly circular in shape and ranges from about 0.5 to 2 cm in diameter. The consolidation has indistinct and ill-defined outlines and maybe more than one but never as numerous as the smaller areas of infiltration.

The third type of consolidation is the occasional lesions of chronic pulmonary tuberculosis. The lesion appears as large areas of homogeneous consolidation with area may be of any extent from a small sub segmental lesion, up to involvement of a whole lobe. Consolidation may resemble pneumonia and only due to aetiology. Increase in marking running between the diseased area and the hilum. Evidence of fibrosis may

also be seen with each type and it is common for more than one type of consolidation to be present at the same time.

3.3.2.3 Lung Damage and Fibrosis

Lung damage and fibrosis causes destruction of lung and heals by fibrosis. In most cases the shadow of infiltration are combined with evidence of fibrosis. There is sometimes presence of emphysema and sometimes causes partial and complete lung collapse. Some collapses are temporary due to sputum collection blocking the bronchi. Healing formation is often accompanied by bronchostenosis and will depend upon the size of the bronchus occluded and condition of the lung beyond occlusion.

3.3.2.4 Cavitation

Cavitation indicates active disease and frequently the source of Tuberculous Bacili. There are two types of cavity. The first type appears when an area of homogeneous consolidation breaks down (translucent appearance within consolidation area). The Inner margin of the cavity may be rough and irregular sometimes showing projections into the lumen wall. When consolidation clears the cavity wall will become apparent.

The second type of cavitation is the presence of a wall of chronic tuberculosis usually has even thickness of about 1-3mm thicker than of a bulla, but not as thick as the wall of a breaking down neoplasm. Cavitation is usually present with patchy consolidation and fibrosis. Isolated cavity should not be considered as tuberculous unless strongly supported by evidence.

3.3.2.5 Calcification

Tuberculosis lesion often caseates and as they heal they calcify. Calcium is often laid down in the centre of the healing lesion. Calcification located elsewhere aside from the healing lesion. Calcified foci are irregular in size and shape and are often grouped and clustered.

3.3.2.6 Evidence of Spread and Healing

Active phase shadows in the lungs have indistinct hazy outline and larger homogeneous areas of consolidation which may show cavitations. Evidence of healing in one part of the lung while spread is occurs elsewhere.

3.3.3 Milliary Tuberculosis

The appearance of Milliary Tuberculosis can be a widespread of mottling evenly distributed in all zone with individual shadow of 1-2mm in diameter and commonly uniform in size and with indistinct margin. Initially discrete and may coalesce into areas of patchy consolidation towards terminal stages of the illness.

No evidence of any increase streakiness nor any change in neither the lung markings nor the mediastinal glands enlarge. Lungs do not become fibrotic. Dissemination arises from an intrathoracic source the miliary mottling may be superimposed on those of the original illness and in these cases there is evidence of active pulmonary tuberculosis or mediastinal glandular enlargement due to primary infection.

The difficulty here is to distinguish between military tuberculosis with pneumoconiosis, sarcoidosis and variety of extrinsic allergic alveolitis which show mottling. Mottling distribution for pulmonary tuberculosis is evenly spread throughout the lungs. Pneumoconiosis and sarcoidosis has lesions that tends to be more closely packed in the midzones while for pneumoconiosis there may be evidence of emphysema and sarcoidosis the hilar glands are often enlarged.

3.4 Pulmonary Tuberculosis Decision Tree

The main primary decision tree for Pulmonary Tuberculosis classification is as shown in Figure 3.1. The figure shows that Pulmonary Tuberculosis is classified into three types.

