A CASE BASED REASONING SYSTEM FOR DIAGNOSIS OF MALNUTRITION FOR UNDER-FIVE YEAR CHILDREN: THE CASE OF TIRUNESHE BEJING

A Thesis Presented

by

Daniel Kahsu Tesfay

to

The Faculty of Informatics

of

St. Mary's University

In Partial Fulfillment of the Requirements
for the Degree of Master of Science

in

Computer Science

January, 2022

ACCEPTANCE

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DECLARATION

I, the undersigned, declare that this thesis work is my original work, has not been presented for a degree in this or any other universities, and all sources of materials used for the thesis work have been duly acknowledged.

Daniel Kahsu Tesfay

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Signature

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

Dr. Temtim Assefa

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December 31, 2021

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Acknowledgement

First and foremost, I want to express my gratitude to the Almighty God, who has blessed each and every minute of my life by allowing me to do all of my tasks in his manner.

Next, I'd want to express my gratitude to Dr. Temtim Assefa, my adviser, without whom none of this work would have been possible. I owe a special appreciation to all members of the Tiruneshe Beijing General Hospital personnel, particularly the malnutrition domain specialists and nurse, for their assistance in the knowledge collection, testing, and assessment of the prototype system.

It is also my pleasure to thank my wonderful mother, Ashkuti Mersa, and all of my loving family members for their encouragement, love, and support, which helped me complete this study project.

Last but not least, I'd want to convey my heartfelt appreciation to everyone who has helped and supported me during my thesis research, especially my friends who have praised my work and encouraged me to finish it.

Daniel Kahsu

Contents

Acronyms

AI	Artificial Intelligence
CBR	Case Based Reasoning
CBRSDMUFYC	Case Based Reasoning System for Diagnosis of Malnutrition under-five year children
ES	Expert System
HTP	Harmonized Training Package
GAIA	Group for Artificial Intelligence Applications
JCOLIBRI	java Cases and Ontology Libraries Integration for Building Reasoning Infrastructures
KBS	Knowledge Based System
MOPED	Ministry of Planning Economic Development
MUAC	Mid-Upper Arm Circumference
OTP	Out-patient Therapeutic Programmed
PEU	Protein-Energy Under-nutrition
RBR	Rule Based Reasoning
RUTF	Ready-to-Use Therapeutic Food
SAM	Sever Acute Malnutrition
UNICEF	United Nations Children's Fund
WHO	World Health Organization

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ABSTRACT

Malnutrition is a broad word that refers to an insufficient intake of nutrients to support healthy growth; it can refer to both under and overnutrition. It's possible that it's one of Ethiopia's leading causes of disease and mortality in children under the age of five. Lack of specialists, practitioners, and health facilities at lower level health institutions in order to detect and treat malnutrition at an early stage are some of the factors that exacerbate the spread of malnutrition in the country. Artificial Intelligence (AI) was used in the study to diagnose malnutrition by using computer tools that mimicked human intelligence. The general objective of this study was to design a case based reasoning system that provides expert advice for diagnosis of malnutrition under five year children. The examples were gathered from Tiruneshe Bejing General Hospital, and design principles were used to create a prototype case-based reasoning system. Domain specialists from Tiruneshe Bejing General Hospital were selected using a purposeful sampling strategy for knowledge acquisition, system testing, and assessment. The researcher utilized the jCOLIBRI version 1.1 implementation tools and the closest neighbor technique to create the prototype system. The produced prototype was put to the test in terms of system performance and user approval. 7 test cases and 6 domain experts were used to put the prototype to the test. The average accuracy and recall values acquired based on evaluating the system's performance were 71 percent and 83 percent, respectively. Domain specialists were also included in user acceptability testing, which resulted in an average of 83 percent approval. The CBR system's performance might be improved by adding more cases. This investigation yielded a positive outcome that satisfied the study's aims.

Index Term ------*Case Based Reasoning, Malnutrition, Artificial Intelligence, Design science*

CHAPTER ONE

INTRODUCTION

1.1.Background of the study

Malnutrition refers to energy and/or nutritionary deficits, excesses, or imbalances in an exceedingly person's diet. Deficiency disease is also divided into 2 classes. Stunt flying (low height for age), wasting (low weight for height), lean (low weight for age), and matter deficiencies or insufficiencies are all samples of undernutrition (a lack of vital vitamins and minerals). Overweight, obesity, and diet-related noninfectious diseases are the opposite 2 (WHO, 2020).

In 2011, associate calculable one hundred and one million (16%) youngsters below the age of 5 were lean over the globe, down from a expected 159 million (52%) in 1990. (Nutritional standing Report 2016 by UNICE). 24.7, 7.8, and 15.1 % of kids below the age of 5 were scrawny (height-for-age), wasted (weight-for-height), and lean, severally (weight-for-age) deficiency disease is accountable for concerning thirty five % of fatalities among youngsters below the age of 5, in line with a World Health Organization study.

Malnutrition could be a serious public health issue, notably in developing countries, with simple fraction of all cases occurring in geographic area, and malnutrition-related morbidity and death are high in youngsters below the age of 5. Poverty, an absence of access to a healthy food, and underlying ailments (tuberculosis, malaria, diarrhea, then on) all contribute to high levels of deficiency disease, in line with many studies. As a result, it's the foremost simply known, and it's going to contribute to kid financial condition (Afework et al., 2010).

Chronic deficiency disease and lean were found to be rife in thirty-nine.9% and 26.6 % of individuals in Africa and Southeast Asia, severally. One among the first causes of sickness and mortality among Ethiopian youngsters below the age of five is deficiency disease. The amount between the ages of half-dozen and fifty nine months is taken into account a major era of development since it spans the transition from childhood to adolescence. Rising children's nutritionary standing, in line with Uthman et al., (2009), is advantageous. In line with a United Nations agency report, the worldwide distribution of kid mortality and deficiency disease is considerably uneven (VandePoel, 2008).

The government of African nation has developed variety of ways that give a framework for rising kid health. one in every of the priorities within the Health Sector Development set up (HSDP) IV is rising kid health, with a goal to cut back the under-five rate to 68per one,000 live births and therefore the death rate to thirty one per one,000 live births by 2015 (MOH, 2010). According to data from the previous four Ethiopian Demographic and Health Surveys (2000, 2005, 2011, and 2016), the prevalence of lean has decreased over the last sixteen years (41, 33, 29, and 24 percent, respectively), but it remains high, and we need to understand the factors that are driving this trend (Tekile et al., 2019).

Malnutrition in youngsters will take the shape of stunt flying, wasting, or lean (Mahgoub et al., 2006). Youngsters whose weight-for-age indicator is quite 2 or 3 normal deviations below the median for the international reference population (ages 0-59 months) square measure thought-about moderately or severely lean (WHO web site 2011b). Moderately or seriously scrubby youngsters are those who have a height/length-for-age measure that's quite 2 or 3 normal deviations below the international reference population (ages 0-59 months) (World Bank web site, 2011).

AI in medicine (AIM) is the name for the application of intelligent systems in health sciences, and a Case-Based Reasoning (CBR) system is one approach of using AIM in medical decision-making. The idea of analogy and derivational analogy are used in cosmic microwave background systems, which is the traditional method of developing information mainly based (KB) systems (Kolodner, 1993; Veloso & Carbonell, 1993). A case is a data graphic that depicts a previous problem and its solution. It has a rough solution that will be identified and altered to achieve a good response to a new problem (J. S. Gero et al.1996).

Case-based reasoning (CBR) could be a methodology for resolution downside that uses previous information or memorized downside things known as cases. The processes of cosmic microwave background system proceed in four main steps like retrieve, reuse, revise, and retain (Fig. 1.1) Aamodt et al., 1994.The new case starts at the highest of stage, wherever Associate in Nursing input is entered into the system. The previous case is compared to the new case and begin retrieve step. In sensible cosmic microwave background system could be a comparison between all the cases within the system and a replacement case, and then result can list the ranking of comparable cases

1.2.Statement of the problem

As the prediction of World health organization (WHO) on deficiency disease prevalence, it's found that around three million folks are exposed from deficiency disease of 1 kind or different (Fletcher & Carey, 2011). deficiency disease is one in every of a heavy unhealthiness primarily within the developing countries consequently affects around 800 million people who accounts the biggest proportions found in Africa and south East Asia. Therefore, it's the foremost recognizable and maybe results in impoverishment in kids (Afework et al., 2010).

Worldwide trends show that deficiency disease and lack of sanitation contribute to over half all under-five deaths (UNICEF, 2012). With this regard, a paper by Bantamen et al., (2014) and Grover and Eele, (2009) has shown that concerning simple fraction of deaths among kids below 5 years mature were happened thanks to beneath nutrition. Hence, it will exposed kids to a larger risk of death and severe ill health as a result of common kid infections like respiratory disease, diarrhea, malaria, human immunological disorder virus, measles, Marasmus, malnutrition, anemia, goiter, symptom, symptom and alimentation deficiency. Therefore, under-five deficiency disease is that the commonest risk that enormously occurred in rural and concrete space

There are sturdy reasons justifying the vigorous pursuit of cosmic microwave background analysis and development within the field of AI and Health (Ferihiwot, 2009). Case-based approaches will supplement rule-based knowledgeable systems, up their talents to reason concerning statutory predicates, solve issues with efficiency, and justify their results. Cosmic microwave background may contribute to the look of intelligent legal information retrieval systems, improve legal instrument assembly programs and contribute to scientific discipline models of the utilization in numerous fields of case comparison ways to rework ill-structured issues into higher structured ones.

Study reasons out the poor sensible performance of health professionals as nutrition education within the medical curricula has been random, unsure and much from adequate (MOPH, 2012). In addition, there's no dietitian allotted within the health centers and it's not determined a health education session on nutritionary problems (Zelalem and Anteneh, 2015). So as to boost this downside, there's a necessity to use case based mostly reasoning systems as a robust tool with in depth potential in deficiency disease. However, to the most effective of the investigator information, there's no analysis has been done to use case based mostly reasoning system for diagnosing deficiency disease for under-five year kids within the case of national capital.

The goal of this work is to use this information to enable domain specialists in providing appropriate diagnosis and treatment of malnutrition to children using a case-based reasoning approach. The researcher selected case-based reasoning over rule-based legal decision support systems because, unlike rule-based techniques, CBR acquires and maintains domain knowledge through comparable instances and does not require a domain expert or prior understanding of the issue area. s a result, the current study attempts to answer the following research topics.

- What are the appropriate cases for diagnosing malnutrition in children under the age of five?
- In a case-based reasoning system, how will acquired cases be modeled and represented?
- Scope of the prototype CBRS works for diagnosis of malnutrition under five year children. ?
- To what extent the performance of the prototype system gets user acceptance

1.3. Objective

The study will be conducted by drawing from both general and specific objectives, which are clearly stated as shown below:

1.3.1. General Objectives

The general objective of the study is to design a case based reasoning system that provides expert advice for diagnosis of malnutrition under five year children.

1.3.2. Specific Objective

The specific objectives of the research are as follows:

- To review literature and identify methods and techniques that are suitable designing for case based reasoning system for diagnosis of malnutrition under five year children
- To acquire domain knowledge from previously solved cases and relevant documents for diagnosis of malnutrition.
- To model and represent the acquired knowledge from knowledge experts and solved cases for diagnosis of malnutrition.
    - To design a prototype CBR system that provides appropriate advice for diagnosis of malnutrition under five year children.
    - To evaluate the prototype using system performance and user acceptance testing techniques.

1.4. Significance of the Research /Contribution

The implementation of the prototype system will decreases the death of child and capable of assisting malnutrition experts in making accurate, consistent and timely diagnosis and treatment of malnutrition. In general, the proposed Case based reasoning reduces the problem of the limited numbers of expert in giving preliminary diagnosis of malnutrition.

The direct beneficiaries of the system are primary health care workers and health professionals working in the diagnosis of malnutrition. The prototype system will give advisory services for health professionals who have basic skill in health care. In addition to this, the prototype will be great significance to teach primary healthcare workers and malnutrition nurses in order to understand well about malnutrition. As a result, those health workers can use the system in diagnosing malnutrition in primary healthcare sectors where highly qualified malnutrition health professionals are unavailable. The CBR system will be developed using the knowledge of Tiruneshe Bejing Hospital malnutrition domain experts and documentary sources, which is used as organizational memory.

In addition, the focuses of all medical systems are to build better health care facility in order to reduce time, cost and medical error (Marget, 2013). The same as true the proposed CBR can provide the efficient and effective way to take care of the child's health, provide malnutrition monitoring , control and improve the medical facilities by reducing the time, cost and medical error to diagnosis and treatment of common childhood diseases.

In general, the proposed CBR act as a decision support tool for malnutrition experts, senior nurses in rural health centers with limited or no experts, provide an alternative way to reach a reasonable diagnosis and treatment of childhood diseases.

1.5.Scope and limitation of the research/Thesis

The goal of the project is to create a case-based reasoning system for diagnosing malnutrition in children under the age of five and providing expert advice. The use of a case-based reasoning method to treat malnutrition helps to minimize the number of children who die as a result of malnutrition. Because children under the age of five are the most commonly affected age group in Ethiopia, the cases will be collected for malnutrition patients in hospitals (WHO, 2012). Individual cases of malnutrition symptom will be collected from Tiruneshe Bejing hospital in order to develop prototypes.

The four key tasks of a Case Based Reasoning system, such as retrieve, reuse, revise, and keep, will be utilized when creating the prototype. By obtaining and utilizing previously solved instances, the prototype CBR system will diagnose new malnutrition responders. If no precise match exists, the closest neighbor similarity method is used to determine which adaptation procedure would be used. If new symptoms are needed, the system will conduct medication and adaptation to modify the present therapy, and then the new case will be retained in the case base for future new case diagnosis.

The focus area of this study will be restricted only at Tiruneshe Bejing Hospital, since this hospital is the only one in Akaki Kality sub city

1.6. Organization of the study

This study will have five chapters. The initial chapter provides background of the study, statement of the problem, objectives of the study, significance of the study, scope and limitation of the study, and definition of key terms.

The second chapter will focus on a study of similar literature on the principle of introduction. Malnutrition as a concept, Protein-energy as a concept in nutrition the big picture AI stands for Artificial Intelligence, Overview of the Knowledge-Based System Knowledge Based System (KBS) Advantages and Limitations, Knowledge Based System (KBS) Architecture, Knowledge Based System (KBS) Advantages and Limitations, Knowledge Based System (KBS) Architecture Knowledge-based processes, knowledge-based logic approaches, and their application of knowledge-based reasoning methods, Rule-Based System, Advantage of rule based reasoning, Case-based Reasoning, Learning in CBR, Case Based Reasoning Tools, CBR-Based Framework jCOLIBRI, Case based reasoning life cycle, Advantage of case based reasoning, Comparison of Rule-based and Case-based Reasoning and related works on case base reasoning system.

The third chapter will presents research design, data sources, sampling technique, instruments of data collection, procedures of data collection, methods of data analysis and ethical considerations.

The fourth chapter deals with the presentations, analysis, and interpretation of data. Finally, chapter five will summarizes the investigation up on bringing the findings obtained, the conclusions drawn, and the recommendations made

1.7.Definition of key terms

Malnutrition: is a range of conditions occurring when intake of one or more nutrients doesn't meet the requirements**.**

Stunting: Signifies low height for age, and is considered an indicator of chronic malnutrition. Height-for- age measurements track linear growth, with low scores indicating cumulative growth deficit. "Stunting is often the result of inadequate feeding practices over a long period and/or repeated illness.

Wasting: Refers to low weight-for-height and measures the body's mass in relation to body length. It is, generally, though to reflect the level of acute malnutrition.

Underweight: Is a description based on weight for age, and is thought of as "…a composite of height for age and weight for height".

Protein-energy under-nutrition (PEU): is a deficiency of energy due to insufficient consumption of all macronutrients.

CHAPTER TWO
LITERATURE REVIEW

2.1. Introduction

It is vital to conceive the key principles of case-based reasoning systems in order to fully grasp the concept of case-based reasoning systems. As a result, this chapter tries to give a broad overview of malnutrition, artificial intelligence, case-based systems and knowledge-based systems, rule-based systems, and case-based systems development phases. The merits and limitations of case-based systems are discussed, as well as the architecture of case-based systems and the stages of case-based system development.

2.2. Overview of malnutrition

Malnutrition is a general concept for the insufficient intake of nutrients required for optimal growth; it refers to both under and overnutrition (UNICEF, 2015). Overnutrition is defined as an excess of calories consumed, whereas undernutrition is defined as a lack of sustenance or poor use of nutrients after ingestion, both of which can contribute to sickness (UNICEF, 2015). Because nutrients are essential for both development and growth, a nutritional deficiency will have an impact on both. Nutrient deficiencies will manifest in the body in one or more of the following ways: physiologically, anatomically, cognitively, and/or immunologically. The body will fail to absorb the nutrients required to maintain a healthy weight (Mekdes 2018).

The person's body needs nutrients in order to grow and improve its health (HTP, 2008). Nutrients are obtained through caloric intake; hence, nutritional status is defined by the quantity and quality of food consumed (HTP, 2008).

2.3. Protein-energy under nutrition

Protein-energy undernutrition (PEU) is a lack of energy induced by insufficient consumption of all macronutrients. PEU comes in two varieties: acute malnutrition and chronic malnutrition (Morley, 2014). Following a PEU diagnosis, the cause and severity of protein-energy undernutrition are classified as main or secondary. Furthermore, according to Morley (2014), the primary form of PEU is "caused by inadequate nutritional intake," while the secondary form is "caused by disorder or drugs that interfere with nutrient use" (classification and etiology sect.). In essence, primary PEU relates to acute malnutrition symptoms, whereas secondary PEU refers to chronic malnutrition symptoms. The PEU categorization supports clinicians in acting properly based on the severity of the condition. In third-world countries, the prevalence of PEU in its mild-moderate and severe versions is 20 and 2 percent of the total, respectively (Duncan, 2015).

2.4. Overview Artificial Intelligence

The task of developing intelligent systems is referred to as artificial intelligence (AI). It is a technique that allows computers to replicate human intellect (Edward, 2017). An intelligent system is one that demonstrates and contains fundamental characteristics such as executing activities, thinking about a certain domain, making decisions, and goal-oriented problem-solving capabilities. When the performance of a system or agent cannot be differentiated from that of a human executing the same activity, the system or agent is said to be intelligent (Honavar, 2006, P.1-2, 12). According to Munakata (2008), Artificial Intelligence is the study of having computers accomplish things that humans must do.

The primary objective of artificial intelligence is to create and execute intelligent agents, which can be programs or physical entities that display certain features of human intelligence in a certain area (Honavar, 2006; Raza, 2009).

Artificial intelligence evolved from a range of disciplines, including philosophy, mathematics, psychology, computer science, and linguistics (Sajja & Shah, 2010). According to Russell and Norvig (2003), the area of artificial intelligence (AI) aims to understand how we think, that is, how we perceive, interpret, anticipate, and manage the environment.

AI also aspires to develop intelligent agents that can solve problems in the same way that people do (Russell and Norvig, 2003). The phrase "artificial intelligence" was coined in 1956. (Detore, 1989). Several AI interpretations have been offered. (Russell and Norvig 2003) seek to categorize meanings into two groups. The first are ideas about mental processes and reasoning, while the second are definitions about conduct.

The key aim of Artificial Intelligence research is to improve human knowledge in all areas, such as perceptual, reasoning, learning, and innovative thinking (Honavar, 2006). Expert systems, also known as knowledge-based systems, were the first important and successful Artificial Intelligence research application technologies (Pomykalski et al., 1999). Initially, attempts to develop Artificial Intelligence systems were aimed at creating general-purpose problem solvers. Those endeavors, however, were futile. Expert systems for general-purpose problem solving were challenging to develop. This resulted in the creation of expert systems that solve issues by utilizing domain-specific knowledge (Sasikumar et al., 2007).

