ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

SCHOOL OF INFORMATION SCIENCE

# PROTOTYPE KNOWLEDGE BASED SYSTEM FOR ANXIETY MENTAL DISORDER DIAGNOSIS

SEBLEWONGEL ESSEYNEW

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A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfilment of the Requirements for the Degree of Master of Science in Information Science

By

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# DEDICATION

I would like to dedicate my thesis to my Dad and Mam, who passed away without seeing my achievement, and to my dear brother, Gizachew Esseynew whom God used as an instrument to guide me the way to education. Thank you Eyaya! God bless your life in the best of His ways.

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| | |
|---|---|
| **AMDDKBS** | Anxiety Mental Disorder Diagnosis Knowledge Based System |
| **APA** | American Psychiatric Association |
| **DSM _ IV** | Diagnostic and Statistical Manual of Mental Disorder fourth edition |
| **WFMH** | World Federation for Mental Health |
| **WHO** | World Health Organization |

# ABSTRACT

Mental health is the basic building block for the entire healthy life of a person. There is a motto which explains the significance of mental health as “Without mental health no health!” Mental health problems touch every aspects of human life such as humans’ general health condition, work, family life, social relations, etc.

However, mental health issue is one of the neglected issues throughout the world. Particularly, in developing countries, mental health has the least attention it deserves. Ethiopia is one of the developing countries. In Ethiopia, mental health issue is not getting sufficient attentions. The major challenge for mental health service in the country is shortage of skilled mental health professionals. In Ethiopia, the number of mental disorder patients and mental health professionals are disproportionate too. Due to this the distribution of mental health professionals is greatly unfair. Lacks of knowledge among primary health care workers, the allocation of insufficient budgets for mental health issue, and the absence of adequate awareness about mental illnesses are the other challenges that are creating obstacles to address mental health services satisfactorily.

In an attempt to address such problems, the objective of this research work is to look into the possibility of applying knowledge based systems technology to diagnose patients with anxiety mental disorders by developing prototype knowledge based system that can mimic /simulate the services of psychiatrists and psychologists.

To achieve this objective, knowledge is acquired using both structured and unstructured extensive interviews with three experts, which are selected purposively from Amanuel Mental Specialized Hospital and Rank Higher Clinic. Additionally, knowledge is acquired from secondary sources by using document analysis method of knowledge elicitation.

The knowledge acquired is modelled using decision tree structure that represents concepts, parameters and procedures involved in anxiety disorders diagnoses. Based on the model, the prototype is developed with SWI Prolog by using ‘if – then’ rules. The prototype developed uses backward chaining to infer the rules and extract conclusions and recommendations.

Domain experts evaluate the prototype and satisfactory result is found; about 86% of system evaluators accept the prototype. Additionally, the performance of the system is evaluated by using predictive validation technique with twenty test cases. The result of the validation revealed the accuracy of the prototype to be 85%.

The prototype knowledge based system needs further studies to expand its scope and to enhance the performance of it by integrating with other knowledge representation techniques.

# CHAPTER ONE

# INTRODUCTION

## 1.1. Background

There are many kinds of diseases in the world that affect human beings in different aspects. Mental disorder is one of those diseases that affect mental health. It is one of the most common non-communicable diseases in the world, and it is one of the great invisible burdens on developing societies (Paris et al., 2006). Currently, mental disorder becomes a major public health problem, and it makes a substantial independent contribution to the burden of disease worldwide (Teferra et al., 2004, P.110; WFMH, 2010). However, the provision of mental health care is one of the most under resourced and neglected health services (WHO-AIMS, 2009).

Mental disorder refers to problems of the brain and mind that cause severe and unusual changes or problems in feelings, behaviours and senses, thoughts, understanding of events and ability to communicate to other people (Korhonen, 2006, P.3). Additionally, they expose for other diseases like HIV, TB, diabetes, cardiovascular diseases, cancer and respiratory diseases (WFMH, 2010). Due to this, people with these disorders are often subjected to social isolation, poor quality of life and increased mortality. Mental disorders touch the lives of everybody. The social relationships, education, work, productivity, etc can be disturbed by these diseases.

Mental health professionals classify mental disorders in to some categories based on their resemblance in their symptoms and syndromes. According to APA (2000) classification, there are sixteen mental disorder groups/categories. Some of them are anxiety disorders, mood disorders, psychotic disorders, personality disorders, substance-induced disorders, adjustment disorders and somatoform disorders.

Among these, anxiety disorders are the major neurological disorders that prevalently occurred generally throughout the world, particularly, in developing countries like

Ethiopia (Ashenafi et al., 2001; Derek, 2008). As Ashenafi et al. (2001), Atalay et al. (2006), Derek (2008) and Menelik (2008) stated these disorders are occurring in all ages of people in Ethiopia. Hence, this research focuses on anxiety disorders.

### 1.1.1. Anxiety Disorders

Anxiety disorders are mental and physical manifestations of anxiety. Anxiety is a natural response and a necessary warning adaptation in humans, and they are the most common emotional disorders. Persistent, unrelenting stress often leads to anxiety and unhealthy behaviours (APA, 2000).

Anxiety disorders fill people's lives with overwhelming anxiety and fear. Anxiety can become a pathologic disorder when it is excessive and uncontrollable, requires no specific external stimulus, and manifests with a wide range of physical and affective symptoms as well as changes in behaviour and cognition (Rowney & Hermida, 2010). Anxiety disorders belong to the most prevalent psychiatric disorders. Considerable burden is associated with these disorders, not only for the individual sufferer but also for the health care systems (Bandelow et al., 2008).

However, most of the anxiety disorders are treatable (Griez et al, 2001; Korhonen, 2006; Bandelow et al., 2008). Recognising the early signs and symptoms of these disorders and accessing effective treatment early is important (Bandelow et al., 2008). The earlier treatment starts, the better the outcome. Effective treatments for anxiety disorders include psychological therapies (like cognitive and behavioural therapies), psychosocial support, avoidance of risk factors such as harmful alcohol and other drug use and learning self-management skills (Griez et al, 2001; Mayo Clinic Staff, 2010).

However, many patients who might benefit from treatment are not diagnosed or treated. This may partly be due to lack of awareness of the anxiety disorders by primary care practitioners. Also, the stigma still associated with psychiatric disorders and lack of confidence in psychiatric treatments are likely factors leading to non-recognition and subsequently to a lack of treatment or the use of unnecessary methods (Griez et al, 2001; Bandelow et al, 2008, P.249).

The causes of anxiety disorders are not fully known, but physiologic and psychological factors are the major causes, which include combinations of brain chemical imbalances and exposure to a life-threatening disaster. Mostly, anxiety disorders are caused by an interaction of a specific neurobiological vulnerability and such environmental factors (Griez et al, 2001; Bandelow et al., 2008, P. 254).

The most widely occurring anxiety disorders include panic disorder, agoraphobia, social phobia, specific phobias, obsessive-compulsive disorder, posttraumatic stress disorder and generalized anxiety disorders.

### 1.1.2. Mental Disorder in Ethiopia

Mental health is a global health problem and mental health challenge is acute through out the world (WHO, 2009; Bauer et al., 2010). However, it has not received the attention it deserves, particularly in developing countries (WHO, 2005, P. 3; WHO, 2009; Bauer et al., 2010; WFMH, 2010).

Ethiopia is one of the poorest and low-income countries in the world (WHO, 2005). She faced mental health problems. Financial resources for mental health care in Ethiopia are extraordinarily inadequate (WHO, 2006). Moreover, Ethiopia does not have sufficient mental health professionals. In the country, mental health often receives low priority and gets limited resources. As a result, mental health services in Ethiopia lag behind other health services (WFMH, 2010). In Ethiopia, the Amanuel Mental Specialized Hospital is the only specialized hospital for inpatient and out patient services for mental illness related problems. Almost all mental health professionals are residing in this hospital (WHO, 2006).

The other critical issue in the development of mental health care in Ethiopia is absence of mental health awareness and basic management skills among primary health care workers (Menelik, 2008). Primary health care workers do not have good and enough knowledge about mental disorders. As WHO (2006) reported, there have been a lot of instances where mentally ill people come to mental health services after spending lengthy and painful periods because of being misdiagnosed and mismanaged by primary health care workers. These workers have little training on mental health issues. Moreover, most of the primary health care workers in Ethiopia graduate without having any exposure to the practical management of even common mental disorders. As a result, the majority of primary health care professionals have not good mental health awareness (WHO, 2006).

Studies indicate that in Ethiopia, particularly in rural Ethiopia, many people in all ages and sexes are affected by anxiety disorders (Ashenafi et al., 2001; Menelik, 2008). In rural Ethiopia, fewer than 10% of the individuals with anxiety disorders had got little mental health services. This gap indicates that existing mental health service deliveries are failing to deliver services to a majority of those in need (Bauer et al., 2010).

### 1.1.3. Knowledge Based Systems

As discussed above, mental health care in Ethiopia lags. Particularly, mental health services in the countrywide are not well addressed. However, there is an increasing appreciation of the role that computers are playing to improve the overall health delivery systems. Particularly, knowledge based technology plays a great role in medicine (Kalogeropoulos et al., 2002).

Knowledge based systems are one branch of Artificial Intelligence that help to represent expert knowledge in artificial way (Pomykalski et al., 1999). They are computer programs that replicate the problem solving abilities of human beings and develop to overcome difficulties in solving complex problems (Martinsons, 1995).

Currently, knowledge based systems are receiving much attention in many fields of areas. Medicine is one of the areas in which knowledge based systems received much attention mainly because of the potential benefits that can be gained from using these technologies (Kalogeropoulos et al., 2002). They are essential tools in the area of medical domains particularly to overcome the shortage of human experts in particular domain area. There is a clear role for clinical knowledge based applications in medical domain like diagnostic assistance systems, drug advisory systems, protocol design, laboratory systems, clinical workstations, image recognition and interpretation for clinicians (Coiera et al., 1993).

## 1.2. Statement of the Problem

As stated above, delivery of healthcare services is a major challenge for governments in most developing countries. Some of these challenges are lack of highly qualified medical human resources, financial as well as the ability to manage and transform scarce resources to meet healthcare needs (WHO-AIMS, 2009). Studies indicate that mental disorder is a serious health problem in developing countries (Ashenafi et al., 2001; Derek, 2008). Ethiopia is one of the developing countries, which are exposed to mental disorder problems (WHO, 2005, Pp.1, 3; Abebaw et al., 2007, P.1). Mental health is the basic and serious health problem in the country (Kebede & Alem, 1999, Pp.11-16; Teferra et al., 2004; Amare et al., 2008, Pp. 228-229, P.110; Yeup et al, 2008, Pp. 1-3).

Shortage of psychiatrists, their unfair distribution and lacks of knowledge among primary health care workers are the major challenges that become obstacle to address mental health services satisfactorily through out the country (WHO, 2006, Pp. 15-17; WHO-AIMS, 2009;

The Amanuel Mental Specialized Hospital is the only mental specialized hospital that gives inpatient and outpatients services. Almost all mental health professionals are working in this hospital.

Some other hospitals like St. Paulos Hospital and Zeweditu Hospital are giving some outpatient services but in most of such kinds of hospitals, experts work as part time workers. The same is true for other private clinics such as Rank Higher Clinic.

Moreover, in the majority of primary health care institutions there are no higher qualified mental health professionals. Primary health care workers do not have good and enough knowledge for mental disorders. Due to this, in most of primary health care sectors mental disorder patients may not get the appropriate treatment. This is because the lacks of knowledge among primary health care workers and general practitioners. Not all clinicians are competent diagnosticians of mental disorders

(WHO, 2006; WHO-AIMS, 2009). So, mental disorder patients are exposed to misdiagnose by primary health care workers and non-mental health professionals.

The other problems are little allocation of budgets and poor awareness about mental disorder related problems. Financial resources, which are allocated for mental health care, are very few. Mental health spending in the country is less than 1% of the total health budget (WHO-AIMS, 2009). Additionally, as Ministry of Health (WHO, 2006) and Yeshashwork (2010, Pp.2-3) indicate there is no awareness about mental disorders among first aid heath workers, among the society and among the patients.

To lessen the above mentioned problems, this research attempts to give light as alternative means of diagnosing to the conventional way of diagnosing disorders. In this regard, the application of knowledge based system technology, particularly in the area where highly qualified shortage of experts there, is the best solution to solve those problems. This research explores the applicability of using knowledge based system technology in the domain of mental disorders diagnosis by developing prototype rule based systems that can diagnose patients with anxiety disorders.

General, shortage of mental health professionals and their unfair distribution throughout the country motivate the researcher to focus on representing and modelling domain knowledge of experts in the field so that the research output would serve as a highlight to provide expertise diagnosing and advisory service in the area where highly qualified specialized experts are unavailable. To the best of the researcher knowledge, no research has been devoted to using knowledge-based systems for mental illness diagnosis in general and Anxiety Mental Disorders in particular in Ethiopia.

## 1.3. Objectives of the Study

The research has the following general and specific objectives.

### 1.3.1. General Objective

The principal objective of this study is to design and develop a prototype knowledge based system for diagnosing patients with anxiety mental disorders with the over all aims of exploring the applicability of knowledge based system technology to the specific area of mental disorder diagnosis.

### 1.3.2. Specific Objectives

The following are the research specific objectives that help to achieve the general objective of the study.

- ✓ To review literature in order to have an understanding on concepts, principles and technologies of knowledge based system
- ✓ To acquire the necessary tacit and explicit knowledge from primary and secondary sources using interview, detailed discussion with domain experts and document analysis
- ✓ To analyze and model the domain knowledge used in the real life
- ✓ To develop a prototype knowledge based system that demonstrates the capacity of a knowledge based system for diagnosing patients with Anxiety Disorders
- ✓ To test and evaluate the performance and user acceptances of the new system
- ✓ To forward recommendations and suggestions for further work in the application of knowledge based systems in mental disorder diagnosis

## 1.4. Scope and Limitation of the Study

The study is intended to develop rule based prototype system that diagnose patients with anxiety disorders and giving advisory services primarily for domain experts and then for any interested party capable of reading English language. There are about sixteen mental disorder categories such as anxiety disorders, psychotic disorders, mood disorders, personality disorders, sleep disorders and substance abuse disorders. The research concerns only on anxiety disorders. This disorder has eight sub sections in it, specifically panic disorder, generalized anxiety disorder, agoraphobia, social phobia, specific phobia, obsessive-compulsive disorder, posttraumatic stress disorder and acute stress disorder.

The prototype gives advisory services only using psychotherapies, self-help treatment strategies and first line medications only. Even though most anxiety disorders are treated by using psychotherapy techniques, some like stressor disorders use a combination of both psychotherapy and medication. However, the prototype does not give detail treatment advising services by using medications. To treat anxiety patients with medication it requires selection of the appropriate medicine, dosage, duration, frequency of the medication, etc. It needs detail study on those medications. Due to the short time available for the research, the study does not address all the pharmacotherapy treatment planning.

Observation methods of knowledge elicitation are not done practically as much. Observation is essential to extract tacit knowledge of domain experts, which are not addressed by interviewing the domain experts. However, due to ethical considerations (to keep the privacy of patients) observation methods are not applied as data collection methodology for the study.

Additionally, the domain experts are so busy. It is difficult to get the golden time of the experts. Even though relevant knowledge is acquired from them, the knowledge acquisition activity of the study takes longer time than the allotted one (more than one month).

## 1.5. Significance of the Study

The immediate beneficiaries of the study are primary health care workers and mental health professionals. Particularly, the prototype will have great significance to teach primary health care workers, general reactionaries and nurses in order to have well understanding about anxiety disorders. As a result, those health workers can use the system in diagnosing anxiety disorders on primary health care sectors where highly qualified mental professionals are unavailable. The developed prototype knowledge based system is used to give advising services for diagnosing patients with anxiety disorders. The prototype knowledge based system is developed using the knowledge of multiple domain experts and documentary sources to be preserved for in case experts soon retire or unavailable. Therefore, it gives better advisory services where highly qualified mental health professionals are occupied or where they are not found.

Additionally, the prototype can be used for mental health professionals as a guide. Even though those mental health professionals are highly qualified persons, they may get difficulty of remembering all the critical symptoms and signs of each disorder. Identifying the right disorder is the difficult task in mental disorders diagnoses. Since the prototype is already codified by using appropriate domain knowledge, it solves the problem of forgetting the important issues and concepts of the domain knowledge by remembering the facts and rules already feed.

## 1.6.Methodology of the Study

In order to achieve the objectives of the research, the following methods and techniques are employed.

### 1.6.1. Methods of Data Collection

In this study to acquire the needed knowledge, both secondary and primary (documented and undocumented) sources of knowledge are used. Primary knowledge is gathered from mental health professionals, psychiatrists and Psychologists, in Amanuel Mental Specialized Hospital and Rank Higher Clinic by using interviewing and critiquing knowledge elicitation methods. In the same way, secondary sources of knowledge are collected by using document analysis.

Interview (both structured and unstructured) is used to collect tacit knowledge from the domain experts. In addition, critiquing (analyzing) elicitation methods are used to purify the collected knowledge. The acquired knowledge is refined with the consultation of the experts. Moreover, secondary sources of knowledge are gathered from the Internet, mental disorder diagnosis guidelines (especially, DSM – IV), research papers and articles by using document analysis technique.

### 1.6.2. Sampling Techniques and Sample Size

Purposive sampling technique is used to select domain experts for knowledge acquisition. The selection criteria of domain experts for the study are based on the professions/expertises, educational qualification level, year of experience and their immediate position in the mental disorder diagnosis.

Purposive sampling is one of the most common sampling techniques in qualitative research in which participants group are decided to pre-selected criteria relevant to a particular research question (Mack et al, 2005, P.6). Purposive sampling helps the researcher to use different characteristics to select the subject of the study.

At the beginning, to get some overview about anxiety mental disorders unstructured interviews are conducted with eight experts who include psychiatrist doctors, trainee psychiatrists, psychiatrist nurses and psychologists. Among these, three experts were selected purposively for detail discussions using structured and unstructured interview to discover relevant tacit knowledge and for further consultations through out the study. These experts were selected based on their years of experience, their roles, their case group they work, their educational qualification and specialization. Additionally, all they are psychiatrist doctors with twenty five, twenty four and five years of experience.

The knowledge acquisition from these experts is carried out during their free time, after work hours and on weekends.

### 1.6.3. Knowledge Representation Methods

After the knowledge is acquired, it is represented by using rule based knowledge representation method. For this research the knowledge representation method, rule – based, is chosen because it clearly demonstrates the domain knowledge. In a rule based system, much of the knowledge is represented as rules, that is, as conditional sentences relating statements of facts with one another. Most mental disorder diagnosis procedures have predefined sets of rules. There are already defined sets of symptoms, syndromes and basic issues that should be address to confirm the presence of a disorder. As a result, rule based representation method is more appropriate to represent and demonstrate the real domain knowledge in diagnosing mental disorders. Additionally, rule based systems are the most commonly used knowledge representation language in medicine (Choi & Usery, 2004, P.217; Sasikumar et al., 2007).

### 1.6.4. Implementation Tool

Prolog programming language is used to develop the prototype knowledge based system. Prolog (programming in logic) is one of the most widely used programming language, especially in the artificial intelligence research, natural language processing, system development, and so on. It is very useful especially on those mentioned areas to specify the situation (rules and facts) and the goal (query).

The reason of the selection of this programming language is the features and abilities of the language that incorporate it. Prolog is a declarative language (we specify what problem we want to solve rather than how to solve it) and has the capacity to describe the real world. In addition,

- ✓ it is easy to learn the design tools;
- ✓ it has rule based programming and built in pattern matching features;
- ✓ it has comprehensive help system on each feature and
- ✓ it is readable code that will also make updating of the system a relatively manageable task.

SWI Prolog is the most inclusive and widely used Prolog development environment. It has flexible and fast interface. In addition, it is portable to many platforms, including almost all UNIX/Linux platforms and Windows Vista. Additionally, it is non-commercial version of Prolog. So, it can be easily accessed. Therefore, the prototype knowledge based system is developed in SWI Prolog.

### 1.6.5. Testing and Evaluation

The developed prototype rule based system is tested and evaluated to ensure the performance of the system in meeting towards established objectives. The evaluation process is more concerned with system user acceptance and validations of the prototype. User acceptance efforts are concerned with issues impacting how well the system addresses the needs of the user whereas validation efforts determine if the system performs the intended task satisfactorily.

To assess human factors visual interaction together with questionnaires methods are used. Domain expert evaluators interact with the system by using appropriate cases.

Then they evaluated the system by using both closed ended and open ended questionnaires.

Similarly, the validity of the prototype knowledge based system is tested using twenty test cases which have similar parameter with the rules of the prototype by using predictive validation technique. During this testing procedure, twenty cases are selected purposively and used to test the performance of the prototype. The correct and incorrect results are identified by comparing decisions made by domain experts on those cases and with the system conclusions. Decisions without significance differences between the experts and the prototype knowledge based system are accepted as good performance for the prototype knowledge based system.

## 1.7. Organization of the Thesis

The study is organized in to six chapters. Chapter one is the introduction part, which contains the background, problem statements, objectives, scope and limitations of the study, significance of the study and methodology to carry out the research.

Review of literature on the knowledge based systems, about its background, architecture, development phases, and knowledge based system application areas in medical domain are presented in chapter two.

Chapter three discusses the knowledge acquisition procedures; Chapter four deals about the development of the prototype under study. Chapter five presents the results found in the evaluation and testing process of the prototype knowledge based system. Finally, chapter six highlights the conclusion and recommendations for further research work in the domain area.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

Conceptualizing the basic ideas of knowledge based systems is essential to understand sufficiently the notion of knowledge based systems. So, this chapter attempts to give some overview of Artificial Intelligence and knowledge based systems, state the merits of knowledge based systems, explore the applicability of knowledge based systems (particularly in medical domains), assess the architecture of knowledge based systems and discuses knowledge based systems development phases.