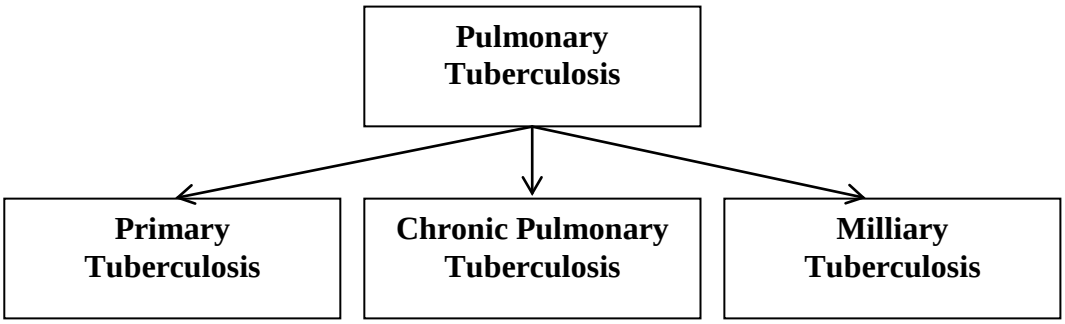

Figure 3.1 Pulmonary Tuberculosis Classifications

The two main features for Primary Tuberculosis infection are the lung lesions and the glandular components as shown in the second level of the Figure 3.2. The deciding factors for primary infection are items shown in the third level of the decision tree.

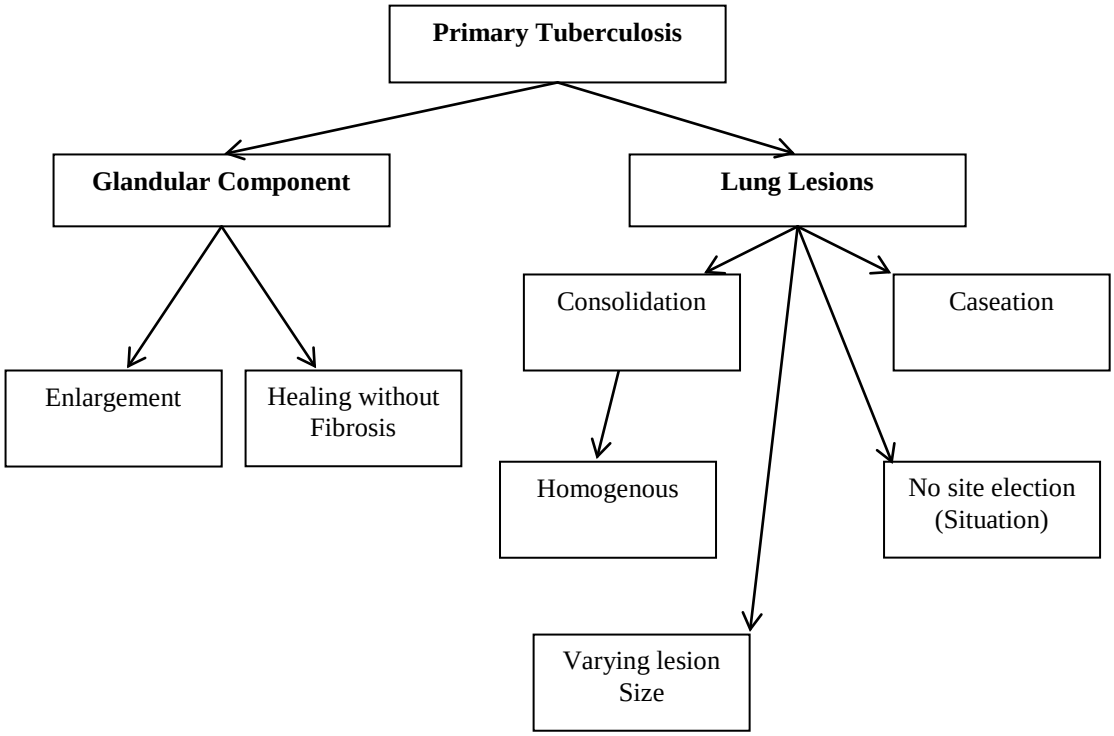

Figure 3.2 Primary Tuberculosis Decision Tree

For chronic Pulmonary Tuberculosis infection is determined by aspects given in the second level of the decision tree in figure 3.3. The components are then further divided into a more precise group within the third level of the decision tree.