In 1943, McCulloch and Pitts developed the first Artificial Intelligence experiment, which was a model of artificial neurons that imitated the operation of the human brain. The DENDRAL program was then developed to infer molecule structure from mass spectrometer data (Pomykalski et al., 1999). DENDRAL was an expert approach whose reasoning was based on a single molecule model. DENDRAL made significant contributions to the development of knowledge-based systems. This is due to the fact that it was the first rule-based system to leverage human problem-solving skills to translate information into a wide number of particular purpose rules (Masizana-Katongo et al.2009).

The second well-known expert approach was MYCIN, which was created by Buchanan Bruce and Edward Short life for identifying blood infections. MYCIN is a popular and widely used medical diagnostic expert equipment (Sasikumar et al., 2007; Masizana-Katongo et al., 2009). MYCIN made use of roughly 450 laws. Using these standards, MYCIN performed as good as some specialists and much better than certain younger doctors. MYCIN has had a significant effect on the history of expert systems. MYCIN's ability to gain intelligence was one of its accomplishments. The knowledge that went into the creation of MYCIN was derived from a collaboration of various doctors in the field. As a result, MYCIN has developed a set of heuristic rules that clinicians use to diagnose certain illnesses (Masizana-Katongo et al, 2009).

2.5. Overview Knowledge Based System

The thought of knowledge-based systems comes from the sphere of computing (AI) (F. Edward, et al,1993AI intends understanding of human intelligence and building of laptop programs that area unit capable of simulating or acting one or a lot of intelligent behaviors. Intelligent behaviors embrace psychological feature skills like thinking, downside determination, learning, understanding, emotions, consciousness, intuition and creativeness, language capability, etc. recently a number of the behaviors like downside determination, learning and understanding area unit handled by laptop programs (Azeb, 2009) and (F. Edward, et al, 1993)

Knowledge primarily based systems area unit subtle interactive laptop programs that use prime quality, specialized information in some slim downside domain to resolve advanced issues therein domain. It is a software package system that contains a important quantity of information in a certain and declarative type. information primarily based Systems (KBS) have been referred to with a range of names such as knowledgeable systems, intelligent assistants, epistemic systems and style and analysis systems. The two terms most well-liked in common usage, typically used synonymously, area unit KBS and knowledgeable systems (Raman & Prasad, 1987).

With the right utilization of information, the information primarily based systems increase productivity, document rare information by capturing scare experience and enhances downside determination capabilities in most versatile manner (Sajja & Akerkar, 2010). in step with Sajja & Akerkar, (2010), such systems additionally document information for future use and coaching. This ends up in exaggerated quality in downside determination process; but, the scarceness and nature of information create the KBS development method troublesome and complicated. The clear and abstract nature of information is principally answerable for this. Additionally, this field wants a lot of pointers to accelerate the event method.

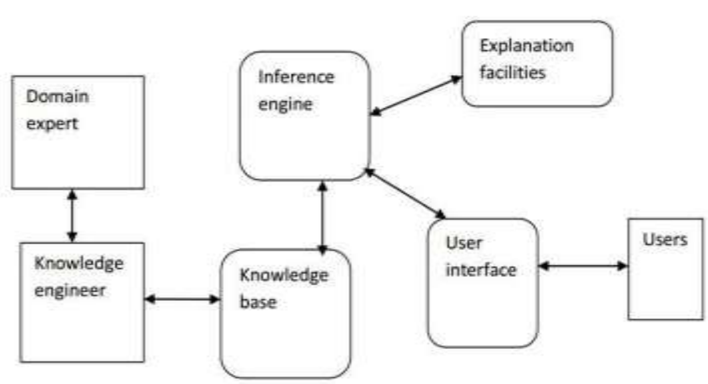
2.6. Architecture of Knowledge Based System

Architecture is a blueprint that aids in the representation of an object's or system's structure. System architecture is a conceptual model that describes a system's structure, behavior, and other aspects. Furthermore, a system's architecture aids in the description of sets of norms, rules, and standards that should be included in the related system. Knowledge-based systems, like other systems, have its own architecture that outlines the primary components, the essential functions that the system performs, and the basic tools that help in the construction of such knowledge-based systems (EMNET,2016)

The KBS is made up of two parts: a Knowledge Base and an Inference Engine search software (IE). The IE is a computer program that infers information from a database. The knowledge base may be used to store a variety of types of information. An empty Workspace might be used to store temporary results and information/knowledge pieces/chunks. The expert system's credibility is also dependent on the Explanation and Reasoning of the conclusion made/suggested by the system, since an expert's power resides in his ability to explain and reason. Humans may also learn new things and forget old ones (EMNET, 2016).

A knowledge-based system is one that consists of multiple diverse components that work together to achieve a common purpose (Krishnamoorthy & Rajeev, 2010). A typical knowledge-based system's structure includes components such as a knowledge base, an inference engine, an explanation facility, and a user interface (Sasikumar et al, 2007). In order to simulate the problem-solving process, all of these diverse components interact with one another. These key components are depicted in Figure 2.6-1

Figure 2.6-1 Architecture of a KBS adopted from (Srinivas and A. Rajendra, 2010)



- **Knowledge Engineer:** Gaines and Shaw (1992) define a knowledge engineer as someone who can design, create, and test knowledge-based systems, such as:
    - ✓ The knowledge engineer interviews the expert to elicit his or her knowledge;
    - ✓ The knowledge engineer encodes the elicited knowledge for the knowledge base;
    - ✓ Interrogates the domain expert to find out how a particular problem is solved;
    - ✓ Determines what reasoning methods the expert uses to handle facts and rules and decides how to represent them in the knowledge based system;

Domain Expert: is a person who is knowledgeable and experienced in a certain area or domain and is capable of addressing problems in that domain. This individual possesses the most knowledge in a certain field. In the construction of a knowledge-based system, expertise was collected. In a team developing a knowledge-based system, the domain expert is the most crucial member (Holland, 2011).

Knowledge base: Any expert system's knowledge base is its foundation. It contains the domain expert's expertise (Khan et al., 2008). The knowledge base of rule-based expert systems is divided into two parts: a rule base comprising heuristic rules for solving specific issues in a domain, and facts. A rule is a conditional statement that connects a set of criteria with specific actions or outcomes. Multiple human specialists' expertise can be pooled into a knowledge base (Abraham, 2005). For a knowledge-based system, it represents a knowledge repository for a specific and constrained subject. So, the knowledge base is the most significant aspect of a knowledge-based system, and the strength of any knowledge-based system or Expert System lies intrinsically in the appropriate and integrated knowledge representation forms employed for the domain. In this view, the creation of a knowledge base is the most essential phase in the development of a knowledge-based system; this process is part of knowledge engineering, which is a growing area in the twenty-first century (B. Bruce G. and S. Edward, 2017)

Inference Engine: The component that offers a process for thinking and producing conclusions is the inference engine. The inference engine gives instructions on how to solve issues using the system's knowledge (Ayman Al Ahmar, 2010). The inference engine's job is to search the knowledge base for information and correlations, then deliver answers, forecasts, and recommendations in the same manner that a human expert would. The inference engine must identify and correctly combine the correct facts, interpretations, and rules. Forward chaining and backward chaining systems are the two types of inference engines commonly employed in rule-based systems. A rule-based system is made up of if-then rules, a set of facts, and an interpreter who controls how the rules are applied depending on the facts. The conditional statements that make up the whole knowledge base are created using these if-then rule statements. The if-part of the rule 'x is A' is called the antecedent or premise, while the then-part of the rule 'y is B' is called the consequent or conclusion, and a single if then rule has the form 'if x is A then y is B.' Backward chaining systems are goal-oriented, whereas forward chaining systems are predominantly data-driven (Abraham, 2005).

The inference engine must seek for a solution in an efficient and effective manner to reach conclusions about an issue. Forward chaining allows a knowledge engineer to create information from a small set of raw data by using rules. Backward chaining starts with a goal and goes backward to examine data and restrictions to see if it's possible to achieve that objective. Backward chaining occurs when the inference engine recognizes one or more hypotheses and begins looking for rules that include the hypothesis as a result (i.e., concluding that the hypothesis is correct). The inference engine checks the veracity of the rule's predicates (if-clauses) for every such rule discovered. The hypothesis is verified if the predicates are true, and the inference engine goes on to the next hypothesis. If the truth of a predicate is uncertain, the hypothesis that the unknown predicate is true is added to the list of hypotheses to be checked by the inference engine. This method is frequently used in selection or classification applications when just one item must be chosen from a group of options (Abraham, 2005).

Both tactics will lead to a solution in the end, but the effectiveness of the search will be determined by the nature of the problem. A forward chaining technique would usually be preferable for a problem with few premises and many conclusions, whereas a backward chaining strategy would usually be better for a problem with many premises and few conclusions. In certain cases, combining the two tactics is a good idea (Ignizio, 1991). Structure the knowledge engineering process by diagramming system interdependencies, flow, and function to decide when and where this is essential (Plant and Stone, 1991 and Warren, 1999).

- **Explanation Facility:** A knowledge-based system is usually able to explain why it came to the conclusions it did. In all nontrivial areas, providing explanations to users is critical for understanding how the system works and assessing whether or not its logic is right.
- The ability to explain is a vital feature of a knowledge-based system. Knowledge-based systems can explain how they arrive at their findings using this capacity. The user has the ability to ask inquiries about the what, how, and why of a situation. The Knowledge-based system will then show the user a trail of the consultation process, highlighting the important reasoning routes that were taken during the consultation. Other challenges, maybe unrelated to the specific problem at hand, but whose solution will have an influence on the overall problem-solving process, may necessitate the use of a knowledge-based system. The explanation feature aids the Knowledge Based System in clarifying and justifying why such a detour is necessary (Bachman et al., 1988).
- **User Interface:** The user interface mimics interactions between the user of a knowledge-based system and the system itself using the environment unit of the functional model of a human system (Owaied et al., 2010). The user interface enables the user to enter data in answer to inquiries posed by the system. It will also be able to provide guidance and, more crucially, explain why it is providing that guidance (Bethune, 2007)

2.7. Knowledge Based System (KBS) Advantages and Limitations

According to (Sajja and Akerkar, 2010) Knowledge-based systems are more useful in many situations than the traditional computer based information systems. Some major situations include: When expert is not available, When expertise is to be stored for future use or when expertise is to be cloned or multiplied, When intelligent assistance and/or training are required for the decision making for problem solving and When more than one experts' knowledge have to be grouped at one platform.

However Knowledge Base Systems have some major limitations due to the following main reasons: (Sajja and Akerkar, 2010), Abstract nature of the knowledge and Limitations of cognitive science and other scientific methods. Due to this and other factors acquisition, representation and manipulation of the large volume of the knowledge is the major problem.

2.8. Applications of knowledge based systems

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

- Diagnosis
- Designing
- Controlling
- Monitoring
- Prediction
- Planning
- Selection
- Interpretation

2.9. Knowledge based reasoning methods

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

2.9.1. Rule-Based System

RBR is a system in which the knowledge representation consists of a collection of rules and facts (P. Jim and H. Ioannis, 2007). Symbolic rules are one of the most widely used approaches for representing and reasoning information. This appeal stems mostly from their naturalness, which aids understanding of the facts portrayed. If condition> then conclusion> is the most basic form of a rule, where condition> represents premises and conclusion> represents related action for the premises.

The conditions of rules are linked together using logical connectives like AND, OR, NOT, and so on, generating a logical function. When a rule's adequate criteria are met, the conclusion is drawn, and the rule is said to be fired. To express generic knowledge, rule-based reasoning was used the most. Expert systems based on rules play an important role in a variety of domains, including computer maintenance, medical diagnosis, electronic troubleshooting, and data interpretation. A rule-based system typically consists of a set of rules, a set of facts, and an interpreter (P. Jim and H. Ioannis, 2007).

2.9.1.1. Rules

When particular conditions are met, the phrase rules refers to what to do or not do. Domain knowledge is represented by a collection of rules in the same way (P. Jim and H. Ioannis, 2003). The following diagram depicts the general form of a rules-based system (M. Dennis, 2000).

IF
First premise,
and Second
premise, and
.

.
.
T
H
E
N
Conclusion

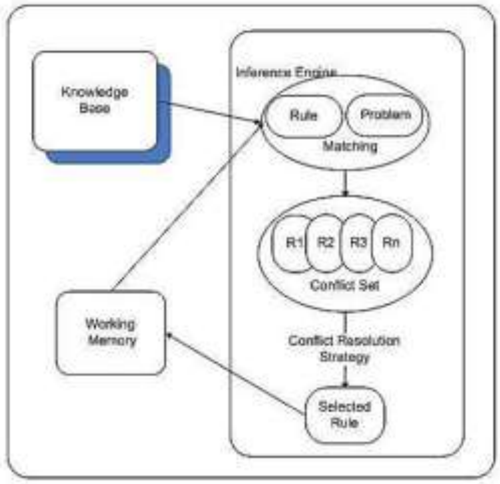
The IF side of the rule is referred to as the left-hand side (LHS) and the THEN side of the rules referred to as the right-hand side (RHS). This is semantically the same as a Prolog rule:

Conclusion: -
First_premise
,
Second_prem
ise …

It's worth noting that this is perplexing since Prolog's syntax relies on THEN IF, because the RHS and LHS are on opposing sides. The present state of knowledge about the problem being solved is used to assess antecedents. This means that if all of the rule's antecedents (premises) are true, the actions in the consequents section are carried out. Each antecedent of a rule often verifies that the issue instance in question meets specified criteria. The rule is considered to be fired when the rules' consequences are performed (J. Freeman-Hargis, 2017).

Figure 2-3 depicts the RBR's main components. Given an input problem, applicable rules are first identified by comparing them to the knowledge base's rules; then, intermediate results are generated using the chosen inference mechanism (such as forward or backward chaining), and the process is repeated until the desired solution state is reached. According to (B. Bruce G. and S. Edward H., 2017), the inference mechanism used (forward and/or backward chaining) determines whether the antecedents (forward) or consequents (backward) of the rules in the knowledge base are used for matching, and whether the desired solution state is the achievement of a specific conclusion (forward) or the determination of the existence of specific data (backward) (backward). The domain information relevant to the problem is stored in the knowledge base, and the solution is obtained by progressively traversing the rule graph generated by the rules in the knowledge base.

Figure 2.9.1.1-1 RBRS components and processes (Bruce and Edward , 2017)



There are two main inference methods in rule based reasoning mechanism. These are backward chaining and forward chaining

Forward chaining: During forward chaining, the inference engines first predetermine the criterion, and then add the criterion one by one until the complete chain is trained. Facts in the system are represented in a working memory that is constantly updated with data driven control.

Backward chaining: It works in a similar way to forward chaining, with the exception that it receives the issue description as a series of conclusions rather than conditions and attempts to locate the premises that lead to the conclusion. Given a target state, the system attempts to demonstrate that the goal fits the beginning facts. The aim is achieved when a match is discovered. If it doesn't, the inference engine will evaluate the following rules to see if their conclusions (formerly known as actions) fit the supplied fact. A backward chaining system, on the other hand, does not need updating a working memory; instead, it keeps track of which goals are required to establish its fundamental premise (M. Dennis, 2000 and J. Freeman-Hargis, 2017, A. G. KARTINI, 2004).

2.9.1.1.1. Advantage of rule based reasoning

The rule-based reasoning technique has a lot of advantages. The key advantages of rule-based reasoning in the construction of knowledge-based systems, according to Jim Prentzas (P. Jim and H. Ioannis, 2007), are:

- **Compact representation of general knowledge**. General knowledge about a problem domain may be conveniently represented by rules.
- **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 highly natural way to describe information that is also extremely easy to understand. In natural expression, rules might imitate the expert's style of thinking.
- **Modularity**. Each rule is a separate piece of information that may be added to or withdrawn from the knowledge base without regard for any other technological details. This property allows rule-based reasoning to be more flexible. Because it allows for the gradual expansion of the knowledge base.
- **Provision of explanations.** The capacity to offer concise explanations for the derived results. Symbolic rules have this property as a result of their naturalness and modularity.

2.9.1.1.2. Disadvantage of rule based reasoning

As rule based reasoning of prototype knowledge, based system has many advantages. However, it has the following limitations (P. Jim and H. Ioannis, 2003).

- **Knowledge acquisition bottleneck**- The standard way of acquiring knowledge through interviews with domain experts is bulky and time-consuming.
- **Brittleness/fragility of rules**- It is not possible to draw conclusions from rules when there are missing values in the input data.
- **Inference efficiency problems-** In certain cases the performance of the inference engine is not the desired one especially when the rules are too large.

- **Difficulty in maintenance of large rules**- The maintenance of rule bases is getting a difficult process as the size of the rules increases.
- **Interpretation problems**- The general nature of rules may create problems in the interpretation of their scope during reasoning process.

2.9.2. Case-based Reasoning

2.9.2.1. Case / Problem

A case is a distinct experience or piece of information associated with a specific scenario that is worth remembering for future reference. As a result, cases in the knowledge base reflect a collection of distinct application domain scenarios that have been collected and learnt (Aamodt and plaza, 1994; Kolodner, 1992). Case structure and substance have a significant impact on case-based reasoning performance (Aamodt and plaza, 1994). Each instance must include the three components listed below: (Bergmann et al, 2005). It's worth noting that the phrase "issue solving" is commonly used in the field of knowledge-based systems. This means that problem resolution does not have to be limited to the discovery of a real solution to an application problem; it might be any issue raised by the user (A. Agnar and P. Enric 1994).Therefore, and cases have three different aspects namely situation, solution, outcome. This can be described as follows.

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

According to Shiu and Pal (2004), Case-based reasoning mechanism requires the following primary activities

- *Index assignment*: Characterizes the given problem by assigning the appropriate attribute that describe the features of the case.
- *Retrieval*: Retrieves the relevant case from the case library
- *Explanation*: Explains the deficiencies of the retrieved case by making a

comparison of the differences between this case and the input problem. The explanation involves two aspects, i.e., which features are unsatisfactory and require modification and how to modify these features so as to satisfy new conditions

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

2.9.2.2. Learning in CBR

In CBR, learning is accomplished by simply remembering new solutions. It is evident, however, that not all new instances should be preserved. This is due to the amount and quality of instances kept in the knowledge base, which are both limited. It is evident, for example, that we do not need to preserve the solution created by the null adaptation process since the offered solutions are identical to those in the knowledge base, thus adding them is unnecessary. In addition, we must be wary about maintaining situations that are very similar to those in the knowledge base. This is due to the fact that the knowledge base will be brimming with situations that are very similar (Mekdes et al, 2018). Learning entails not just saving new cases, but also eliminating cases from the knowledge base. Maintaining a high-quality knowledge base necessitates the deletion of cases that are unnecessary or outdated. Also, any noisy cases that have been improperly kept should be deleted (Aha, 2004). (Aha, 2004) has explored Case-Based Learning (CBL) algorithms and techniques, where the learning and memorization is done in CBR.

2.9.2.3. Case Based Reasoning Tools

Various commercial and non-commercial tools are utilized in the development of CBR systems. The majority of case-based reasoning tools are advertisements. The following are some of the CBR tools mentioned by Ashraf and Iqbal (2008) in their paper.

CBR-Express: CBR-Express is a CBR-based utility created by Inference Corporation (Gianni et al,. 1999). Perhaps the most effective application of CBR is CBR-Express. Asymetrix Tool Book was used to create the CBR Express interface. It's a customer service system (Chris, N.d). To extract cases, it uses a basic case structure and nearest neighbor matching.

ReCall: That CBR-based technology was created by ISoft (an AI company) (Gianni et al,. 1999). The C++ language is used to create this case-based reasoning tool. Nearest neighbor and inductive case retrieval are combined in the recall tool. It can operate on Windows and UNIX workstations running Motif, Sun, HP Series 700, and DEC Alpha, and is built with an open architecture that allows users to incorporate case-based reasoning into their programs..