### 2.1.1 An overview of Artificial Intelligence and Knowledge Based Systems

The term Artificial Intelligence (AI) refers to the activity of building intelligent systems. It is a technology of making computers to simulate human beings intelligence (Raza, 2009). An intelligent system is a system that exhibits and posses some basic attributes such as performing some actions, reasoning about a particular domain, making decision and goal oriented problem-solving capability. A system or an agent can be said to be intelligent when the agent's performance cannot be distinguished from that of a human performing the same task (Honavar, 2006, P.1-2, 12).

Munakata (2008) defines Artificial Intelligence as the study of making computers do things that the human needs to do.

The primary aim of Artificial Intelligence is to design and implement intelligent agents, that may be programs or physical agents, which shows some features of human intelligence in a particular domain area (Honavar, 2006, P9; Raza, 2009).

The field of Artificial Intelligence is emerged from many different disciplines such as philosophy, mathematics, psychology, computer engineering, and linguistics (Sajja & Shah, 2010).

The prime goal of Artificial Intelligence research is to increase human beings understanding in all aspects like in human being's perceptual, reasoning, learning, and creative processes (Honavar, 2006, P. 9). The first major and successful Artificial Intelligence research application technologies are expert systems1 or knowledge based systems (Pomykalski et al., 1999, P.5). Early efforts in building Artificial Intelligence programs were intended to create general-purpose problem solvers. However, those attempts were failed. It was difficult to create successful general-purpose problem solvers expert systems. This led to the development of expert systems that use domain specific knowledge to solve problems (Sasikumar et al., 2007, P.17).

The first work in the area of Artificial Intelligence, which was proposed by McCulloch and Pitts in 1943, was a model of artificial neurons that imitate the structure of the human brain. Next, DENDRAL program was developed to infer the molecular structure from the information provided by a mass spectrometer (Pomykalski et al., 1999). DENDRAL was an expert system, which used a model of a particular molecule as the basis for its reasoning. DENDRAL played a significant role in the development of knowledge based systems. This is because it was the first system to use the expertise of human problem solvers and translate that knowledge into a large numbers of special purpose rules, known as a rule based system (Masizana-Katongo et al., 2009).

The next well known expert system was MYCIN that was developed by Buchanan Bruce and Edward Shortliffe for the purpose of diagnoses blood infections. MYCIN is the well known and widely used expert system in medical diagnosis (Sasikumar et al., 2007; Masizana-Katongo et al., 2009). MYCIN used about 450 rules. By using these rules, MYCIN was able to perform as well as some experts, and considerably better than some junior doctors were. MYCIN had considerable contributions to the history

[1] The terms expert system and knowledge based system are used interchangeably in this thesis work

of expert systems. One of the contributions of MYCIN was the way of its knowledge acquisition process. Knowledge for the development of MYCIN was gathered from a mix developed from various doctors in the particular domain. As a result, MYCIN contains a number of heuristic rules that are used by physicians in the identification of certain infections (Masizana-Katongo et al., 2009).

In addition, there were other early expert systems like PUFF and DELTA/CATS which were played major roles in expert system applications development (Pomykalski et al., 1999).

### 2.1.2 Definition of Knowledge Based Systems

In the literature, many researchers have given their definitions of knowledge based systems. Some typical definitions are given below.

According to Krishnamoorthy & Rajeev (2010) definition, knowledge based systems are computer programs that are designed to solve a problem in a particular domain like experts do. Knowledge based systems use the knowledge of human experts that is written in it and a specified control strategy to arrive at solutions.

In the same way, Abdullah and others (2006) define knowledge based systems as computer software that uses knowledge of a particular domain to perform a somewhat difficult task usually undertaken by a human expert.

Similarly, Sasikumar et al. (2007) define knowledge based systems as computer programs that use knowledge and inference procedures to solve difficult problems. Knowledge based systems are systems that imitates the thinking process of a human expert to solve complex decision problems in a specific domain.

Moreover, according to Pomykalski et al. (1999, P. 3) definition “Knowledge-based system is a computer program that is designed to mimic the decision-making ability of a decision-maker(s) (i.e., expert(s) in a particular narrow domain of expertise.”

The above definitions talk all about the same thing with different sayings. Hence, to recapitulate the above definitions, a knowledge based system is an intelligent program that uses knowledge of human experts and its own inference procedures to solve problems that are difficult enough to require significant expertise in a particular domain. So, for this research, knowledge based system is considered as a technology that is aimed at developing software agents that perform almost similar tasks of experts in specific domain area of human experts.

## 2.2 Advantages of Knowledge Based Systems

Using knowledge based system applications provide many advantages (Martinsons, 1995). Knowledge based systems are important sets of applications of Artificial Intelligence for both commercial related problems and scientific importance (Abdullah et al., 2006). Apart from research purposes, there are some main motivations for building expert systems. As Martinsons (1995), Abraham (2005) and Abdullah et al. (2006) sated the main inspiration of developing expert systems include:

- ✓ **Replication of Expertise:** Knowledge based systems are vital to provide many (electronic) copies of an expert's knowledge and it can be consulted even when the expert is not personally available. Expertises may not be available within the needed place and time due to many critical problems such as geographic distance and retirement.
- ✓ **Union of Expertise:** Moreover, knowledge based systems integrate knowledge of different expertises in a particular domain and providing in one place the union of what several different experts know about a particular domain.
- ✓ **Documentation:** In addition, knowledge based systems provide a clear record of the best knowledge available for handling a specific problem. Hence, knowledge based systems are the best technology to preserve expertise knowledge for future use.
- ✓ **Increase Efficiency and effectiveness:** They help to distribute widely rare human knowledge and minimize human expertise needed at a number of locations at the same time, and with less amount of time. When expertise is unavailable, a knowledge based system can act as an expert on demand to save time. Knowledge based systems can save money by leveraging expert, and allowing users to function at higher level and

promoting consistency. Additionally, knowledge based systems can increase cost-effectiveness in the transfer and dissemination of existing knowledge.

- ✓ **Used as Learning Tool:** Similarly, knowledge based systems can be used to distribute experts' knowledge in a structured manner. Particularly, they provide beginner with expert advice on a specific subject and aids in training new employees. As a result, knowledge based systems bring greater innovation by allowing creative professionals to explore, understand; discard and rework many alternative paths to a needed solution.

Besides the above listed advantages, there are some better features of a knowledge based system that differentiate it from both conventional programs and human expertises. The following table (Table 2.1) summarizes the major differences among them (Sasikumar et al., 2007):

| Human Experts | Knowledge Base Systems | Conventional Programs |
|---|---|---|
| Use knowledge in the form of thumb or heuristic to solve problems in a narrow domain | Process knowledge expressed in the form of rules and use symbolic reasoning to solve problems in narrow domain | Process data and use algorithms in a series of well defined operations to solve general numerical problems |
| In human brain, knowledge exists in a compiled form | Provide a clear separation of knowledge from its processing | Do not separate knowledge from the control structure to process this knowledge |
| Use inexact reasoning and can deal with incomplete, uncertain and fuzzy information | Permit inexact reasoning and can deal with incomplete, uncertain and fuzzy data | Work only on problems where data are complete and exact |
| Can make mistakes when information is incomplete or fuzzy | Can make mistakes when information is incomplete or fuzzy | Provide no solution at all, or wrong one, when data are incomplete or fuzzy. |
| Enhance the quality of problem solving via years or learning and practical training. This process is slow, inefficient and expensive | Enhance the quality of problem solving by adding new rules or adjusting old ones in the knowledge base. When new knowledge is acquired, changes are easy to accomplish. | Enhance the quality of problem solving by changing the program code, which affects both the knowledge and its processing, making changes difficult |

Table 2.1 Comparisons of Expert Systems with Conventional Programs and Human Experts

## 2.3 Knowledge Based Systems Architecture

Architecture is a blue print that helps to represent the structure of an object or a system. System architecture is the conceptual model that defines the structure, behaviour and more views of that system. Moreover, architecture of a system helps to describe sets of conventions, rules, and standards that should be incorporated in the corresponding system. Similar to other systems, knowledge based system has its own architecture that describes the main components of it, the core functionalities that are carried out in the system and the basic tools that aid for development of that knowledge based systems.

Knowledge based system is a system that encompasses several different components that interact to each other to achieve the desired goal (Krishnamoorthy & Rajeev, 2010). The structure of a typical knowledge based system contains components like knowledge base, inference engine, explanation facility, user interface, knowledge acquisition unit, and blackboard (Sasikumar et al., 2007; Wiriyasuttiwong & Narkbuakaew, 2009). All these different components interact together in simulating the problem-solving process. Among those components of knowledge based systems, the knowledge base and the inference engine are the most significant one (Krishnamoorthy & Rajeev, 2010). These basic components are indicated by the following figure.

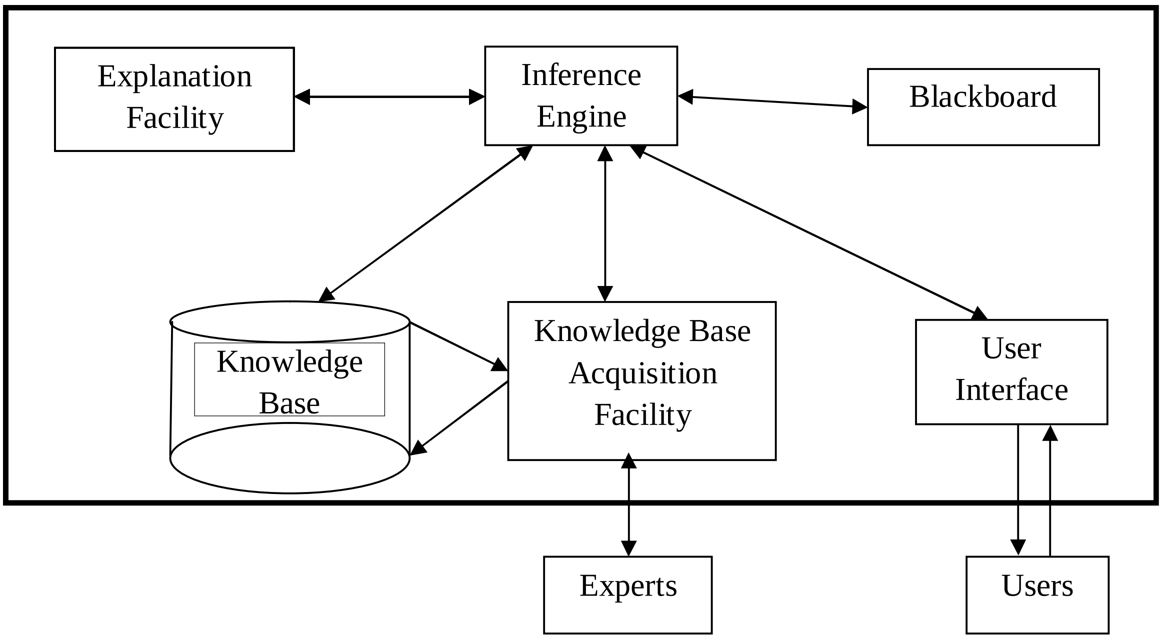



Figure 2.1 Architecture of Knowledge Based Systems

- **The Knowledge Base:** The knowledge base is the heart of knowledge based systems, which contains the problem solving knowledge of a particular application. The knowledge base stores all relevant information, data, "domain knowledge", rules of inference, cases and related factual information. It combines the knowledge of multiple human experts (Abraham, 2005) and contains the domain-specific knowledge required to solve a particular problem (Krishnamoorthy & Rajeev, 2010).

Typically, a knowledge base consists of sets of rules that the inference engine applies (fires) them and computes values of parameters dependent on the rules (Sasikumar et al., 2007).

- **The Inference Engine:** Inference mechanisms are control strategies and search techniques that search through the knowledge base to arrive at decisions. The knowledge base is the state space while the inference mechanism is a search process (Yap & Clarke, 1996). The major task of the inference engine is to schedule the rules, deciding in what order they should be fired and on handling of certainty factors (Sasikumar et al., 2007).

  The inference engine manipulates symbols by selection of rules, matching the symbols of facts and then firing the rules to establish new facts. This process is continuing like a chain until a specified goal arrived at. Therefore, the main purpose of the inference engine is to seek information and relationships from the knowledge base and to provide answers, predictions, and suggestions in the way a human expert would (Abraham, 2005).

  In a knowledge based system, inference can be done in a number of ways depending on the types of applications they are aimed at (Sasikumar et al., 2007, P.29). The two popular methods of reasoning mechanisms are forward chaining and backward chaining (Sasikumar et al., 2007; Krishnamoorthy & Rajeev, 2010).

  a. **Forward Chaining:** Forward chaining is data – driven inference process in which the system starts with the initial set of elements (facts) in the working memory. Then it keeps on firing rules until there are no rules, which can be applied, or the goal has been reached. In other words, in forward chaining inference approach, the system is moving forward from the current state to a goal state (Sasikumar et al., 2007). The inference mechanism tries to establish the facts as they appear in the knowledge base until the goal is established. Forward chaining strategy is especially appropriate in situations where data are few in quantity (Abraham, 2005).

b. **Backward Chaining:** Backward chaining (also called goal-driven approach) is an inference strategy in which the inference is starting with conclusions and working backward to the supporting facts (Abraham, 2005). Backward chaining tries to establish goals in the order in which they appear in the knowledge base. In addition, this strategy involves decomposing a problem into sub-problems and solving each one of them. That is, the goal is reduced to sub-goals and each sub-goal is reduced further, and so on, until they are solvable directly. Backward chaining is used when the number of possible initial states are large, compared to the number of goal states (Sasikumar et al., 2007).

- **Explanation Facility:** The explanation facility allows the program to explain its reasoning to the user and allows a user to understand how a knowledge based system arrived at certain conclusions or results (Abraham, 2005). The explanation facility of a knowledge based system provides a mechanism for querying the context for getting the answer of what and knowing how a fact is established (Krishnamoorthy & Rajeev, 2010).
- **Knowledge Acquisition facility:** Knowledge acquisition facility is used to build the knowledge base and to add new knowledge into the system. It provides a convenient and efficient means for capturing and storing all components of the knowledge base component (Abdullah et al., 2006). Moreover, this component helps to update and/or append the knowledge base based on the growth of knowledge in the domain. Additionally, it acts as an interface between knowledge engineer and the knowledge base (Abraham, 2005).
- **The User Interface:** The user interface is used for effective communication among both experts and users with systems. The user interacts with a knowledge based system through a user interface that may use menus, natural languages or any other technique of interactions (Krishnamoorthy & Rajeev, 2010).
- **Blackboard:** This component is used to store facts supplied by users, which are inferred by the inference engines of a knowledge based system (Wiriyasuttiwong & Narkbuakaew, 2009).

## 2.4 Phases in Knowledge Based System Development

Mostly knowledge engineering, the process of building an expert system, involves some basic steps. The main phases of a knowledge based system development processes are planning, knowledge acquisition, knowledge representation and evaluation (Raza, 2009; Sajja & Shah, 2010).

For the purpose of this research, the researcher gives more attention on the later three knowledge based system development phases because the development process of the prototype passes through these phases. For that reason, the next sections discuss about knowledge acquisition, knowledge representation and evaluation of knowledge based systems.

### 2.4.1 Knowledge Acquisition

Knowledge Acquisition is the process of acquiring knowledge from the domain expert and secondary sources, and structuring and organizing that knowledge in to suitable form for knowledge representation (Sasikumar, et al., 2007; Wiriyasuttiwong & Narkbuakaew, 2009; Shadbolt & Burton, 2011).

Knowledge acquisition is the fundamental at the same time the difficult task in knowledge based system development. Particularly, acquiring tacit knowledge is the tricky activity (Baria & Pandey, 2004; Leondes, 2000; Raza, 2009). There are many factors that make knowledge acquisition is a complex task. Some of them are (Abraham, 2005):

- ✓ experts may not know how to express and communicate their knowledge or may be unable to do so;
- ✓ experts may be unwilling to share their knowledge;
- ✓ testing and refining knowledge is complicated;
- ✓ system builders tend to collect knowledge from one source, but the relevant knowledge may be scattered across several sources;
- ✓ experts may change their behaviour when they are observed or interviewed and

- ✓ problematic interpersonal communication factors may affect the knowledge engineer and the expert.

Knowledge acquisition contains many activities and procedures. The major activities of knowledge acquisition include identifying, extracting, gathering, organizing and analyzing of experts' knowledge from what ever sources. According to Leondes (2000) these fundamental activities can be grouped in to three as knowledge elicitation, knowledge analysis, and knowledge modelling.

#### 2.4.1.1 Knowledge Elicitation

Knowledge elicitation is the process of acquiring knowledge from human experts and learning from data (Shadbolt & Burton, 2011). It is the heart of knowledge acquisition process. There are many different types of knowledge elicitation techniques. Some of the common used methods include interviews, analyzing (critiquing methods), prototyping, observation and document analysis.

- **Interview:** Interview is the most commonly used knowledge elicitation technique and takes many forms such as structured and unstructured interviews. The structured interview is a formal version in which the knowledge engineer has planned the whole session whereas unstructured interview involves informal kinds of asking domain experts to elicit their knowledge (Abdallah et al., 2005; Shadbolt & Burton, 2011). The success of an interview session is dependent on the questions asked, the ability of experts to articulate their knowledge and communication skills of a knowledge engineer to ask domain experts.
- **Prototyping:** In Prototyping, the expert is asked to evaluate a prototype of the proposed system being developed. This is usually done iteratively as the system is refined. The common prototyping methods include system refinement, system examination, system validation and rapid prototyping (Shadbolt & Burton, 2011).
- **Observation:** This method involves observation of expert(s) during performing their tasks. Similar to interviewing, observation may take different forms like on site observation, discourse analysis and active participation (Abdallah et al., 2005).

- **Document Analysis:** Document analysis involves gathering knowledge from existing documentations. Document analysis may involve the interaction with a human expert to confirm or add to the existing information or knowledge (Burge, 1998; Shadbolt & Burton, 2011).
- **Critiquing:** This knowledge elicitation method helps to find critiques from domain experts. In most cases, this method is used to validate the results of other knowledge elicitation methods and perform mostly at the end of the knowledge elicitation. The purpose of it is to validate and confirm the acquired knowledge by domain experts (Burge, 1998).

#### 2.4.1.2 Knowledge Analysis and Knowledge Modelling

Knowledge analysis is the process of making sense of knowledge acquired from domain experts and secondary sources (Leondes, 2000). The primary purpose of knowledge analysis is to analyze and organize the knowledge gained during the knowledge acquisition phase (Raza, 2009).

Similarly, knowledge modelling, also known as conceptual modelling is one of knowledge acquisition activities that help to shed light on the structure of knowledge based systems. It is the process of expressing the analyzed knowledge in an understandable and usable form such that preparing the knowledge for knowledge representation phase (Leondes, 2000). It is the representation of domain specific knowledge in the manner, in which the experts think. A knowledge model provides an implementation-independent specification of knowledge in a particular domain. This activity is useful to clarify the structure of a knowledge based systems and to preserve well documented knowledge (Speel et al., 2001). Well documented knowledge will lead the knowledge engineer to better understanding of the system or the problem domain (Sajja & Akerkar, 2010). In addition, knowledge modelling helps to write rules and reasoning strategies in which domain knowledge is used to solve a particular problem (Speel et al., 2001).

### 2.4.2 Knowledge Representation

Knowledge representation is the process of encoding human knowledge in computer understandable form. It is concerned with designing and using systems for storing knowledge (Abdullah et al., 2006). The purpose of knowledge representation is to organize the acquired and modelled knowledge into a form that a knowledge based system can readily access for decision making (Kong et al., 2008; Sajja & Akerkar, 2010; Sajja & Shah, 2010).

To develop knowledge based systems there are several knowledge representation techniques (Baria & Pandey, 2004; Krishnamoorthy & Rajeev, 2010). The same piece of knowledge can be represented using more than one formal scheme, but with varying degrees of difficulty. The selection of a scheme depends on the domain knowledge it represents and the inference mechanism it uses (Kong et al., 2008). A knowledge representation method should allow adequate representation of knowledge that is needed for a problem domain.

The most commonly used knowledge representation methods are frames, semantic networks, cases and rules (Krishnamoorthy & Rajeev, 2010).

#### 2.4.2.1 Frames

A frame is a knowledge representation approach that used to store highly structured knowledge in a well define manner (Kong et al., 2008). It is a collection of a concept, one or more slots, one or more attached procedures one or more values that describe some real world entity (Abraham, 2005). A frame-based representation is ideally suited for object-oriented programming techniques (Abdullah et al., 2006). Frames have some problems. One of the problems is difficult to instantiating new frames by matching to archetypes. In addition, it is difficult to implement some logical relationships between concepts.  Frame representation scheme is mostly used to represent knowledge in to well define highly structured knowledge.

#### 2.4.2.2 Semantic Networks

The other knowledge representation method is network – based representation. A semantic network is often used as a form of knowledge representation with graphs consisting of vertices that represent concepts, and edges to represent semantic relations between the concepts. The method stores human beings knowledge in the form of a graph, with nodes representing objects in the world, and arcs representing relationships between those objects (Huntbach, 1996; Kong et al., 2008). Because of the hierarchical nature of nodes and links (arcs) and their ability to represent class relationships such as "is-a" natures, semantic networks are beneficial to show inheritances among object classes.

Semantic networks have some limitations. One major problem of them is difficult to distinguish between nodes which representing classes of things and nodes representing individual objects. Additionally, similar to frames, it is difficult to implement some logical relationships between concepts (Huntbach, 1996).

