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KNOWLEDGE BASED SYSTEM FOR PRE-MEDICAL TRIAGE TREATMENT AT ADAMA UNIVERSITY ASELLA HOSPITAL

TAGEL ABONEH

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KNOWLEDGE BASED SYSTEM FOR PRE-MEDICAL TRIAGE TREATMENT AT ADAMA UNIVERSITY ASELLA HOSPITAL

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By

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Name of member of the examiner board

Name	Title	Signature	Date
----------	Chairperson	----------	----------
----------	Advisor	----------	----------
----------	Examiner	----------	----------

DEDICATION

I would like to dedicate my thesis to my old friend Tadesse Welde, who passed away without seeing my achievement and to all my best friends who gives me their support to achieve my dream.

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LIST OF ACRONYMS

AI ---------- Artificial Intelligence

KBS ---------- Knowledge-based system

KBSPTT ---- knowledge based system for pre-Medical triage treatment

KE ---------- Knowledge Engineer

KE ----------Knowledge elicitation

KA ---------Knowledge acquisition

TB --------- Bacterium M. Tuberculosis

WHO ---------- World Health Organization

RBR---------- Rule Based Reasoning

CBR ---------- Case Based Reasoning

KB ---------- Knowledge Based

KR ---------- Knowledge Representation

QMR ---------- Quick Medical Reference

ABSTRACT

Health problems touch every aspect of human life such as health condition, working environment, family life, social relations, economic and political activities of every endeavor.

However, health care services are not efficient throughout the world as it is required to be. While the burden of chronic disease in sub-Saharan Africa is very high, the current density and distribution of the health workforce suggested that sub-Saharan Africa can't respond to the growing demand of chronic disease care. Ethiopia is one of the developing countries in sub-Sahara Africa. In Ethiopia the health problems are a hot issue for every stakeholder, to minimize the death of citizen by different chronic diseases. In the health domain the gap exists due to low patient handling capacity of health institutions and the growing demand of individuals who need response from the health sectors.

The major challenge for health service in the country is shortage of skilled manpower in the health sector. In Ethiopia the number of health professionals and patients' demand are disproportionate. Some indicators of these problems are holding capacity mismatch, which includes emergency department (ED) over-crowded by number of patients', ambulance service problem and boarding of admitted patients due to lack of hospital beds. Most patients experience very lengthy wait before receiving care, and some leave without getting treatment. Lacks of enough knowledge among primary health care workers, allocation of insufficient budgets for health sectors and the absence of adequate awareness about epidemic illnesses are the other challenges that create obstacles to address the health care services satisfactorily. The factors are the challenges that affect the quality of health care service in hospitals and reduce the quality of decisions made by physicians in the domain area.

As a result, objective of the study was to investigate the applicability of rule-based reasoning approach in the development of knowledge based system for hospital triage service so as to improve the quality of decision made by general practitioners, to provide effective and efficient services to the patients and to improve shortage of human expert in specific domain area.

To achieve this objective, domain knowledge is acquired using semi-structured interview technique is implemented. Domain experts are selected from Adama University Asella hospital

using purposive sampling instrument. In addition, secondary data is acquired from different sources such as journal articles, health care guidelines, manuals, books and different websites.

The conceptual model of the knowledge based system used a decision tree structure which is easy to understand and interpret the procedures involved in patient diagnoses. Based on the conceptual model, the prototype is developed with LPA WIN prolog by using 'if – then' rules. The prototype developed uses backward chaining to infer the rules and provide appropriate recommendations.

Generally, the performance of the prototype knowledge based system has got good acceptance by the system evaluators. According to the system evaluators 85% of the users are satisfied with the prototype. In addition, the performance of the system is evaluated by using predictive validation techniques with twenty test cases. The results of the validation test case indicate that the prototype is about 80% accurate.

In the end, some recommendations are forwarded such as the integration of rule based reasoning with case based reasoning to improve the performance of the inference engine, to develop the knowledge based system in different local languages to enable the users to communicate using their own local language and to further strengthen the study in the domain area.

CHAPTER ONE

INTRODUCTION

1.1. Background of the study

The population distribution in Ethiopia was with an area of 1.1 million Square kilometers and an estimated total population of 77 million in 2008. Population density is midyear population divided by land area in square kilometers. Ethiopia is the second most populous country in Sub-Saharan Africa. A very large proportion of the population (84%) Lives in the rural areas and the country experiences a heavy burden of disease mainly attributed to communicable infectious diseases (Sebhatu, 2008).

While the burden of chronic disease in sub-Saharan Africa is very high, the current density and distribution of the health workforce suggested that sub-Saharan Africa can't respond to the growing demand of chronic disease care. In Ethiopia the number of physician and nurse for 100,000 people are 3 and 6 respectively which clearly shows the shortage of qualified human power in the domain area (Henok, 2011).

The Ethiopian Government has designed a series of Health sector Development programs in line with the expansion and improvement of health services. The focus under the Growth and Transformation Plan (GTP) will continue towards primary health care and preventive services. Furthermore, the Government has been strengthening its measures to improve the number, skills, distribution and management of health professional through accelerated training of physicians (specialists and general practitioners). A new system for the health care service includes financial and drug management implemented to overcome the bottlenecks in the sector. Incentive package is further strengthening in order to domestically produce pharmaceutical products. These progressive strategic plans would adequately strength the potential of hospitals to provide an effective and efficient health care service (FDRE, 2010).

The term "triage" originates from the French word "Trier" which means to sort, pick out, classify or choose. The primary objectives of triage in emergency departments are to prioritize' or classify patients on the basis of illness, injury severity and need for medical and nursing care (Samuel, 2007).Therefore, the contextual definition of triage system for the purpose of this study

is the process of allocating a limited health care resources and patients into the categories of medical, surgical, gynecology and psychiatric patient.

Triaging task in the hospital is done mainly by experienced general practitioner who has demonstrated competency in the triage role. The goal is to provide effective diagnosing service for the patient and categorize them sufficiently to the expected human expert for further diagnosis. So it is recommended to have a comprehensive triage service which needs knowledgeable human expert in order to minimize the complexity of diagnosing process. Knowledge based system have their own contribution in assisting physicians to carry out specific task in the domain area.

In this thesis triage and Emergency Department was used interchangeably. Triage decisions are often complex and usually made under the conditions of uncertainty. There are many contributing factors to the complexity and uncertainty of triage decision-making. For one, a general practitioner's judgment is usually subjective in nature and depends on the experience and expertise of the nurse on duty, severity of illness or injury of the patient, availability of medical supplies, beds, and physician (doctors). Another reason is that the treatment category depends on the level of urgency of medical attention. Decisions are based on nurse's primary observations and must be made in the shortest time. Furthermore, triage decisions are not consistent with existing triage guidelines because of the ad hoc nature. Moreover, the stressful environment where patients arrive in pain and frightening situation contributes to the complexity and uncertainty of the decision (Burtein, 2004).The triage nurse is expected to obtain a complete history, vital sign, pillar symptom and complete department specific screening questions. Sufficient knowledge is required to make the correct triage decision (Gilboy, 2005).

Integrating computer technology and artificial intelligence into health services is one of the approaches to address the shortage of qualified health professionals, experts, advisors and trainers in the area. Application of knowledge based system is one of the mechanisms that improve the qualities of health service and minimize the shortage of manpower in the medical domain (Henok, 2011).

The concepts of knowledge based system are a branch of artificial intelligence (AI), and were developed by the AI community in the mid-1960s. A knowledge based system can be defined as

“an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solutions”. Knowledge based systems solve problems in a human expert like fashion. The field became a main application area that aids clinical decision making across the medical spectrum (Al-Taani, 2005).

In recent years, Knowledge Based System (KBS) and Expert System (ES) have become increasingly popular computer software approaches and are being used in a wide variety of application areas. Medicine is one of the areas in which knowledge based system has received much more attention. The attention is mainly because of the potential benefits that can be gained from using these technologies. Today knowledge based systems are essential tool in the area of medical domain particularly to over-come the shortage of human experts. There is a clear role for clinical knowledge based applications in the medical domain like diagnostic assistant systems, drug advisory system, protocol design, laboratory system, clinical workstations, image recognitions and interpretation for clinicians (Reffat, 1996; Sebelewongel, 2011).

Since uncertainty is unavoidable in medical reasoning, it is critical that future research in knowledge based systems should address the problems of uncertainties. To come up with the best solution designing a novel knowledge based system helps the human expert to successfully address health problems in the domain area.

1.2. Motivation for the study

Health care is highly complex and interdependent system in nature. In the triage treatment, for example, effective patient care depends on the interaction of emergency physicians, triage nurse, emergency nurses, laboratory and diagnostic imaging services, and inpatient units among others. If any one of these interdependent components was performed poorly or overwhelmed, delivery of care in the Emergency Department will suffer. Thus, the triage department may experience “operational inefficiencies” as a result of inadequate staffing levels, or poor communication with laboratory, imaging services and restricted access of beds for admitted patients. As a result the process of diagnosing patient face serious problems with the service provided in the hospital. Therefore, designing an efficient knowledge based system would help the institution to minimize the above interrelated problems that is caused due to lack of potential human expert or lack of potential skills to solve the patient's health problem (Moskop, 2008).

1.3. Statement of the problem

Triage decisions are made in response to the patient's presenting signs or symptoms. There are two types of triage decisions these are primary and secondary decisions. Primary triage decisions are relate to the triage assessment and assignment of patient into the triage category. Secondary triage decisions relate to the initiation of nursing interventions in order to expedite emergency care and promote patient comfort (Samuel, 2007).

The skill required by the triaging staff includes clinical experience, good judgment, sense of humor, stress-tolerance, knowledge of available resources, problem solving ability and sense of anticipation. Identifying and triaging patient accurately and efficiently was a challenging task. Particularly, many health care institutions are increasingly overcrowded and this leads to longer waiting time of patient and increase treatment delay. As a result it leads to miss- categorization of patient (Aronsky, 2008). Because, the more efficient triage system the better health care service becomes.

In Ethiopia Triage examination is commonly completed by a triage nurse or general practitioner. The general practitioner collects the required pillar symptoms and relevant information during patient history taking. Based on the acquired information, then the triage nurse categorizes the patient into the categories of the triage system for further examination. The current documentation of triage system is paper based, which takes time and creates a difficulty in reusability of patient information for different stages of diagnosing process. Accessibility of this information would help the human expert to make a proper decision regarding the patient's health problem.

Triage treatment is the main gateway to process the patients' health problem in the hospital. Therefore, building a sound knowledge based system would help the general practitioner to provide effective and efficient health care services in the institution.

The major problem which is common for all health care institutions regarding triage treatment is that the professional level of expertise used are at nurse level. They employ simple department oriented question in order to categorize the patient into appropriate human experts. But the main problem also relates to the following facts that affect the decisions of general practitioner.

- Because he/she uses one or two symptom but patients' health problem may need further investigation to identify problem.
- Because the general practitioner or the nurse may be temporary biased or frustrated to do in a normal condition.
- Because of the overcrowded number of patients, the patient handling capacity of the hospital and related reason enforce the general practitioner to miss-categorize the patient into different triage categories.

Therefore, due to the above mentioned reasons most of the time the general practitioner is not in a position to make good decisions. As a result, these factors expose the patient for long waiting and additional cost in the hospital. The problem also enforces the physician to perform the same patient case by different expert and create burdens on his/her the daily activity.

The integration of Triage services with the hospital information technology infrastructure remains scarce, despite availability of potential expert knowledge across the institution.

In Ethiopia designing an expert system in the area of medical domain is found at the infant stage. Therefore, designing a knowledge based system would reduce the repetition of task, the burden of human expert and waiting time of patient in the hospital. The knowledge based system could be used to assist human expert by providing the required knowledge at the right time for decision making.

To this end, this study attempts to explore and answer the following research questions:

- What types of knowledge the human expert use in the diagnosing process of patient health problem
- What are the suitable models, representation techniques and implementing tools that are applicable to the proposed knowledge based system?
- What is the extent of user satisfaction with the proposed knowledge based system?

1.4. Objective of the study

The study has the following general and specific objectives

1.4.1. General objective

The main objective of the study to investigate the applicability of rule-based reasoning approach in the development of knowledge based system for hospital triage service so as to improve the quality of decision made by general practitioners, to provide effective and efficient services to the patients, and to improve shortage of human expert in triage service.

1.4.2. Specific objective

To achieve the general objective of the study, the research has the following specific objectives:

- To review the literature of different sources of information to understand the basic concept, principle and technologies of knowledge based system.
- To make an interview or discussion with the domain experts and to analyze relevant document. This would help to have the required knowledge in order to build prototype knowledge based system for triage service.
- To design conceptual model and representing the acquired knowledge for triage patient categorization purpose.
- To develop prototype knowledge based system for patient categorizations in the triage service.
- To evaluate and validate the performance of the knowledge based system.

1.5. Scope and limitation of the study

Even though there are a number of different approaches for designing knowledge based system, this study focuses only on rule based approach. The focus area of this study is Adama University Asella Hospital triage system. The study is limited to design a knowledge based system for the purpose of triage services in order to categorize the patient based on the identified symptom. The knowledge based systems' rules are limited to diagnose patients' diseases and provide possible suggestion to make appropriate decisions by human experts and to further examine the patient case. Because, inferring from large or complex rules reduce the performance of the system.

Since the human health problem is unlimited in number this study is focused on patient categorizations of triage system. The triage system has four categories. For the purpose of this study a sample of diseases is taken from each category as follows:

- From medical domain researcher select TB, influenza diseases, malaria, pneumonia and Skin diseases are selected randomly
- The system also takes symptoms of sample surgical cases in order to categorize the patient into surgical operations.
- The system also takes known symptoms of gynecology and obstetrics in order to categorize the women and related complication into their respective categories.
- The system takes known symptoms of mental disorder and then tries to categorize the patients into psychiatric cases for further consultation.

The prototype is limited to diagnosis the proposed diseases based on the symptoms given by the patient and then categorize the patient into the appropriate category for further examination. On the other hand, for any disease that does not have a rule in the knowledge base, and then the system provides recommendation which helps the general practitioner to assign the patient into one of the triage category. The knowledge based system doesn't deal further with drug management in response to patient diseases.

Some of the major limitations during system development are:

- Medical knowledge is described by its scientific name and this makes the knowledge elicitation process difficult.
- Domain experts are not feeling confident to share their experience and expertise.
- Representing and codifying natural language into computer language is the challenging and time consuming task.
- The knowledge based system does not cover all patient cases that come to the triage department. Because human health problems are unlimited in number.

Because of the above and related reasons the knowledge based system gives more attention to triage treatment. In return it helps the general practitioner to provide efficient service to categorize the patient, symptom identification, gives possible suggestions to makes better decisions. This effort would greatly reduce the burden of human expert and waiting time of

patient due to the overcrowded number of patients' and minimizes repetition of the same patient case by different physician.

1.6. Methodology of the study

The following method and techniques have been employed in order to achieve the general and specific objectives of the study.

1.6.1. Literature review

Extensive literature reviews of different books, journal articles, conference papers, thesis and the internet are reviewed. To understand the principles, techniques and tools of knowledge based systems that are specifically applied to triage treatment services in patient categorization process.

Further, researches that are conducted on knowledge based system in the medical domain and other related works have been reviewed to clearly show the contribution of the study.

1.6.2. Data collection

For the purpose of this study, both primary and secondary data collection methods are employed to collect the required domain knowledge. As primary sources, health professionals from Adama University Asella Hospital have been interviewed. In addition, relevant literature from all possible sources including journal articles, health manuals, and guidelines were reviewed.

Domain experts were selected by using purposive sampling techniques. Burns and Grove (2001) have defined purposive sampling as "Judgmental sampling that makes the conscious selection of certain subjects or elements to be included in the study". Purposive sampling techniques are employed to select sample which can help to acquire the required knowledge from the domain experts. Domain experts are selected based on their educational qualifications related to the domain area, year of experience and willingness (Tongco, 2007; Palys, 2008).

Semi-structured interview techniques have been employed to acquire the required knowledge from the selected domain expert. It allows the interviewer to change the order of the questions and add new question based on the participant response. Therefore, this interview focuses on the concept, procedures, guidelines and experience which domain expert used while diagnosing patient health problem (Margaret, 2009).

1.6.3. Knowledge modeling and representation

Constructing knowledge based systems was viewed as a modeling activity for developing structured knowledge. To ensure well-formed models selecting appropriate knowledge modeling methodology would be a critical task. Additionally, reusing models can significantly reduce the time and costs of building a new application (Maria, 2009).

The acquired knowledge from the domain expert has been represented by using decision tree modeling in a formal language logic which is suitable for the selected algorithm. Rule based reasoning mechanism were employed for the inference engine. In knowledge based system there are many reasoning mechanisms among that the most commonly used are rule based approach, case based approach or the combination of the two. Case based approaches are designed to work in the way that the basic idea of similar problems having similar solutions (Robert, 2000). It is a Knowledge Based System that solves problems by remembering past situations and reusing its solution and lesson learned from it. Cased based approach represents situations or domain knowledge in the form of cases and it uses case based reasoning techniques to solve new problems or to handle new situations (Salem, 2007). Rule based reasoning, on the other hand reason from domain knowledge represented in a set of rules. The basic format of a rule is If<condition> then <conclusion> where <condition> represents premises and <conclusion> represents associated action for the given premises (Henok, 2011).

The framework for medical diagnosis intends to create a medical expert system which used from the patients' side to diagnose the disease he/she is suffering from. A set of rules exists that operate over a collection of facts stored in a working memory. Logic is provided to identify which rule is fired first (based on the antecedents) and then modify working memory (based on the consequents). Therefore, for the purpose of this research, the researcher applies rule based approach in order to represent the knowledge for specific domain area (Deepti, 2010).

1.6.4. Designing and implementation

The proposed knowledge based system is implemented by using prolog programming language. The reason is that prolog is open source software and it is preferred programming language for developing a knowledge based system. Prolog makes the representation of the solution much easier, allowing one to concentrate on solving the problems rather than coding the solution.

Prolog contains a number of features which are not found in the normal programming languages, which make it very powerful in the logical programming. These features include (Ghan, 2004).

- A powerful search and backtracking inference mechanism,
- A powerful built-in 'pattern matching' mechanism,
- A simple but sophisticated data structure with the ability to manipulate the data structure

In addition, the researcher is familiar with prolog software.

1.7. Testing and Evaluation

The developed rule based system is tested and evaluated to ensure the performance of the system. The evaluation processes focus on system's user acceptance. User acceptance measurements are concerned with issues how well the system addresses the needs of the user, whereas validation measurement determine if the system perform the required task successfully.

The system evaluators use visual interaction methods together with questionnaire. Based on that, they evaluate the performance of the system by using both close ended and open ended questions.

Similarly validation process of the prototype knowledge based system is tested using twenty test cases. Evaluators from the domain area interact with the system by taking a sample of test cases. Each case are selected purposively and used to test the performance of the prototype. The testing procedure is carried out by identifying correct and incorrect categorization of cases into their respective category. The comparison is the decision made by system against domain expert. Decisions without significance difference between the domain experts and the knowledge based system are accepted as good performance.

There are a number of well-known knowledge based systems which use such approach to validate the accuracy of knowledge based system such as MYCIN and chest pain diagnosis system called EMERGE (Demmelash, 2010).

The knowledge based system incorporate learning component to update the existing facts in working memory. Finally user evaluation would be conducted by group of domain experts. The domain expert uses different cases (based on patient symptom) to interact with a knowledge based system. After assessing the result concluded system against human expert decision, then system evaluator measure its performance.

1.8. Significance of the study

Knowledge is a valuable asset to any institutions as a substantial source to support decisions making. In other word accessibility of knowledge strengthen institutional competency. Researchers and practitioners in the area of knowledge management view knowledge in a broad sense as a state of mind, an object, a process and an access to information (Kerdprasop, 2011).

Knowledge based system try to solve problems in a human expert like fashion by using stored knowledge elicited from domain expert. Therefore, the proposed knowledge based system has the following significance in the triage service.

- Thus the study is conducted to improve the efficiency of service provided by triage treatment. Therefore, by leveraging knowledge of physician into triage system we can help general practitioner to make better decision during patient categorization based on their symptom.
- Domain expert uses different sources of information and their expertise for solve the human health problem. The proposed system can be used as quick reference for general practitioner to diagnose the patient health problem.
- Knowledge based system is developed for the purpose of supporting or assisting decision maker. Therefore, propose system can used to fill gap of lack of human expert in the domain area.
- The proposed knowledge based system can be used as teaching instrument for medical students how to identify patient symptoms and to provide appropriate recommendation. .

1.9. Organization of the thesis

The study is organized into six chapters. Chapter one is the introduction part, which contains the background of the study, motivation for the study, problem statement, objectives, scope and limitations of the study, the 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 overview and application areas in medical domain are presented in chapter two.

Chapter three discusses the knowledge acquisition, representation and conceptual modeling procedures; Chapter four deals with implementation of knowledge based system. Chapter five

presents the results found in the evaluation and testing process of the prototype knowledge based system. Finally, chapter six focuses on the conclusion and recommendation based on the results of the research finding for further research work in the domain area.

CHAPTER TWO

LITERATURE REVIEW

The notion of knowledge based system is derived from the field of AI. The representation of knowledge and the reasoning processes that brings knowledge to life is the central point to the entire field of artificial intelligence. Knowledge and reasoning mechanism are important aspect for artificial intelligence because they enable successful behaviors that will be very hard to achieve otherwise (Norving, 2003).

2.1. Artificial intelligence

Artificial Intelligence (AI) is one of the up-to-date sciences; the name artificial intelligence itself was coined in 1956. Majority definitions of artificial intelligence proffered over decades have relied on comparisons to human behavior. Thus according to Fogel in 2006 different authors define artificial intelligence in different ways such as: -"the sciences of making machines do things that would require intelligence if done by men"—and suggested that some people define AI as the "mechanization or duplication of the human thought process." "Artificial intelligence is the study of mental process through the use of computational models," "An intelligent program is one that exhibits behavior similar to that of a human when challenged with a similar problem. It is not necessary that the program actually solve or attempt to solve the problem in the same way that a human would" (Fogel, 2006).

