JIMMA UNIVERSITY
COLLEGE OF NATURAL SCIENCES
DEPARTMENT OF INFORMATION SCIENCE

A CASE BASED REASONING SYSTEM FOR DIAGNOSIS OF MALNUTRITION FOR UNDER-FIVE YEAR CHILDREN

By:
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June, 2018
Jimma Ethiopia

JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF INFORMATION SCIENCE

A CASE BASED REASONING SYSTEM FOR DIAGNOSIS OF MALNUTRITION FOR UNDER-FIVE YEAR CHILDREN

A research submitted to the Department of Information Science, College of Natural Sciences, Jimma University, in meeting the partial fulfillment for the award of the degree of master of Information Science (Information and Knowledge Management)

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June, 2018

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DEDICATION

This work is dedicated to my beloved family especially for my father Derbie Gonit and my mother weyzero Almaz Sefefe.

DECLARATION

I declare that this thesis is my original work and it has not been presented for a degree in any other universities. All the material sources used in this work are duly acknowledged.

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Mekdes Derbie

June, 2018

This thesis has been submitted to the department for examination with our approval as university advisors:

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June, 2018

AKNOWLEDGEMENT

First of all, I would like to gratitude almighty God for giving me strength and wisdom to complete this thesis work. Next to God, My greatest appreciation goes to my advisors; Dr. Million Meshesha and Mr. Berhanu Megersa, for their scholar guidance, encouragements and comments throughout the research work.

I want to appreciate the management and staffs of Jimma University Specialized hospitals and Hawasa university comprehensive specialized hospitals, for their great assistance during the time of my research work.

I would also like to express my warm thanks to Assosa University for sponsoring my Msc. study at the Department of Information science, specialization in information knowledge management in Jimma University, my families and all my friends who provided me with moral support and encouragements throughout my study.

Finally, I would also like to give my sincere gratitude for those who are not mentioned in name but who encourage, support, challenging comments without those this research would be incomplete.

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LIST OF ACRONYMS AND ABBREVIATIONS

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

ABSTRACT

Malnutrition is an umbrella term for the unsuitable intake of nutrients needed to sustain healthy development; the term applies to under or over nutrition. It is possibly known to be one of the predominant causes of illness and death for under-five children in Ethiopia. Some of the reasons which worsen the spread of malnutrition in the country are: lack of specialists, practitioners and health facilities at lower level health institutions in order to diagnose and give treatment at early stage. Artificial Intelligence, which uses computer applications by simulating human intelligence, was applied in the research especially for malnutrition diagnosis. 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 cases were collected from both Jimma University specialized hospital and Hawasa university comprehensive specialized hospitals and design science were followed to design prototype case based reasoning system. Stratified sampling technique was employed to select domain experts for knowledge acquisition and for system testing and evaluation from Jimma University specialized hospital. For the development of the prototype system, the researcher used jCOLIBRI version 1.1 implementation tools and nearest neighbor algorithm. Evaluation of the developed prototype was performed for both system performance and user acceptance. For testing of the prototype seven test cases and six domain experts were used. Based on evaluating the performance of the system, the average precision and recall values achieved were 71% and 83% respectively. User acceptance testing also performed by involving domain experts and an average of 83% acceptance was achieved. Insertion of additional cases could increase the performance of the CBR system. In this study a promising result was obtained and met the objectives of the study.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Malnutrition is possibly one of the predominant causes of illness and death for under- five children in Ethiopia. Since under-five age is an indication of changes between life as child and life as adolescents covering the ages between 6-59 months, it is considered to be an important period of development. The study conducted by Uthman *et al.*, (2009), revealed that increasing nutritional status for under- five ages tell to the fact that under-five gain up to 50% of their adult weight, more than 20% of their adult height, and 50% of their adult skeletal mass.

According to Konje *et al*., (2007), Jump, (2010), Beers *et al*., (2004), and Ahmed *et al*., (2009) the most frequent causes of death in children under-five years old are acute diarrhea and acute respiratory infection. Several studies have shown that malnutrition is commonly causally associated with these deaths. As noted by the world health organization, child malnutrition is known to be one of the measures of health status on behalf of equity in health. Stunting, wasting, and underweight are among those Anthropometric indicators that are frequently used to measure malnutrition in a population of under-five children. Underweight (low weight-for-age) which reveals both low height-for-age and low weight-for-age and hence, it shows both cumulative and acute exposures of malnutrition (Janevic *et al*. 2010). There were 925 million undernourished people in the world in 2010, an increase of 80 million since 1990 (Jump, 2010).

According to Mamiro *et al*., (2001), malnutrition has long been associated with poor diet and inadequate access to health and sanitation services. Malnutrition remains a major public health problem particularly in the developing countries where it accounts for more than 90 % of all nutritional connected conditions with two third of all cases originating from Sub-Saharan Africa and morbidity and mortality due to malnutrition is high among children under 5 years of age. Several studies have reported that poverty, inadequate access to a balance diet and underlying diseases (tuberculosis, malaria, diarrhea, etc.) contribute to high levels of malnutrition (Alderman, 2006). Even children with mild and sensible malnutrition have an increased risk of death. Identifying children with malnutrition and treating them can help avoid many severe diseases and death (WHO, 2011). A study by the World Health Organization (WHO) also demonstrates that child death and malnutrition have a substantial unequal, global distribution (VandePoel, 2008).

Malnutrition in children can take the form of stunting, wasting, or underweight (Mahgoub *et al.,* 2006). Children whose weight-for-age indicator is more than two or three standard deviations below the median for the international reference population (ages 0-59 months) are considered moderately or severely underweight (WHO website 2011b). Children whose height/length-for-age indicator is more than two or three standard deviations below the median for the international reference population (ages 0-59 months) are considered moderately or severely stunted (World Bank website, 2011).

In line with this, according to the study by the Botswana Ministry of Health and UNICEF, (2008), Children whose weight-for-height/length indicator is more than two or three standard deviations below the median for the international reference population (ages 0- 59 months) are considered moderately or severely wasted.

Knowledge based system is a branch of Artificial Intelligence that help to represent expert knowledge in artificial way (Wilke and Bergmann, 2004). It is a computerized system which uses tacit and explicit knowledge of highly qualified professionals with different approach in order to assist decision making in different working areas.

There are different types of case representation techniques used for diagnosis; among which the most common are rule based and case based reasoning (Pandey and Mishra, 2009). According to Fag and Songdong (2007), Prem *et al* (2012) and Mitra and Basak (2005); rules represent general knowledge of the domain, whereas cases represent specific knowledge. Rule-based systems solve problems from scratch, while case based systems use pre-stored situations to deal with similar new instances. In rule based updatability of solution is challenging and prepared to work only on the existing rules. While CBR used to reduce the knowledge acquisition task, providing flexibility in knowledge modeling. This indicated that case based system is ease technique for developing knowledge based system for diagnosis of malnutrition for under-five year children. In addition, knowledge in the form of new cases faced during real-time operation can be incorporated into the case base in extending the effectiveness of the case based system.

According to Prem and Saxena (2011), CBR is solving new problems by adapting solutions that were used to solve old problems. CBR is a type of knowledge representation which uses previous experiences in form of cases to understand and solve new problems. CBR has been applied in different areas: medicine (Alemu, 2010), law (Ethiopia, 2010) and education (Baisen, 2013).

Solving a problem by CBR involves gaining a problem description, measuring the similarity of the current problem to previous problems stored in a case base with their known solutions, retrieving one or more similar cases, and attempting to reuse the solution of one of the retrieved cases, possibly after adapting it to account for differences in problem descriptions. The solution proposed by the system is then evaluated. If we have a new problem, it has to be represented as a case, and then four steps involved in CBR; retrieve the most similar case or cases, reuse the case or cases to attempt to solve the problem, revise the proposed solution if necessary and retain the new solution as a part of a new case (Aamodt and Plaza, 1994).

CBR in medicine helps to diagnose diseases by using previously successfully solved experiences of specialized doctors. It doesn't mean CBR approach replaces the work of a specialist doctor but helps in decision making to apply the experience of highly qualified health professionals in their absence. CBR has been used in different application of medicine for diagnosing patients. Some of CBR systems applied in medicine include: “CASEY” that gives a diagnosis for the heart disorders Salem *et al*.,(2005) and “COSYL” that gives a consultation for a liver transplanted patient (Schmidt *et al*.,(2001).

1.2. Statement of the problem

As the prediction of World health organization (WHO) on malnutrition prevalence, it is found that around 3 million people are exposed from malnutrition of one kind or other (Fletcher & Carey, 2011). Malnutrition is one of a serious health problem mainly in the developing countries consequently affects around 800 million people that accounts the largest proportions found in Africa and south East Asia. Therefore, it is the most identifiable and perhaps leads to poverty in children (Afework *et al*., 2010).