ReMind: Cognitive Systems Inc. creates ReMind (Gianni et al,. 1999). It is primarily designed for Macintosh computers. It is also developed for Windows and UNIX after some time. Template, closest neighbor, inductive, and knowledge-based retrieval are all available with ReMind. SQL queries are supported using template retrieval, and all queries are returned. User-defined vital information that may be added on case characteristics informs the nearest neighbor. Tree-based situations are used in inductive retrieval (Widiastuti, 2015).

Kate: Kate is a CBR tool developed by AcknoSoft (Watson, 1997) that runs on Microsoft Windows, Mac OS X, and SUN. Kate consists of four components: Kate-Induction, Kate-CBR, Kate Editor, and Kate-Runtime. Both types of closest neighbor and induction methods are supported by this tool. Tree retrieval is exceedingly fast in the induction process.

Casuel: Casuel was created as part of the European INRECA project (Watson and Marir, 1994). It's a language for representing cases that's widely used. It serves as a link between all INRECA component systems. Casuel is a frame-like language that is flexible and object-oriented.

Caspian: it is a CBR tool created by Aberystwyth University in Wales (Watson & Marir, 1994). It is compatible with both MS-DOS and Macintosh. It features a basic command line interface that, if necessary, may be connected with a GUI front end. It employs criteria for case adaptation and performs a basic nearest-neighbor match.

myCBR: MyCBR is one of the most popular CBR software systems, according to (Stahl & Roth-Berghofe, 2008). It's a framework with certain capabilities and constraints. The most common version of myCBR is a plug–in for the open source ontology editor protégé, although web-based versions and integration into other tools are also available. The German Research Center for Artificial Intelligence (DFKI) created myCBR (Stahl and Roth-Berghofe, 2008). The platform's code is open source and written in Java, and it is available to everyone. Users can simply adjust it depending on their needs. The goal of myCBR is to make creating CBR apps as simple as possible. No programming skills are necessary for this usual use, as long as the source code is not modified, but knowledge in a specialized CBR-developed application is required. It has well-documented programming code. The framework myCBR allows for case explanations using a variety of characteristics, including numeric, character, string, logical, and class type. Case templates are created as classes or subclasses with a set of attributes known as slots.

2.9.2.4. CBR-Based Framework jCOLIBRI

jCOLIBRI is an object-oriented framework for designing CBR systems. It simplifies the development process by reusing previous concepts and implementations. jCOLIBRI formalizes CBR information using a domain-independent CBR ontology (CBROnto) that is mapped over the framework's classes, a knowledge-level description of CBR tasks, and a library of reusable Problem-Solving Methods (PSMs) (D.-A. Bel'en et al 2007). The open source framework jCOLIBRI was chosen for this study because of its availability (open source framework), implementation (the Java implementation suggests a high level of usability, flexibility, and user acceptability), and GUI (the provided graphical tools facilitate the system design). Another reason for this study is that jCOLIBRI allows you to use the Case Retrieval Nets (CRN) model as the Case Base structure (D.-A. Bel'en et al 2007).

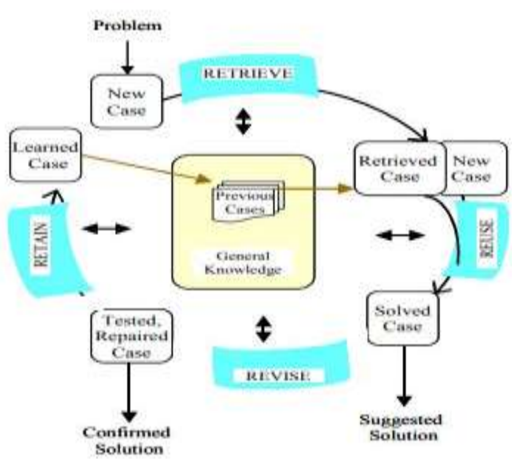
jCOLIBRI is a white-box tool that allows programmers to have complete control over the software's internal elements. This framework is the platform's lowest layer and lacks any type of user interface. The upper layer, on the other hand, has graphical development tools that assist users in the construction of CBR systems. These tools are included in the COLIBRI Studio IDE and allow you to create applications that use the jCOLIBRI components. The following tools are included in COLIBRI Studio: a Case Designer that allows you to specify the structure of your cases; a tool to set case storage in text files; a tool to pick the case's in-memory organization; a tool to define case similarity; and various tools to define the system's behavior. COLIBRI Studio also has a number of wizards that help with the design process (D.-A. Bel'en et al. 2007).

jOCLIBRI will be employed in the research. It is a non-commercial tool that supports the entire CBR cycle (Retrieval, Reuse, Revise and Retain). It is possible to work with external databases utilizing jCOLIBRI and other connections, such as text connectors in our instance. jCOLIBRI may also be used to construct large-scale applications.

2.9.2.5. Case based reasoning life cycle

The four essential components that make the reasoning process successful are included in the case based reasoning life cycle. Retrieval, reuse, revision, and retention are the four steps. Figure 2.2 depicts the life cycle of a CBR. The task of recovering a case from a collection of previously solved instances is known as retrieval. The recovered case is joined with the new case to create a solved case that may be reused later. If repair fails, revise is a procedure that evaluates the success of a remedy by putting it into a real-world setting. When valuable experience is retained, a new learnt case is added to the case (Abdullah, 2007)

Figure 2.9.2.5-1 The CBR Cycle (source Abdullah, 2007)



- **Retrieve**

Using a matching algorithm, one or more instances comparable to the present case are obtained from a database of previously solved cases during the retrieve process. One of the most significant study topics in CBR is retrieval. The closest neighbor technique, induction approaches, and knowledge driven indexing are some of the most often used retrieval methods. Asif Moinul (Asif Moinul, 2003)

- **Reuse**

In reuse process, a solution for the current problem is proposed using the retrieved cases. Adaptation of the solution is done in this step if needed to fit the new case.

- **Revise**

The proposed solution is tested implementing it in real life or through simulator in the revise process.

- **Retain**

The case base is updated with the successful solution of the problem during the retention procedure. Asif Moinul (Asif Moinul, 2003) The goal of CBR is to give decision-makers the opportunity to draw on particular knowledge about previously encountered, tangible issue situations or unique patient instances when making decisions. This method for creating CBR-based knowledge-based medical decision support apps is based on a novel technology. It is employed not just in the medical field, but also in the financial, agricultural, and management fields, among others. 2011 (Investopedia.com)

Case-based reasoning systems have a wide range of applications in the healthcare industry, and have produced answers for illness diagnosis and treatment based on past experiences. For example, Arshadi et al., 2005 developed a mixture of experts for case-based reasoning (MOE4CBR).

2.9.2.6. Advantage of case based reasoning

A case based reasoning approach has tremendous advantages in the development of knowledge-based system. The following are main the advantages of case-based reasoning Ability to convey specific knowledge: This property of cases, among other benefits, avoids the issues that rules have with interpretation (due to their generality).

Naturalness of representation: Cases are a basic approach for representing information that is easily understood by the user.

Modularity: Each case is a distinct, self-contained knowledge unit that may be easily inserted or deleted from the case foundation

Self-updatability: New instances encountered during real-time operation can be included into the case base, enhancing the system's efficacy. This self-updatability also makes case base maintenance easier.

Handling unexpected or missing inputs: A case-based system can manage unexpected or missing input values by comparing them to stored cases and reusing relevant cases. The system's self-updateability makes it easier to deal with unanticipated situations.

Inference efficiency: Adapting existing examples to address new situations is generally more efficient than solving a problem from start, as is the case with rule-based systems.

2.9.3. Comparison of Rule-based and Case-based Reasoning

The benefits and drawbacks of the two reasoning processes, as well as the complementary nature of the reasoning, lead us to combine/hybridize them. Case-based reasoning and rule-based reasoning are two different approaches to issue solving in clinical decision-making. Their techniques of knowledge representation and reasoning are inevitably different. A comparison of them is shown here, based on their knowledge representation and problem-solving capacity. Rules represent broad information about the topic, whereas cases provide knowledge gained from unique instances. When compared to cases, learning rules is difficult. As a result, changing and maintaining rules is more difficult than updating and maintaining cases.

Case based reasoning (P. Jim and H. Ioannis, 2007) and rule based reasoning (B. E. Azeb, 2009) employ answers that have been solved in comparable earlier cases, but rule based reasoning solves problems from scratch, even if similar problems have been solved previously. When dealing with missing values or unexpected aspects in the issue description and selected cases, the case based reasoning technique is more effective than rule based reasoning.

The case-based method looks for similarities between the issue and the cases, even if there are certain elements that don't match. The rule-based method, on the other hand, looks for rules that completely match part or all of the issue description. P. Jim and H. Ioannis (2007) found that rule-based reasoning is more effective at explaining a given solution than case-based reasoning (M. CINDY et al, 2006).

Case based reasoning systems provide effective knowledge representation, problem solving power, and exceeding in various areas of applications due to their handling of missing values, learning over time, making predictions of the likely success of proffered solution, providing a means of explanation, and other more features.

2.10. Related work

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

As an alternative to the solely rule-based strategy, K.A.Kumar et al. provide a hybrid approach combining case-based reasoning and rule-based reasoning to construct a clinical decision support system for ICU. This enables their system to deal with issues such as high complexity, new employees with little expertise, and changing medical situations. In contrast to rule-based inference models, which are very domain knowledge specific, their work proposes a case-based reasoning and rule-based reasoning based model that can provide clinical decision assistance for all domains of ICU. Experiments using real ICU data as well as generated data show that their suggested strategy is effective, with a maximum precision of 0.85 and a recall of 0.62.

Baisen (2013) created a prototype case-based system that uses the CBR approach to advise students in higher education on area of study choices. He built and tested the prototype system with the help of 105 pupils. He achieved an average recall of 85 percent and accuracy of 55 percent using six test cases from the case base.

Santosh et al. (2010) built an expert system for diagnosing human illnesses in another study. The system is a rule-based system that produces conclusions using symbols to represent knowledge. Interviews and observations were utilized to gather tacit information from experts, while document analysis was employed to extract explicit knowledge from papers, journals, books, and websites. They urge that the automated diagnosis system explain the result, since this is a key aspect in user approval. The accuracy of the system's diagnosis would be assessed by a certified expert.

Henok (2011) created a prototype of KBS for hypertension treatment utilizing the CBR approach. He built and tested the prototype using 45 hypertension patient cases. He achieved an average recall of 86.1 percent and accuracy of 60 percent using 7 test cases from the case base. The researcher used accurate performance assessment to assess his system's reusability, and Henok developed a hybrid knowledge-based system that combines rule-based and CBR systems to improve the prototype's performance.

Getachew Wassie (2012) has created a prototype case-based reasoning system that can assist anxiety disorder diagnosticians at various levels of experience in making decisions. The goal of the study was to overcome the drawbacks of rule-based knowledge systems, such as incremental learning and particular knowledge acquisition. Successfully solved cases from Amanuel mental specialized hospital are utilized in the system's implementation, and important parameters are defined in conjunction with anxiety disorder experts and implemented using the jCOLIBRI CBR framework. The system's performance was assessed using several ways, and potential users received an overall score of 83.2 percent. Combining RBR's explanation capabilities with CBR's incremental learning and specialized knowledge acquisition capability has been suggested as a way to improve the system's performance.

Alemu (2010) created a CBR system for consulting on antiretroviral medicine adverse drug reaction instances. He studied 51 typical adverse medication response instances to build and test the prototype. He attained an average recall and accuracy of 72 percent and 63 percent, respectively, using ten test instances. He has to deal with a variety of issues, including extracting features from free text, weighing the value of the retrieved characteristics, and deciding which adaption system to apply. He advocated looking into natural language processing to extract features, employing machine-learning algorithms for feature weighting, and looking into alternative adaption approaches to solve these difficulties.

To summarize, various investigations in the medical area have been undertaken both worldwide and locally, as mentioned above. However, all researchers must use the same approach to investigate the applicability of knowledge-based systems in the medical sector (rule or case base reasoning). This demonstrates that attempting a knowledge base system for clinical decision-making in malnutrition using case or rule-based reasoning is effective and yields favorable results.

Summary

The main objective behind this chapter has been to provide a detailed background of case- based reasoning and techniques in the field of health importantly relevant for the present thesis. The type of the case-based reasoning used in this research is a problem solving approach in which the CBR compares new situation to recalled experience. In addition the CBR framework i.e. jCOLIBRI1.0 is discussed with common components that are included in the framework. Based on the literature review and as the research knowledge, the present work is a new research that applies arguments that adapts a new case from previous cases for future use in diagnosis and treatment of malnutrition.

CHAPTER THREE

METHODOLOGY

3.1. Literature Review

Extensive literature reviews of different books, journal articles, conference papers, thesis and the internet will be reviewed. To understand the principles, techniques and tools of case based systems that are specifically applied to pediatric pain treatment services. Further, researches that are conducted on case based system in the medical domain and other related works will be reviewed to clearly show the contribution of the study.

3.2. Research design

In this study, researchers will use a design science approach to create a case-based system for diagnosing malnutrition in children under the age of five. Design science incorporates many qualitative and quantitative research approaches used in information system research. Within the research process, the procedure will be divided into three primary parts: "issue identification," "solution design," and "assessment." These phases will interact with one another (Philipp et al., 2009). As a result, this study will use design science to develop and analyze models.

3.3. Data collection method

For the purposes of the study, both primary and secondary data collecting methods will be used to gather the essential domain knowledge in order for the researcher to have a better understanding of the area under examination. Interviews with malnutrition specialists who work at Tiruneshe Bejing hospitals will be used to collect both primary and secondary data, dependent on their degree of expertise and availability, in order for the researcher to have a better understanding of domain knowledge.

In addition, relevant material from all conceivable sources, including the internet, books, and journal articles, prior research, malnourished case management guidelines, modeling and case representation, and system design and development.

3.4. Study population and sampling technique

Malnutrition patients from Tiruneshe Bejing hospitals will be employed in the prototype development. A method of selective sampling will be applied. If there are just a limited number of primary data sources who can participate to the study and the most cost-effective and time-effective sample techniques available, this sampling may be the only viable option available.

Ethiopia (2002), Yemisrach (2009), Alemu (2010), Henok (2011), Mekdes (2018), and Getachew (2012) utilized cases 39, 40, 51, 45, 65, and 50 to design and test their prototypes, despite the fact that there is no standard number of instances to use for CBR system development.

For the creation and testing of the prototype system, 55 cases will be utilized after cleaning the redundant and inconsistent data, which are accessible cases of data. The case base for diagnosing new patients from Tiruneshe Bejing hospital was previously solved cases. Instances that are redundant for diagnosis will be removed, leaving just relevant cases for analysis. As a result, the system and testing will employ 55 cases and 30 cases. The study's case selection criteria will be based on doctors' expertise diagnosing malnutrition in children under the age of five.

3.5. Implementation tools

CBRS may be created with a wide range of free and commercially available programming tools. SWI-prolog, myCBR, and jCOLIBRI are three of the most widely utilized and well-known academic research and teaching frameworks (Antanassov and Antonov, 2012). Each of the following instruments has its own set of powers and limitations. Some of myCBR's key flaws are as follows: Does not manage the whole CBR cycle (just Retrieval and Retain), does not communicate with other databases, and is only appropriate for simple CBR applications. According [22], the jCOLIBRI framework has the following qualities.

A CBR tool might be used to create a variety of applications that rely on case-based reasoning. As a result, the researcher will use JCOLIBERI version 1.1 in this study to develop a CBR prototype system, which is an object-oriented framework with the following unique capabilities, according to Triki and Bellamine (2013). The major advantage of JCOLIBERI is that it supports the entire CBR cycle (retrieve, reuse, revise, retain). It's also good for creating large-scale applications since it's built on an object-oriented architecture. It works well with external databases, has an extendable foundation, and is compatible with a variety of applications.

3.6. Testing and Evaluation

The assessment of knowledge-based systems is an essential part of knowledge-based system development that is necessary to demonstrate if a system achieves its intended goal. The system's functioning and user acceptance will be tested throughout the assessment. The assessment procedure focuses on the prototype's user acceptability as well as the system's performance. User acceptability measures look at how well the system meets the user's needs, whereas performance measurements look at whether the system completes the task effectively.

In addition, the prototype's performance will be evaluated using the conventional effectiveness metrics of the case-based system, such as accuracy and recall. The ratio of the number of relevant cases returned to the total number of relevant cases for the new case in the case base is known as recall (McSherry, 2001). The ratio of the number of relevant cases returned to the total number of cases for a given new case is called precision (McSherry, 2001)

3.7. Ethical Consideration

The suggested study findings should be beneficial to the participants and society as a whole. At all times, privacy and confidentiality were respected; all findings were presented in a private way, and no personally identifying information was recorded or printed in the study. During the interviewing procedure, no names were recorded. There was no transmission of data to a third party.

CHAPTER FOUR

KNOWLEDGE ACQUISITION, MODELING AND REPRESENTATION

4.1.Knowledge acquisition

Knowledge acquisition is one of the most critical steps in the creation of knowledge-based systems. The utility of a system is determined by how and where knowledge is gathered. The acquisition of knowledge is a crucial stage in the evolution of a knowledge-based system. When building expert systems, it is a significant stumbling block and a time-consuming process (Tehran, 2014). The act of eliciting, organizing, and expressing knowledge from some knowledge source, generally human specialists, in order to develop a knowledge-based system is referred to as knowledge acquisition (P. Education, 2012). Knowledge elicitation and structuring are two of the most significant activities in knowledge acquisition procedures that knowledge engineers perform in order to construct knowledge-based systems (P. Education, 2012).

The following is a general sequence of events that knowledge engineer goes through while creating a knowledge-based system: (2009) (Miller)

I. Gathering data and information from the domain expert;

II. Interpreting the data and information and drawing conclusions about the domain expert's underlying knowledge and reasoning processes

III. Building a model that describes the expert's knowledge

IV. Repetition of processes i-iii as the knowledge-based system grows into a working system

The knowledge acquisition process in a case-based reasoning system follows the same pattern as the knowledge acquisition method described above. Problem analysis is carried out in case based reasoning by translating the information obtained from the domain expert into the problem and solution fields in the case based data structure (Miller, 2009).

As a result, the primary goal of this chapter is to gather information from specialists and relevant papers in order to structure and develop a model by defining the ideas and factors involved in the diagnosis and treatment of malnutrition. The procedure in this study was carried out by interviewing domain experts, reviewing pertinent materials, and collecting case histories.

4.2. Knowledge Acquisition from Domain Expert

Human specialists frequently apply their expertise and experience to address real-world challenges at work. In such cases, professionals employ not only their heuristics knowledge, but also their experience, which necessitates subjective judgment in making decisions about the topic at hand. A medical diagnosis is a common example of such a choice. When confronted with a new patient, the expert studies the patient's present symptoms and compares them to previous patients who had comparable symptoms. The therapy of those similar patients is then applied to the present new patient instances and, if necessary, changed. This demonstrates how crucial it is to capture expert knowledge and the techniques by which they do their tasks when designing a knowledge-base system. Furthermore, it is critical to examine the sort of knowledge to be obtained while seeking to capture and maintain knowledge.

A certain piece of information may exist in either tacit or explicit form. Experts possess the most useful information (tacit knowledge). Tacit information is only useful for a short time. As a result, the large quantity of tacit information held in the minds of experts should be codified and digitized so that it may be used and understood by non-experts. Despite the fact that information may be created from a variety of sources such as textbooks, manuals, and simulation models, the knowledge at the core of a well-built knowledge-base system originates from human specialists. As a result, tacit information is obtained from human experts (doctors, pharmacists, and nurses) utilizing the chosen knowledge acquisition techniques, usually through direct engagement with the expert (P. Education, 2012).

4.3. Knowledge Acquisition from Relevant Documents

Explicit knowledge, in addition to tacit information, has played a significant role in the development of Case Based Reasoning systems. These documents came from a variety of places. As a result, information is gathered from national guidelines for the diagnosis and treatment of malnutrition (FMOH, 2016), as well as relevant malnutrition-related books, research journals, and both published and unpublished materials such as WHO, UNAIDS, FMOH, and other websites (to download publications by Ethiopian researchers on different malnutrition area as well as researches have been done abroad the country).