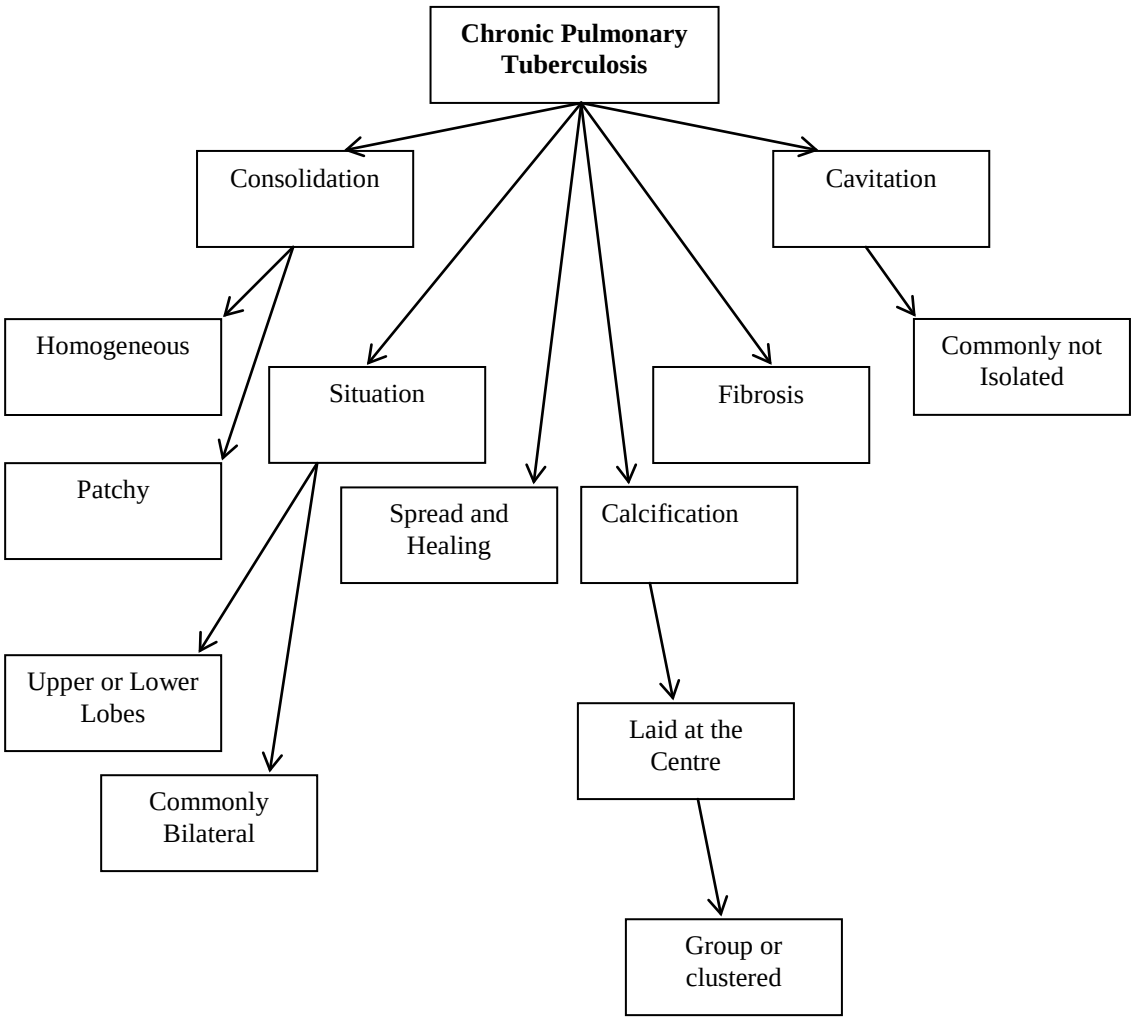

Figure 3.3 Chronic Pulmonary Tuberculosis Decision Tree

For Milliary Tuberculosis infection is determined by aspects given in the second level of the decision tree in figure 3.4. Milliary Tuberculosis is very characteristic however there is difficulty in determining between military tuberculosis with pneumoconiosis, sarcoidosis and variety of extrinsic allergic alveolitis which also shows mottling. The main distinction would be in the mottling distribution.