#### 2.4.2.3 Case-Based Representation

Case-based representation is a reasoning mechanism that utilizes the specific knowledge of previously experienced and concrete problem situations (cases). In case-based representation method, a new problem is solved by finding a similar past case and reusing it in the new problem situation (Aamodt & Plaza, 1994, P.40). Even though case based reasoning has some advantages, such as learning and suggesting new problem situations based on the previous cases, it has a number of disadvantages. Some of them are (Schmidt et al., 2001; Nilsson & Sollenborn, 2004; P. 1):

- **Adaptation Problem:** Since a medical case involves very large numbers of features, adaptation of cases becomes problematic in medical domains.
- **Unreliability Problem:** In case based representation, adding new cases will affect the reliability of a system. As a result, reliability cannot be guaranteed in such types of systems.
- **Concentration on Reference:** Case based knowledge based systems are concentrated on reference as opposed to underlying diagnostic factors. Thus,

systems cannot function as sources of previous experience unless a suitable case exists in the case base.

- **The Ever-Increasing Storage Requirement:** Data storage becomes a major problem when a large number of examples need to be stored in the system to maintain case base variety while each example requires a lot of storage space.

#### 2.4.2.4 Rule Based Representation

Rule based representation is the most common form of knowledge representation technique (Antoniou et al., 1998; Choi & Usery, 2004, P.217; Sasikumar et al., 2007, P. 21). Especially, in medical knowledge based system development, rule based representation methods have been the dominant knowledge representation scheme (Wiriyasuttiwong & Narkbuakaew, 2009, P.55) since the days of MYCIN (Kong et al., 2008). Rule based expert systems have significant role in modern intelligent systems in many domains such as in medical diagnosis, electronic troubleshooting, and data interpretations (Abraham, 2005, P.910).

A typical rule based system consists of list of rules, a cluster of facts, and an interpreter (inference engine) (Abraham, 2005; Sasikumar et al., 2007, P. 21-25).

- **Rule Bases:** Rule bases are the set of rules that represents the knowledge about the domain. Rules can be defined in the form of “if – then” statement where the “if” part is the condition to be satisfied while the “then” part is the action to be executed (Abraham, 2005). The general forms of rules can be illustrated as (Sasikumar et al., 2007):

  IF condition 1,

  and condition 2,

  and condition 3, ..., condition n

  THEN action 1,

  action 2, ..., action n or

IF condition 1, or condition 2, or condition 3, ..., THEN action 1, action 2, ...

The conditions (condition 1, condition 2, condition 3, etc.) known as antecedents whereas the actions in the consequents (i.e., action 1, action 2, etc.) are known as consequents. Antecedents are evaluated based on what is currently known about the problem being solved. Such kinds of rules are talking to mean if all antecedents of the rule evaluate to true, the actions in the consequents can be executed. Each antecedent of a rule typically checks if the particular problem instance satisfies some conditions. When the consequents of a rule are executed, the rule is said to have been fired.

- **Fact Base (Working Memory):** The fact base is the storage medium that represents the set of facts known about the domain and the means by which rules communicate with one another. It helps the system to focus its problem solving on a particular domain. The inference engine uses facts from working memory in conjunction with the rules in the rule base to derive additional information about the problem being solved (Sasikumar et al., 2007).
- **Interpreter** (**Inference Engine):** The interpreter helps to control the application of the rules given the facts. The interpreter tries to derive new information about a given problem using the rules in the rule base and the situation-specific knowledge in the fact bases. Inference engines in rule based systems can use different strategies to derive the goal, depending on the types of applications they are aimed at. The two major forms of reasoning in rule based system are forward chaining and backward chaining inference mechanisms (Abraham, 2005; Sasikumar et al., 2007).

The following figure indicates the above mentioned basic components of rule based systems.

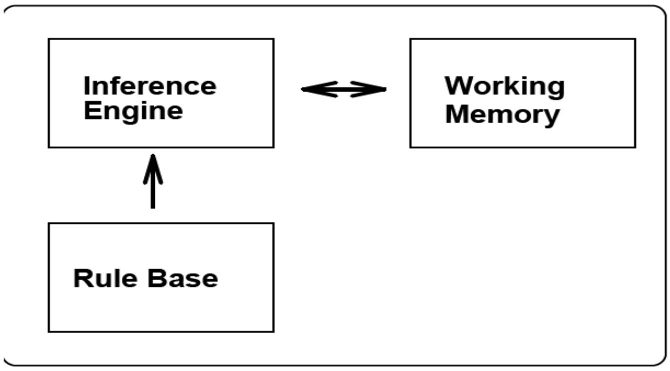



Figure 2.2 Components of Rule Based Systems (Sasikumar et al., 2007, P.22)

**Advantages of Rule Based Representation:** Rule based systems have good features. As Sasikumar et al. (2007) stated the major advantages of rule based representation of knowledge based systems are indicated below.

- **Declarative Nature:** Rule based representation method represents the knowledge of the world declaratively in the form of rules and facts.
- **Homogeneity:** Rule based representation has uniform syntax. Hence, the meaning and interpretation of each rule can be easily analyzed.
- **Simplicity:** Rule based representation has simple syntax. It uses English like human languages to write rules. Therefore, both technical and nontechnical persons can easily understand the rules. As a result, domain experts can often understand the rules without an explicit translation of them.
- **Independence:** In rule based representation, a new rule can be added without affecting the existing rules. Each rule is an independent piece of knowledge about the domain.
- **Modularity:** A rule based system exhibits a high degree of modularity. Each rule represents an independent piece of knowledge. Therefore, it is possible to add new rules without affecting already existing rules of the knowledge base.
- **Separation of Knowledge from Use and Control:** In rule based representation method, there is a clear separation between the knowledge about the domain (facts) and the control (how the knowledge is to be used to solve the problems). In other words, the same inference engine can be used with different rule bases and a rule base can be used with different inference engines.

### 2.4.3 Evaluation and Testing of Knowledge Based Systems

According to William (2006), evaluation can be generally defined as the process of systematic assessment and endeavour of the worth of a system. Similarly, Anumba and Scott (2001) defined knowledge based system evaluation as "a process of examining knowledge based system's ability to solve real world problems in a particular domain". The evaluation of a knowledge based system aids to prove whether a system fulfils its specified objectives or not (Jeremic et al., 2009).

Knowledge based system evaluation process involves assessment of many aspects of a knowledge based system. Effective knowledge based system evaluation process, especially medical knowledge based systems, incorporates both non-human (technical) and human (non-technical) aspects (Forsythe & Buchanan, 1992; Anumba & Scott, 2001; Pu & Chen, 2010). Some of the non-human aspects include exploring of the code, examining the correctness of reasoning techniques, checking the efficiency and performance of the system and detecting errors in the early age of a system.

On the other hand, some of non technical issues include systems compatible with users' needs and desires, the easiness of the system for users, the quality of the user interface and the fitness of the system in the real working environments of the domain area (Forsythe & Buchanan, 1992).

However, in most cases, developers of medical expert systems focus primarily on performance characteristics of their systems. This concern is clearly important, but only measuring performance is not sufficient. User acceptance is a key issue for the successful knowledge based system implementation and application.

#### 2.4.3.1 Goals of Evaluation

For the evaluation of knowledge based system, the first question that must be answered is "what to evaluate?" To answer this question, well described evaluation goals and selection of suitable evaluation parameters are required to compare the evaluation results with the goals. According to Burkle et al. (2001), preferably the goals should have a close connection to the evaluated system in order to assure that positive evaluation results may be definitely attributed to the system.

Moreover, Burkle et al. (2001) stated that the base for every evaluation is comparison. The comparison may take place among expected system effects, results and system statuses. Therefore, the main purpose of evaluation of a system is to compare evaluation results with the goal of the evaluation. According to Burkle et al. (2001) the main purposes of the evaluation process of a system are

- ✓ to compare the results with the goals and expected effects of the system;
- ✓ to use the findings and outcomes of the evaluation process for future research use and
- ✓ to compare systems during the development and the introduction stages.

#### 2.4.3.2 Knowledge Based System Evaluation Methods

After answering the question “what to evaluate?” the next query in the evaluation of knowledge based system is “How to evaluate?”

To evaluate a system, there are two most common and general existing approaches. These are quantitative (objectivist) approach and qualitative (subjectivist) approach (Anumba & Scott, 2001; Burkle et al., 2001). Qualitative approach employs subjective comparisons of performance (Anumba & Scott, 2001), and it assumes observation results that depend on contexts and observers. Due to this, a system value depends on individual’s preferences and opinions (Burkle et al., 2001). This approach is the most commonly used (Anumba & Scott, 2001) and effective (Burkle et al., 2001) approach to evaluate knowledge based systems. On the other hand, quantitative approach uses statistical techniques to compare a system performance against either test cases or human experts (Anumba & Scott, 2001). This approach focuses on important attributes of a system, which can be measured and interpreted (Burkle et al., 2001). Both approaches comprise many knowledge based systems evaluation methods which help to answer the above “How to evaluate?” question.

Engelbrecht et al. (1995) and Ohmann & Belenky (1995) cited in Burkle et al. (2001) stated that knowledge based system evaluation may be divided in to several phases. In most cases, the evaluation process of knowledge based system starts during the development of the system and can be split into verification, validation and assessment of human factors.

- **Verification:** Verification is a knowledge based system evaluation process, which is employed during the development of the knowledge based system. It is used to answer the question "Did we build the system correctly?" In addition, verification is the work of reviewing, examining, testing, checking, documenting of a system. It ensures whether the system has been developed according to the predefined specifications and objectives and verifies consistency, completeness and correctness of the system (Burkle et al., 2001).

  To verify a knowledge based system, it is possible to use either a program proof or a test strategy. The first methodology proves the total correctness of the program logic with mathematical methods whereas the later methodology checks partial correctness of the program with given test cases.

- **Validation:** Validation is an evaluation process that is implemented after a program developed to answer the question "Did we build the right system?" It checks whether the system performs the tasks for which it has been designed in the real working environment or not. This process is very important to test the accuracy of knowledge based systems.

  There are several methods to measure the accuracy of medical knowledge based system predictions when the correct decisions are known. The widely used approach is using predictive validation, which involves the use of historic test cases and comparison of test results with that of the historic case or with expert performance (Burkle et al, 2001). In other words, this strategy involves simply counting the number of correct and incorrect classifications the system produces to find the sensitivity and specificity of the system.

- **Assessment of Human Factors:** This phase is a very essential part of knowledge based systems evaluation process, but it is the most neglected and forgotten issue by most system developers (Forsythe & Buchanan, 1992; Pu and Chan, 2010). This phase helps to answer users' acceptance question "Will the system be accepted and used?" (Burkle et al., 2001). Although a system has been verified and validated, it may be so uncomfortably designed and it cannot be used in real life. Therefore, systems that have been judged acceptable from the knowledge engineers' point of view may not necessarily been viewed positively by potential users (Forsythe & Buchanan, 1992; Burkle et al, 2001; Pu and Chan, 2010).

There are varieties of methods to assess human factors of a knowledge based system. Some of the most commonly used methods include interviews, questionnaires, log studies, reaction studies and visual interaction. Among these visual interaction is the most commonly method which allows the experts or domain users to make comments while interacting with the system.

## 2.5 Knowledge Based Systems Development Tools

A knowledge based system tool is a set of software instructions and utilities taken to be a software package designed to assist the development of knowledge based systems. In knowledge based system development both general purpose programming languages like java and framework l.NET and specific purpose readymade utilities (knowledge based system shells) such as Expert System Shell (JESS), GURU, Vidwan are useful. In most cases tailor made knowledge based system can be developed using programming languages like LISP (List Processing) and Prolog (Nilsson & Maluszynski, 2000).

There are many knowledge based system tools. Sajja & Shah (2010) groups the products into three main categories primarily based on functionality, which also happen to differ markedly in the platforms on which they are available. These groups are (i) Shells, (ii) Languages and (iii) Toolkits. Inference ART and KEE were among the first commercially successful toolkits to develop knowledge based systems. Besides support towards knowledge acquisition and representational features, there are other features like price, flexibility, ease of use, user friendliness and vendor availability and support, and documentation support from the tool need to be considered before final selection.

The most useful and widely used language, particularly in rule based system is Prolog (Russel & Norvig, 2003; Wielemaker, 2010). Prolog is declarative logic programming language that emphasize on the logical properties of parameters (Nilsson & Maluszynski, 2000). It has a purely logical subset, called "pure Prolog", as well as a number of extra logical features. Declarative nature of the language provides many benefits. Some of them are

- ✓ Logic programming languages are inherently ``high level'' because they focus on the computation's logic and they are well suited to expressing complex ideas. This is because the presence of computational engine that performs the difficult/hard work of memory management, stack pointers, etc. Since the inference engine incorporates logical inference, it is already a powerful tool which can be exploited in developing inference engines specific to a particular domain.
- ✓ Logic offers the opportunity to represent data both as an explicit fact and intentionally as a rule, which implicitly describes the fact. In addition, it helps to represent many facts efficiently.
- ✓ Logic programming languages helps the developer to concentrate on what should be represented and how. Since Prolog has built in inference engine, using this built in inference engine permits rapid and straightforward evaluation of the code.

There are various types of Prolog variants like SWI Prolog and YAB (Wielemaker, 2010). Some Prolog versions are free for non commercial use and available and compatible for UNIX and Windows environment. Others like Sicstus Prolog is costly and others are less complete. Additionally, there are differences among Prolog versions in comfort and speed (Nilsson & Maluszynski, 2000).

**SWI Prolog:** SWI Prolog is the most comprehensive and widely used Prolog development environment. It has excellent development facilities. It supports a graphical debugging environment and a range of libraries that allow for graphical user interface implementation. Moreover, SWI Prolog is well maintained and available for all major platforms such as Windows, Mac OS, Linux, etc. The big advantage of SWI Prolog is the friendly development: the graphical debugger is indispensable, and even the command line interface offers some goodies like a help system, command completion and command history (Wielemaker, 2010).

## 2.6 Application of Knowledge Based Systems

Knowledge based systems have many differing functions and application areas. The area of applications for knowledge based system technology ranges from highly embedded turnkey expert systems for controlling certain functions in a car or in a home to systems that provide financial, medical, or navigation advice to systems that control spacecraft (Pomykalski et al., 1999; Speel et al., 2001). The following table shows major types of problems, which can generally solve by using knowledge based systems.

| **Problem Type** | **Knowledge Based System Application Areas** |
|---|---|
| Diagnosis | Inferring System Malfunction from observables |
| Design | Configuring Objects under constraint |
| Control | Governing system behaviour to meet specifications |
| Instruction | Diagnosing, debugging, and repairing student behaviour |
| Interpretation | Inferring situation description from data |
| Monitoring | Comparing observations to expectations |
| Planning | Designing actions |
| Prediction | Inferring likely consequences of given situation |
| Prescription | Recommending solution to system malfunction |
| Selection | Identifying best choice from a list of possibilities |

Table 2.2 Application Areas of Knowledge Based Systems (Pomykalski et al., 1999, P. 9)

As indicated in the above table, there are many different types of problems that can be solved by using knowledge based system technology. Currently, the majority of knowledge based system applications are diagnostic systems (Abraham, 2005).

Particularly, rule based expert systems have played an important role in medical diagnosis domains (Sasikumar et al., 2007). As a result, building knowledge based application technology used to enhance productivity in medicine, business, science and engineering (Feigenbaum et al., 1994; Speel et al., 2001; Abraham, 2005).

knowledge based systems are structured with the feature that enable them to simulate functional model of human system therefore the applications of knowledge based system is in the areas where human beings work (Owaied et al., 2010).

### 2.6.1 Knowledge Based Systems in Medicine

Artificial Intelligence has been applied and made significant contributions in numerous applications in the medical domain (Nilsson & Sollenborn, 2004).

Knowledge based system is essential in medical information technology for emulation of human reasoning process and human expert problem solving skills. Starting from early times, there are many medical technologies that were applied in health institution (Sasikumar et al., 2007).

MYCIN was one of the first successful expert system to demonstrate the feasibility of developing intelligent agent programs with performance rivalling that of a human expert (Sasikumar et al., 2007; Kong et al., 2008; Masizana-Katongo et al., 2009). The task of MYCIN was diagnosis and therapy selection for bacterial infections of blood. It introduced the notion of certainty factors, the idea of an expert system shell and putting a knowledge base to multiple uses (Sasikumar et al., 2007).

In addition, PUFF had developed to diagnose lung disease. ANGY helps physicians to diagnose the narrowing of coronary vessels by identifying and isolating coronary vessels in angiograms, and BABY aids clinicians by monitoring patients in a newborn intensive care unit (NICU). In the same way, MECS-AI helps physicians to make diagnoses and to suggest treatments for cardiovascular and thyroid diseases; PIP assists physicians by taking the history of the present illness of a patient with edema, and WHEEZE diagnoses the presence and severity of lung disease by interpreting measurements of pulmonary function tests. Furthermore, NEOMYCIN helps physicians diagnose and treat patients with meningitis and similar diseases, and

MED1 helps physicians diagnose diseases associated with chest pain. GUIDON for instruct in bacterial infections, and HEME helps physicians diagnose hematologic diseases (Coiera et al., 1993; Davis et al., 1993; Sasikumar et al., 2007; Wiriyasuttiwong & Narkbuakaew, 2009).

Moreover, Anteneh's and Redit's research work are sample researches which was done in Ethiopia. Anteneh (2004) has done a rule based system to design and develop prototype knowledge based system for antiretroviral therapy to assist in the choice of drug for individual patients (Anteneh, 2004).

Redeit (2006) designed rule based prototype knowledge based system for HIV pre-testing counselling. The main objective of the research work was to look into the feasibility of employing the expert system in the area of pre-test counselling by using the knowledge base system technology (Redit, 2006).

Currently, knowledge based systems in medicine have received much attention, mainly because of the potential benefits that can be gained from using them. They may facilitate in increasing productivity in a medical environment, support the making of diagnoses and other types of medical decisions (like medical planning and treatment), assist in the training of medical professionals, and can even handle some routine tasks in a medical environment (Martinsons, 1995; Kalogeropoulos et al., 2002).

#### 2.6.1.1 Clinical Knowledge Based Applications Areas

Medical informatics and artificial intelligence in medicine have many application areas and the technology provides many benefits for medical domains. Knowledge based systems can support and facilitate clinical decisions that will help to improve the quality of patient care, optimise the cost–benefit equation, and ultimately transform the traditional structure of health care provision (Nilsson & Sollenborn, 2004). As a result, knowledge based systems are becoming increasingly ubiquitous in various clinical settings (Kalogeropoulos et al., 2002).

According to Coiera et al. (1993), some of the lists of clinical application areas include:

- **Advisory systems:** Advisory knowledge based systems development is a noticeable opportunity which assist clinicians with the diagnosis of diseases, prescription of medications, checking for drug-drug interactions, inspecting side effects of drugs and selecting the most cost-effective treatments.
- **Protocol design and maintenance tools:** Since clinical care is increasingly moving to protocol driven processes knowledge acquisition and maintenance technologies are good application areas for protocol design in clinical settings.
- **Laboratory systems:** Coiera et al. (1993) stated, “Clinical laboratories have proven to be a good domain for the use of experts systems, both for the interpretation of measured values and automated preparation of reports, as well as in the process of guiding clinicians in the selection of appropriate tests to order.”
- **Clinical Workstations:** Knowledge based systems are vital in clinical work stations to provide easily access of clinical data for health care workers and to optimize the views of the data made available to different clinical workers.

## 2.7 Knowledge Based Systems and Mental Disorders Diagnosis

Computer based methods are increasingly used to improve the quality of medical services. Artificial Intelligence is the area of computer science focusing on creating machines that can engage on behaviours that humans consider intelligent (Samy et al., 2008). Artificial Intelligence plays a great role in medical domain. There are many reasons for the applications of knowledge based systems in health institution. One of the reasons is that scarcity of expertises in medical sector. As stated in the first chapter of this thesis, mental disorder professional and psychiatrics, particularly in developing countries like Ethiopia are very scarce. Hence, knowledge based systems are crucial to fill this gap with in the country.

The other reason for the need of knowledge based systems application in clinical decision making processes is the presences of increased numbers of symptoms, medicines and treatments for a particular disease. Since medical expertises are human begins, they may faced problems to remember all the symptoms, recommended medicines and treatments. As a result, knowledge base system is required to assist doctors in diagnosing diseases based on its symptoms and to recommend the appropriate treatments and medicines.

The aim of this study is to apply the concept of knowledge base systems as a tool on anxiety mental disorder diagnosis. In diagnosing of anxiety mental disorders, it is expected that knowledge based systems can assist doctors to determine a corresponding disease/disorders and to recommend the appropriate treatments accordingly. The availability of knowledge base systems in mental disorder diagnosis is essential to provide, for both users and professionals, the alternative solution method with less time, minimum finance and on time services.

# CHAPTER THREE

# KNOWLEDGE ACQUISITION

## 3.1 Introduction

Knowledge acquisition is the process of extracting, structuring and organizing knowledge from human experts and other sources such as books, databases, the Internet, research papers, documents, one's own experience and transferring to the knowledge base (Abbas et al., 2008). It is the general term used for the process of developing a computational problem-solving model such as developing a program to be used in some consultative or advisory role (Birmingham & Klinker, 2009). Knowledge acquisition is the most significant step in the development of knowledge based systems, but at the same time it is the most difficult one that needs great care, patience and attention.

Accordingly, the main objective of this chapter is to gather and analyze the basic domain knowledge regarding to anxiety disorders and the fundamental concepts that are gained about the diagnosis procedures that help to develop the proposed prototype knowledge based system. Generally, this chapter covers the knowledge acquisition phase and the conceptualization process. The basic parameters and concepts, which are crucial in the diagnosis process, are identified. For the purpose of this study, this proposed knowledge based system is named as Anxiety Mental Disorder Diagnosis Knowledge Based System (AMDDKBS).

## 3.2 The Knowledge Acquisition Process

The process of knowledge acquisition of this research encompasses some basic activities such as gathering the needed knowledge, analyzing that knowledge, identifying important concepts and parameters (symptoms) and finally modelling them in using decision tree structure.