Intelligent program (AI) has interdisciplinary approach of various disciplines like computer science, cognitive science, hardware field, etc. In the medical applications areas such as diagnostic techniques in ultrasonography, x-ray, computerized tomography scans, nuclear magnetic resonance imaging etc. The other areas can be clinical laboratories, pathological investigations and computer assisted decision-making. Therefore, the field is potentially relevant to any sphere of human intellectual activity. AI started with a goal to replicate human level of intelligence in machine learning (Shah, 2010).

2.2. Knowledge based system

Knowledge-Based System (KBS) is one of the major family members of the AI group. KBS can act as an expert on demand without wasting time, anytime and anywhere. KBS can save money

by leveraging human expert, allowing users to function at higher level and promote consistency of work. One may consider the KBS as productive tool that have knowledge of more than one expert for long period of time. In fact a KBS is a computer based system which uses and generates knowledge from domain expert (Akerkar, 2010; Heijst, 2006).

Human experts use their knowledge in particular field of expertise to solve day today activities. In the same way, knowledge based system handles problems; the computer needs an internal model of the world using the stored knowledge. All information is stored in such a way that it is readily accessible. To design knowledge based system, the expert knowledge was represented in a way that it supported for reasoning mechanism in computer languages. Representing knowledge into the expert system could offer potential advantages over human expertise. Because, knowledge based system can use the acquired knowledge permanently, consistently, easy to transfer and document expert knowledge (Fogel, 2006).

2.2.1. Architecture of knowledge based system

Figure 2.1 below shows the building blocks of knowledge based system architecture adopted from (Saxena, 2011).

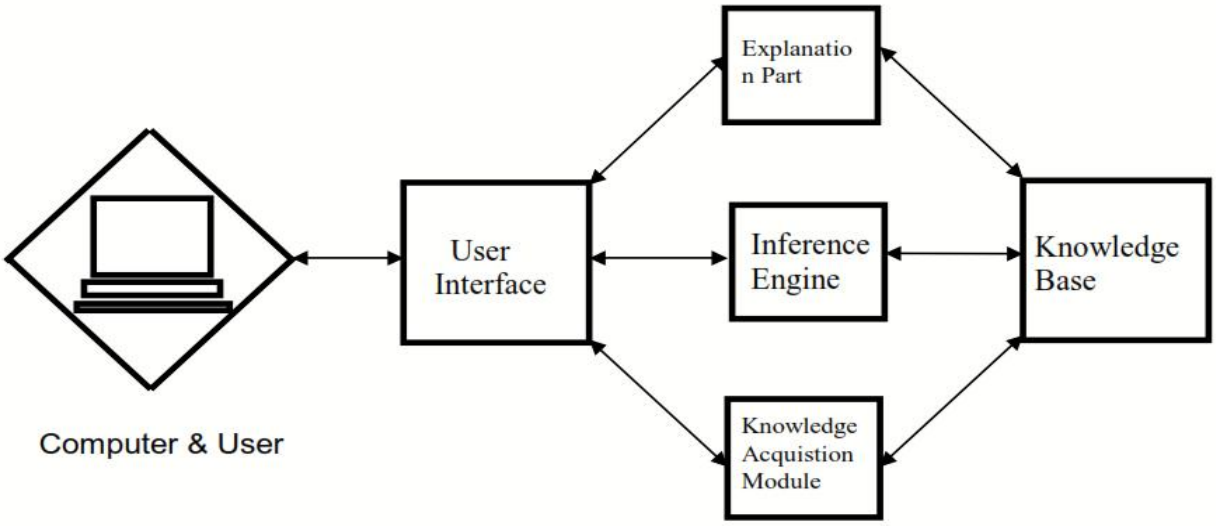


Figure 2.1 Architecture of knowledge based system

The architecture of knowledge based system consists of different components such as Knowledge Base, Knowledge acquisition module, inference engine, user interface and explanation module. The Knowledge Base contains all relevant knowledge acquired from

domain experts. Knowledge also acquired from the user during their interaction with the system. The knowledge acquisition module helps in the collection process of knowledge from the set of human experts as shown in Figure above. The inference engines formulate questions and assert the answers provided by the user in a natural language form. It provides a mechanism for conveying recommendations to the end user. The explanation module provides a brief description to the user why the system arrived at a certain conclusion (Aref, 2000).

2.3. The Knowledge engineering process

The development of knowledge based system is the integration of many components. Figure 2.2 below shows the overview of knowledge based system development process (Akerkar, 2010).

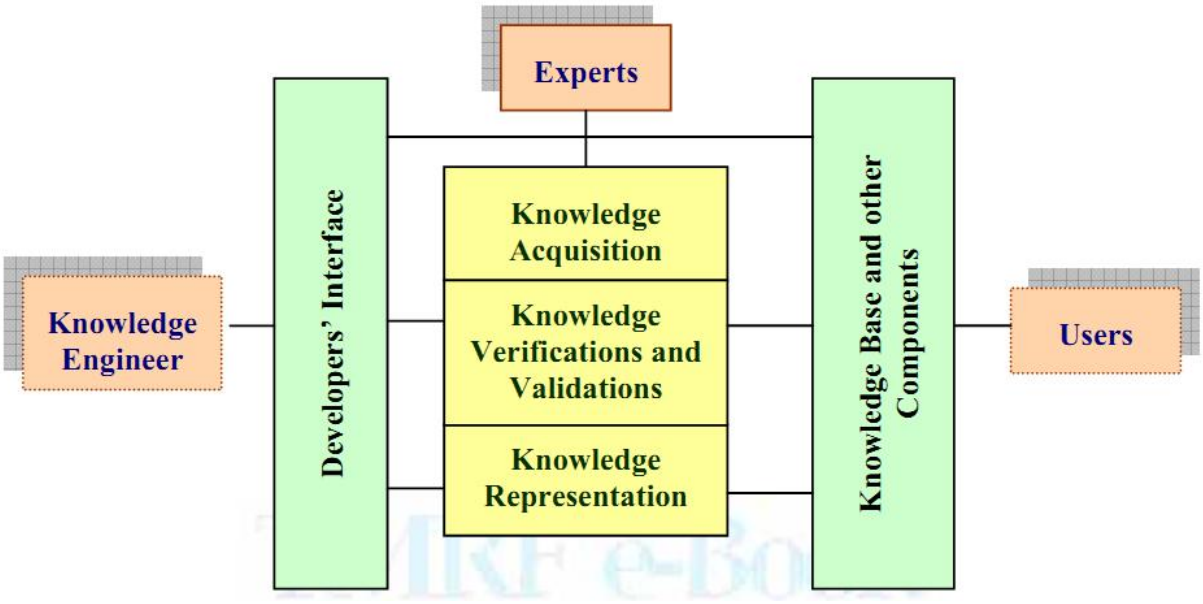


Figure 2.2 Development of a Knowledge-Based System (Akerkar, 2010)

2.3.1. **Knowledge acquisition**- Knowledge acquisition is the process of acquiring relevant knowledge from human experts, books, documents, sensors, or computer files. The knowledge can be specific to the problem domain or to the problem-solving procedures, it can be general knowledge (e.g., knowledge about business) or it can be meta-knowledge (knowledge about knowledge). Knowledge acquisition is the bottleneck in knowledge based system development today. Because, the trustworthiness and the

performance of the knowledge based system mainly depends upon the acquired knowledge (Alechina, 2012).

The knowledge acquisition process incorporates different methods such as interviews, questionnaires, record reviews and observation to acquire factual and explicit knowledge (Gil, 1999).The performance of the expert systems depends upon the reliability, validity and accuracy of the elicited knowledge. The process of knowledge elicitation is affected by different contributing factors such as communication between the expert and ability of knowledge engineer (Tehrani, 2009).

Therefore, effective elicitation techniques facilitate to acquire relevant knowledge form domain experts. The commonly used knowledge acquisition techniques are discusses as follows (Wang, 2011).

a. Interview

An interview technique is the process of interacting with domain expert on how they perform their tasks based on their expertise. Knowledge acquired through direct elicitation methods are procedural knowledge. Based on its structure, interview can be classified into structure, semi-structure and unstructured interview (Burge, 1998; Henok, 2011).

- **Structured Interviews**- A structured interview method is questioning the domain expert directly. It is goal-oriented process. It forces organized communication between the knowledge engineer and the domain expert. The structure reduces the interpretation problems inherent in unstructured interviews and allows the knowledge engineer to prevent the bias caused by the subjectivity of the domain expert (Ranjan, 2006).
- **A semi-structured interview** is an interview which has a guide that usually includes both closed-ended and open-ended questions. It is more flexible than structured one. In these kinds of interview the interviewer has a chance to change the order of questions and expand the dimension of questions based on the participants' responses (Ranjan, 2006).
- **Unstructured Interviews**- sessions are conducted informally, usually as a starting point. Unstructured interview techniques provide complete or well-organized descriptions of cognitive processes. There are many reasons that enforced to applying unstructured interview. Domain the experts usually find it very difficult to express some of the most

important elements of their knowledge. Through structured interview it is difficult to acquire the required knowledge. With good training and personal experience knowledge engineers can use unstructured interview to acquire relevant knowledge from domain expert (Ranjan, 2006).

Therefore, efficient and effective interview techniques largely depend on the ability of knowledge engineer to articulate their implicit knowledge. Because every interview is different in very specific ways and it is difficult to provide comprehensive guidelines for the entire interview process. Therefore, interpersonal communication and analytic skills of knowledge engineer is very important. On the other hand eliciting knowledge using indirect methods requires human intervention such as observation, document analysis, etc. (Wang, 2011).

b. Observation

In many ways, this is the most obvious and straightforward approach to knowledge acquisition. Through this technique knowledge engineer directly observe how problems are solved by domain expert. Observation was particularly fruitful in seeing what the expert physically does when solving diagnostic problems. It was useful in determining what types of knowledge the human expert used to solve problems and the forms in which the knowledge were stored. Observations are used primarily as a way of supporting verbal protocols. Generally, acquiring knowledge through observation is expensive and time-consuming task (Gau, 1990).

c. Document Analysis

The final form of knowledge acquisition method is concerned with a detailed analysis of the existing document. This technique is used to collect relevant knowledge from the existed documents of different format. These documents include professional literature, brochures, manuals, guidelines, employee handbooks, reports, glossaries, course texts, and other relevant materials (Gau, 1990).

Knowledge elicitation methods can be classified into different types. Direct and indirect is the commonly known methods of knowledge elicitation. The way of classification depends upon how knowledge engineer directly obtains information from the domain expert (Osuagwu, 2006).

A direct method involves directly questioning a domain expert on how they do their job. In order to implement direct methods successfully, the domain expert has to reasonably articulate and willing to share his/her knowledge. However, in case of indirect methods the required knowledge is not requested directly. Instead, the result of the knowledge elicitation session must be analyzed in order to extract the required knowledge. Indirect methods are thought to be more suitable when knowledge is not easily expressed by the domain expert (Osuagwu, 2006).

2.3.2. **Knowledge representation**- Acquired knowledge is structured so that it was ready for use in the process of knowledge representation. This activity involves preparation of a knowledge map and encoding of knowledge in the knowledge base.

2.3.3. **Knowledge validation**- Knowledge validation (or verification) involves validating and verifying the content of knowledge (e.g., by using test cases and confusion matrix) and user acceptance. The testing result of knowledge based system was validated by domain expert.

3.2.4. Inference- This activity involves the design of software to enable the computer to make inferences based on the stored knowledge for the specific domain problem. In other word inference engine is a programs that reason over extensive knowledge bases.

2.3.4. **Explanation**- This step involves the design and programming of an explanation facility. Explanation module is program that answered how the knowledge based system arrived at certain conclusion. Explanation module addresses the issues of system user interactivity.

2.4. Knowledge based reasoning techniques

There are a number of knowledge based reasoning methods. The well-known reasoning approaches are ontology based reasoning, semantic network, neural network, fuzzy logic, case based reasoning and rule based reasoning. For the purpose of this research work case based and rule based reasoning approach are discusses as follows.

2.4.1. Case based Reasoning

Case-based reasoning (CBR) means “adapting old solutions to meet new demands, using old cases to account for new situations, using old cases to evaluate new solutions, or reasoning from precedents to interpret a new situation” (Chen, 2007).CBR is more comfortable to make better

decision in dynamically changing environment. People learn from their success and wrong activities to handle similar situations in the right manner and not to repeat their mistake of the past.CBR approach is more compatible to reuse previously solved problems and learning from experiences for future decision (Salem, 2007). Similarly, CBR is an approach to incremental learning. Once a problem has been solved, CBR approaches use the solution to solve for future problems (Plaza, 1994).

2.4.2. Cases

In CBR terminology cases are usually denotes a problem situation. A case can be defined as previously experienced situation which has been captured and learnt, is referred to as a past case, previous case, stored case or retained case. Note that the term problem solving is used with common practice in the area of knowledge-based systems. This means that problem solving is not necessarily the finding of a concrete solution to an application problem, it may be any problem put forth by the user (Plaza, 1994).Therefore, and cases have three different aspects this can be described as follows.

- Situation/ problem description: describes specific circumstances, the state of a situation and state of the environment when this case is recorded.
- Solution: provide how the problem described was solved or treated in a particular instance.
- Outcome: describe the final result, consequence and feedback gained from the proposed solution.

According to Shu Huang Sun (2007) Case-based reasoning mechanism requires the following primary activities.

- Index assignment: Characterizes the given problem by assigning the appropriate attribute that describe the features of the case.
- Retrieval: Retrieves the relevant case from the case library.
- Explanation: Explains the deficiencies of the retrieved case by making a comparison of the differences between this case and the input problem. The explanation involves two aspects, i.e., which features are unsatisfactory and require modification and how to modify these features so as to satisfy new conditions.

- Modification: Modifies the retrieved case to conform to new situations according to the result of explanation.
- Store/adapt: Saves the modified case as a new case into the case library. The case libraries are incrementally expanded as the numbers of cases increase.

2.4.3. Case based reasoning life cycle

Case based reasoning life cycle incorporate four major components that make the reasoning mechanism successful. These are retrieval, reuse, revise and retain. Retrieval is the task that involves retrieving a case from the collection of previously solved cases. The retrieved case is combined with the new case for later reuse into a solved case. Revise is a process that tests the success of a solution by applying into a real world environment, if repair is failed. When useful experience is retained the case is updated by a new learned case (Plaza, 1994).

Cased based reasoning process generally involves both determining the differences between the retrieved cases and the current query case. It also involves modifying the retrieved solution to appropriately reflect these differences (Shiu, 2004).

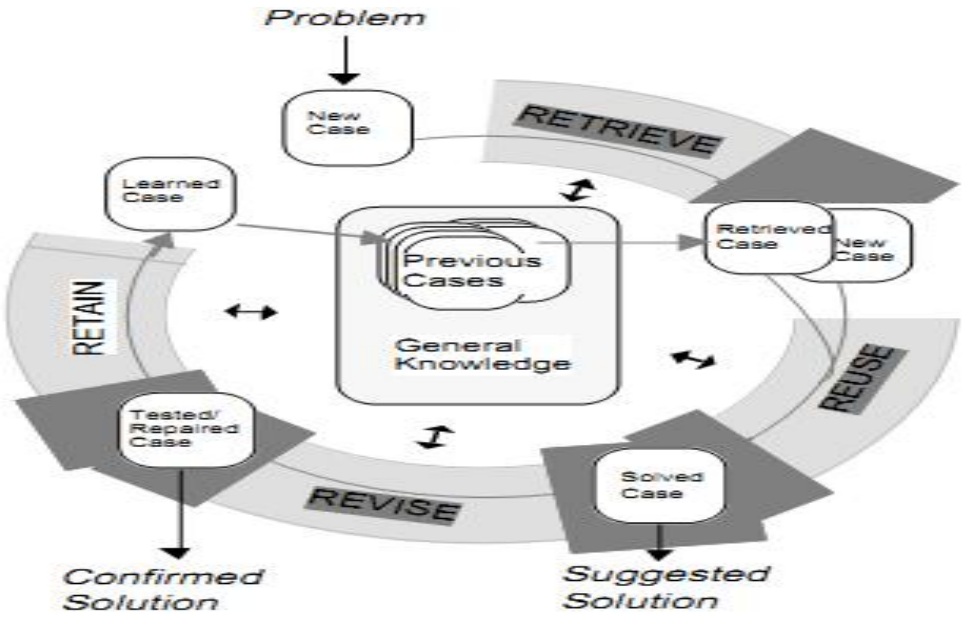


Figure 2.3 case based reasoning cycle (Plaza, 1994)

2.4.4. Advantage of case based reasoning

A case based reasoning approach has tremendous advantages in the development of knowledge based system. The following are main the advantages of case-based reasoning (Simon, 2004).

- Ability to express specialized knowledge.
- Naturalness of representation
- Modularity
- Easy to knowledge acquisition
- Self-updatability.
- Handling unexpected or missing values.
- Inference efficiency.

2.4.5. Disadvantage of case based reasoning

Even though case based reasoning approaches have a numbers advantage. But, due to lack of sufficient cases, the construction and inference mechanism of a case-based system loss the required objective. Some of the limitation issues in case-based reasoning are (Prentzas, 2007):

- Inability to express general knowledge
- Knowledge acquisition problems
- Inference efficiency problems and Provision of explanations

2.5. Rule based reasoning

Rule based reasoning is a system whose knowledge representation in a set of rules and facts. Symbolic rules are one of the most popular knowledge representation and reasoning methods. This popularity is mainly due their naturalness, which facilitates comprehension of the represented knowledge. The basic forms of a rule, If<condition> then <conclusion> where <condition> represents premises and <conclusion> represents associated action for the premises. The condition of rules are connected between each other with logical connectives such as, AND, OR, NOT, etc., thus forming a logical function. When sufficient conditions of a rule are satisfied, then the conclusion is derived and the rule is said to be fired. Rules based reasoning was dominantly applied to represent general knowledge. Rule based expert systems have a significant role in many different domain areas such as medical diagnosis, electronic troubleshooting and data interpretations. A typical rule based system consists of a list of rules, a cluster of facts and an interpreter (Prentzas, 2007).

2.5.1. Rules

The term rules represent what to do or not to do while certain conditions are satisfied. Similarly, domain knowledge is represented by a set of rules (Hatzilygeroudis, 2006). The general form of rules based system can be illustrated as follows (Merritt, 2000).

IF
First premise, and
Second premise, and
...
THEN
Conclusion

The IF side of the rule is referred to as the left hand side (LHS) and the THEN side of the rules referred to as the right hand side (RHS). This is semantically the same as a Prolog rule:

Conclusion:-
first_premise,
second_premise …

Note that this is confusing since the syntax of Prolog rely on THEN IF, and the normal RHS and LHS appear on opposite sides.

Antecedents are evaluated based on what is currently known about the problem being solved. This mean if all antecedents (premise) of the rule evaluated is true, the actions in the consequents part is executed. Each antecedent of a rule typically checks if the particular problem instance satisfies certain conditions. When the consequents of the rules are executed, the rule is said to be fired (Seblewongel, 2011).

2.5.2. Rule based reasoning techniques

There are two main inference methods in rule based reasoning mechanism. These are backward chaining and forward chaining. The former is guided by the goals (conclusions), whereas the latter one is guided by the given facts (Prentzas, 2007).

2.5.2.1. Forward chaining

During forward chaining, the inference engines first predetermine the criterion and the next steps are to add the criterion one at a time, until the entire chain has been trained. With data driven

control, facts in the system are represented in a working memory which is continually updated. Rules in the system represent possible actions to take when specified conditions hold items in the working memory. The conditions are usually patterns that must match with the items in the working memory. In forward chaining, actions are usually involves adding or deleting items from the working memory. Interpreter of the inference engine controls the application of the rules, given the working memory. The system first checks to find all the rules whose condition holds true (Shaffer, 1991).and (Freeman-Hargis, 2012).Both data driven and goal driven chaining method follows the same procedures. However, the difference lies on the inference process. The system keeps track of the current state of problem solution and looks for rules. This cycle will be repeated until no rules fire or the specified goal state is satisfied (Merritt, 2000).

2.5.2.2. Backward chaining

This strategy focuses its effort by only considering rules that are applicable to the particular goal. It is similar with forward chaining the difference is it receives the problem description as a set of conclusions instead of conditions and tries to find the premises that cause the conclusion. Given a goal state and then the system try to prove if the goal matches with the initial facts. When a match is found goal is succeeded. But, if it doesn't then the inference engine start to check the next rules whose conclusions (previously referred to as actions) match with the given fact. Note that a backward chaining system does not need to update a working memory instead it keeps track of what goal is needed to prove its main hypothesis. Goal driven control is commonly known as top-down or backward chaining (Freeman-Hargis, 2012; Ghan, 2004).

2.5.2.3. Forwards Vs Backwards Reasoning

According to Freeman-Hargis (2012), both forward chaining and backward chaining have similar function. But, the difference occurs due to the data structure of knowledge based system. The following point give us a clear ideas how and when to apply each reasoning mechanisms.

- Whether you use forward or backwards reasoning to solve a problem, it depends on the properties of your rule set and initial facts.
- Sometimes, if you have particular goal (to test some hypothesis), then backward chaining is more efficient, as you avoid drawing a conclusions from irrelevant facts.

- Sometimes backward chaining can be very wasteful - there may be many possible ways of proving the hypothesis, and it may require checking almost all of the rules before you find one that works.
- When you have a small set of initial facts; and when there is lots of different rules which allow you to draw the same conclusion it is better to use forward chaining.
- Backward chaining may be better if you are trying to prove a single fact, given a large set of initial facts. Because if you used forward chaining lots of rules would be eligible to fire in any cycle.