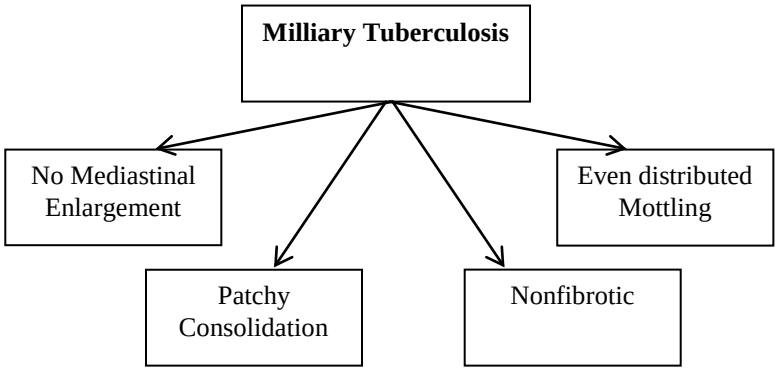

Figure 3.4 Milliary Tuberculosis Decision Tree

3.5 Pulmonary Tuberculosis Compounding Factors

Table 3.1 gives the overview of both similarity and the dissimilarity of the three types of Pulmonary Tuberculosis. This is part of the data structuring and sorting out process used to develop the flowchart given in Appendix C.

Table 3.1 Tuberculosis Compounding Factors

Types / Factors	Primary Tuberculosis	Chronic Pulmonary Tuberculosis	Milliary Tuberculosis
Consolidation			
Patchy	No	Yes	Yes
Homogeneous	Yes	Yes	No
Disease Situation			
No site of election	Yes	No	Yes
Even distribution	No	No	Yes
Bilateral foci	Yes	Yes	No
Spread and Healing	No	Yes	No
Calcification	No	Yes	No
Caseation	Yes	No	No
Cavitation	Yes	Yes	No
Fibrosis	No	Yes	No
Mediastinal Enlargement	Yes	No	No
Mottling	No	Yes	Yes
Emphysema	Yes	Yes	No

3.6 Conclusion

This chapter elaborates on Pulmonary Tuberculosis definition, types and signs of infection. The chapter also gives differential diagnosis of pulmonary tuberculosis and the disease decision tree. A compounding factor table was also included in the chapter. The following chapter will elaborate on the methodology used in the Expert System for Pulmonary Tuberculosis with Image Enhancement software development. The chapter will expound on the certainty values and classification of the disease. Included into Chapter 4 is the explanation of the imaging tools used in the system.

Chapter 4

METHODOLOGY

4.1 Introduction

The expert system design is made able to diagnose and forecast the certainty of infection by using information from the disease database. The system is made to function within the domain of infection identification of the Tuberculosis disease. Diagnosis is done by analyzing the chest x-ray images with the present structuralized rule set. The chest x-ray images are allowed to be manipulated and enhance by contrast improvement techniques built into the system. The effectiveness of the system therefore depends not only on the database information itself but the ability of the system client to use both available features. Therefore imaging tools chosen to be integrated should not only be effective imaging tools but also emphasis on simplicity of application

4.2 Borland C++ Software

C++ Builder is an object oriented programming software that facilitates Rapid Application Development (RAD). Furthermore with the application of C++ Builder window programs development is simplified and development is at a higher speed. Applications control tools can be simply drag and drop into the form (User interface window). With Borland C++ Builder 6.0 the two main pallets available to aid the interface design are the object tree viewer and object inspector. The object inspector allows you to choose object specification such as height or width of the object on the properties tab. The second tab available on the object inspector is the event tab. The event tab enables functions use such as “on click” or “on scroll” for window interfacing. The object tree view is a pallet showing content of a particular frame and the tree linked view from the child window to the software mainframe. The builder main window is as shown in figure 4.1.