In this study to acquire the needed knowledge, both secondary and primary sources of knowledge are used. Primary knowledge gathered from various experts in the domain area from Amanuel Mental Specialized Hospital and Rank Higher Clinic by using structured and unstructured interviews (interview questions used are presented in Appendix I). During the preliminary investigation, psychiatrist doctors, trainee psychiatrists, psychiatrist nurses and psychologists (eight experts) are included to understand the dimensions of mental disorder problems. During this time, the researcher is trying to conduct informal kinds of interviews with these experts. All the experts replied similar information about anxiety disorders and they said that they used DSM _ IV as their guideline for diagnosing mental disorders. Due to this, the researcher selects only three experts.

These three experts selected purposively for extensive discussions using structured and unstructured interview to discover relevant tacit knowledge. These experts were principally participating through out the research work, and they were consulted to confirm the correctness of the acquired knowledge. The following table summarizes the professional profiles of these experts.

| **No.** | **Educational Level** | **Specialization** | **Years of Experience** | **Case Team** | **Role** | **Reference Used** |
|---|---|---|---|---|---|---|
| 1 | PhD | Psychiatrist | 25 years | Anxiety Case Team | Anxiety Case Team Coordinator | DSM – IV |
| 2 | PhD | Psychiatrist | 24 years | Anxiety Case Team | Medical Director | DSM – IV |
| 3 | PhD | Psychiatrist | 5 years | General | Psychiatrist | DSM – IV |

Table 3.1 Profiles of Professions Who Participated In the Detailed Interview

In addition, secondary sources of knowledge have been gathered from the Internet, mental disorder diagnosis guidelines (especially, DSM – IV), manuals, research papers and articles.

Results of the discussion with the experts indicate that almost all mental professionals in Ethiopia use international guidelines for mental disorders diagnoses. As the experts explained, Ethiopia does not have its own guideline(s). Instead, mental health professionals in Ethiopia use international guidelines for diagnosing mental disorder related problems. Currently, almost in all cases the two major international guide lines used are International Classification of Disease tenth edition (ICD – 10) which is developed by World Health Organization (WHO) and Diagnostic and Statistical Manual for mental disorder fourth edition (DSM – IV) which is developed by American Psychiatric Association (APA). Particularly, DSM – IV has been using practically in Ethiopia.

Essential disorders and their symptoms identified from both the domain experts and documentary sources, and refined through consultations with the experts. These identified anxiety disorders include Phobic (Agoraphobia, Specific Phobia and Social Phobia), Panic Disorder, Generalized Anxiety Disorder, Obsessive – Compulsive Disorder and reactions to severe stress disorders like Post – Traumatic Stress Disorder and Acute Stress Disorder.

## 3.3 Anxiety Disorders

Anxiety is a natural response and a necessary warning adaptation in humans. Anxiety can become a pathologic disorder when it is excessive and uncontrollable, requires no specific external stimulus, and manifests with a wide range of physical and affective symptoms as well as changes in behaviour and cognition.

The most widely occurring and principal anxiety disorder groups are identified during the knowledge acquisition process. These include phobic disorders (agoraphobia, social phobia and specific phobia), disorders due to severe stressors (post – traumatic stress disorder and acute stress disorder), obsessive – compulsive disorder, generalized anxiety disorder and panic disorder.

As indicated in the following figure (Figure 3.1), the diagnosis of anxiety disorders includes five sub diagnoses. These are obsessive – compulsive disorder diagnosis, phobic diagnosis, panic disorder diagnosis, generalized anxiety disorder diagnosis and reactions to severe stress disorder diagnosis. Again, phobic diagnosis and reactions to severe stress diagnosis has three and two sub diagnosis respectively. The following figure shows these disorders.

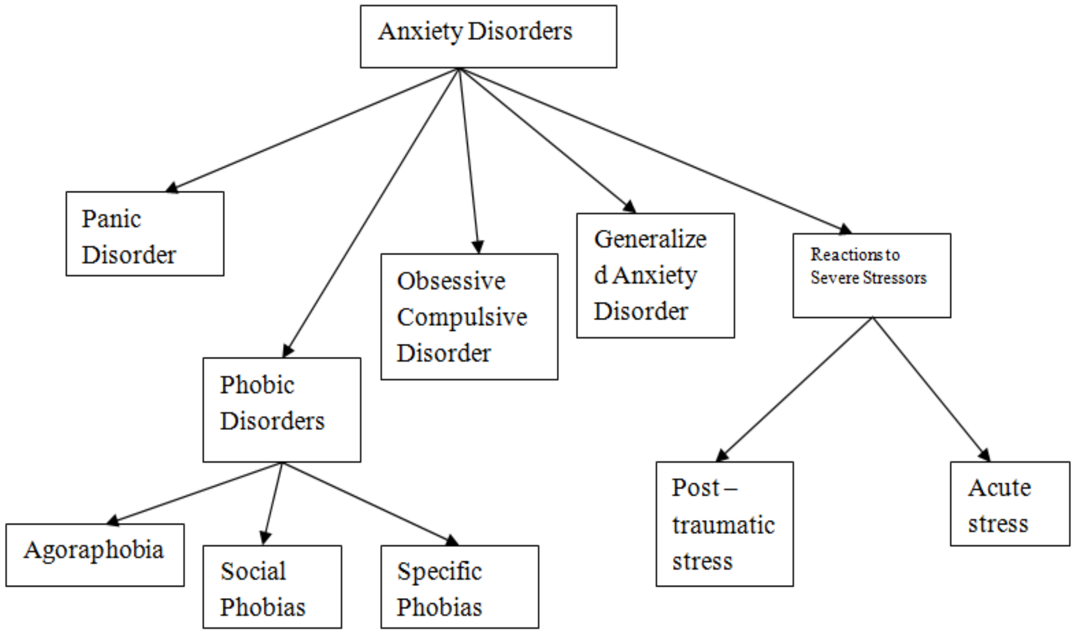



Figure 3.1 Major Types of Anxiety Disorders

### 3.3.1 Panic disorder

Panic disorder is an anxiety disorder characterized by the spontaneous unexpected occurrence of panic attacks. The attacks are relatively short-lived (usually less than one hour) periods of intense anxiety or fear, which is accompanied by somatic symptoms such as palpitation and tachyon (Paris et al., 2006). Panic disorder is a serious health problem, but in many cases it can be successfully treated (APA, 2000).

The main symptom of panic disorder is the occurrences of persistent panic attacks. A panic attack is a period of intense fear or discomfort, developing suddenly and peaking within 10 minutes.  Panic attacks are characterized by a short period of intense fear and a sense of impending doom, derealisation, increasing heart bit with accompanying physical symptoms, such as chest pain, dizziness and shortness of breath.

### 3.3.2 Phobic Disorders

Phobic disorders are disorders, which result in due to fear of some situations or objects. Phobia is an irrational fear of an object, place, activity or situation (Paris et al., 2006). The most commonly occurring phobic disorders are agoraphobia, social phobia and specific phobia.

Agoraphobia is a condition where the sufferer becomes anxious in environments that are unfamiliar or where he or she perceives that they have little control. Triggers for this anxiety may include crowds and wide open spaces or travelling, even short distances (APA, 2000). Agoraphobia consists of multiple and varied fears and avoidance behaviour that center around three main themes:

- ✓ Fear of leaving home
- ✓ Fear of being alone and
- ✓ Fear of being away from home in situations where one can feel trapped, or embarrassed.

The other commonly occurring phobia is social phobia and specific phobia. Social phobia occurred mostly in social related situations (Paris et al., 2006). On the other hand, specific phobia is a disorder, which is characterized by marked and persistent fear that is excessive or unreasonable, cued by the presence or anticipation of a specific object or situation. Associated to this fear, patients with specific phobia show symptoms like heart pounding and sweating.

### 3.3.3 Obsessive – Compulsive Disorder

Obsessive-compulsive disorder is a mental disorder most commonly characterized by intrusive and repetitive thoughts resulting in compulsive behaviours and mental acts that the person feels driven to perform aimed at reducing anxiety by preventing some dreaded event or by resolving a more nebulous sense of tension (Bandelow et al, 2008). Intrusive thoughts are unwelcome, involuntary thoughts, images or unpleasant ideas. In severe cases, it affects a person's ability to function in everyday activities. The disorder often has a serious impact on the sufferer's and their family's quality of life. In addition, the psychological self-awareness of the irrationality of the disorder can be painful (APA, 2000). A person who is affected by obsessive – compulsive disorder shows either obsessions or compulsions. As experts said, in most cases both are occurred together.

Obsessions recurrent and persistent thoughts, impulses or images that are experienced as intrusive and causing marked anxiety. The thought, impulses or images are not simply excessive worries about real-life problems. The person attempts to ignore or suppress such thoughts, impulses or images or to neutralize them with some other thought or action.

Similarly, compulsion can be defined as repetitive behaviours such as praying, counting, checking repeatedly that the person feels driven to perform in response to an obsession. The behaviours or mental acts are aimed at reducing distress or preventing some dreaded events or situations. However, these behaviours or mental acts either are not connected in a realistic way with what they are designed to neutralize or prevent.

### 3.3.4 Generalized Anxiety Disorder

Generalized anxiety disorder is an anxiety disorder that is characterized by excessive, uncontrollable and often irrational worry about everyday things that are disproportionate to the actual source of worry. This excessive worry often interferes with daily functioning. Generalized anxiety disorder brings catastrophes and anticipates disaster on everyday matters such as health issues, money, death, family and friend related problems, or work difficulties (APA, 2000).

Generalized anxiety disorder often exhibits a variety of symptoms and physical signs including fatigue, headaches, muscle tension, difficulty swallowing, trembling, twitching, sweating and hot flashes. As experts said, these symptoms must be consistent and on-going persisting at least for 6 months for a formal diagnosis of generalized anxiety disorder to be introduced.

### 3.3.5 Reactions to Severe Stress Disorders

Reactions to stress disorders are developed due to the presence of severe stressor events in the later life of a patient. These include posttraumatic stress disorder and acute stress disorder.

Posttraumatic stress disorder and acute stress disorder are anxiety disorders that can be developed after exposure to one or more traumatic events that threatened or caused grave physical harm. It is a severe and ongoing emotional reaction to an extreme psychological trauma. This stressor may involve someone's actual death, a threat to the patient's or someone else's life, serious physical injury, an unwanted sexual act, a threat to physical or psychological integrity or overwhelming psychological defences (Bandelow et al., 2008). Posttraumatic stress disorder and acute stress disorder are conditions where a person begins to experience anxiety symptoms and begins to relive certain events from one's past (Paris et al., 2006). It can also involve a person trying to avoid certain stimuli that can relate to a particular event. The diagnosis of both of them is similar. The difference lies in duration of the traumatic events. The diagnosis of acute stress disorder can be given only within the first month following a traumatic event whereas if posttraumatic symptoms were to persist beyond a month, the clinician would assess for the presence of posttraumatic stress disorder.

All the symptoms of posttraumatic stress disorder and acute stress disorder are categorized in to three clusters as intrusive (re-experiencing) symptoms, avoidance symptoms and arousal symptoms.

As experts said, to diagnosis for posttraumatic stress disorder and acute stress disorder a person must have experienced a traumatic event where he/she experienced, witnessed or was confronted with an event where there was the threat of or actual death or serious injury. The event may also have involved a threat to the person's physical well-being or the physical well-being of another person.

All the basic identified concepts, symptoms, syndromes and parameters of each anxiety disorder are modelled in figure 3.2.

## 3.4 Conceptual Modelling

### 3.4.1 Introduction

As stated in the literature review section of this thesis, conceptual modelling is the heart of knowledge acquisition phase. It is the crucial step to understand well the problem domain and to prepare for the knowledge representation phase.

Decision trees are modelling tools that are used in a variety of different settings to organize and break down clusters of data (Lidtke & Sato, 2003). Decision tree is a schematic tree-shaped diagram used to determine a course of action and models the possible consequences of a series of decisions in some situation (Lau & Chan, 2004).

A decision tree helps to select the best of several alternative courses of action and to clarify and find an answer to a complex problem (Podgorelec et al., 2002). The structure allows users to take a problem with multiple possible solutions and displays it in a simple, easy-to-understand format that shows the relationship between different decisions (Lau & Chan, 2004). Additionally, decision trees incorporate uncertainty (outcome probability). Hence, they help to demonstrate such kinds of systems that are full of uncertainty like medical diagnosis (Tsang et al, 2011.).

Similarly, decision trees have been widely used in practical applications owing to their interpretability and ease of use (Scott, 2004). Currently, decision trees are used in many different disciplines including medical diagnosis, cognitive science and artificial intelligence (Quintana et al., 2009).

Particularly, decision tree in medical domain is a well known tool that aid clinicians in understanding diseases concepts, ideas and the better decision to be made (Quintana et al., 2009; Tsang et al, 2011). Each decision tree starts with a set of clinical features. When one of these features is a prominent part of the presenting clinical picture, the clinician can follow the series of questions to rule in or rule out various disorders (Podgorelec et al., 2002).

### 3.4.2 Anxiety Disorders Diagnosis and Decision Tree Structure Logical View

A mental health diagnosis involves many steps beginning with asking questions about the patient's symptoms, medical history, and performing a physical examination. Although there are no laboratory tests to diagnose specifically mental illness, the doctor may use various tests to make sure something else is not causing the symptoms. The doctor bases his or her diagnosis on the person's report of symptoms including any social or functional problems caused by the symptoms and his or her observation of the person's attitudes and behaviours. The doctor then determines if the person's symptoms and degree of disability point to a diagnosis of a specific disorder. Mental disorder diagnosis is one and basic parts in the diagnosis of mental health conditions which needs carefully examination and diagnosis.

Mental disorder diagnosis is dominated by gathering sufficient information from a patient or his or her relatives/family members. During the diagnosis session, the critical step is getting a patient history to understand well the dimensions of a patient's problems. After that, asking a patient (or anybody who is with the patient) why he/she comes to the hospital/clinic and what happen in the later life of the patient. During this time, an expert (mostly a psychiatrist or a psychologist) extracts important symptoms and syndromes from the sessions and identifies the mental disorder category/group of the patient. After identifying the disorder group, the expert continues with detail diagnosis of that group of disorders. Then, the expert will probably refer to the Diagnostic and Statistical manual of Mental Disorders (DSM-IV-4th Edition) to compare the patient symptoms to those in the DSM. Finally, the psychiatrist estimates the probable presence of a disorder and recommends the appropriate treatment(s) or sends the patient to clinical psychologists accordingly.

Anxiety disorders are medical conditions and require a diagnosis to be made by a qualified medical professional. However, unlike other disease, there are no blood tests, or other lab tests; there are no x-rays or brain scans, which will definitively determine if someone has an anxiety disorder.

As with many mental disorder problems, the diagnosis of an anxiety disorder is based on the symptoms of the patient. In the initial evaluation stage of the diagnosis, a psychiatrist will ask questions about the medical history of the patient. He/she will ask questions about physical as well as emotional illnesses and disorders the patient has had in the past. In addition, the doctor will assess:

- ✓ What symptoms the patient is experiencing, both emotionally and physically
- ✓ How often the patient experiences symptoms of anxiety
- ✓ How long the patient has been having symptoms
- ✓ How the symptoms interfere with the patient daily life
- ✓ Whether the patient is experiencing a stressful situation in his/her life
- ✓ Whether the patient drinks alcohol or use drugs

In the case of other diseases such as flu, the patient symptoms are looked at as a group and the doctor will determine if these symptoms are similar enough to those of the flu to decide if the patient does indeed have the flu. For anxiety, the process is somewhat different. Because anxiety can cause a multitude of physical symptoms, such as heart palpitations, sweating and feeling as if the patient cannot breathe. As a result, from the initial sessions of the diagnosis, a psychiatrist first rule out or eliminate physical illness and substance related problems before diagnosing an anxiety disorder. Once the doctor ruled out all physical illnesses and substance related problems, he/she will continue the diagnostic process.

Clinicians use longitudinal stepwise process to diagnosis anxiety disorders. The diagnosis of anxiety disorders usually starts with fear, avoidance, or increased arousal. Anxiety and fear represent the core problem of this group of disorders.

Usually individuals suffering from anxiety disorders have a heightened alarm reaction. For example, in panic disorder the ultimate alarm of the panic attack is the main feature. However, a simple increase in alarm reactivity resulting in fear and anxiety is not enough to explain the complex presentation of anxiety disorders. Additionally, patients usually have faulty information processing that drives misinterpretation of the situation or their physiological reaction to the situation as "dangerous" or extremely unpleasant. The best examples of these misinterpretations are cognitive distortions in obsessive compulsive disorder (i.e., interpreting selected objects as “contaminated” or “dirty”). It is important that clinicians realize that while increased alarm reactivity and cognitive distortions is the core of the patients’ problems, other symptoms are often present and affect the patient’s normal functioning.

To summarize, during the diagnosis of anxiety disorders a doctor performs the following activities:

- ✓ History taking (gathering sufficient information from the patient or the person who is with the patient)
- ✓ Checking the presence of common/core anxiety symptoms (fear, avoidance, or increased arousal)
- ✓ Rule out a general medical condition as direct physiological cause of the anxiety symptoms
- ✓ Rule out a substance use as the direct physiological cause of the anxiety symptoms

Then, if there is fear, increased arousal or avoidance which are free from any medical condition and substance use, the expert proceeds the diagnosis of anxiety disorders.

Moreover, to diagnosis each anxiety disorder, the expert asks one or more screening questions for each anxiety disorder by using the fundamental/core symptom(s) of each disorder. For instance, the presence of panic attacks (as in panic disorder), the presence of obsession or compulsion (as in obsessive compulsive disorder), avoidance of thoughts and/or situations (as in social anxiety disorder and agoraphobia), etc. However, the first screening questionnaire(s), the first fundamental symptoms, alone is/are insufficient to diagnosis each anxiety disorder. As indicated from table 3.2 to table 3.8, there are other important characteristics or symptoms for each anxiety disorder. Therefore, to complete the diagnosis successfully and to reach the best decision or conclusion, further assessment is necessary by incorporating the first fundamental screening symptoms and other identified symptoms which are indicated in the tables 3.2 to table 3.8.

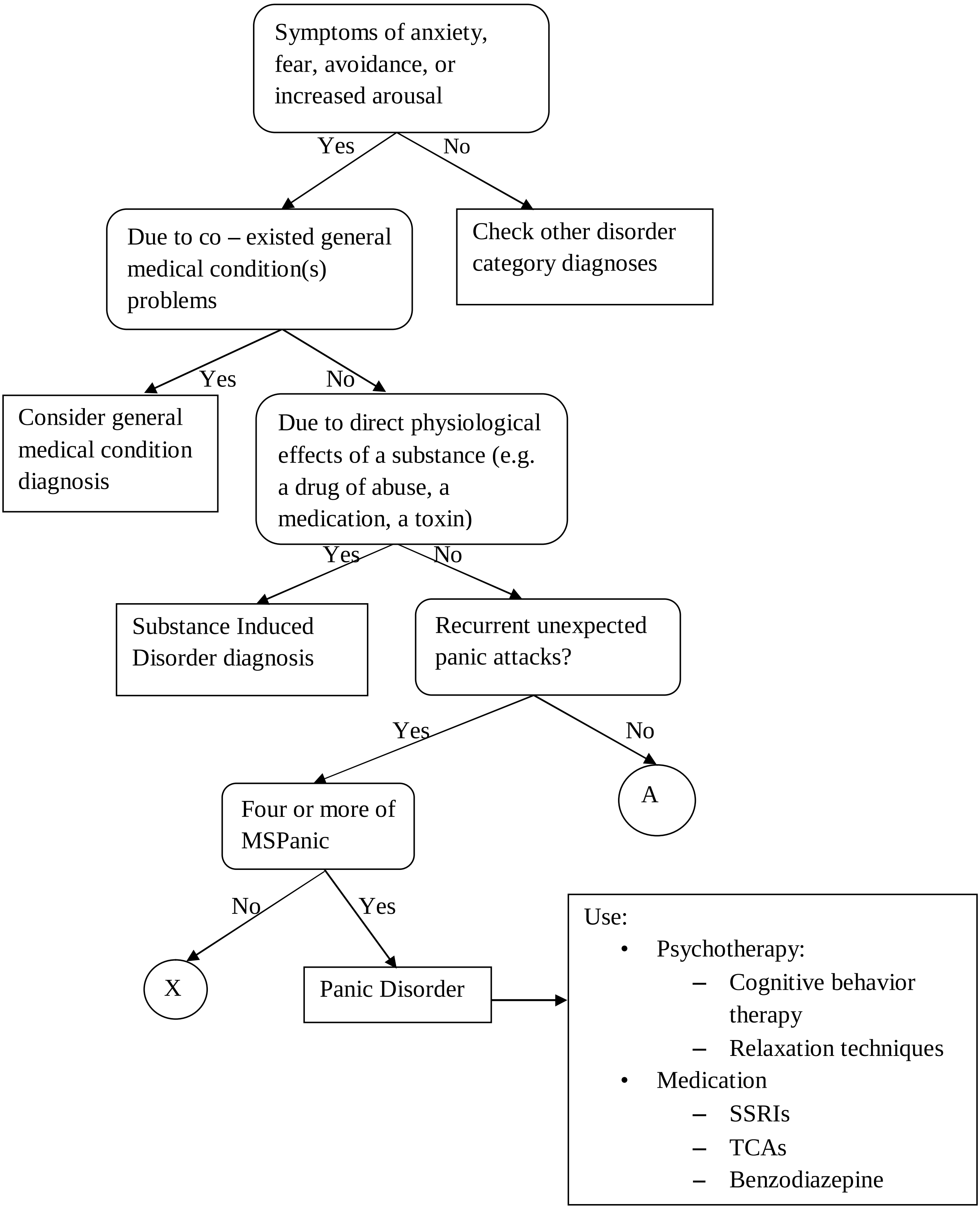
All the relevant knowledge about the diagnosis of anxiety disorders are acquired and identified from the above mentioned (primary and secondary) sources of knowledge. The fundamental concepts, parameters and characteristics (symptoms) of each anxiety disorder are identified in the consultation and confirmation of domain experts.