2.5.3. Advantage of rule based reasoning

Rule based reasoning approach have a numbers of good features. According to Jim Prentzas (2007) the major advantages of rule based reasoning in the development of knowledge based system are:

- Compact representation of general knowledge. Rules can easily represent general knowledge about a problem domain.
- Homogeneity. Rule based representation has uniform syntax. Hence, the meaning and interpretation of each rule can be easily analyzed.
- Independent. In rule based knowledge representation a new rule can be added without affecting the existing rules. Each rule is an independent piece of knowledge about the problem domain.
- Naturalness of representation. Rules are a very natural knowledge representation method with a high level of comprehensibility. Rules can emulate the expert's way of thinking in natural expression.
- Modularity. Each rule is a discrete knowledge unit that can be inserted into or removed from the knowledge base without taking care of any other technical detail. This characteristic grants flexibility of rule-based reasoning. Because it enables incremental development of the knowledge base.
- Provision of explanations. The ability to provide explanations for the derived conclusions is a straightforward manner. This feature of symbolic rules is a direct consequence of their naturalness and modularity.

2.5.4. Disadvantage of rule based reasoning

As rule based reasoning of prototype knowledge based system has many advantages. But, it has the following limitations (Hatzilygeroudis, 2007).

- Knowledge acquisition bottleneck- The standard way of acquiring knowledge through interviews with domain experts is bulky and time-consuming.
- Brittleness/fragility of rules- It is not possible to draw conclusions from rules when there are missing values in the input data.
- Inference efficiency problems- In certain cases the performance of the inference engine is not the desired one especially when the rules are too large.
- Difficulty in maintenance of large rules- The maintenance of rule bases is getting a difficult process as the size of the rules increases.
- Interpretation problems- The general nature of rules may create problems in the interpretation of their scope during reasoning process.

2.6. Integrating Rule-based and Case-based Reasoning

Cased based reasoning uses partial matching to draw a conclusion. If some of the given problem descriptions match with a given case, then the case is applicable to the proposed solution. It also tries to handle novel problems by referring previously solved cases. Rule based reasoning uses perfect matching to apply a rule for a given problem. It doesn't handle missing information and unexpected data values (Hatzilygeroudis, 2007).

Rules are suitable to represent general knowledge, whereas cases are suitable for representing specific situations. Rules in a rule based system have the abilities to represent experiential knowledge acquired from experts in a direct fashion. Cases are capable of representing specific historical knowledge. The problem here is that it is difficult to acquire complete and perfect knowledge in a complex domain. Cases are natural and easy to obtain. They can be collected from the historical record, repair logs or other sources (Winterton, 2005).

Therefore, the integrated reasoning approach makes use of both existing knowledge and the past experiences. This integrated approach eliminates the drawbacks of each method and provides a better way to handle problems, which combine both inductive and deductive approaches (Lee, 2007).

2.7. Approaches to evaluate the performance of RBR system

Evaluation can be defined as an iterative process of systematic assessment of knowledge based system. The evaluation process carried out at different stage of system development life cycle. The performance of the system was assessed or measured through quantitative and qualitative techniques to achieve the expected objective. We can evaluate the KB structure, inference engine, user interface, etc. For this reason, evaluation must follow an order, it has to be planned and it must be controlled to reduce the cost of the final system (Gomez, 1994).

Basically, system performance evaluation procedure tends to assess not only the technical aspects of knowledge based system but also user's satisfaction. The evaluation criteria depend up on the purposes of designed knowledge based system in the domain area. Therefore, system's evaluation process tries to evaluate whether a set of rule achieved the expected goal or not (Lech, 2000).

Knowledge based system evaluation process involves to determine the suitability and desirability of the prototype (Mak, 2010). Effective knowledge based system evaluation process incorporates both technical and non-technical aspects. The technical aspects include exploring of the code, examining the correctness of reasoning techniques, checking the efficiency and performance of the system and debugging errors in the early age of a system development. The non-technical aspect includes system compatible with users' satisfaction, the easiness of the system, the quality of the user interface and the acceptability of the system in the real world environments (Seblewongel, 2011).

2.7.1. Methods of evaluation

Knowledge based systems evaluation method can be split into Verification, validation, assessment of human factors and assessment of clinical effect (Thomas, 2001).These evaluation methods are discussed as follows:

Verification is an evaluation process that should be implemented during system design and development to answer the question 'Did we build the system correctly'. Verification can be defined as the process that involves checking for compliance with the system specifications, checking for syntactic and semantic errors in the knowledge based system. Specification assessment includes user interface, explanation facility, real time performance and security provisions specified in the system design. To verify a knowledge based system, it is possible to

use either a program proof or a test strategy. The program proof confirms total correctness of the program logic with mathematical methods and the test proof strategy confirms partial correctness of the program with given test cases (s).

Validation: The concept of validation refers to determining the correctness of the system with respect to users' needs. Validation criteria include comparisons with known results (e.g. past cases or solved problem), comparison against expert performance, and comparison against theoretical possibilities. Empirical validation checks whether the results of content remain stable when the system is under full workload. The system test examines the complete system performance in its working environment. Validation tests include user acceptance surveys, direct comparison on random test cases between human expert and that of the system.

Evaluation of human factors is the process of determining the acceptability and usability of the knowledge based system. Usefulness of a system is often measured by examining user satisfaction. User satisfaction measured from different point of views such as content satisfaction, interface satisfaction and institutional objective. Personal aspect such as individuals' dislike of computer takes into consideration (Ohmann, 1997).

Evaluation of explanations is used to evaluate the explanation ability of knowledge based system (Stranieri, 2000). According to Andrew Stranieri (2000) explanation facility was measured based on the following criteria which used to judge the user interaction with the system:

- Naturalness- Explanations should be natural to the end user. Explanations that are not structured according to standard patterns of human dialogue create ambiguous information.
- Responsiveness- An explanation facility must have the ability to accept feedback from the user and provide response for the given feedback.
- Flexibility- An explanation facility must be able to offer brief description in more than one way.
- Sensitivity-An explication module should take into account the user's goals, the problem domain and the previous explanatory dialogue.
- Fidelity/accuracy- An explication system must accurately reflect the system's knowledge and reasoning.

- Sufficiency- An explanation module should be able to answer a range of questions that a users' wishes to ask and not limited to those questions predicted by developers.

2.8. Knowledge based system development tools

In the 1980s and early 1990s, when commercial interest in knowledge based system was reach at its peak, approximately there are more than 200commercially available KBS tools. Many are still available but no longer described as KBS tools for marketing reasons. A knowledge based system tool is a set of computer software that manipulates programs and other information in order to design and assist the development of knowledge based systems (Kaiser, 1992).

The actual implementation of KBS was based on high level programming languages. However, modern knowledge based system development tools highly depend on their purposes, functionality and some additional features. Based on their purposes, KBS tools are classified as general purpose programming tools such as Java, and framework 1.NET. On the other hand, there are also specific purpose programming languages such as JRULES, CLIPS, JESS (java expert shell system) (Lamma, 2001). In addition programming Language such as C++ provides objects as a mechanism for programmer to control the layout and data structures (King, 2000). Finally, the popular expert system development tool was CLIPS. The programs are represented by list structures. Lisp is the foundation of many expert systems and shells such as CLIPS (Nalepa, 1998).

There are many knowledge based system tools. According to (King, 2000) different author classified KBS development tools based on their functionality. The simplistic nature and additional feature it provides is used as parameters to select KBS development tools.

Prolog (programming in logic) is one of the most widely used programming languages in artificial intelligence research. As opposed to imperative languages such as C or Java (which also happens to be object-oriented) prolog is a declarative programming language. When implementing the solution to a problem we specify what the situation (rules and facts) and the goal (query) then let Prolog interpreter derive the solution. Prolog is very useful in some problem areas, such as artificial intelligence, natural language processing, databases . . . but it is pretty useless in others domain such as graphics or numerical algorithms (Endriss, 2007).

Prolog derives its power from a procedural interpretation of logic. It represents knowledge in terms of procedure and reasoning becomes a simple process of calling the right procedures (Convington, 1995). Consider this example:

1. For any X, if X is in Asella, then X is in the Ethiopia.
2. Asella is in Ethiopia.

Therefore, there are many widely used prolog programming languages such as Quintus Prolog, Arity Prolog, ALS Prolog, LPA Prolog, and a number of other commercially available as well as freeware Prologs from ESL and SWI. For the purpose of this research study, LPA Prolog programming language is used.

2.8.1. LPA Win-Prolog Programming language

WIN-PROLOG provides a complete development environment including easy-to-use pull-down menus, support for multiple edit windows and rich edit (e.g. automatic syntax coloring, multiple fonts in a window, etc.).**WIN**-PROLOG has incremental and optimized compilation, together with a hashed compilation mode which allows a matching clause to be found almost instantly.

WIN-PROLOG allows you to create polished Windows applications; it provides an extensive range of graphics predicates allowing convenient access to a large number of Windows Graphical User Interface (GUI) functions (Shalfield, 2002)..

WIN Prolog is a programming language which is completely different from other languages. Programming language such as BASIC, C, C++ and PASCAL uses their main techniques or methods to splitting a problem into discrete steps and following those steps in sequential order (Ghan, 2004).

Prolog is attractive logic programming language for professionals in the area of knowledge Engineering and Artificial Intelligence. Indeed it has been used in a various real world applications. Some of the most common domain areas are Environmental Modeling, Sales Modeling, medical domain, Fungus Identification, image Recognition, Management Consultancy, Shift Allocation, etc. (Pfenning, 2007).

In Prolog the data and the program are the two different ways of looking at the Prolog objects. Prolog has the ability to change its program whilst that program is running. Another important aspect of Prolog is that it relates to a logic called predicate calculus. This gives Prolog a number of distinct properties it inherits from logic and gives better foundations than other conventional

programming languages. One of the properties is that prolog is a declarative language. This allows one to develop a program by concentrating on "what" needs to be done instead of "how" it is done. It can also allow a programmer to understand without the need of following through its dynamic execution (Convington, 1995).

2.9. Knowledge based system in medical domain

Artificial intelligence has been made significant contributions for numerous of applications in the medical domain. The knowledge based systems contain medical knowledge usually about specifically defined task. The fields of knowledge based system are getting more attention in medical domain due to its applicability to emulate human reasoning process and human expert problem solving skills. One of the driving forces of AI was the development of computer program that imitate the human learning ability from its environment. The introduction of AI in the 1970's allows the researchers and scientist to develop complex and powerful knowledge based system in the domain of medicine. Simple data structure but powerful reasoning ability makes the development of knowledge based system more popular. Different researches have conducted study in the medical domain to proof the applicability of knowledge based system. The most well-known application areas were described as follows (Prasad, 2011).

2.9.1. Commonly known Rule based system in medicine.

CADUCEUS is a medical expert system completed in the mid-1980s. The system was developed to improve on MYCIN which focused on blood-borne infectious bacteria. MYCIN is a computer program designed to aid physicians in the diagnosis and treatment of meningitis and bacteremia infections. The system was focus on more comprehensive issues than a narrow field like blood poisoning. CADUCEUS worked using an inference engine similar to MYCIN's. It also made a number of changes to incorporate inductive reasoning to deal with additional complexity of internal disease (Kulkarni, 2009).

INTERNIST-I (1974) is a rule based expert system which used for patient observations. The reasoning process is carried out by listing compatible state of disease based on a tree structure database that links diseases with symptoms. By the early 80s it was recognized as the most valuable product of the system which was used as the basis for successor systems. These

products are used as Quick Medical Reference (QMR) and commercialized diagnosis Decision Support System for internists.

MITIS It is another expert system that was designed and developed in 2004 at the National Technical University of Athens. It was designed to help in managing and processing data's related to obstetrical, gynecological and radiological. MITIS is a WWW-based medical information system based on three-tier client-server architecture and designed to provide mainly gynecologists with unified patient management capabilities, either internally in the hospital or external at private office (Vijayalakshmi, K. and et al, 2004**)**.

MYCIN is a computer program designed to aid physicians in the diagnosis and treatment of meningitis and bacteremia infections. It is one of the most popular medical expert system used to assist diagnose and treat blood diseases. It was developed at Stanford University in the mid-1970s. It was the first in the demonstrating how a system can be used to successfully perform medical diagnosis (William van Melle, and et al. 1981).

ONCOCIN is a rule-based medical expert system for oncology protocol management developed at Stanford University. The incursion was designed to assist physicians in the treatment of cancer patients receiving chemotherapy (Abu Naser, 2010).

PACE stands for the patient care expert system. It was designed in 1977 with the intention of making an intelligent selection from vast and ever changing information related to health. The knowledge base is used by the system software to make easy care plan development. At first the system was designed for educational purpose for the nursing profession. After years PACE has evolved and passed through many development generations. Now PACE has become an advanced clinical management system that can assist the entire health care field to diagnose and care for patient with pulmonary diseases (Masizana-Katongo et al, 2009).

Currently, knowledge based systems in medicine has received much attention, because of the potential benefit that can be gained from using this technology. They used to increasing productivity in a medical environment, assist diagnoses process, assist to train medical professional and used to handle some routine tasks in the medical domain (Seblewongel, 2011).

2.9.2. Clinical application of knowledge based system

Artificial intelligence in medicine has many application areas. Applying this technology gives a number of potential benefits in the domain area. Knowledge based systems as field of artificial intelligence can provide support and facilitate clinical decisions support. As result it help to improve the quality of patient care, optimize the cost-effective service and ultimately transform the traditional structure of health care provision (Nilsson, 2004).In addition, knowledge based systems has practical use for routine clinical activity in medical domain (Kalogeropous, 2002).

According to Krishna Prasad (2011) there are many types of clinical application area which needs the support of knowledge based system:

- **Diagnostic assistance**: When a patient's case is complex and rare case then diagnosis is simply inexperienced. Therefore, expert system can help to come up with best solution based on the existed knowledge.
- **Therapy critiquing and planning:** the Systems look for inconsistencies, errors and omissions in an existing treatment plan. It used to formulate a treatment based upon a patient's specific condition.
- **Image recognition and interpretation**: current many medical images were automatically interpreted from plane X-rays to more complex images like angiograms, CT and MRI scans.
- **Advisory system**: advisory knowledge based systems provides a noticeable opportunity in assisting clinicians with the diagnosis of diseases, prescription of medications, checking for drug-drug interactions, inspecting drug side effects and selecting the most cost-effective treatments (Coiera, 1993).
- **Protocol design and maintenance tools:** since clinical care is increasingly moving to protocol driven processes, knowledge acquisition and maintenance technologies are good application area for protocol design in clinical setting.
- **Clinical workstations**: knowledge based systems are vital in clinical work stations to provide easy access of clinical data for health care workers and to optimize the views of the data made available to different clinical workers.
- **Laboratory system:** coiera et al. (1993) stated that “clinical laboratory has proven to be a good domain area for the use of expert 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."

2.10. Knowledge based systems for triage patient treatment

Application of knowledge based system in the medical domain was the few decades' trend. Computer based systems provide powerful and flexible means to obtain solutions to a variety problems that cannot be handled by the conventional methods. Artificial intelligence is the field of computer science aiming at creating mechanisms that can engage in acting like human expert which makes it intelligent (Ja'afar, 2007).

As different domain areas require the application of knowledge based systems, triage treatment is one of medical domain that needs more support by expert system. There are numbers of researcher globally conducted research study in the area of triage system. The main intensions of the studies are to show the applicability of the new technology to simply working environment.

The triage service provider needs to consider different attributes to optimize the quality of the Emergency Medical Service and to utilize limited institutional resources. The Knowledge based system can be used for patient assessment in the triaging processes. Therefore, knowledge based systems play a significant role especially if the triage workforce and supporting staffs number not enough to handle the situation (Burkle, 2008).

In 2007 Talmor and colleagues proposed 'The Simple Triage Scoring System' (STSS) which uses only those vital signs and patient characteristics that are readily available at initial presentation. They also propose alternative tool in predicting death and the utilization of critical care resources during epidemics. The system uses attributes such as age, shock index (heart rate > blood pressure), respiratory rate, oxygen saturation and altered mental state to draw a conclusion (Rebecca Cusack, 2011).

Similarly, in 2007 Siti Syazana developed a prototype web-based emergency triage system using fuzzy logic expert system. The objective of the research is to change the manual processes to computerized system. The system is tested to determine its accuracy by system evaluators. The emergency triage enables the users to store patient details. The application is developed using

open source software such as Apache web server, PHP programming language and etc (Siti, 2007)

In 2005 Gtreatch, D. and his colleague developed expert system for the British telephone triage services of National Health Service direct (NHS). The system known as clinical assessment system (CAS) is designed to standardized and control the interaction between NHS direct nurses and caller through telephone medicine. CAS achieves only limited success due to the professional ideology of nursing, but also the fact that rule based expert systems capture only part of the what ‘ human expert’ do. NHS directs uses an integrated telephone line and computerized clinical assessment system, which is designed to support triage nurse by providing expert clinical reasoning (Gtreatch, D. et al, 2005).

2.10.1. Related research work

Some the related works conducted by local researchers in the medical domain have been reviewed as follows.

Seblewongel (2011) has done research study on prototype knowledge based system for anxiety mental disorder. Objective of the study is to design and develop a prototype knowledge based system for diagnosing a patient with anxiety mental disorders with the overall aim of exploring the applicability of knowledge based system technology to the specific area. The researcher used rule based technique and back ward chaining mechanism to achieve the proposed objective. The finding of the study reveal that the proposed knowledge based system applicable to the domain area and study result show the system gain a promising user acceptance. Finally, the researcher recommended that to fully implement the functionality of the prototype and integrating rule based system with case based techniques for a better result.

Solomon Abebe (2010) conducted research study on application of knowledge based system for settling Tort claims under The Ethiopian Law. This research deals with the development of KBS as an alternative approach for handling tort climates under the Ethiopian law. CommonKADS and decision tree modeling techniques are used in the modeling of expertise. Rule-Based reasoning (RBR) approach is adopted to represent the necessary knowledge base of the system. The knowledge base is developed using SWI prolog which supports backward chaining to make inferences by reading the composed rules in the knowledge base. The testing of the prototype system is done first by using artificial test data and then a sample of thirteen previously decided

test cases is taken in law of torts to make comparisons on the decision made by the system and human experts. Therefore, the development of KBS that incorporates predictive capacity to predict judicial decisions by taking precedents (or decided cases) and examining closely the personal attitudes of the presiding judges towards political, cultural, economic, religious, and social factors are demanding to make the system credible in the legal community.

Dejene Alemu (2009) conducted research on the Application of Knowledge Based System for Woody Plant Species Identification. This study attempts to design prototype KBS for woody plant species identification. The knowledge based system uses rule based approach for the proposed system. The system is modeled in decision laddering, domain knowledge is represented using production rules in prolog to construct the knowledge base. The prolog built in backward inferring mechanism is used for the identification of the species. . Finally, the system is tested and evaluated by the users. The result shows that, the system identifies the woody plant species correctly and can be applicable in woody plant species identification. As compared to existing way of identification we come up with new knowledge/rules with minimum features that registers comparable performance.

Redit (2006) conducted a study to investigate KBS for HIV pre-testing counseling. The main objective of her work is to look into the feasibility of employing the expert system in the area of pre-test counseling by the knowledge based system technology. She used rule based reasoning techniques and pro gold expert system shell in developing prototype. The prototype is able to show the applicability of the technology to the area at a satisfactory level

Anteneh (2004) conducted research study to investigate the rule based reasoning approach in designing and developing knowledge based system prototype for Antiretiroval therapy in area of HIV treatment as sources of knowledge. The acquired knowledge is representing using hierarchical structure modeling. The research inference engine uses backward reasoning mechanism. EXPART has been tested and evaluated by users and senior physician. Based on the research finding encouraging result is obtained. He explores the applicability of knowledge based system in assisting the choice of drug for individual patients in the area.

A numbers of local researches have been done research in the medical domain. The main intension of all researchers is to investigate the applicability of knowledge based system in the

medical domain area. The researcher employ similar approaches such as rule based techniques to develop the knowledge based system. In addition most of the researches are implemented for specific domain area.

Similarly, the proposed knowledge based system is in this study is conducted to explore the applicability of rule based system for triage patient treatment. The main objective of the research study is to categorize the patient based on their pillar symptoms into the triage category. Furthermore, in this research the attempt is to implement rule based system for general knowledge. Therefore, the proposed knowledge based systems can assist human expert during the diagnosis process and to recommend the appropriate treatments.

CHAPTER THREE

KNOWLEDGE ACQUISITION AND CONCPTUAL MODELLIING

Knowledge acquisition (KA) is the process of acquiring relevant knowledge from domain experts and other sources of information such as books, databases, guidelines, manuals, journal articles, computer files, etc. KA is the process of eliciting, structuring and representing (formalizing) domain knowledge acquired from different sources. The term knowledge acquisition and knowledge elicitation have been used interchangeably in the field of artificial intelligence (AI) literature. The acquired knowledge can be specific to the problem domain, it can be general or it is meta-knowledge (knowledge about knowledge). Knowledge acquisition is the first step and time consuming task in the development of knowledge based system (Sagheb, 2009).

There are certain important steps that the knowledge engineer need to carry out during knowledge acquisition process. These are (Miller, 2009):

- Eliciting data and information from the domain experts
- Interpreting the acquired information to understand human expert reasoning processes
- Constructing model to represent the expert's knowledge
- Repeating step I-III as the knowledge base system involves into a functional system

3.1. Pre-acquisition phases

Before the actual knowledge acquisition process, the researcher has conducted a preliminary investigation in the domain area. During the preliminary investigation a numbers of stakeholders from different domain, i.e., medical director, general practitioner, nurses, specialist and medical students are participated. These stakeholders are used to understand the dimensions of the domain area. During this phase, the researcher has tried to conduct pilot study and informal discussion with the domain experts to understand the dimension of the problems. In addition, secondary sources of knowledge are reviewed on each proposed diseases. Based on the finding of pilot study, the researcher constructed semi-structured interview questions in a way that helps to acquire the required knowledge from the domain experts.

Therefore, the main objective of this chapter is to interact with domain experts in order to collect, gather and analyze the required knowledge. The knowledge content covers issues such as how general practitioner diagnosis patient based on their pillar symptoms. The acquired knowledge is then represented into rule based system using if then rules. Generally, this chapter covers the knowledge acquisition phases, conceptual modeling and knowledge representation process.

