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# Hybrid Knowledge Based System for Pregnancy Related Disease Diagnosis

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# HYBRID KNOWLEDGE BASED SYSTEM FOR PREGNANCY RELATED DISEASE DIAGNOSIS

**MSc. Thesis**

**By**

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# HYBRID KNOWLEDGE BASED SYSTEM FOR PREGNANCY RELATED DISEASE DIAGNOSIS

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A thesis submitted to the school of Research and Graduate Studies of Bahir Dar, Institute of Technology, BDU in partial fulfillment of the requirements for the degree of

Master of Science in the Information technology in the faculty of Computing.

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## DECLARATION

I, the undersigned, declare that the thesis comprises my own work. In compliance with internationally accepted practices, I have acknowledged and refereed all materials used in this work. I understand that non-adherence to the principles of academic honesty and integrity, misrepresentation/ fabrication of any idea/data/fact/source will constitute sufficient ground for disciplinary action by the University and can also evoke penal action from the sources which have not been properly cited or acknowledged.

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# 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. The major challenge for health service in Ethiopia is shortage of skilled manpower in the health sector, In Ethiopia the number of health professionals and patients demand are unequal. Lacks of enough knowledge among primary health care workers, allocation of insufficient budgets for health sectors and the absence of adequate awareness about pregnancy* Related *diseases 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 and reduce the quality of decisions made by physicians. As a result, objective of the study is to explore the applicability of hybrid reasoning approach in the development of knowledge-based decision support system for the pregnancy* Related *diseases diagnosis. This also improve the quality of decision making, provide effective and efficient services, and improve shortage of domain expert in specific domain area. The designed hybrid knowledge-based system use Jcolibri programming tool integrated with Eclipse and Nearest Neighbor retrieval algorithm. The designed prototype system is evaluated differently including statistical analysis, comparative evaluation, user evaluation, and other evaluation techniques. The experimental study shows a significant improvement while the study used a hybrid approach of RBR and CBR as compared with RBR and CBR individually for designing a knowledge-based decision support system. We achieved an overall recognition accuracy of 88.75% while using a hybrid knowledge-based system. We therefore recommended a further investigation on the different reasoning methods so as to improve the knowledge-based decision making.*



***Keywords:*** *Hybrid learning knowledge-based system, knowledge-based system, jCOLIBRI, Rule Based and Case Based.*

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# ABBREVIATIONS

| | |
|---|---|
| AI | Artificial Intelligence |
| CBR | Case Based Reasoning |
| RBR | Rule Based Reasoning |
| CBRF | Case Based Reasoning Framework |
| IDE | An Integrated Development Environment |
| GUI | Graphical User Interface |
| KBS | Knowledge Base Systems |
| KB | Knowledge Base |
| MBR | Model Based Reasoning |
| NLP | Natural Language Processing |
| RBR | Rule based Reasoning |
| DM | Data Mining |
| KDD | Knowledge Discovery in Databases |
| KDP | Knowledge Discovery Process |
| WHO | World Health Organization |
| ES | Expert System |
| KA | Knowledge Acquisition |
| KE | Knowledge Engineer |
| DSS | Decision Support System |
| CDSS | Clinical Decision Support System |
| jCOLIBRI | Java Cases and Ontology Integration for Building Reasoning Infrastructure |
| UTI | Unary Trace Infection |

# CHAPTER ONE
# INTRODUCTION

## 1.1. Background

Complications of pregnancy are health problems that occur during pregnancy. They can involve the mother's health, the baby's health, or both. Some women have health problems that arise during pregnancy, and other women have health problems before they become pregnant that could lead to complications. It is very important for women to receive health care before and during pregnancy to decrease the risk of pregnancy complications(B. Deepth, M. Prasanna, Babu2017).

There are many kinds of diseases in the world that affect human beings in different aspects. Pregnancy Related diseases are the diseases that affect pregnant women's(Abdella, 2010). Pregnancy Related diseases are health problems that are caused by pregnancy. In this study we also discuss the common pregnancy Related diseases and an over view on frequent causes of the pregnancy Related diseases and their treatments. Artificial Intelligence is a field of science (computer science) and engineering which deals with the design and development of intelligent computer systems, which is capable of having the characteristics associate with intelligence in human behavior such as understanding language, learning, reasoning, patient monitoring, medical diagnostic systems, drug dosage administration and solving problem(Poola, 2017). Knowledge base systems, natural language processing, computer vision, intelligent computer aid instruction, intelligent agents, automatic programming and summarizing news and others can be considered as artificial intelligence technologies. KBS is one of the main popular types of AI technologies and it can be referring as a computer program that represents and reasons with knowledge of some specialist subject and documents with a view of solve problems

or provide recommendation. It is a type of programs that plays a great role in particular fields, specifically in health care centers(Gudu, 2012).

Pregnancy Related diseases are common public health problem and significantly affects the pregnant women's, who suffers socio economic problems. This is because of shortage of Health professionals, and scarcity of health instruction and laboratory equipment, especially in developing countries. So, it is difficult to have satisfactory diagnosis and provide appropriate treatment for pregnant with these kinds of situations. In order to solve thesis problems, it is important to Design Hybrid Knowledge-based system (KBS) that can provide support for health professionals to diagnosis and decision-making during pregnancy Related diseases diagnosis. CBR and RBR are the two more popular problem-solving techniques in artificial intelligence. Both techniques in this study use medical data and domain knowledge to diagnose patient conditions as well as recommend suitable treatments. They improve the quality of medical decision making, increases patient compliance, minimize complications and medical errors. By combined RBR and CBR systems we can to form an intelligent hybrid knowledge based system(Soltani, 2013).

This research focuses on Design Hybrid KBS and revolutionize diagnosis and decision-making process by apply and combine Case-based and rule-based reasoning artificially intelligent techniques. RBR depends on basic rules and regulations of the relevant field and the knowledge from the experts. However, CBR is a way of solving new problems that can adapt to conditions without need the help of experts(Diriba & Meshesha,2016). Knowledge acquisition is one of the greatest bottlenecks in the development of knowledge-based systems. This is due to that the human experts are usually having insufficient knowledge and the experts are finding it difficult to describe his/her knowledge completely and correct.

## 1.2. Statement of the problem

Delivery of healthcare services is a major challenge for governments in most developing countries. Some of these challenges are lack of highly qualified medical human resources, financial as well as the ability to manage and transform scarce resources( WHO, 2015). Currently, shortage of health care institutions and health professionals in Ethiopia leads to have too small number of health professionals and large number of patient ratio. The problem is even worse in rural areas. Most diseases specifically, pregnancy Related diseases are the main health problems in our country. Studies indicate that pregnancy Related diseases is a serious health problem in developing countries(Abdella, 2010).

Almost all health institutions including hospitals found in Bahir Dar are using manual paper-based diagnosis system, which lacks the capability of automatically using the previously solved patient cases for the diagnosis of new patient. But, such access of previously solved diagnosis information can help the professionals to improve their decision-making confidence and it enables them to make proper decision on the current health problem of their patient. Most diseases like pregnancy related diseases share several similar symptoms with other diseases, this makes difficult for Experts to diagnoses and treatment. Due to the above reason and relate limitations in diagnosis and treatment services given to patients is not yet satisfactory. Therefor it is required to Hybrid Knowledge-based system (KBS). This study improves the service of health care centers by giving and advises the physician to diagnosis pregnancy related diseases.

To this end, the study answers the following research questions

- How to acquire, model, represent, and implement HKBS prototype for pregnancy related diseases?
- How to classify and identify the cause of the pain and severity level using HKBS?

- What is the extent of satisfaction the user gets from the proposed HKBS?
- How to design the components to provide the Hybrid reasoning KBS?

## 1.3. Objectives of the study

The study has both general and specific objectives as stated below.

### 1.3.1. GENERAL OBJECTIVE

The main objective of this study was to design & develop a Hybrid Knowledge Based System for Pregnancy Related Diseases Diagnosis.

### 1.3.2. SPECIFIC OBJECTIVES

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

- To acquire tacit and explicit knowledge in domain experts for Pregnancy related disease.
- To identify the most determinant Disease, symptoms and parameters.
- To model and represent the domain knowledge using suitable knowledge representation techniques.
- To develop Hybrid knowledge-based system for diagnosis pregnancy related diseases.

## 1.4. Scope and Limitation of the Study

The scope of this study was developing knowledge-based system for diagnosis pregnancy related diseases. The study was focus on the most frequently occurrence of pregnancy related diseases in developing countries especially in Ethiopia which is illustrated by different health researches. The study is limited to diagnosis pregnancy related Diseases. Most well-known common pregnancy related disease are UTI, Anima, Hypertensive disorders, Heart disease, Liver disease, Respiratory diseases, Hematological abnormalities and obstructed labor(Abdella, 2010). But due to limitation of time and resources the research is to focused on the following three common disease. I.e. Anima, UTI and Hypertension.

The following are the main constraints and limitations identified for the study.

- Medical Knowledge is described by its scientific name and this make the knowledge election process is more difficult.
- Domain experts are not feeling well to share their knowledge and experiences.
- Representing and codifying natural languages into computer language is the challenging and time consuming.
- The design of this study limit on small number of cases due to the existing manual record system and time limitations.
- Even though RBR and CBR are broad discipline of AI only the core tasks and methods of the reasoning are investigating in this medical KBS based system.

## 1.5. Methodology

With the aim of achieving the objective through answering the research questions of this study, the following methods and techniques are used.

### 1.5.1. LITERATURE REVIEW

In order to have deep understanding on the problem of this study, it is vital to review several literatures that have been conduct in the field so far. For this reason, related literature such as books, articles, proceeding papers and some other sources that are retrieved from the internet are consulted so as to understand the domain knowledge, concepts, principles and methods that are important for developing Knowledge-Based Systems.

### 1.5.2. DATA COLLECTION

In this study explicit and tacit knowledge is acquired from both codified (documented) sources and non-codified (non-documented) sources respectively. Non-codified sources of knowledge are acquired from gynecologists, Modifier's and General medical doctors who work in the Felege Hiwot Hospital by using interview and critique knowledge elicitation methods to filter the acquired knowledge. Similarly, codified sources of knowledge such as medical books, Family planning Journals, Health manuals, training manuals and journal medical articles are acquired by using document analysis technique. Six domain experts are selected by using purposive sampling techniques. This technique is selected by the researcher as the research need in-depth investigation on Diagnosis pregnancy related Diseases. Purposive sampling techniques enable to select sample which can provide the needed information. Domain experts are selected based on their educational qualifications related to the domain area, year of experience and willingness. From the six experts, two of them are medical doctors who specialized in gynecologist and having more

than ten years of experience. Three of them are Midwife's with more than 5 years' experience. The remaining one is a General Doctor having more than 2 years of experience.

### 1.5.3. KNOWLEDGE MODELING AND REPRESENTATION

Design hybrid knowledge-based systems view 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(Baris, 2018).

In this study, after the knowledge is extracted from documentary and non-documentary sources, it is modeled by using decision tree and represented using production rule which is one of the knowledge representation techniques. Decision trees models by constructing a tree based on training instances with leaves having class labels is used. It is easy to interpret. Production rules are easy for a human expert to read, understand and maintain. Production rules contain simple syntax that is flexible and easy to understand and are reasonably efficient in diagnosing problems of the form:

IF---------- <Condition>
THEN---------- <Conclusion>

Where <Condition> represents premises and <conclusion> represents related action for the given premises. The reasons for using productions rules for this study are because of its ease of encapsulation of knowledge and ease of extensions to the knowledge base in the future(Ahmed, 2013). The prototype system uses backward chaining technique which begins with possible solutions or goals and tries to gather information that verifies the solution.

### 1.5.4. PROGRAMING TOOLS

jCOLIBRI and myCBR are the main programing tool used for designing Case Based Reasoning. The main reason use jCOLIBRI supports the full CBR cycles (4R). These implementations are developed by Group of Artificial Intelligence Applications (GAIA) and German Research Center for Artificial Intelligence. JCOLIBRI is used for the implementation of this study by integrating it with eclipse IDE. We use Prolog (programming logic) also for knowledge representation. Prolog is one of the most widely used programming language, especially in the artificial intelligence research, natural language processing, system development, and so on. Prolog programming language is use to Hybrid 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.

### 1.5.5. TESTING AND EVALUATION

To address the established objectives of this study, the designed system is tested and evaluated both performance of the prototype system and issues of user's acceptance. Ten patient cases are selected by applying purposive sampling technique from Felege Hiwot Referral Hospital for testing performance of the prototype system. These patients' cases are divided into three based on the similarities of the patient's cases. These are UTI Cases, Anima Cases, and Hypertension patients' cases.

The correct and incorrect results are classified by comparing decisions made by the domain experts on the cases of patients and with the prototype system conclusions. The performance comparison parameters such as precision and recall are used to measure the accuracy of the prototype system. user's acceptance testing is also done to get the quality of advice and to access to what extent the KBS satisfies the domain experts.

## 1.6. Significance of the Study

Knowledge-based systems are artificial intelligent tools functioning in a specific domain used for diagnosis, provide advice and consultation in decision making(Shabbir, 2018). With the proper application of knowledge, the knowledge-based systems increase productivity, and improve problem solving capacity in a flexible manner. The developed Hybrid knowledge-based system enables to minimize the problem of the limited numbers of expert's in health sector. This is because expert's knowledge and work experiences are store to the knowledge base and provide accurate and effective result for diagnosis diseases. The study of this medical Hybrid KBS is to build better health care facility in order to reduce time, cost and medical error. The develop Hybrid KBS can act as an expert on demand by learning from new facts and rules in the course of providing diagnosis diseases. Pregnant women's and health professionals are the main beneficiary from this hybrid KBS. As we discuss in the methodology this Hybrid KBS is mainly Developed from the knowledge of well experienced domain experts. So, any domain expert performs diagnosis alongside the advice of these experienced professionals at hand regardless of the distance of their address. Finally, this Hybrid KBS benefits the patients by enhancing the service provided by the health care organization. Furthermore, this research can act as bases for farther research in the area.

## 1.7. Organization of the Thesis

The main body of this thesis is organized in six chapters.

Chapter 1: Introduction part, which contain back ground of the study, statement of the problem. It also presents objectives of the study, scope and limitations of the study, methodology, and significance of the study

Chapter 2: Presents review of related literature. It provides an overview of knowledge-based system, architecture of KBS, Case based reasoning, rule-based Reasoning, applications of knowledge-based system, and review of related works.

Chapter 3: Discusses the Research methodology, knowledge acquisition from different sources, and conceptual modeling of the acquired knowledge using decision tree. It also discusses the representation of the validated acquired knowledge using production rules for developing the prototype system.

Chapter 4: Design and Implementation In this chapter the design and implementation of the prototype are realized. The architecture of the new prototype Hybrid Knowledge based system for pregnancy related diseases diagnosis is developed. The implementation tool used is jCOLIBRI.

Chapter five: Testing and Performance Evaluation of the Prototype In this chapter the performance of the prototype is evaluated both the performance of the system and the acceptance of the system by the users. In addition, the functionality of all the CBR cycles is tested.

Finally, chapter six puts the major findings, based on which it provides concluding remarks and recommendations for further research in the domain area.

# CHAPTER TWO

## 2.1. 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.

## 2.2. Artificial Intelligence

The term intelligence refers to the ability to acquire and apply different knowledge and skills to solve problems. In addition, intelligence is also concerned with the use of general mental capability to solve, reason, and learning various situation. Artificial intelligence (AI) is a field of computer science which tries to understand how human beings think, perceive, understand, predict, manipulate towards the world and it also tries to develop intelligent entities that can handle complex problems in similar way as human beings handle it(Topol, 2019). The main aim of Artificial Intelligence is to study how to build artificial systems that perform tasks normally performed by human beings(Poningsih, 2017).

Artificial Intelligence has the capabilities to imitate human intelligence, performing various tasks that require thinking and learning, solve problems and make various decisions. Artificial Intelligence software or programs that are inserted into robots, computers, or other related systems which them necessary thinking ability(Shabbir, 2018).

## 2.3. Knowledge Based System

Knowledge based system (KBS) is a computer program that is derived from a field of Artificial Intelligence (AI). The systematic aim of AI is understanding intelligence by developing computer programs that show intelligent behavior. Intelligent behaviors include cognitive skills like thinking, problem solving, learning, understanding, emotions, consciousness, intuition and creativity, language capacity, etc. It deals with methods of inferring mechanisms using the computer and in what way knowledge can be represented using different techniques for inferring(Solomon, 2013).