4.4. Knowledge Acquisition Process

The Knowledge Acquisition method was used to elicit knowledge. In order to get the necessary knowledge for the case study, both primary and secondary sources of information were utilized. Different medical professionals from Tiruneshe Beijing General Hospital physicians and nurses were contacted as primary sources. As secondary sources, relevant literature from all feasible sources and formats was evaluated, including journal articles, malnutrition guidelines, and malnutrition-related books, dissertations, and the Internet and associated websites.

To grasp the dimension malnutrition, 25 specialists from Tiruneshe Beijing General Hospital were consulted during the early research. The researcher is attempting to conduct informal interviews with these experts at this time. However, the researcher uses selective sampling approaches to pick 8 specialists who are actively working in the under five departments and are directly involved in the diagnosis and treatment of malnutrition. The researcher chose this approach since the study requires a thorough assessment of malnourished case treatment.

Purposive sampling allows the researcher to choose the study's topic based on a variety of factors. "Think about the person, place, or scenario that has the most potential for furthering your understanding and look there," says the basic concept (T. Palys, 2008). Furthermore, it is possible to choose a sample that will supply the necessary information (TAN, 2008). Domain experts are chosen based on their educational qualifications, expertise in the domain area, and desire to help. During preliminary observation, two of the 25 specialists who work at Tiruneshe Beijing General Hospital's five departments are medical doctors who specialize in the subject and have more than four years of experience. Six of them have more than four years of experience as nurses. Two of them have more than three years of experience as data clerks. These experts are consulted throughout the research work to evaluate the correctness of the acquired knowledge and to verify the cases acquired from the previous patient history. They work for a period of time (after a month, they move to another department based on the hospital schedule except case manager workers) and they are consulted throughout the research work to evaluate the correctness of the acquired knowledge and to verify the cases acquired from the previous patient history.

Semi-structured interviews with selected health professionals are conducted and used for the study among the numerous interview approaches accessible in order to collect the essential knowledge for the study. The researcher chose a semi-structured interview over other forms of interviews because a semi-structured interview guides the interviewer by offering both closed-ended and open-ended questions. It allows the interviewer to rearrange the questions and add new ones based on the context of the participant's response in order to gain a deeper understanding. The conversation focuses on the principles that health professionals consider while managing malnourished cases. On Appendix, you'll find the major semi-structured questions that were used in the interview. Interviewing domain experts during working hours is likely to be interrupted, as domain experts are frequently busy during working hours. As a result, experts are questioned outside of business hours and on weekends.

In addition, the Tiruneshe Beijing General Hospital provided information on documented malnutrition cases. These cases provide information on the patient's specifics, treatment length, drug details, and kind of adverse drug reactions, severity, solution, and outcome of investigations undertaken, which were gathered by consulting specialists for those cases and terminology that needed clarification.

4.5. Knowledge Acquisition to Identify Case Feature

While adverse drug responses are a dangerous, unwelcome side effect of a medicine, they can also be fatal if not appropriately controlled. Because malnutrition may have a substantial influence on a child's quality of life, health-care professionals should be familiar with malnutrition diagnostic and management options. Table 4.1 shows the concepts employed in the treatment of five malnourished youngsters. Document analysis, interviews with domain experts, and investigation of the gathered patients' case history talking with specialists are used to capture and determine these ideas. The use of these principles aids in the development of the framework needed to assess patients' severity reports and treat them appropriately.

Table 4.5-1 systematic treatment of patients

	Direct admission to in-patient (Phase I)	Direct admission to out-patient (Phase II)
Vitamin A	- 1 dose at admission (conditional) - 1 dose on discharge - do not give when transferred to OTP management - it will be given in OTP	- 1 dose on the 4th week (4th visit)
Folic Acid	- 1 dose at admission if signs of anemia	- 1 dose at admission if signs of anaemia
Amoxicillin	- Every day in Phase 1 + 4 more days in Transition	- 1 dose at admission + give treatment for
Malaria	- According to national protocol	- According to national protocol
Measles (from 9 months old)	- 1 vaccine at admission if no card - 1 vaccine at discharge	- 1 vaccine on the 4th week (4th visit)
Iron	- Add to F100 in Phase 2	- No - iron is already in all RUTF
Deworming	- 1 dose at the start of Phase 2	- 1 dose on the 2nd week (2nd visit)

4.6. Case Modeling

Knowledge modeling employs a variety of methodologies, including decision trees, semantic networks, UML, and hierarchy of frames. Decision trees have the benefit of being understandable by domain experts and readily convertible into production rules, i.e. decision trees having the capacity to describe the problem in natural and straightforward if-then statements [24]. Furthermore, when applied to a specific scenario, a decision tree not only reveals the answer, but also the rationale behind that result. In this work, a decision tree is employed to model the elicited domain knowledge.

4.6.1. Conceptual model of CBRSDMUFYC System

The CBR cycle (Aamodt and Plaza, 1994), which incorporates four R's procedures such as Retrieve, Reuse, Revise, and Retain, was used by the researcher to create the prototype case based reasoning system (see Figure 5.1). A case or query (issue) is compared to previously solved cases in the case database when it is put into the system through the query window. If the retrieved case was discovered to be identical to a query in a case database, the reuse phase solved the new case and produced a proposed solution. If an exact match could not be found, relevant instances were found using the global average similarity measurement, and if the similarity value was more than 80%, the best comparable case from the recovered cases was picked as a solution for adaptation during the reuse stage.

When there are no relevant similar examples retrieved with the provided threshold for a specific query, or when there is a requirement to amend the problem characteristics or update a solution, domain experts revise them for confirmation of both the problem and/or solution. If the domain experts acknowledge that the updated or incremented case is legitimate, the new learnt case is saved to the case base in the retain step for future use. As a result, the new learnt case may be used to update the case database. The knowledge engineer's job is to gather data for the case base and manage case structure so that the relevant connections may be added to the cases represented as text. The prototype CBR system entitled Case Based Reasoning System for Diagnosis of Malnutrition in Under-five-Year-Old Children was used in this study (CBRSDMUFYC).

Figure 4.6.1-1 Decision tree for CBRSDMUFYC application

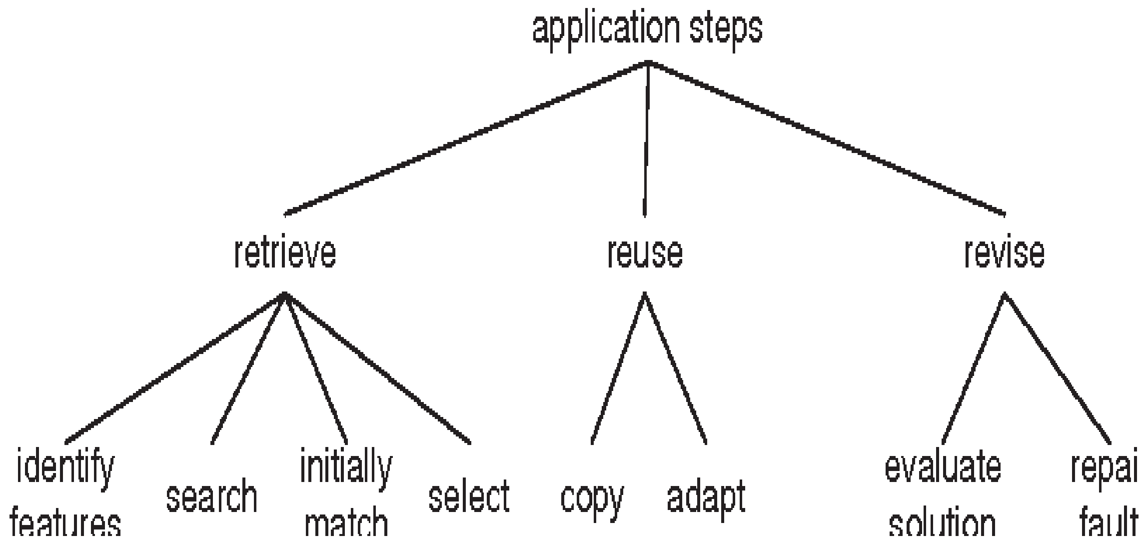
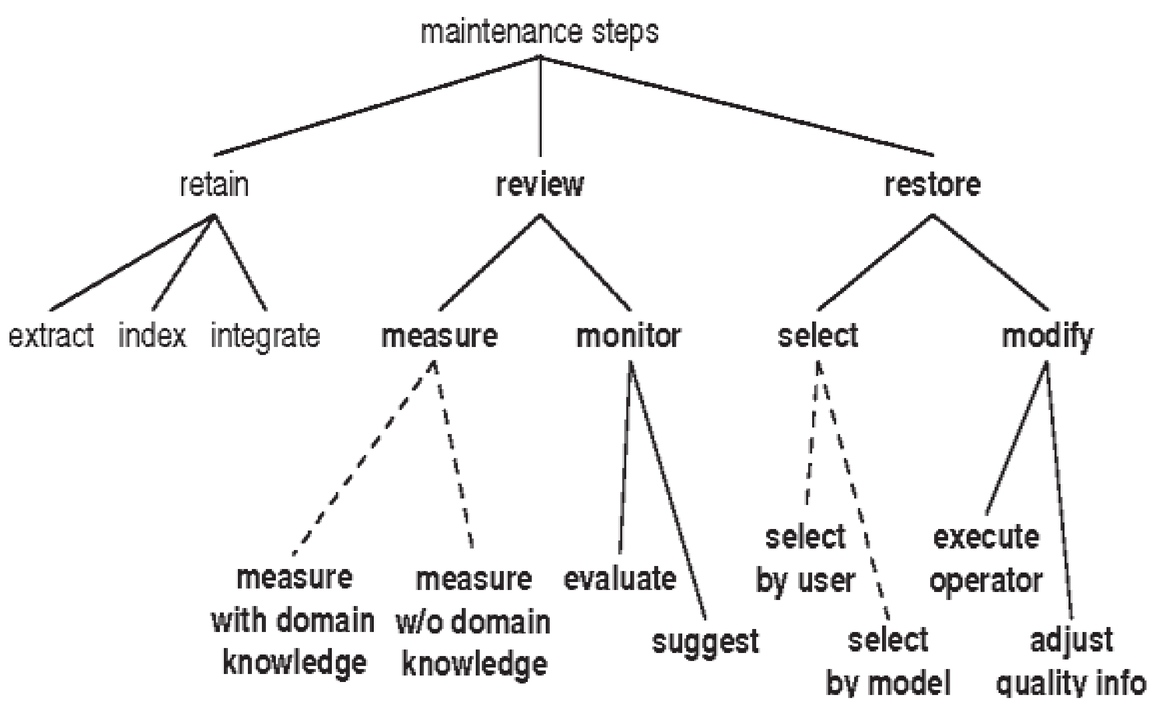


Figure 4.6.1-2 Decision tree for CBRSDMUFYC application Maintenance



4.6.2. Conceptual Modeling for diagnosis and treatment malnutrition

Malnutrition is defined as any condition resulting from an excessive or insufficient intake of dietary energy or nutrient, resulting in a health concern. It can refer to either a nutritional condition caused by a lack of or an excess of one or more vital nutrients. Malnutrition can be caused by a variety of reasons, the most of which are related to inadequate food or severe and recurring illnesses, especially among poorer communities. Inadequate nutrition and disease are, in turn, directly connected to a population's overall level of life, environmental circumstances, and its ability to satisfy basic necessities including food, shelter, and health care. Malnutrition affects people of all ages and both genders. There are, however, certain people who are more susceptible to the condition.

4.7.Malnutrition diagnosis and treatment

Malnutrition is defined as any condition induced by an excessive or insufficient intake of dietary energy or nutrient, resulting in a health concern. It can refer to either a nutritional condition caused by a lack of or an excess of one or more vital nutrients in the diet. Malnutrition can be caused by a variety of reasons, the majority of which are related to a poor diet or severe and recurring illnesses, especially in poorer communities. Inadequate nutrition and disease are, in turn, directly connected to a population's overall level of life, environmental circumstances, and its ability to satisfy basic requirements such as food, shelter, and health care. Malnutrition affects people of all ages and genders. However, there are certain people who are more susceptible to the condition.

Diseases having an environmental component, such as those spread by insect or protozoan vectors, or those induced by a micronutrient-deficient environment, plainly impact nutritional health (Wardlaw, 2013). Variables such as socioeconomic and demographic factors, environmental health conditions, maternal care and features, infections, and child care practices have all been linked to an increased chance of acquiring the disease. Malaria, pneumonia, HIV, and measles are all common childhood infections that have been recognized as a substantial risk factor for malnutrition in children under the age of five. Malnutrition is most prevalent in children aged 0 to 5, which results in a decrease in replacement generation.

4.7.1. Classification of malnutrition

Malnutrition is divided into two categories depending on its clinical manifestations: acute and chronic malnutrition.

4.7.2. Conceptual model of acute malnutrition

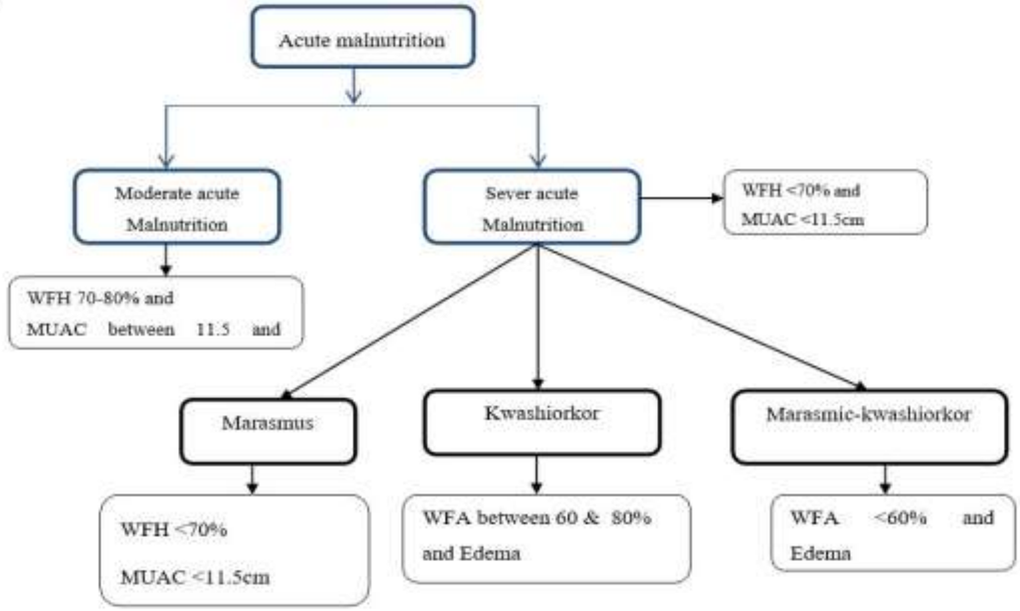
Acute malnutrition produces changes in the organism's cellular composition, tissue function, and organ function. Malnutrition can be severe or moderate in the case of acute malnutrition. Sever Marasmus, Kwashiorkor, and Miasmic-kwashiorkor are all words for the same issue when it comes to acute malnutrition (HTP, 2008). Marasmus, often known as "wasting," is characterized by a fast loss of fat and muscle mass as the body attempts to compensate for its inability to produce energy (HTP, 2008). The bones are beginning to protrude and the body's fat is dwindling at this time.

Severe acute malnutrition: The appearance of severe wasting and/or bi-pedal edema is indicative of SAM. If a kid aged 0-5 years exhibits one or more of the following symptoms, he or she is categorized as severe acute malnourished: mid-upper arm circumference 11.5 cm, weight-for-length z-score (WLZ)* - 3 or weight-for-length z-score (WHZ)-3, and bipedal edema.

The designation of children under the age of six months as SAM is controversial. A kid aged 6 months should be classed as SAM if he or she has one or more of the following: WLZ-3, Bipedal edema, and Visible wasting, until better information becomes available. If the length is less than 45 cm, the WLZ cannot be calculated.

All children's edema is graded using the following classification: Grade + is defined as Mild: both feet/ankles, Grade ++ is defined as Moderate: both feet, plus lower legs, hands, or lower arms, and Grade +++ is defined as Severe: both feet, plus lower legs, hands, or lower arms, and Grade +++ is defined as Severe: both feet, plus lower legs, hands, or lower arms, and Grade +++ is Severe: edema affecting the feet, legs, hands, arms, and face.

Figure 4.7.2-1 conceptual model for acute of malnutrition adapted from (Arare, 2007)



4.7.3. Chronic malnutrition

Chronic malnutrition is a long-term consequence of malnutrition that can begin in childhood and extend into maturity (HTP, 2008). Stunting occurs when a child's height-for-age is less than normal as a result of chronic malnutrition (HTP, 2008). A child's body will be proportionately sized, but he or she will be shorter in height than a child of the same age, necessitating the classification measurement of height-for-age (HTP, 2008). In some cases, a child might be both wasted and stunted (short and thin), increasing their risk of sickness and death (HTP, 2008).

4.7.4. Diagnostic tools/measures of malnutrition

Anthropometric measures and a physical examination are used to identify malnutrition. According to Schaible and Kaufmann (2007), the correlation of malnutrition and growth retardation provides for a more accurate evaluation of an individual's nutritional status, which is often determined by BMI. The BMI is calculated as a weight-for-height ratio. Body measurements, height, and weight are used to determine acute and chronic malnutrition. The most efficient and cost-effective markers for detecting undernutrition in children are the mid-upper arm circumference

(MUAC) and weight-for-height Z-score (WHZ is especially for ‘wasting'). Other methods have shown to be more precise, but they take more time and are more difficult to apply.

A. Mid-Upper Arm Circumference (MUAC)

Weight-for-height is replaced by MUAC as a measure of "thinness." It is most often used in children aged one to five years, although it has recently been expanded to cover children above 65cm in height - or those who have reached walking age. A tape measuring the muscle mass of the mid-upper arm is used to get MUAC readings (HTP, 2008). Although it has shown growing usage in evaluating adult nutritional status, it is a quick and effective indicator of malnutrition for children under the age of five (HTP, 2008).

B. Weight-for-Height Z-score (WFH Z-score/WHZ)

The WFH Z-score is a combination of weight and height measurements that allows children of various ages to be compared. To determine if an individual is "wasted," WHZ compares the individual's weight to the average weight of a person of the same height using the WHO Growth Standards (HTP, 2008).

C. Checking For Bilateral Edema

The symptom of kwashiorkor is bilateral edema. Kwashiorkor is a kind of malnutrition that is usually severe. Children with bilateral edema do not need to have their anthropometric measurements taken since they are clearly malnourished. Those youngsters are at a significant risk of death and require immediate treatment in a therapeutic feeding program. Normal thumb pressure is administered to both feet for three seconds to assess the presence of edema. If the youngster has a shallow print on both feet, he or she has edema. Nutritional edema is only reported in children who have bilateral edema.

D. Weight-for-Age (WFA)

Reflect body mass in relation to chronological age; frequently used to determine if a kid is normal, underweight, or overweight. It is a basic index that does not take into account height. It is influenced by a child's height (height-for-age) and weight (weight-for-height), and it is difficult to evaluate because of its composite character. Weight-for-age, for example, fails to discriminate between short, healthy youngsters and tall, skinny children.

E. Height-for-Age (HFA)

Often used to determine if a kid is normal, underweight, or overweight in relation to his or her chronological age. It is a basic index that does not take into account height. It is influenced by a child's height (height-for-age) and weight (weight-for-height), and it is difficult to evaluate because of its composite character. Weight-for-age, for example, makes no distinction between short children with acceptable body weight and tall, skinny youngsters.