3.2. The Process of Knowledge Acquisition

For the purpose of this research, the process of knowledge acquisition includes some basic activities such as interview of domain expert's and review of relevant sources of information. The objective of knowledge acquisition is to gather the required knowledge, interpreting the acquired knowledge, analyzing and validating the knowledge content. Based on the acquired knowledge, the proposed knowledge based system is designed using decision tree model. Therefore, knowledge acquisition process of this thesis is based on domain expert interviewing of and reviewing of related documents. This section discusses the detail of knowledge acquisition techniques as follows.

3.2.1. Interviewing domain experts

Primary sources of knowledge are collected from human experts in the domain area at Adama university Asella hospital. To gather the required knowledge semi-structured interview technique is used. Since one of the main focuses of this research is eliciting relevant tacit knowledge from the domain experts, four (4) domain experts were selected using purposive sampling technique. During the interview phase, the main challenge is willingness of domain expert to share their expertise and experience, which is important to acquire the relevant knowledge. To handle this challenge domain expert were selected based on their interest in addition to purposive sampling technique. The domains of interview with expert covered issues such as how the expert interact with patient, what are techniques used to identify the pillar symptoms of the patient, the procedures of diagnosing and what are the possible treatment recommended to the patient.

During the extensive discussion, the researcher tries to acquire the relevant tacit knowledge which is significant to generate the proposed rule. In addition the domain experts were actively participated throughout the research work and they were consulted to confirm the correctness of the acquired knowledge. During face to face communication, the acquired knowledge from

domain experts has been recorded manually by using pen and paper sheet. Profiles of domain experts participated in the interview process are presented in the Table 3.1 below.

No	Educational level	Specialization	Area interviewed	Role
1	MD	Medicine	Medical category	General
2	MD	Medicine	Surgical category	Medical director
3	MD	Medicine	Gynecology category	Team coordinator
4	MD	Medicine	Psychiatric category	General

Table3.1. domain experts' profiles

As indicated in the Table 3.1 above, the health professionals are devoted to providing health care services in the institution. In addition they participate in conducting research and teaching of medical students in the university. According to the domain experts, the investigation of patient health problem starts by collecting some relevant information such as location, age and family history of the patient. History of patient is important attribute to determine the types of health problem; because some diseases have unique associations with geographical location, age factors and family inheritance case. The actual diagnosing task of the physician started using a medical instrument which is called vital sign. This instrument is used to investigate particular part of patient body affected by certain diseases or unknown feeling. According to the domain expert vital sign are classified into four main categories. Each category of vital sign is discussed as follows:

1. Pulse rate: the physician check the pulse rate of the patients. There are different parameters which are used to check the normal health condition of patient is usually between "60-90" in number. But, Patient pulse rate above or below of the given interval shows that he/she is not at normal condition. This measurement helps the physician to understand the health status of the patient related to their pulse rate. If there is any disordered (shock) in the patients pulse rate, then the expert tries to investigate the underlying causes that affect the normal condition of the patient pulse rate.
2. Respirator rate: The normal condition of respirator rate is usually between"12-24" in number. Respirator rate of an individual is between the above intervals shows that the

patient respiratory rate is at regular pattern. This measurement is used to check how the patient breathing system shows a pattern. But, if the patient register respirator rate below or above this interval, it indicates that the patient has some complication in relation to his/her respirator rate. Therefore, the physicians take this into consideration to investigate those causes affected the patient respirator rate.

3. Temperature measure: usually the normal condition of human body temperature is between“36.5 - 37.2”. Above and below this normal condition shows the abnormal health status of the patients. Therefore, the increment and decrement in temperature helps the physicians to identify underlying causes that affect the normal condition. But, location of the patient contributes significant roles for the increment of body temperature.
4. Blood pressure: blood pressure is used to measure the flow of blood in our body circulation system. The normal range of human blood pressure is 120/90, the upper threshold can increase from 90 to 140 and the lower thresholds are “between 65 and 85” which is considered as normal state. But, below and above this range shows the patients’ are at risks condition. Then the physician tries to investigate the causes of this condition which helps him/her to arrive at certain conclusion.

Therefore, human expert uses the above four tools as inference mechanism in addition to the pillar symptoms collected from patient response during triage examination.

To select the proposed diseases the researcher considers different factors. First, sometimes it is difficult to start diagnosing a disease without getting laboratory result. Second, some diseases are not prevalence to the research area. Thirdly, the sign and symptoms of some diseases are changed from time to time; as a result it makes difficult the diagnosing process. The proposed knowledge based system is developed based on the pillar symptom of each disease in the knowledge base. Therefore, the diseases are selected purposively by considering the above factors. In addition secondary sources of information contribute a lot to indentify the pillar symptoms of each proposed diseases.

3.3. General structure of triage system

According to Attorney-General's (2007), Triage decision-making is an inherently complex and dynamic process. Decisions are made within a time-sensitive environment, with limited manpower and information (response of the patient). Especially, the situations become more difficult for those patients who do not have a medical diagnosis experience. To handle such complexity in the triage treatment, general practitioners are required to possess specialized knowledge as well as experience with a wide range of illness and injuries.

For the purpose of this research study, Triage system is classified into four categories namely, medical, surgical, gynecology and psychiatric, even though the human health problems can be categorized into numbers of divisions. The current working triage system of Adama university Asella hospital has the above four categories. When a new category is identified during the diagnosing process, the human experts re-assign the case into the specific category. Figure 3.1 below shows the general structure of triage system of Asella hospital.

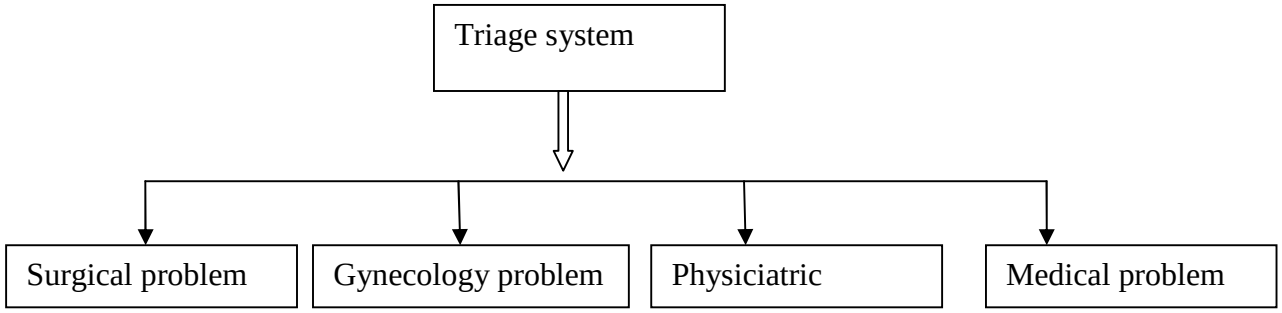


Figure3.1. General Structure of triage system

3.3.3. The categories of triage system

Figure 3.1 above indicates, the current triage system of the institution is categorized into Surgical, Medical, Gynecological and psychiatric sections. For the purpose of this study sample of diseases (cases) are selected from each category. For example, from medical domain (allergy, swine-flu, TB, malaria and pneumonia) are selected. From the surgical domain (appendicitis, cancer, sleep apnea, and heart disease) are selected. From gynecology domain (pregnancy and menopause) are selected. Finally, from psychiatric domain (mood and mental disorders) are

selected. Therefore, this section discusses the characteristics, symptoms and possible treatment of each disease in their respective category.

1. **Medical health problem**

Medical category is one part of triage system which involves none operative management of human health problems. Medical diagnosis includes physical examination, internal medicine and providing appropriate medication to the patient. The medical diagnosis process of the physician depends upon the pillar symptoms each disease. In addition to the pillar symptoms, vital sign instrument have significant roles to identify the patient health problem. In the real situation there are a numbers of medical health problems. For the purpose of this study, the proposed lists of diseases under the medical category are discussed as follows:

A. TB (Bacterium M. Tuberculosis)

Tuberculosis is a serious infectious disease caused by the bacterium M. Tuberculosis. The disease may affect all organs of the body, but most frequently TB affects the lungs. Tuberculosis is curable with early detection and proper treatment. Tuberculosis is spread through the air. Only persons with tuberculosis in the lungs can infect others. Some have tuberculosis in their lungs without feeling ill, they can infect others.

Domain expert suggested that common symptoms such as long term cough (more than two weeks), fever, night sweat and weight loss are the pillar symptom of TB disease.
The examination of TB patient consists of a skin test, possibly a blood sample and a chest x-ray for persons greater 15 years old.
Treatment of tuberculosis: Tuberculosis is usually treated with tablets for six months. To be cured it is vital to follow the treatment and completed in the correct manner as it prescribed by doctor.

B. Swine flu (H1N1)

Swine flu is an infection caused by a virus. It's named for a virus that pigs can get. People do not normally get swine flu, but human infections can and do happen. The virus is contagious and can spread from human to human with ease transmissions. Because it is caused by a re-assortment of virus, no one has immunity against this virus and is at risk of being caught by flu. Swine flu is a

highly contagious acute respiratory disease of pigs, caused by Swine Influenza the Virus referred to as the novel H1N1. Because of the dynamic nature and changeable characteristics, the scientific name of the diseases and their types changed from time to time. The dynamic nature of the diseases makes difficult the developments of immunities.

A vulnerable group of people includes pregnant women, caretakers of less than 6 months old infants, health care workers, adults with Asthma, diabetic and people with immune-compromised systems.

The actual transmission of swine flu in human is through coughing, sneezing, touching nose, mouth or contaminated surfaces.

Swine flu shows clinical symptoms is similar to seasonal flu and acute upper respiratory tract infection. The common symptoms of swine-flu are headache, fever, cough, sore-throat, body aches, chilling; fatigue, diarrhea and vomiting are observed.

There are generally two kinds of vaccines these are inactivated virus vaccine and live attenuated vaccine (LAIV). The extent of this disease in humans is still unknown due to the escape of mild or asymptomatic case from recognition.

Therefore, commonly used treatments to prevent swine flu are:

- Antiviral medications
- To keep the infected person at home
- By having no contact with pigs

C. Malaria

Malaria is a parasite transmitted by Anopheles mosquitoes. Anopheles mosquitoes transmit malaria by injection sporoites into the human host. Malaria is mostly a disease of the hot climate region, warm, humid climates where pools water provides perfect breeding grounds. Epidemics are increasing in highland areas where malaria was uncommon, partly due to climatic changes including high rainfall patterns. Refugees and people who are internally displaced as a result of civil war and natural disasters are particularly vulnerable to epidemics of malaria.

Symptoms and Diagnosis of malaria

Symptoms of malaria are generally non-specific, but domain expert describe that common symptoms of malaria consists fever, malaise, weakness, nausea, vomiting, diarrhea, confusion, disorientation or coma, headache, back pain, chills, and cough.

The diagnosis of malaria should also be considered in any person with fever of unknown origin regardless of travel history. Patients suspected of having malaria infection should be urgently evaluated. Laboratory diagnosis of malaria can be made through microscopic examination of thick and thin blood smears.

Early diagnosis and treatment will save lives and prevent the development of complications. Complications due to malaria may mimic many diseases, so a good history and physical examination are critical, followed by blood examination to confirm the diagnosis. For example, careful examination of the chest pain may distinguish malarial breathing from pneumonia.

Most cases of insignificant malaria can be cared at home, but the patient or care provider should be aware of the following points:

- Dosage and frequency of the medication
- Symptoms will return if treatment is not completed (even if symptoms disappear immediately after first eradication)
- Vomiting soon after medication may require more treatment
- Fever which persists during treatment or returns after a few days of completed anti-malaria treatment may indicate treatment failure.

Pregnant women in malaria endemic areas are more susceptible to malaria infections because of their reduced natural immunity and may develop complications such as fever and severe anemia. In addition, all pregnant women should attend routine pre-natal clinic and should be protected from malaria by sleeping under treated mosquito nets.

There are different commonly used basic techniques to prevent the spread and production of malaria parasite these are:

- Provision of early diagnosis and prompt treatment
- Planning and implementation of sustainable prevention measures including vector control
- Early detection of containment and prevention of epidemics
- Strengthening of local capacities in basic and regular assessment of the malaria situation within countries.

D. Pneumonia

Pneumonia is a severe acute lower respiratory infection that specifically affects the lungs. Push and fluid fill the alveoli, which is the smallest air spaces in the lungs and make it difficult to absorb oxygen.

Bacteria are more likely to result in severe pneumonia, because bacteria are the causes of pneumonia. Pneumonia can also be caused by viruses, such as influenza and fungi which is the cause of pneumonia in persons with AIDS. Children are at greater risk for acquiring pneumonia. For example, undernourished children, low birth-weight infants, infants who are not breastfed and children suffering from other illnesses such as AIDS are more likely to develop pneumonia. Environmental factors such as overcrowding in homes, exposure to tobacco smoke and indoor air pollution increase the risk of acquiring pneumonia:.

The common symptoms of pneumonia are: fever, Cough producing yellow and green mucus, fast breathing, chest pain, shaking chill, and feeling tired.

Pneumonia is a serious infection disease that requires prompt treatment with an appropriate course of antibiotics. The type of antibiotic, route of administration and duration of therapy depends on the age of the patient. Pneumonia is diagnosed most often by the combination of presenting clinical symptoms. There is no easy way of distinguishing whether bacterial or viral cause's pneumonia, because there is a large overlap in presented clinical symptoms.

A chest X-ray can help to confirm the diagnosis. A blood culture may help to determine the exact cause of a bacterial pneumonia. Preventing under-nutrition in children can reduce their risk of acquiring pneumonia or dying from pneumonia.

The following table shows the identified symptoms of each disease in the medical category.

Medical health problem	The common pillar symptoms
TB	Long term cough (more than two weeks), fever, muscle fatigue, night sweat and weight loss.
Malaria	fever, malaise, weakness, nausea, vomiting, diarrhea, confusion, disorientation or coma, headache, back pain, myalgia, chills, and cough
Pneumonia	Cough producing yellow and green mucus, fast breathing, chest pain, shaking chill, and feeling tired
Swine-flu	headache, fever, cough, sore-throat, body aches, chilling; fatigue, diarrhea and vomiting

Table3.2. common symptoms of medical health problems

2. **Surgical health problem**

As the name indicated surgery is the process of patient or client operative management. Operative management mainly involves the cutting or incisions of human body parts which causes health problem. There are a numbers of causes for surgical patient such as accident, fighting, foreign entrance, obstruction, pain, burn, etc. Domain expert suggested that a common symptom like swelling, wound and injury are considered as surgical case. But, sometimes the symptoms can be occurred in patient with medical problem. Most of the time surgical cases result in bleeding and fluid of substance from the patient body.

There are different factors for the causes of surgical cases. But, these factors are depends upon the types of cases. Some of the common risk factors are high prevalent to accident such as car, fighting, and burn. Once surgical problem of the patient identified, then the next step would be to take different intervention mechanisms to arrest the disease in a living body. This can be done through:

- Evaluate the patient set up
- Taking investigation to identify the cause of the problem

Patient investigation can be done through operative procedure, watching patient set-up and X-ray methods. Sometimes physician can understand the severity of the case by watching the wound, injury, swelling and fractures of the patient's body. For the purpose of this study, the researcher take four surgical cases that would be discuss as follows

A. Appendicitis facts

- The appendix is a small, worm-like appendage attached to the colon.
- Appendicitis occurs when bacteria invade and infect the wall of the appendix.
- The most common complications of appendicitis are abscess and peritonitis.

Appendicitis Symptoms

The main symptom of appendicitis is abdominal pain. Symptoms of appendicitis may take 4-48 hours to develop. Other common symptoms of appendicitis include loss of appetite, nausea, vomiting, and fever.

Appendicitis diagnosis

Appendicitis usually is suspected on the basis of a patient's history and physical examination; however, a white blood cell count, urinalysis, abdominal X-ray, ultrasonography, Computer tomography scans, and laparoscopy also may be helpful in diagnosis process.

Appendicitis treatment

The treatment for appendicitis usually is antibiotics and appendectomy (appendectomy or surgery to remove the appendix). A complication of appendectomy includes wound and infectious disease.

B. Cancer diseases

Cancer refers to illnesses that result from abnormal growing of cells in the body. These cells divide and produce new cells in an uncontrolled way that can spread throughout the body and cause damage to essential organs. Sometimes identifying the underlining causes of cancer becomes is difficult, because cancer caused due to different factors. The two main factors are:

- Inherent cause: - patients can gain cancer due his/her parent genetic. The genetic factor is caused by mutation (mutated gene of a patient from his/her parent)
- Environmental factors are caused due to change in the environment and an exposure of the patient to the new environment. Some of the main environmental factors are dietary factors, chemical and radiology exposure of patient.

The main common symptoms of cancer disease are: Thickening or lump in the body, Cough or hoarseness that does not heal, unexplained bleeding, any sore that does not heal, and unusual upset stomach or difficulty of swallowing

Characteristic and features of the disease depend upon the types of cancer. But, the diagnosing of the patient goes from head to toes. The diseases become more severe when patient pain detects around his abdominal. Biopsy is a good method for diagnosing cancer with certainty. Domain expert uses different investigation techniques to identify cancer disease. These are:

- Investigation of common symptoms
- By taking Patient and family history
- Physical and laboratory examination

Generally cancer disease is not curable. But, the best ways to control and manage the spread of cancer disease is through early detection and follow up the growth of the disease.
The common methods of cancer treatment are through radiology (X-ray), chemo stat, biological therapy, hormone therapy and surgery. Treatment options depend on the stage and type of cancer.

C. Coronary artery disease

Coronary artery disease is the narrowing or blockage of the coronary arteries, usually caused by atherosclerosis. Atherosclerosis (sometimes called “hardening” or “clogging” of the arteries) is the build-up of cholesterol and fatty deposits (called plaques) on the inner walls of the arteries.
Coronary artery disease starts when you are very young. Before your teen years, the blood vessel walls begin to show streaks of fat. As you get older, the fat builds up, causing slight injury to your blood vessel walls. In addition substances traveling through your blood stream, such as inflammatory cells, cellular waste products, proteins and calcium begin to stick the vessel walls.
According to domain expert patient with coronary artery disease present common symptoms such as chest discomfort, heaviness tightness, pressure, aching, burning, or squeezing.

In addition to the above pillar symptoms coronary artery patient may feel the following symptoms namely:

- Shortness of breath
- Palpitations (irregular heartbeats, skipped beats or a “flip-flop” feeling in your chest)
- A faster heartbeat
- Dizziness or Nausea
- Extreme weakness and Sweating

There are certain risk factors for the causes’ of artery diseases. These factors include:

- High blood cholesterol
- High blood pressure
- Cigarette smoking
- Diabetes
- Being overweight or obese
- Lack of physical activity.

Treatment for coronary artery disease involves reducing your risk factors, taking medications as prescribed, possibly undergoing invasive surgical procedures and visiting your doctor regularly. Treating coronary artery disease become more effective by reduce your risk of a heart attack or stroke. In addition regular exercise has significant contribution to recover the patient from his/her illness.

D. Sleep apnea facts

Sleep apnea affects the way you breathe when you are sleeping. These breathing pauses typically last between 10 to 20 seconds and can occur up to hundreds of times a night. Untreated sleep apnea prevents you from getting a good night’s sleep. This chronic sleep deprivation results in daytime sleepiness, slow reflexes, poor concentration, and an increased risk of accidents. Sleep apnea can also lead to serious health problems over time, including diabetes, high blood pressure, heart disease, and weight gain.

Major signs and symptoms of sleep apnea

- Loud and chronic snoring
- Choking or snorting during sleep
- Long pauses in breathing

- Daytime sleepiness

Self-help treatment options for sleep apnea

While a diagnosis of sleep apnea can be scary, it is a treatable condition. Home remedies and lifestyle modifications can go a long way in reducing sleep apnea symptoms.

- Lose weight- Some people find that even moderate to severe sleep apnea can be completely corrected by losing excess weight.
- Quit smoking- Smoking is believed to contribute to sleep apnea by increasing inflammation and fluid retention in your throat and upper airway
- Avoid alcohol, sleeping pills, and sedatives
- Avoid caffeine and heavy meals within two hours of going to bed**.**
- Maintain regular sleep hours

Medical treatment options for sleep apnea

- Treating the underlying medical condition causing the apnea, such as a heart or neuromuscular disorder.
- Using supplemental oxygen while you sleep.
- Breathing devices that are used to manage obstructive sleep apnea.

The following table shows the summary of identified pillar symptoms of each disease from surgical category.

Surgical health problem	The common pillar symptoms
Appendix	Lower abdominal pain, loss of appetite, nausea, vomiting
Cancer	Thickening, Cough or hoarseness, Unexplained bleeding, sore that does not heal, Unusual upset stomach and difficulty of swallowing
Sleep apnea	Loud and chronic snoring, Choking or snorting during sleep, Long pauses in breathing and Daytime sleepiness
Coronary artery disease	chest discomfort, heaviness tightness, pressure, aching, burning, or squeezing

Table3.3.The common symptoms of surgical cases

3. Gynecological health problems

Gynecology is the process of delivering and labor of pregnant women. The main activity of gynecology section is to deals with the diseases and hygiene of pregnant women health problem. These problems are mainly caused due to women pregnancy and related complications. For the purposes of this study, pregnancy and menopause cases are selected under this category. The description and features of each case are discusses as follows.

A. pregnancy

Pregnancy is the state of being pregnant, the period from conception to birth when a woman carries a developing fetus in her uterus. Pregnancy is not a disease and happened during the period of female fertility, between the ages of '15 to 45'years. During the diagnosis process the physician takes the age of patients into consideration. For example, if the patient is below the age of 15 and above the age of 45 their health problem may relate to other complication. Therefore, careful examination helps to the physician to identify the possible problem of the patient.

According to gynecologist the common symptoms of pregnant women's are period interruption, body swelling, vomiting, pushing down pain, lower abdominal pain and increased blood pressure.

There are a numbers of risk factors that complicate the normal pregnant conditions. These are Family history of pregnant, history of hypertension, Diabetic problem, multiple pregnancies and twine pregnancy.