The goal of the design Hybrid knowledge based system is to encapsulate tacit and explicit knowledge in a particular area and code this in a computer in a way that the knowledge of the expert is accessible to novice users(Patel & Mehta, 2011). Domain experts use the knowledge they have about the domain and techniques that lead how to use the knowledge to solve problems. Knowledge based expert systems also designed and developed to handle problems in the same way(Eshete, 2009). With the proper utilization of knowledge, the knowledge based systems increase productivity, document rare knowledge by capturing scare expertise and enhances problem solving capabilities in most flexible way(Sajja & Akerkar, 2010). According to Sajja and Akerkar, ( 2010), such systems also document knowledge for future use and training. This leads to improved quality in problem solving process; however, the scarcity and nature of knowledge make the KBS development process difficult and complex.

### 2.3.1. Types of knowledge

Knowledge can be classified in many different ways(Sajja & Akerkar, 2010). Tacit knowledge, explicit knowledge, factual knowledge, procedural knowledge, commonsense knowledge, domain knowledge, Meta knowledge, etc.

*Table 2*. 1 Briefly Introduces Various Types of Knowledge.

| Knowledge | Type Description |
|---|---|
| Domain knowledge | Domain knowledge is valid knowledge for a specified domain. Specialists and experts develop their own domain knowledge and use it for problem solving. |
| Meta knowledge | Meta knowledge can be defined as knowledge about knowledge. |
| Commonsense knowledge | Common sense knowledge is a general-purpose knowledge expected to be present in every normal human being. Common-sense ideas tend to relate to events within human experience. |
| Heuristic knowledge | Heuristic is a specific rule-of-thumb or argument derived from experience. |
| Explicit knowledge | Explicit knowledge can be easily expressed in words/numbers and shared in the form of data, scientific formulae, product specifications, manuals, and universal principles. It is more formal and systematic. |
| Tacit knowledge | Tacit knowledge is the knowledge stored in subconscious mind of experts and not easy to document. It is highly personal and hard to formalize, and hence difficult to represent formally in system. Subjective insights, intuitions, emotions, mental models, values and actions are examples of tacit knowledge. |

### 2.3.2. KNOWLEDGE BASED SYSTEM ARCHITECTURE

The general architecture, components and interaction among components in knowledge-based system show below figure.

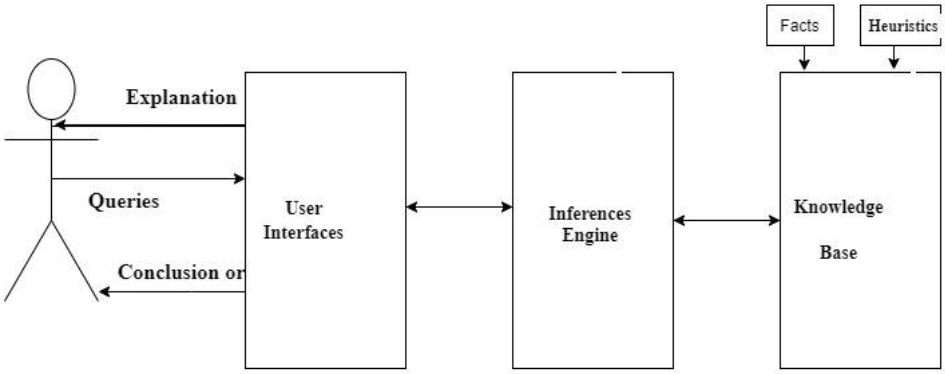



*Figure 2. 1: Knowledge Based System Architecture*

The Above Figure shows that knowledge-based Architecture and components such as knowledge Base, Inferences engine, user interfaces and Explanation method.

**Knowledge Engineers:** A person having knowledgeable and skilled, capable of solving problems in a specific domain(Tanwar, 2011). He/ She create and develop the knowledge base by applying sequential different types of interview with the domain experts and represent it in a suitable format to solve the problem.

**Knowledge Base:** The knowledge base represents the repository of knowledge for specific area. The knowledge base contains domain specific knowledge required to solve the problem(Kingston, 2017). The process of acquiring knowledge involves two major steps; knowledge elicitation and knowledge representation. Knowledge elicitation used for extracting knowledge from

domain experts, related documents or related sources regardless of their structure, whereas knowledge representation applies structuring and representing the knowledge based on the general concept discovered during knowledge elicitation phase(Owaied & Qasem, 2010).

**Inference engine**: - Inference is the process of chaining multiple rules together based on available data in the knowledge base. The inference engines are applicable in answering and solving complex queries in order to infer possible answers. The purpose of the inference engine is to seek information and form relationships from the knowledge base and provide answers. IT is the core component of knowledge-based system which mainly provides reasoning methodology about the current information in the knowledge base and formulation of conclusion. The inferences engine caries out the reasoning whereby the KBS reaches the solution. It links the Rules given in the knowledge base with the fact provided in the Database(Kayali, 2018; Negnevitsky, 2002). Now a day variety of important techniques and tools of knowledge-based systems are available and in the last years this field of AI had been enormously expanded.

**Explanations Facility**: - Knowledge based system typically able to provide explanation regarding to the conclusion it makes. It is essential in all nontrivial domains to provide explanations to users to understand how the system works and determining whether its reasoning is correct or not.

**User Interfaces**: - It allowing the user to input information in response to questions generated by the system.

### 2.3.3. ADVANTAGES OF KNOWLEDGE-BASED SYSTEM

The main advantages of using a knowledge-based system are descried as follows(Sajja & Akerkar, 2010):

- Permanent documentation of knowledge: A knowledge engineer extracts knowledge from domain experts and relevant documents for a certain problem domain and represents it using one of the knowledge representation techniques and transfers it into the knowledge base. This helps end-users to use the knowledge stored for a long-term from the documented knowledge in the knowledge base at any time.
- Cheaper solution and easy availability of knowledge: It is assumed very huge, complicated and expensive to develop a KBS. Nevertheless, it costs once for building the knowledge base. After duplicating it into many copies, it is simple to use the knowledge in many places. This interrupts the dominations of domain experts and makes simple to acquire and utilize knowledge. On the contrary, educating new domain experts is inefficient and costly. Therefore, the aim of developing KBSs is to reduce cost, time, human expertise and medical error.
- Dual advantages of effectiveness and efficiency: Since knowledge-based systems are computer-based systems, they have efficiency directed factors such as speed, accuracy, control, and permanent content storage. It is possible to make the knowledge-based system effective by integrating the knowledge element. They are more efficient than domain experts and attempts to become equally effective like domain experts.
- Consistency and reliability: Since the knowledge element are integrated into the KBS and the capability to perform effectively, the honesty of the system rises. Besides, dupery and errors can be stopped. Information

can be accessible rapidly for making decision with appropriate justification. As the level and amount of knowledge rises, making right decision is rise and thereby reduces the threat of wrong decision.

- Justification for better understanding: The reliability of the domain experts relies on the capability to explain their decisions. This can be offered by using the reasoning and justification component of the KBS to the end-users. If there is a well understanding of the decisions made by end-users of the system, then it increases the quality and trustworthiness of the system.
- Knowledge Engineer: With the assistance of the inference engine of the system, the knowledge base always updates its knowledge from experience. The knowledge engineer updates the knowledge-based system.

### 2.3.4. LIMITATIONS OF KNOWLEDGE-BASED SYSTEM

The following are some of the major drawbacks of using the KBS(Sajja & Akerkar, 2010).

- Partial self-learning: - The knowledge-based systems can explain when they made a decision and learn from experience by updating its knowledge. However, the represented knowledge may not be completely known so that the knowledge-based system can learn partially from experience. Besides, domain experts can conform automatically to new conditions though KBSs should explicitly update their knowledge.
- Creativity and innovation: - It is not possible computer-machines to show a certain behavior as creative as humans do. Domain experts can

answer back in a creative manner to new conditions though knowledge-based systems as a maximum can deal with the five basic senses. KBSs do not have any methodology to deal with invention, the ability to create and common sense. If we use AI methods in KBS, human like five basic senses can be partly applied. The vision, listening, smell, taste, and touch tasks are implemented so that they cannot totally assist activities related to perception, emotion, and enjoyment. This is because knowledge-based systems are now reliant on symbolic input though human beings have a varied of sensory experience.

- Weak support of methods and heuristics: - Knowledge-based systems cannot operate with their full capacity if there is no response given or the problem is out of the system's knowledge. When the heuristics is applied to look for a solution from the search space, the success of the systems relies on the quality of the heuristics. Thus, the responsibility depends on the knowledge engineer to develop the heuristics.
- Development Methodology: - System development is not only an art but also a science. For example, in the development of information systems there is no one common accepted methodology. There are common guidelines and lifecycle models that help to develop all types of computer-based information systems. However, there is no common development model that helps knowledge engineers to develop a KBS.

## 2.4. Case Based Reasoning

Human being approaches to solve new problems by recalling and relating previous similar problems and their solutions to the new situations. To simulate this problem solving skill of humans, in recent years the way human beings

solve problems based on their previous experience with similar situation is realized by researchers(Salem, Roushdy, & Hodhod, 2005). But it doesn't mean that the complete solution of previous problem can be taken as a complete solution for similar new problem. So, the experience gained from lastly solved solution helps to derive and customize solution for new problems by using different reasoning techniques. Case-based reasoning is a problem solving and learning method based on knowledge representation. It solves current problems by referring to the experience and knowledge of similar previous cases(Su et al., 2019). We normally learn from our successful and wrong activities to handle future similar situations in the right way and not to repeat our mistakes. Remembering and reusing previously solved problems, and learning from experiences for future use, is natural and useful. Case-Based Reasoning works this way with principle of similar problems have similar solutions as depicted in figure 2.2 below.

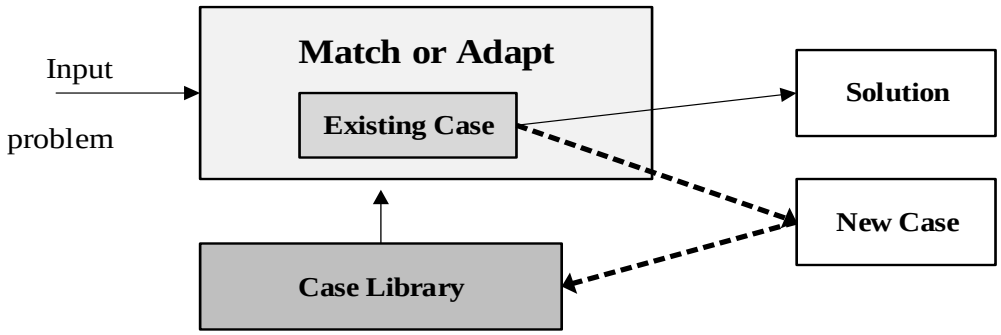



Figure 2. 1. Case Based Reasoning(Richter & Weber, 2013)

Finally, the name case-based reasoning can be defined as using previously solved cases to meet new demands, using old cases to explain new problem, using old cases to critique new solutions, or reasoning from precedents to interpret a new situation or create an equitable solution to a new problem(Kolodner, 1992).

A long side the solution and result the problem situation is usually denoted by a case in case-based reasoning terminology which is called old case or past case (Adla & Bella, 2018).

Description of new problem to be solved denotes new case.

- **Problem Description**: - Gives description of a particular case when it is recorded.
- **Solution**: - Tells how the particular described problem is treated or solved.
- **Result**: - Provides the final result and feedback gained from the solution.

Case-based reasoning is a problem-solving paradigm that in many respects is fundamentally different from other major AI approaches and A case-based reasoned solves problems by using or adapting solutions to old problems(Soltani, 2013).

## 2.5. Types of Case Based Reasoning

As Kolodner and Salem (2007) both problem solving and interpretive are the two major types of case-based reasoning.

### 2.5.1. PROBLEM SOLVER

A case-based reasoning is said to be problem solving when it adapt/generate/ solution for new problems by reusing similar past cases. Old solutions provide solutions for new problems and warning of potential mistakes and failures. Such types of case-based reasoning fits well for problem solving tasks in diagnosis, planning and design(Bonissone & Analytics, 2016) and applies both

adaptation process to generate new solution and interpretive process to judge derived solutions(Adla & Bella, 2018).

### 2.5.2. INTERPRETIVE

This type of case-based reasoning limits itself from directly generating solution for new problems from old cases; instead it uses the old cases to evaluate new cases and to provide justifications for solutions. Mainly interpretive case-based reasoning is used in courts and other domain areas for the purpose of justification of solution, classification, evaluation of a solution, argumentation, interpretation and projection of effects of a decision or plan(Nasiri & Fathi, 2017). Interpretive type can be found in problem solving type and both types of case-based reasoning are depending heavily on a case retrieval and storage of new situations back into memory which allows learning from experience(Syed-abdullah, 2015).

## 2.6. Case Based Reasoning Cycle

A case-based reasoning technique follows four processes, Retrieve, Reuse, Revise and Retain, to accomplish its reasoning task (Hiluf & Assefa, 2015). Figure 2.3 Shows sequence or cycle of the processes and each process is described below.

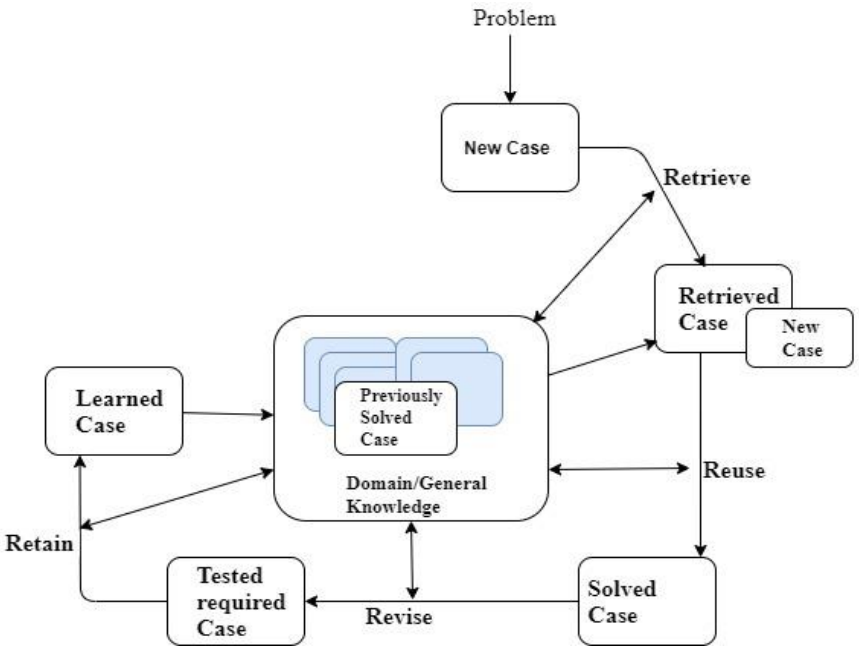



Figure 2. 2. The Case Based Reasoning Cycle(Mechitov 1995)

### 2.6.1. Retrieve

In Case Based Reasoning, processes retrieving is the first step, it is also defined as the process of recalling the most similar cases from the case base by taking problem description as input and gives the most similar cases as an output(Richter & Weber, 2013). The complete CBR performance is determined by its retrieval performance since retrieval is the core process for the CBR cycles.

As Sqalli and Rissland (2002) the process of case retrieval is subdivided in to three different subtasks:

- **Identify features**: this task identifies the most relevant descriptive feature in the problem to match it with saved cases.

- **Initially match**: involves the task of identifying old cases that matches with the current problem and retrieves the matched cases. Searching and similarity measurement are the two main tasks take place here to get similar case/cases.
- **Select:** finally, the best-matched case is selected and taken as the output of the retrieval process based on the result of similarity assessment.

The retrieval process has been also subdivided in to two tasks by (Merelli & Luck, 2004; Sqalli & Rissland, 2002) as;

I. **Recall previous cases**: involves retrieving matched cases from the available past cases that helps to solve the new case.
II. **Select the best subject:** involves the selection of the best case from the retrieved matched cases.

Searching algorithm, similarity assessment method and descriptive feature identification are the main critical factors affecting the retrieval process in CBR. Nearest Neighbor and Induction algorithms are the most well-known algorithms for case retrieval(Prasath, 2017; Recio-García, 2008). There is also a possibility of using these algorithms in combined as hybrid or alone for retrieval purpose.