Consequently, the prevalence of stunting (height-for-age) in children under the age of five years in East Africa averages estimated to be 48 percent (ACC/SCN 2005), which is the highest in the world. Different evidence possibly assured that the situation regarding malnutrition in Ethiopia is worse than in other East African countries.

According to Amsalu *et al.*, (2008), Poor infant and young child feeding practice, poor socio-economic background and nutritionally inadequate diet donate more for severe acute malnutrition in Ethiopia. Another study by SCUK, (2009) showed that, Ethiopia is the second most populous country in Africa, at nearly 105 million; approximately 14% are children under five years of age (Central Statistics Agency, 2012). Population projection, according to the Ethiopia Census 2007, these children and their mothers suffer disproportionately from the poor health and nutrition situation in the country. In fact, malnutrition is the underlying cause of 57% of child deaths in Ethiopia, with some of the highest rates of stunting and underweight in the world (Gezae and Nigatu, 2014). Worldwide trends show that malnutrition and lack of sanitation contribute to over half of all under-five deaths (UNICEF, 2012). With this regard, a paper by Bantamen *et al*., (2014) and Grover and Eele, (2009) has shown that about one-third of deaths among children below five years of age were happened due to under nutrition. Hence, it can exposed children to a greater risk of death and severe illness because of common child infections such as pneumonia, diarrhea, malaria, human immunodeficiency virus, measles, Marasmus, kwashiorkor, anemia, goiter, hypernatremia, hypokalemia and vitamin deficiency. Therefore, under-five malnutrition is the most common risk that tremendously occurred in rural and urban area.

Black *et al.,* (2013), noted that Children malnutrition is the single biggest contribution to under-five mortality as a result of greater exposure to infection. Childhood under nutrition is being a predominant health problem as worldwide by contributing childhood morbidity, mortality, impaired intellectual development, suboptimal adult work capacity and increased risk of diseases in adulthood. Beside this, the burden of malnutrition in Ethiopia is also a serious problem specifically for Children under-five. With this regard, in 2014 the prevalence of under-five stunting was at 40%; which is numerically around six million people were affected (UNICEF, 2015). Wasting among children under-five were at nine percent, a total value of more than 1.2 million affected in 2014 (UNICEF, 2015).

Due to the rate, prevalence and spread of malnutrition in Ethiopia, under-five children are extremely exposed to different diseases especially in area where health services and knowledge towards malnutrition is not fully expanded. Beside this, Lack of diagnostic facilities and low quality health services might contribute to low case detection rates of malnutrition (FDRE-MoH3, 2008).

To get a diagnosis of malnutrition in rural areas of the country, people may expect to pass the referral system. Poor socio-economic background and inaccessibility of diagnosis system and equipment nearby make the rural people to suffer and not to get proper diagnose for malnutrition. In Ethiopia even though primary health care workers available at lowest level, they lack enough knowledge and facilities for diagnosis of the disease at their level. There is lack of highly experienced health professionals and are not equally distributed in the country for better nearby diagnosis and treatment (WHO, 2013).

To tackle the problem at the starting point, remoteness and inaccessibility of rural areas, lack of enough funding to the health sector by the patrons, lack of skilled health professionals, time taking, lack of medical equipment's, costly and unavailability of high performance diagnostic methods in the country are the main bottlenecks in diagnosis and treatment of the diseases (WHO, 2002).

It is obviously known that human experts are essential to give the diagnostic knowledge, but this is still a problem in some health service sectors. Consequently, health professionals had not enough knowledge about the case detection and appropriate management of malnutrition in children (Zelalem and Anteneh, 2015). The possible reason for this might be that only a few health care workers have been trained on malnutrition (Yuna, 2014, Kim *et al*., 2009; Antoinette *et al*., 2011; Kobe, 2006). Other study reasons out the poor practical performance of health professionals as nutrition education in the medical curricula has been random, uncertain and far from adequate (MOPH, 2012). Additionally, there is no nutritionist assigned in the health centers and it is not observed a health education session on nutritional issues (Zelalem and Anteneh, 2015). In order to improve this problem, there is a need to apply knowledge base systems as a powerful tool with extensive potential in malnutrition.

Current medical practices are more knowledge intensive and the need for intelligent KBS has been increased (Djam and Kimbi, 2011). The knowledge consists of rules and cases that are available in codified materials (books, manuals, articles, etc.) and gained from experiences (Schmidt and Gierl, 2001). In case based reasoning, experience of previously solved cases was used for the diagnosis of the new case; and with the possibility of updating previous cases with a new case (Schmidt and Gierl, 2001).

In Ethiopia, there are different research attempts that are conducted to apply a knowledge based system in supportive medical and other service but some of them uses a rule based reasoning techniques. For instance in health area, Getachew (2012) attempt to design a prototype knowledge based system for anxiety disorder diagnosis using case based reasoning technique and Alemu (2010) tried to design a knowledge based system for AIDS resource center using a case based reasoning approach. However as per the researcher knowledge there only few research attempts to assess the current status and effect of malnutrition on under-five year children (Solomon and zemene, n.d; Zelalem and Anteneh, 2015).

Therefore, on the current study the researcher was aimed to design a prototype case base reasoning system for early diagnosis of malnutrition to strengths the contributions made so far by providing system based help for diagnosis of malnutrition. To this end, the study attempted to investigate and answer the following research questions.

- What are the suitable cases used for diagnosis of malnutrition under-five year?
- How the acquired cases were modeled and represented in developing the CBR system?
- To what extent the prototype case-based KBS works for diagnosis of malnutrition under five year children?
- To what extent the performance of the prototype system gets user acceptance?

1.3 Objective of the Study

The study has the following general and specific objectives.

1.3.1 General objective

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 objectives

The specific objectives of the research are as follows:

- To review literature and identify methods and techniques that are suitable for designing a CBR system.
- To acquire domain knowledge from previously solved cases and relevant documents.
- To model and represent the acquired knowledge from knowledge experts and solved cases.
- 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. Scope and limitation of the study

The study is emphasized to develop a prototype case based system that diagnoses for malnutrition patients. The cases are collected for those malnutrition patients in the hospital in under-five year, because they are the most commonly affected age group in Ethiopia (WHO, 2012). Individual patient's card history or cases were collected from Jimma University specialized referral hospital and Hawasa University comprehensive specialized hospital. In this study for prototype development only under-five year children malnutrition symptoms used. During testing and evaluation of the prototype, only Jimma university Specialized Hospital malnutrition case team members were involved. Because highly qualified and experienced malnutrition professionals are presented in that area.

In designing the prototype of Case Based Reasoning system, four major tasks of Case Based Reasoning system are applied, such as retrieve, reuse, revise and retain. The prototype CBR system could diagnose new malnutrition respondents by retrieving and reusing previous solved cases. If there is no exact match, nearest neighbor similarity algorithm matched based on which adaptation process were take place. If there is a need for new symptoms and medicine, adaptation to revise the current treatment could be taken place by the system and finally retaining the new case in the case base is performed for diagnose of future new cases.

There were some limitations which can be expressed as resources and time. One of the challenges was the difficulty in acquiring more cases during data collection. The reason for this was: the first one is patients' cards were kept in scattered places mixed with other disease types and malnutrition all age group patient cards. So it is difficult to identify only malnutrition under-five year children cases from others; the second one is, after malnutrition under-five year children patients' cards were collected, the necessary information needed might not be exist; and the third limitation was, there were difficulty in extracting features from texts which have taken more time. The other limitation of the study was relates to the number of limited cases obtained by the researcher. Even if those cases can be used for the research successful computation, it would be possible to obtain a better result with more number of cases.

1.5. Significance of the study

The system designed enable to reduce the problem of the limited numbers of expert in giving preliminary diagnosis of malnutrition especially in rural areas. The direct beneficiaries of the system are primary health care workers and health professionals working in the diagnosis of malnutrition. The prototype system could give advisory services for health professionals who have basic skill in health care. In addition to this, the prototype was being 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 is developed using the knowledge of multiple malnutrition health domain experts and documentary sources which is used as organizational memory. Therefore, it gives better advisory services where highly qualified malnutrition health professionals are not found.

1.6. Methodology

1.6.1. Research design

In this study design science research approach were followed to design a case based system for diagnosis malnutrition of under-five children. Design science combines different research methods used for qualitative and quantitative information system research. The process is structured in three main phases "problem identification", "solution design" and "evaluation" that can interact with each other within the research process (Philipp *et al*., 2009). As a result, this research was followed design science model building and analysis.