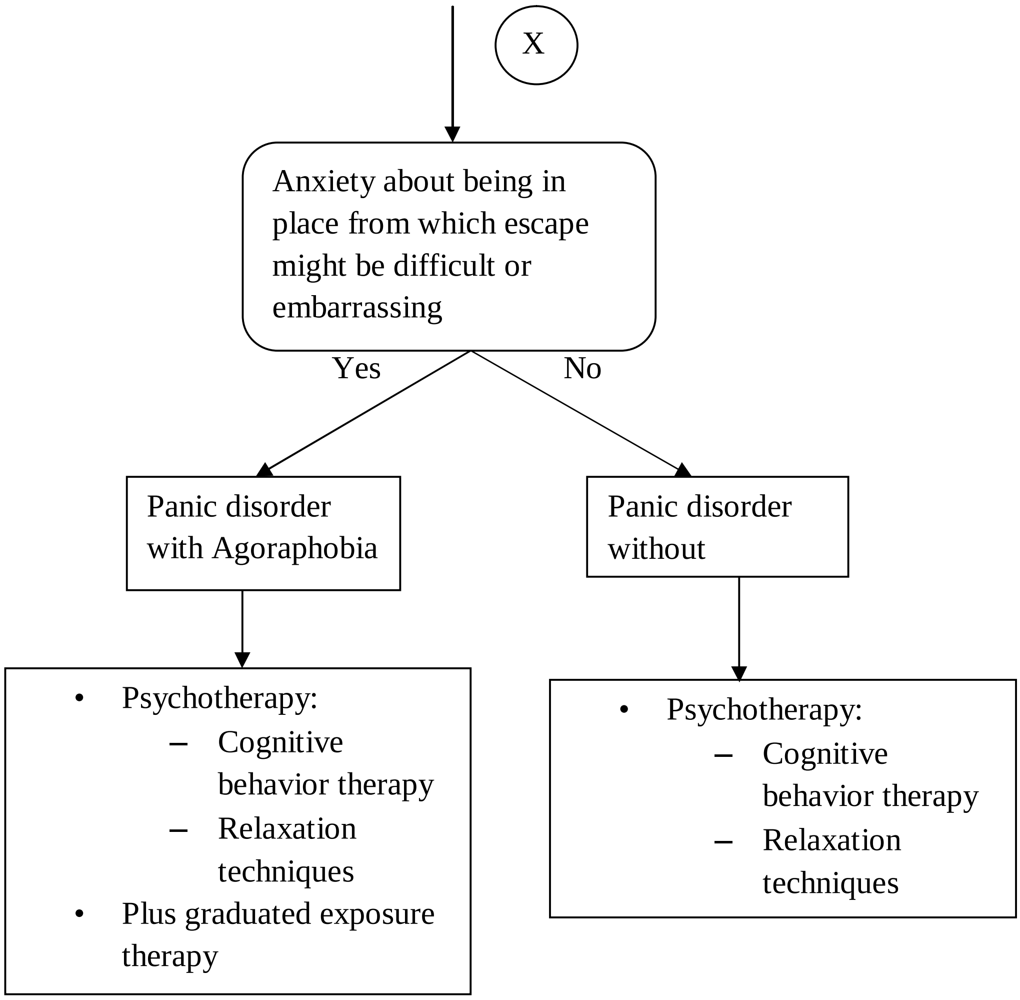
To make the acquired knowledge sensible for knowledge representation, it is modelled using decision tree structures. In the context of this study, decision tree is used to demonstrate clearly the diagnosis procedures of anxiety disorders which are implemented by using SWI Prolog in the next chapter (chapter four).

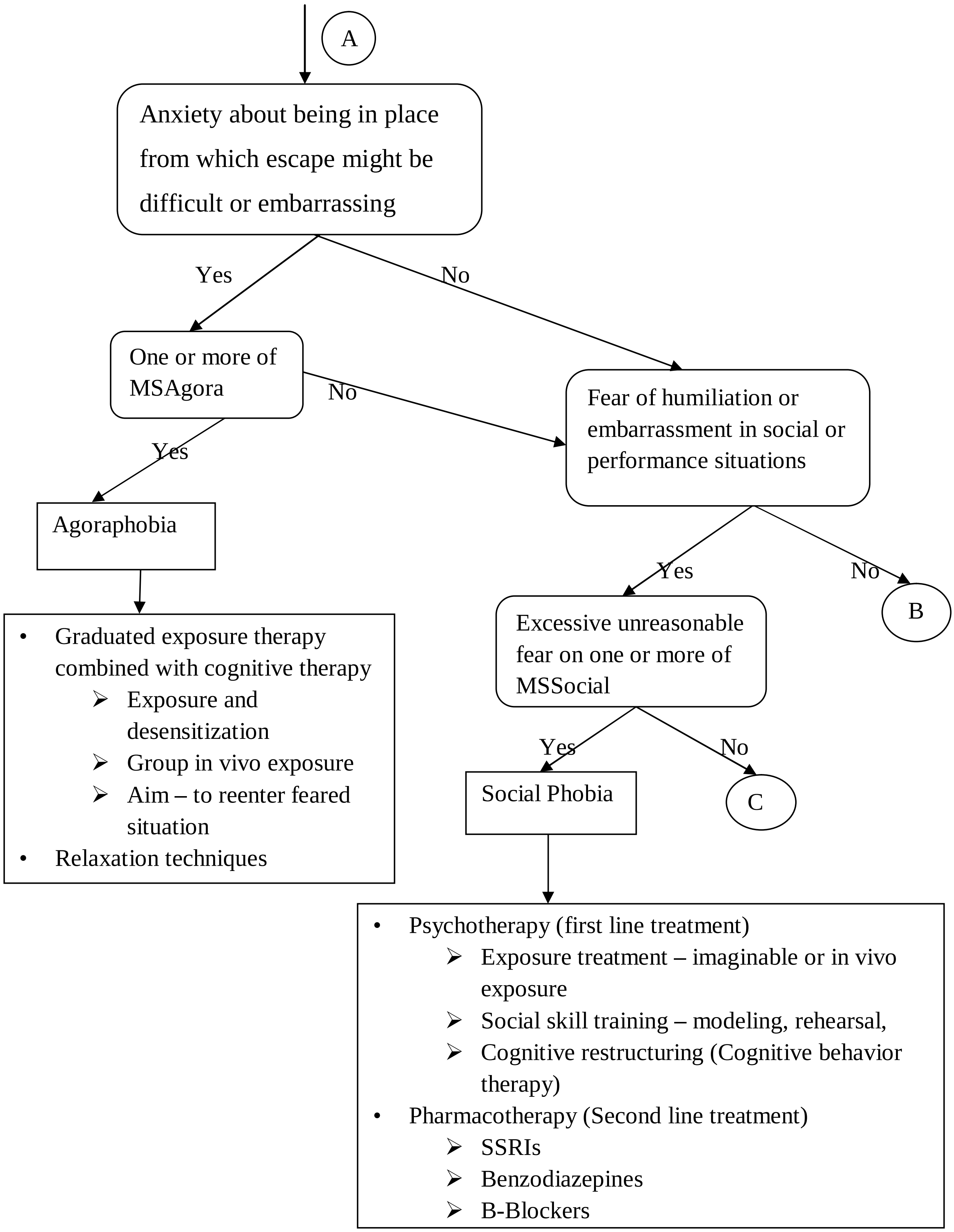
The decision tree structures (Figure 3.2) are derived from the knowledge acquired from experts and secondary sources in the consultations and confirmations of experts.

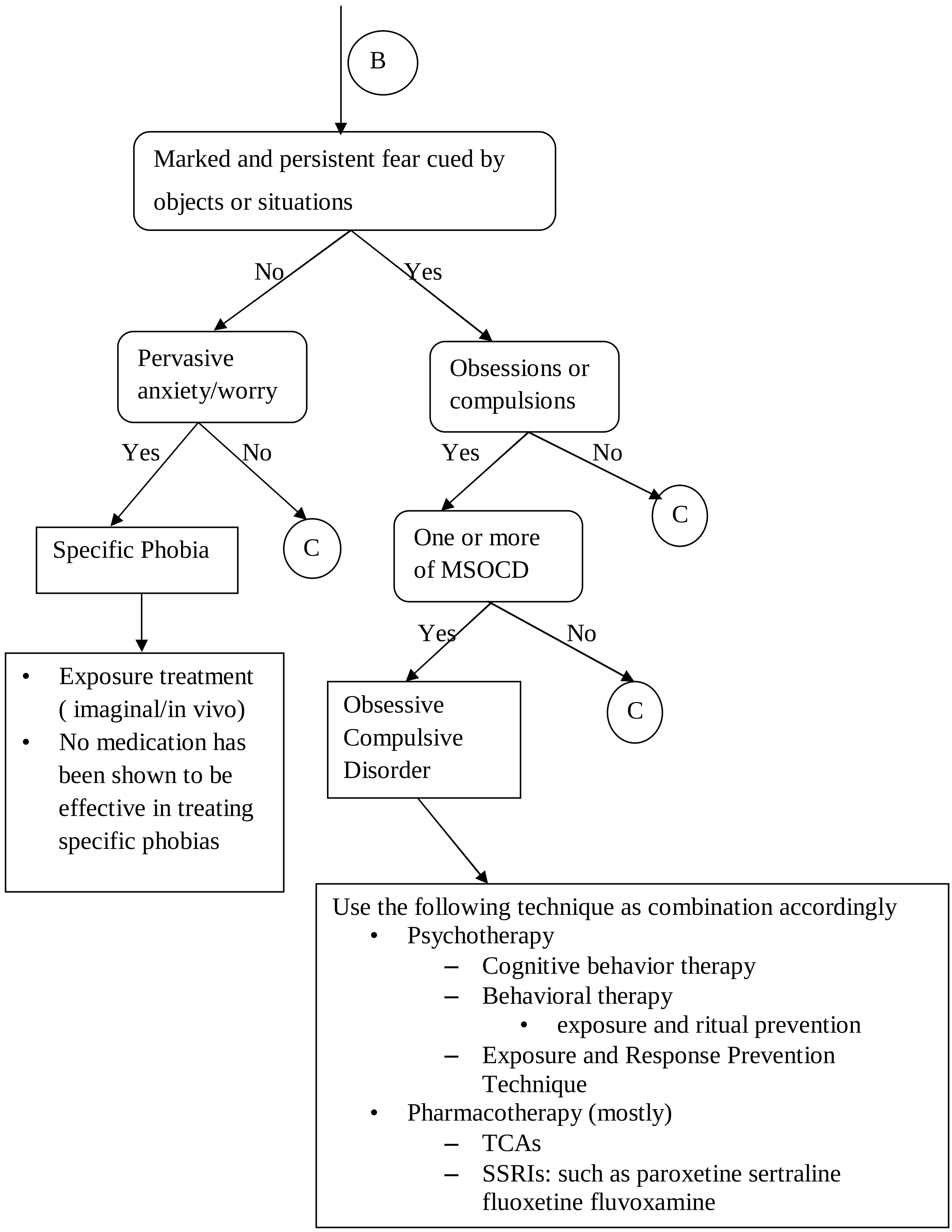
These decision tree structures are the bases for the prototype knowledge based system development. The prototype knowledge based system is developed based on the model presented in these decision tree structures. The prototype follows the same procedures presented in the decision trees to diagnosis anxiety disorders. First it checks the presence of panic disorder then continues agoraphobia, social phobia, specific phobia, obsessive compulsive disorder, generalized anxiety disorder, posttraumatic stress disorder and acute stress disorder respectively.

In the following decision trees (Figure 3.2), the core symptoms of each anxiety disorder, which are the main indicators to identify the plausible presence of the disorder and to reach a better decision, and the fundamental procedures during the diagnosis of anxiety disorders, are structured.


Symptoms of anxiety, fear, avoidance, or increased arousal
Yes
No
Due to co – existed general medical condition(s) problems
Check other disorder category diagnoses
Yes
No
Consider general medical condition diagnosis
Due to direct physiological effects of a substance (e.g. a drug of abuse, a medication, a toxin)
Yes
No
Substance Induced Disorder diagnosis
Recurrent unexpected panic attacks?
Yes
No
Four or more of MSPanic
A
No
Yes
X
Panic Disorder
Use:
• Psychotherapy:
– Cognitive behavior therapy
– Relaxation techniques
• Medication
– SSRIs
– TCAs
– Benzodiazepine


X
Anxiety about being in place from which escape might be difficult or embarrassing
Yes
No
Panic disorder with Agoraphobia
Panic disorder without
• Psychotherapy:
– Cognitive behavior therapy
– Relaxation techniques
• Plus graduated exposure therapy
• Psychotherapy:
– Cognitive behavior therapy
– Relaxation techniques


A
Anxiety about being in place from which escape might be difficult or embarrassing
Yes
No
One or more of MSAgora
No
Yes
Agoraphobia
Fear of humiliation or embarrassment in social or performance situations
Yes
No
B
Excessive unreasonable fear on one or more of MSSocial
Yes
No
Social Phobia
C
• Graduated exposure therapy combined with cognitive therapy
➢ Exposure and desensitization
➢ Group in vivo exposure
➢ Aim – to reenter feared situation
• Relaxation techniques
• Psychotherapy (first line treatment)
➢ Exposure treatment – imaginable or in vivo exposure
➢ Social skill training – modeling, rehearsal,
➢ Cognitive restructuring (Cognitive behavior therapy)
• Pharmacotherapy (Second line treatment)
➢ SSRIs
➢ Benzodiazepines
➢ B-Blockers


B
Marked and persistent fear cued by objects or situations
No
Yes
Pervasive anxiety/worry
Obsessions or compulsions
Yes
No
Yes
No
Specific Phobia
C
One or more of MSOCD
C
Yes
No
Exposure treatment ( imaginal/in vivo)
No medication has been shown to be effective in treating specific phobias
Obsessive Compulsive Disorder
C
Use the following technique as combination accordingly
Psychotherapy
Cognitive behavior therapy
Behavioral therapy
exposure and ritual prevention
Exposure and Response Prevention Technique
Pharmacotherapy (mostly)
TCAs
SSRIs: such as paroxetine sertraline fluoxetine fluvoxamine

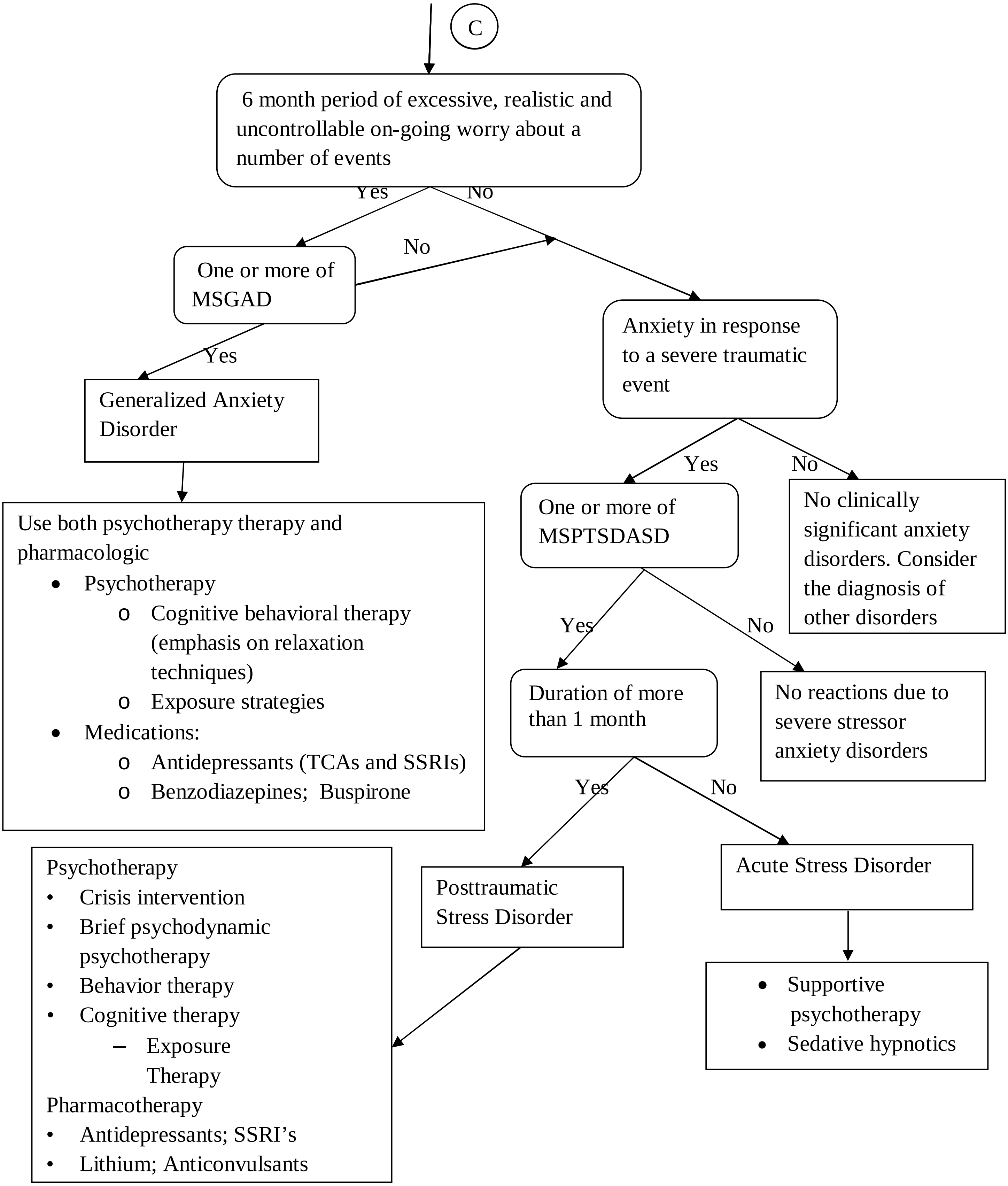



Figure 3.2 Decision Trees for the diagnosis of Anxiety Disorders

**Key:**

- MSPanic:- Major Identified Symptoms of Panic
- MSAgora:- Major Identified Symptoms of Agoraphobia
- MSSocial:- Major Identified Symptoms of Social Phobia
- MSOCD:- Major Identified Symptoms of Obsessive Compulsive Disorder
- MSGAD:- Major Identified Symptoms of Generalized Anxiety Disorder
- MSPTSDASD:- Major Identified Symptoms of severe stressors disorders

In addition to the fundamental symptoms, which are clearly indicated in the decision tree structures, there are some sets of symptoms (syndromes) which should be looked during the diagnosis of each anxiety disorder. These symptoms are crucial and help to infer (determine) the most probable presence of an anxiety disorder. The screen out syndromes of each anxiety disorders are presented in table 3.2 to table 3.8. These syndromes are indicated in the decision tree structure by specifying their quantity in each anxiety disorder diagnosis accordingly.

| **Anxiety Disorder** | **Major Symptoms of Panic (MSPanic)** |
|---|---|
| Panic Disorder | Trembling |
| | Palpitation |
| | Chest pain |
| | Nausea |
| | Unrealistic Intense fear |
| | Breathlessness |
| | Feeling of unreality (derealisation) |
| | Fear of sudden attack |
| | Difficulty concentrating |
| | Excessive Sweating |

Table 3.2 Panic Disorder Syndromes (Set of Symptoms)

| **Anxiety Disorder** | **Major Symptoms of Agoraphobia (MSAgora)** |
|---|---|
| Agoraphobia | Fear of being alone in public places |
| | Fear of being alone at home/outside home |
| | Feeling sense of being lost |
| | Fear of having sudden attack |
| | Anticipatory anxiety |

Table 3.3 Agoraphobia Syndromes

| **Anxiety Disorder** | **Major Symptoms of Social Phobia ( MSSocial )** |
|---|---|
| Social Phobia | Marked and persistent fear of social settings |
| | Blushing |
| | Fear of being watched |
| | Difficulty being assertive |
| | Fear judging by others |

Table 3.4 Social Phobia Syndromes

| **Anxiety Disorder** | **Major Symptoms of Specific Phobia (MSSpecific)** |
|---|---|
| Specific Phobia | Fear of Specific object or specific situation |
| | Marked and persistent worry |
| | Limited fear |
| | Heart pounding |

Table 3.5 Specific Phobia Syndromes

| Anxiety Disorder | Major Symptoms of Obsessive Compulsive Disorder (MSOCD) |
|---|---|
| Obsessive Compulsive Disorder | Recurrent and persistent disturbing thoughts, images or |
| | impulses experienced as intrusive and marked anxiety |
| | Excessive repetitive behaviours and/or mental acts |
| | Frequent thoughts of violence |
| | Fear of being poisoned/ contaminated |
| | Feelings of doubt |

Table 3.6 Obsessive Compulsive Disorder Syndromes

| Anxiety Disorder | Major Symptoms of Generalized Anxiety Disorder (MSGAD) |
|---|---|
| Generalized Anxiety Disorder | Difficult Concentrating |
| | Being easily fatigue |
| | Muscle Tension |
| | Sleep Disturbance |
| | Irritability |

Table 3.7 Generalized Anxiety Disorder Syndromes

| Anxiety Disorder | Major Symptoms of severe stressors disorders (MSPTSDASD) |
|---|---|
| Disorders due to severe stressors | Re - experiencing of the traumatic events |
| | Flashbacks |
| | Nightmares |
| | Avoiding things that remind the trauma |
| | Intense physical reactions to reminders of the event |
| | Increased arousals of traumatic events |

Table 3.8 Posttraumatic and Acute stress disorders Syndromes

To recap the chapter, the transformation process of acquiring required knowledge from human experts and document analysis was helpful in pinpointing the specific parameters fundamental for the diagnosis of anxiety disorders. From thereon it is possible to arrive at the ‘Goals’ and build the ‘Rule Base’ by formulating the rules, which is discussed in the following chapter.