## Nearest Neighbor Algorithm

This retrieval algorithm works by measuring the similarity of new case with the stored cases based on matching a weighed sum of features/attributes(Campillo-Gimenez, 2012; Gerhana, 2017).Nearest Neighbor algorithm returns nearest match from case-based reasoning library. This algorithm best fits when the new case doesn't exactly match with the old cases and when attributes have numeric

(continuous) values(Bach, 2018). But as the cases in the case base increases the retrieval time in this s algorithm also increases.

The following is the algorithm for Nearest Neighbor(Bazmara & Jafari, 2013)

*For each feature in the input case:*

*Find the corresponding feature in the stored case*

*Compare the two values to each other and compute the degree of match*

*Multiply by a coefficient representing the importance of the feature to the match*

*Add the results to derive an average match score*

*This number represents the degree of match of the old case to the input.*

*Nearest Neighbor algorithm can be represented as in the following equation*

$$NN\ (I,R) = \frac{\sum_{i=I}^{n} Wi\ x\ sim(f^{I}, f^{R})}{\sum_{I=1}^{n} Wi}$$

*Equation 2.1 nearest neighbor algorithm*

*Where:*

NN: nearest neighbor

w: is the importance weighting of an attribute,

I and R: are target and source cases respectively

i: represents each attribute from 0 to n,

Sim: is the local similarity function, and

$\boldsymbol{fi^{I}}, \boldsymbol{fi^{R}}$: are the values for attribute i in the input case (I) and a case in the case base (R) respectively. And n: is number of attributes in the case

## 2.6.2. Reuse

After selecting one or several similar cases, the reuse step tries to apply the contained solution information to solve the new problem. Often a direct reuse of a retrieved solution is impossible due to differences between the current and the old problem situation. Then the retrieved solutions have to be modified in

order to fit the new situation. How this adaptation is performed strongly depends on the particular application scenario(Stahl & Roth-Berghofer, 2008). In general, adaptation methods require additional general knowledge about the application domain. Because this leads to additional knowledge acquisition effort, many CBR systems used today do not perform case adaptation automatically, but leave this task to the user. Then, of course, the quality of the retrieval step influences the problem-solving capabilities of the entire CBR system primarily. Even if automatic adaptation is provided, the qualities of the retrieval result will strongly influence the efficiency of the system due to its impact on the required adaptation effort.

### 2.6.3. Revise

Once the solution is designed for the new problem the correctness and how much it is good should be evaluated by different techniques such as by feedback from human experts of the domain area or by applying in actual tasks and see the result, by using simulators and other techniques. After the evaluation result is realized the system learns from the result and it needs to be repaired and corrected for the failures and errors occurred during revision to prevent it from having future such similar problems and failures(Elouni, 2016)

### 2.6.4. Retain

Retain is the final task of CBR approaches and takes place after the newly solved case passes all early cycles successfully. It retains tested case which represents new experience that might be used in the future to solve similar problems. Due to this the knowledge base of the case-based reasoning is upgraded by the new experience as well as problems are solved. The retain process selects useful and worth remembering new experiences and decides

how to mix and integrate with existing knowledge. The new case is added to the case base and this type of learning is known as incremental learning because it always adds knowledge that is new and useful in addition to the existing knowledge(Aamodt, 2014; Gerhana, 2017; Sqalli & Rissland, 2002).

Generally, the new experience gained may be either success or failure and if it is success, the retain process keeps how the problem is solved by modifying existing cases or by creating a new case if it has significant difference with the existing ones(Chan, 2018). Keeping failure processes helps to prevent future similar problems from such similar failure including task failure and expectation failure.

## 2.7. ADVANTAGE OF CASE BASED REASONING

A case-based reasoning approach has wonderful advantages in the development of knowledge-based system. The following are main the advantages of case-based reasoning.

- Ability to express specialized knowledge: - This feature of cases among other advantages circumvents interpretation problems suffered by rules.
- Naturalness of representation: - Cases are a simple knowledge representation method and very comprehensible to the user.
- Modularity: - Each case is a discrete, independent knowledge unit that can be inserted into or removed from the case base without any problem.
- Easy knowledge acquisition: - Knowledge acquisition in case-based representations is not usually a problem, due to the fact that cases are available in most application domains. However, there are domains where they are not.

- Self-updatability: Knowledge in the form of new cases faced during real-time operation can be incorporated into the case base extending the effectiveness of the system. This self-updatability also facilitates the maintenance of the case base.
- Handling unexpected or missing inputs: A case-based system can handle unexpected cases not recorded in the system or missing input values by assessing their similarity to stored cases and reusing relevant cases.

### 2.8. 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(Leeland, 2009)

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

## 2.9. Rule Based Reasoning

Rule-based reasoning is one of the most popular reasoning models used in artificial intelligence. It is the idea of revving knowledge from human experts using a certain rule that goes through a series of cycles. knowledge is stored as if condition then action sentences. In health care system the if condition may be antecedence and then may be the consequence. Therefore, symptoms, causes, laboratory data, image tests and other risk factors are stored on the if condition the disease may be on then actions.

In rule-based reasoning knowledge is represented by rules as follow.

IF Condition…….... THEN Conclusion……...

Where the condition parts of the rule represent the premises formed from facts combined each other by different logical operators such as AND, OR and others whereas the conclusion part represents the corresponding result as a conclusion for the premises. Conclusions are drawn when the condition (IF part) of the rule is become satisfied and the rule is said to be active(Syed-abdullah et al., 2015). As knowledge-based systems, rule-based systems have also the following main components in addition to user interface and explanation facilities:

i. **Working memory**: - is used by the inference engine to get problem description facts and to match them against available rules in the knowledge base.
ii. **Inference engine**: - It is a brain of expert system. It uses the control structure (rule interpreter) and provides methodology for reasoning. It acts as an interpreter which analyzes and processes the rules. It is used to perform the task of matching antecedents from the responses given by the users and firing rules. The major task of inference engine is to trace its way through a forest of rules to arrive at a conclusion.
iii. **Knowledge base:** - The knowledge base consists rules (as a rule base) and facts (as a database) which are necessary for understanding, formulating and for solving problems. It is a warehouse of the domain specific knowledge captured from the human expert via the knowledge acquisition module. To represent the knowledge production rules, frames, logic, semantic net etc. is used.

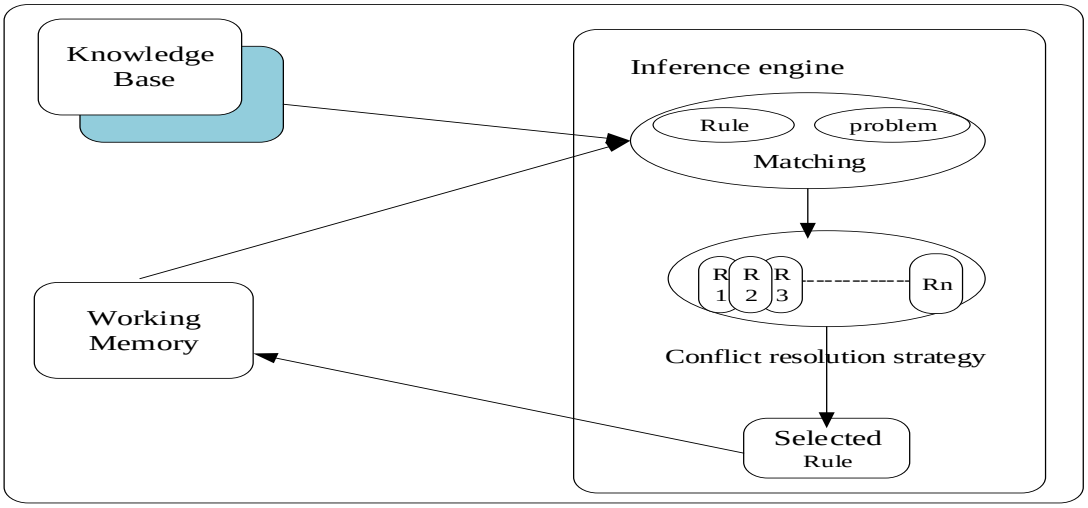



*Figure 2. 3. Rule Based Reasoning*(Pal & Campbell, 1997)

### 2.9.1. ADVANTAGE OF RULE BASED REASONING

Rule based reasoning approach have a number of good features(Bonissone & Analytics, 2016; Pal & Campbell, 2004). 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 grant 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 straight forward manner. This feature of symbolic rules is a direct consequence of their naturalness and modularity.

### 2.9.2. DISADVANTAGE OF RULE BASED REASONING

As rule-based reasoning of prototype knowledge-based system has many advantages. But, it has the following limitations(Kang, 2018).

- Knowledge acquisition bottleneck: 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.

### 2.9.3. RULE BASED REASONING TECHNIQUE

Rule based reasoning technique represents how a system solves a problem by using knowledge of the application domain that is represented in form of rules. There are two rule-based reasoning methods.

#### Forward Chaining

Forward chaining starts with the facts, and sees what rules apply given the facts. In a forward chaining system fact are held in a working memory condition action rules represent actions to take when specified facts occur in working memory. Forward chaining is commonly referred to as data driven reasoning. It is one of several inferential control strategies that use existing or deduced data to trigger future deduction and conclusions about the data(Kapoor & Bahl, 2016). Forward chaining in rule-based system begins by triggering all of the rules whose "if clause" are true. It is then using the facts it has established to determine what additional rules might be executable because their "if clauses" are satisfied. In a forward chaining system, the initial facts are processed first, and keep using the rules to draw new conclusions given those facts.

#### Backward Chaining

This strategy focuses its efforts by only considering rules that are applicable to some particular goal. It is similar with forward chaining in most process, the big difference is it receives the problem description as set of conclusions, instead of conditions, and tries to find the premises or causes of the conclusions(Kapoor & Bahl, 2016). Goal-driven control is variously known as top-down, backward chaining, or consequent reasoning. In this research we use backward chinning reasoning mechanism. A primary virtue of this strategy is that it does not seek

information and does not apply rules that are unrelated to its overall goal(Al-Ajlan, 2015; Kapoor & Bahl, 2016).

## 2.10. Hybrid Knowledge Based System

The advantages and disadvantages of the two reasoning systems and the complementary nature of the reasoning motivate us to combine them. The final aim of artificial intelligence discipline is to develop systems that exhibit human like, or better intelligence(Saraiva, 2015). The combination of two or more different problem solving and knowledge representation methods is a very active research area in AI. Hybrid Intelligent System is a combination of two techniques with more strength and less weakness. Combinations of CBR and RBR have been explored for more effective knowledge representation and problem solving(Khandelwal & Prasad, 2013; Prentzas & Hatzilygeroudis, 2008).

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 and Cases are also 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(Syed-abdullah et al., 2015). Therefore, the hybrid reasoning approach makes use of existing knowledge, rules and the past experiences. This integrated approach eliminates the drawbacks of each method and provides a better way to handle problems(Elouni et al., 2016).

## 2.11. APPROACHES TO EVALUATE THE PERFORMANCE THE INTEGRATED SYSTEM

Both system performance measurement (statistical analysis) and user acceptance are the main methods for evaluation of knowledge-based systems performance(Salem, 2005). The statistical analysis for integrated reasoning KBS can be conducted for both retrieval and reuse process. The first task of any integrated reasoning KBS is to retrieve cases that are relevant to the new case(Roth-berghofer , 2012). As retrieval task of the integrated reasoning KBS aims to retrieve relevant cases from the case base, precision and recall are useful measures of retrieval performance in hybrid reasoning. Recall is defined as the ratio of the number of relevant cases returned to the total number of relevant cases for the new case available in the case base. Whereas precision is the ratio of the number of relevant cases returned to the total numbers of cases retrieved for a given new case(Integration, 2016; Wako, 2017)

$$\text{Recall} = \frac{\text{Number of relevant cases retrieved}}{\text{Number of relevant cases in the case base}}$$

$$\text{Precision} = \frac{\text{Number of relevant cases retrieved}}{\text{Total number of cases retrieved}}$$

Accuracy is also another important measurement to evaluate the hybrid reasoning performance(Elouni, 2016). It is used to measure and evaluate the second hybrid reasoning cycle tasks (reuse task), as the aim of the reuse process in Hybrid. Accuracy is defined as the ratio of the number of correctly diagnosed cases to the total number of tested cases(Roth berghofer 2012).

$$Accuracy = \frac{\text{Number of correctly diagnosied case}}{\text{Total } nuumber\ of\ tested\ case}$$

But, having hybrid performance evaluation based on statistical analysis lonely does not assure the applicability of the designed intelligent system in the real life. Hybrid system that achieves good performance statistically could not be a guarantee for the user acceptance which should be the main concern in the evaluation phase, because the newly designed hybrid prototype may not be comfortable enough by the user's side in solving a particular problem(Saraiva., 2015). As a result of this user acceptance is conducted to assess the applicability of the hybrid intelligent system for the real life.

## 2.12. Related Work

The researcher review different research works which contains the following concepts. Hybrid knowledge-based system, Decision Support System, Knowledge base system, and case based and rule-based reasoning, integration of data mining with knowledge base system, integration of case based and rule-based reasoning.

Alemu(2010) investigated the potential of case-based reasoning in solving complex side effects of HIV/ADIS cases for person living with HIV/ADIS who have begun antiretroviral therapy. He used JCOLIBRI version 1.1 in designing the prototype. He uses ten (10) test cases and the system registers 72% and 63% of recall and precision respectively.

Henok(2011) developed a prototype knowledge-based system using CBR technique for hypertension management. He used 45 hypertension patient cases for building and testing the prototype by using seven (7) test cases from the case base. Henok registered 86.1% recall and 60% average precision.

Alemu (2010) developed a CBR system for adverse drug reaction antiretroviral drug cases consultancy service. For building and testing the prototype Alemu

(2010) used 51 typical adverse drug reactions cases. Using 10 test cases, he achieved average recall and precision 72% and 63% respectively. Alemu (2010) faces different challenges such as extracting features from free text, weighting importance of the extracted features and the adaptation system to be used. To overcome these problems, he designed investigating natural language processing to extract features, using machine learning algorithms for feature weighting and investigating different adaptation techniques.

Generally, almost all researchers who investigated case-based reasoning in different domain area faces similar challenges, since the retrieval algorithms and case representation used are similar. In addition to this most of the local authors as shown in the table 2.1 below recommend that increasing the number of cases are improve the performance of the CBR systems. Therefore, the aim of this study is by using both rules based and case-based reasoning techniques to explore the applicability of Knowledge based system in health domain to improve the decision-making problem and enhance the process of diagnosis and provide appropriate treatment for pregnancy related diseases.

Table 2. 1: Comparison of Related Works

| **Researcher** | **Objective** | **Result** | **Research Gap** | **Recommendation** |
|---|---|---|---|---|
| Henok<br>In Health | To investigate the applicability of CBR approach in development of KBS hypertension management | 86.1% recall<br>60% precision<br>88.9%accuracy<br>79.8% expert's Evaluation | Not self-update the case library Not implemented LeaveOneOutEvaluator and HoldOutEvaluator method | Integration of NLP. Using machine learning for improvement. Integrating other reasoning Approach |

| | | | | |
|---|---|---|---|---|
| Getachew<br>In Health | To develop a prototype of CBR application for anxiety disorder diagnosis. | 71% precision<br>82% recall<br>75.5%Accuracy<br>83.2% experts | It doesn't update the knowledge Not implemented<br>LeaveOneOutEvaluator and<br>HoldOutEvaluator method | Investigate case maintenance technique<br>Ontology based retrieval<br>Hybrid CBR with RBR. |
| Alemu<br>In Health | To explore the potential of CBR in solving complex side effects of HIV/AIDS cases. | 63% precision<br>72% recall<br>73.8% expert's evaluation | measurement<br>Case update /revise are not done.<br>Not done<br>LeaveOneOutEvaluator &<br>HoldOutEvaluator method | Using NLP to generate case structure.<br>To apply machine learning to select relevant attributes.<br>To use other retrieval algorithms.<br>Integrate with other approaches |
| Aster<br>In Health | Develop medical expert system which advices patient physician in malaria diagnosis & treatment Process. | 83% recall<br>83% precision<br>83% F-measure<br>88% expert's Evaluation | The system cannot Learn from experiences.<br><br>Not implemented<br>LeaveOneOutEvaluator and<br>HoldOutEvaluator method | Applying CBR to use available case<br>Add attractive GUI<br>Apply data mining techniques for extracting necessary knowledge.<br>To include capabilities learning from experience.<br>A method to integrate with existing HIS |

# CHAPTER THREE

# RESEARCH DESIGN AND METHODOLOGY

## 3.1. RESEARCH DESIGN

To achieve the stated objectives, design science research approach and methodology is used for this study. The design science research methodology is basically problem-solving paradigm and it has high contribution in the fields of computer science. The intention of design science research is to address important unsolved problems of organizations in unique or innovative ways(Elragal & Haddara, 2019).