4.7.5. Symptoms and signs of malnutrition

Chronic malnutrition is marked by stunted growth, whereas acute malnutrition is marked by wasting, with or without symmetrical bilateral pitting edema, a weight-for-height (WFH) of 70 percent, a mid-upper arm circumference (MUAC) of 11.5 cm, and other signs, such as the presence of medical complications such as hypothermia (feeling cold), dehydration, electrolytes, infection, shock, high-grade fever, and skin

Symptoms of sever acute malnutrition

Patients with severe acute malnutrition manifest with damaged diverse body parts in addition to the usual signs of malnutrition in children under the age of five. Marasmus, Kwashiorkor, and Miasmic- Kwashiorkor are the most prevalent variants of SAM and the most common presentations.

Growth is slowed in Marasmus to preserve energy; nevertheless, this change has a negative impact on the body's immunological response to infection(s) (HTP, 2008). As a result, a wasted person is more prone to "liver, kidney, heart, and gut infections, as well as catastrophic organ failure" (HTP, 2008). Marasmus is physically visible in its most severe phases, where the bones may be seen and the skin becomes exceedingly thin (HTP, 2008). WFH 70%, MUAC 11.5%, No edema, WFA 60%, and loose skin around the buttocks in baggy trousers are common symptoms. WFA between 60 and

80 percent, Kwashiorkor Edema, bodily swell, weight loss, cough, sadness, moon face, swollen hands and feet, hair color change, and skin flaking are all symptoms of edema. Kwashiorkor: Miasmic- Kwashiorkor: 60% WFA & Edema Loss of appetite, vomiting, diarrhea, skin lesion, skin rash, weakness, and rapid breathing are all symptoms to look out for.

4.7.6. Conceptual model of symptoms and signs for malnutrition

There are frequent symptoms and indicators to identify in the initial course when diagnosing malnutrition in children under the age of five. Weight-for-height (WFH) of 70%, Mid-Upper Arm Circumference (MUAC) of 11.5%, and Bilateral pitting edema are the three. If the patient exhibits the majority of these symptoms, he or she is regarded to have suggestive signs of malnutrition, and the health professional should proceed to the next stage in the diagnostic process, which includes checking for medical consequences. If the majority of the symptoms aren't visible on the youngster, a different diagnosis must be made.

If the youngster exhibits the aforementioned indicative symptoms and indications, the health professional must assess whether the suspect has any other symptoms or medical issues. These extra symptoms and indicators can assist determine if the kid needs to be admitted for in-patient care or treated as an out-patient. Hypoglycemia, feeling chilly, diarrhea, vomiting, weakness, severe anemia, high grade fever, and skin lesions are among symptoms of in-patient or acute malnutrition.

If a kid develops symptoms and indications in other sections of the body, he or she may be suffering from severe acute malnutrition. Skin bone legs and feet are examples of body components that can be contaminated by deficient and malnutrition. So, in addition to the symptoms of severe acute malnutrition, if a person exhibits indicators such as WFH 70%, MUAC 11.5%, no edema, WFA 60%, loose skin around the buttocks in baggy trousers, she/he may have Marasmus, or if WFA is between 60% and 80%, she/he may have Marasmus. Edema, swollen hands and feet, weight loss, cough, sadness, moon face, hair color change, shedding of the skin She/he had kuwashikor; or if she/he had both Marasmus and kuwashikor symptoms; or WFA 60 percent & Edema

She/he had Miasmic-kwashiorkor, which caused loss of appetite, vomiting, diarrhea, skin lesion, skin rash, weakness, and rapid breathing.

Malnutrition for under-five year children Diagnosis Case Structure

Malnutrition in children under the age of five The structure of a diagnosis case is divided into two components. The first is the description of the problem or condition, and the second is the solution.

Problem Description/Situation: This section of the case structure is made up of characteristics that explain the problem that has to be addressed.

The suggested diagnosis given to patients based on the problem descriptions is provided in this section of the case structure.

The researcher identified the numerous description and solution characteristics with the help of malnutrition professionals and the suggestions for the management of severe acute malnutrition handbook. The qualities that are utilized to form the case structure are summarized below in brief:

Is the patient's age indicated?

Gender is a word that refers to a person's self-identification as either male or female**.**

Weight: A person's bulk or weight is referred to as weight**.**

Height is the distance between the bottom of the feet and the top of the head.

The mid-upper arm circumference (MUAC): is a measurement of nutritional status based on the circumference of the mid-upper arm in centimeters.

Bilateral pitting edema: Edema on both feet is present.

Loss of appetite: When someone has a lessened desire to eat, they are said to have a decreased appetite.

Hair color change: is the transformation of hair color (yellow/orange to brown).

Skin lesions: When compared to the skin surrounding it, is a region of the skin that has an abnormal growth or look.

Fever: a body temperature that is unusually high

Moon Face: is a medical condition in which fat deposits on the sides of the face cause the face to round out.

Skin rash: is a change in the hue and appearance of the human skin.

Body swelling: is swollen in several parts of the body

Fast breathing: is the rapid movement of air into and out of the lungs..

Diarrhea: is a rise in bowel movement frequency or a reduction in the type of stool

Vomiting: via the mouth, dislodging the food in the stomach

Cough: a persistent cough that has lasted more than two or three weeks and is not improving

Weakness: Is a loss of muscular strength in one or more muscle groups.

Weight loss: the reduction in body weight

Swollen hands and feet: A accumulation of fluid in the body causes this condition.

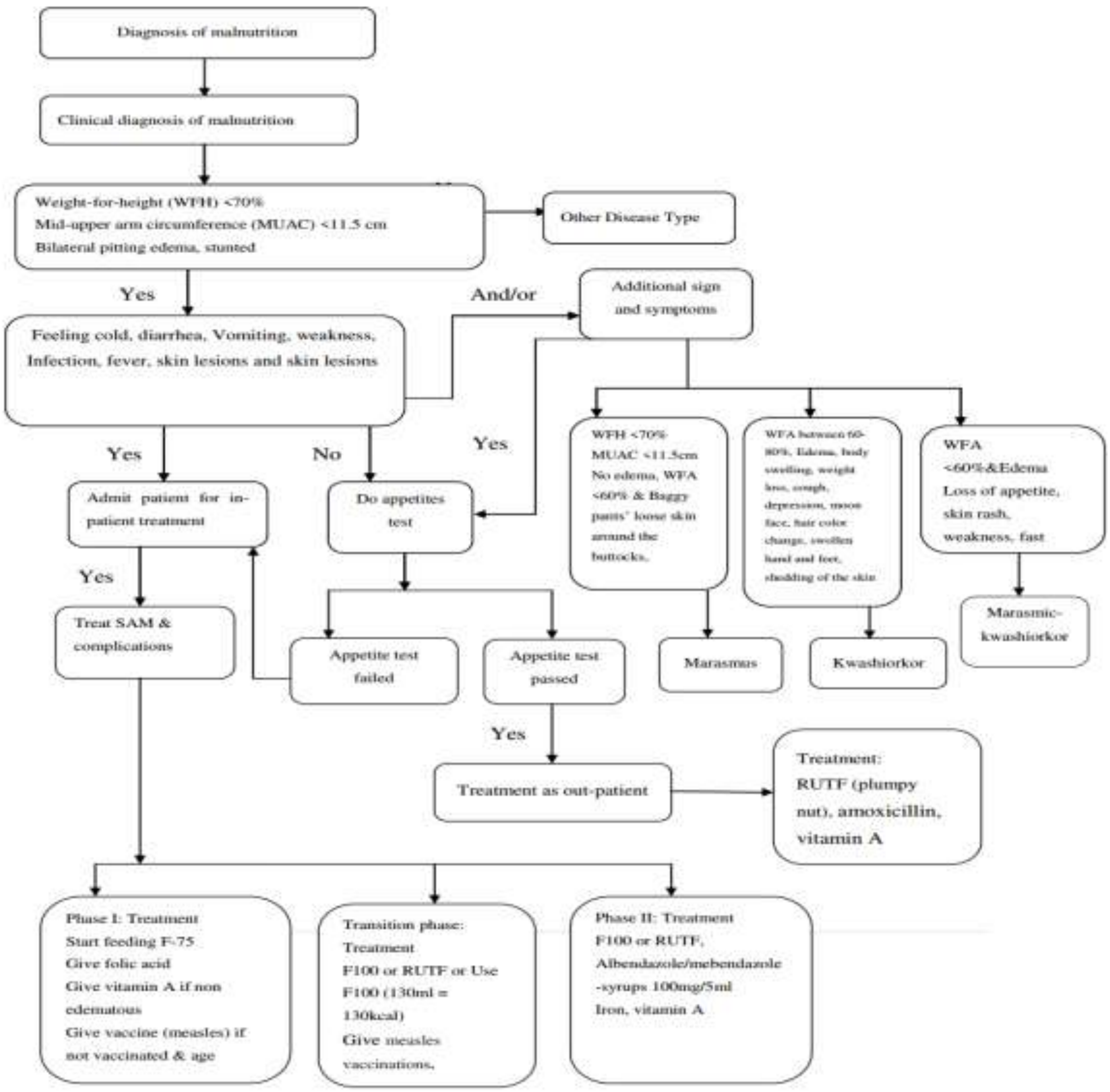
Feeling cold: is the sensation of having a lower body temperature or of being colder than usual.

Depression: is a prevalent mental illness marked by chronic unhappiness and a lack of interest in previously enjoyed activities.

Body sweating: Excessive sweating is a common phenomenon.

Diagnosis: is a solution characteristic that advises the kind of malnutrition based on the similarity of the input case and the previous instances in the case

Figure 4.7.6-1 Decision Tree for Diagnosis of Malnutrition



4.8. **Case Representation**

Knowledge representation is one of the most important stages in the development of a knowledge-based system. Knowledge representation is the process of transforming domain information into a computer-readable format utilizing knowledge representation methods (Tobias, 2010). In this study, the CBR knowledge representation technique is used to organize cases from malnutrition specialists as well as recommendations for malnutrition diagnosis and treatment.

CBR is a case representation technique that employs prior experiences in the form of cases to help people comprehend and solve new challenges. The prototype is a CBR system for diagnosing malnutrition in children under the age of five. Cases are used to express the knowledge of a system. System knowledge is represented in the prototype CBRSDMUFYC in the form of cases. According to Gebhardt (1997), cases in many practical CBR applications are usually represented as two unstructured sets of attribute value pairs: the issue and solution characteristics. Because using attributes with characteristic values makes it straightforward to represent the instances gathered.

While there are several case representation methods, such as relational database case representation, predicate-based representation, and soft computing case representation methods, each with its own set of advantages and disadvantages, the feature-value representation approach is appropriate for this study.

The use of feature-value representation to express cases is justified since it makes it easier to specify cases and allows for the use of the closest neighbor retrieval strategy (Salem et al., 2005; Bergmann et al., 2005). This method also draws on previous experiences to aid in the comprehension and resolution of new difficulties. Case indexing, in addition to case representation, is an essential topic in CBR systems for assisting case retrieval. Cases are chosen and retrieved in a sorted order based on their similarity to the new case query. The closest neighbor retrieval strategy was employed in this work to compare the input case to cases in the case database.

For the diagnosis of malnutrition in children under the age of five, a case structure was created to convey knowledge in a feature-value pair style. The issue descriptions and solution are the two most significant aspects of the case structure. As shown in table-1, the issue description was made up of characteristics (symptoms and signs) that specified the difficulties to be handled as part of the case structure. Based on the issue descriptions, the solution section presents the suggested diagnostic for malnutrition in children under the age of five.

As a result, the researcher used domain experts, national guidelines, manuals, and other resources to identify the various issue description attributes and solutions.

Age, gender, weight, height, weight-for-age(WFA), weight-for-height(WFH), height-for-age(HFA), and mid-upper arm circumference were all used to diagnose malnutrition in children under the age of five (MUAC), Pitting edema on both sides, Appetite loss, and Changes in hair color, Lesions on the skin, Fever, Skin rash, Moon Face Swelling of the body Breathing quickly Diarrhea, Vomiting, Cough, Weakness, Diarrhea, Vomiting, Diarrhea, Vomiting, Diarrhe Losing weight, Hands and feet swollen, Coldness, depression, 'Baggy Pants,' loose skin around the buttocks, excessive sweating Diagnosis and Treatment Recommendations

The majority of the properties chosen are of the Boolean data type, while a few are of the string type. Age and height have integer values, while weight and the mid-upper arm circumference (MUAC) have double values. Because the age of the patients is difficult to depict due to the fact that time is measured in many units such as days, weeks, months, and years, and it is also difficult to utilize different units, the researcher switched to a comparable unit (months) to be used as an attribute.

Sample case representations (Case 3):

Sample that show the case representations working mechanisms, the researcher selected randomly selected case from the excel file connectors.

Case3:27,m,9.9,86,underweight/between 60 and 80%,mild wasting/80-90%,normal/10, 25, 12, yes, yes, no, no, no, no, no, no, yes, yes, no, no, no, no, no, no, no, no, no, SAM+Desseminated TB(LN petroneam)+AGE with no dehydration,INO2(intranazolo2)F-75(170ml/Q 3hr) Ampicillin 500g IV daily Anti-TB 2tabs Po daily AND Resomal(like ORS).

In this specific case, the main attributes which has more weight for diagnosis and treatment of malnutrition as height, weight, weight-for-age, weight-for-height, height-for- age, MUAC and Bilateral pitting edema shows values as 86 cm of height ,weight of 9.9 kg, weight for age value of underweight since that is between 60 and 80%, height-for-age value of middle wasting (80- 90%), height-for-weight obtained normal/10-25, and MUAC result of 12 and positive Bilateral edema results which shows that the child is victim of severe malnutrition. As a result treatment of F-75(170ml/Q 3hr), Ampicillin 500g IV daily and Anti-TB 2tabs Po daily AND Resomal (like ORS) were ordered by the specialist.

This would indicate that the malnutrition diagnosis procedure follows an approach which checks a serious of attributes values and the treatment would be given based on the diagnosis results.

Finally, after the case structure is constructed the cases that build the case base are collected from the malnutrition for under-five year children patients' card history. This stage is one of big challenge for the researcher because the patients' history is recorded on paper and manual record keeping situation in both hospitals. Since converting cases from paper recorded format to computer understandable format so that to represent it with plain text connector is the other problem that was a hard work for the researcher, two nurses professional participated from both hospitals during the conversion. Hence the researcher changed the obtained knowledge in to case representations of collected data on excel using note pad.

CHAPTER FIVE

Implementation and discussion of results

The next parts cover the development of a scaled-down, functional CBR system for malnutrition diagnosis in children under the age of five. As a consequence, once you've gathered all of the necessary examples and information from the domain expert, as well as a number of key papers, the next stage is to encode the knowledge into the computer using appropriate and efficient knowledge representation methods.

The prototype for this study is built using the jCOLIBRI 1.1 CBR framework. In this study, the retrieval technique employed was the closest neighbor retrieval approach. This is because the retrieval job in jCOLIBRI is performed using this technique. When there are characteristics with a numeric (continuous) value, the nearest neighbor retrieval approach is also appropriate (Fang and Songdong, 2007).

5.1. Case Based Reasoning System for CBRSDMFUYC

A CBR application is created by gathering cases and background information, modeling, case representation, establishing an acceptable similarity measure, providing retrieval functionalities, and designing user interfaces. The prototype in this study was created using the principal feature of jCOLIBRI. According to Recio-Garcia, Diaz-Agudo, Recio Garcia, and González-Calero (2008), jCOLIBRI was created as a core module to give the basic functionality for building CBR applications. Implementing a CBR application from the ground up is a time-consuming software engineering process that requires a lot of specialized knowledge as well as pure programming skills (Stahl & Roth-Berghofe, 2008). As a consequence, using the jCOLIBRI CBR framework cuts down on the time and effort needed to build an application in another programming language.

To use jCOLIBRI for the first time, double-click the JColibriGUI.bat file, and it will launch, as shown in Figure 5. 2 includes a toolbar in the upper left corner with four menu lists: File, CBR, Evaluation, and Help.

Figure 5.1-1 Windows of jCOLIBRI

5.2.Building a case base

One of the objectives of this research is to collect malnourished patient cases in order to create a case base and represent the cases using the right case representation approach. As a result, the researcher obtained malnutrition data from Tiruneshe Beijing General Hospital patients under the age of five. The examples were picked with the goal of learning from a range of experienced doctors and then sharing that knowledge with non-experienced and other first-line health professionals to help identify malnutrition in children under the age of five. Malnutrition cases in children under the age of five years old that have been identified.

The case base is shown as plain text, with n columns representing case attributes (A1, A2, A3,..., An) and m rows representing individual cases (C1, C2, C3,..., Cm), each attribute having a series of potential values connected with each column attribute A=V1, V2, V3,..., Vk. The reason for utilizing feature-value representation to represent cases is that it supports the closest neighbor retrieval technique and makes it simple to express cases (Salem et al., 2005; Bergmann et al., 2005).

Figure 5.2-1 Collected data in CSV File

case_no	Age	Gender	Weight	Height	Weight-for-age(WFA)	Weight-for-height(WFH)	Height-for-age(HFA)	Mid-upper arm circumference (MUAC)	Bilateral pitting edema	Loss of appetite	Hair color change	Skin lesions	Fever	Moon Face	Skin rash	Body swelling	Fast breathing	Diarrhea	Vomiting	Cough
Case1	3	M	5.7	67	marasmus/betwe 60%	moderat wasting/70-80%	stunting/below 3rd centile	11	no	no	no	no	no	no	no	no	yes	yes	no	yes
Case2	29	M	8.5	45	kwashiorkor/60-80%	mild wasting normal/between 80 and 85%	normal/between 25 and 50	14	no	yes	no	no	no	no	no	no	no	no	no	yes
Case3	27	M	9.9	86	underweight/between 60 and 80%	mild wasting/80-90%,	normal/10-25	12	yes	yes	no	no	no	no	no	no	yes	yes	no	no
Case4	48	F	12.6	91	marasmic kwashiorkor/<60%	mild wasting/80-85%	stunting/below 3rd centile	14	no	no	no	yes	no	no	no	no	yes	yes	no	no
Case5	24	M	11.8	83	normal	mild wasting	under weight	14	no	no	no	no	no	no	no	yes	yes	yes	no	yes
Case6	24	M	10.7	78	kwashiorkor/80-100%	normal/between 85-100%	stunted/between 10-25	17	no	no	no	no	yes	yes	no	no	yes	no	no	no
Case7	48	F	11.7	97	kwashiorkor/60-80%	mild wasting normal/between 80 and 85%	normal/between 25 and 50	14	no	yes	no	no	no	no	no	no	no	no	no	yes
Case8	4	F	3.5	55	marasmic/<60%	moderate wasting/between 70 and 80%	med/<3rd cen	0	no	no	no	no	no	no	no	yes	no	no	no	no

5.3.Case representation

The casing is designed to fit inside jCOLIBRI without difficulty. The construction of a case structure like this makes it easier to define case characteristics and compare old and new cases. As a result, the overall purpose of this research is to uncover comparable cases in the case database that can be utilized to guide future reasoning and problem solving, as well as to adapt a solution identified to the current issues. To make retrieval easier, the feature-value representation is utilized to express groups of cases. Indexing is the process of assigning indices to cases so that they may be retrieved and compared to the case base (Luzelschwah, 2007).

Feature-value pairs are the easiest way to characterize a case in CBR systems. In the study, the researcher also used a feature-value pair structure, which was simple to apply and speeded up retrieval. Special attention was devoted to establishing the case's features and comparing the similarity values of existing and new instances while building a case structure. As a result, the focus of this research was on gathering comparable cases from the case database to improve decision-making in problem-solving by locating solutions that were relevant to the current scenario.