The commonly known treatment of pregnant case is to understand the stage of pregnant and conducting investigation to identify any complication that comes with pregnancy.

- Taking investigation
- Physical examination including pulp examination, ultrasound if uterus aged more than three month, spectrum examination
- Antenatal follow up to the time of delivery or birth
- Counseling of pregnant women with her couple

B. menopause

Menopause is the moment when a woman has had her last menstrual period and is no longer fertile, which is confirmed after she has not had a period for 12 months. It is certainly not an illness; menopause can cause physical and emotional symptoms.

The time leading up to menopause, called per-menopause, begins on average in women aged 45 years. However, it can start at any time between the ages of 39 and 51, may last an average of 5 years. Menopause is not always caused by the natural decline of hormone production in the body. However, menopause can be brought on by one of the following factors:

- Hysterectomy**.** When a women uterus is removed during surgical procedure
- Chemotherapy and radiation therapy**.** Undergoing cancer therapies can induce menopause and lead to symptoms during the course of therapy or months later.
- Primary ovarian insufficiency**.** Though the cause of this condition is not fully understood, it is a result of your ovaries not producing normal levels of reproductive hormones.

The common symptoms of menopause begin to appear in per-menopause, which may begin many years before menopause is reached.

The women in the menopause period present with the following common symptoms, but every will not experience them and certainly not to the same degree.

- Hot flashes**.** Increases in temperature that can lead to sweating
- Changes to mood and memory**.** Mood swings, irritability, anxiety and occasional difficulty with remembering things or concentrating problem
- Sexual changes**.** Vaginal dryness or decreased lubrication can be caused by low levels of estrogen
- Sleep disturbances**.** includes difficulty falling or staying asleep and sleep apnea
- Irregular periods**.** Your menstrual cycles may become longer, shorter or completely irregular with lighter or heavier flow.

Depending on the client menopausal symptoms, physician provides a treatment that relief the client from discomfort. There are different treatment of menopause namely Hormone therapy, vaginal estrogen which comes in the form of a tablet, ring, or cream; vaginal lubricants or moisturizers, Psychotherapy or couples counseling**,** and alternative medicines.

The following table shows the summary of identified pillar symptoms of each disease from gynecology category.

Gynecology health problem	The common pillar symptoms
Pregnant case	Period interruption, body swelling, headache, vomiting, pushing down pain, lower abdominal pain.
Menopause case	Vaginal dryness, irritability, hot flashes, Sexual changes/discomfort, Sleep disturbances, and Irregular periods

Table3.4.The common symptom of gynecology health problem

4. **Physiciatric health problem**

A Physiciatric health problem is a cognitive disorder that caused due to different factors. Physiciatric problem causes mainly due social, economic and political related factors of an individual. Cognitive disorder of an individual can be described as mental health problem which is characterized by depression, anxiety, epilepsy, and the act of suicide due to mood disorder.

The common symptoms of Physiciatric problems are loss of attention (attendance), word rape, flitting, word mixing and the act of suicide. There are different risk factors for the causes of mental health problems. The two main risk factors of Physiciatric problems are:

1. Environmental factors: common drug, drugozine, stress, social related problems
2. Genetic factors: factors that causes due to inheretism

Physician used various techniques to solve the mental health problem of the patients. The common medical decision is based on the acquired knowledge from the patient's family history. Then the diagnosing process is followed by providing a drug therapy and psychotherapy. In addition, counseling treatment is given for individuals and groups. For the purpose of this study mood and mental disorder cases were incorporated in the knowledge based. Therefore, the descriptions and feature of each disorder discusses as follows.

A. Mood disorder

Mood disorders are biological disorders that affect children, adolescents and adults. No matter the age of the person, mood disorders present with similar symptoms.
Commonly known symptoms of mood disorder are: sad or unhappy mood that lasts for days at a time, vegetative symptoms such as lack motivation, and somatic symptoms such as changes in eating or sleeping habits, feelings of helplessness, irritability/moodiness, and suicidal thoughts.

Effective treatment of mood disorders combines psychotherapy and medication. Treatment is usually at least partially effective within a few weeks to a couple of months. The treatment also prevents individual from future depressive incidents. Early (child/adolescent) treatment of mood disorders is lowers the risks of eventual development of Bipolar (manic depression) Disorder.

B. Mental disorder

Mental disorder is any illness which affects individual's emotions, thoughts and behavior. Patient with mental illness are not able to keeping them with their cultural beliefs and personality. The victim of this problem gradually produces negative attitudes on their lives or the lives of their families. It is difficult to know exactly what causes of mental illness. But, truly the most destructive aspect of mental illness is its devastating effect on its victims and their families. According to domain expert the common symptoms of mental disorder are: Suicide, alcoholism, drug abuse, damaged social relationships, incalculable pain a, etc.
Therefore, physician classifies the causes of mental illness into six broad categories.

- common mental disorders (depression and anxiety);
- 'bad habits', such as alcohol dependence and drug misuse;
- severe mental disorders (the psychoses);
- mental retardation;
- mental health problems in the elderly;
- mental health problems in children.

With effective treatments most of mental illness responds very well to psychotherapy, in which a skilled clinician talks to you and helps you to change your feelings, choices and behaviors.

Medications have been used for successfully treatment of mental illnesses such as depression, anxiety, bipolar illness, and schizophrenia. Psychiatrists perform a medical examination, order tests, assessment for signs and symptoms of mental illness. Based on the results of diagnosis, the physician prescribes medication, perform psychotherapy or make a referral to a qualified therapist.

The following table shows the summary of identified pillar symptoms of each disease from Physiciatric category.

Physiciatric health problem	The common pillar symptoms
Mood disorder	sad or unhappy mood, lack motivation, changes in eating or sleeping habits, feelings of helplessness, irritability/moodiness, and suicidal thoughts
Mental disorder	Stress, Suicide, incalculable pain, word rape, loss, alcoholism or drug abuse, damaged social relationships,

Table3.5. the common symptoms of Physiciatric health problem

3.4. Conceptual Modeling

Conceptual Modeling of domain knowledge implies capturing the static structure of information and knowledge types (Schreiber, 1999). Decision trees (DTs) are modeling tools that use in a variety of different settings to organize and break down clusters of data (Lidtke, 2003).

Similarly, decision tree have been widely used in practical applications area, due to its interpretability and ease of use (Scott, 2004). Currently, decision trees are used in many disciplines such as medical diagnosis, cognitive science and artificial intelligence (Quintana, 2009).

Particularly, decision tree in medical domain is a well-known tool that aids clinicians or general practitioners to understand the dimension of disease. Each decision tree starts with a set of clinical attributes. Each attribute is important to present the picture of the problems. General practitioners followed serious of department oriented question to rule in or rule out the patient's health problem using the decision tree structure (Podgorelec, 2000).

3.4.1. Triage treatment and Decision tree structure

Triage system is the systematic representation of triage treatment using decision tree structure. As a result, representing patient disease based on decision tree structure helps the general practitioner to identify each disease with little effort. Therefore, the system improves the health care service; minimize the burdens physician, fill the gaps of limited manpower, delay of time and late care.

A triage treatment involves multi steps activity, first the treatment started by asking some department oriented questions about the patient's symptoms and medical history. Triage treatment is dominated by gathering sufficient information from the patient or his/her family members. During the diagnosis session the critical step is getting history of the patient which is important to understand the dimension of a patient's health problems. During this time, the general practitioners try to extract some important symptoms and syndromes of the disease to identify its category. Finally, the general practitioner assigns the patient into correct category for further examination by human expert.

The Physician's patient assessment begins by integrating the essential elements of clinical care. This includes listening patient feeling, the ability to interview patients of all ages, moods, and backgrounds. Moreover, experience of the physician has a great value as examination process further get deeper. The underlying process of patho-physiology or psycho-pathology is carried out to establish testing a set of explanatory hypotheses on the patient cases. The skill that physician used allow him/her to assess the unique characteristics of the patient health problem.

The human expert diagnosing process involves Laboratory examination and drug management. Finally the physician estimates the probable presences of the diseases and recommends the appropriate treatment(s).

To summarize, during the diagnosis process the physician performs the following specific activities:

- ✓ History taking (gather sufficient information from the patient or the person who is with the patient). History taking includes; chief patients, present illness, past history, family history, personal and social history.
- ✓ Checking the presence of pillar symptom.

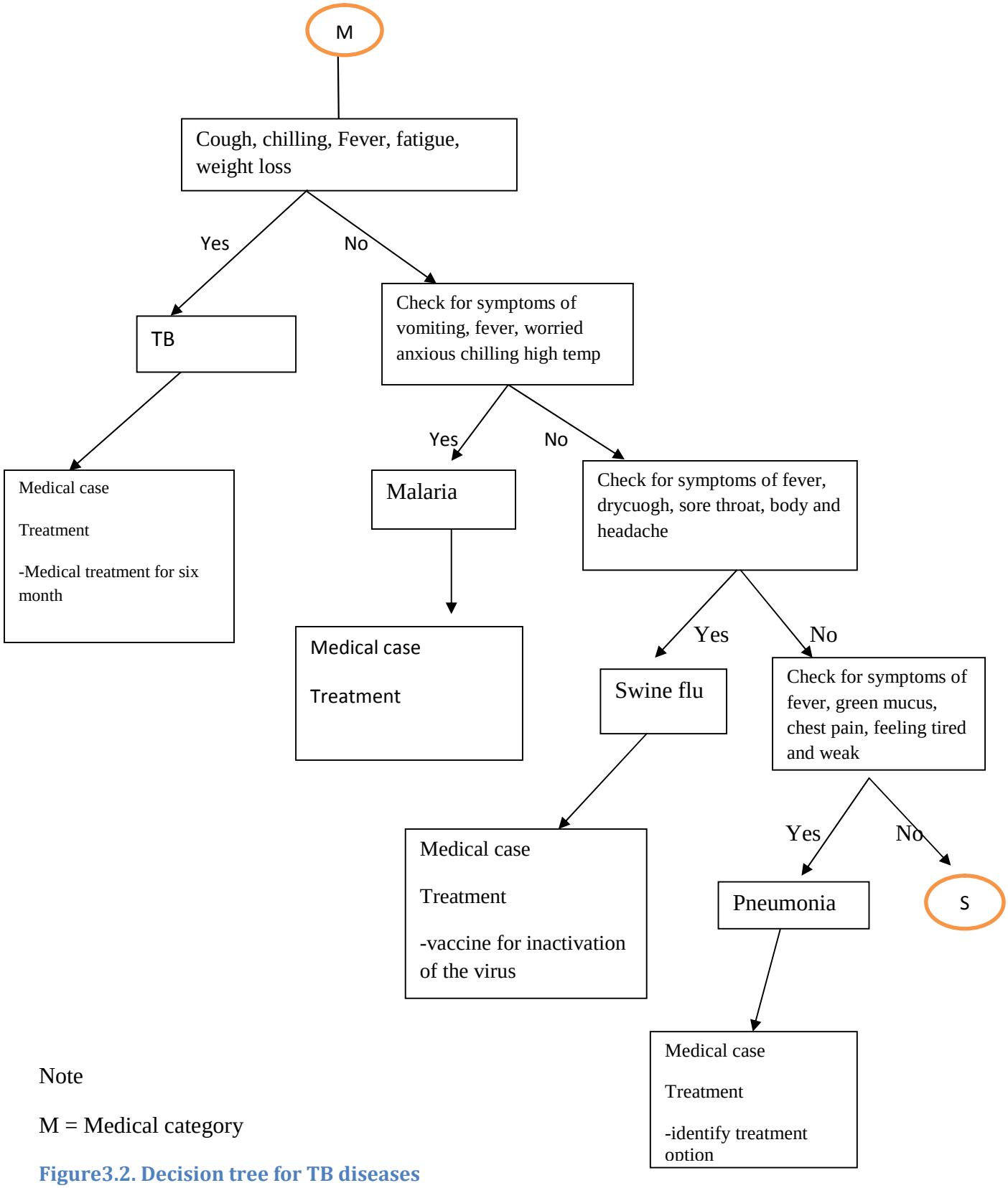
- ✓ Rule out a general medical condition as direct physiology cause of the symptom.
- ✓ Rule out a substance use as the direct physiological cause of the symptoms

Additionally, patient's response may be ambiguous when describing symptoms and even cannot specify the details of their feeling clearly. Therefore, the first screening question(s) on the pillar symptoms alone are insufficient to diagnose the patient health problem. To complete the diagnosis successfully and reach at certain conclusion further assessment on physical examination and laboratory test has a great value.

Finally, to make the acquired knowledge functional in knowledge representation, the knowledge based system is modeled by using decision tree structures.

Decision tree structures are the bases for the development of prototype knowledge based system. The prototype follows the same procedures as presented in the decision tree to triage the patient during the diagnosis process.

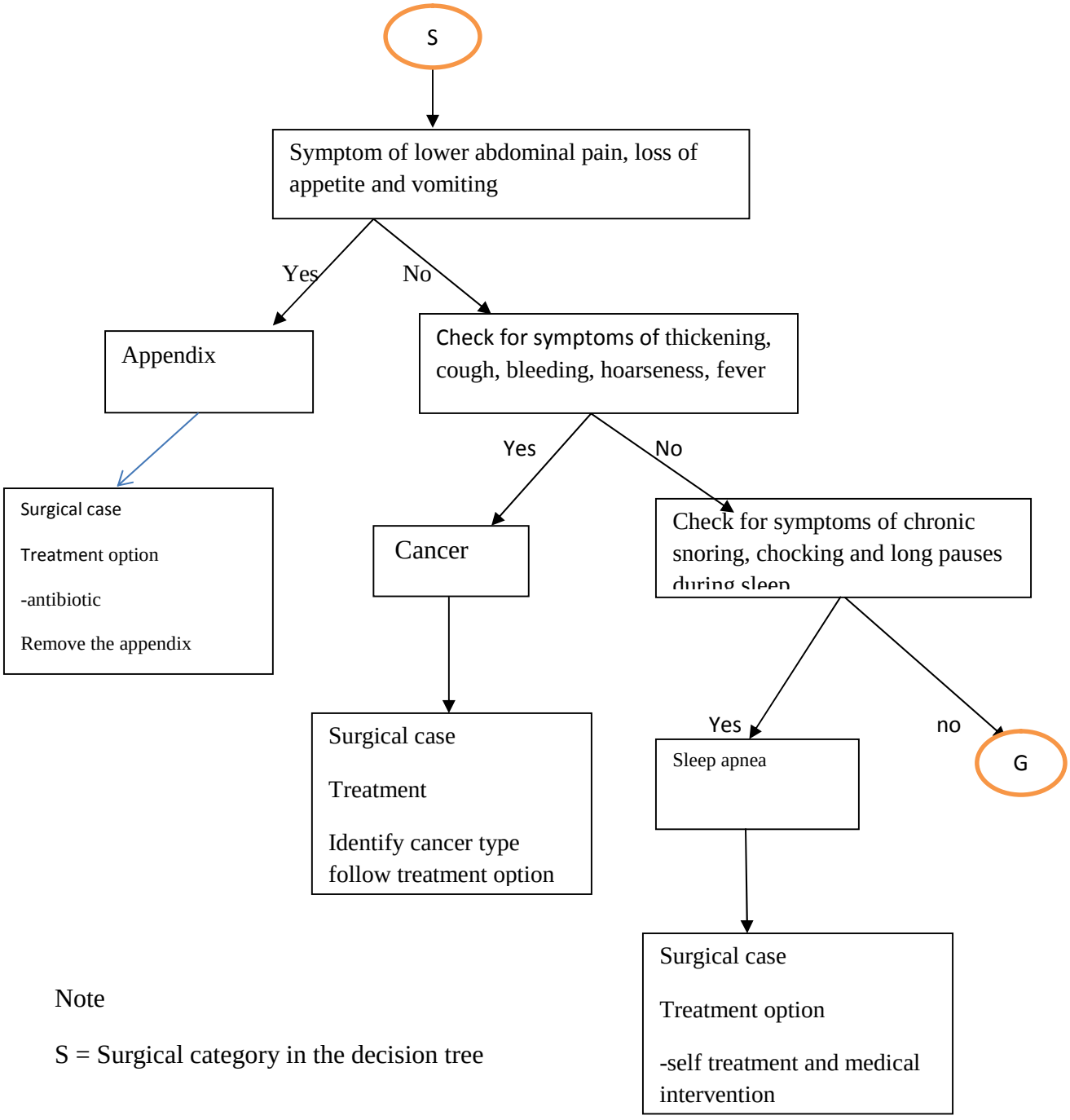
The common symptom of each disease is used to determine the presence of specific cases that has been illustrated from figure 3.2 to figure 3.5 using decision tree structures. Based on the decision tree structures, some diseases which have similar characteristic in nature were incorporated in the knowledge base to show that some symptoms can also be symptoms for other diseases. Therefore, similar procedures have been followed for all triage categories.



Note

M = Medical category

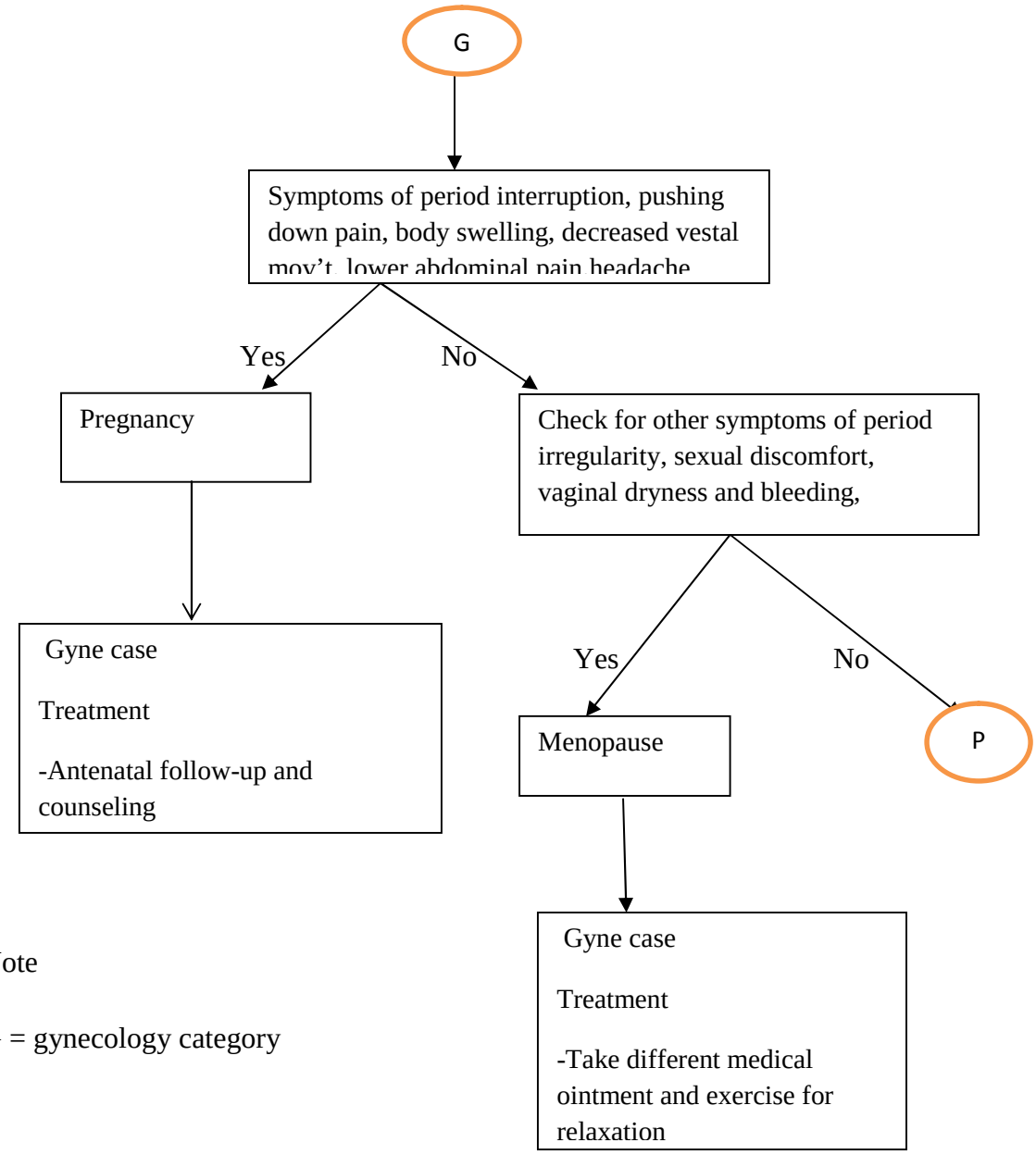
Figure3.2. Decision tree for TB diseases



Note

S = Surgical category in the decision tree

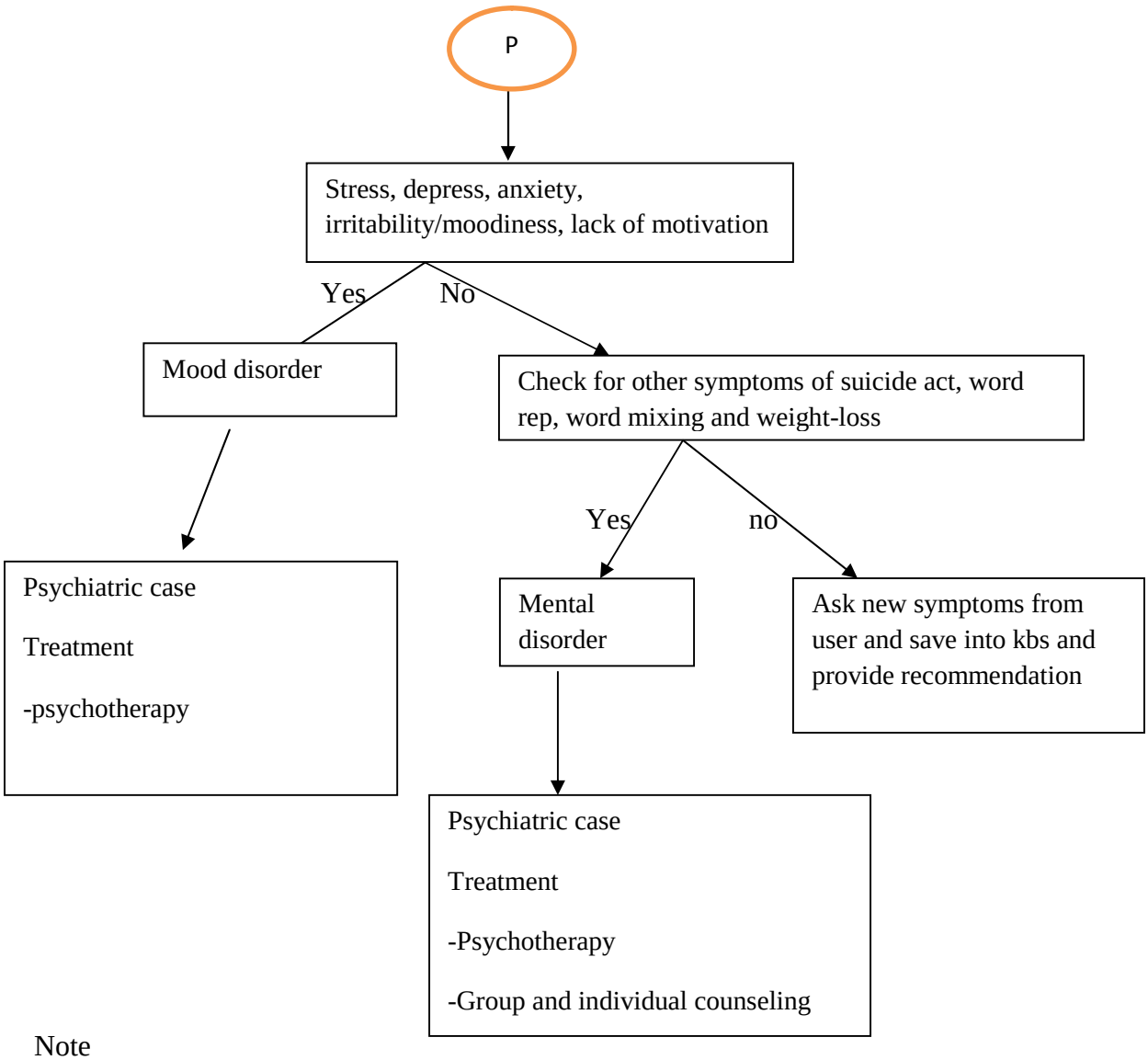
Figure3.3. Decision tree for surgical category



Note

G = gynecology category

Figure3.4. Decision tree for gynecology category



Note

P = represent psychiatric category

Figure3.5. Decision tree for psychiatric category

3.5. Knowledge representation

Knowledge representation is one of the basic steps in the process of knowledge based system development. Knowledge representation is the process of interpreting domain knowledge into computer understandable form using knowledge representation methods.