Design science researches creates and evaluates artifacts capable of solving institutional problems and it involves a rigorous process in designing artifacts to solve identified organizational problems, to make research contributions, to evaluate the designs and to evaluate the results with the concerned group In the other hand the knowledge base is composed of foundations and methodologies(Laumer & Eckhardt, 2012; Peffers , 2006). Foundations provide theories, outlines, constructs, models, methods and instantiations which could be used in the design phase of design science research. DSR methodology presented here to incorporates principles, practices, and procedures required to carry out such research and meet three objectives. It is consistent with prior literature, it provides a nominal process model for doing DSR, and it provides a mental model for presenting and evaluating DSR in is (Elragal & Haddara, 2019).

## 3.2. Structures of Design Science Research KBS

The figure 3.1 below shows the design science research structure of this study. As shown in the design science research framework the environment defines the study area in which reside the phenomena of interest. For this study the environment is health institutions with its institutional need of technology infrastructure, automations and efficiency of service and other complementary facilities for improved diagnosis mechanisms of pregnancy related Diseases. The design of this medical KBS research work is conducted in design science research paradigm which conducts research through designing and evaluation of KBS for diagnosis related pregnancy Diseases to meet the institutional needs.

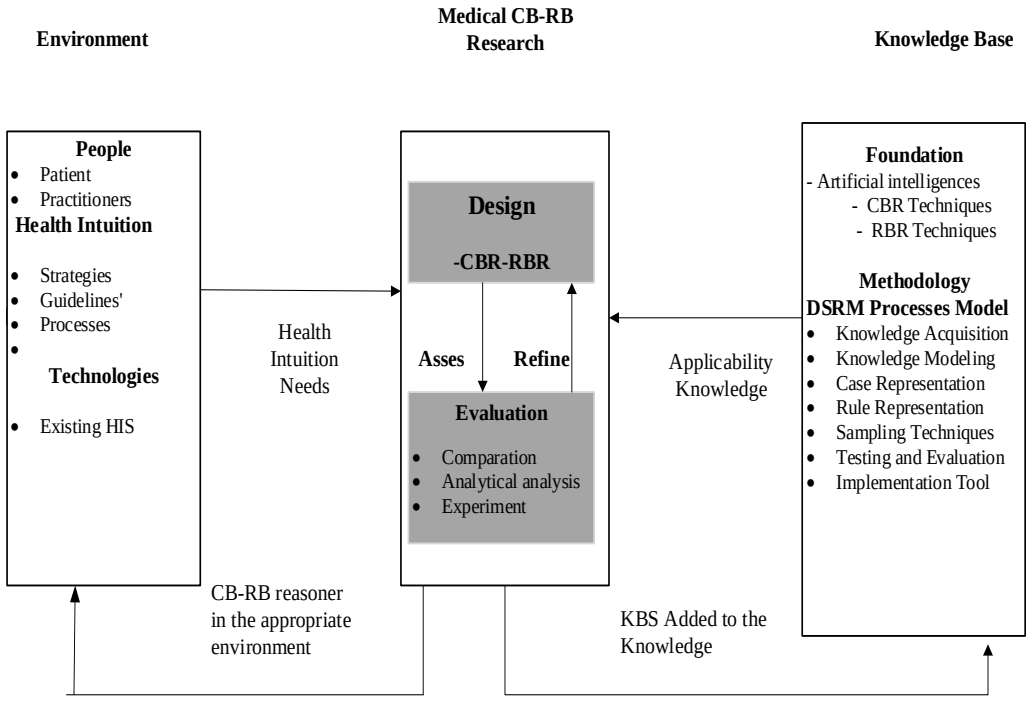



Figure 3. 1 Design science research KBS ((Peffers 2006))

## 3.3. Design Science Research Process Model

Design science research process model offers KBS for successfully conducting design science researches and good DSR are initialized by identifying problems in different domain areas.

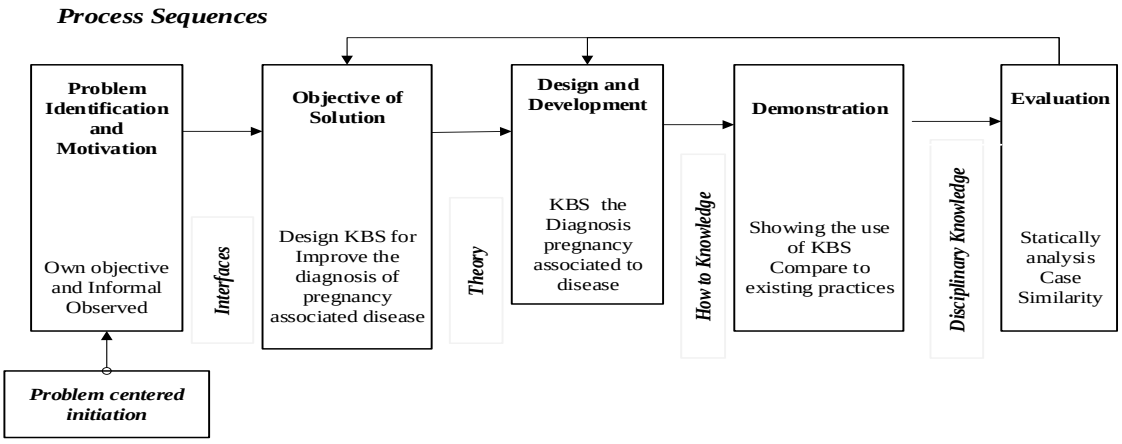



Figure 3. 2 Design Science Research Process Model ((Peffers, 2006)

In the above five main activities are presented in the process model and each activity is described as follow.

**Problem Identification and motivation**: - The first activity is all about identifying the problem and its motivational pressure. Here the problem is identified by the researcher personal Inspires and informal observation from health domain specifically in diagnosis related pregnancy Diseases. Current work experience also motivates the researcher to design KBS that diagnosis pregnancy related diseases. The main problems identified here are mainly the professional's decision-making problem during diagnosis and long queue of patients demanding diagnosis are the top listed problems. These problems make us to find any solutions which could solve the observed problems. As a result of this we are motivated to thinking about Develop knowledge-based system which could facilitate the diagnosing process of pregnancy related Diseases.

**Objective of a Solution: -** The objective of this study is defined as design KBS for diagnosis pregnancy related Diseases by using the most relevant attributes. As objective of a solution for the problem identified, we want to design KBS capable to handle the diagnosis process mainly to support the practitioner's decision-making confidence and to improve the total service.

**Design and Development:** - The third activity is develop an artifact. Here we practically intended an artifact for diagnosis pregnancy related diseases by configuring all tasks and methods with all required components.

**Demonstration: -** In this phase we have tried to see how the designed KBS approaches the pregnancy related diseases diagnosis process by considering the requirements supposed to be performed by the artifact. Demonstrating how the designed artifact solves problem of the domain area in specifically pregnancy related diseases diagnosis is the main task we have here.

**Evaluation: -** Lastly evaluation of the artifact to observe and measure how well the design artifact supports users in the domain area and how much it is effective in the diagnosis task as per the objective's solution is incorporate in this phase of the process. To do this different evaluation techniques such as statistical analysis, case similarity and domain acceptance evaluation are the main methods are used to evaluate the artifact.

## 3.4. Knowledge Acquisition

In knowledge engineering, there are two most important steps that are significant during the development of knowledge-based systems that every knowledge engineer should consider. The first one is acquiring the required knowledge from experts and relevant documents and the second one is representing the acquired knowledge with the appropriate knowledge representation method. Knowledge acquisition (KA) is the process of acquiring

relevant knowledge from some knowledge source in order to construct a knowledge-based system. Essentially, the knowledge acquisition is the technique by which a knowledge engineer obtains information from experts, textbooks, and other authentic sources for ultimate translation into a machine language and knowledge base. On the other hand, it refers computer files and transferring to the knowledge base using knowledge representation techniques used in knowledge-based system(Gudu, 2012).

Knowledge acquisition is the first step and time-consuming task in the development of knowledge-based system. There are certain important steps that the knowledge engineer needs to carry out during knowledge acquisition process. These are (Laumer & Eckhardt, 2012) :

- 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.

In this chapter, the knowledge engineer collects pregnancy related diseases cases and models it by using decision tree structure. The major features concerning to pregnancy related diseases diagnosis and the essential concepts are identified about the diagnosis procedures. These aids to develop the KBS by integrated both rule and Case-based reasoning. The study explores the applicability of rule-based and cased based reasoning in health and medicine particularly for diagnosis and treatment of the disease related with pregnancy. The knowledge for this study is acquired from domain experts by using interviewing and critiquing knowledge elicitation methods and from relevant documents by using documents analysis technique which has been employed to purify the acquired knowledge.

## 3.5. Knowledge acquisition process

The process of knowledge acquisition of the designed research includes some basic activities such as gathering the needed implicit and explicit knowledge about pregnancy related diseases with from different sources, analyzing this knowledge, identifying the important pattern from acquired knowledge (symptoms, sign, risk factors, diagnosis procedures, pain sites and treatments) of pregnancy compilation. Finally, this is incorporated into the knowledge base.

### 3.5.1. Data Collection Method

The study acquires needed knowledge from primary and secondary sources of knowledge. The primary source of knowledge is gathered from domain experts and work in Felege hiwot referral hospital, Ethiopia (Bahir Dar) by using different data collection methods such as structured and unstructured interview, observations (direct attending the working area of the above Health intuition and questionnaires. For these, physicians, gynecology doctors, nurses and the patient have participated in order to get accurate and needed knowledge about the pregnancy related diseases. During this time, we have conducted informal kinds of interviews with domain experts because they are buried in different tasks in the hospital.

Even the interview is continued still getting accurate and needed knowledge for developing knowledge-based decision support system. Six domain experts are purposively selected for the interview. They said, diagnosis of pregnancy related diseases has several steps. First, the experts take the symptom of the pain (history taking from patient). The history of the patient is the first and important step for diagnosis of pregnancy related diseases. The experts take history of the patient using the following types of questions. Second, experts identify the type of pain by physical examination. There are different methods for physical examination.

- Inspection is the thorough or unhurried visualization of the patient. The examiner observes external signs, body features and symmetry appearance of the part of complicated part.
- Palpation: examination with hand, feeling for organs, Masses, or infiltration of a part of the complicated part.
- Percussion: the act or technique of tapping the surface of the complicated part to learn the condition of the parts beneath by the resulting sound and Massage consisting of the striking of abdominal part with light rapid blows called also tapotement.
- Auscultation: listening noise raise from complicated part and specific signs.

Finally, the experts use laboratory results to identify the type of pregnancy related diseases. Ultrasonography, Microscopy and x-ray are the most important test aspects to identify and make decision for urgent Medication for pregnancy related Diseases.

### 3.5.2. Hybrid KBS Development Methodology

In the system development, different researchers us different tools to develop the prototype of the study. The study used to develop the prototype were the integration of rule based and Case-based reasoning approaches. To illustrate this approach, SWI-prolog 7.7.14 and jCOLIBRI also we use to deliver the actual prototype. SWI-prolog 7.7.14 were used for developing fact and rules which were helpful for the diagnosing pregnancy complicated patients whereas jCOLIBRI development tools were used for developing the of HKBS and rule that used to retrieve facts in KB and cases in case library and some activities which is helpful for facilitating decision making using case based, rule based and hybrid approaches as well as activities that control the interaction of the three reasoning approaches.

## 3.6. Conceptual Modeling

The knowledge modeling step involves organizing and structuring of the knowledge gathered during knowledge acquisition. This activity provides an implementation independent specification of the knowledge to be represented in the knowledge base. Knowledge modeling is the concept of representing information and the logic for the purpose of capturing, sharing and processing knowledge to simulate intelligence (Sołtysik-Piorunkiewicz et al., 2014). Conceptual modeling is a crucial step in the knowledge acquisition process so as to understand well the problem domain and to prepare the knowledge representation phase. There are different conceptual modeling techniques and for this study decision tree structure is used to model how pregnancy related diseases diagnosis is performed.

## 3.7. Pregnancy Related Diseases Diagnosis Structure

In our study Cases in Case Based Reasoning includes two main parts which are known as problem description and solution. In this study have both problem description and solution part.

**Problem description:** this is a part of the case structure which contains attributes of Pregnancy related diseases.

**Solution:** this part of case structure justifies the type of pregnancy related diseases and the way of pregnancy related diagnosis and treatment based on the result of problem description part. The identification of attributes which comprises both problem description and solution parts is performed by the researcher with the help of domain experts. All attributes are identified and selected from the patient history but attributes to design the case structure are finally selected by applying information gain approach for attribute selection.

Even though there are a lot of attributes in the record, but only attributes which have high relevancy based on information gain values of attributes in the diagnosis diseases are selected.

The cases that build the case base are collected from patient's history in the case acquisition phase are shaped to the constructed case structure. This stage was too challenging, because all patients of any disease including Pregnancy related diseases history is kept in a single room so it is a difficult task to find the required patient card from these millions of patient card histories. Not only searching is the challenge, but even after the required patient card history there are also other challenges. For instance, some patient card history lacks the treatment and other necessary attributes such as the laboratory result gained due to the carelessness of the physicians. Another difficult challenge here is converting the hard copy contents of the case in to soft copy based on the constructed case structure.

Table 3. 2. Attributes used Diagnosis Pregnancy Related Diseases.

| **Attribute Name** | **Parameter** |
|---|---|
| abdominal pain | Problem Description |
| Sweating | Problem Description |
| Fever | Problem Description |
| Systolic blood pressure | Problem Description |
| Diastolic blood pressure | Problem Description |
| Alcoholic | Problem Description |
| Smoking | Problem Description |
| Fainting | Problem Description |
| Smoking | Problem Description |
| Vomiting | Problem Description |
| Dizziness | Problem Description |

| | |
|---|---|
| Chills | Problem Description |
| Weight loss | Problem Description |
| Shortness of breath | Problem Description |
| irregular heartbeat | Problem Description |
| Cold hands | Problem Description |
| Palpitation | Problem Description |
| abdominal pain | Problem Description |
| Skin rash | Problem Description |
| yellow skin | Problem Description |
| Co illness | Problem Description |
| Darker colored urine | Problem Description |
| No appetite | Problem Description |
| Assessment | Solution |
| Treatment | Solution |
| Explanation | Solution |

The above Table 3.2. shows the main attributes considered in the decision making of pregnancy related diseases diagnosis. Each attribute is defined shortly as follow.

**Abdominal pain:** Abdominal pain is pain that occurs between the chest and pelvic regions. Abdominal pain can be cramp, achy, dull, intermittent or sharp. It's also called a stomachache

**Sweating:** Refers to release of a salt-based fluid from the patient's gland for regulating body temp.

**Fever:** Is the patient's body temperature response to fight infections caused by bacteria, viruses, parasite and others.

**Headache:** it is also referred as the brain ache and occurred due to different factors in the internal body or other related actions of the patient.

**Weakness:** It is the patient status being with weakness, malaise and prostration.

**Vomiting:** Is the patient's body way of purging a contaminated substance when the stomach feels discomfort.

**Myalgia:** It is also known as muscle pain and it is painful feeling in the muscle tissue. It is extremely common in almost all patients.

**Chills:** Refers to a feeling of being cold without an apparent cause. Most of the time; it occurs with a fever and causes shivering or shaking.

**Shiver:** this is patient's body feeling of cold and having shaking.

**Loss of Appetite:** It is patient's sign of decreased appetite including not wanting to eat, unintentional weight loss, and not feeling of hungry.

**Systolic blood pressure:** It is one of critical attribute that helps clinician to identify hypertension. It is the amount of pressure that blood exerts on vessels while the heart is beating. In the patient card, blood pressure of the patient is usually written in the form of A/B, where A represent systolic blood pressure and B represent diastolic blood pressure.

**Diastolic blood pressure**: it is the amount of the pressure in blood vessels between heartbeats (when the heart is resting).