1.6.2. Data collection method

For the purpose of the study, both primary and secondary data collection methods were employed to collect the required domain knowledge to better understand the domain under investigation by the researcher. The primary data were collected by using interviews from malnutrition experts who work in specialized hospitals based on their level of experiences and availability, because to understand about domain knowledge by the researcher. In addition, relevant literature from all possible sources, including internet, books, and journals articles, different previous researches, guideline for malnutrition case management, modeling and cases representation, system design and development.

Numbers of attributes are determined according to their importance by domain experts. Previously solved cases (experiences) were collected by the researcher with the help of nurses who have working specifically in malnutrition diagnostic centers like hospitals and clinics. To supplement secondary sources, tacit knowledge was acquired by interviewing highly qualified experienced health professionals. A semi-structured interview questions were conducted with the selected health professionals in order to acquire the necessary knowledge for the study. The main reason that the researcher used a semi-structured interview compare to other type of interview is that semi-structured interview guide interviewer by providing both types of closed-ended and open-ended questions. It allows the interviewer to change the order of the questions and add new questions based on the context of the participant response so as to get depth knowledge. The interview focuses on the concepts, procedures, guidelines, and experience which the health professionals focus on, during malnutrition management.

1.6.3. Study population and sampling technique

For the prototype development, cases of malnutrition patients from Jimma University specialized hospital and Hawasa University comprehensive specialized hospital were used because to eliminate the scarcity of case that was occurred during case collection by the researcher and as literature shown on those areas malnutrition under-five year children was sever. Stratified sampling technique was used for selection of previously solved cases often classifying the cases based on cluster. The case class was done by considering the experience and qualification of medical professional. For interviewing domain experts, four experienced health professionals were selected depending on their qualification and experience from Jimma University specialized hospital and Hawasa University comprehensive specialized hospital.

Three experts are consulted in the course of the study and one nutritionist nurse involved in the registration of the patient cases from the card. Even if there is no standard number of cases to be used for CBR system development, for example, Ethiopia (2002), Yemisrach (2009), Alemu

(2010), Henok (2011) and Getachew (2012) used cases 39, 40, 51, 45 and 50 respectively for building and testing their prototype.

Among 64 cases, 26 cases were collected from Hawasa University comprehensive specialized hospital and the remaining 38 previously solved cases were collected from Jimma University specialized hospital. The main reasons for selecting few cases (64) cases from the available cases were: firstly, patients' cards were kept in scattered places mixed with other disease types and malnutrition for all age group, so was difficult to identify malnutrition for under-five year children cases from other disease types and malnutrition for all age group; again, after malnutrition for under-five year children patients' cards were collected, the necessary information (problem attributes and solutions) needed might not written on the card; and thirdly, there were a difficulty in extracting features from the texts from card history of patients. So data collection was so challenging task in terms of time. Therefore, these factors limit the number of records to be used in this research

The researcher used 56 cases after cleaning the redundant and inconsistent data which was fully available cases of data, for the development and test of the prototype system. Previously solved cases were used for the case base to diagnose the new cases from both specialized hospitals. Redundant cases for diagnosis were cleaned and only relevant cases were used for the analysis purpose. So from collected 64 cases 56 cases were used for the system and testing. The selection criterions of cases for the study were based on the experience of doctors in diagnosis of malnutrition for under-five year children.

1.6.4. Implementation tools

To develop KBS there are various programming tools which are available both freely and commercially. Among this SWI-prolog, myCBR, and jCOLIBRI are among the most 11 widely used and known frameworks for teaching and academic research purpose (Antanassov and Antonov, 2012). All of the aforementioned tools have their own capabilities and limitations. For example, the main limitations of myCBR are: Does not support full CBR cycles (only Retrieval and Retain are supported), does not work with external database and Applicable for simple CBR applications. According to Juan *et al*. (2009), jCOLIBRI framework has the following features. A

CBR tool could be used to develop several applications that require case based reasoning methodology. Hence in this study for the development of CBR prototype system, the researcher used JCOLIBERI version 1.1 which is object oriented framework based on the following unique capabilities, according to Triki and Bellamine (2013), the major advantage of JCOLIBERI comes from its support of full CBR cycle (retrieve, reuse, revise, retain). It is also suitable for developing large scale applications works well with external data base, extensible framework and compatible with different applications as its developed based on object oriented framework.

1.6.5. Evaluation procedure

After developing CBR prototype, it was tested its functionality and user acceptance of the system. The evaluation processes focus on system's user acceptance of the prototype and the performance of the system. User acceptance measurements are concerned with issues how well the system addresses the needs of the user, whereas performance measurement determine if the system perform the required task successfully. In addition to this, the standard effectiveness measures of the case based system, such as precision and recall used to evaluate the performance of the prototype. Recall is defined as the ratio of the number of relevant cases returned to the total number of relevant cases for the new case in case base (McSherry, 2001). Whereas precision is the ratio of the number of relevant cases returned to the total number of cases for a give new case (McSherry, 2001).

The researcher evaluated the CBS using system performance testing by preparing test cases and user acceptance testing questionnaire which was help the researcher to test the proposed system with potential users to check the proposed systems meets user requirements. The normal effectiveness measures of the case based system, such as precision and recall used to evaluate the performance of the prototype. And also system performance testing was conducted using prepared seven test cases; whereas User's acceptance testing was conducted by taking six health professionals (2 medical doctors, 2 health officers and 2 nurses) from Jimma University referral hospital. So, an evaluation was performing on how much the system performed and by how much users accept the CBR system in helping the diagnosis of malnutrition under-five year

Childs. Therefore, both system performance and user acceptance were performed for testing the prototype system.

1.6.6. Validity and reliability

Knowledge-based systems (KBSs) can be defined to be a computerized system that uses knowledge about some domain to arrive at a solution to a problem from that domain. In fact, the quality of CBRs is often adequate to the quality of the knowledge stored in the case base. Ensuring the quality of CBRs involves two types of activity (Gasching, 1983): 1) activities intended to assure that the case base system is structurally correct or verification activities and 2) activities intended to demonstrate CBR ability to reach correct conclusions or validation activities. These two activities are complementary, each is effective at detecting errors that the other will miss, and they are therefore usually employed together.

Validation concerns both the quality of a system' decision and advice, and the correctness of the reasoning techniques used. The most widely used empirical validation technique is testing (Preece, 1995). This technique involves running a set of test cases on the CBSs and compares the output for agreement with those of an expert or a panel of experts. Therefore, validation would involve comparing a human expert to the output of the system, with the system being accepted if it were at least as competent as the human was (Reggia, 1988). Beside validation verification has also a lot of contribution on system testing. It has two approaches that can be used to verify knowledge-based systems: verify knowledge base formation and verify knowledge base functionality.

1.6.7. Ethical consideration

The proposed study findings should benefit and cause no harm to the participants and society. Privacy and confidentiality were maintained at all times; all findings were portrayed in a confidential manner no personal or identifiable information was recorded or printed in the study. No names were recorded during the interviewing process. The data was not being transferred to any third party.

1.7. Organization of the Thesis

The thesis is organized in to six chapters. The first chapter presents background information about malnutrition, knowledge based system, statement of the problem, objective, scope and limitation of the study, significance of the study and methodology of the study.

Chapter two presents the review of related literature, Chapter three discusses about knowledge acquisition, modeling and representation of knowledge, chapter four deals about the architecture of CBRSDMUFYC and its implementation, the fifth chapter discuses about analysis and interpretation on the evaluation result for the performance of the prototype system and user acceptance testing. Finally, chapter six discuss the major findings, based on which it provides concluding remarks and recommendation for further research.

1.8. Operational definitions

Anthropometry: Measurement of the variation of physical dimensions and the gross composition of the human body at different age levels and degrees of nutrition by weight-for-age, height-for-age and weight-for-height.

F-75: Formula 75 (75kcal/100 ml) is the milk based diet recommended by WHO for the stabilization of children with SAM with in inpatient care

F-100: Formula 100 (100kcal/100 ml) is the milk based diet recommended by WHO for the nutrition rehabilitation of children with SAM after stabilization in inpatient care.

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

LITRATURE REVIEW

2.1 Overview

In order to have deep understanding on the problem of this study, it is vital to review several literatures that have been conducted in the area. For this reason, related literatures such as books, journal articles, guidelines, manuals, proceeding papers and some other sources that were retrieved from the internet have been revised so as to understand the domain knowledge, concepts, principles and methods that are important for evolving CBR systems.