# CHAPTER FOUR

# KNOWLEDGE REPRESENTATION

## 4.1 Introduction

As discussed in literature review chapter, knowledge representation is one of the basic phases of knowledge based system development, and it is the process of encoding domain knowledge in computer understandable form using knowledge representation methods. In the earlier chapter, the domain knowledge has been collected, structured and analyzed. This knowledge is represented by using rule based representation technique in SWI Prolog. So, this chapter deals with the development of the prototype knowledge based system.

The development of the prototype involves user interface, knowledge base, explanation facility and inference engine as shown in the following figure (Figure 4.1).

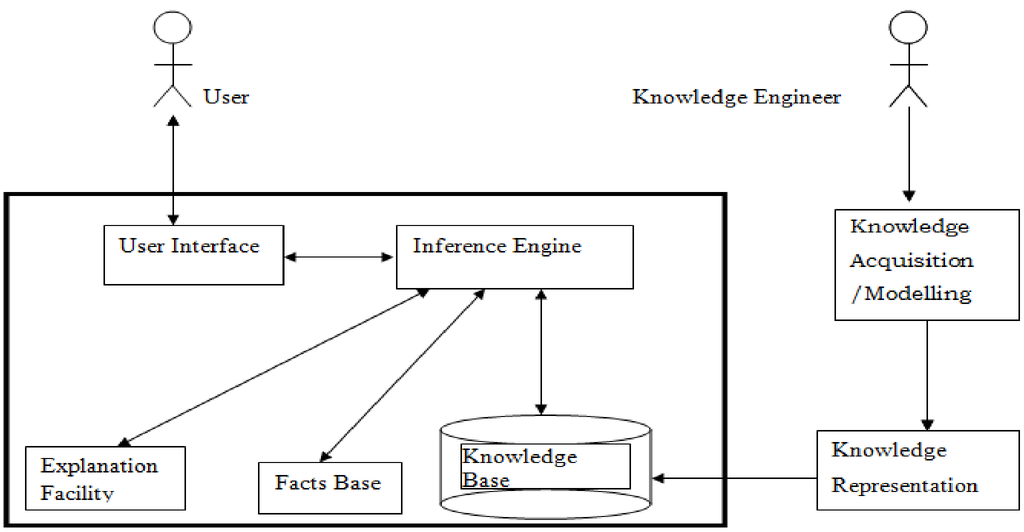



Figure 4.1 the Prototype Knowledge Based System Architecture

The knowledge acquisition and knowledge representation activities are performed by the knowledge engineer. The system and a user interacts with each other in such away that the system asks serious of questions and the user responds each question as “yes” or “no”. Based on the user responses, the system suggests the conclusion made with appropriate recommendations for the conclusion and with more explanations for the users “how” question. These basic components of the prototype are discussed under Section 4.3.

## 4.2 Goals

The reasoning mechanism of the prototype AMDDKBS (Anxiety Mental Disorders Diagnosis Knowledge Based System) is backward chaining (goal driven) reasoning approach. The goal driven approach is practical when there are reasonable number of possible final answers, as in the case of a diagnostic or identification system. The system methodically tries to prove or disprove each possible answer, gathering the needed information as it goes.

To decide the contents of the knowledge base, identifying the goals of what the system should aim to accomplish is the first task in this prototype knowledge based system development. Setting the goals help the system what tasks it performs and how to carry out those tasks.

Possible goals are identified based on the selected disorder types as discussed in the knowledge acquisition chapter (chapter three). During the process of inferences, eight goals are used as top goals and the rest goals are considered as sub goals. Based on this assumption, the prototype AMDDKBS top goals are:

- ✓ Hypothesis/Goal 1: Diagnosis (Panic Disorder)
- ✓ Hypothesis/Goal 2: Diagnosis(Agoraphobia)
- ✓ Hypothesis/Goal 3: Diagnosis (Social Phobia)
- ✓ Hypothesis/Goal 4: Diagnosis (Specific Phobia)
- ✓ Hypothesis/Goal 5: Diagnosis (Obsessive Compulsive Disorder)
- ✓ Hypothesis/Goal 6: Diagnosis (Generalized Anxiety Disorder)
- ✓ Hypothesis/Goal 7: Diagnosis (Posttraumatic Stress Disorder)
- ✓ Hypothesis/Goal 8: Diagnosis (Acute Stress Disorder)

In all goals, the inference engine manipulates symptoms of each goal/disorder by selecting rules from the knowledge base. To accomplish this activity, the inference engine starts from a goal by selecting a rule; searches the facts that satisfy the goal and then firing the rules accordingly. In other words, the system's inference engine proves facts and rules based on the given goal. First, the system checks whether anxiety disorders are present or not. If all the conditions are satisfied, the system assures the presence of anxiety disorders. Then, the diagnosis proceeds to panic, agoraphobia, social phobia, specific phobia, obsessive compulsive disorder, generalized anxiety disorder and reactions to severe stressors disorders accordingly.

## 4.3 The Structure of the Knowledge Based System

The prototype rule based system has five components as the knowledge base, the fact base, the inference engine, the user interface and the explanation module.

### 4.3.1 The Knowledge Base

The knowledge base of the prototype contains the domain knowledge (knowledge about anxiety mental disorders). The acquired domain knowledge is represented using rule based representation method as a set of "if – then" rules in the clause section of the program. The "if" side (also known as the left hand side) of the equation states the condition or conditions that must be true in order for the rule to apply an action and the "then" side of the equation specifies the appropriate action to take. The inference engine evaluates the "if" portion of a statement and concludes whether a goal is satisfied or not. If the goal is not satisfied, the inference engine proceeds to the next rule.

Rules for the knowledge base of the prototype are constructed based on the knowledge modelled using decision trees, which are discussed in the knowledge acquisition chapter.

To simplify formulating Prolog rules, the acquired knowledge is represented using the "if – then" form. These rules are the bases for the knowledge base construction. The following rules are sample rules of the knowledge base in their English like translation.

If the patient has anxiety about being in place from which escape might be difficult

And the patient has fear of being alone in public places

And/Or the patient feels fear of being alone at home/outside home

And/Or the patient feels sense of being lost

And/Or the patient has fear of having sudden

And/Or the patient has anticipatory anxiety

Then Agoraphobia will be diagnosed

If the patient has fear of public scrutiny

And the patient is ashamed (blushed)

And/Or the patient has fear of being watched

And/Or the patient fears judging by others

And/Or the patient has difficulty in being assertive

Then Social Phobia will be diagnosed

If the patient has fear of specific objects or specific situations

And the patient has excessive fear

And/Or the patient has marked and persistent worry

And/Or the patient heart is pounding

Then the patient is affected by Specific Phobia

If the patient has unrealistic on-going worry about a number of events

And the patient has sleep disturbance

And/Or there is concentration difficulty

And/Or the patient feels irritability

And/Or the patient is being easily fatigue

And/Or the patient has muscle tension

And/Or the worry is occurring at least for 6 months

Then Generalized Anxiety Disorder will be diagnosed

If the patient has got one or more traumatic events

And the patient has anxiety in response to a severe traumatic event

And/Or the patient is re-experiencing the trauma

And/Or the patient flashbacks the trauma

And/Or the patient has nightmares

And/Or the patient has avoidance of anything to do with the trauma

And/Or the patient has intense physical reactions to reminders of the event

And/Or the patient has increased arousal associated with the trauma

And/Or the traumatic event(s) have more than one month duration

Then Post – Traumatic Stress Disorder will be diagnosed

The knowledge base is constructed based on such English like rules by using SWI Prolog.

Sample Prolog rules of the prototype knowledge based system are presented in Appendix II.

### 4.3.2 The Facts Base

The facts base of the prototype knowledge based system holds basic facts about anxiety mental disorders. This facts base is constructed based on the knowledge gained from domain experts. The facts in the facts base are used to match against the ‘if’ (condition) part of rules stored in the knowledge base. To construct the facts base, some important attributes are identified based on their similarity nature of the facts.

### 4.3.3 The Inference Engine

The system uses backward chaining reasoning mechanism. During the reasoning process, the inference engine starts from the goal and searches backward to find facts, which satisfy the corresponding goal.

As decision trees of the anxiety disorders indicate (chapter three), during the diagnoses of anxiety disorders, a psychiatrist first asks the presence of irrational fear, avoidance, or increased arousal. Next, the psychiatrist tries to prove whether these symptoms are due to general medical conditions or substance uses like a drug abuse, a medication or a toxin. After then, he/she starts the diagnosis of anxiety disorders. The inference engine of the prototype knowledge based system follows the same procedures like the psychiatrist(s). The inference engine first checks the presence of irrational fear, avoidance, or increased arousal by using the first rule of the knowledge base.

**Rule 1:** isanxiety(Anxiety, Behaviour):-

```
anxiety_worry(Anxiety), Anxiety == 'yes' ;
 behaviours(Behaviour), Behaviour == 'yes',
symptom(gmc), nl.
```

From the above rule, if both or either of the two conditions are satisfied, this means if a patient has irrational fear, avoidance or increase arousal, the inference engine go to the next rule which talks about whether those fears, avoidances or increased arousals are co – existed with other general medical problems or not. To check the general medication problem of a patient, the inference engine confirms whether those anxiety symptoms occurred due to general medical conditions of the patient or not as indicated in the following rule.

**Rule 2:** isgmd(Anxietygmc):-

```
gmc(Anxietygmc), Anxietygmc == 'yes',
write('\nYour anxieties may be due to your general medical problem!\nSo, take the diagnosis of General Medical Conditions');
symptom(substanceuse),nl.
```

If those symptoms of anxiety are due to general medical conditions of the patient, the inference engine concludes that the anxiety symptoms are occurring due to general medical conditions of the patient and it gives recommendation for the patient to take general medical condition diagnosis.

On the other hand, if the patient is free from any co-existing medical problems, the inference engine passes to the next rule to check whether these symptoms are due to substance use or not. The inference engine uses the following rule to confirm whether the fears, avoidances, or increase arousals are due to substance use or not.

**Rule 3:** issubstanceuse(Anxietysu):-

```
su(Anxietysu), Anxietysu=='yes',

write('\nYour anxieties may be due to your substance use!'),

write('\nSo, take the diagnosis of Substance Induced Disorder'), nl;

symptom(panicn),nl.
```

After checking the presence of anxiety symptoms, which are free from other co – medical related problems and substance use, the system continues to diagnosis each anxiety disorder. The diagnosis starts from panic disorder and proceeds to agoraphobia, social phobia, specific phobia, obsessive compulsive disorder, generalized anxiety disorder, posttraumatic stress disorder and acute stress disorder respectively.

During the diagnosis of panic disorder, the inference engine checks primarily the presence of panic attacks. From the decision tree of the previous chapter, the prominent symptoms of panic disorder are the presence of recurrent unexpected panic attacks plus a month of worry, concern about the attacks. So, the inference engine searches facts to prove the presence of recurrent panic attacks with those fears by using the following rule.

**Rule 4:** ispanic(RECURRENT):-

```
feels(RECURRENT), RECURRENT == 'yes',
symptom(panic);
symptom(agoraphobian).
```

If there is recurrent panic attack, the inference engine goes in to detail diagnosis of panic disorder to reach a conclusion with appropriate recommendation. If not, it passes to the diagnosis of agoraphobia by using the major identified syndromes of panic (Table 3.2) and the criterion set on the decision tree about these symptoms (presence of one or more of the syndromes which is indicated in the table 3.2). The backward chaining of the entire knowledge based system uses the same procedure of panic disorder diagnosis. In other words, to diagnosis an anxiety disorder, first inference engine proves the presence or absence of a disorder by using fundamental symptoms of each disorder which is explicitly indicated in the decision trees of the previous chapter (chapter three). If the condition(s) are satisfied, the inference engine continues detail diagnosis of that disorder by using the identified syndromes of the corresponding disorder, if not it continues to the next rule.

Generally, the inference engine starts from the top level goal and proceeds to the sub goal by backtracking the rules and the facts. To execute a rule, the inference engine searching facts from the fact base and match those facts with variables in the rules of the knowledge base. If the conditions are satisfied, the rule is fired (executed). If not, the inference engine searches the next rule to be fired or gives a conclusion accordingly.

### 4.3.4 The User Interface

The user interface of the prototype is used as the means of communication between a user and the prototype knowledge based system. The first page of the user interface welcomes users and describes what the system does as shown in the figure below (Figure 4.2).

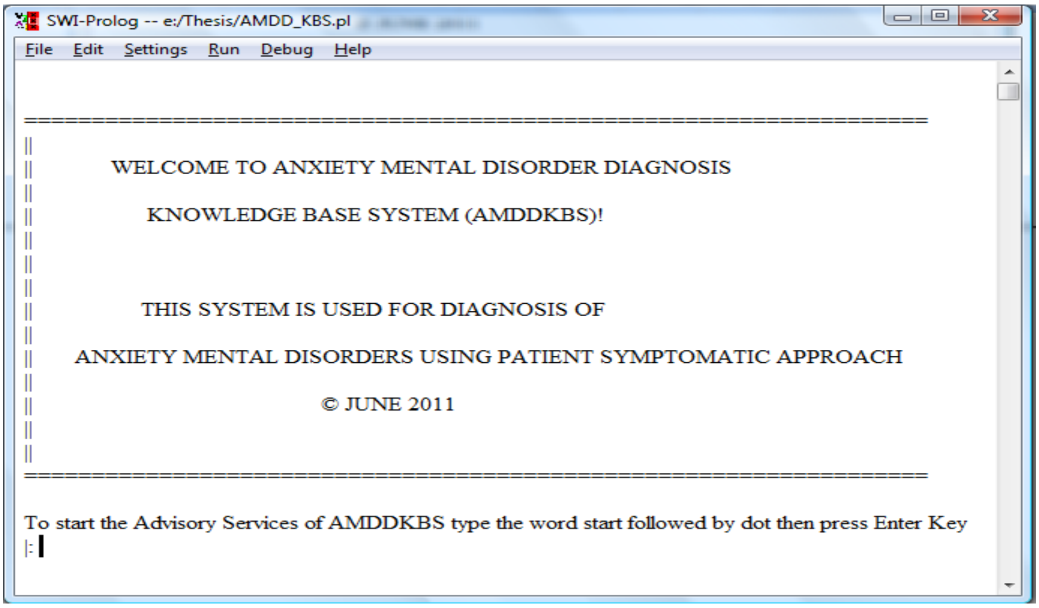



Figure 4.2 Welcoming Window of AMDDKBS User Interface

After the prototype displays the greeting page, a user can interact directly with the system by typing start followed by full stop next to the welcoming screen of the SWI Prolog window. As soon as a user types “start” followed by full stop, the system gives guide line for users by saying “Please respond the following questions by saying yes or no” and proceeds with asking the questions. After this, the system performs the diagnosis service as long as a user wants the system’s consulting service. The facts are asked to be answered as ‘yes’ or ‘no’. As discussed in the above section of this chapter, in the diagnosis process, the first target which will be checked is the occurrences of anxiety symptoms. If the system assured that the patient has at least one critical anxiety symptom which is free from general medication cases and substance use, it continues with a detailed diagnosis of each anxiety disorder. The following figure (Figure 4.3) shows the first three rules with all conditions are satisfied to check those symptoms.

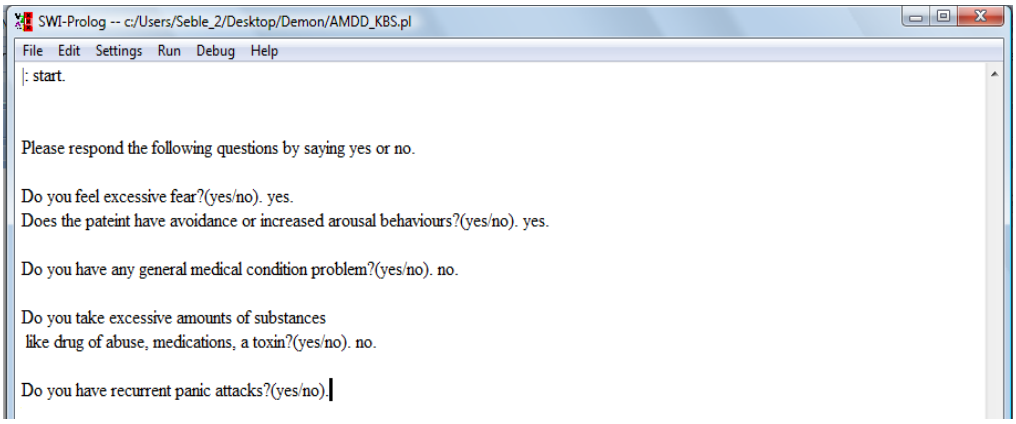



Figure 4.3 Dialog Windows between the Users and the System on Screening Anxiety Disorders

From the above figure, since the patient has excessive and irrational fear and avoidance or increased arousals which are free from general medical condition problems and substance use, the diagnosis of panic disorder is continued. As stated above, if there is panic attack the diagnosis of panic disorder is started. The following figure (Figure 4.4) shows detail diagnosis of panic disorder with all satisfied conditions.

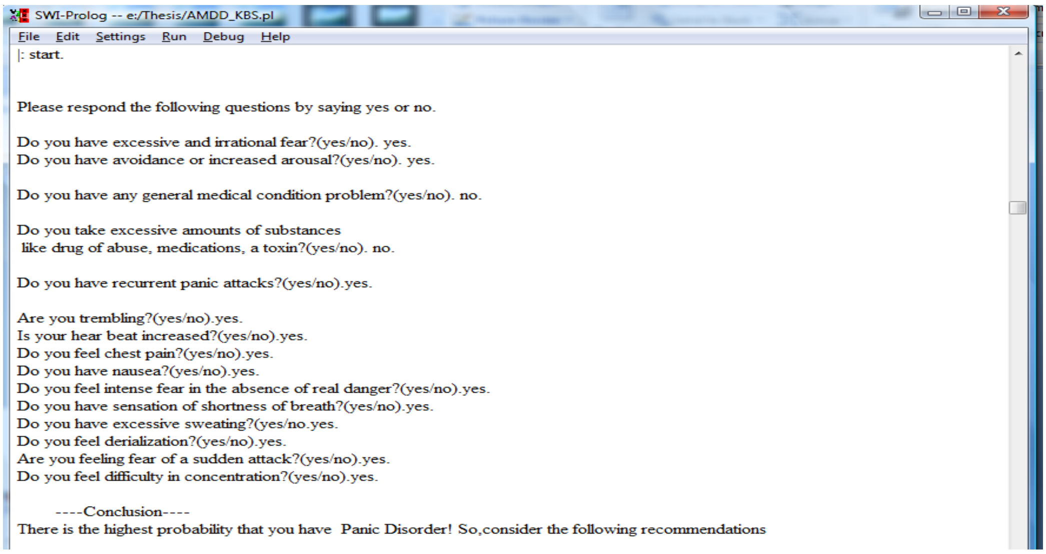



Figure 4.4 Sample Dialog Windows between the User and the System to Identify Panic Disorder with All Conditions Satisfied

The system diagnoses a patient and gives its conclusion together with best recommendations about the conclusions made. For instance, the detail diagnosis of panic disorder with all conditions satisfied together with the conclusions made and the recommendations given are indicated by the following figure (Figure 4.5).

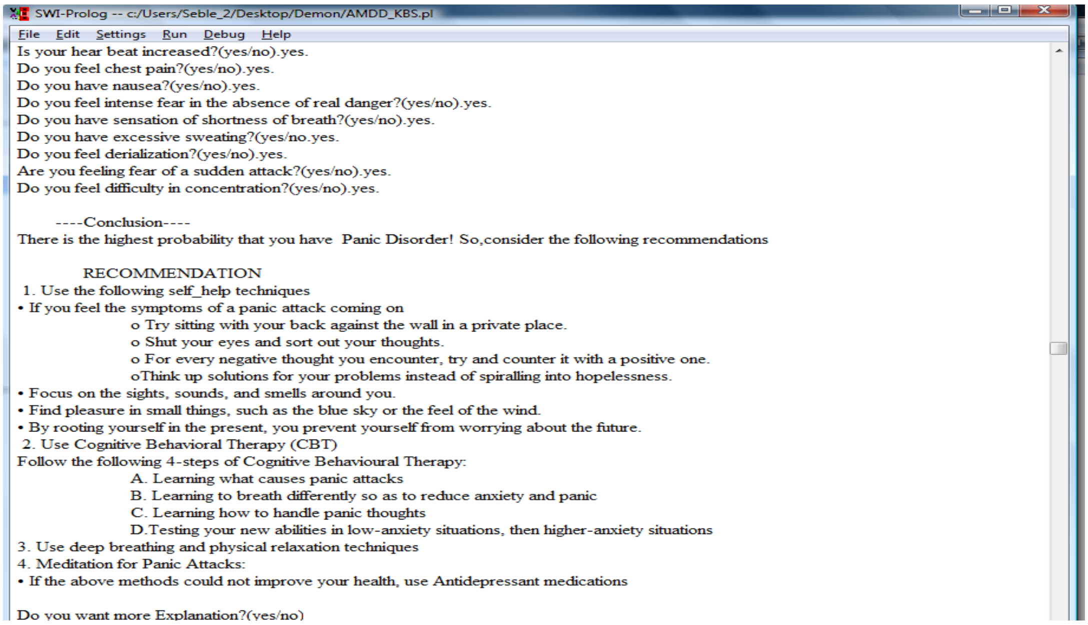
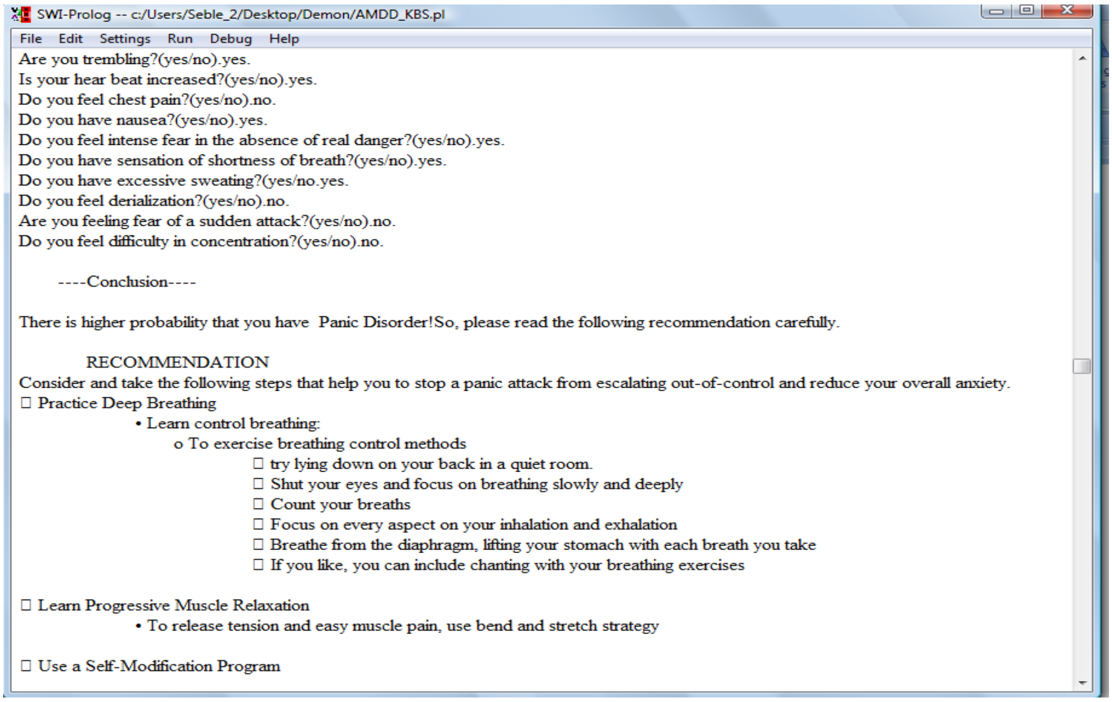



Figure 4.5 Sample Dialog Windows of the System's Conclusion and Recommendations

As shown in the above figures (Figure 4.4 and Figure 4.5), since all conditions are satisfied, the system concludes that the presence of panic disorder with the highest probability and forwards the appropriate recommendations. Similarly, as indicated in the decision tree structure (Figure 3.2) among the ten symptoms of panic disorder (Table 3.2), if there are at least four of them then the system concludes that the higher probability of the presence of panic disorder and suggests appropriate recommendations for it (in this case, psychotherapies only no medication). The following figure (Figure 4.6) illustrates the presence of some of the symptoms and the corresponding recommendations of the systems.