**Fainting:** it is an attribute that show whether the compliant is conscious or not. It is a sign that can be shown when the hypertension patient is at a very higher stage or when the hypertension causes an end organ damaged.

**Smoking**: This attribute that shows whether the compliant is a smoker or not. Smoking is one of the life style (habit) that is considered as risk factor for hypertension. Smokers are highly exposed to hypertension compared to non-smokers.

**Alcoholic**: Like smoking, alcoholic is a life style that is considered as a risk factor for hypertension. From non-alcoholic person, alcoholic persons are prone to hypertension disease.

**Co illness:** this attribute shows whether the compliant has other kind of disease such as diabetics, renal failure or CHF. Co illness is one of a major risk factor that affects the hypertension management.

**Palpitation:** It is an attribute that determine whether the patients have the symptom of palpitation or not. Palpitation is a rapid irregular heartbeat.

**Headache:** It is one of the symptoms is shown in the hypertension patients. This attribute used to determine whether the patient has a headache or not.

**Dizziness:** This attribute used to determine whether the patient has dizziness or not.

**Assessment:** All discussed attribute early in the above are description attributes while this is a solution attribute which states the type of illness types detected on the patient.

**Treatment:** It is also solutions attribute which tells the provided treatment and recommendation for patient's diagnosed for illness

**Recommendation:** The attribute Recommendation is the solution part of the case, and it is the final decision that the physicians make after he/she analyze all the patient profile, life style and risk factors.

# CHAPTER FOUR

## 4.1. KNOWLEDGE BASED SYSTEM DEVELOPMENT

The design and implementation part of this section involves the actual development of a scaled down workable Hybrid knowledge-based system for pregnancy related diseases diagnosis. Therefore, having all the necessary cases and the knowledge from the domain expert and different relevant documents, the next task is coding the knowledge into computer using appropriate and efficient knowledge representation methods. For this research, jCOLIBR 1.1 CBR frame work is used to develop the prototype. The retrieval algorithm used in this research is nearest neighbor retrieval algorithm. This is because jCOLIBRI uses this algorithm for retrieval task. Nearest neighbor retrieval algorithm is also suitable when there are attributes which have numeric or continuous value(Changes, 2008).

## 4.2. Designing the Architecture of HKBS

The architecture of the HKBS system shown in figure 4.1 depicts how the prototype works during pregnancy related diseases diagnosis. As the new query (problem) is entered, the prototype of the system matches the new case to the solved case in the case base of the system by using similarity measurement. If relevant cases are found within the case base, then the prototype rank the relevant retrieved cases based on their global similarity. Next, the prototype proposes a solution. The proposed solution can be derived directly from a retrieved case that matches exactly or partially to the problem of the new case. But, using the proposed solutions directly may have a risk. Therefore, the user of the system should have made an adaptation by altering the differences

between the proposed case and the new case. In addition to adaptation, case inconsistencies are revised if the retrieved case is not the same as the new case. Finally, the revised solution is retained in the case base for future problem solving.

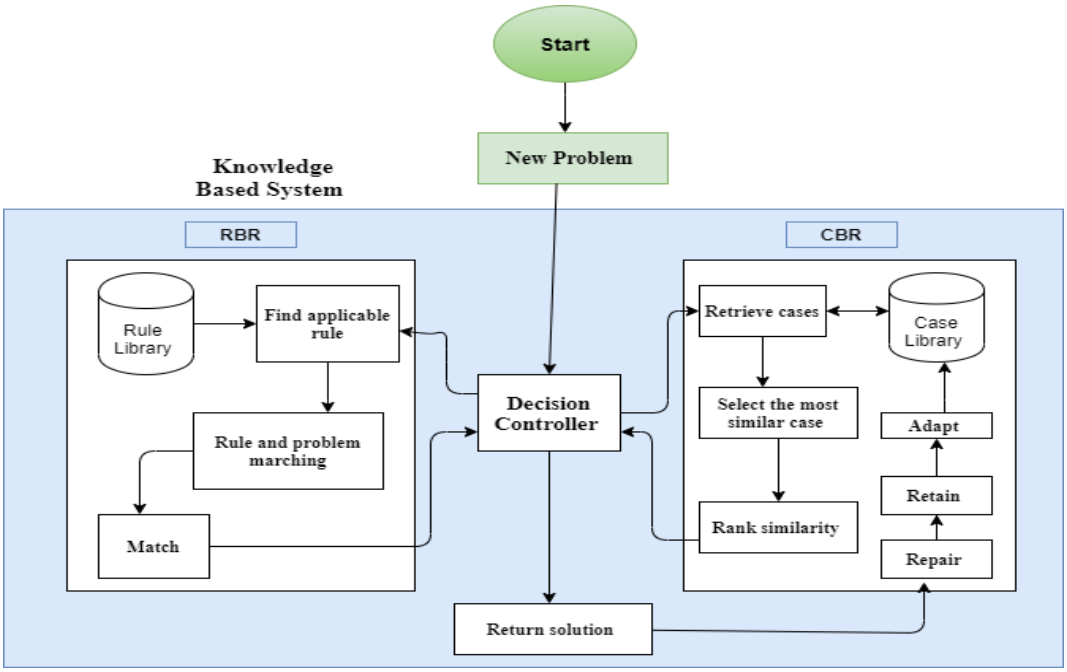



Figure 4.1: HKBS Architecture(Markov, 2003)

## 4.3. Domain Experts Decision Making Approach

Health care has strategic processes to make decisions for a given problem. The processes are starting taking history from the patients. Other investigations such as taking symptoms from the patient, physical examination, laboratory examination are the basic processes for making decisions for a given problem. Physicians can diagnose the patients using rules form their tacit knowledge. The tacit knowledge of the experts is accumulated form past experience of success cases.

The basic problem for experts is accurate diagnosis and taking appropriate decision, because different experts have different tacit and explicit knowledge. Therefore, this study can minimize this problem by sharing knowledge of each expert and by learning previously successes diagnose cases.

This study solves the problems by used integrate case based and rule-based reasoning approaches. The prototype HKBS system for diagnosing patients with pregnancy related diseases in order to provide advice to domain experts and enhance services given to patients.

The rule of clinical diagnosis was explicit knowledge and can be collected from written documents. It is simple to incorporate in to rule-based reasoning approach. However, there was difficulty acquisition of tacit knowledge from domain experts. Therefore, any domain experts can learn their tacit knowledge in Case library by using CBR approach which helps for diagnosing the new coming cases or problems. The physicians identifying the type of pregnancy related diseases by using the symptoms, sign, laboratory investigation, and risk factors of the patient. However, the type of pregnancy related diseases symptoms, sign, and risk-factor are approximately similar and it makes difficult and time taking to diagnose the patients with full confidence.

## 4.4. Decision Making Approaches by KBS

The clinical decision support system passes different process stages in giving a decision to the given problem. The processes include activities starting from collecting of facts form domain experts about the given case to the given determination of final treatment. In healthcare system to have a final decision for specific problem or case, different processes are applied. 1) Rules are created to retrieve the stored facts and compare each other. 2) Knowledge of

domain experts is stored in the fact base and the stored facts of each case of the diseases related pregnancy can be compared.

The rule refers to the applied statement and declaration which is helpful for health sectors to diagnose patients. Rules are applied to healthcare system, how the physicians diagnose the patients. Therefore one of the major tasks KBS, rule comparison for a given problem. Rule comparison refers to the analysis done by collecting the history of the patients and taking another evidence from the patients compare with the knowledge for the physician to give the appropriate decision for a given complication case. The same procedure is applied in the computer assisted KBS. The physician collects the patient's history and other evidences, feed knowledge received from the patients to the computer based on the given knowledge-based system, the system generates the result to the physician which is helpful for decision making to a given problem and recommends how the patient to be treated. In this research we apply hybrid reasoning approach for diagnosis pregnancy related Diseases.

Hybrid reasoning approach is the alternative knowledge representation method to improve decision making performance by experts. To minimize the individual reasoning approaches limitation, hybrid reasoning is best regards for getting good performance of the system. There are three common integrated rule and case-based reasoning approaches. These are rule dominant, case dominant and balanced approach. But in this research we use balanced approach, the main reason to select balances approach two individual reasoning approaches have equal status for problem solving.

## 4.5. Rule Dominant Integrating Approach

This is the way of integrating of rule-based and case-based reasoning in which rule-based reasoning is more applicable and case-based reasoning can be the supportive of rule-based reasoning. The rule-based reasoning can be applied first and then case-based reasoning.

The problem solving is applied for rule-based first, when if the problem is not solved by rule-based reasoning; case-based reasoning is applied as supportive of rule-based reasoning. The picture below shows that physicians or users of the KBS uses the system and first enter sign, symptom, risk factor and lab investigation results through the user interface of the system. Once the necessary data is entered the system checks the entered data to compare it with the stored rules in the knowledge base. By taking the data and comparing it with the given rule in the knowledge base the system calculates the similarity between the given data and the stored rules in the knowledge base. Based on the rule and the input information or data the system provides a diagnosis result for the physicians. If the problem is not solved based on based on the stored rule the system checks some similar cases that have solved before. By comparing the given case with the previously diagnosed similar case the system provides a diagnosis for the required cases. In rule dominant reasoning approach superiority is given for rule-based approach than case-based reasoning approach.

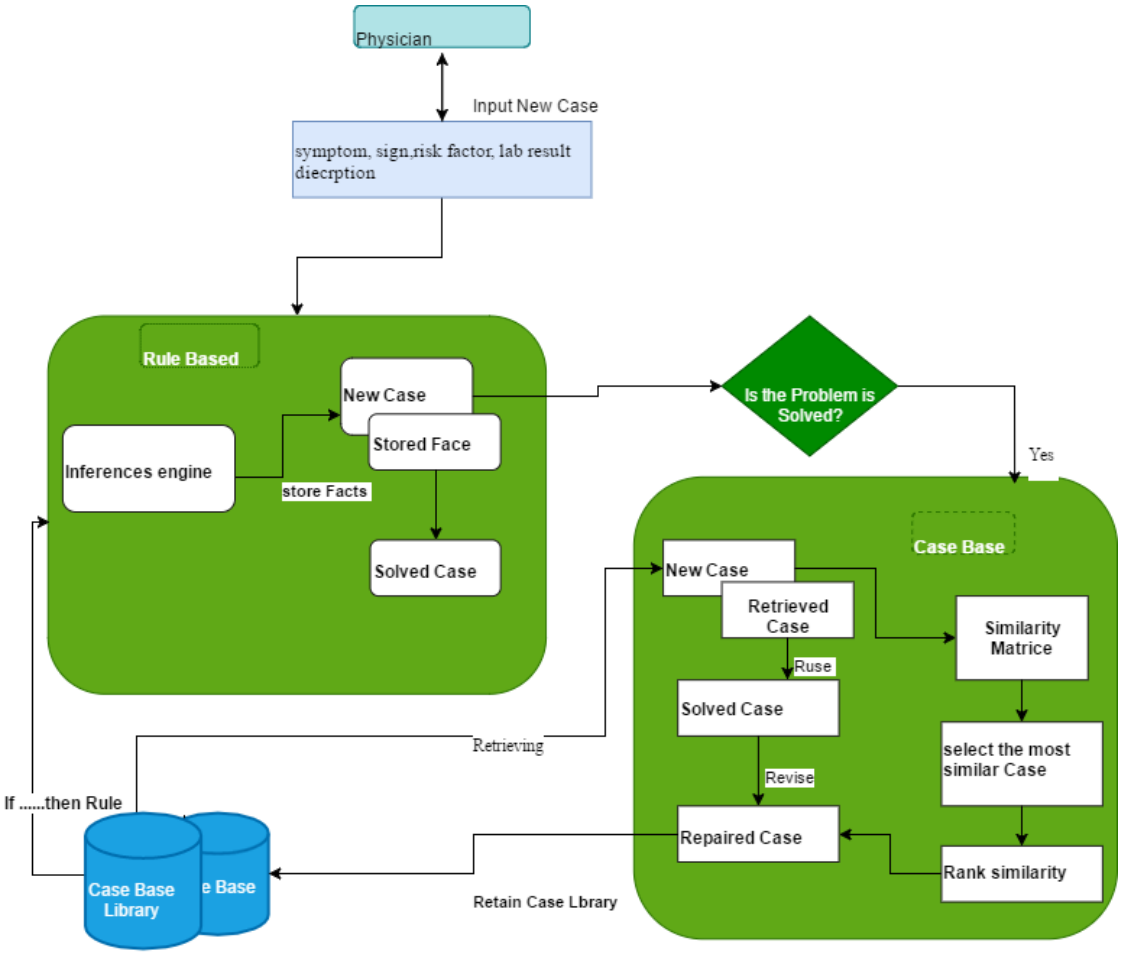



Figure 4. 2. Rule dominant integrating approach (From Alemu -36- )

## 4.6. Case Dominant Integrating Approach

The rule-based reasoning is involved when the case-based reasoning cannot produce the solution in the given problem. Case-based reasoning is dominated to involve for solving a given problem and the rule-based reasoning can solve the problem when if case-based reasoning is not capable of solving a particular problem. Rule-based reasoning is the supporting of case-based reasoning. Case based reasoning depends on collecting the previous experience of a medical

expert knowledge in the form of cases and uses this knowledge for inference. CBR has many advantages for medical diagnosis problems. The stored data, such as symptoms, medical history, physical examinations, lab tests, diagnoses, treatments, and outcomes for each patient, can be used to define the case-base knowledge. This solves the knowledge acquisition bottleneck problems found in the area of artificial intelligence technology. Generally, CBR is a technique for solving a problem by remembering similar past experiences(Chabuk, Prentzas & Hatzilygeroudis, 2003)

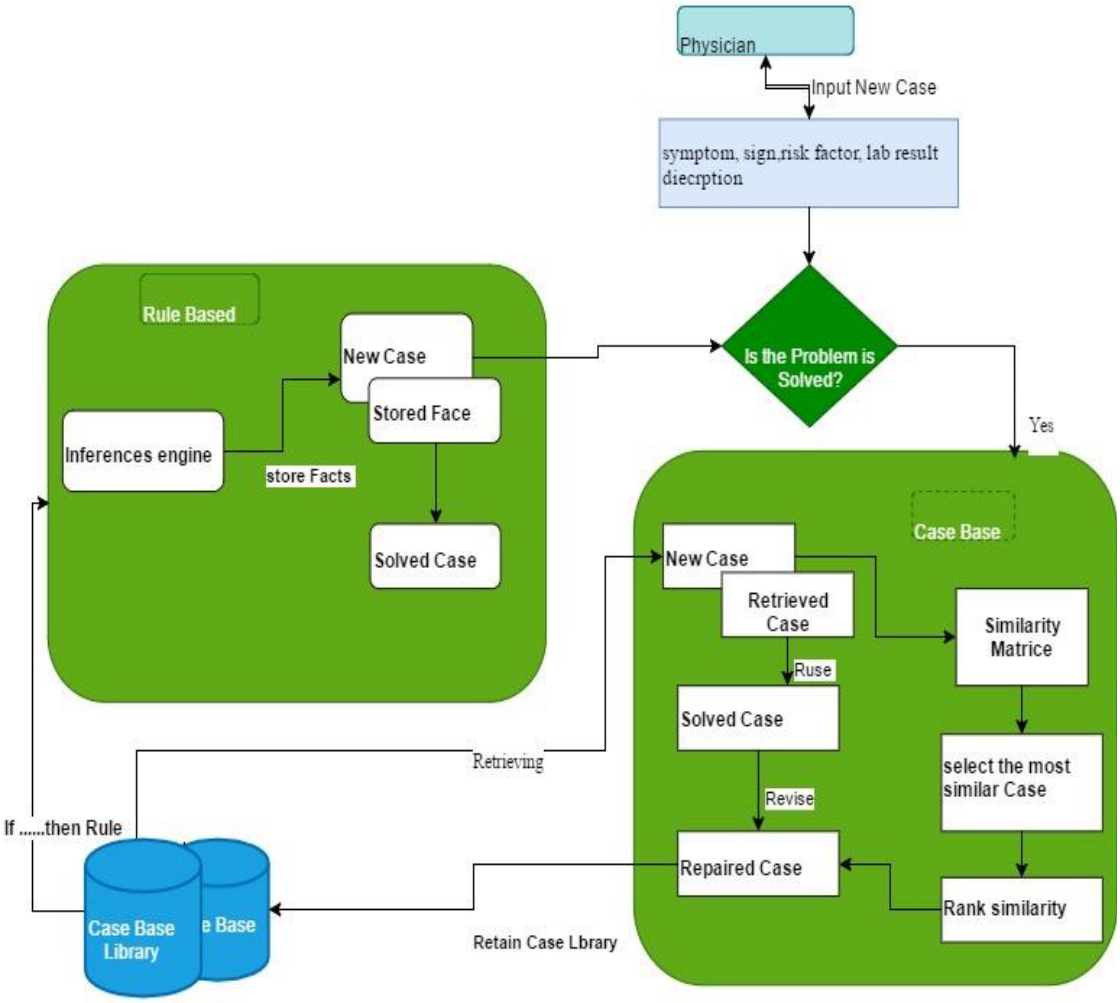



Figure 4. 3. Case dominant integrating approach (From Alemu -37-)

From the above figure by using the user interface the physicians enter sign, symptom, risk factor and lab investigations in to the system. After the data is entered the system checks whether similarity cases are present or not. If there are any similarity cases that have entered before, the data is entered in to the knowledge base. Then by calculating the similarity with stored similar cases the inference engine infers or deduces a diagnosis result for physicians. However, if there are no any similar cases stored in the knowledge base the data is stored into the knowledge base and the inference engine infers some decision by using some standard rules stored in the knowledge base. However, in this case accurate decision results cannot be obtained. From the above statement we can understand that in case-based reasoning approach we cannot access appropriate decision if there are no other similar cases stored in the knowledge base before. This the reason why we choose hybrid reasoning approach is better than case based and rule-based reasoning. In case-based reasoning system if the given case is similar with the stored cases in the database, we can reuse the stored cases for the diagnosis of a given new case. Once the case is solved it is revised and modifies it and finally retains it to store it in the database.