The acquired domain knowledge is represented as a set of "IF – THEN" rules in the prototype. The "if" side (also known as the left hand side) of the equation which states the condition(s) that

must be true in order to fire the rule and the “then” side of the equation specifies the appropriate action to be taken. 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 then the inference engines proceed to the next rule until the conditions are satisfied.

A rule is a conditional statement that links the given conditions to actions. Rules in the knowledge based are constructed based on the decision tree structure on conceptual model discussed above.

To make easy and understandable prolog rules, the acquired knowledge from the domain expert is represented using the “IF-THEN” form. The rules are the base for the construction of knowledge base system. The following are sample rules which are incorporated in the knowledge base.

If the patient has symptom of extreme fever,

And/or patient has symptoms of more than two week cough,

And/or patient has symptom of chilling,

And/or patient has symptom of fatigue,

And/or patient has symptom of weight-loss.

Then TB case of the patient will be diagnose

If the patient has symptom of lower abdominal pain,

And/or patient has symptom of appetite loss,

And/or patient has symptom of vomiting,

Then appendix case of the patient will be diagnose

If the patient has symptom of period interruption,

And/or patient has symptom of pushing down pain,

And/or patient has symptom of lower abdominal pain,

And/or patient has symptom of vomiting and headache,

Then the pregnant case of the patient will be diagnosed

If the patient has symptom of cough or hoarseness,

And/or patient has symptom of unexplained bleeding,

And/or patient has symptom of thickening,

And/or patient has symptom sore that does not heal,

And/or patient has symptom of difficulty of swallowing.

Then the cancer case of the patient will be diagnosed

If the patient has symptom of bad feeling,

And/or patient has symptom of anxiety or trouble,

And/or patient has symptom of depression,

And/or patient has symptom of stress,

Then the mood disorder case of the patient will be diagnosed

If the patient has symptom of loud and chronic snoring,

And/or patient has symptom of patient snorting during sleep,

And/or patient has symptom of long pauses in breathing,

And/or patient has symptom of day time sleepiness.

Then the sleep apnea case of the patient will be diagnosed

Similar procedures have been used for all rules incorporated in the knowledge base.

To summarize the chapter, the transformation process of the acquired knowledge from human expert and document analysis is helpful to investigate the specific attributes which are significant in the process of triage treatment. Once the relevant knowledge is acquired then it represented in human understandable manner to arrive at the expected goals. Therefore, the proposed knowledge based system is implemented by articulating the rules.

CHAPTER 4

KNOWLEDGE BASED SYSTEM IMPLEMENTATION

The most important criterion for any knowledge based systems' is the accuracy of their inferences engines. Also important are, robustness of the system when some information is missing, redundant and inconsistent. Human readability helps the domain experts to understand knowledge content and even to modify its content. The system's dynamic nature to adapt a new knowledge from the user response is critically important to measure system performance.

The proposed knowledge based system implementation depends on the decision tree structure. Because of their simplicity, decision trees or generic rule-based models are commonly used to describe the knowledge acquired from domain expert. The if-then rules of knowledge based system are generated based on the decision tree structure.

However, the main challenge of implementing a knowledge based system was choosing the appropriate representation method. Too large rules may reduce the performance of the system because, as the numbers of rules increases the inference engine fails to infer from the complex rules. This chapter describes the development of prototype Knowledge-Based system for triage pre-medical treatment. The knowledge based system incorporates knowledge base, inference engine, user interface, and explanation facility components as shown in figure 4.1.

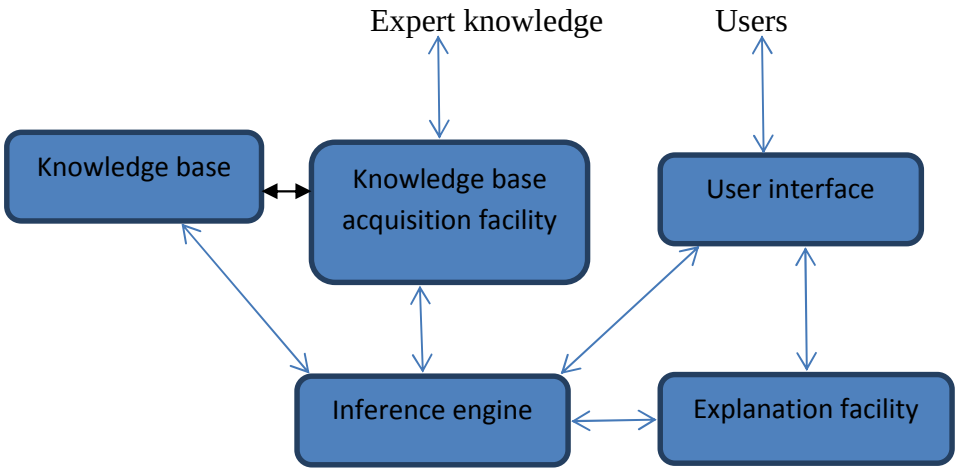


Figure4.1.Architecture of rule based system

The goals of any system is to insure that the final result of the system was usable and practical applicable for the end user. To achieve this goal, the knowledge based system is divided into different subtasks. To accomplish this task, the inference engine starts from a goal by selecting a rule; searches back to find the facts that satisfy the given condition in the knowledge base. If the conditions are satisfied then inference engine fire the rules accordingly. If the rules satisfy all the conditions then the system draw a conclusion for the given case. The same procedures are applied for all rules incorporated in the knowledge based. Therefore, the different components of knowledge based system are discus as follows.

4.1. The knowledge base

The knowledge base stores all relevant knowledge, fact, rules, and relationships used by the knowledge based system. The knowledge base incorporates the relevant knowledge that was acquired from the domain experts. The knowledge base of the prototype contains the domain knowledge which used to identify the types of disease, description and treatment in the triage services. Based on this, the knowledge base is constructed by using LPAWIN prolog implementation tools in the forms of 'if then' rule.

The fact base component of knowledge based system includes basic facts of different cases that are handled during triage treatment. The numbers of facts depends on the numbers of rules incorporated into the knowledge base. Functionally, the facts in the facts base are used to compare against the "if" (condition) part of rules stored in the knowledge base.

In other words, if the given facts satisfy all the conditions which proved to be true, then the inference engine draw a conclusion. This is based on the pattern matching between the fact in fact base and their respective rules in the knowledge base.

4.2. The inference engine

The inference engine simulates the domain expert reasoning process. It works from the facts in the working memory (fact base) and stored knowledge in the knowledge base to fire the rule. It achieves the goal by searching through knowledge base to find rules whose premises match with the given facts in working memory. The searching process continues until the inference engine unable to match any premise with the facts in the working memory.

As the result, the proposed system uses backward chaining reasoning mechanism. During the reasoning process, the inference engine starts from the consequents (type of disease) and checks

the symptoms of the occurrence of this disease to prove the hypothesis (types of disease). If certain antecedents (symptoms) are evaluated as true, then it logically follows the consequent are proved, and then the category, description and treatment of the disease is provided.

As the model indicated in the decision tree (chapter three) of figure 3.2, during the diagnosis of TB diseases the general practitioner first asks the presence long term cough, chilling, muscle fatigue, and weight loss. Next the general practitioners try to prove whether these symptoms are match with the causes of TB disease or not. Then the general practitioner categorize the patient into their respective category to starts the actual diagnosis process. The inference engine of the rule based system follows similar procedures like the general practitioner(s). The inference engine sequentially searches each rules, if match is found, i.e., if patient has more than two week cough, chilling, muscle fatigues, and/or weight loss, then the inference engine draw the conclusion for TB disease.

The rules that used to diagnose TB disease in LPA win prolog programming language are represented as indicated below.

Rule1: patient has (TB):-

Extreme fever == (yes);

More than two weeks cough == (yes);

Chilling == (yes);

Muscle fatigue, weight_loss == (yes)

From Rule1 above, if the patient's response satisfies the given conditions, i.e., if patient has extreme fever, more than two week coughing, chilling, muscle fatigues and/or weight loss, then a match is found and the inference engine draws a conclusion. The conclusion is to identifying the type of disease, category and first line treatment that the patient need to follow while he/she diagnosed by human expert. But, if the patient does not have any symptom of long term cough in the above rule, then the inference engine start sequentially searching until the patient response satisfied the condition. For example, from rule1 above the patient respond he/she does not have long term cough but, when the inference engine sequentially checks the next rule it identified that the patient has symptom of worried anxiety, then a match found and inference engine diagnose malaria.

Rule2: patient has (malaria):-

Fever == (yes);

More than two weeks cough == (no);

Feel of worried anxiety == (yes);

Vomiting == (yes).

On the other hand, if the patient responses satisfy the first condition of Rule1 and if not fulfilled the second condition, then the inference engine starts to check all the conditions under medical category as indicated (figure 3.2) until the conditions are satisfied the given rule. When a match is found, i.e., if the patient has extreme fever, feel of worried anxiety, vomiting, then the inference engines execute Rule2. Therefore, based on the satisfied condition malaria disease is identified.

The inference engine uses a check function to search all the associated rules under each category. In the knowledge base each disease are associated with each other by their common symptoms. The searching continues until all the associated rules are completed in each category.

Rule3: patient has (appendix):-

Fever == (no);

Lower abdominal pain == (yes);

Loss of appetite or vomiting == (yes).

From the above rule, if the patient response does not satisfy the first condition of Rule1, according to the decision tree structure in figure 3.3 the inference engine move to the next category to find a match. Therefore, a match is found, i.e., if the patient has lower abdominal pain and loss of appetite or vomiting, then the inference engine indentified that the patient has appendix problem.

Rule4: patient is (pregnant):-

Period interruption == (yes);

Lower abdominal pain == (yes).

From the rule above, with similar searching procedure the inference engine identified that patient response match with new symptom, i.e., if patient has lower abdominal pain and period

interruption, then the inference engine execute the above rule. Based on the match pregnant case of the client was diagnosed. Therefore, patient health problem is now assigned to the gynecology category of triage system. Inference engine follows similar procedure for all rules incorporated in the knowledge base to categorize the patient based on the satisfied conditions.

The main challenge of inference engine in rule based approach is, it follow a pattern matching during the reasoning process. But, it is difficult to infer from only few satisfied conditions in this approach. Therefore, to draw the conclusion based on the satisfied conditions it is better to apply case based approach which uses similarity measurement to solve the new problem.

On the other hand, if the patient response does not match with any conditions in the knowledge base, then the system will be confused to infer the solution. To handle this issue there are two possible conditions. The first condition is for unknown patient case, the system provide possible recommendation which helps the general practitioner to assign the patient into one category of triage system. Second condition is for specific patient disease inference engine incorporate partial learning component. This component works when the solution of patient health is out of the knowledge content for inference engine to draw a conclusion. The learning module requests the user to add new symptoms, and then add the new symptom permanently into the working memory. After validating the patient response the system draw a conclusion and when the user starts a new session the inference engine consider the new symptom to execute the rule.

Finally, systems continuously displaying the following message after execute one rule.

continue:-

write ('Do you want to continue? (Yes. or no.)'), nl,

read (ANSW),

determine (ANSW),

change (ANSW).

If the system user responds ‘yes’ the inference engine starts to execute a new rule or repeat the previous one. Else, if the system user responds ‘no’ the system display the following message and stop running the program.

Continue:-

Write ('Thank you very much for using this system!').

Cut (!) Command is used to control the Prolog program when the backward searching takes an action. It means the system does not have to do the backward search again even though the operation fails.

'Assert' function is used so that the questions will not be asked again even if the operation fails. When the instructions fail, the 'retract' is used to perform a backward search in the previous information to see whether those queries could be satisfied or not.

Therefore, the inference engine starts searching from the top level goal and proceeds to the sub-goal by using backward searching mechanism. To fire the rule, the inference engine searches fact from fact base and try to match those fact with a give goal in the knowledge base. If a match is found, the inference engine executes the rule. But, if condition is not satisfied then the inference engine starts to searches the next rule until the conditions are satisfied. Similar procedures have been used for each rules incorporated in the knowledge base.

4.3. The user interface

The acceptability of a knowledge based system depends on the quality of the user interface. The user interface is used as the means of interaction between a user and the knowledge based system. For the proposed knowledge based system, users interact with the system through "yes" and "no" response only. Based on the user's response the system draws a conclusion for each rule in the knowledge base. The systems conclusion displayed in the user interface window. Figure 3.4 below shows the welcome window and it describes the functions of knowledge based system.

```
============================================================
||            WELL COME TO
|| KNOWLEDGE BASED SYSTEM FOR PRE-MEDICAL TRIAGE
|| TREATMENT IN CASE OF ADAMA UNIVERSITY ASELLA HOSPITAL
||
|| THIS SYSTEM IS USED FOR TRIAGE TREATMENT TO DIAGNOSE
|| PATIENT HEALTH PROBLEM AND CATEGORIZE PATIENT
============================================================
* Please type "main." and dot then press enter to start *
************************************************************
```

Figure 4.3 Welcoming Window of KBSPTT User interface

Once the welcome window of KBSPTT user interface displayed, the user can interact with the system by typing “main” followed by full stop next to the welcoming screen of the LPA WIN prolog Window. After the user types “main” followed by full stop, to start the actual task system requests the user to enter their name, sex, age and location. These user’s profiles are the basic input in addition to their pillar symptoms to make a good judgment. Next, the system provides a guideline for users on how to interact with the system. The system asks “please respond to the following questions by saying “yes or no”. The user response depends on the given guidelines and proceeds for all questions.

“Askable” function is used to keep track of the questions that can be asked and askable is retracted when the question is answered. Ask is responsible for getting information from the user and remembering the user’s response. If the program does not already know the answer to a question it will ask the user. Then it will assert the answer. "Ask" only deals with simple ‘yes’ or ‘no’ answers.

The user interaction with system is carried out by responding some department oriented questions about specific cases. Every time ask is called, first it checks to see if the answer is

already **known** to be “Yes or No” If it is not already **known**, then **ask** will **assert** the user response.

Furthermore, inference engine uses menuask to expand the dimension of user interaction with the system. "Menuask" has the same function as “ask”. The only difference is that it gives the users’ list rather than a single question about the causes and symptom(s) of each disease.

As discussed in the above section of this chapter, during the triage diagnosis process the basic function of general practitioner is to check the presences of each pillar symptoms of the specific disease. If the system is certain that the patient has symptoms of disease X, then the inference engine draws the conclusion. The following run information in the figure4.4 shows the rule1 where all the conditions are satisfied.

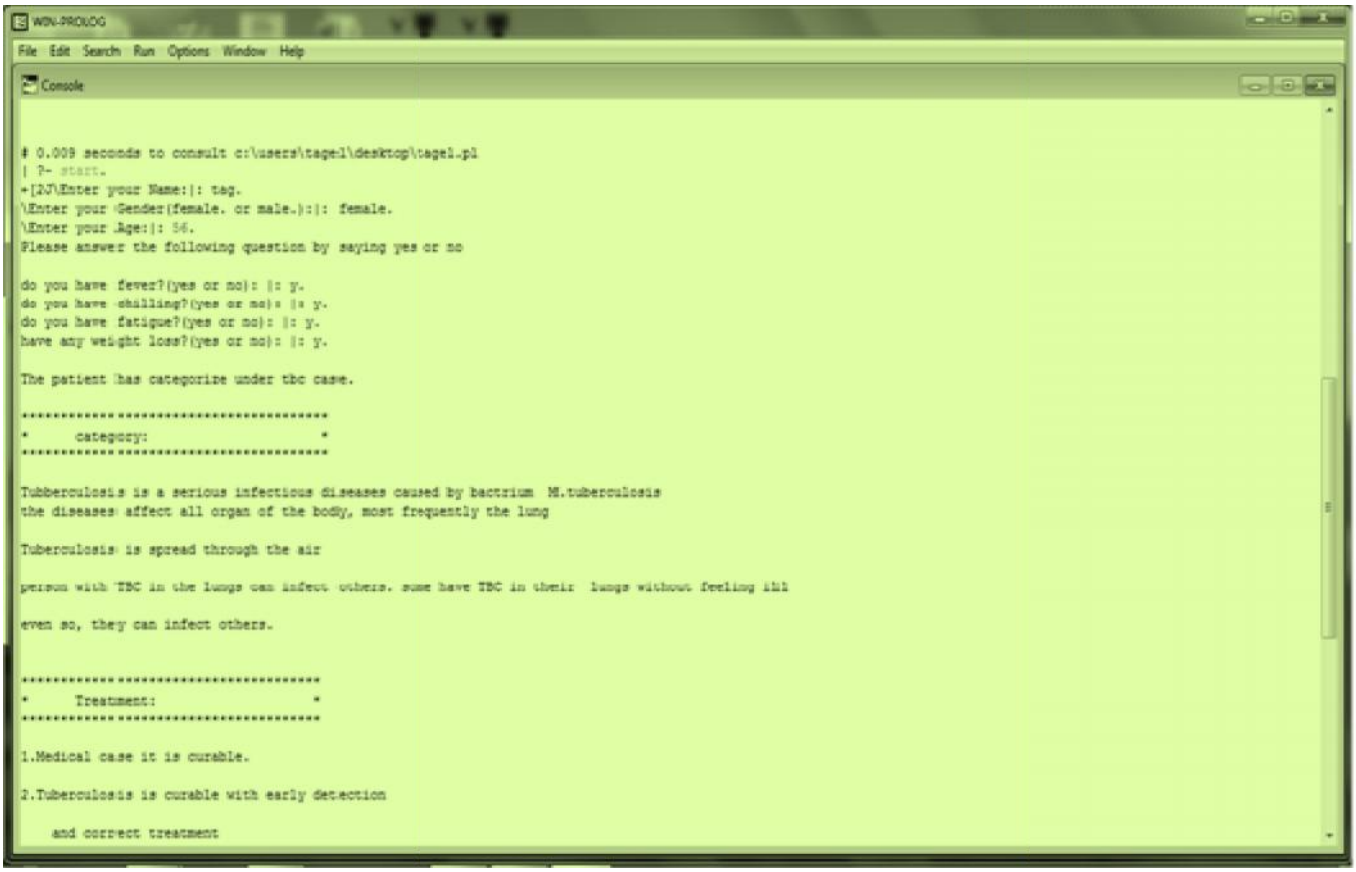


Figure4.4 dialog Window between the user and system on TB diagnosis

From figure 4.4 above, since the patient’s response satisfies the given conditions, i.e., if patient has extreme fever, more than two week coughing, chilling, muscle fatigues and/or weight loss, then a match is found and the system conclude that patient has TB disease.

The system concludes by identifying the types of disease, category and treatment of the disease. But, if the patient response does not match with given symptom(s) of TB disease, then the inference engine starts to check the next rules until a match is found. The following figure (figure 4.5) shows cancer disease with all satisfied conditions of rule2.