SWI-Prolog -- c:/Users/Seble_2/Desktop/Demon/AMDD_KBS.pl
File Edit Settings Run Debug Help
Are you trembling?(yes/no).yes.
Is your hear beat increased?(yes/no).yes.
Do you feel chest pain?(yes/no).no.
Do you have nausea?(yes/no).yes.
Do you feel intense fear in the absence of real danger?(yes/no).yes.
Do you have sensation of shortness of breath?(yes/no).yes.
Do you have excessive sweating?(yes/no.yes.
Do you feel derialization?(yes/no).no.
Are you feeling fear of a sudden attack?(yes/no).no.
Do you feel difficulty in concentration?(yes/no).no.

----Conclusion----

There is higher probability that you have Panic Disorder!So, please read the following recommendation carefully.

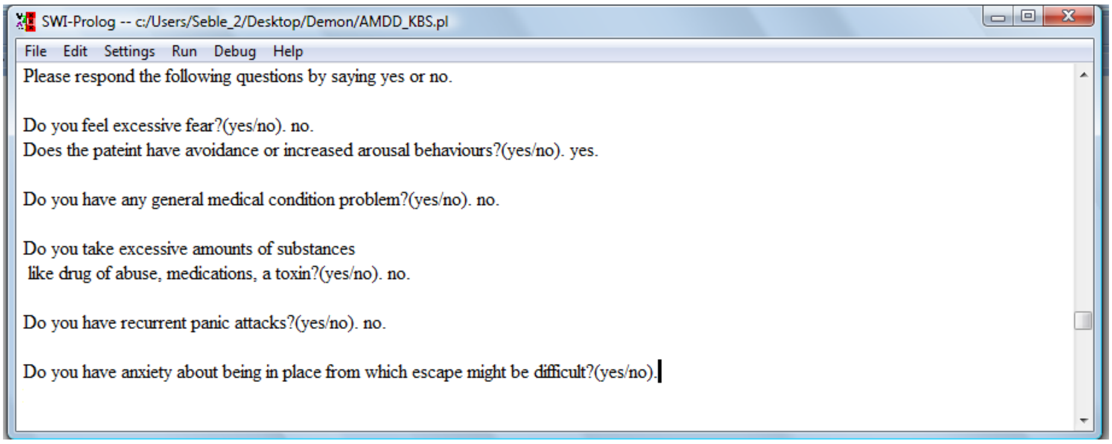
RECOMMENDATION
Consider and take the following steps that help you to stop a panic attack from escalating out-of-control and reduce your overall anxiety.
☐ Practice Deep Breathing
• Learn control breathing:
o To exercise breathing control methods
☐ try lying down on your back in a quiet room.
☐ Shut your eyes and focus on breathing slowly and deeply
☐ Count your breaths
☐ Focus on every aspect on your inhalation and exhalation
☐ Breathe from the diaphragm, lifting your stomach with each breath you take
☐ If you like, you can include chanting with your breathing exercises

☐ Learn Progressive Muscle Relaxation
• To release tension and easy muscle pain, use bend and stretch strategy

☐ Use a Self-Modification Program

Figure 4.6 Sample Dialog Windows between the User and the System to Identify Panic Disorder with Only Some Conditions Satisfied

On the other hand, as indicated in the decision tree structure (Figure 3.2) at the beginning of panic disorder diagnosis, if there is no panic attack, the system passes to agoraphobia diagnosis. The following sample figure (Figure 4.7) indicates the diagnosis of panic disorder with its fundamental condition is unsatisfied.


SWI-Prolog -- c:/Users/Seble_2/Desktop/Demon/AMDD_KBS.pl
File Edit Settings Run Debug Help
Please respond the following questions by saying yes or no.

Do you feel excessive fear?(yes/no). no.
Does the pateint have avoidance or increased arousal behaviours?(yes/no). yes.

Do you have any general medical condition problem?(yes/no). no.

Do you take excessive amounts of substances
like drug of abuse, medications, a toxin?(yes/no). no.

Do you have recurrent panic attacks?(yes/no). no.

Do you have anxiety about being in place from which escape might be difficult?(yes/no).

Figure 4.7 Sample Dialog Windows between the User and the System on Identifying Panic Disorder with an Unsatisfied Condition

Similarly, the interaction between the user and the system to identify each anxiety disorder continues in the same manner as the above sample panic disorder identification process. The system uses the decision tree structures by integrating the syndromes of each anxiety disorder which are presented in the knowledge acquisition chapter (chapter four).

### 4.3.5 The Explanation Module

In this prototype, the 'how' feature explanation facility is integrated. This 'how' feature of the prototype is incorporated to give more explanation about the conclusion made by the system. The following sample windows (Figure 4.8 and Figure 4.9) indicate the 'how' explanation of the conclusions made about generalized anxiety disorder and panic disorder, respectively. As indicated in the following figures, the system concludes that the patient is affected by generalized anxiety disorder and panic disorder, respectively. After giving the appropriate recommendations, the system invites the patient(s) whether he/she wants more explanation about the conclusions made by asking "Do you want more explanation?" After the patient chooses "yes" option, the system gives brief explanation about the conclusions made about generalized anxiety disorder and panic disorder respectively.

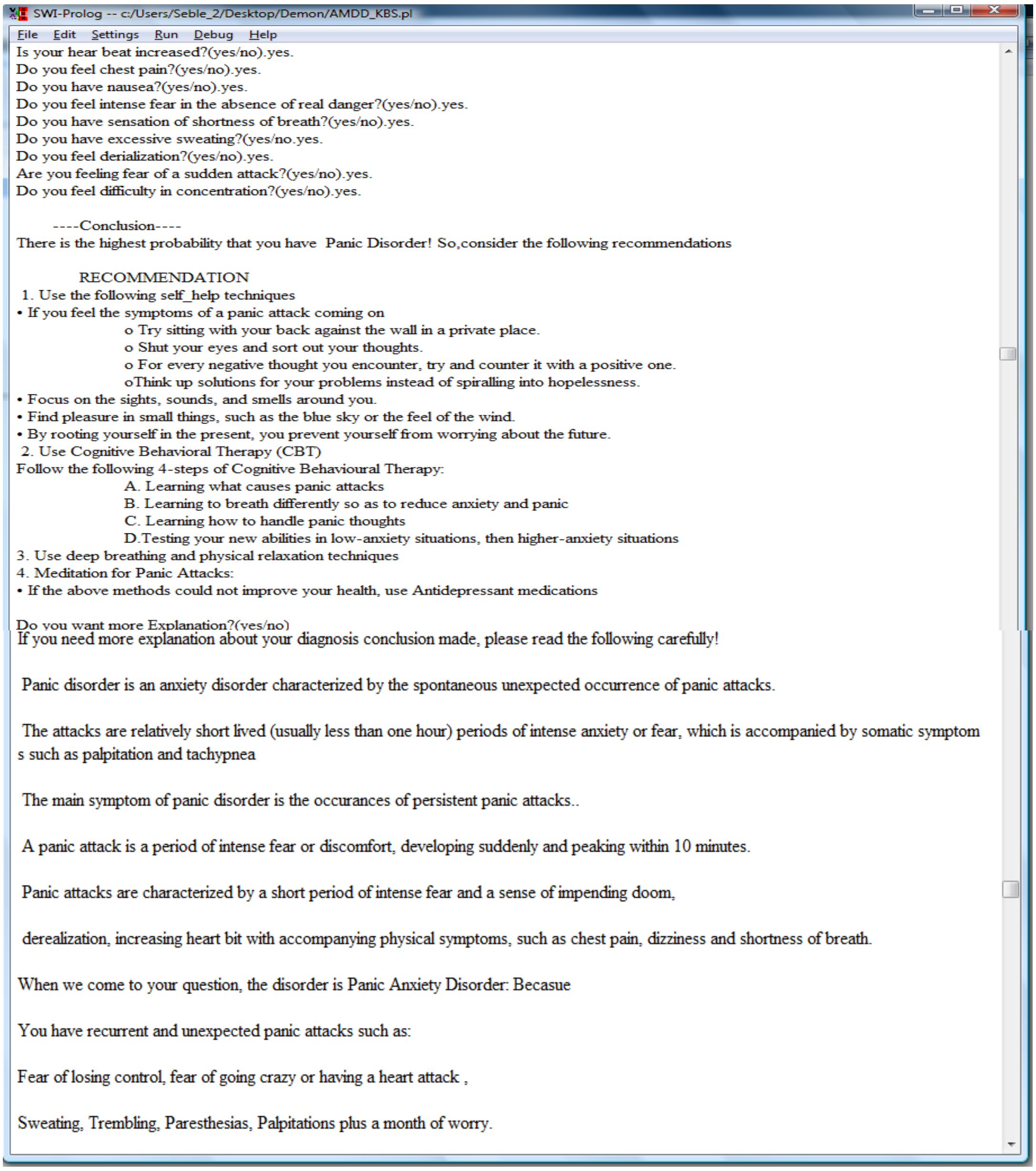



Figure 4.8 Sample How Explanation Facility Dialog Windows for Generalized Anxiety Disorder

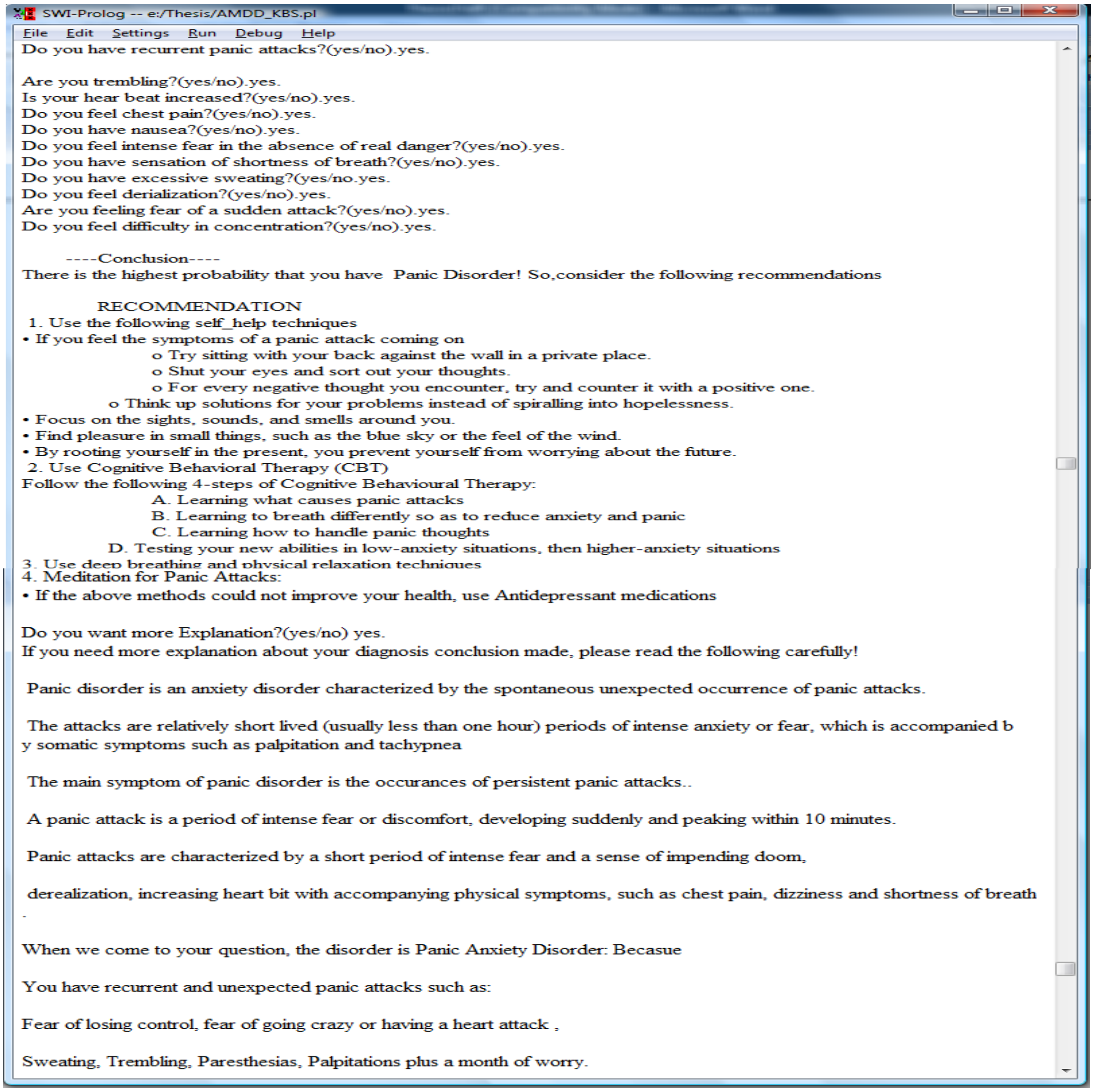



Figure 4.9 Sample How Explanation Facility Dialog Windows for Panic Disorder

To recapitulate the chapter, to represent the acquired knowledge (chapter three) a set of rules is created where each rule contains an IF part that has the symptoms and in THEN part that has the disease/disorder that should be realized. The prototype knowledge based system uses backward chaining reasoning method. In addition, the architecture of the prototype holds core rule based system components like knowledge base and inference engine components. After the system is developed, assessing its performance is an important activity to validate the system's accuracy and to ensure the systems user acceptance issues. Therefore, the following chapter discusses about the evaluation and testing procedure of this prototype knowledge based system.

# CHAPTER FIVE

# TESTING AND EVALUATION

## 5.1 Introduction

The developed system, Anxiety Mental Disorder Diagnosis Knowledge Based System (AMDDKBS), is tested and evaluated to check whether the objectives of the research are achieved or not. The evaluation and testing issue of the system is summarized by the question "Does AMDDKBS give acceptable and accurate advisory service to diagnosis patients with anxiety disorders?" To address this question, predictive validation testing method and visual interaction evaluation technique are used. In this research predictive validation method is used to test the performance of the system whereas visual interaction method is used to address user acceptance issues.

Predictive validation test involves the use of historic test cases and comparing the system's output with known results. Additionally, visual interaction evaluation method allows the user to make comments while interacting with the system. In other words, predictive validation helps to test the ability of AMDDKBS to diagnose patients with anxiety disorders whereas visual interaction method helps to assess the performance of the system from users' perspective. The details of the testing and evaluation processes of AMDDKBS are discussed in the following sections of this chapter.

## 5.2 User Acceptance Evaluation

As discussed in the literature review chapter, user acceptance is the basic issue for the application of successful and effective knowledge based system. To address the issue of user acceptance, the researcher uses visual interaction along with both close ended and open ended questionnaires.

Visual interaction evaluation method allows the domain expert to make comments by interacting with the system. It is used to evaluate the performance of the prototype from the users' point of view. Similarly, the questionnaires are helped to assess and evaluate the acceptability and applicability of AMDDKBS in the domain area. Additionally, they are used to consider the attitude of the users about the prototype knowledge based system. These questionnaires are attached in Appendix III.

The evaluation questionnaires are adapted from Pu and Chen (2010) that used to evaluate the model called ResQue (Recommender Systems' Quality of user experience) with users' point of view and Redeit (2006) which used for evaluating the rule based prototype system for HIV pre test counselling by domain experts. The adopted questionnaires are modified to some extent to fit them to the context of this study.

For the purpose of user acceptance evaluation process, ten domain experts (nine experts from Amanuel Mental Specialized Hospital and one expert from Rank Higher Clinic) selected as system evaluators. These experts are selected purposively from physiologists and psychiatrists of the hospital and the clinic. Most of the selected experts are working in the anxiety disorders case related issues. Additionally, these experts are from two groups of domain experts, i.e., experts who have prior knowledge about the system during their involvement in the different stages of the prototype development and those who do not have prior knowledge. Before starting the evaluation process, the researcher gave explanation about the system. This explanation helped the expert evaluators to avoid the variation of awareness among them about the prototype knowledge based system.

After evaluators are interacting with the system by using test cases, which have similar parameters with the rules in the prototype, they give their feedbacks on the questionnaires.

The first seven questions are close ended questions. Among them, the first three questions are on the user interface design aspects, which is basic for users interface satisfaction. These questions assessed whether the user interface of the system is easy to use, attractiveness and time efficiency of the system. The next four questions are used to evaluate the prototype's accuracy, adequacy, the problem solving ability and significance of the prototype knowledge based system in diagnosing anxiety disorders.

All these seven closed ended questions answered as Excellent, Very Good, Good, Fair, and Poor. Therefore, for the comfort of analysing the relative performance of the system based on users evaluation, the researcher assigned numbers for each word as Excellent = 5, Very good = 4, Good = 3, Fair = 2 and Poor = 1. The system evaluators give the value for each closed ended questions. The following table indicates the results obtained.

| **No.** | **Questions** | **1** | **2** | **3** | **4** | **5** | **Average** |
|---|---|---|---|---|---|---|---|
| 1. | Is the prototype easy for you to use and interact with it? | 0 | 0 | 0 | 5 | 5 | 4.5 |
| 2. | Is AMDDKBS attractive? | 0 | 0 | 1 | 4 | 5 | 4.4 |
| 3. | Is the system more efficient in time? | 0 | 0 | 0 | 6 | 4 | 4.4 |
| 4. | How accurately does the system reach a decision about anxiety disorders identification? | 0 | 0 | 0 | 6 | 4 | 4.4 |
| 5. | Does the system incorporate sufficient knowledge to diagnoses anxiety disorders? | 0 | 2 | 0 | 5 | 3 | 3.9 |
| 6. | Is the system giving the right conclusions and the right recommendations? | 0 | 1 | 0 | 4 | 5 | 4.3 |
| 7. | How do you rate the significance of the system in the domain area? | 0 | 0 | 1 | 5 | 4 | 4.3 |
| | | **Total Average** | | | | | **4.31** |

Table 5.1 AMDDKBS Users Performance Evaluation Results

As shown in Table 5.1, 50% of the respondents rated ‘easiness to use and interact with the prototype’ as very good while the remaining 50% responded the same question as excellent. In the same way, for question ‘attractiveness of the prototype’ 10% of the respondents evaluated as good, 40% of them as very good and the rest

50% of them as excellent. Similarly, 60% of the respondents rated the criterion ‘more efficient in time’ as very good and the remaining 40% of them as excellent.

Additionally, 60 % of them responded as very good to the criteria ‘the accuracy of the prototype to make correct decision’ whereas the rest 40 % of them rated the criteria as excellent. Likewise, for the criteria ‘the prototype incorporate adequate knowledge’ 20% of the respondents rated it as fair, 50% as very good and the rest 30% as excellent. As well, using the criterion ‘the ability of the system in making right conclusions and right recommendations’ 10% of the respondents evaluated as fair, 40% as very good and the rest 50% as excellent. Lastly, concerning to the question related to the ‘significance of the prototype’ 10% of the respondents ranked as good, 50% of them as very good and the rest 40% of them as excellent.

Based on the results obtained, the overall average performance of the prototype with users’ point of view is 4.31 on a scale of 5, where 5 = Excellent, 4 = Very good, 3 = Good, 2 = Fair and 1 = Poor. This result indicates that about 86% of users are satisfied by the performance of the system.

In addition to the close ended questions, the evaluators give their feedbacks on open ended questions. Their feedbacks include the missed knowledge from the system, the limitations, strengths, and so on.