## 4.7. Balanced Approach

This integration of case-based and rule-based reasoning approach, the two-individual reasoning approaches have equal status for problem solving in which each individual reasoning approaches are equally involving to solve the given problem and the final result is the combination of the individual result of rule-based and case-based reasoning's.

From these integrating approaches, balanced integration approach has been selected for the process of designing and developing an integrated approach of rule-based and case-based reasoning for diagnosis pregnancy related diseases, because the two reasoning approaches are equally diagnosing the patient and identify the disease, then the result of the two-reasoning approach be combined in order to verify the result. This approach helps for the diagnosing process for getting the qualified result and enhances the performance of knowledge-based system. Using this reasoning approach hybrid KBS use to diagnosis for pregnancy related diseases. The process of diagnosis patients by using balanced reasoning approach as presented in the architecture can be discussed as follow. By using the systems user interface, the physicians enter sign, symptom, risk factors and lab investigation into the system. Once this information has entered into the system both the rules and other similar cases are accessed and checked to give a decision for the required cases for physicians. In this type of reasoning approach both the facts and cases that are stored in the knowledge base of the system equally accessed and checked against the given cases to be solved by the system. The result that have been accessed from this type of reasoning approach is better than that can accessed by using the other two reasoning approach by using the same patient cases.

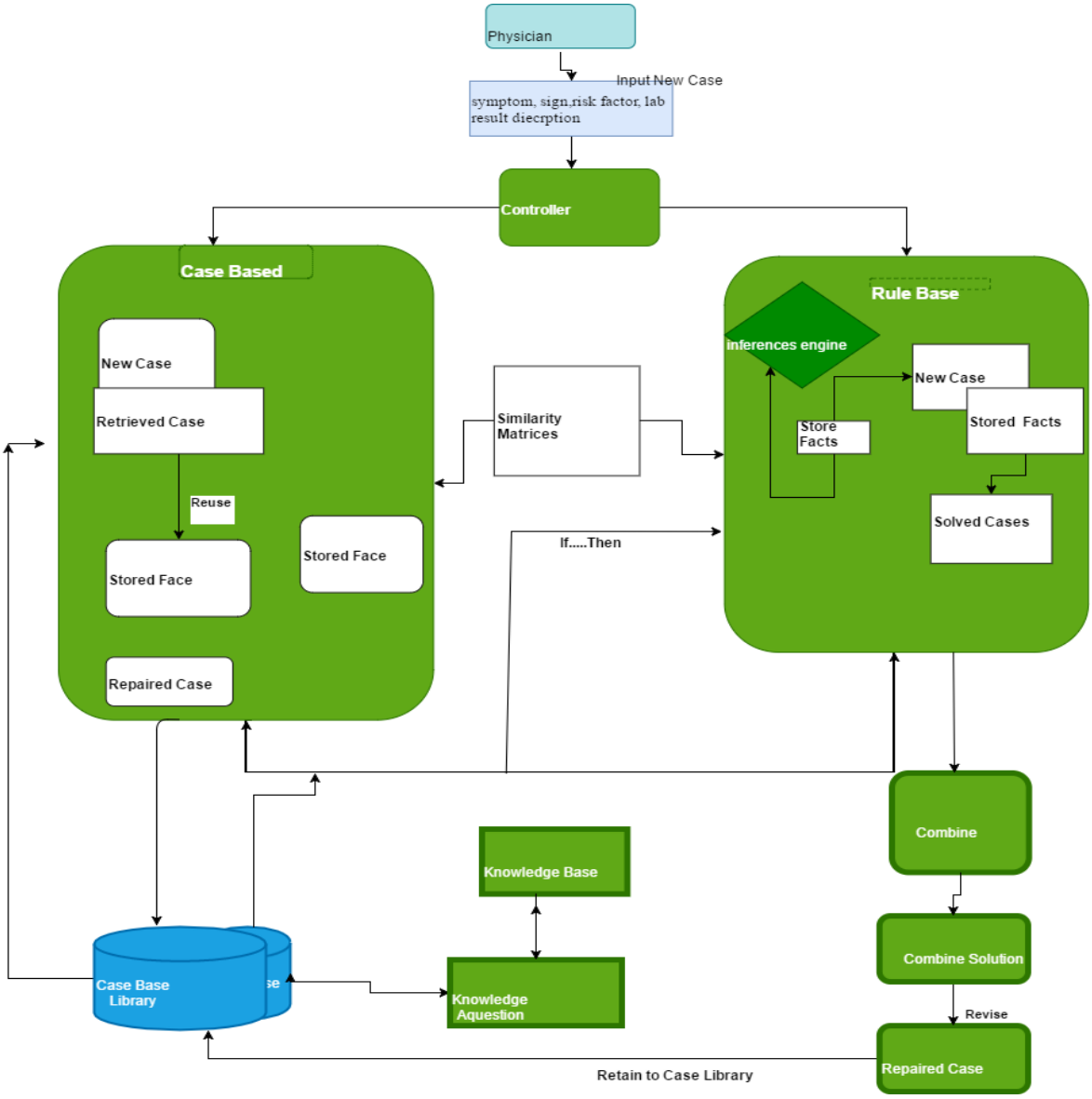



Figure 4. 4. Balanced approach (From Alemu -37-)

From the above conceptual model, two reasoning approaches were applied participated for solving the given problem. According to (Nega & Kumlachew, 2017) Balanced approaches follow a 'mixed' paradigm, where the invocation order of the integrated components is not preset and usually during inference one component dynamically calls the other and vice versa.

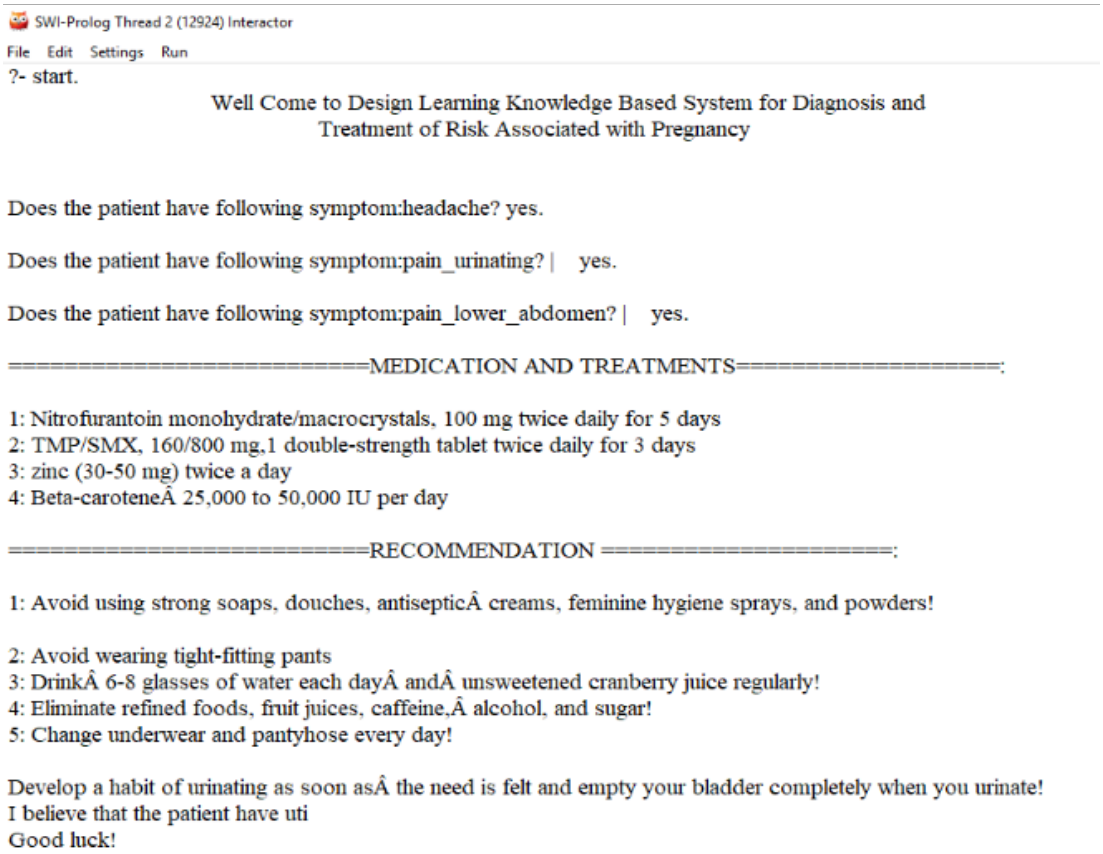
In balanced approach problems are equally distributed to both rule-based and case-based reasoning by using controller. If the problems are presented to the ruled-based interface, the rule retrieves the fact according to the problem and stores it in to the temporary storage. The inference engine is between the rule base and the working memory. The integration of rule-based and case-based reasoning approach have better performance than case based and rule-based reasoning approach. In this research we use balanced approach.

## 4.8. Knowledge Based

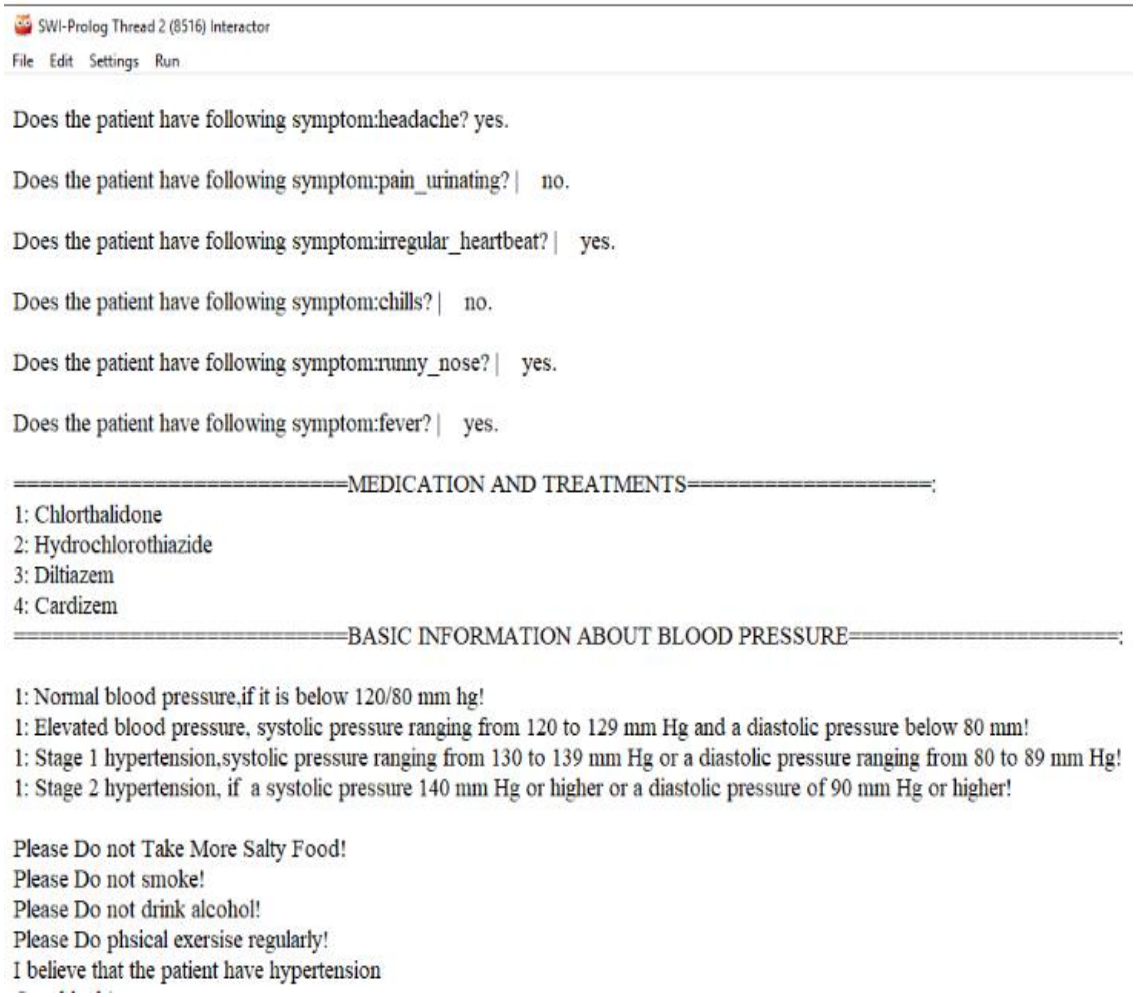
A knowledge base (KB) is a technology used to store complex structured and unstructured information used by a computer system. A knowledge base is a database which used for storing, sharing and management knowledge. It is an organized repository of knowledge in a computer system. The knowledge base stores relevant knowledge's, facts, rules and the relationship of these in the knowledge-based system. The knowledge base incorporates the relevant knowledge which is acquired from domain experts. The knowledge base of the prototype contains the domain knowledge which used to identify causes (diseases) of pregnancy related diseases. On this result the knowledge base is developed by using the integration of SWI-prolog 7.7.14.

## 4.9. Inference Engine

To achieve the goal of the research, inference engine helps to determine the order of testing the knowledge base rule, determine a Boolean (true, false uncertainty factor) application rules, and justifies user process of reasoning and generating the result in quantification form. It works between the rule and the working memory to achieve the goal by searching through knowledge base to find rules whose premises match with the stored facts in the working memory.
The inference engine can calculate the probability of truth value and made decisions accordingly. As a result, the deigned system uses backward chaining inference technique.




Dialog windows between physician and Hybrid KBS




Dialog windows between physician and Hybrid KBS

## 4.10. Diagnosis Pregnancy Related Diseases

The development of a reasonably simple CBR application already involves a number of steps, such as collecting cases and background knowledge, modeling a suitable case representation, defining an accurate similarity measure, implementing retrieval functionality, and implementing user interfaces(Stahl & Roth-Berghofer, 2008).

In this study, the researcher uses the main feature of jCOLIBRI to deliver the actual prototype. As Agudo and González (2008) presented jCOLIBRI has been constructed as a core module to offer the basic functionality for developing CBR application. Implementing a CBR application from scratch remains a time consuming software engineering process and requires a lot of specific experience beyond pure programming skills (Stahl & Roth-Berghofer, 2008). Therefore, using jCOLIBRI hybrid approach minimizes the effort to develop an application by using other programming languages. Figure 4.6 shown to run jCOLIBRI for the first time, and it becomes ready for usage.