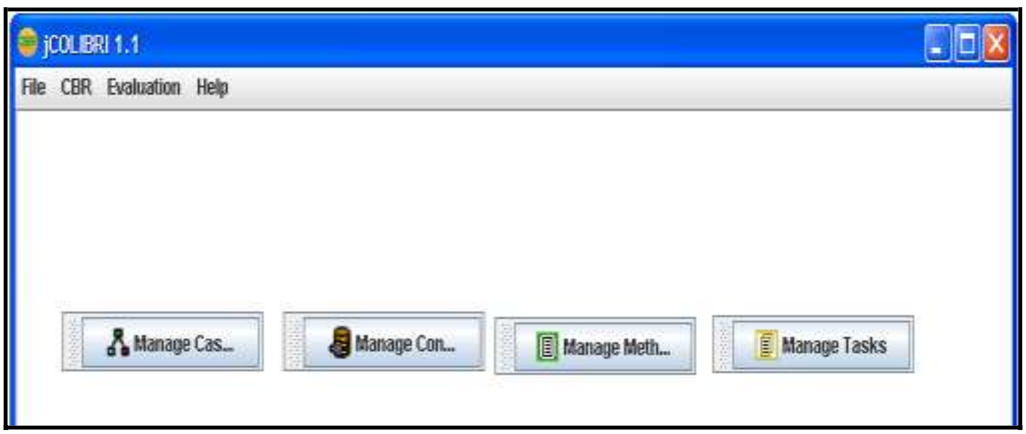
5.4.Classification using jCOLIBRI 1.0

Development of CBR Judicial application with jCOLIBRI has been done using three processes:

1. Managing/Defining the Case structure
2. Managing Connectors and
3. Managing Task/Managing Method

These processes are dependent on each other. For instance connecters depend on case structure of application. Each task or process are classified and configured properly. These classified tasks in judicial application are represented in Fig 5.4:

Figure 5.4-1 Classification Task of jCOLIBRI



5.5.Managing Case Structure

The information gathered is saved in unencrypted format. Before it could be constructed, the CBR application case structure had to be set up. A new window emerges, as illustrated in Figure 5.4, which is a visual tool for designing case structures. The left panel shows the case's structure as a tree, while the right panel shows the property values of the selected attributes. There might be a description, a solution, and a conclusion in a case. Simple attributes were defined by the four properties of name, type, weight, and local similarity function. Compound attributes combine simple and compound features to allow for more complex case structures. The properties of compound attributes are explained by the name and the global similarity function.

Figure 5.5-1 plaintext format of collected data

```
Case1,3,M,5.7,67,marasmus/belwo 60%,moderat wasting/70-80%,stunting/below 3rd centile,
11,no,no,no,no,no ,no,no,no,yes ,yes ,no,yes,no,yes ,no,yes,no,no,no,(NE)+persistent diarrhea
F-100 100ml every 3-hr 8x per day amoxicillin 125mg/5ml syrup 1tsp po BID and plumynat 1 saac
Case2,29,M,8..5,45,kwuashikor/60-80%,mild wasting normal/between 80 and 85%,
normal/between 25 and 50 centile,14,no,yes,no ,no ,no ,no ,no ,no ,no ,no ,no ,
yes,no,no,no,yes ,yes,no,no,(E) + sever persistent +retal proplapse,Ampicillin 600mg IV BID g
Case3,27,M,9.9,86,underweight/between 60 and 80%,"mild wasting/ 80-90%,",
normal/10-25,12,yes,yes,no,no,no,no,no,no,yes,yes,no,no,no,no,no,no,no,no,no,
SAM+Desseminated TB(LN petroneam)+AGE with no dehydration,
INO2(intranazolo2) F-75(170mL/Q 3hr) Ampicillin 500g IV daily Anti-TB 2tabs Po daily AND Reso
Case4,48,F,12.6,91,marasmic kwuashikor/<60%,mild wasting/ 80-85%,stunting/below 3rd centile,
14,no,no,no,yes,no,no,no,no,yes ,yes ,no,no,no,yes ,yes,no,no,no,no,(E) + stunted +tungiasis,
F-100 215mL/feed Q 3hr plupynut 1 sechat/day petroleum gel apply BID,
Case5,24,M,11.8,83,normal,mild wasting,under weight,14,no,no,no,no,no,no,no,
yes,yes,yes,no,yes,no,yes ,no,no,no,no,no,SAM(E) + UTI(uninary truct infection),F-75(170mL/q
585mg IV BID gentmaycin 125mg 15mL,
Case6,24,M,10.7,78,kwuashikor/80-100%,normal/between 85-100%,stunted/between 10-25,17,
no,no,no,no,yes,yes,no,no,yes,no,no,no,no,no,yes,yes,no,no,no,urinary infection,
F-100 350mL/feed 6 feed/day plumynut 3sachet/day Amoxicillin 125mg/15mL,
Case7,48,F,11.7,97,kwuashikor/60-80%,mild wasting normal/between 80 and 85%,
normal/between 25 and 50 centile,14,no,yes,no ,no ,no ,no ,no ,no ,no ,no ,no ,
yes,no,no,no,yes ,yes,no,no,(E) + sever persistent +retal proplapse,Ampicillin 600mg IV BID g
Case8,4,F,3.5,55,marasmic/<60%,moderate wasting/between 70 and 80%,stunted/<3rd centile,0,no,
Case9,24,M,5,69,marasmic kwuashikor/<60%,sever wating/<70%,stunted<3rd antile,9,no,no,no,yes,
```

The majority of the cases characteristics are of the Boolean data type, but a handful are of the string data type. Weight and the mid-upper arm circumference (MUAC) have a double data type, whereas age and height have integer data types. The adoption of a Boolean data type for most of the characteristics is due to the fact that during the diagnosis of malnutrition in children under the age of five, the physician merely examines the absence and presence of symptoms with regard to the attribute's relevance for her/his decision. Even the local similarity of all Boolean and double data type properties is identical. There is a difference between age and height. The degree of similarity between solution qualities is average.

Simple attribute values are compared using local similarity methods. The following are the local similarity functions that were employed in the study.

Equal: If equal was chosen for each characteristic, the input value and the value in the case base must be identical to obtain the desired outcome; otherwise, failure will occur. This equal likeness was utilized in the study to demonstrate if the patient had the symptoms and/or signs or not; if a sign or symptom was found on the specific patient, the similarity value would be one, otherwise it would be zero.

Interval: Exact match is not necessary for similarity in the interval case; when applied to the attributes in jCOLIBRI, the interval value is valid when looking for similarity from the case base.

Global Similarity is related to compound attributes and is used to calculate the average similarity of all attributes with their own unique similarity value. Average similarity, a sort of global similarity that takes the average of all attribute local similarity values, is employed in this study.

Average: It's a form of global similarity that takes the average of all attribute local similarity values into consideration. This is how the algorithm works: (Watson & Marir, 1994; Salem et al., 2005; Henok, 2011).

Step 1: Determine the local similarity of step for all case qualities that make up the case base.

Step 2: Multiply the result of the local similarity of characteristics by the weight of the attribute that corresponds to it (importance value)

Step 3: Add the value of all attribute results of step two

Step 4: Multiply the number of attributes by the weights of the attributes that denote the important value of the attributes.

Step 5: Divide the result of step 3 by the result of step 4, and the result is the global similarity, which shows the degree of similarity between the old and new input cases.

5.6.Description of CBRSDMUFYC Case Attributes

For the prototype CBRSDMUFYC, domain experts developed 27 description characteristics and 2 solution qualities for detecting malnutrition in children under the age of five. Following the selection of the most comparable case, solution attributes are used to indicate the kind of malnutrition and the recommended treatment. Domain experts assigned a weighted value to the traits, assuming that higher weighted values signified more important features in the diagnosis of malnutrition.

Age, gender, weight, height, weight-for-age(WFA), weight-for-height(WFH), height-for-age(HFA), and mid-upper arm circumference were the major features employed in the CBRSDMUFYC system (MUAC), Pitting edema on both sides, Appetite loss, and Changes in hair color, Lesions on the skin, Fever, Face of the Moon, A rash on the skin, Swelling of the body Breathing quickly Diarrhea, Vomiting, Cough, Weakness, Diarrhea, Vomiting, Diarrhea, Vomiting, Diarrhea Losing weight, Hands and feet swollen, I'm feeling chilly. Depression, saggy jeans, and loose skin around the buttocks are all symptoms of depression, sweating on the body, diagnosis, and treatment options.

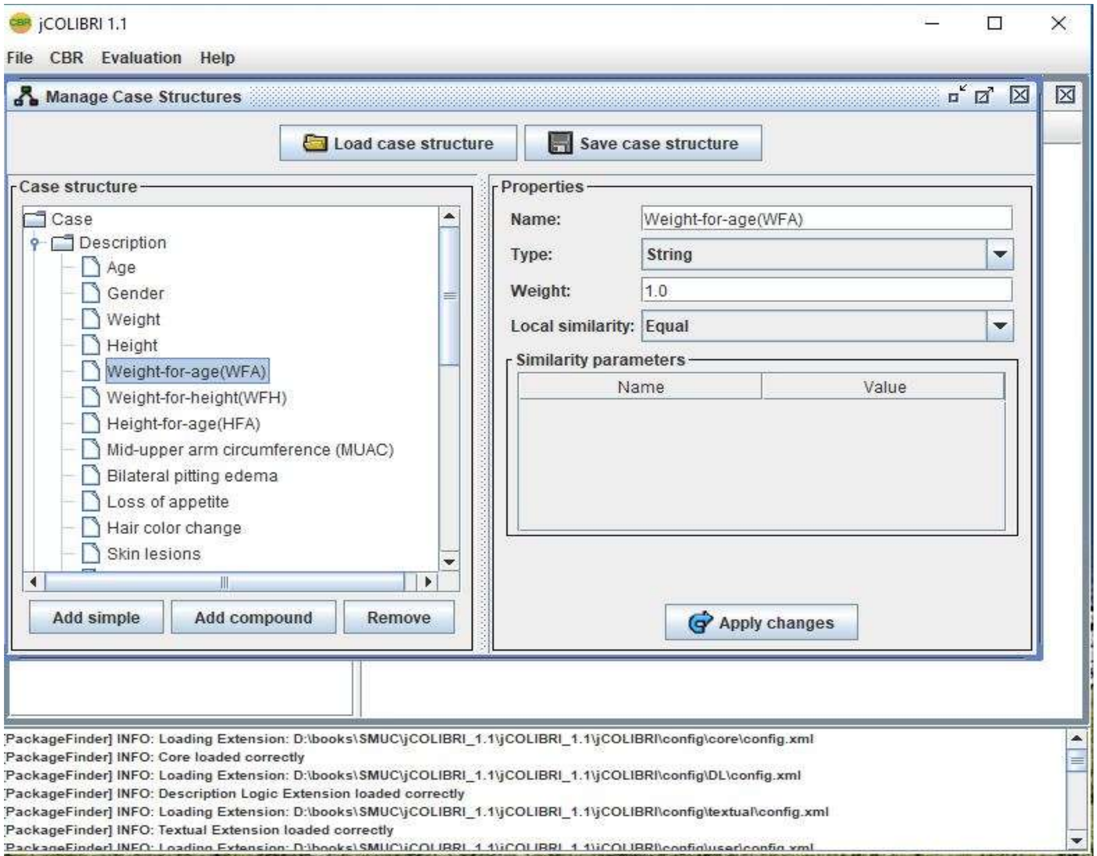
Domain specialists apply weights in the hopes of finding the optimal solution to the situation at hand. As a result, some traits were given a lower weighted value than others, implying that they were less essential in the diagnosis of malnutrition. In the table below, case properties such as name, data type, weight value, and local and global similarities are described (Table 5.1). The weights used to construct the prototype range from 0 to 1, with 0 denoting insignificance and 1 denoting critical importance, and the values' differences believed to be on a linear scale.

The weight values are assigned by domain experts, along with their relevance in the diagnosis of malnutrition in children under the age of five.

Table 5.6-1 List of attributes and description

Attribute Name	Data Type	Weight	Local Similarity
Age	Integer	0.7	Interval
Gender	String	0.5	Equal
Weight	Double	1.0	Equal
Height	Integer	1.0	Interval
Weight-for-age(WFA)	String	1.0	Equal
Weight-for-height(WFH)	String	1.0	Equal
Height-for-age(HFA)	String	1.0	Equal
Mid-upper arm circumference (MUAC)	Double	1.0	Equal
Bilateral pitting edema	Boolean	0.9	Equal
Loss of appetite	Boolean	0.9	Equal
Hair color change	Boolean	0.7	Equal
Skin lesions	Boolean	0.8	Equal
Fever	Boolean	0.6	Equal
Moon Face	Boolean	0.6	Equal
Skin rash	Boolean	0.7	Equal
Body swelling	Boolean	0.8	Equal
Fast breathing	Boolean	0.8	Equal
Diarrhea	Boolean	0.8	Equal
Vomiting	Boolean	0.8	Equal
Cough	Boolean	0.6	Equal
Weakness	Boolean	0.9	Equal
Weight loss	Boolean	0.9	Equal
Swollen hands and feet	Boolean	0.8	Equal
Feeling cold	Boolean	0.8	Equal
Depression	Boolean	0.8	Equal
‘Baggy pants’ loose skin around the	Boolean	0.7	Equal
Body sweating	Boolean	0.6	Equal
Diagnosis	String	0.9	Equal
Recommended Treatment	String	0.9	Equal

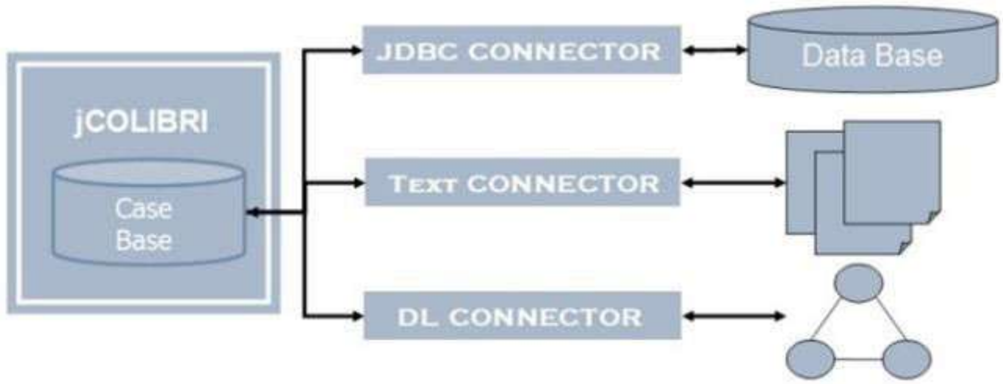
Figure 5.6-1 Defining the case structure for CBRSDMUFYC



5.7.Managing connectors

After case structures have been defined in jCOLIBRI, CBR systems must be able to retrieve the stored cases quickly. jCOLIBRI divides the challenge of case base management into two distinct but related concerns: persistence techniques and in-memory organizing. Cases are frequently produced from historical databases, turning available organizational resources into usable information. jCOLIBRI provides a collection of connectors to manage case persistence in order to take use of previously existing resources, simplify intelligent access to existing information, and include it as seed knowledge in the CBR system (the case base).

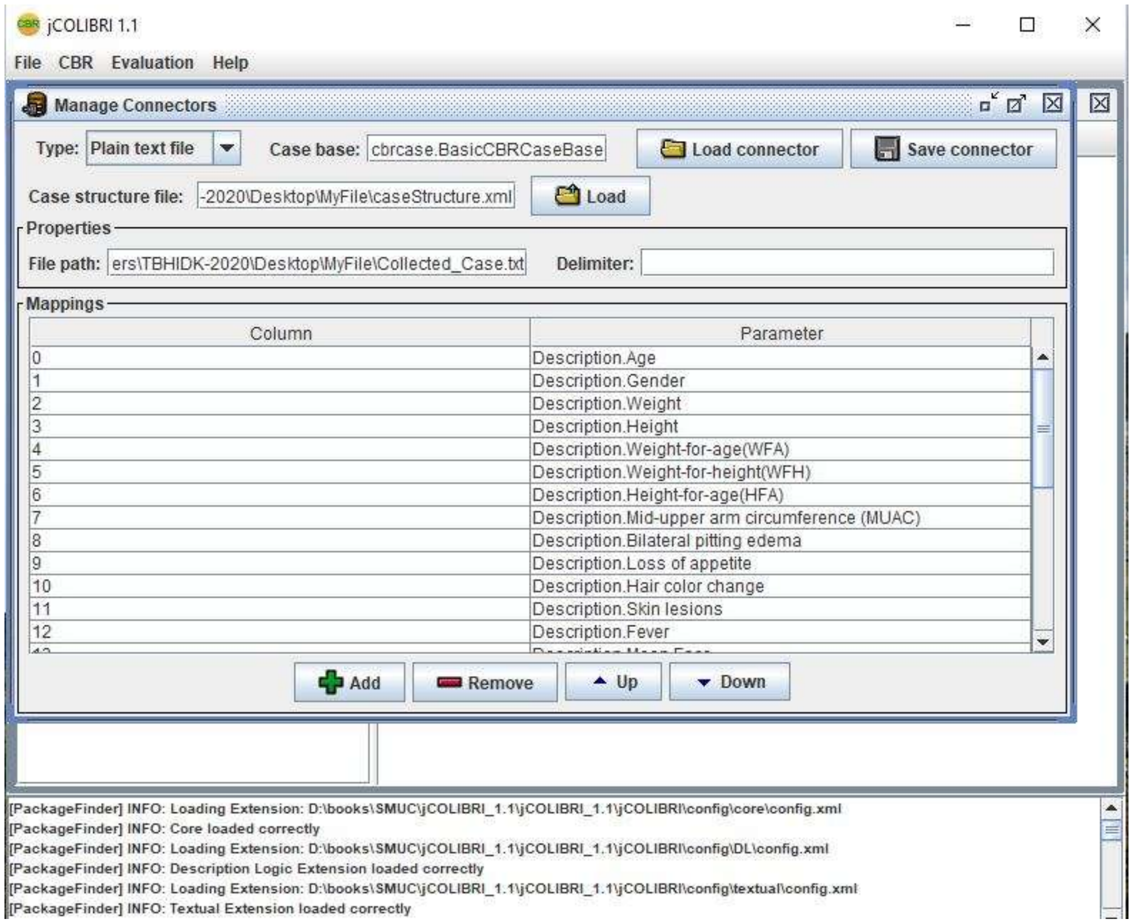
Figure 5.7-1 jCOLIBRI connector architecture



Connectors are objects that show how to access and retrieve cases from storage media and return them to the CBR system in a consistent manner. As a result, connectors provide an abstraction method that enables users to load cases from a variety of storage sources in a transparent manner. As seen in Figure 5.5, jCOLIBRI has connectors for plain text files, relational databases, and Description Logics systems. In order to build the prototype system using jCOLIBRI, we used connectors that work with plain text files and XML files.

Because malnutrition in children under the age of five is documented in plaintext files, the researcher built the CBRSDMUFYC prototype using plaintext connection. A plaintext file case base connection is used for case persistence. In this situation, the researcher must specify the location of the case structure as well as the path of the text file. All of the attributes of a case should be mapped. Connectors are in charge of getting information from the case database and providing it to the user interface. Case structure and connector are saved in the same xml format..