2.1.1. Background of malnutrition

To have good growth and obtain a better health, human body needs nutrients (HTP, 2008). Nutrients are reached through the consumption of food; thus, nutritional status is determined by the amount and quality of food we consume (HTP, 2008).

Malnutrition is an umbrella term for the unsuitable intake of nutrients needed to sustain healthy development; the term applies to under or over nutrition (UNICEF, 2009). Over nutrition refers to an overconsumption of calories, whereas under nutrition is the insufficient supply of sustenance or inadequate utilization of nutrients upon consumption that lead to illness (UNICEF, 2009). Since nutrients are required for growth and development, an undersupply of nutrients will affect both areas. The body will display nutrient deficiencies in one or more of the following ways: physiological, anatomical, cognitively, and/or immunologically. Physiologically, the body will fail to uptake the nutrients needed to maintain a healthy weight.

2.1.2. Protein-energy under nutrition

According to Morley, (2014) protein-energy under-nutrition (PEU) is a deficiency of energy due to insufficient consumption of all macronutrients. PEU takes two forms: acute malnutrition and chronic malnutrition (Morley, 2014). Upon a diagnosis of protein-energy under-nutrition, the cause and severity of PEU is classified in two ways: primary or secondary. In addition to this a study conducted by Morley (2014), the primary form of PEU that is "caused by inadequate nutrient intake”, whereas the secondary form of PEU is a “result from disorder or drugs that interfere with nutrient use” (classification and etiology sect.). In essence, primary PEU encompasses acute malnutrition symptoms and secondary PEU involves chronic malnutrition characteristics. The classification of PEU allows physicians to act appropriately in accordance to the degree of severity. In third world countries, PEU has a prevalence of 20% and 2% in its mild-moderate and severe forms, respectively (Duncan, 2015).

2.2. Artificial Intelligence

A study conducted by Russell and Norvig, (2003), the field of Artificial intelligence (AI) tries to understand how we think, that is how we can perceive, understand, predict, and manipulate a world. AI also tries to develop intelligent entities that can handle problem in the same ways as humans do (Russell and Norvig, 2003). The name of AI was coined in 1956 (Detore, 1989). Various definitions for AI are proposed. Russell and Norvig (2003) try to classify the definitions into two dimensions the first one is definitions that are concerned with thought processes and reasoning, the second one is the definitions that address behavior.

2.3. Knowledge Based System

Knowledge-Based System (KBS) is one of the major family members of the AI group. With availability of advanced computing facilities and other resources, attention is now turning to more and more demanding tasks, which might require intelligence. Artificial Intelligence is all about how to make the system think, or act like human. The expert`s knowledge is available when the human expert might not be and so that the knowledge can be available at all times and in many places, as necessary (Abu-Naser *et* al*.,* 2008). The society and industry are becoming knowledge oriented and rely on different experts’ decision-making ability. KBS can act as an expert on demand without wasting time, anytime and anywhere. KBS can save money by leveraging expert, allowing users to function at higher level and promoting consistency. One may consider the KBS as productive tool, having knowledge of more than one expert for long period of time. In fact, a KBS is a computer based system, which uses and generates knowledge from data, information and knowledge. These systems are capable of understanding the information under process and can take decision based on the residing information/knowledge in the system whereas the traditional computer systems do not know or understand the data/information they process (Sajja and Akerkar, 2010).

The KBS consists of a Knowledge Base and a search program called Inference Engine. The IE is a software program, which infers the knowledge available in the knowledge base. The knowledge base can be used as a repository of knowledge in various forms. This may include an empty Workspace to store temporary results and information/knowledge pieces/chunks. As an expert's power lies in his explanation and reasoning capabilities, the expert system's creditability also depends on the Explanation and Reasoning of the decision made/suggested by the system. Also, human beings have an ability to learn new things and forget the unused knowledge from their minds. Simulation of such learning is essential component of KBS. The life of KBS may vary according to the degree of such simulation. KBS may be either manually updated (manual update)or automatically updated by machine (machine learning). Ideally, the basic frame of a KBS rarely needs to be modified. In addition to all these, there should be an appropriate User Interface, which may have the Natural Language Processing facility (Sajja and Akerkar, 2010).

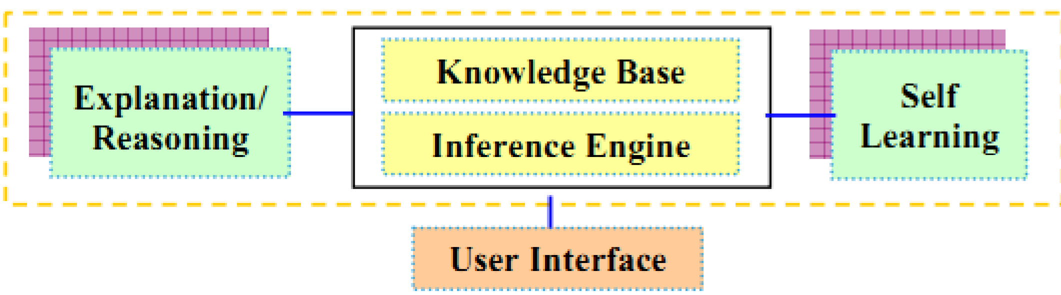


Figure 2. 1: Architecture of a KBS (Source: Akerkar and Sajja, 2009).

As shown in figure 2.1, knowledge base system is a system that embraces several components that interacts each other to achieve desired goal (Krishnamoorthy and Rajeev, 2010). KBS structure has different components like knowledge base, inference engine, explanation facility and user interface (Sasikumar *et al*., 2007) that interact together in simulating the problem solving process.

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.

2.4. Case-based Reasoning

Human beings have the skill to handle situations by remembering or recalling the past experiences that we have on similar situations. As Kolodner (1992) indicate we are likely to observe peoples who try to handle problem by relating it with other experienced situations. We normally learn from our successful and wrong activities to handle future similar situations in the right way and not to repeat our mistakes. Remembering and reusing previously solved problems, and learning from experiences for future use, is natural and useful (Aamodt and Plaza, 1994; Kolodner, 1992).

Case-Based Reasoning (CBR) is a branch of artificial intelligence. CBR can be seen as a machine learning approach Sthal, (2003) and Sthal, (2005) that is built on the idea of human way of solving problems i.e. as similar problems have similar solutions (Aamodt and Plaza, 1994). CBR is established on strong mathematical foundations (Richter and Aamodt, 2006) like similarity measures which are the back bone of CBR. Any CBR system has a knowledge base that contains cases representing the knowledge of the modeled system. Each case is a pair of a problem and a solution. For any new problem, CBR systems retrieve the relevant cases from the knowledge base which contains cases, then reuse and adapt them for application on the new problem. If the adaptation and reuse phase produces new cases then they are retained in the knowledge base for later reuse. This process represents the learning mechanism, as learning is performed in CBR via retaining new cases. In the following section we will elucidate CBR working mechanism and its fundamentals.

According to Stuart, (2002) it is a recent approach of AI to solve problem and learning. In CBR, new problem are often similar to previously encountered problem and the current solution mostly based on past solution. So, it also requires little knowledge acquisition. In CBR, experiences are stored in cases. Sometimes cases are not well structured and derived from pervious databases. In CBR applications, matching and retrieval algorithms used case base for past problem-solution pairs. But sometime especially in complex application it is insufficient to recall the best matching case. Now-a-days CBR field is developing rapidly. It is used in many areas like diagnoses, pattern recognition, planning and troubles shooting. Today, most of the software companies start developing commercial and industrial base applications by using this technique (Stuart, 2002).

2.4.1. Cases

A case refers to specific experience or knowledge tied to specific situation that is worth remembering for future use. So cases in the knowledge base represent collection of specific experienced captured and learned situations of the application domain (Aamodt and plaza, 1994; Kolodner, 1992). The structure and content of cases highly affect a case based reasoned performance (Aamodt and plaza, 1994). Each case has to have the following three parts: (Bergmann *et al*, 2005)

Situation/Problem description: describes specific circumstances, states of a situation, and state of the environment when this particular case is recorded.

Solution: provides how the problem described in the problem description was solved or treated in a particular instance.

Outcome: describes the final result or consequence and feedback gained from following the proposed solution.

As indicated by Bergmann *et al*., (2005), case representation in case based reasoning uses similar knowledge representation formalisms from AI to represent the experience contained in the cases for reasoning purposes. Different case representations have been proposed. The three classical types of case representations are: (Bergmann *et al*, 2005),

Feature vector (or propositional) cases: Feature-vector approaches represent a case as pairs of attribute-value format. It is similar to the propositional representations used in Machine Learning. It supports Nearest Neighbor matching and instance-based learning.