Figure 4. 5. Depicts the Main Window of jCOLIBRI

### 4.10.1. Building Knowledge Based

Collecting pregnancy related diseases patient cases from hospitals to build the respective Knowledge base and representing the Case by using appropriate knowledge representation method is one from the specific objectives of this study. The acquired Knowledge used to build hybrid KBS for pregnancy related diseases diagnosis, and offering decision support to Gynecologists, Midwife's, nurses and other first line health professionals. All the acquired cases are stored as plaintext file in a feature-value representation format. An easy way of case representation and good integration with nearest neighbor retrieval algorithm are the main reasons to select feature-value case representation for this research(M. Salem, 2005). Therefore, the case representation is given as a plaintext feature-value representation consisting of N columns representing case attributes (A1, A2, A3... AN) And each M row representing individual cases C ({C1, C2, C3... CM}). each attribute has a sequence of possible k values related to each column attribute A= {V1, V2, V3... Vk}.

### 4.10.2. Managing/Defining the Case Structure in jCOLIBRI

The acquired Knowledge's are saved in plaintext file format. Case attributes are abdominal pain, Sweating, Fever, Systolic blood pressure, Chest pain, Fainting, Vomiting, Breathlessness, Decreolization, Dizziness, Diastolic blood pressure, Being easily fatigue, Muscle tension, irregular heartbeat, Irritability, Cold hands, Palpitation, Skin rash, Loss of Interest, yellow skin, Loss of weight, Headache, Darker colored urine, Bloody during urine, Restlessness, Class and Recommended Treatment are the important attributes chosen from all attributes.

These attributes have significant impact on pregnancy related diseases diagnosis. Most of the case attributes have Boolean data type and a few attributes have string data type. Only age has integer data type. The reason for the use of Boolean data type for most of the attributes is, during the diagnosis of pregnancy related diseases the physician simply checks the absence and presence of the symptoms with respect to the significance of the attribute for her/his decision. Even the local similarity of all attributes which Boolean data type is equal and only is age has interval. Global similarity of solution attributes is average.

Table 4. 1 Depicts Case Description

| **Attribute name** | **Data type** | **Weight** | **Local similarity** |
|---|---|---|---|
| abdominal pain | Boolean | 1.0 | Equal |
| Sweating | Boolean | 0.9 | Equal |
| Fever | Boolean | 0.8 | Equal |
| Headache | Boolean | 0.7 | Equal |
| Weakness | Boolean | 0.9 | Equal |
| Vomiting | Boolean | 0.8 | Equal |
| Dizziness | Boolean | 0.8 | Equal |
| Chills | Boolean | 0.9 | Equal |
| Weight loss | Boolean | 0.8 | Equal |
| Shortness of breath | Boolean | 0.6 | Equal |
| irregular heartbeat | Boolean | 0.6 | Equal |
| Cold hands | Boolean | 0.9 | Equal |
| Skin rash | Boolean | 0.7 | Equal |
| yellow skin | Boolean | 0.8 | Equal |
| Darker colored urine | Boolean | 0.8 | Equal |
| No appetite | Boolean | 0.7 | Equal |
| **Solution Attributes** | | | |
| Assessment | Boolean | 1.0 | Equal |
| Treatment | Boolean | 1.0 | MaxString |
| Explanation | Boolean | 1.0 | MaxString |

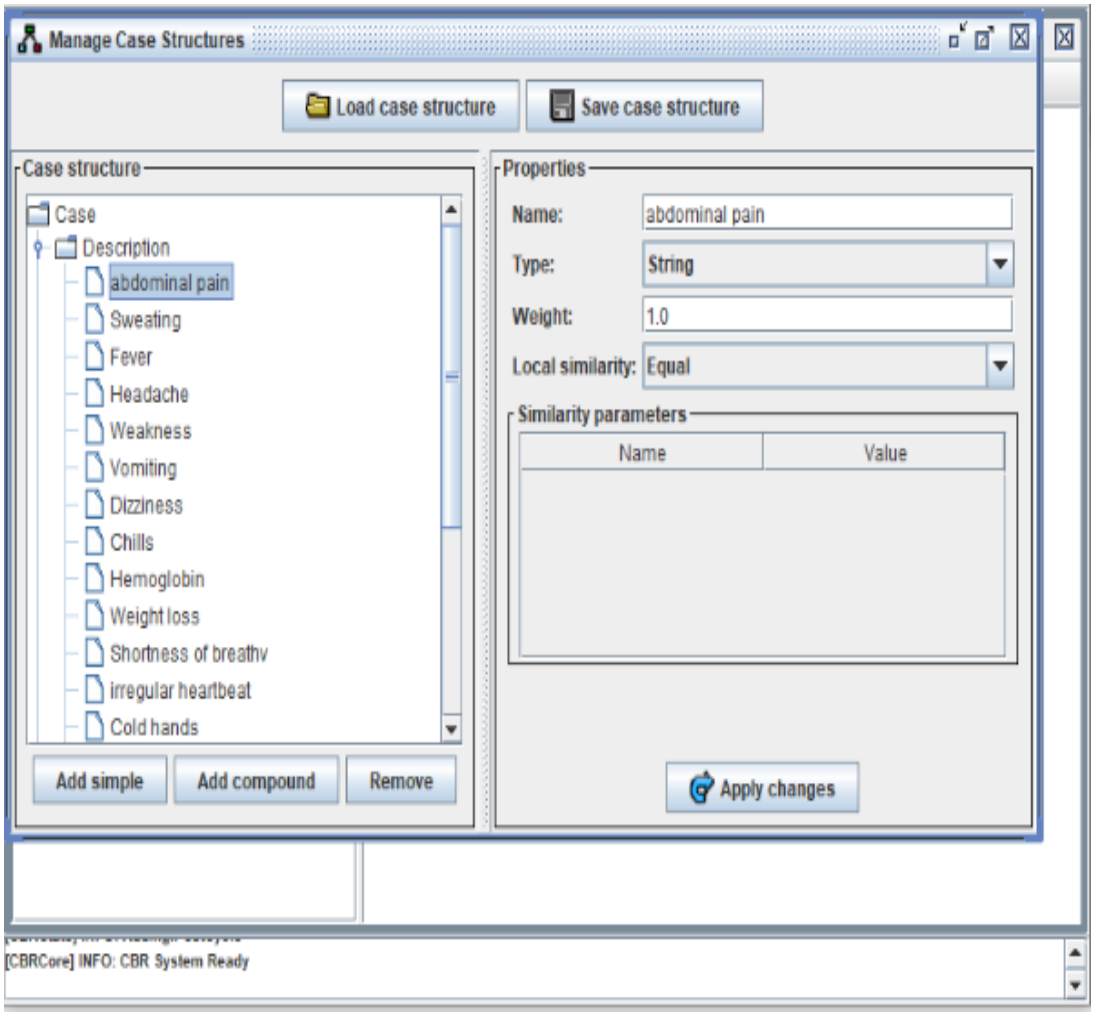



Figure 4. 6. Configurations of Case Structure and Similarities

### 4.10.3. Managing Connectors

After the configuration of case structure, the stored cases must be accessed efficiently by the case-based reasoning in the jCOLIBRI. Connectors (with Plain text file) are persistence of cases which are built around the concept of connector representing objects or attributes which know how to access and retrieve cases from and to the case base and case-based reasoning in jCOLIBRI.

Therefore, connectors provide an abstraction mechanism that allows the developer to load cases from case base sources in an easy way.

For the prototype, implementation the researcher used plaintext connector because the required cases are stored in plaintext file format. Plaintext file case base connector is used for persistence of cases. In this connector, the researcher has to specify the path of case structure and also path of text file. All the attributes of a case should be mapped. This is connector's responsibility to retrieve data from case base and return it back to GUI. Like that of case structure, connector is also saved in xml format.

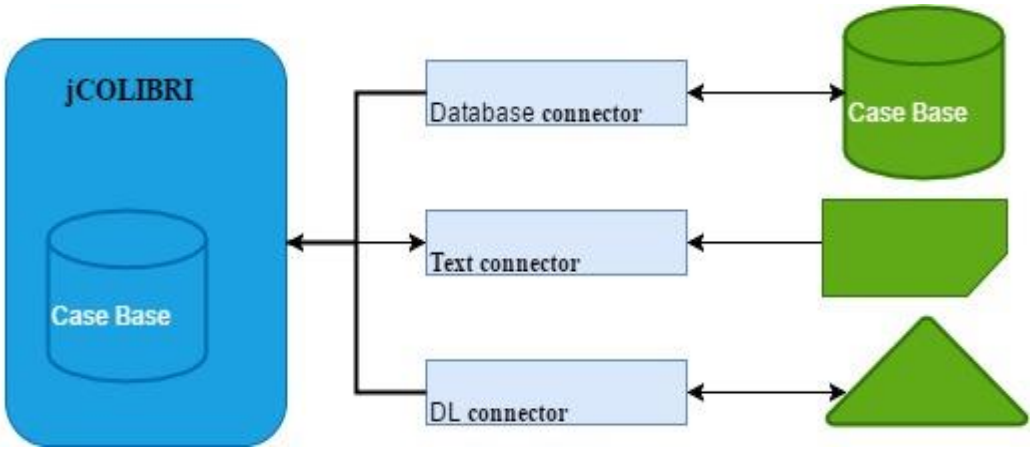



Figure 4. 7. Managing Connecter

### 4.10.4. Managing Tasks

For the development of Hybrid intelligent KBS prototype, the researcher used core package tasks. The main reason of the researcher to select core package of the jCOLIBRI for this study is that all classes which represent the core functionality of CBR (case base, similarity functions and retrieval algorithm) are available on it. Several core packages are available in jCOLIBRI, whereas PreCycle, main CBR and PostCycle are the main components of core packages used in the designing of CBR for pregnancy related diseases diagnosis.

The main tasks and activities of these core components are discussed in detail as follow.

**PreCycle task:** Loading the cases from storage sources of the case base is the main activity of this component of core package. Here defining the path of the connector on the sub task of the PreCycle called Obtain Cases Task is mandatory to load cases from the case base. Obtaining case task is the only sub task of PreCycle task which is used to retrieve stored case from the case base before the execution of the next component of core package called main CBR cycle.

**Main CBR Cycle:** is the main task of CBR cycle and it also has sub tasks. The developer has to give path of case structure in it. It knows number of case attributes that are available. It is called obtain query task. In addition to obtain query task, there are other significant tasks under the main CBR cycle. These are retrieve tasks, reuse tasks, revise task and retain tasks.

- **Retrieve tasks used to retrieve case(s)** from the stored case base. Retrieve tasks also decomposed in to different subtasks. The subtasks include select working cases task, compute similarity task and select the best case. Select working case task selects cases from case base and stores them into current context. Compute similarity task compute similarity of the stored cases with the case entered by the user using the query window. Select best case shows the best matched of case(s) after computing the similarity of stored cases against the new case. It means that the number of best matched case(s) is shown to the user depending on the method used and the threshold.
- **Reuse tasks** enable to reuse previously stored cases. It has three subtasks. These subtasks are: prepare cases for adaptation task, atomic reuse task reuse task. Prepare cases for adaptation task select cases from case base and stores them into context. Here also specifying the path of

case structure in this method is needed. Atomic reuse task should be resolved by reuse resolution method.

- **Revise task** is the evaluation stage about the selected solution in reuse phase. After selecting the most similar cases from the retrieved results, the solution for the problem should be confirmed and validated before the solution is stored for future use.
- **Retain tasks** also used to CBR case retention on a persistence layer. It has also its own subtasks like select cases to store task and store cases task. Select cases to store task give authentication to the user for storing case. The store cases task enables to store case(s) into the case base.

**PostCycle Task:** is executed at the end of main CBR cycle and its main task is to terminate the connection between GUI and case base. It has only subtask called close connectors task which is purposely used to close the database server and the connector

### 4.10.5. Managing Methods

The following are lists of methods which are used to solve tasks for this HKBS application.

1. **Load Case Base Method:** This method returns the whole available cases from the case base to designer. This method use connector to retrieve case base.
2. **Config Query Method:** This method resolves obtain query task By receiving case structure as input parameters, it displays a GUI window so that user can enter query to retrieve cases from the case base.
3. **Select All Method:** This method allows displaying all the available cases from the case base to the result window.

4. **Select Some Method:** This method resolves to select best task by choosing the ‘n’ most high similarity value from the returned cases. It requests the number of cases to give as input get best match with the requested input**.**
5. **Numeri Similarity Computational Method**: this is used to calculate similarity between the query and cases that are stored in the case base.
6. **Numeric Proportion Method:** it is the sub method of reuse task which involve in computing numeric proportion between the description attributes and solution attributes.
7. **Manual Revision Method:** This method helps users to modify the case whenever changing the case is needed at task of revise phase.
8. **Retain Chooser Method:** Finally, this method enables the user to choose the method which store in the case base. User can choose this method when he/she want to store in case base. So, to store in case base user have to choose this method.

In general, these are some of the methods discussed and used for this research. But there are many other methods available in jCOLIBRI method library. It is the task of the knowledge engineer to choose the most appropriate method during designing CBR application. Figure 4.6 shows the configuration of tasks and methods. In the configuration window depicted in figure 4.6 the left side shows the tasks and subtask and the right side shows the methods.

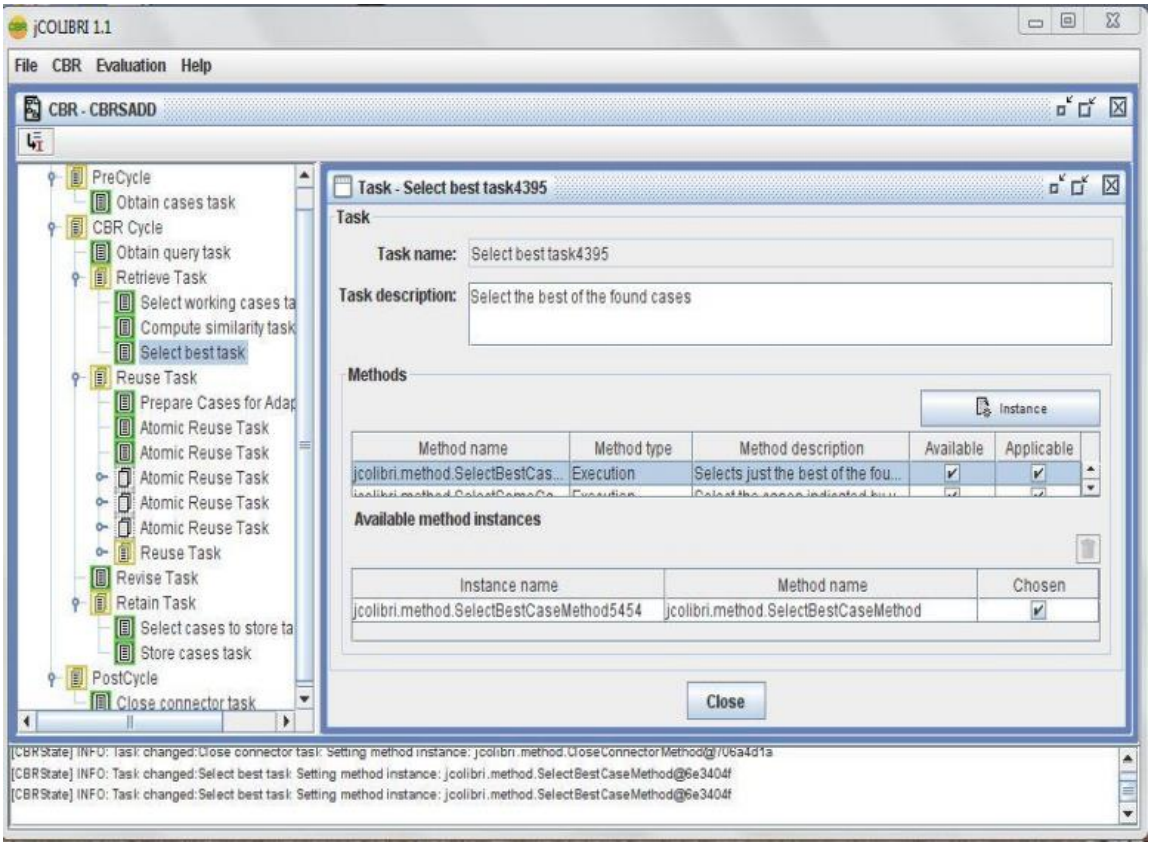



Figure 4. 8. Tasks and Methods Configuration

## 4.11. Hybrid Reasoning Based Reasoning

This study concerned with the combination of RBR and CBR in a Hybrid intelligent knowledge-based system to diagnosis pregnancy related diseases. Once hybrid reasoning approach is constructed, an experiment is made to decide the order of using them for diagnosis purposes(Topol, 2019; Yared Agizew, 2019). Individual reasoning approaches have their own limitations to develop the knowledge-based system to solve a particular problem as discussed in the above. Therefore, Hybrid approach can minimize the drawback of single reasoning in designing and developed knowledge-based system. The integration

of rule-based and case-based reasoning has better performance than each of rule-based and case-based reasoning.