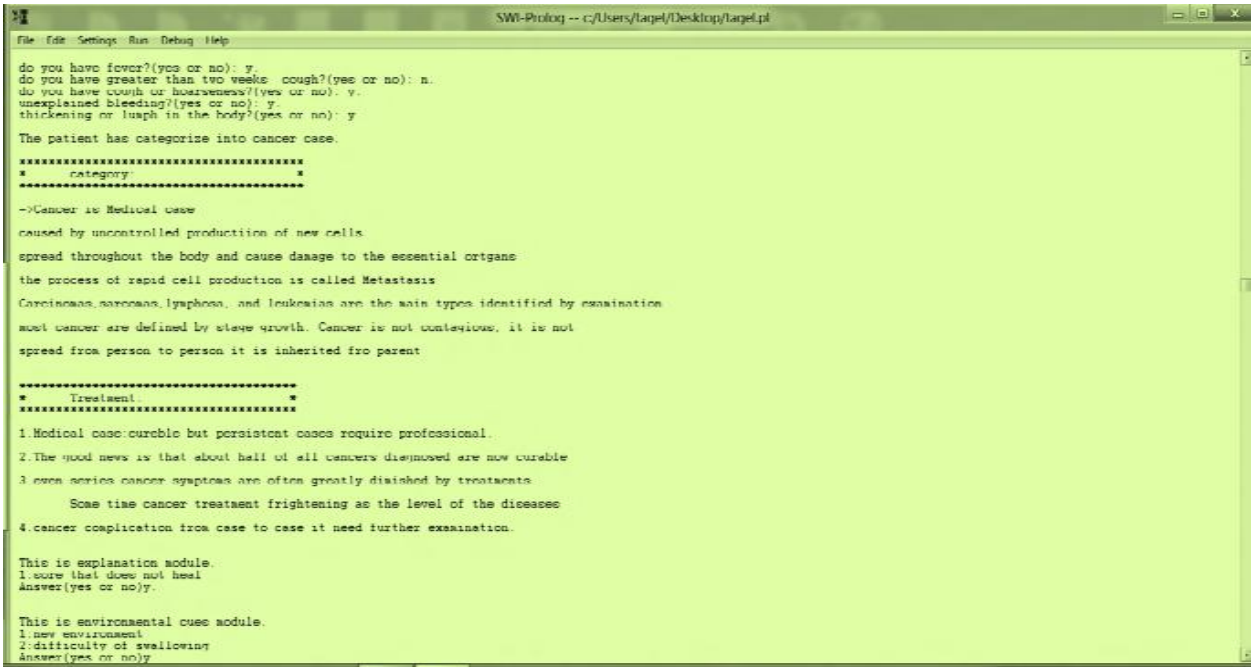


Figure.4.5. Sample dialog window between the user and system to diagnose cancer disease

Figure 4.4 above shows, the system concludes that the patient has TB disease when all the possible conditions are satisfied. But, if the patient response fails to satisfy some of the conditions, i.e., if the patient has fever but , no long term cough, then the inference engine starts to search the next rule until it satisfied conditions. The result of the satisfied condition identified that the patient has cancer disease. The run information in figure 4.5 above shows system conclusion for patient with cancer disease.

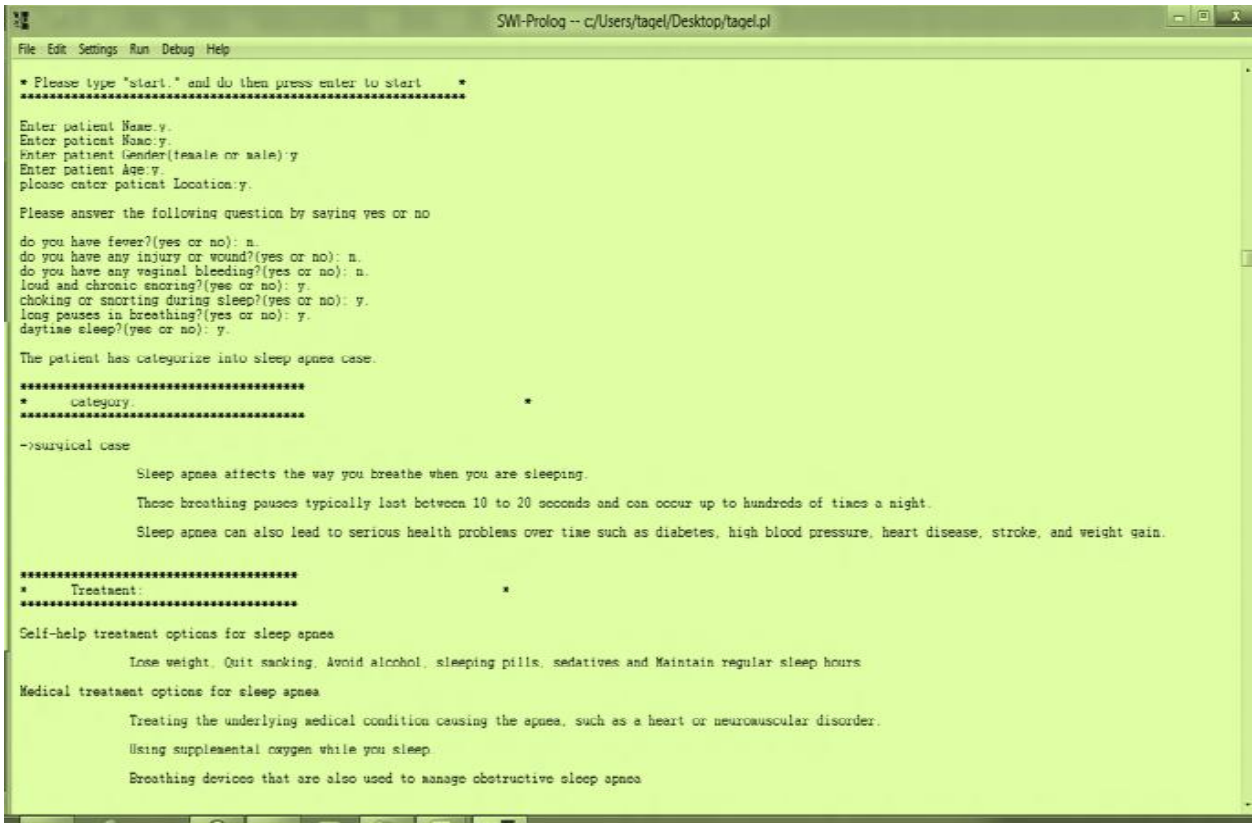


Figure4.6 sample window of the system that provide description and treatment

From figure 4.6 above, when the patient response satisfied all the conditions of the given rule, then the system provide a conclusion. Therefore, the above figure shows the detail description, category and treatment for patient with sleep apnea health problem. The following figure 4.7 below shows when user's responses are partially satisfied with their respective recommendation of the systems. When we say partially satisfied condition, it mean that the combination of "yes" and "no" user response. But, the internal structures of the algorithms consider all the "yes" response. In other word, when the user respond "no" the inference engine will not stop rather it check the next rules until all the possible conditions are satisfied.

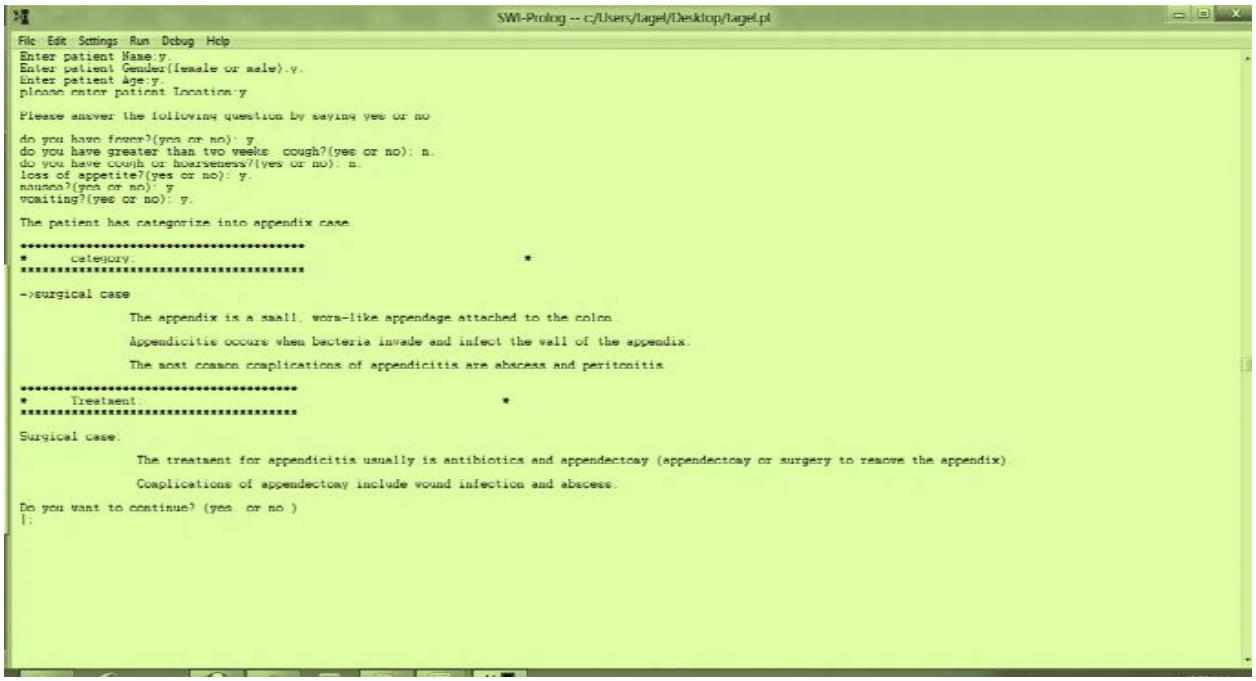


Figure.4.7. Sample dialog windows between the user and system to identify appendix with only satisfied conditions

4.4.1. Learning components of the system

As discussed in the decision tree structure of chapter three, the knowledge base system incorporated rules for all diseases. But, for any disease that does not have knowledge in the knowledge base, the system provides recommendation which help the general practitioner to categorize the patient into one of triage categories.

To show the possibility of integrating learning component in the knowledge based system, the researcher integrates simple feature to dynamically update the fact base in the working memory for cancer disease. The inferences dynamically update the new symptom in the fact base. The learning function works when the inference engine unable to find any match from the knowledge base, then it requests the user to add any new symptom that the patients feel. Then confirms patient response whether it is true or false by saying “are you sure this is symptom of cancer disease?” If patient response is “yes” then the system add the new symptom permanently into the working memory.

Therefore, when a user starts a new session the inference engine consider the new symptom to draw a conclusion. But, if the compliant confirms “No” response, then the system does not add

anything into fact base. The following sample figure (figure 4.8) indicates the system recommendation based users' feedback.

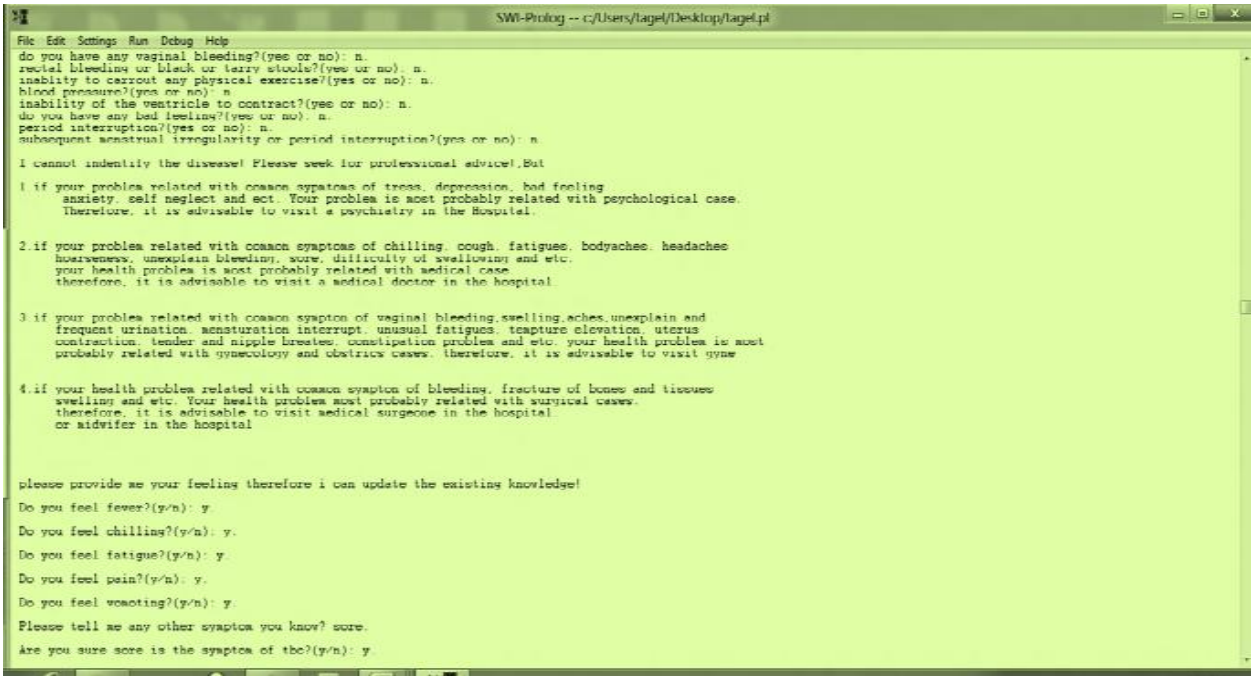


Figure4.8. the learning component integrated in the knowledge base

The categorizations of patient based on the identified symptoms follow the same procedures for all rules in the knowledge base. To execute the rule, the inference engine follows the decision tree structures as it is shown in the conceptual modeling of this thesis.

4.4. The explanation module

One of the interesting features of knowledge based systems is the ability to explain itself. The knowledge based system developer uses the explanations module to have more realistic dialogs with the system user. The 'how' feature of the prototype are incorporate into inference engine to give explanations how the system reach at certain conclusion.

As indicated in the following figure 4.9, once the inference engine identified the categories of TB disease and its treatment, then the inference engine requests the patient whether he/she needs further explanation 'how' the system arrive at certain conclusion. Explanation module provides further information with a simple "yes or no" user response.

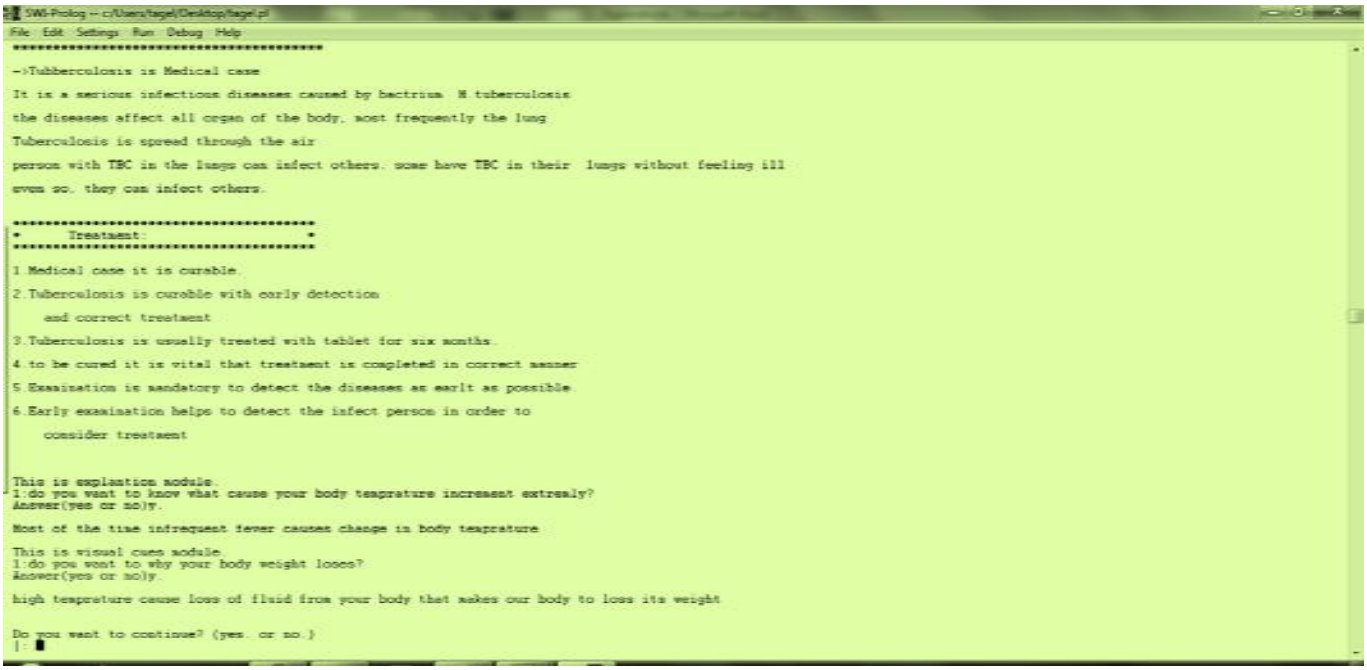


Figure 4.9 sample of explanation facility dialog windows for TB cases

Figure4.9 above indicates, the system conclude that the patient has TB disease. After identifying the category, description and treatment, the system requests the patient whether he/she want more information about the dimension of the disease by asking “do you want to know what causes the change in your body temperature?’ based on the patent response the system gives a brief explanation about the causes.

To summarize the chapter, the acquired knowledge from the domain expert was represented using a set of rules. The rules are constructed in the prototype with if then format. If then format of the prototype is mainly depends on the decision tree model which discussed in chapter three. To achieve the goals of system, the inference engine uses backward chaining reasoning mechanism. Furthermore the knowledge based systems have different components as indicated in the knowledge based system architecture. The knowledge based system components are knowledge base, fact base, inference engine, and user interface and explanation module.

CHAPTER FIVE

TESTING AND EVALUATION

After implementing knowledge based system the final step is measuring the performance of the system whether is achieve the objective or not. Testing and evaluation of the prototype knowledge based system is the final step that helps the knowledge engineer to measure the whether the system achieve the propose objective or not. For the purpose of this research study, knowledge based system for pre-medical triage treatment (KBSPTT) is tested and evaluated based on the objective of the system. This is to measure the accuracy of the system during the diagnosing processes. Measurement is from the point of whether the system achieved its objective or not. In this study the performance of the system is measured against human expert decision using predictive validation method. The user acceptance of the system is carried out during system user interaction.

The knowledge based system user acceptance is measured by using open and closed ended questions. The system evaluators directly interact with the system to measure its performance from the points of its correctness in assigning the patient case in the correct category. In addition, the validation test was done by comparing solved cases against the system conclusions on the similar issues. By comparing the result obtained from the system conclusion, the evaluators determine the performance of the system. Therefore, knowledge based system performance is measured first by using open and close ended question, and second by using the test case validation method. The details of each evaluation method are discussed in the following section.

5.1. KBSPTT User Acceptance Evaluation

Knowledge based system Visual interaction evaluation method allows the domain expert to directly interact with the system. Direct interaction intend system user to evaluate the performance of the knowledge based system from the users' point of view. In addition, this method helps to ensure the performance of the prototype by assessing the feedback acquired from the domain expert towards the developed system. Semi-Structure questions are developed to assess and evaluate the appropriateness and applicability of KBSPTT in the domain area

Different local researchers have been adapted evaluation questionnaires that used to evaluate the model called ResQue (Recommender systems quality of user experience) from user's point of view (Seblewongel, 2011). Redeit (2006) also used this technique to evaluate research study titled with knowledge based system for HIV pretest counseling. Therefore, for the purpose of this research the evaluation questionnaires were converted and adapted into the context of triage patient treatment.

To achieve the goals of evaluation ten domain experts are selected purposively from Adama university Asella hospital. The domain experts are selected purposively from medical, surgical, gynecology, physiology and psychiatrists departments in the hospital. During the knowledge based system development these domain experts were actively involved in the different stages of pilot study, knowledge acquisition, prototype development and consulting on the content of knowledge. The informal discussion with domain experts has significant role to understand the dimension of the problem. Before the actual evaluation process conducted, some guideline and brief explanation is given to the system evaluators on how the system works.

The system performance evaluation is carry out by using questionnaires. The questionnaire includes both closed and open ended questions. Using these questions system evaluators directly interact with knowledge based system. Totally fifteen evaluation questions are prepared for system evaluators. The questions are divided into two parts, the first seven questions are close ended questions which helps system evaluators to check on the user interface design aspects, easiness of the system to use, attractiveness, correctness of the decision, adequacy of knowledge content, the problem solving ability and significance of knowledge based system in triage patient categorization service. On the other hand, the remaining eight questions are open ended questions which used to collect constructive feedback from the system evaluator's based on the system's conclusion.

The first seven closed ended questions are answered based on the given scale of **excellent**, **very good, good**, **fair**, and **poor**. The researcher assign values in numbers for each scale as excellent=5, very good=4, good=3, fair=2, and poor =1. Based on the given scale, system evaluators provide a value for each closed ended questions. Thus, this method helps the researcher to manually examine the user acceptance based on evaluator's response. The user acceptance of the system is measured manually as follows:

$$avp = sv1\ x\ \frac{nr1}{tns} + sv2\ x\ \frac{nr2}{tnr} + sv3\ x\ \frac{nr3}{tnr} + \cdots$$

Where, SV scale value, TNR total number of respondent and NR is number of respondent. To get the result of user acceptance average performance is calculated out 100%.

$$\text{Avp} == (sv1\ x\ \frac{nr1}{tns} + sv2\ x\ \frac{nr2}{tnr} + sv3\ x\ \frac{nr3}{tnr} + \cdots) \text{ x } 100/NS$$

Where NS is number of scale and avp is average performance. The following table summarizes the results obtained from the respondents'.