Structured (or relational) cases: The structured approach represents cases around frame-based formalism like relational representations in Machine Learning.

Textual (or semi-structured) cases: Textual case representations decompose the text that constitutes a case into information entities (IEs). An IE is a word or a phrase contained in the text that is relevant to determine the reusability of the episode captured in the case.

2.4.2. CBR System versus Rule-Based System

The approach of CBR can be contrasted with that used in other knowledge-based systems, such as rule-based or combined frame-rule-based systems. In rule-based systems, one has a rule-base consisting of a set of production rules of the form: IF X, THEN Y, where X is a condition and Y is an action. If the condition X holds true, the action Y is carried out. Condition X can be a composite condition consisting of, say, a conjunction of premises X1; X2; ...; Xn. In addition, a rule-based system has an inference engine that compares the data it holds in working memory with the condition parts of rules to determine which rules to fire.

The use of production rules for solving problems demands rule-based reasoning. Rule-based reasoning is the process of drawing conclusions by linking together generalized rules, starting from scratch (Leake, 1996). According to Kolodner (1993), although some rules are very specific, the goal of rule-based reasoning is to formulate rules that are generally applicable. An important advantage of rules, in general, is the economy of storage they allow (Kolodner, 1993). Conversely, the following are some disadvantages of rule-based reasoning (Eshach and Bitterman, 2003):

The problem of applicability: In rule-based reasoning, bringing some general piece of knowledge to solve a specific problem situation is too difficult. When rules are expressed too abstractly, the terms tend to be unintelligible to the novice and tend to mean a variety of specific things to the expert.

III-defined domains or domains which have weak domain theory: In domains that are not completely understood, the rules do not encompass all the situations they are asked to cover or are assumed to cover, may admit tacit exceptions, or can be contradicted and negated by other rules.

The limitation of mental capacity: Rule-based reasoning requires that the problem solver takes into account all the domain rules. However, in many real-life situations the problem solver is not capable of doing that, under the pressure of time, as the number of rules required for solving a problem may be unmanageably large (Leake, 1993). Subsequently, these shortcomings in rule-based reasoning based knowledge base has given rise to the idea of development of CBR (Alterman, 1989) based knowledge base.

CBR systems are an alternative, in many situations, to rule-based systems. In many domains and processes, referring to cases as a means of reasoning can be an advantage due to the nature of this type of problem solving (Pal & Shiu, 2004). One of the most time consuming aspects when developing a rule-based system is the knowledge acquisition task. Acquiring domain-specific information and converting it into some formal representation can be a huge task and in some situations, especially those with less well understood domains, formalization of the knowledge cannot be done at all. Case-based systems usually require significantly less knowledge acquisition, since it involves collecting a set of past experiences without the added necessity of extracting a formal domain model from these cases. In many domains there are insufficient cases to extract a domain model, and this is another benefit of CBR. A CBR system can be created with a small or limited amount of experience and then developed incrementally, adding more cases to the case base as they become available.

Case based reasoning has many advantages as compare to other sub fields of Artificial Intelligence (AI)**.** According to Sankar and Simon (2004), the following are qualities of using CBR approach.

A CBR system is used past experience as domain knowledge and can provide reasonable solution, appropriate solution through adaptation. But, modeled base system cannot solve problem due to fixed modeling and formulation that is on the boundary of their knowledge.

Reasoning in domains that have not been fully understood, defined or modeled: CBR system can still be developed by only adding small set of causes from the domain, in situation where too insufficient knowledge exists to build a causal model. The addition of new cases is caused of expanded knowledge of CBR System. These are used in this direction that is determined by the cases encountered in its problem solving.

Learn over time: As CBR systems are used; they encounter more problem situations and create more solutions. If solution cases are subsequently tested in the real world, and a level of success is determined for those solutions, then these cases can be added into the case base, and used to help solving future problems. As cases are added, a CBR system should be able to reason in a wider variety of situations, and with a higher degree of refinement and success.

Avoid repeating all the steps that need to be taken to arrive at a solution: In problem domains that require significant processes to create a solution from scratch, the alternative approach of modifying a previous solution can significantly reduce this processing requirement. In addition, reusing a previous solution also allows the actual steps taken to reach that solution to be reused for solving other problems.

Reflect human reasoning: as there are many situations where humans use a form of CBR, it is not difficult to convince implementers, users and managers of the validity of the paradigm. Likewise, humans can understand a CBR system's reasoning and explanations, and are able to be convinced of the validity of the solutions they receive from a system.

Making prediction of the probable success of proffered solution: The past solution information is stored in the bases of level of success; case based reasoned may be able to predict success of solution for current problem. The level of success of these solution and differentiate between pervious and current cause of applying these solution, the whole procedure is done by referring stored solution.

Providing a means of explanation: CBR systems can explain solution to user by explaining how pervious case was successful in that situation, by using similarities between the cases. It is possible because, CBR system can provide information about pervious case and its successful solution to help a user.

2.4.3. Case based reasoning life cycle (RE)

Case based reasoning, as its name indicates, uses cases to reason about a given problem. Generally case based reasoning process is divided in to four; (Aamodt and plaza, 1994; Lopez *et al*, 2006), Retrieve the most similar case or cases; Reuse the case or cases to attempt to solve the problem; Revise the proposed solution if necessary, and Retain the new solution as a part of a new case.

When a problem occurs, the method searches its knowledge base and retrieves the most similar case or cases. The information and knowledge in the retrieved case is reused to propose a solution for the problem. The proposed solution is then evaluated to check that the problem is solved successfully or failed. A case based system updates its knowledge from its experiences, so based on the evaluation result the method retains the new experience learned from this problem solving process (Aamodt and plaza, 1994; Lopez et *al,* 2006; Kolodner, 1992).Each of the processes is discussed in the following sections. The Figure 2.6 below shows sequence of the processes.

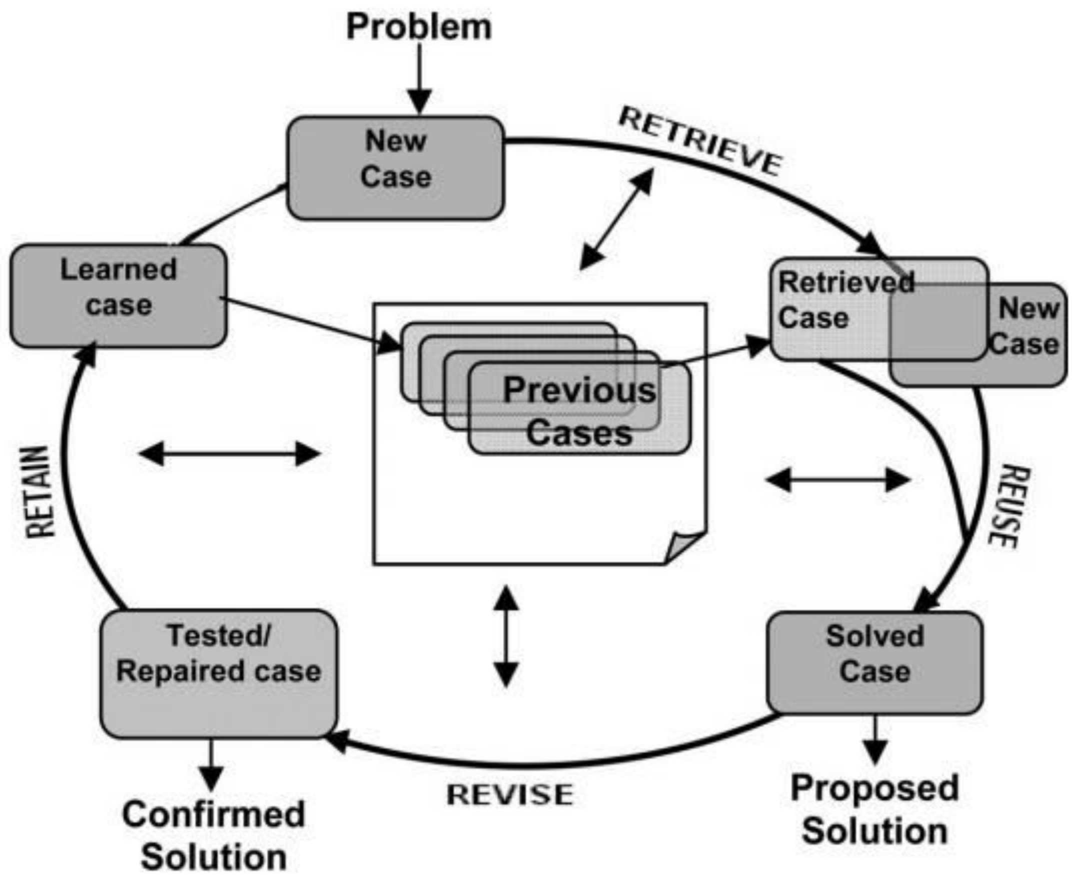


Figure 2. 2:Case-based Reasoning Life Cycle(Source: Aamodt and Plaza, 1994)

2.4.2.1. Retrieve

Retrieving in this context is remembering one or more similar cases. It is the main and the first step of the case based reasoning method. It takes the description of a problem as its input and provides the best matched case or set of cases as output. The quality of a case based reasoning system as a whole is highly affected on the quality of its retrieval process due to its being the base for the rest of processes. The CBR system retrieves the most similar case or cases from the knowledge base by applying the similarity measures (Aamodt and Plaza, 1994). One of the most vital phases in CBR cycle is retrieve.