Figure 5.7-2 Managing connector for the prototype CBRSDMUFYC



5.8.Managing Tasks

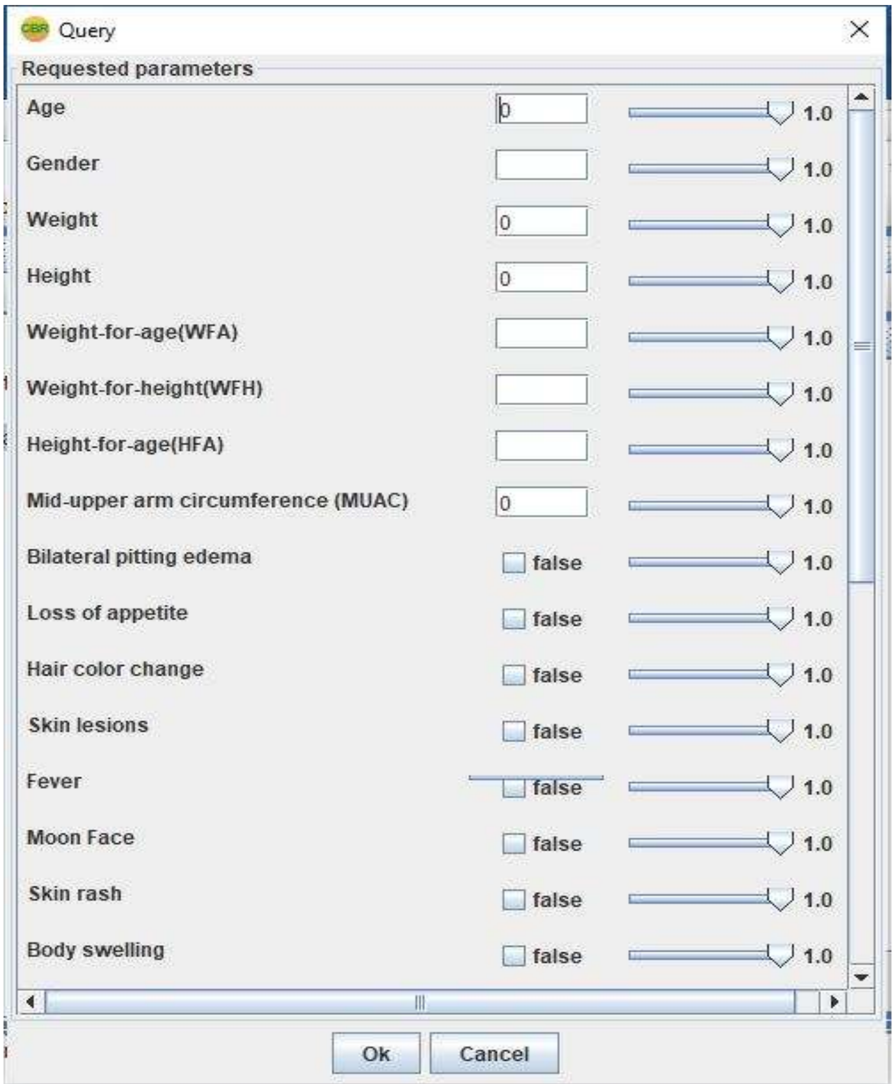
The system's goals create tasks, and each job is accomplished using one or more procedures. To execute a job, a method must have knowledge of the general application domain as well as information about the current problem and its context. The collection of subtasks assigned to a task is intended to be adequate for completing the task at that level. The prototype CBRSDMUFYC, which contains three essential elements of the CBR system: PreCycle, principal CBR cycle, and PostCycle, was built using core package tasks.

The major work completed in PreCycle was the Obtain cases task, which examined and presented the number of cases in the case base using the plain text connection. In preparation for the following tasks, 56 cases were saved and shown for the prototype CBRSDMUFYC.

Five basic activities were completed throughout the primary CBR cycle. Obtain query task, Retrieve, Reuse, Revise, and Retain tasks were among them. There were a number of subtasks to do for each major task, which are listed below.

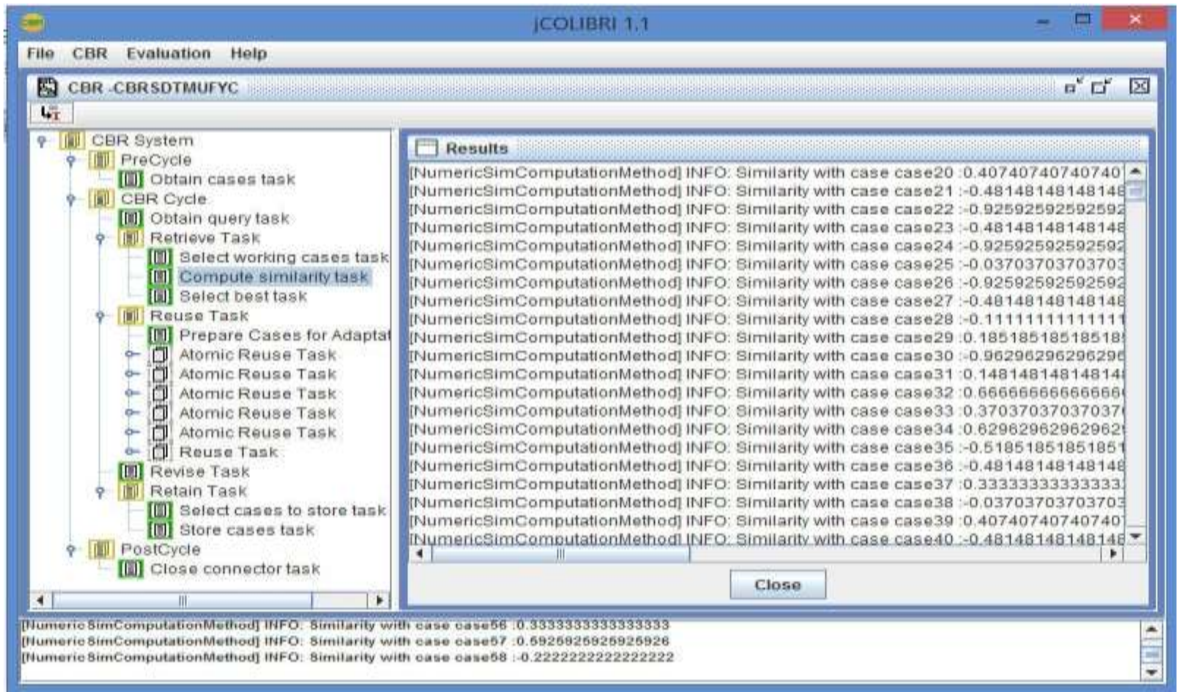
Obtain query task: used to retrieve case attributes from the case base and provide a query windows interface for entering cases. Signs and symptoms (attributes) for a malnutrition suspect are presented in the query box for the process of diagnosing malnutrition in children under the age of five.

Figure 5.8-1 jCOLIBRI Windows for the case entry



Retrieve task: The first sub task, Select working cases, is used to retrieve all working cases from the case base, the second sub task, Compute similarity, is used to calculate similarities using average nearest neighbor similarity for each case available, and the third sub task, Select best, is used to choose the best similar case from all listed cases for diagnosing malnutrition in children under the age of five.

Figure 5.8-2 Case similarities for the query from the case base

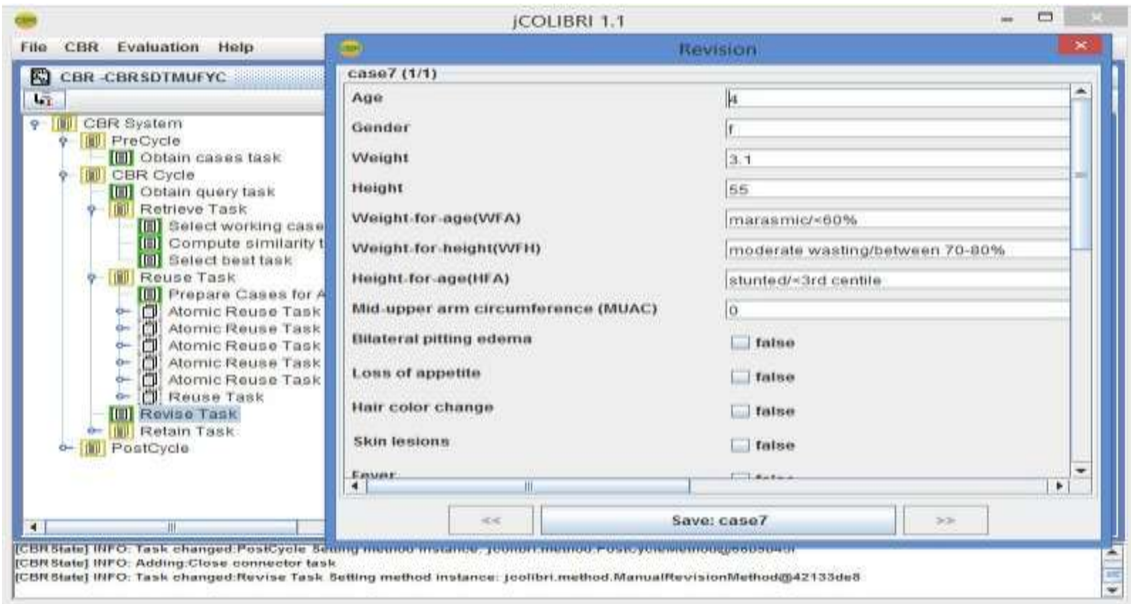


Reuse / Adaptation task: Selects working cases from the case database and puts them in the current context for the new solution's requirements. The recommended solution for the problem is generated at the reuse stage. The reuse phase (also known as the adaption step) modifies the obtained cases' solutions to the query's criteria.

Revise task: In the Reuse phase, this is the assessment stage for the chosen solution. The solution for the problem should be checked and certified by domain experts before being put in a case base after picking the most comparable instance using closest neighbor similarity.

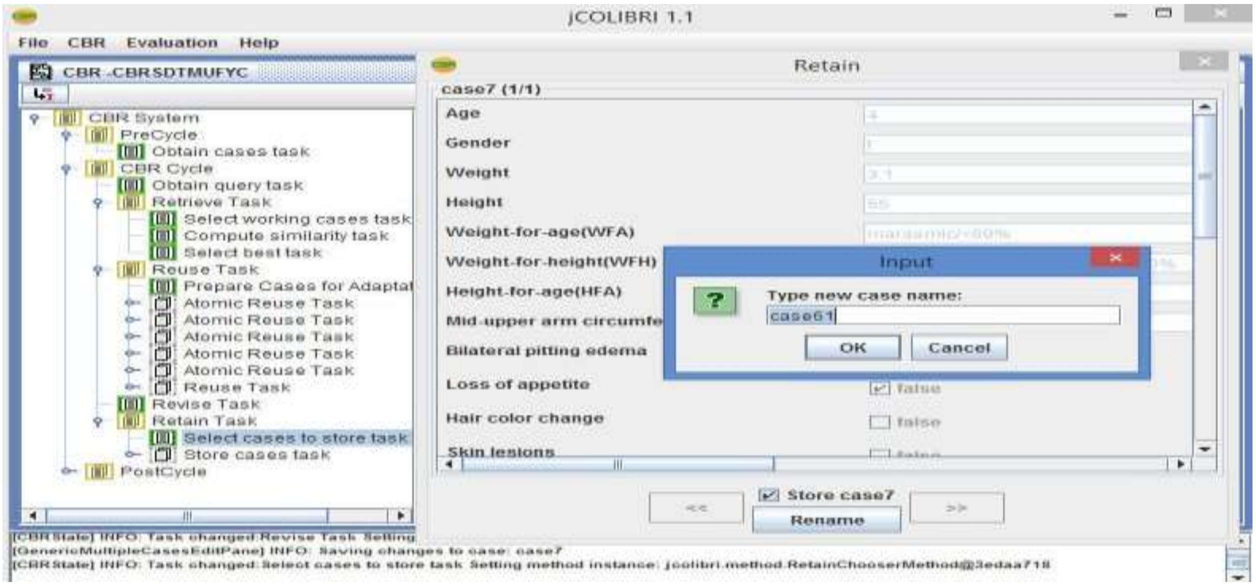
If the returned best case does not meet the criteria for diagnosing and treating the new case/Query, it is suitable for modification. As a result, this new case may be updated and saved in the case database, where it can be used to identify and treat malnutrition in future cases. This demonstrates that the prototype CBRDMUFYC can learn when new instances are entered, and users can then reuse that information in the diagnostic and solution process.

Figure 5.8-3 Revision task



Retain task: After domain experts have approved the change, the problem and its solution may be saved in a case database using the Select cases and Store cases subtasks. At this point, the case has been confirmed, validated, and learnt and is ready to be permanently stored in a case base. And once validated, it was ready to be saved indefinitely for the following assignment.

Figure 5.8-4 Retain task



PostCycle Task: After the CBR cycle, this work was completed. The Close connection task saves the learnt case to a persistent layer of a case base, thus closing the connector.

Case Similarity, Matching and Ranking

The CBR system's main goal is to find the most similar samples using heuristic techniques that quantify similarity. The similarity function calculates the degree of similarity between the stored instances in the case base and the query, then selects the most similar examples. As a result, for case retrieval, jCOLIBRI uses the nearest neighbor strategy. The Nearest Neighbor algorithm is used to compare saved and new queries and present search results in the order they were sorted. For each attribute in the query and case, the local similarity function examines the similarity between two simple attribute values. The weighted sum features from those simple characteristics are used to provide a similarity score between the queries and stored examples for each simple attribute.

Finally, the object is assigned the average score (global similarity) of each attribute between the case and the query (the similarity between the stored case and the query). According to their ranking order, the examples with the highest degree of resemblance are shown.

5.9. Managing Methods

The method library contains the classes that really do the job. These classes employ programming or a graphical user interface to resolve the CBR cycle. Each of the responsibilities stated above should have its own method of accomplishing the goal. A technique describes how to detect and control subtask execution, as well as how to obtain and use the relevant knowledge and information. The following are the main ways used to apply the tasks in the CBRSDMUFYC implementation and application.

LoadCaseBaseMethod: This method returns to the designer all of the accessible cases from the case base. To obtain the case from the case base, this technique uses a plain text connection**.**

ConfigureQueryMethod: opens a graphical user interface (GUI) window where the user may input a query to get cases from the case database. Case structures are used as input parameters.

SelectAllCasesMethod: By holding attributes, this method allows you to display all accessible cases from the case base to the result pane**.**

SelectBestCaseMethod: This approach prioritizes the similarity findings to find the best comparable case among the shown examples**.**

NumericSimComputationMethod: This method is used to calculate the similarity between the query and the cases in the case base. The computation is based on nearest neighbor similarity**.**

CopyCasesforAdaptationMethod: Working cases are selected from the case database and stored in the current context. As an input, it takes the case structure.

CombineQueryAndCasesMethod: atomic task for CBR case reuse A reuse resolution mechanism must be used to complete this operation.

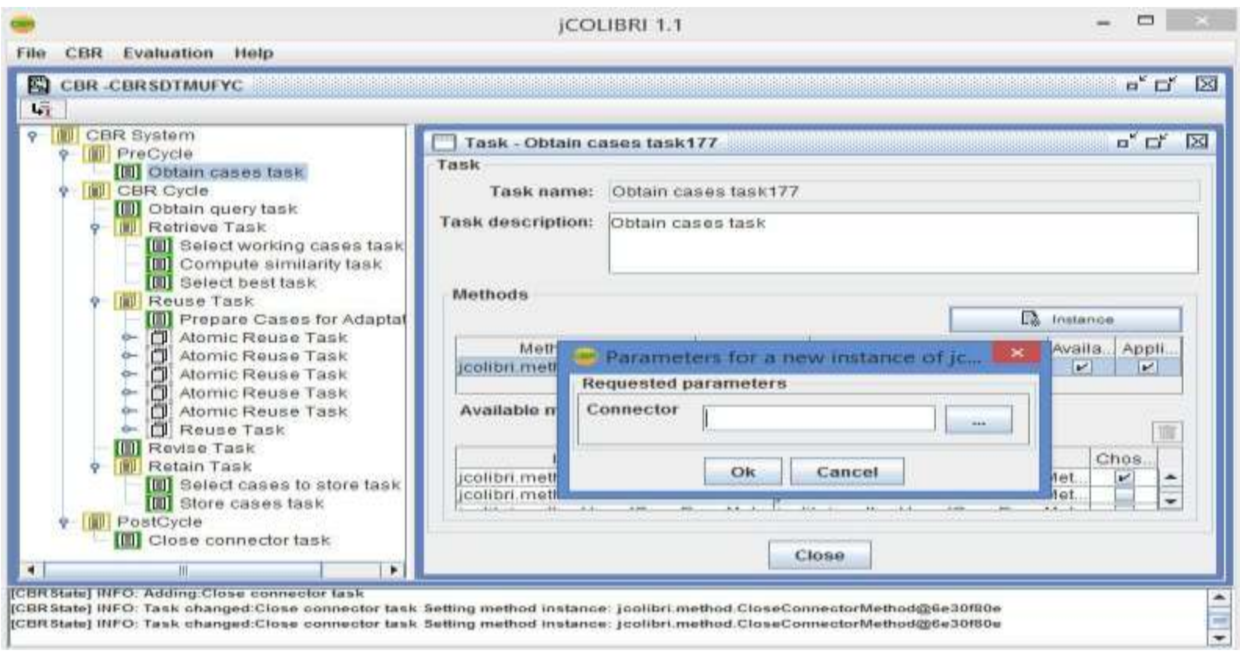
ManualRevisionMethod: When needed, it's utilized to manually change the properties or/and the solution.

RetainChooserMethod: The user can select the technique with this method. The case base will be saved using the technique chosen. The user can choose whether or not this method should be stored in the case base..

StoreCasesMethod: Cases are stored in the Case base using this manner..

CloseConnectorMethod: Closes the connection by storing the case to the case base indefinitely.

Figure 5.9-1 Tasks and methods configuration



In this chapter, the researcher explains how the prototype CBRSDMUFYC works using jCOLIBRI. All four CBR cycle components were employed and handled in the prototype system, including retrieve, reuse, revise, and keep. In terms of giving recommendations for the diagnosis of malnutrition in children under the age of five, the created CBRSDMUFYC satisfied the study's requirements.

System performance testing is the process of determining if the prototype system meets the necessary level of accuracy. It checks to see if the right prototype was constructed. As a result, the next chapter delves into the results of the system evaluation in terms of system performance and user acceptance testing.

5.10. Evaluation of the prototype

The size, complexity, and other characteristics of the knowledge-based system determine the breadth of testing and evaluation that is carried out, as well as the importance attached to it. Because the goal of knowledge-based system testing and evaluation is to ensure that the prototype system accomplishes what it is supposed to do, we may test and evaluate a knowledge-based system as long as we know what to anticipate.

The production of previously solved cases for the case base was one of the most critical steps in the development of the prototype CBR system. At Tirunehse Bejing General Hospital, over 55 previously solved cases were gathered and utilized to create and test the prototype CBRSDMUFYC. The cases were represented by feature-value pairs, with each instance having a different number of attributes. During data cleansing, missing values, erroneous data, and redundant data were all addressed. For this study's testing and evaluation of the prototype, the system has two components. Two examples are user acceptance testing and system performance testing.

5.11. System Performance Testing

The process of assessing whether the prototype system is right, that is, whether it satisfies the specified degree of accuracy, is known as system performance testing. It verifies that the correct prototype system has been constructed.

The metrics accuracy, recall/ sensitivity, F-measure, and specificity are used in this testing procedure to evaluate the prototype system's performance. These three criteria are used to assess the prototype system's precision.

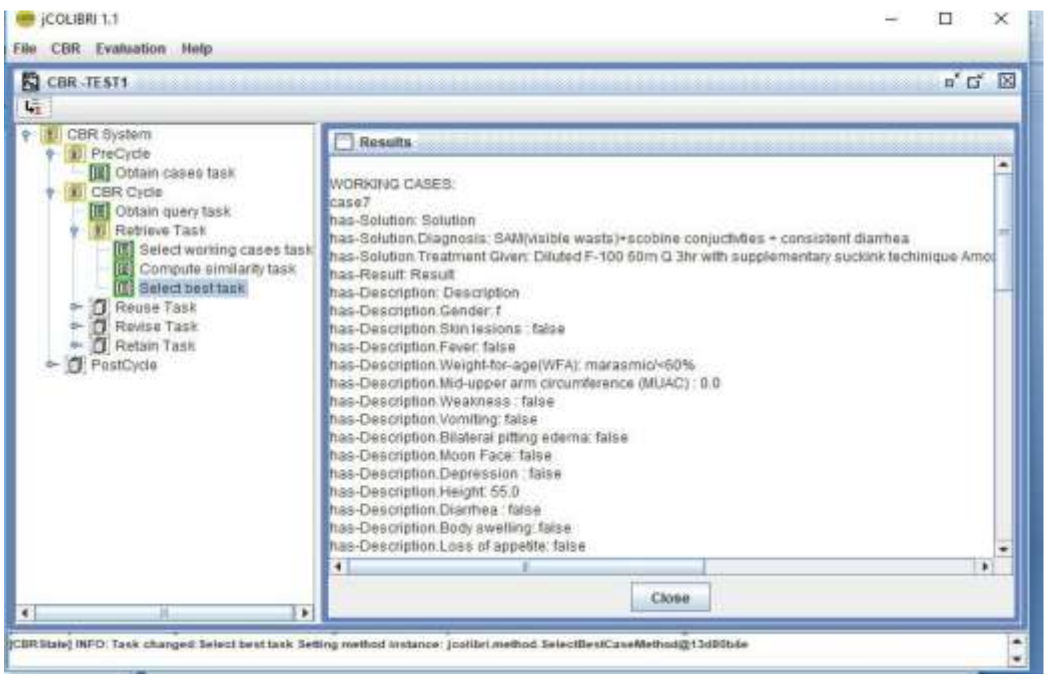
5.12. Testing the CBR Cycle and evaluating the performance of CBRSDMUFYC

Now is the time to evaluate the CBR cycles' functionality and the prototype's soundness using a set of test cases in front of domain experts to ensure its validity and performance. Test cases are used to evaluate the prototype's effectiveness. User acceptance testing is also used to assess the system's performance from the standpoint of the users. Potential system users evaluate the system's applicability in their day-to-day tasks during user acceptance testing.