Table5.1. users' evaluation of the performance of KBSPTT

No.	Questions	(poor) 1	(fair) 2	(good) 3	(v.good) 4	(excellent) 5	average	Total Av/ Perf. %
1	Is the rules in the prototype are easy to understand?	0	0	2	4	4	4.2	84
2	Is user interface of KBSTT attractive?	0	0	1	4	5	4.4	88
3	Is the KBSTPMT system efficient in time?	0	1	0	4	5	4.3	86
4	How much accurate the system is in categorizing the patient into the correct category?	0	0	3	4	3	4.0	80
5	Does the system incorporate sufficient knowledge to diagnosis a given diseases?	0	0	2	5	3	4.1	82
6	Does the system provide appropriate treatment for the patient?	0	0	0	6	4	4.4	88
7	Does the system have contribution in the domain area?	0	0	1	3	6	4.5	90

		Total average	4.27	85.43%

Note AVG = average, Perf. = performance

As indicated in table 5.1 above, 20% of the respondents rated ‘easiness of the prototype’ as good, for the same questions 40% of respondent respond as very good, and the remaining 40% responded excellent. In the same way, for question ‘attractiveness of the prototype’ 10% of the respondents rated as good, 40% of them as very good and the rest 50% of them respond as excellent. Similarly, for question ‘efficient in time’ 10% of the respondents rated the criterion as fair, 40% respondent evaluated as very good and the remaining 50% of them respond as excellent. At the same time for criteria ‘the accuracy of the prototype to make correct decision’ 30% respondent rated as good, 40% of the respondent respond as very good and the remaining 30% evaluated as excellent. Likewise, for the criteria of ‘does the prototype incorporate adequate knowledge’ 20% of the respondents rated it as good, 50% as very good and the rest 30% as excellent. Again 60% of the respondent rate as very good for the criteria of ‘the ability of the system in making right conclusions and right recommendations’ and the rest 40% respond as excellent. Finally, for the question related to ‘significance of the knowledge base system in the domain area’ 10% of the respondent rated as good, 30% of them evaluated as very good and the rest 60% of them respond as excellent.

To summarize table 5.1 above based on the responses of ten system evaluator, the average performance obtained is 4.27 on a scale of 5. This value is the result obtained from the values assigned for each close ended question. The result indicates that about 85% of users are satisfied by the performance of the knowledge based system. It means that the proposed knowledge based system gain about 85% of user acceptance.

The system evaluators were also provided open ended questions to collect expert’s feedback, suggestion and opinions. These questions focus on how the KBSPTT is different from human expert in diagnosing patent health problem. Furthermore the open ended questions help evaluators to provide their feedbacks on the contributions of the system, the uncovered knowledge issues, knowledge content of the system, the limitations and strength of the knowledge based system.

The first open ended question concern on the differences of decision between human experts and knowledge based system in diagnosing triage treatment. The system evaluators responded that KBSPTT solve problem based on the stored knowledge in the knowledge base in time and cost wise. But, the human expert uses their expertise, vital signs, experience, manuals and guidelines which is time consuming and difficult to remember. In addition human expert further require physical and laboratory examination of patients to make better decision. Domain experts use physical examination as main tool to understand the status of patient during the diagnosis processes. They observe the patient's appearance, dressing, hearing ability, sitting style, walking style, speaking, tone of sound, etc. However, the prototype depends on the contents of knowledge it incorporate in the knowledge base. Therefore, it lacks robustness such as sensing and responding ability.

Regarding the question of knowledge covered issues by KBSPTT, the respondents reply that the knowledge based system is efficient enough to respond from the stored knowledge in the knowledge base. The knowledge base contains knowledge of about fourteen diseases to represent the triage category. But, knowledge based system lack the incorporation of physical and laboratory examinations results. In similar way, some respondent suggested that at triage level identifying pillar symptoms is enough to categorize the patient into their respective category. Therefore, the knowledge base contains relevant knowledge for the selected diseases to make the triage decision. But, some respondent argue that knowledge base system will not replace the function of human expert.

Similarly, the respondents were asked to express their opinion for the question of "Does knowledge based systems replace the tasks of general practitioner in triage treatment?" Most of the respondent confirmed positive feedback. As their response indicated, as far as the knowledge base contain all the relevant knowledge acquired from the domain expert, the knowledge based system provide similar decision as human expert. Even the system can be considered more flexible due to its reusability of the existing knowledge in a better way than the human experts. The truth is human expert consider different conditions during the examination processes such as the physical set up of the patient, conditional feeling and environmental factors. In addition, medical decision is related with human life and needs critical attention. We can design

knowledge based system to support or assist the domain expert but, the main challenge is incorporating knowledge of physical examination and sensing ability into the system.

At the same time, most of the respondents reply that the knowledge based system contains adequate knowledge for all rules incorporated in the knowledge base. As their suggestions indicated, the system must be update the existing knowledge and learn from the environment. To handle such issues the researcher incorporated single case to dynamically update the existed fact in working memory. This component helps knowledge engineers to design a knowledge based system that update the fact base dynamically. But, it is clear that incorporating learning component for rule based system is difficult and complex as the numbers of rule expanded. Therefore, for specific domain area incorporating such component will improve the efficient of the system. For the question that concern about the significance of the system in the domain area, all the system evaluator's responds that the system add value in the domain area. Therefore, the applications of new technology simplify the working environment in domain area. In addition the system also can reduce the burden human expert by saving their time and energy spent while referring books and other manuals. Some respondents commented that the system would increase the interests of patient. Because they feel confident to respond any question about their feeling. Not only that the system can also contribute for the reusability and sharing of the same knowledge for different purposes in the institution. Finally, the system can be used as teaching and learning instrument for academic purpose.

Lastly, the system evaluators also provide their suggestions and comments on the weakness and strength of the knowledge based system. According to the system evaluators the following are some of the basic limitations of the knowledge based system:

- Cannot make creative and intelligent responses as human expert
- Lacks robustness such as sense and response ability
- The system lack the incorporation of some basic task in diagnosis processes such as physical and laboratory test which is significant to make conclusion.
- The system interacts with the user using only 'yes' or 'no' replies. Therefore, it lacks some flexibility.

Not only that, system evaluators also forwarded their constructive feedback on the strength of the knowledge based system. The strong sides of the knowledge based system are:

- Help to diagnosing many patients in short time frame and solve shortage of manpower in the triage department.
- Consistent answers for repetitive decisions, processes and tasks
- More accurate and Easy to use
- Applicable anywhere, even at home we can advise ourselves by having the software
- Make the diagnosing processes more clear, by showing the steps and procedures carry out by domain expert.
- Encourage self-treatment
- Encourages organizations to clarify the logic of their decision-making
- Never "forgets" to ask a question even if the operation fail

5.2. Test KBSPTT validation by using test cases

Section5.1 discussed about the evaluation of system performance using both closed and open ended questions. System evaluators directly interact with system using these questions in order to forward their feedback and suggestion on the performance of the system.

In this section the performance of the system is tested and validated using test cases. The test cases are used to measure the accuracy of the system. For the purpose of validation process a total of twenty test cases are selected. Then the system evaluators categorize those cases into their respective category based on the given pillar symptoms. To achieve the goal system evaluators were purposively selected according their nearness to each triage category. Therefore, the system evaluators are from different category namely medical, surgical, gynecology and psychiatric domain.

As discussed in section5.1 above system evaluators are selected using purposively sampling techniques from the domain area. From selected ten domain expert who measure user acceptance of knowledge based system, four of them are selected purposively to evaluate the test case. Then to perform the test procedure, the selected system evaluators are grouped into four class of medical expert, surgeon (surgical expert), gynecologist and psychiatrics to represent triage system. For each class one domain expert is assigned to evaluate five cases.

The knowledge based system testing procedure is carried out by system evaluator to classify the test cases into correct or incorrect classes. System evaluators compare the decisions made by the system against human expert. Then system evaluators validate the numbers of correct decisions made by the system. The result of the comparison shows that the rule based system has made close decision in the diagnosing process of patients as human expert did. As indicated in table5.2 below, the case test result provided by system evaluators showed that the knowledge based system is about 80% accurate in triage patient categorization.

Selected cases	Total number of cases selected for testing	Number of correctly classified cases by the system	Number of incorrectly classified cases	The accuracy of the prototype in %
Medical cases	5	4	1	80%
Surgical cases	5	3	2	60%
Gynecology cases	5	4	1	80%
Psychiatrics cases	5	5	0	100%
Total	20	16	4	80%

Table 5.2 Testing the Accuracy of KBSPETT using test cases

From figure 5.2 above twenty test cases are select purposively to validate the accuracy of the system and five cases are assigned for each triage category. For any case stored in the knowledge base, the system can classify correctly for a numbers of times. Purposively selected test cases are used to challenge the system performance. As a result, for medical category in the above figure 5.2 from the given five cases four of them are correctly classified. Similarly, from the given five cases only three of them are classified correctly in the surgical category. The result show that the overlapping symptoms of patient with surgical health problem. This means the more similarity in patient symptoms the better challenge for the system in identify the correct patient category in surgical domain. Finally, the system classified all of the given cases in the psychiatric category and it achieves the maximum performance. The result indicated that all the cases are directly

similar with knowledge incorporated in the knowledge base. Finally, sample of test cases are attached at the appendix part of the thesis.

5.2.1. Decision variation between system and human expert

As discussed in section 5.2 above the decision made by the system have slight difference with decision of human expert during test case validation. There are different contributing factors for the variation of decision made by the knowledge based system. First, the knowledge based system is limited to the knowledge incorporated in the knowledge base. The main problem is contextual understanding of patient symptoms. This mean sometimes the patient symptoms may be a medical case but due to high similarity of patient symptoms the case can be considered as surgical case. For examples, patients may present with symptoms of cough. But, if the patient waits more the two weeks without getting treatment, the patient problem may change other complication such as TB disease. As the numbers of day gone the complication again change another health problem like pneumonia. In medical domain age, sex and case duration have determinant factors to solve patient health problem. Therefore, by considering only the time range, the physician may decide the type of disease. Another example is symptom like lower abdominal pain is difficult to identify, especially when the patient is pregnant women. Because, both pregnancy and appendices disease has symptom of lower abdominal pain in common. Therefore, if a patient keeps silent when he/she feels such symptom, it will expose the patient into life threatening complication. As result, the case can be considered differently by different domain expert. Such issues affect the accuracy of the system during the test case validation.

On the other hand, to show the possibility of updating the existed knowledge, the researcher incorporated single case to update the facts from working memory based on the patient response. Once the new symptom acquired from the user the system store it permanently in the fact base. When user starts a new session, the system remembers previously stored symptoms to make a decision. In addition, the knowledge based system provides recommendation which help general practitioner to categorize the patient considering symptoms given by the users. Therefore, case based reasoning technique need to incorporate with rule based reasoning, which enables the system to learn from past practices. Then it will facilitate the full-fledge learning capability of the system by integrating the hybrid reasoning mechanism.

5.3. Discussion

As the system evaluator's response indicated, the proposed knowledge based system is promising and applicable in the domain area. The feedback and suggestion of domain expert reveals that the proposed knowledge based system satisfactorily gain user acceptance. The system acceptance evaluations used open and closed ended questions to directly interact with system.

The table below shows the summary of system performance evaluation result obtained from close ended questions.

Respondent who respond as	Poor(1)	Fair (2)	Good (3)	Very good (4)	Excellent (5)	Avg perf.
Total number	0	1	9	30	30	4.27%
avge out of 100%	0	1.42%	12.8%	42.28	42.28%	85.43%

Table 5.3 summary of system evaluators Result on Close Ended Questions

As the table 5.3 above indicates based on system performance gained from user's visual interaction using the closed ended questions. There is no evaluators respond as poor, evaluators reply fair only one times (1.42%), good nine times (12.8 %), very good thirteen times (42.28%) and excellent thirteen times (42.28%). The total average user acceptance evaluation result of knowledge based system is about 85.43%. This result show that more than 85% users accepted the easiness, attractiveness, correct decision, knowledge content, contribution and significance of the knowledge based system. Therefore, the proposed knowledge satisfactory makes the right decisions and providing appropriate recommendation during triage treatment.

In addition to the closed ended questions, the system evaluator provided valuable feedbacks and suggestions on the open ended questions. The system evaluators prove that this prototype is helpful to save time, easily accessible, store expert knowledge permanently, and cost effective in solving the human health problem. Therefore, with the addition of others category and different features, the knowledge based system could improve the working environment in the triage treatment.

Similarly, the response of system evaluators confirm that developing such prototype knowledge based system can reduce the existed knowledge gap in remote areas. As discussed in section 5.2 the system testing validation is carried out using solved cases by human expert. As the result indicated the prototype has made close decision with domain experts in the processes of triage diagnosis. The causes of the difference between human expert and the knowledge based system in decision making processes has been discussed under sub section of 5.2. The system also contributes valuable roles in the process of sharing experiences and skill in the health sector.

Generally, the performance of the prototype knowledge based system has got good user acceptance by the system evaluators. As a result, the knowledge based system would assist human expert to provide a better health care service. Therefore, this system helps the general practitioner to categorize patient disease into the respective category. In addition the system provides first line treatment in order to increase the quality of health care services. However, the system needs to be intelligent and learn automatically during users' examination. The knowledge based should also further strengthen to include the knowledge acquired from laboratory result for better decision.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

In Developing country like Ethiopia the coverage of health care services remain at its infant stage. Different factors are identified such as quality of health care, shortage of skilled manpower in the area, the distribution of physician per patient, the holding capacity of hospital, over-crowded number of patient and shortage of budget.

To address the above problems knowledge base system is proposed, the system aims to assist the general practitioner in the processes of triage patient categorization and making proper decisions. The relevant knowledge is acquired from domain expert and document analysis. Different challenges also identified during acquisition phases such willing and confidence of domain expert to share their knowledge. The proposed knowledge based system is conceptually modeled using decision tree structure to the logical relationships between pillar symptoms and the respective disease of the patient. The prototype of KBSPTT is developed by using LPA WIN prolog programming language.

Finally, the following conclusions are drawn from the finding with regard to the research questions:

- ✓ Applicability of knowledge based system for triage patient treatment haven been proved. But, to fully provide triage service other categories such as paediatrics, ART, OPD, etc need to be incorporated into the current system.
- ✓ The system provides advices on the bases of patient disease during physical and laboratory examinations by human expert.
- ✓ Knowledge is represented from in the form of if then rules generated from the decision tree. But, some challenges are identified during inferring from the given conditions, since, rules need pattern matching. Therefore, it is possible to conclude that other approaches such as case based system which infer from previous solved similar cases to draw a better solution.
- ✓ The proposed knowledge based system uses user acceptance and test case validation techniques to measure the performance of the system. The result of system performance

indicated that user are satisfied with proposed system and the test case validation result showed the system correctly classified patient into the triage category with slight difference. Therefore, the proposed system registered encouraging then it is possible to say the system address its objective.

- ✓ In the proposed knowledge based system an attempt is made for specific case to dynamically update the fact base in working memory. So that it s possible to conclude that, it is possible to make system to learn from the user response and permanently remember the new knowledge if the system works for specific domain.

6.1. Recommendation

The study achieves its main objectives by proving the applicability of the rule based system in triage patient treatment service. Based on the findings of the study the following recommendations are suggested for further study the applicability of knowledge based system in the domain area. The recommendation can initiate interested researcher to investigate further implementation of prototype knowledge based system in related health domain.

- The scope of the knowledge based system should be extended to incorporate others categories of triage system such as paediatrics, OPD and ART in order to expand the domain of the triage system.

- Rule base system can handle any domain specific problem, if there is perfect knowledge. But, most of the time that we gain from the patient may not satisfy the conditions of the given rule. Therefore, if we want to conclude better solution based on the few respondents response, then it is better to apply case based techniques.

- Triage treatment is often complex and subject to conditions of uncertainty. This is due to timely and accurate clinical assessment based on limited information and the stressful environment contributes to the complexity of triage decision making. Therefore, further investigation should be done to integrate an intelligent agent that has a capability to self-learning and update its knowledge base.
- The knowledge based system can be used self treatment purposive then the patients are possibly from different local language speakers and patients can express their feeling

using their own languages. Therefore, a user interface should be designed to enable the users to communicate using their own language with the knowledge base system.

- In this study an attempt is made to apply rule based systems. But, there are different solved cases available in each triage category. Rule based systems solve problems from scratch, while case based systems use pre-stored situations to deal with similar new instances. Therefore, the integration of rule based reasoning with case based reasoning would solve the limitation when representing knowledge in the form of if then rules unable to draw a conclusion.
- The researcher identified the availability of accumulated data in the triage record office. Therefore, we can discover a new pattern by implementing data mining techniques which help us to improve the content of knowledge that we acquire manually from the domain expert.

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Appendix I

Interview Questions

After introducing the objective of the study, respondents were requested to participate by responding the interview questions. The answers of the respondents were recorded by using paper and pen for the following interview questions. The following interview questions are the main area to cover how general practitioners diagnose a patient.

1. How health problems are defined from the aspect of their categories in triage system?
2. What are the method and techniques general practitioner used to identify the causes of patient diseases in each triage category?
3. What are the common types of diseases that can identify using their common pillar symptom?
4. How general practitioners identify the unique characteristics of each disease?
5. What are common symptoms each disease and their association with one another in their respective categories?
6. What are the main inheretism and environmental risk factors of diseases during patient diagnosis?
7. Does a disease have common behaviors and their complication due to different factors?
8. What are the decisions of general practitioner in providing good treatment?
9. What are the most important areas focused by general practitioner to diagnose the patient?
10. What are recommended techniques used to manage specific diseases?

Appendix II

Sample codes of the knowledge based system

```
/*----------rules to identifying the case----------*/

patient(TB):-

 do_you_have_fever ==yes/no

 do_you_have_chilling == yes/no,

 do_you_have_fatigue == yes/no

 have_you_weight_loss == yes/no

patient(appendix):-

 check1,

check3,

lower abdominal pain == yes/no,

do_you_have_fever == yes/no

loss_of_appetite == yes/no,

nausea or vomiting == yes/no.

patient('sleep apnea'):-

  check,

  loud_and_chronic_snoring == yes/no,

  choking_or_snorting_during_sleep == yes/no,

  long_pauses_in_breathing == yes/no,

  daytime_sleepiness.

patient(cancer):-

 fever == yes,

cough_or_hoarseness == yes/no

 unexplained_bleeding == yes/no
```

thickening_or_lumph_in_the_body == yes/no

patient(pregnancy):-

check,

period_interruption == yes/ no,

lowoer abdominal pain == yes/no.,

patient('heart disease'):-

check,

any_injury_or_wound ==yes/no

inability_to_carrout_any_physical_exercise == yes/no

blood_pressure == yes/no

inability_of_the_ventricle_to_contract == yes/no.

patient(malaria):-

check1,

check3,

fever == yes,

feelworried anxious == yes/no

frequentvomotting == yes/no

chilling_and_high_temprature_fever == yes/no

patient(pneumonia):-

do_you_have_fever == yes/no,

patient_has_cough_produce_yellow_tan_or_green_mocus == yes/no,

fast_breathing_and_feeling_short_of_breath == yes/no,

chest_pain_that_often_feels_worse_when_you_cough_or_breathe_in == yes/no,

patient_has_shaking_chill_and_very_ill == yes/no.

Appendix III

Questionnaire to test and validate the performance of the triage premedical diagnosis rule based knowledge based system

1. Is the rule easy for you to interact with it?
   1. Poor 2. Fair 3. Good 4. Very good 5. Excellent
2. Is KBSTPMT attractive?

   1. Poor2. Fair 3. Good 4. Very good 5. Excellent

3. Is the system more efficient in running time?

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

4. Does the system incorporate sufficient knowledge to categorize a given diseases into sub-category that have a prototype?

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

5. Is the system provides the right description and treatment patient need to follow while diagnosis by human expert.
   1. Poor 2. Fair 3. Good 4. Very good 5. Excellent
6. How do you rate the significance of the system in the domain area?
   1. Poor 2. Fair 3. Good 4. Very good 5. Excellent
7. How is KBSPTT different from a diagnosis conducted by human expert?
8. What issues are covered by the advisor service of the system?
9. Do you feel any uncovered areas by the prototype about patient diagnosis system? If you feel please state them.
10. In your opinion, can knowledge based system (such as the rule based presented by KBSPTT) handle the diagnosis task of triage treatment?
11. Do you think that the system incorporate sufficient knowledge to provide triage treatment?
12. Does the system are have any significance in the domain area?
13. What is the strength of KBSPTT?
14. What are the limitations of KBSPTT?

Appendix IV

Sample of test case used to validate the accuracy of KBSPTT system

Case1: cancer disease

Domain expert decision	System decision
Patient history: name, age, sex, location	
Symptom: unexplained bleeding, local pain, thecking, difficult to swallow, hoarseness, anxiety, constipation Treatment: surgical option Chemo therapy, hormone therapy and radiation therapy	Symptom: Unexplained bleeding, hoarseness, cough, thickening, fever
Similar decision is made, the system does not identify the type of cancer	

Case2: cough

Domain expert decision	System decision
Patient history: name, age, sex, location	
Symptom: discomfort cough, sensation, irritation blowing Treatment: Determine the underlying causes Eliminating the risk factors	
Domain expert decide based on the duration of cough and system decide based on the symptom. Different decision is made	

Case3: appendix disease

Domain expert decision	System decision
Patient history: name, age, sex = female, location	
Symptom: lower abdominal pain, appetite loss, vomiting, fever, Treatment: Surgical operation	Symptom: lower abdominal pain, loss of appetite, vomiting
Domain expert decide as surgical case but, the system decide as gynecology case by considering sex factor.	

Case4: pregnant case

Domain expert decision	System decision
Patient history: name, age, sex, location	
Symptom: period interruption, vomiting, fever, lower abdominal pain, anxiety, discomfort Decision based on the age factor	Symptom: lower abdominal pain, period interruption, vomiting,
Domain expert decides menopause case but the system decide as pregnant case.	

Case5: TB disease

Domain expert decision	System decision
Patient history: name, age, sex, location	
Symptom: fever, long term cough, loss of appetite, weight loss Treatment: Six month courses of medication	Symptom: fever, long term cough, chilling, weight loss muscle fatigue
Similar decision have been made in both case	

Case6: mood disorder

Domain expert decision	System decision
Patient history: name, age, sex, location	
Symptom: depression, anxiety, loss of concentration, acts of suicide, and sever stress. Treatment: Medication and individual or group counseling	Symptom: depression, anxiety, loss of concentration, acts of suicide, and sever stress.
Similar decision have been made in both case	

A symptom for the system side is taken as it described in the decision tree structure in the conceptual modeling part of the thesis.

DECLARATION

This thesis is my original work and has not been submitted as a partial requirement for a degree of master in any other university

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January 2013

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