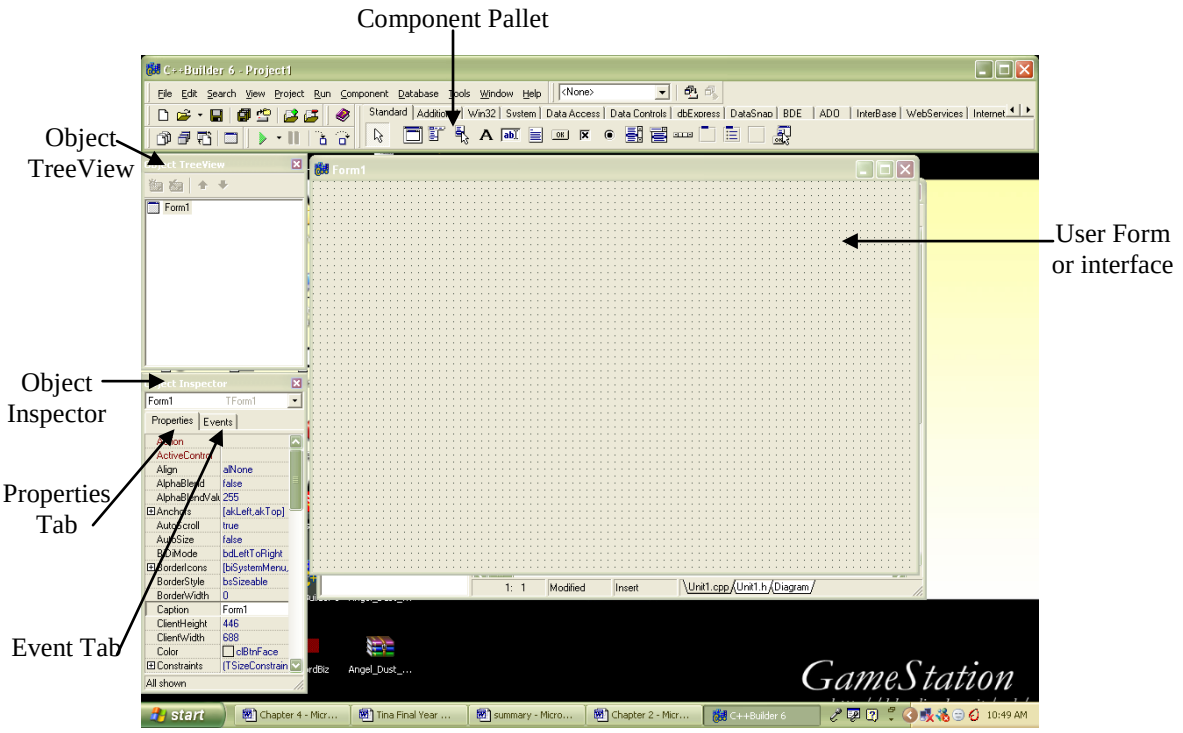

Figure 4.1 C++ Builder Version 6.0 Main Window

4.3 Question Set Details

For every question ask by the expert system there are four classification of the answer given. The question set and structure given by the expert system are shown and listed in the flowchart in Appendix C. Pulmonary Tuberculosis is classified into four factors. For all the four factors certainty values are given based on the relevance of a particular symptom or radiographic findings. Both classification and certainty setting are explained in greater detail in segment 4.3.1 and 4.3.2.

4.3.1 Tuberculosis Classification

There are actually six classification of Tuberculosis infection. In the expert system built the classification is reduce to four. The reasoning behind the reduction is further explained in the following sub segments. The four classification of Pulmonary Tuberculosis are definitely not Tuberculosis, probably not Tuberculosis, suspicious infection and active Tuberculosis.

4.3.1.1 Definitely not tuberculosis

Patient shows no signs or symptoms of Tuberculosis and has not come into contact with persons suffering from Tuberculosis.

i. No exposure, no infection.

4.3.1.2 Probably not Tuberculosis (Latent or Inactive)

When we say that someone is infected with a particular disease it means that the disease is manifested through symptoms. Someone with latent infection is someone who has dormant infection but is not suffering from Pulmonary Tuberculosis. As for those who had previous infection and was adequately treated Tuberculosis infection lays inactive. The grouping is done because the certainty of infection for the two groups is the same because both members have certain immunization towards the disease.

i. Latent infection, no disease.
ii. Inactive, healed or adequately treated.

4.3.1.3 Suspicious Infection

The member of these two classes is group together because both are at high risk of tuberculosis infection. Where the first group was exposed to the disease and with infection status unknown and the second class shows infection sign (symptoms manifestation) it is not known whether he or she has been exposed to Tuberculosis.

i. Exposed and infection unknown.
ii. Possible infection status unknown.

4.3.1.4 Active tuberculosis

Person who is rated at a high certainty level of Tuberculosis infection, this is due to the fact that the disease has manifested by symptoms and the patient was confirmed to have been exposed to Tuberculosis.

i. Person exposed and confirmed infection