Rule based and case-based reasoning approaches have done their task, integrating the two reasoning approaches was going to be done to get a good performance of prototype system. There is also a controller, which observes the task or operation of the whole system and each reasoner separately. The controller assigns tasks to each reasoner. The result of each co-reasoner is temporarily stored in the case library which helps for integrating the two co-reasoners. Therefore, integrating the two reasoning approaches increase the efficiency and accuracy of diagnosed process of diseases.

# CHAPTER FIVE

## 5.1. TESTING AND PERFORMANCE EVALUATION

After Designing and implementing hybrid knowledge-based system the next step is testing the performance of the system whether is achieve the objective or not. The design prototype system is tested and evaluated based on the objective of the Study. This is to measure the accuracy of the system during the diagnosing processes. Measurement indicates that whether the prototype achieved its objective or not. In this research the performance of the prototype is measured. The user acceptance of the system is carried out during system user interaction. Therefore, in this study testing and evaluation of the designed prototype system has two aspects. These are system performance testing, and user acceptance testing.

## 5.2. Retrieval Cycle Performance Testing

Performance of the hybrid prototype system is evaluated by preparing test cases. This retrieval of relevant cases allows users to understand new cases and to manage it by taking a lesson from the retrieval of solved relevant cases. In this study the retrieval process is performed by using Nearest Neighbor retrieval algorithm. Therefore, jCOLIBRI uses the nearest neighbor algorithm as a cases retrieval technique(Gweon ,2019). Nearest neighbor algorithm used to measure the similarity between the stored and the new queries, and return the search results within their ranked order. Good and effective retrieval performance increases its accuracy. We use Precision and recall to analysis and measures to

evaluate retrieval performance and effectiveness of this prototype system. Precision indicates that the ability of the designed prototype system to retrieve more relevant cases to a given query beside the specified threshold similarity boundary. Recall also indicate that the ability of the prototype system to retrieve all relevant cases to the current new problem.

*Table 5. 1 Sample test cases and their relative cases assigned by domain experts.*

| Test cases | Identified relevant cases from the case base |
|---|---|
| Case29 | Case30, Case3, Case46, Case21, Case56, Case21, Case50, Case4 |
| Case31 | Case5, Case72, Case23, Case63, Case26, Case1, Case33, Case67, Case41, Case22 Case69, |
| Case32 | Case10, Case24, Case14, Case13, Case17, Case54, Case 71 |
| Case33 | Case19, Case9, Case23, Case61, Case18, |
| Case34 | Case28, Case76, Case 43, Case27 |
| Case35 | Case79, Case12, Case11, Case6, Case25 Case16, Case45, |
| Case36 | Case7, Case37, Case4, Case53, Case51, Case41, , Case14, |
| Case38 | Case38, Case29, Case 80, Case58, Case49, Case31, |
| Case42 | Case77, Case52, Case40, Case15, Case73, |

Even though, there is no standard threshold interval stated for the degree of similarity in retrieving cases for any case-based reasoning exhibition, different threshold intervals have been used by different researchers for their case similarity. Some researchers use threshold interval of [1.0, 0.8). This implies that any case from the case base scored global similarity of 80% and greater than 80% with the queries are retrieved. As the threshold level closes to 1.0 the value of precision increase and the value of recall decreases, whereas the value of precision decrease and recall increases as threshold level goes far away from 1.0.

Different threshold level case similarity is tested for this study such as [1.0, 0.5), [1.0, 0.6), [1.0, 0.7), [1.0, 0.8) and [1.0, 0.9) to be selected and used. When the highest threshold level ([1.0, 0.9)) is tested the precision is much better than the lower threshold level ([1.0, 0.5)) whereas the recall value is very low and the reverse is true as the lower threshold level is tested. Little reduction on precision also observed while [1.0, 0.6) and [1.0, 0.7) are tested. The threshold level case similarity [1.0, 0.8) obtains an average precision and recall when it is tested in its turn. After all selected threshold level case similarities are tested and analyzed by the researcher [1.0, 0.8) threshold level is used for this study.

Finally, with the threshold value of [1.0,0.8) and leave-one-out cross validation testing proportion an experiment could be conducted for the whole cases to measure precision and recall performance of the prototype system. But, due to time limitation only nine test cases are selected and confusion matrix is used to visualize the precision and recall measures. Precision represents the proportion of relevant retrieved cases to all retrieved cases while recall represents the proportion of relevant retrieved cases to all relevant case in the case base and these can be obtained as;

$$Recall = \frac{\text{Number of relavant case retraived}}{\text{Total } nuumber\ of\ relevant\ cases}$$

$$Precision = \frac{Number \text{ of relavant case retraived}}{\text{Total } nuumber\ of\ case\ \ relevanted}$$

Table 5. 2 Recall and Precision Calculated

| Test Case | Retrieval performance measure | | | | |
|---|---|---|---|---|---|
| | Total number of relevant cases | Relevant cases retrieved | Total number of retrieved cases | Recall | Precision |
| Case29 | 8 | 7 | 8 | 0.88 | 0.88 |
| Case31 | 11 | 11 | 12 | 1.0 | 0.92 |
| Case32 | 7 | 6 | 8 | 0.86 | 0.75 |
| Case33 | 4 | 3 | 6 | 0.75 | 0.5 |
| Case34 | 5 | 5 | 6 | 1.0 | 0.83 |
| Case35 | 7 | 6 | 10 | 0.86 | 0.6 |
| Case36 | 7 | 5 | 8 | 0.71 | 0.63 |
| Case38 | 6 | 6 | 7 | 1.0 | 0.86 |
| Case42 | 5 | 4 | 8 | 0.80 | 0.5 |
| **Total** | **60** | **53** | **73** | **0.87** | **0.72** |

The above Table 5.2 shows in the above both precision and recall scored above average (87%) and 72% respectively, which is also promising result.

## 5.3. Evaluation of Reuse cycle

In our study Hybrid Knowledge based system approach; after the relevant cases are retrieved to the current query at retrieval phase the next task is reusing the solution of the best selected case to solve the new problem or case. The first and most objective of reuse cycle is driving old solutions to the new problem (case) and solving it correctly. To evaluate reuse performance of this study an accuracy measurement is undertaken. Accuracy is the proportion of number of correctly solved cases to the total number of tested cases. To do this testing proportion is conducted by the researcher for 80 cases experimentation and an exciting accuracy is registered which is hopeful result as shown in the table below.

*Table 5. 3 Reuse cycle accuracy value*

| Total Leaveoneout testing experiment taken | Correctly diagnosed cases | Incorrectly diagnosed Cases | Accuracy |
|---|---|---|---|
| 80 | 71 | 9 | 88.75% |

### 5.3.1. Testing Average Case Similarity

Average similarity of cases is performed using the method LeaveOneOutEvaluator and HoldOutEvaluator. LeaveOneOutEvaluator evaluation method takes all the cases as queries. It executes so many cycles as cases in the case base. In each cycle one case is used as a query. Hence, using this method the average similarity of cases in the case base is 77% as described in the Figure 5.1 below.


Figure 5. 1 : LeaveOneOutEvaluator

Average similarity of cases using HoldOutEvaluator achieved a better result compared to LeaveOneOutEvaluator. This method splits the case base in two sets: one used for testing where each case is used as a query, and another that acts as a normal case base. This process is performed several times. In this experiment nine test cases are used from the case base and achieved average similarity of around 95% as shown.

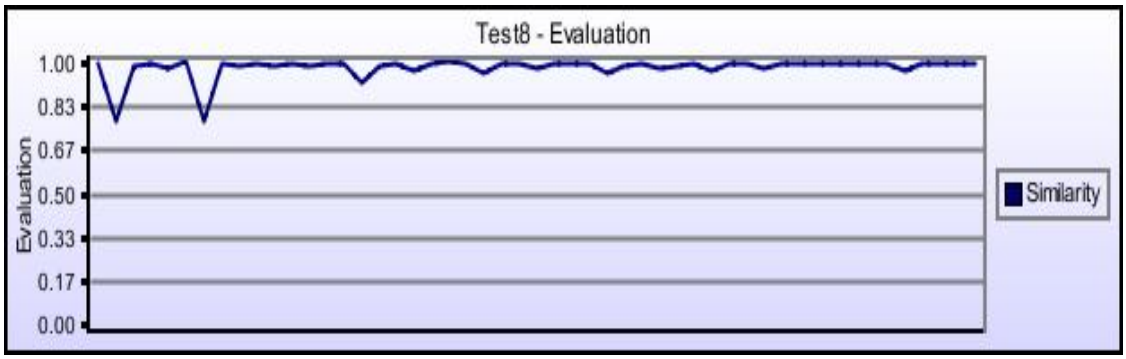



Figure 5. 2: HoldOutEvaluator

### 5.3.2. User Acceptance Testing

The aim of undertaking user acceptance testing is that to make sure how well combined KBS is performing on the eyes of users so as to make sure that the system is accepted and usable by users. Six domain experts are selected to test the system by responding a series of questions. These experts are taken from Felege Hiwot Referral Hospital staff members. After providing training the experts, how combined KBS works, are given test cases to use and evaluate the system. Every domain expert evaluator offers various patients history test to the prototype system and search decisions made by the prototype system. The evaluators assess the accuracy of the prototype system by using the following standards, these are:- simplicity of use and interact with the prototype system, attractiveness of the prototype system, efficiency in time, the accuracy of the prototype system in reaching a decision to identify the types of disease, including adequate knowledge in the prototype system, the ability of the prototype system in making the right conclusions and recommendations, the ability of the prototype system to remember the patients history, and the importance of the prototype system in the domain area. The researcher fixed values for each attributes of the questionnaire for the purpose of evaluating the performance of the prototype system on the side of the end users. The values for all attributes are fixed as: Excellent = 5, Very good = 4, Good = 3, Fair = 2

and Poor = 1. This allows the domain experts to put their values for each criteria of evaluation. The following table 5.3 illustrates the outcomes achieved after evaluation by domain experts.

Table 5. 4 Performance Evaluation by Domain Experts

| **Evaluation Criteria** | **Poor** | **Fair** | **Good** | **V.good** | **Excellent** | **Average** |
|---|---|---|---|---|---|---|
| Simplicity to use and interact with the prototype system | 0 | 0 | 1 | 1 | 3 | 4.4 |
| Attractiveness of the prototype system | 0 | 0 | 3 | 1 | 1 | 3.6 |
| Efficiency in time | 0 | 0 | 0 | 0 | 5 | 5 |
| The accuracy of the prototype system in reaching a decision to identify the problem | 0 | 0 | 2 | 3 | 1 | 4.6 |
| The ability of the prototype system in making right conclusions and recommendations | 0 | 0 | 1 | 2 | 2 | 4.2 |
| Importance of the prototype system in the domain area | 0 | 0 | | 2 | 3 | 4.6 |
| **Average** | | | | | | **4.4** |

As we can see from the above table, most (60%) of the evaluators replied excellent, good, and very good 20% each for **simplicity to use and interact with the system.** It is because of the interface developed by java and simple to use or operate.

**For the attractiveness of the system**, 60% of respondents replied Good and the same percentage, 20% Very Good and Excellent for it. With regard to **Efficiency in time** 100% of evaluators replied excellent.

Concerning the **accuracy of the system in reaching a decision to pregnancy related diseases,** 40% of evaluators scored Good, 60% of evaluator scored very good and 20% of them as excellent. The ability of the system to make right conclusions and recommendation achieves 40% Very good and 40% excellent.

According to the evaluation filled by domain experts, Hybrid Knowledge based system has registered 88% user acceptance. This can be taken as a very good achievement. Generally, in this research the combination of CBR and RBR was took place by using a java eclipse interface to come together the two reasoning's. From the result of the hybrid KBS, we have seen that the performance of the diagnosis capability of the system is much better than the CBR and RBR independently.

As per the hypothesis and experimental result of this research, the combination of RBR and CBR perform better decision and result for pregnancy related diseases diagnosis. The result of case based reasoning experiment that performs 84%. On the other hand, the report of the result of rule based reasoning system for diagnosis pregnancy related diseases has scored 80.5% overall performance. The following table shows the comparison.

| **Reasoning System** | **%Performances** | **Difference with Hybrid System** |
|---|---|---|
| CBR | 84% | 4.75% |
| RBR | 80.5% | 8.25% |
| Hybrid system | 88.75% | |

Table 5.5. The comparison of the performance of reasoning systems

As shown in table 5.5, comparing with to the result of above two reasoning's with the hybrid system, the performance of hybrid reasoning system for diagnosis pregnancy related diseases score 88.75%. Which is a very good enhancement and improvement for diagnosis the diseases.

# CHAPTER SIX

## 6.1. CONCLUSION AND RECOMMENDATIONS

In this time, the implementation of AI in medical domain attracts many researchers especially applying hybrid reasoning for medical diagnosis. The main focus of this research is Design Hybrid Knowledge based system to diagnosis pregnancy related diseases by Integrating Rule Based and Case based reason Techniques. Therefore, this chapter concludes the overall findings of this research and based on the findings recommend other problems to be investigate by other researchers.

## 6.2. Summary

The Designed Hybrid Knowledge Based was evaluated and its accuracy scored 88.75%. The main contribution of this research is that the Combine rule based and case-based reasoning approaches and the related knowledge base can support the process of diagnosis diseases. The registered score indicates that higher accuracy rate and user satisfaction than traditional diagnosis. The Success of our designed hybrid prototype system inspires us to look for ways to increase the scope of this research to answer more types of questions such as comparative and similarity points. In addition, the Hybrid Knowledge based system can be extended by adding more reasoning techniques, data and relevant information.

## 6.3. Conclusion

In our country, the coverage of health care services remains at its infant stage. Different factors are identified such as quality of health care center, shortage of skilled manpower in the area, unbalanced ratio of physician per patient, the holding capacity of health instructions and shortage of budget. To solve the above problems hybrid knowledge base system was designed, the Designed hybrid system assists the general practitioner in the processes of diagnosing and proper making decisions. The relevant knowledge was acquired from experienced domain expert and document analysis. Different challenges also identified during knowledge acquisition phases such willingness and confidence of domain expert to share their knowledge. The acquired knowledge was representing using production rule representation technique and codified using SWI-Prolog editor tool for building the knowledge-based system.

Also, in testing and evaluation of the prototype system, nine cases of patients are selected using purposive sampling method in order to test the accuracy of the prototype system. The correct and incorrect results are identified by comparing decisions made by the domain experts on the cases of patients and with the conclusions of the prototype system. And also, the process of ensuring that the prototype system satisfies the requirements of its end users is performed. This permits end-users to test the prototype system by actually using it and evaluating the benefits received from its use. As the testing result show, the overall performance of the prototype system registers 88.75%. The strong side of the hybrid prototype system shows that the Case base of the system is able to learn/ update its knowledge from experience automatically.

In general, the study achieves its objective by developed the hybrid knowledge-based system with promising performance and user acceptance, and demonstrated hybrid RBR-CBR approach in designed knowledge-based system for diagnosis pregnancy related diseases.

## 6.4. Recommendations

Designing Hybrid Knowledge based System for pregnancy related diseases is the main objective of this study. This is almost achieved by the end of this research work successfully. But, the following are problems to be investigated by future researcher stands with a need of designing Hybrid intelligent knowledge based system in the domain of health specifically for pregnancy related diseases diagnosis.

- Building hybrid knowledge based system which is capable of employing rule based reasoning and case based reasoning with integrated data mining techniques.
- An approach to design localized hybrid reasoning for early self-advise and diagnosis of pregnancy related diseases using mobile phones outside of health institution should be investigated as a future work.
- The retrieval algorithm used for retrieval of cases for HKBS application is nearest neighbor retrieval algorithm. Since the case base of the system increases through incremental learning, the retrieval time increases linearly. Therefore, the retrieval performance will decrease from time to time. To overcome this problem investigating case maintenance techniques essential.
- A method must be investigated on how to integrate the prototype system with the existing health information systems. This would lead to the development of standards applicable to all, enabling suitable information exchange and planning for additional improvement of functionality.

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