5.13. Evaluation of the Retrieval and Reuse Process by Using Statistical Analysis

The statistical analysis is based on 55 malnutrition cases collected from Tiruneshe Bejing General Hospital for children under the age of five. In this study, recall and accuracy are used to assess the efficacy of the CBRSDMUFYC retrieval technique. According to McSherry, the most often utilized measures of retrieval performance in CBR are precision and recall (2001). Recall refers to a retrieval system's capacity to retrieve all relevant cases from the case base for a given new problem (query).

Figure 5.13-1 Retrieval of Cases



Precision, on the other hand, is the proportion of relevant cases returned for a given query. The relevant malnutrition cases for under-five-year-old children from the case base should be selected for each test case in order to conduct the evaluation. In order to discover relevant cases, the domain expert is given test cases to assign likely relevant examples from the case base to each of the test cases. The domain expert uses the value of sickness kind and Recommended Treatment or solution features of the malnutrition for under-five year children case as the key concept to allocate the suitable case to the test cases. Recall, precision, and F-measure are calculated once the domain expert has identified the relevant examples to the test cases..

Table 5.13-1 Relevant cases selected and assigned by domain experts for sample test cases

Test cases	**Relevant cases selected from the case base by domain experts**
Case6	Case12, case19, case29, case21, case17, case22, case24
Case7	Case13,case21,case34,case3,case9,case51,case32,case42,case50,case26,case38
Case8	case2, case11, case20, case24, case36, case40
Case9	Case7, case34, case32, case35
Case10	Case5, case4, case34, case13, case18,case16,case30,case17
Case11	Case36, case24,case46
Case14	case12, case23, case26, case21, case41

The next stage is to calculate the recall, precision, and F-measure value of the CBR system's retrieval performance with a threshold interval once the relevant instances have been selected and allocated to the test cases. According to Henok (2011), there is no standard criterion for the degree of similarity that has been utilized for finding relevant examples in CBR. Previous studies employed (1.0, 0.8) threshold. Different case similarity thresholds are used by different CBR researchers. Henok (2011) utilized a [1.0, 0.8] threshold level, which implies instances with a global similarity score of more than 80% are retrieved. The researcher determines the threshold in this study. The [1.0, 0.8) threshold was employed in this study.

Table 5.13-2 Performance measurement of CBRSDMUFYC using precision and recall

	Relevant cases (domain experts)	Relevant cases retrieved (system)	Total cases retrieved (system)	Recall	Precision	F-measure
Test case6	7	6	9	0.86	0.67	0.75
Test case7	11	9	12	0.81	0.75	0.78
Test case8	6	5	6	0.83	0.83	0.83
Test case9	4	3	5	0.75	0.6	0.67
Test case10	8	6	9	0.75	0.67	0.71
Test case11	3	3	4	1.0	0.75	0.86
Test case14	5	4	6	0.8	0.67	0.73
Average				**0.83**	**0.71**	**0.76**

In the study, the recall value was calculated by comparing the numbers of relevant examples retrieved by the system with the relevant cases chosen by domain experts. For example, the system recovered only six examples from seven relevant cases picked by domain experts for the first test case, resulting in a recall of 0.86 for Test case 6. Furthermore, the rest recall values may be determined in the same way as Table 5.3 shows.

In the case of precision, it is relevant cases retrieved divided by total number of retrieved cases, where total number of retrieved cases includes both relevant and non-relevant instances within the threshold value of [1.0, 0.8]. For example, Test case 6 has six relevant instances and two non-related cases, for a total of nine cases retrieved from the case base. As a result, the precision value is 0.67, and precision values for the other test cases may be determined in the same way as indicated in Table 5.2.

As shown in table 5.3, computed recall values for each test case were over 75%, indicating that the prototype CBR system's capacity to retrieve the majority of relevant instances from the case base was good. When recall values were used to evaluate the performance of the prototype system CBRSDMUFYC, the average recall value was 83 percent, indicating a higher recall value that showed the prototype system could acquire the majority of relevant instances from the case base. As a result, the prototype system, CBRSDMUFYC, has the ability to extract relevant instances that may be used to diagnose and treat malnutrition in children under the age of five.

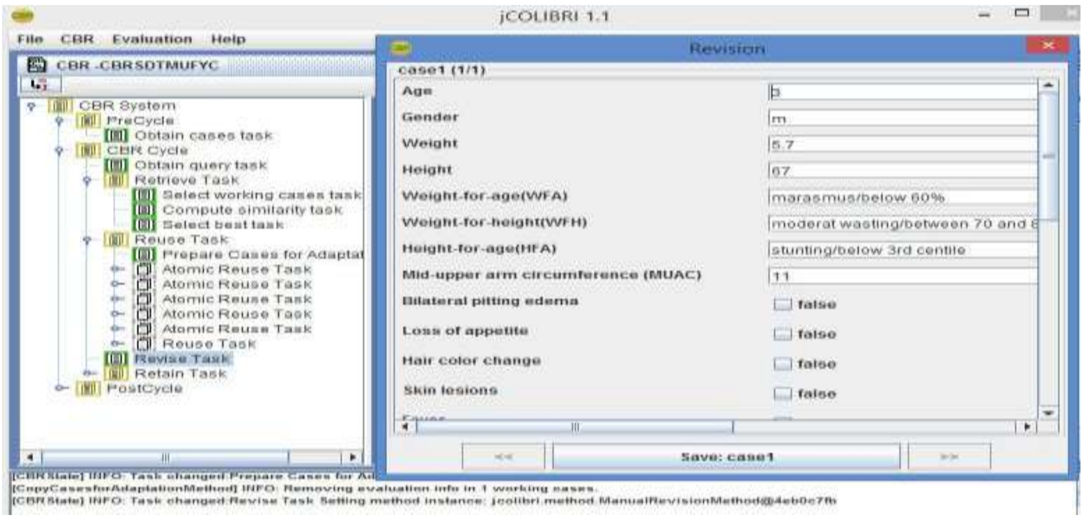
On the other hand, the prototype system recovered relevant examples with an average accuracy of 71%. Although the average accuracy value is good, one of the created system's shortcomings is the small number of examples employed. In reality, however, achieving the required 100 percent accuracy and recall levels proved tough. The recall and accuracy values for the prototype system were an average of 83 percent and 71 percent, respectively, as shown in Table 5.2. The prototype system's performance was also demonstrated by the F-measure value of 0.76. In summary, the system's accuracy, recall, and F-measure average values indicated that it performed well on average and may be utilized to assist health professionals in diagnosing malnutrition in children under the age of five.

5.14. Revise and Solution Adaptation Tests

CBRSDMUFYC's capacity to update the solution whenever necessary is one of its primary features. As medical science progresses in updating treatment, CBRSDMUFYC requires an environment in which it can update itself. When there is an exact match for the query, the adaptation is null, and the retrieved case is utilized without adaptation. However, if an exact matched case cannot be found, the domain experts can change the retrieved best comparable case's answer as needed. Because medicine necessitates extreme caution, altering the solution must be done manually by domain specialists with extensive expertise. After the instances have been modified, the domain expert might manually alter the values of the functioning cases with the domain experts' approval.

After domain experts have verified the modified case in CBRSDMUFYC, it may be saved in the case base for future use. With shifting living situations and new medical findings, not only the treatments, but also the symptoms and indicators, might alter. Manuals and other related documentation used in today's medicine may be updated as well. As a result, as indicated in Figure 5.15, the modification must be done manually by a human domain specialist.

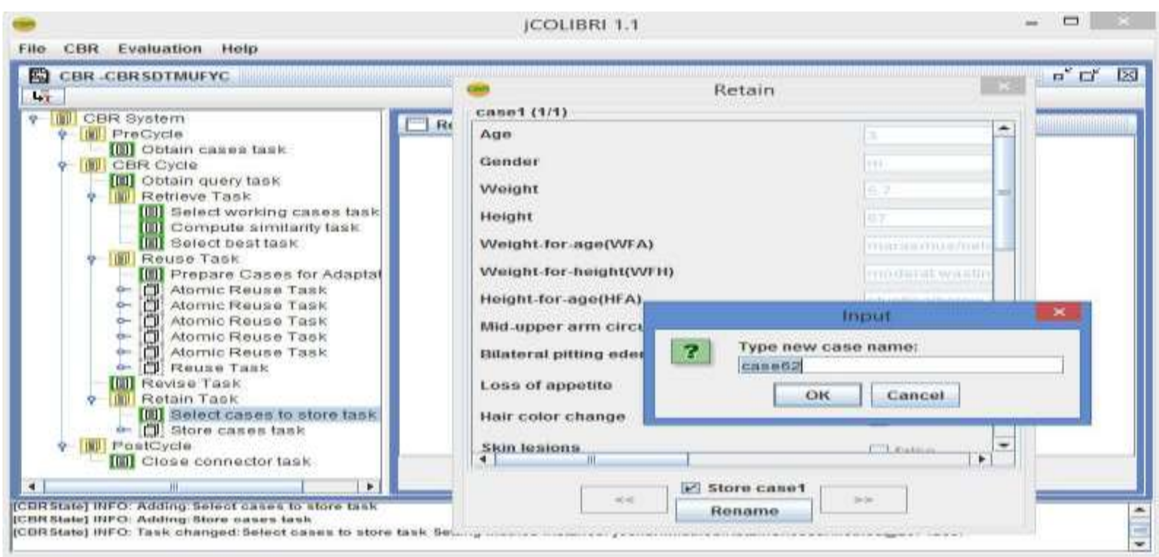
Figure 5.14-1 Revision Interface



5.15. Testing Case Retaining

The last cycle of CBRSDMUFYC is case retention, which is a critical step in saving new cases for future diagnosis. Retaining patients throughout time is very crucial in malnutrition diagnosis since the majority of therapies are for acute malnutrition, which relies heavily on nutritionist tacit knowledge and personal experience.

Figure 5.15-1 Case Retaining Dialog Box



5.16. User Acceptance Testing

Acceptance testing is a sort of testing performed as part of the assessment process to ensure that the generated system meets its goals Abdolzade (2012). User acceptance testing verifies that a solution is usable by the user, i.e. it assesses the app's quality.

For CBRSDMUFYC acceptability assessment, eight (8) domain experts (evaluators) were chosen from Tiruneshe Beijing General Hospital. It's tough to get a large number of responders since the technique necessitates visible engagement with all of the domain experts. The domain experts were shown the prototype system and what it can achieve, including the user interface. The researcher then circulated the questionnaire to the domain experts, who completed it, and data was gathered.

Finally, the prototype system's user approval was assessed. The researcher provided a number value to each choice offered in words to make analyzing easier. Excellent=5, Very Good=4, Good=3, Fair=2, and Poor=1 are the values. The assessed data on user approval of the system that was obtained from the respondents is shown in Table 5.3.

Table 5.16-1 User Acceptance testing from domain experts

No.	Criteria of evaluation	Poor	Fair	Good	Very Good	Excellent	Average	Avera e (%)
1	Is the prototype easy to use and interact with ?	0	1	2	2	3	3.875	77.5%
2	Is CBRSDMUFYC attractive?	0	0	2	3	3	4.125	82.5%
3	Is the system more efficient in time?	0	0	1	2	5	4.5	90%
4	How accurately does the system reach a decision about malnutrition diagnosis?	0	1	1	2	4	4.125	82.5%
5	Does the system incorporate sufficient knowledge about how to diagnosis and treatment of malnutrition?	0	0	3	3	2	3.875	77.5%
6	Is the system give the right treatment and explanation?	0	0	1	3	4	4.375	87.5%
7	How do you rate the significance of the system in the domain area?	0	0	2	4	2	4	80%
						Average	4.125	82.5%

According to Table 5.3, 37.5 percent of consumers thought the prototype were great, 25% thought it was very good, 25% thought it was good, and 12.5 percent thought it was fair. This demonstrates that the system is simple to use and interacts in some way. The second assessment criterion is the prototype system's beauty, which was rated highly by the assessors. The majority (37.5%) were rated exceptional, 37.5%) were rated very good, and 25% were rated decent. In terms of system efficiency, 62.5 percent of the evaluators gave it an exceptional rating, 25% gave it a very good rating, and 12.5 percent gave it a decent rating. Furthermore, the assessors rated 50 percent of the prototype system's accuracy in diagnosing malnutrition as exceptional, 25 percent as very good, 12.5 percent as good, and 12.5 percent as fair. When asked if the prototype system had appropriate knowledge regarding malnutrition diagnosis and treatment, the assessors gave it a 25 percent outstanding rating and a 37.5 percent very good or good rating. The prototype system's capacity to provide the appropriate treatment and explanation for each malnutrition instance was rated outstanding by 50% of the evaluators, very good by 37.5 percent, and good by 12.5 percent. Finally, the system's importance in the domain area criteria reveals that 50% of the evaluators rated the system as very good, and 25% as good or exceptional. Finally, according to the domain experts' evaluation findings, the system's average performance is 4.125 out of 5 or 82.5 percent, which is excellent.

The prototype system's user approval could not be assessed completely. Because the majority of domain specialists are unaware of CBRS and its significance in their domain area. As a result, CBRSDMUFYC can be used to assist in the diagnosis of malnutrition in children under the age of five. According to the feedback received from domain experts during testing, training on the CBRSDMUFYC is required for a better understanding and usage of the prototype system. They also noted the need for more cases to be added to the case database in order to provide a more accurate diagnosis of malnutrition in children under the age of five. They emphasized the CBRSDMUFYC's limitations, such as the lack of detailed descriptions when they were needed.

CHAPTEER SIX

CONCLUSION AND RECOMMENDATIONS

6.1. CONCLUSION

Many health institutions now have IT applications to assist them, which has resulted in enhanced capacity by reducing the time and cost of delivering health services. CBRSs have proven to be quite useful in today's technologically advanced world. It emphasizes the need of early detection and treatment of malnutrition.

Malnutrition management is a big issue all over the world. They are most certainly one of the most common causes of death among children under the age of five. Because just a few health care staff have been trained on malnutrition, as well as health professionals' poor practical performance because nutrition training in medical curricula has been inconsistent, unreliable, and insufficient, especially in undeveloped nations like Ethiopia. Furthermore, the health facilities do not have a dietician on staff, and no health education sessions on nutritional issues have been seen. As a result, this prototype CBR system was developed to share the experience of highly competent medical specialists in order to support decision-making when needed.

Intentionally collected from Tiruneshe Beijing General Hospital for this design science investigation were previously solved situations by competent medical personnel. A hierarchical tree was used to organize and portray the information, which reflects theories and approaches for diagnosing malnutrition in children under the age of five.

The knowledge is expressed utilizing a case-based reasoning technique once the learned information has been modeled. The cases were expressed using the attribute-value format. The researcher used jCOLIBRI to build the prototype CBR system, which is free and can do all of the CBR cycle's actions, including retrieve, reuse, edit, and maintain. The system may locate past examples with their similarity values for the problem case by supplying similarity values for all instances to the issue case.

For the purpose of evaluation, both system performance and user acceptability tests were undertaken, and the findings were positive. The system received an 82.5 percent user approval rating, indicating that the CBRSDMUFYC is acceptable to professionals and necessary for diagnosing malnutrition in children under the age of five, as well as implementation in health facilities. Furthermore, the system's accuracy is 83.3 percent, according to the performance results.

6.2. RECOMMENDATIONS

The research's objectives have been met, as stated in the preceding section. Improvements and open issues are still waiting, as expected, because there is always opportunity for improvement. As a result, the next duty is to suggest some probable issue areas that our study has discovered. As a result, future researchers should look at a variety of issues related to the use of CBR in the treatment of malnutrition in children under the age of five.

- When the nearest technique is used, the retrieval time increases linearly with the number of instances, and the closest match is returned even if the source and new input cases are different. In future investigations, other retrieval approaches, such as template retrieval, which retrieves all instances that fulfill particular criteria, should be employed.
- The prototype was limited to diagnosing malnutrition in children under the age of five. It is preferable to cover all age groups, such as infants and adults, in order to provide a greater perspective

6.3. FUTURE WORK

- Additional combinations, such as knowledge bases and rule bases combined with data mining, can be employed to increase the accuracy of malnutrition diagnostic decisions.
- A future project is a self-learning Case Based Reasoning System for the detection and treatment of malnutrition in children under the age of five. Because the symptoms of that case may change over time owing to various reasons, mentioning these symptoms and signs may be necessary.

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APPENDICES

APPENDIX I

The main objective of this interview questions is to elicit knowledge from Malnutrition experts that will help for the development of a case based reasoning system for Malnutrition diagnosis. The interviewer records the necessary responses from respondents using pen and paper.

I thank you in advance for your willingness and precious time.

1. What is Malnutrition? How can we classify Malnutrition?
2. What are the main risk factors for Malnutrition?
3. What are the main signs and symptoms for Malnutrition disease and which one of them are common to most of patients?
4. How do you identify the major symptoms of Malnutrition?
5. What are the main Malnutrition diagnosis procedures that you follow and which one is the crucial for your decision making process?
6. Does Malnutrition have stages? If it has, what are they and by what measurement they are differentiated?
7. What attributes are considered by the clinician in order to identify whether the compliant has the disease or not?
8. If the compliant is a Malnutrition patient, what things are considered by the clinician in order to manage the disease?
9. What are the main decisions that the clinicians make in Malnutrition treatment?
10. Which attribute are the most important in diagnosing the disease that the clinician should focus Malnutrition measurement?
11. Is there any standard guideline that you use for the diagnosis of Malnutrition patients?
12. What are the major challenges identified during Malnutrition diagnosis? How can you manage them?

APPENDIX II

Questionnaire for performance evaluation of the prototype case based reasoning system (CBRSDMUFYC)

This is an evaluation form to be filled by malnutrition diagnosis experts in order to evaluate the applicability of the prototype case based reasoning system for malnutrition for under-five year children diagnosis.

The developed prototype CBR system can give a decision support for diagnosis of malnutrition for under-five year children at different levels of expertise.

I thank you in advance for your willingness and valuable time.

Description of the parameter values are as follows: Performance Value 1=Poor; 2=Fair; 3=Good; 4=Very good; 5=Excellent

Instruction: Please, tick (X) mark on the appropriate value for the corresponding parameters of the prototype case based reasoning system for diagnosis of malnutrition for under-five year children.

No		Poor	Fair	Good	Very Good	Excellent
1	Is the prototype easy to use and interact with?					
2	Is CBRSDMUFYC attractive?					
3	Is the system more efficient in time?					
4	How accurately does the system reach a decision about malnutrition diagnosis?					
5	Does the system incorporate sufficient knowledge about how to diagnosis and treatment of malnutrition?					
6	Is the system give the right treatment and explanation?					
7	How do you rate the significance of the system in the domain area?					

8. What do you think the limitations of CBRSDMUFYC in diagnosing of malnutrition for under- five year children? ___________________