Various researchers describe it in different ways. Aamodt and plaza (1994), subdivided Case Retrieval into three subtasks;

Identify features: involves indexing the problem with the most descriptive features in order to match it with indexed saved cases. In another words, it identifies its descriptive properties and take out the properties which doesn‘t describe the problem strongly

Initially Match: finding previous cases that match with the problem at hand and it retrieves a set of plausible candidates. That means it involves searching and similarity assessment to produce a set of similar cases.

Select: selecting the best-matched case from the set of similar cases. It is based on the similarity assessment result that the best matched case or set of cases is selected as output of the retrieval process.

According to Singh *et al*., (2007); Watson and Marir (1994) the quality of the retrieval process depends on its descriptive feature identifying algorithm, searching algorithm and similarity assessment method. The two of most well-known algorithm for case retrieval are:

Nearest neighbor algorithm

The Nearest Neighbor algorithm measure the similarity of stored cases with a new input case, based on matching a weighted sum of features. (Kyung and Dongkon, 1999; Watson and Marir, 1994; Singh *et al*, 2007). When a new case doesn‘t exactly match with old cases then this algorithm will return nearest match from case based reasoning library. It is suitable when there are attributes that has numeric (continuous) value (fang and Songdong, 2007). But the retrieval time by this algorithm increases linearly as the case in the case base increases.

Nearest Neighbor algorithm can be represented in the following equation (Watson and Marir, 1994).

$$NN(I,R) = \frac{\sum_{i=1}^{n} w_i \times sim(f_i^{I}, f_i^{R})}{\sum_{i=1}^{n} w_i}$$

Where *w* is the importance weighting of an attribute, *sim* is the local similarity function, and *Ifi* and *fi R* are the values for attribute *i* in the input case (I) and a case in the case base (R) respectively. *n* is number of attributes in the case

Induction

Induction algorithm tries to extract rules or construct decision trees from previously solved cases. In case based reasoning systems, it analyzes the case base in order to construct a decision tree that classifies the cases. The most popular induction algorithm in case based reasoning is called ID3. It uses a heuristic called information gain to find the most promising attribute on which to divide the case base (Salem *et al*, 2005; Singh *et al.*, 2007)

2.4.2.2. Reuse

In this stage, the system makes use of the information of the retrieved cases. The retrieved case in ideal situation represents a solution for the problem without any modification of its information. If not, CBR adapts this information to the query problem and then formulates a new solution (Aamodt and Plaza, 1994). In addition to this When one or several similar cases have been retrieved, the solution (or other problem solving information) contained in these cases is reused to solve the current problem. Reusing a retrieved solution can be quite simple if the solution is returned unchanged as the proposed solution for the new problem. This is mostly appropriate for classification tasks with a limited number of solutions (classes) and a large number of cases. As indicated by Aamodt and plaza (1994), reusing of the retrieved case solution in the context of the new case is based on the differences among the past and the current case, and what part of a retrieved case can be transferred to the new case.

2.4.2.3. Revise

In this phase feedback related to the solution built so far is got. This feedback can be given in the form of an exactness rating of the result or in the form of a manually corrected revised case. The revised case or any other form of feedback enters the CBR system for its use in the subsequent retain phase. A revision of the new solution is important to make sure that it satisfies the requirement of the system. Revising process can be done by applying it to real world (Aamodt and Plaza, 1994) or evaluating it by domain expert. Also revising can be done by simulation approaches (Sthal, 2003).

2.4.2.4. Retain

In CBR cycle's the last step is to retain this new case knowledge for future usage. In this stage if the new generated case represents a valuable improvement to the knowledge base, then it is saved in the knowledge base in order to use it latter. According to (Smyth and McKenna, 2001) the retain phase is the learning phase of a CBR system. The typical form of learning that occurs in a CBR system is learning by adding a revised case to the case base. Thereby, the new problem solving experience becomes available for reuse in future problem solving episodes.

According to Aamodt and plaza, (1994), Case based systems upgrade their domain knowledge by learning from new experiences obtained while problems are solved. After the proposed solution for the given problem is evaluated in the revise process, the retain process identifies useful and worth remembering new experiences and decides how to merge with existing knowledge. This type of learning is known as incremental learning because it always adds knowledge that is new and useful in addition to the existing knowledge.

2.5. Case Based Reasoning Techniques

According to Watson, (2000), Case Based Reasoning, have different techniques. These are: case representation, indexing, storage, retrieval, adaptation, learning and generalization.

2.5.1. Case Representation

Case is a specific piece of knowledge representing an experience (Watson, 1997). It contains the information which is content of case and situation where that information or experience can be used. Different type of data can be stored in a case. CBR community has a lack of consensus what information should be stored in a case. Cases also have to be structured for efficient case retrieval. There are two types of structures. Structures types are Common Structure and Hierarchal Structure. Memory model for chosen form of case representation depend on following factors:

Representation used in case base, Number of features that are used to match cases during search and Number and complexity of cases. Case is a combination of two components. These components are description of a problem and its solution. Problem description consists of a set of attributes and values. That attributes predict a solution.

2.5.2. Indexing

Index is computational data structure can be held in memory and also can search quickly (Watson, 1997). In general, databases use index to speed up retrieval of data. Information in a case can be two types: Indexed information use for retrieval and not needed information that may provide information to user but not used in retrieval.

In medical systems, where patient's age, sex, height and weight can be used as index features, that information is helpful for future retrieval. The patient's photograph can be included as an unneeded feature which cannot be used in the retrieval. Picture should be helpful for doctor for remind patient. Index should have the following features (Aamodt and Plaza, 1994; Sankar and Simon, 2004): be predictive, should show the purpose for which case will be used, it should be easy to recognize it in the future and it must address the future use of the case base. Automated indexing has many methods including: In different-based indexing, index has to differentiate a case from another case, In inductive learning method, features are identified which latterly uses as an indexes, Appropriate set of indexes produce by similarity and explanation-based method for those cases which have same information (Watson, 1997).

2.5.3. Storage

One important aspect of the efficient CBR system is case storage (Watson, 1997). It represents a logical view of what is stored in case. For efficient retrieval, case base should be organized in a manageable way. These methods referred as a case memory model.

2.5.4. Retrieval

Case retrieval is a process of finding cases which are closest to current case (Sankar & Simon, 2004). For efficient case retrieval, there should be selection criteria which will judge a case. CBR major research area is retrieval. Retrieval process is based on similarity measures. Case retrieval is a process of finding cases which are closest to current case (Pal and Shiu, 2004). For efficient case retrieval, there should be selection criteria which will judge a case. CBR major research area is retrieval. There are four retrieval techniques in which all of them are discussed in the case based reasoning cycle section.

2.5.5 Case adaptation

Case adaption is a technique to modify retrieved case for reproducing new solution for new problem (Kang and Lau, 2002). It may be the most important step which enhances intelligence. Case adaptation improves overall problem solving ability of CBR. In this process, adaptation is performed on the most similar cases in order to provide the solution for the query case C_x. In the ideal situations; the adaptation process is limited to reusing without any modifications of the solutions of retrieved cases. There are four types of case adaptation (Wilke and Bergmann, 1998):

2.5.6 Learning in CBR

Learning in CBR is performed by simply retaining new solutions. However; it is obvious that not all new cases should be saved. This is because the limitations of the knowledge base size and the quality of cases stored in the knowledge base. For example it is obvious that we need not to save the solution generated by the null adaptation process, because the provided solutions are the same as those in the knowledge base, so there is no need to add them. Also, we have to be aware of retaining cases with high similarity with those retained in the knowledge base. This is because the knowledge base will be filled with cases that are highly similar to each other. Learning is not restricted to saving new cases, it also require deleting cases from knowledge base. Maintaining a high quality knowledge base requires deleting process for redundant and obsolete cases. Also noisy cases that are that were incorrectly retained should be eliminated and removed (Aha, 2004). Case-Based Learning (CBL) algorithms and approaches have been covered by (Aha, 2004) where the learning and memorizing is carried out in CBR.