The open ended questions consisted of eight questions. The first question deals with the differences among human experts and the prototype knowledge based system in diagnosing anxiety disorders. Most of the evaluators reply the same answer. They said that there is higher similarity between the expert and the knowledge based system. As they said, the difference only occurs in the case of mental status examination. Domain experts use mental status examination during the diagnosis of mental disorders. They look the patient’s appearance, dressing, hearing style, sitting style, walking style, speaking, the tone of the sound, etc. Nevertheless, the prototype does not have such kinds of ability. As a result, it lacks a bit of flexibility. On the other hand, some respondents said that no difference except experts make misdiagnosis and the knowledge gap from expert to expert might lead to unwanted kinds of diagnosis. Similarly, one respondent suggested that “there is a difference between them because:

1. The system is an accurate measure – no room for guess
2. It is important for storing reliable knowledge
3. Every body will have a copy of it and use for next time."

Additionally, the other two questions are regarding to issues that are covered and uncovered by the system. All of them except two (who do not say anything) said that anxiety disorders are well covered. These include the identification of a person with anxiety disorders (sign and symptom of posttraumatic disorder, obsessive-compulsive disorder, generalized anxiety disorder, phobic, and panic disorder) and therapies for each. On the other hand, regarding to the uncovered areas and missed knowledge from the system question, most of the evaluators said that nothing is uncovered for anxiety disorders diagnosis except the mental status examination.

The next open-ended question the respondents were asked was "In your opinion, can knowledge based system (such as the prototype presented by AMDDKBS) handle the diagnoses task of anxiety disorders?" This criterion is set to get users' outlook about the prototype knowledge based system in the domain area (anxiety disorders diagnoses). All of them said yes. They said, since it is working based on experts knowledge, it handles the diagnoses tasks of anxiety disorders.

Furthermore, concerning to the adequacy of the knowledge in the knowledge based system, most of the respondents reply that the knowledge of the system is adequate, but the system must be updated as science and technology advances. The other two respondents answered no because the system should include other disorders to make full diagnoses of mental disorders. Likewise, about the significance of the system in the domain area, all respondents respond that the system has significance in the domain area. As one respondent said, "the system has indispensable importance to people working in the area. Firstly, it can save experts' time and energy that they waste while referring books. Secondly, it can help to diagnose the disorder accurately." Similarly, others said that the system has great importance in the domain area, particularly for primary health care workers. In addition, the evaluators make suggestion about the limitations and strengths of the prototype. Some of the limitations are:

- ✓ Exclusion of mental status examination that is important for confirmation and reaching diagnosis.
- ✓ Probably people who lack computer skills and computer access might not implement it.
- ✓ It has language barriers.
- ✓ The system interacts with the user using only 'yes' or 'no' replies. Therefore, it lacks some flexibility and no facial expression observation.

On the other hand, some of the strengths of the system mentioned by the respondents are:

- ✓ Save time and manpower
- ✓ More accurate
- ✓ Increase patient satisfaction
- ✓ Applicable any where, even at home we can cure ourselves by having the software
- ✓ Easy to use
- ✓ Increase early detection and treating of anxiety disorders
- ✓ Facilitate self referral
- ✓ Improve Health Management Information System (HMIS)

## 5.3 Testing AMDDKBS by Using Test Cases (Predictive Validation)

This testing strategy is used to validate the achievement level of the system and to measure the accuracy of it. To address the issue of validation, twenty test cases are used from Amanuel Mental Specialized Hospital. For the test, cases that have similar parameters with the prototype are selected purposively. These test cases are categorized in to three based on their resemblances and in their characteristics. These are generalized anxiety disorder cases, panic and phobic disorders cases, and obsessive compulsive and stressor disorders cases.

Additionally, among the ten expert evaluators (section 5.2) four experts (who are from Amanuel Mental Specialized Hospital) are selected as test case evaluators. To select these evaluators, first the participants in the visual interaction testing procedure (section 5.2) are grouped in to four categories as trainee psychiatrists, psychologists, psychiatrist nurses and psychiatrist doctors. From each cluster, one expert evaluator is selected randomly, and the test cases distributed equally for each expert evaluator (five cases per evaluator).

During the testing procedure, the expert evaluators identify correctly and incorrectly diagnosed cases by comparing the decisions made by the system with that of the experts' decision on those cases.

The result of the comparison shows the prototype knowledge based system has close decision making in diagnosing patients with anxiety disorders. As show below (Table 5.2), the result of the testing has revealed 85% accuracy in diagnosing anxiety disorders.

The major problem which is observed during this testing process is the prototype does not give possible solutions for those problems that are out of the rule. Hence, other knowledge representation techniques such as case based representation technique, which enable the system to learn from past human practices, should be incorporated with the rule based prototype. Table 5.2 below shows the test results by using test cases.

| Selected Cases | Total number of cases selected for testing | Number of correctly Diagnosed cases | Number of Incorrectly Diagnosed cases | The accuracy of the prototype in % |
|---|---|---|---|---|
| Generalized Anxiety Disorder cases | 7 | 6 | 1 | 85.71% |
| Panic & Phobic disorder cases | 7 | 5 | 2 | 71.4% |
| Obsessive Compulsive and Stressor cases | 6 | 6 | 0 | 100% |
| Total | 20 | 17 | 3 | 85.00% |

Table 5.2 Testing the Accuracy of AMDDKBS Using Test Cases

## 5.4 Discussion

The evaluation and testing procedures help to address the question of user acceptance and accuracy of the prototype.

Visual interaction and questionnaires methods are used to assess users' acceptance issues and applicability of the prototype. Based the evaluation results obtained from visual interaction along with closed ended questions none of the evaluators respond as poor. On the other hand, evaluators reply fair three times (4.3%), good two times (2.9%), very good thirty five times (50%) and excellent thirty times (30.7%). The following table summarizes the results obtained on closed ended questions.

| **Respondents Who Respond as** | **Poor (1)** | **Fair (2)** | **Good (3)** | **Very Good (4)** | **Excellent (5)** | **Average** |
|---|---|---|---|---|---|---|
| Total Number | 0 | 3 | 2 | 35 | 30 | **4.31** |
| %age out of 100% | 0 | 4.3% | 2.9% | 50% | 42.8% | **86.2%** |

Table 5.3 Users Evaluation Result Summary on Closed Ended Questions

As shown in the above table (Table 5.3), the overall average user acceptance evaluation of the prototype knowledge based system is about 86.2%. This means the prototype is accepted by 86.2% of respondents. Therefore, above 85% of users are satisfied with the easiness, attractiveness, speed, accuracy, adequacy, problem solving ability and the significance of the prototype knowledge based system in the domain area. This implied that the prototype modelled relevance and satisfactory domain knowledge in useful way and it performs well in making right decisions on the diagnosis of anxiety disorders.

Similarly, concerning to open ended questions, most the evaluators give valuable feedbacks and comments. As discussed above users showed great interest to use the prototype in their working area with small modification (inclusion of other disorder categories like mood, psychotic, somatoform, substance induced and personality disorder categories).

Additionally, the testing procedure by using historic cases helped to analyze the accuracy of the prototype knowledge based system. The result obtained using test cases indicate that the prototype has close decision making with domain experts, with 15% variation, ability to diagnose anxiety disorders.

Generally, all the evaluation and testing results of the prototype show encouraging finding for further research work to fully implement and apply knowledge based systems technology in diagnosing patients with mental disorders. Therefore, from the research findings, it is possible to conclude that the research achieve its objectives that are designed for.

# CHAPTER SIX

# CONCLUSION AND RECOMMENDATIONS

## 6.1 Conclusion

Mental health issue is the basic concern for the better life of everybody. Mental health problems touch every aspects of human life such as humans' general health condition, work, family life, social relations, etc.

However, mental health issue is the neglected issue throughout the world. Particularly, in developing countries, mental health has the least attention it deserves. Ethiopia is one of the developing countries. In Ethiopia, mental health issue is not getting sufficient attentions.

The major challenge for mental health service in the country is shortage of skilled mental health professionals. In Ethiopia, the number of mental disorder patients and mental health professionals are disproportionate too. Due to this the distribution of mental health professionals is greatly unfair. Lacks of knowledge among primary health care workers, the little allocation of budgets for mental health issue, and the lack of awareness about mental illnesses are the other challenges that become obstacle to address mental health services satisfactorily.

This thesis research make in an effort to explore the application of knowledge based systems in mental disorder diagnosis and develop prototype knowledge based system for anxiety disorders diagnosis. This system helps to identify and screen out the disorder type and the primary actions to be taken for the identified disorder accordingly.

The knowledge domain is acquired with extensive interviewing and consultations with domain experts in the field of mental disorders diagnoses and through document analysis. The acquired knowledge is modelled using decision tree structure and then the modelled knowledge is represented in to rule based system by using 'if…then' rules. The prototype (AMDDKBS) is developed by using SWI Prolog implementation tool. AMDDKBS uses backward chaining, which was found to be appropriate in medical domain diagnosis and diseases identification.

Users interact with the prototype by using natural languages. In other words, the prototype and users interact with each other through a serious of questions and users inputs. The prototype asks a serious of questions whereas users reply as “yes” or “no” accordingly. After the prototype reaches to a conclusion, it provides the identified disorder type together with the appropriate recommendations to be taken to overcome the identified problem.

To test AMDDKBS, visual interactions together with questionnaires and predicative validation technique were used. Domain experts are involved in the testing procedures of AMDDKBS and provide their pertinent feedbacks along with long discussion with the developer. Moreover, the accuracy of AMDDKBS using predictive validation technique is 85%.

AMDDKBS has been adequate in providing diagnosis of anxiety disorders but it cannot perform satisfactorily in cases the problem is outside its knowledge domain. AMDDKBS has also been able to provide useful advices on each anxiety disorder types and the necessary cares that the patient ought to take.

The prototype knowledge based system performs well and meets the objectives of the research. This prototype provides clear view for the developer and domain experts about the integration of knowledge based system technology in mental disorders diagnoses. Through little modification of it and/or addition of new rules, to include other disorder categories, the knowledge based system can be applied fully in the diagnoses of mental disorders.

Generally, in this research, the applicability of knowledge based system is proved as useful approach for facilitating mental disorder diagnoses services, and the research will initiate interests in to its use in the country.

## 6.2 Recommendations

The study achieves its objectives by demonstrating the applicability of rule based system by developing AMDDKBS with hopeful performance and user acceptance. This thesis research is the promising study for further research works to fully implement the knowledge based system in the domain area. As a result, the following recommendations are given based on the observed opportunities and uncover areas by this research. These recommendations are made for further investigations to fully implement the functionality of the prototype or to develop a new knowledge based system in the domain area.

- Due to the short time available for the research, the study attempted to develop advisory knowledge based systems for anxiety disorders (for about eight disorders). However, the scope of the knowledge based system should be expanded to include other mental disorder categories such as mood disorders, psychotic disorders, somatoform disorders, substance induced disorders and adjustment disorder.
- Mental disorder diagnosis is somewhat complex when compared to other disease diagnosis. It involves both physical examination and mental status examination. Therefore, further investigation should be done to integrate an intelligent agent that has the capability to perform mental status examination and observation of facial expressions of a patient.
- The scope of the prototype is limited to identifying anxiety disorders and recommending first line treatments and medications, particularly psychotherapy recommendations. For chronic and acute anxiety disorders detail specification of medications are required. Therefore, further investigation should be done on pharmacotherapy treatment planning of mental disorders.
- In rule based systems, the acquired examples are used to construct decision rules. These rules are further used to make decisions regarding new, unknown cases. However, rule based systems are not able to learn from experience and do not operate with cases which have not matching facts in the rule base of the systems. As a result, the development of self learning system should be considered by using neural networks. Neural networks have the ability to

"learn" from the observed data. Therefore, incorporating a self learning facility that will allow the system to add more results to its knowledge base whenever it faced with a decision that is not incorporated in the original design is essential.

- To enhance the performance of the prototype knowledge based systems, the hybrid strategy approaches should be investigated which combines case-based reasoning. The Inclusion of case based reasoning helps the system to learn from documented experiences.

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# APPENDIXES

## Appendix I

## Interview Questions

After introducing the objective of the study and requesting the respondents' participation in the study, the interviewer records their answers by using paper and pen for the following questions. The following are questions that are asked during the interview with domain experts.

1. What are the different types of anxiety disorders? Which types of anxiety mental disorders are mostly occurring in patients who attend in this health institution?
2. How does the identification of each anxiety disorder approval process go on?
3. What are the basic steps that are carried out during the diagnosis of anxiety mental disorders?
4. How does detail diagnosis of anxiety disorders take place?
5. What are the important points that you take in to account when making diagnosis of anxiety mental disorders?
6. How does diagnosis for each type of anxiety disorders proceed?
7. What are the major issues covered by the diagnosis processes of each anxiety disorder?
8. How do you identify the major symptoms of each anxiety disorder?
9. What are the major symptoms and complications for each anxiety disorder?
10. List the major and critical symptoms of each anxiety disorder that enable you to decide the presence of an anxiety disorder.
11. After completing the diagnosis, what are the major decisions that you may make? Or what are the major important actions that you take in to account?
12. Do you have standardized guidelines for mental disorders diagnoses usage?
13. If your answer for question number twelve is yes, to what extent do you follow the guideline?
14. What are the recommended treatments and suggestions for each type of anxiety disorder?
15. What are the major difficulties and challenges in mental disorders diagnosis?

## Appendix II

### Sample Rules from the Knowledge Base

```
isanxiety(Anxiety,Behaviour):-
        anxiety_worry(Anxiety), Anxiety=='yes' ;
        behaviours(Behaviour), Behaviour=='yes',
        symptom(gmc), nl; symptom(ptsdasdn), nl.
isgmd(Anxietygmc):-
        gmc(Anxietygmc), Anxietygmc=='yes',
        write('Take the diagnosis of General Medical Conditions'), nl;
        symptom(substanceuse), nl.
issubstanceuse(Anxietysu):-
        su(Anxietysu), Anxietysu=='yes',
        write('Consider Substance  Induced Disorder  diagnosis'), nl;
        symptom(panicn), nl.
ispanic(RECURRENT):-
        feels(RECURRENT), RECURRENT == 'yes',
        symptom(panic),nl;
        symptom(agoraphobian),nl.
ispanic(RECURRENT, Breath, Doubtfully, Paresthesias, Fear, ND, DF):-
        feels(RECURRENT),RECURRENT=='yes', breaths(Breath), Breath=='yes',
        feeling(Doubtfully),Doubtfully=='yes', body(Paresthesias),
        Paresthesias=='yes',
        fears(Fear),Fear=='yes', faced_difficulty(ND), ND=='yes',
        faced_difficultys(DF), DF=='yes',
```

```
        write('\n\t----Conclusion----\n'),
        disorder(panic),nl,recommendation(panic),nl,symptom(panics),nl;
isagoraphobia(Anxiety):-
        anxiety(Anxiety), Anxiety=='yes',
        symptom(agoraphobia), nl;
        symptom(socialphobian), nl.
isagoraphobia(Trapped, Fear_of, Alone, Helpless, Attack, Terror):-
        feel(Trapped),Trapped == 'yes',  fear(Fear_of),  Fear_of =='yes',
        fear(Alone),Alone=='yes', feel(Helpless), Helpless=='yes',
        fear(Attack), Attack=='yes', feel(Terror),Terror=='yes',
        write('\n\t----Conclusion----\n\n'), nl,
        disorder(agoraphobia),nl,recommendation(agoraphobia),nl,symptom(agoras),n
        l.
issocialphobia(PUBLIC_SCRUTINY):-
        fear(PUBLIC_SCRUTINY), PUBLIC_SCRUTINY=='yes',
        symptom(socialphobia);
        symptom(specificphobian),nl.
issocialphobia(PUBLIC_SCRUTINY, ASHAMED,
DIFFICULTY_BEING_ASSERTIVE,SHORTBREATH,A):-
        fear(PUBLIC_SCRUTINY), PUBLIC_SCRUTINY=='yes',
        feeling(ASHAMED), ASHAMED=='yes',
        ability(DIFFICULTY_BEING_ASSERTIVE),
        DIFFICULTY_BEING_ASSERTIVE=='yes',
        breath(SHORTBREATH),SHORTBREATH=='yes', a(A),A=='yes',
        write('\n\t----Conclusion----\n\n'),
```

```
        disorder(socialphobia),nl,
        recommendation(soical_phobia),
        nl,symptom(social), nl.
isspecificphobia(Cued_by, Specific):-
        anxiety(Cued_by),Cued_by=='no', fears(Specific), Specific=='no',
        symptom(ocdn),
        anxiety(Cued_by),Cued_by=='yes', fears(Specific),Specific=='no',
        symptom(gadn),nl;
        symptom(specificphobia), nl.
isspecificphobia(Cued_by, Specific, Persistent, Sign):-
        anxiety(Cued_by),Cued_by=='yes', fears(Specific), Specific=='yes',
        anxiety(Persistent),Persistent=='yes', bodys(Sign), Sign=='yes',
        write('\n\t----Conclusion----\n\n'),
        disorder(specificphobia), nl,
        recommendation(specific_phobia),nl,symptom(specific),nl.
isOCD(ObsComp):-
        obssession(ObsComp), ObsComp=='yes',
        symptom(ocd);
        symptom(gadn),nl.
isOCD(ObsComp, Recurrent, Repetitive, Violences, Harm):-
        obssession (ObsComp),ObsComp=='yes',
        feeling(Recurrent), Recurrent=='yes',
        feeling(Repetitive), Repetitive=='yes',
```

```
        feel(Violences), Violences=='yes', fear(Harm), Harm=='yes',

        write('\n\t----Conclusion----\n\n'),

        disorder(obsessive_complusive),nl,
        recommendation(obsessive_compulsive),nl,symptom(ocdds),nl.

isgad(Worry,SixM):-

        anxiety_and_worry(Worry),Worry=='yes',

        duration(SixM), SixM=='yes',

        symptom(gad), nl;

        symptom(ptsdasdn),nl.


isgad(MFU,MMC,F,RT,Excessive,Irritablilty):-

        feel(MFU),MFU == 'yes', sleep(MMC), MMC =='yes',

        fatigue(F),F =='yes', body_movment(RT),RT=='yes',

         anxiety_and_worry(Excessive), Excessive=='yes',

        body(Irritablilty), Irritablilty=='yes',

        write('\n\t----Conclusion----\n\n'),

        disorder(generalized_anxiety_disorder),nl,

         recommendation(generalized_anxiety), nl, symptom(gads),nl.


isptsdasd(Anxeity):-

        feel_any(Anxeity), Anxeity=='yes',

         symptom(ptsdasd), nl.
```

```
isptsdasd(Got_Traumatic, Anxeity, Flashback, Avoidance, Reactions, Remember, Sleep, Sign,
Time):-
        got(Got_Traumatic),Got_Traumatic=='yes',
        feel_any(Anxeity),Anxeity=='yes',
        behaviour(Flashback),Flashback=='yes',
        behaviour(Avoidance),Avoidance=='yes',
        behaviour(Reactions),Reactions=='yes',
        faced_difficulty(Remember),Remember=='yes',
        faced_difficulty(Sleep),Sleep=='yes', body(Sign),Sign=='yes',
        duration(Time),Time=='yes',
        write('\n\t----Conclusion----\n'),
        disorder(post–traumatic_stress_disorder),nl,
        recommendation(psttraumatic_stress),nl, symptom(ptsdss),nl;
        got(Got_Traumatic), Got_Traumatic=='yes',
        feel_any(Anxeity), Anxeity=='yes',
        behaviour(Flashback),Flashback=='yes',
        behaviour(Avoidance),Avoidance=='yes',
        behaviour(Reactions),Reactions=='yes',
        faced_difficulty(Remember),Remember=='yes',
        faced_difficulty(Sleep),Sleep=='yes', body(Sign),Sign=='yes',
        duration(Time),Time==no,
        write('\n\t----Conclusion----\n'),
        disorder(acute_stress_disorder),nl,
        recommendation(acute_stress), symptom(asdss),nl.
```

# Appendix III

**Questionnaires to Test Anxiety Disorders Diagnosis Prototype Knowledge Based System** (Redeit, 2006, P. 110; Pu & Chen, 2010, 19-20)

1. Is the prototype easy for you to use and interact with it?

   1. Poor 2. Fair 3. Good 4. Very good 5. Excellent

2. Is AMDDKBS attractive?

   1. Poor 2. Fair 3. Good 4. Very good 5. Excellent

3. Is the system more efficient in time?

   1. Poor 2. Fair 3. Good 4. Very good 5. Excellent

4. How accurately does the system reach a decision about anxiety disorders identification?

   1. Poor 2. Fair 3. Good 4. Very good 5. Excellent

5. Does the system incorporate sufficient knowledge to diagnoses anxiety disorders?

   1. Poor 2. Fair 3. Good 4. Very good 5. Excellent

6. Is the system giving the right conclusions and the right recommendations?

   1. Poor 2. Fair 3. Good 4. Very good 5. Excellent

7. How do you rate the significance of the system in the domain area?

   1. Poor 2. Fair 3. Good 4. Very good 5. Excellent

8. How is AMDDKBS differ from a diagnosis conducted by a human psychiatrist?
9. What issues are covered by the advisory services of the system?
10. Do you feel any uncovered areas by the prototype about anxiety disorders diagnosis? If you feel, please state them.

11. In your opinion, can knowledge base system (such as the prototype presented by AMDDKBS) handle the diagnoses task of anxiety disorders?
12. Do you think that the system incorporates sufficient knowledge to diagnoses anxiety disorders?
13. Does the system have any significance in the domain area?
14. What are the limitations of AMMDKBS?
15. What are the strengths of AMMDKBS?

# Declaration

I declare that the thesis is my original work and has not been presented for a degree in any other university.

Seblewongel Esseynew

June 2011

This thesis has been submitted for examination with my approval as university advisor.

Gashaw Kebede (PhD)