2.6. Case Based Reasoning Tools

There are different commercial and non-commercial tools which are used in developing CBR systems. Most of the case based reasoning tools are commercials. Some of CBR tools which are indicated in the work of Ashraf and Iqbal (2008) are described as follows**.**

CBR-Express: Inference Corporation developed a CBR-Based tool Called CBR-Express (Gianni *et al*,. 1999). CBR-Express is perhaps most successful application of CBR. The interface of CBR Express is build using Asymetrix Tool Book. It is basically a help desk system (Chris, N.d). It has simple case structure and nearest neighbor matching to retrieve cases.

ReCall: is ISoft (AI Company) made that CBR-based tool (Gianni *et al*,. 1999).This case based reasoning tool is written in C++ language. Recall tool offer a combination of nearest neighbor and inductive case retrieval. It can run on Windows and UNIX workstations under Motif, Sun, HP series 700 and DEC Alpha, designed in open architecture that allows the user to add case based reasoning functionality in the applications.

ReMind: ReMind is produced by Cognitive Systems Inc. (Gianni *et al*,. 1999). It is basically developed for Macintosh. After some time, it is also developed for Windows and UNIX. ReMind offer template, nearest neighbor, inductive and knowledge-based retrieval. Template retrieval support SQL queries returning all queries. Nearest neighbor is informed by user defined important information that can be placed on case features. Inductive retrieval involves tree-based cases (Watson, 1997).

Kate: Kate is another CBR tool which is developed by AcknoSoft (Watson, 1997) that can run on MS Windows, Mac, or SUN. Kate is made up of a set of tools: Kate-Induction, Kate-CBR, Kate Editor and Kate-Runtime. This tool supports both kinds of nearest neighbor and induction algorithms. In induction algorithm, retrieval using trees is extremely fast.

Casuel: European INRECA project developed Casuel (Watson and Marir, 1994). It is a common case representation language. Basically, it is interface between all INRECA component systems. Casuel is a flexible, object-oriented and frame like language.

Caspian: It is a CBR tool developed at the University of Aberystwyth in Wales (Watson & Marir, 1994). It can run on Ms-DOS and Macintosh. It has simple command line interface which can be integrated with a GUI front end if mandatory. It performs simple nearest-neighbor match and uses rules for case adaptation.

myCBR: according to (Stahl & Roth-Berghofe, 2008), myCBR is one of the most popular CBR software platforms. It is a framework with certain capabilities and limitations. The most popular version of myCBR is a plug–in of open source ontology editor protégé, but there are available some web-based versions and incorporation into other software. myCBR is developed by the German Research Center for Artificial Intelligence (Stahl and Roth-Berghofe, 2008). The platform has open source code written in Java and is accessible to all users. It can be easily changed by the users depending on the purpose. The purpose of myCBR is to minimize the efforts to create CBR applications. For this normal use, without modifying the source code, no programming skills are required, but expertise in a specific CBR-developed applications. Its programming code is well documented. The framework myCBR supports explanation of cases with numerous attributes: numeric, character, string, logical and class type. The templates of the cases are generated as classes or subclasses with a number of attributes, called slots.

JCOLIBRI: jCOLIBRI is a technological evolution of COLIBRI and it is an object-oriented framework in Java which is designed for building CBR systems. It is a java-based and uses JavaBeans technology for case representation and automatically generation of user interface. This framework is developed by the GAIA artificial intelligence group in Completeness University in Madrid. The framework is built in two hierarchical levels- upper and lower. The lower level consists of library of classes (Software modules) for full 4REs CBR cycle, also for definition of cases, attributes and connectors for access to outer databases. The upper level is "black box" graphical interface, which allows non-complicated user case based reasoning application generation based on lower levels modules. It is non-commercial compatible tool which supports the full CBR cycle (Retrieval, Reuse, Revise and Retain). Using jCOLIBRI is also suitable for developing large scale applications.

In the study jOCLIBRI was used. It is non-commercial compatible tool which supports the full CBR cycle (Retrieval, Reuse, Revise and Retain). By using jCOLIBRI, it is possible to work with external databases using different connectors; like text connectors in our case. Using jCOLIBRI is also suitable for developing large scale applications.

Design science research

Design-science research supports a pragmatic research paradigm promoting the creation of artifacts to solve real-life problems (Hevner et al., 2004). According to (Philipp *et al*., 2009) The process is structured in three main phases "problem identification", "solution design" and "evaluation" that can interact with each other within the research process.

A. Problem identification

In the first phase of the research process, a problem is identified. It has to be ensured that the problem has practical relevance or might be of relevance once solved. The phase is divided into the following steps: "identify problem", "literature research" "and expert interviews" and "pre-evaluate relevance".

B. Solution design

In the second phase, the solution is designed. It is divided into the steps "artefact design" and supporting "literature research". After identifying a problem and pre-evaluating its relevance, a solution has to be developed in the form of an artefact. Within this phase, research rigour has to be ensured by using all related work available.

C. **Evaluation**

Once the solution reaches a sufficient state, its evaluation can be started. It is possible to iterate back to "design artefact" or even "identify problem" if necessary. Evaluation is to be achieved by the means of a case study or action research (shows applicability in practice), by arranging a broad expert survey (shows general interest) and by laboratory experiments or simulations (used to compare different approaches).

2.7. CBR System Performance Evaluation Methods

Evaluation of knowledge base system includes both system performance (statistical analysis) and user acceptance (Buchanan & Forsythe, 1991). The statistical analysis for CBR can be conducted for both retrieval and reuse process. The first task of CBR is to retrieve cases that are relevant to the new case (Aamodt & Plaza, 1994). As retrieval task of the CBR aims to retrieve cases relevant cases from the case base, precision and recall are useful measures of retrieval performance in CBR (McSherry, 2001). Recall is defined as the ratio of the number of relevant cases returned to the total number of relevant cases for the new case in case base (Junker *et al*, 1999; McSherry, 2001). Whereas precision is the ratio of the number of relevant cases returned to the total number of cases for a give new case (Junker et al, 1999; McSherry, 2001).

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

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

F-measure is the harmonic mean of precision and recall, with a value between 0 and 1. It is calculated as:

F-measure = 2 (recall * precision) / (recall + precision)

Only system performance evaluation based on statistical analysis does not assure the applicability of the system in the real life. Even though system that achieves better system performance statistically, it may not be comfortable to the user in solving the particular problem (Buchanan & Forsythe, 1991). As a result of this user acceptance is conducted to assess the applicability of the system for the real life.

2.8. Related works

There are many knowledge based systems developed by different researchers all over the world. The following are some of the knowledge based systems that are developed international and local.

2.8.1. Case Based Reasoning in Medicine

In medicine, experts' knowledge is not only the knowledge of rules but it is a combination of knowledge, text books and experience Montani and Portinale (2005), Schmidt and Gierl (2000). Physicians exploit from both the explicit knowledge obtained from the guidelines and regulations and tacit knowledge which is based on their experience with prior patients and other physicians (Abdolzade, 2012). Over the years, CBR has been known as an interesting alternative for the manufacture of medical applications of artificial intelligence. One interesting feature of CBR in medicine is that the disease and the patients represent a case (Funk and Xiong 2006).

Case based Reasoning approach has been investigated in improving human decision making and has become popular in developing knowledge-based systems in health and medicine (Salem *et al*, 2005). CBR is appropriate in medicine for some important reasons; cognitive adequateness, explicit experience, duality of objective and subjective knowledge, automatic acquisition of subjective knowledge, and system integration. Different researches have been conducted in medical domain that employed case based reasoning. Some CBR-systems are:

CASEY designed to give heart failure diagnosis. It employs three steps for its reasoning functionality: the first one is that it searches for similar cases, the second step is the determination process concerning differences and their evidences between a current and a similar case, and in the third step it transfers the diagnosis of the similar to the current case or if the differences between both cases are too important it uses general adaptation operators for modifying the diagnosis (Salem *et al*, 2005; Schmidt *et al*, 2001).

Although many advantages of CBR have been identified in the field of medical health, but medical field without doubt is not without problems and some of these problems have affected CBR systems in particular (Funk and Xiong 2006).

2.8.2. International work

Integrated knowledge base system architecture for histopathological diagnosis of breast diseases is other study related the researcher work (Aderonke and Kayode, 2013). The paper presents a knowledge base system that uses a combination of rule-based and case-based techniques to achieve the diagnosis. In this thesis how to acquire domain knowledge, how to model and represent acquired knowledge is not mentioned. Performance and users' acceptance is also not presented.

Another study conducted by Santosh *et al*., (2010) developed an expert system for diagnosis of human diseases. The system is rule-based system and makes inferences with symbols for knowledge representation. Interview and observation were used for acquiring tacit knowledge from expert domains and document analysis was used to get explicit knowledge from articles, journals, books and websites. They are recommended automated diagnosis system should give explanation for the conclusion, a factor that is important for user acceptance. A trained expert would evaluate the quality of the diagnosis performed by the system.

2.8.3. Local work

In domain of law, Ethiopia (2010) developed a prototype CBR system form Amharic legal precedent retrieval using a CBR framework CBR-Works. She used 39 precedent cases for building and testing the prototype CBR system. Using the statistical performance measurement, Ethiopia achieved 95.05% average recall and 82% average precision. Ethiopia recommended that adding high number of cases in the case base would increase the performance of the system.

Baisen (2013) developed a prototype case based system using CBR technique to advice students in field of study selection at higher education. He used 105 students for building and testing the prototype system. Using six test cases from the case base, he registered 85 % average recall and 55% average precision.

By using CBR techniques, there are also different researches done in the area of health. Among them the works of: Alemu (2010), Henok (2011) and Getachew (2012) are described in detail as follows. Alemu (2010) developed a CBR system for adverse drug reaction antiretroviral drug cases consultancy service; Henok (2011) developed a prototype KBS using CBR techniques for hypertension management; and Getachew (2012) developed a CBR system for diagnosis of anxiety disorder.

For building and testing the developed prototype systems Alemu (2010) & Getachew (2012) used 51 and 50 cases respectively. Alemu (2010) investigated the potential of case based reasoning in solving complex side effects of HIV/ADIS cases for person living with HIV/ADIS who have begun antiretroviral therapy. He used JCOLIBRI version 1.1 in designing the prototype and the system registers 72% and 63% of recall and precision respectively (Alemu, 2010). Alemu (2010) proposed investigating natural language processing to extract features, using machine learning algorithms for feature weighting and investigating different adaptation techniques. Whereas Getachew (2012) used seven test cases and achieved average recall and precision values of 82% and 71%, respectively. Getachew (2012) also used additional evaluation's methods: Leave one out and Hold out methods and got values of 73% and 75.5% respectively. Getachew (2012), proposed hybrid knowledge based system using rule based and CBR systems to increase the performance of the prototype. To overcome the challenges raised in the above two studies, Alemu (2010) proposed investigating natural language processing to extract features, using machine learning algorithms for feature weighting and investigating different adaptation techniques. Whereas, Getachew (2012), proposed hybrid knowledge based system using rule based and CBR systems to increase the performance of the prototype.

On the other hand Henok (2011) used 45 hypertension patient cases for building and testing his prototype system. He used seven test cases from the case base and shown 86.1% average recall and 60% average precision. The challenges that Henok faced and the recommendations proposed were almost similar to Alemu (2010) except Henok proposed a hybrid knowledge based system using rule-based and case based reasoning systems to increase the performance of the prototype. Generally, the common features of all the systems are the case representation method and the retrieval algorithm the researchers used are similar. All the researchers used nearest neighbor retrieval algorithm, feature-value case representation method and the standard procedures of performance in information retrieval to evaluate the effectiveness of their system (Ethiopia, 2010; Alemu; 2010; Henok, 2011). But, Henok (2011) is unique from others by using accuracy performance evaluation to evaluate the reuse capability of his system. However as per the researcher knowledge there are no research attempts made to apply knowledge based system for diagnosis of malnutrition on under- five year children. For this reason, researcher attempted to design case based reasoning system for diagnosis of malnutrition for under-five year children.

CHAPTER THREE

KNOWLEDGE ACQUISITION, MODELING AND REPRESENTATION

3.1. Overview

In order to achieve the objective of the study and to effectively design the prototype in the study area design science approach is used.

3.2. Case acquisition

In knowledge engineering, there are two most important steps that are significant during the development of knowledge-based systems that every knowledge engineer should consider. The first one is acquiring the required knowledge from experts and relevant documents. The second one is representing the acquired knowledge with the appropriate knowledge representation method. Knowledge (case) acquisition is the process of extracting and organizing knowledge from human experts and other sources such as books, databases internet, research papers, documents, one's own experience and transferring to the knowledge base (Abbas *et al*., 2008). It is a process used in developing problem solving model which is used for advisory or consultancy role (Birmingham and Klinker, 2009). Knowledge engineering is all about build, maintain and development of knowledge based systems in the field of artificial intelligence.

The first task in the development of knowledge base is knowledge (case) acquisition. In this study the researcher used important factors related to malnutrition which is documented in the patients' card by health professional and direct using of health related expert on behalf of malnutrition which was not available on the patients' card. The two hospitals are selected because of several factors with malnutrition are well organized and sufficiently available. Different methods were applied to make the result better. Among these methods extraction of previously documented cases was collected with the help of experienced nurses from both hospitals and interviewing more experienced health professionals (Specialized doctors and nurses) was mainly be implemented.

The process of knowledge acquisition of this research encompasses some basic activities such as gathering the required knowledge, analyzing that knowledge, identifying important concepts and symptoms for diagnosis, treatment and finally modeling them in using decision tree structure.

Secondary source of knowledge has been gathered from the internet, malnutrition diagnosis guidelines (especially, Guidelines for the Management of Acute Malnutrition (2014), protocol for the management of severe acute malnutrition(EFMH, 2007), guideline updates on the management of severe acute malnutrition in infants and children(WHO, 2013)and manuals, research papers and journal articles. But, the primary data source is patient history of Jimma University Specialized Hospital and Hawasa University comprehensive Specialized Hospital Malnutrition for under-five year children patients were used frequently for knowledge acquisition.

3.2.1. Malnutrition diagnosis and treatment

Malnutrition is any condition caused by excess or low intake of food energy or nutrient that caused health problem. It refers to both dietary condition caused by a deficiency or excess of one or more essential nutrients in the diet. Many factors can cause malnutrition, most of which relate to poor diet or severe and repeated infections, particularly in underprivileged populations. Inadequate diet and disease, in turn, are closely linked to the general standard of living, the environmental conditions, and whether a population is able to meet its basic needs such as food, housing and health care. Malnutrition affects individuals of all age's group and both sexes. There are however groups, which are more vulnerable to develop the disease.

Nutritional status is clearly compromised by diseases with an environmental component, such as those carried by insect or protozoan vectors, or those caused by an environment deficient in micronutrient (Wardlaw, 2013). Socio-economic and demographic Variables, Environmental Health Condition, Maternal Caring and characteristics, Infections and Child Caring practice have been recognized highly to increase the risk of developing the disease. Common childhood infection, such as Malaria, pneumonia, HIV and measles has been identified as a major risk factor for developing malnutrition for under-five year children. The age group mainly affected by malnutrition is between 0 and 5 years, and this leads to decreasing substitute generation.

3.2.2. Classification of malnutrition

Malnutrition is classified as acute malnutrition and chronic malnutrition based on clinical presentation.

3.2.2.1. Acute malnutrition

Acute malnutrition leads to changes in the body related to cellular composition, tissue and organ functions. Acute malnutrition can either present itself as severe or moderate form. Sever Acute malnutrition presents itself in one of the following clinical forms: marasmus, Kwashiorkor, or Miasmic-kwashiorkor (HTP, 2008). Marasmus is also known as “wasting”, and is characterized by thinness due to a rapid diminishing of fat and muscle which is the body’s way to compensate for the inability to create energy (HTP, 2008). At its moderate stages, the bones are beginning to protrude and the body’s fat is diminishing.

Severe acute malnutrition: SAM is identified by the presence of severe wasting and/or bi-pedal edema. A child aged 0-5 year is classified as severe acute malnourished if s/he has one or more of the following: 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.

There are uncertainties regarding the classification of children aged <6 months as SAM. Until better information becomes available, a child aged <6 months should be classified as SAM if s/he has one or more of the following are WLZ <-3, Bipedal edema and also Visible wasting,. If length is <45 cm then calculation of WLZ is not possible.

Edema in all children is graded using the classification are: Grade + define as Mild: both feet/ankles, Grade ++ is known as Moderate: both feet, plus lower legs, hands or lower arms and Grade +++ is define to be Severe: generalized edema including feet, legs, hands, arms and face

Moderate Acute Malnutrition: Moderate Acute Malnutrition (MAM): Description of malnutrition level encompassing children 0-5 year with < -2 to ≥-3 z-scores and/or MUAC >11.5 and < 12.5cm.

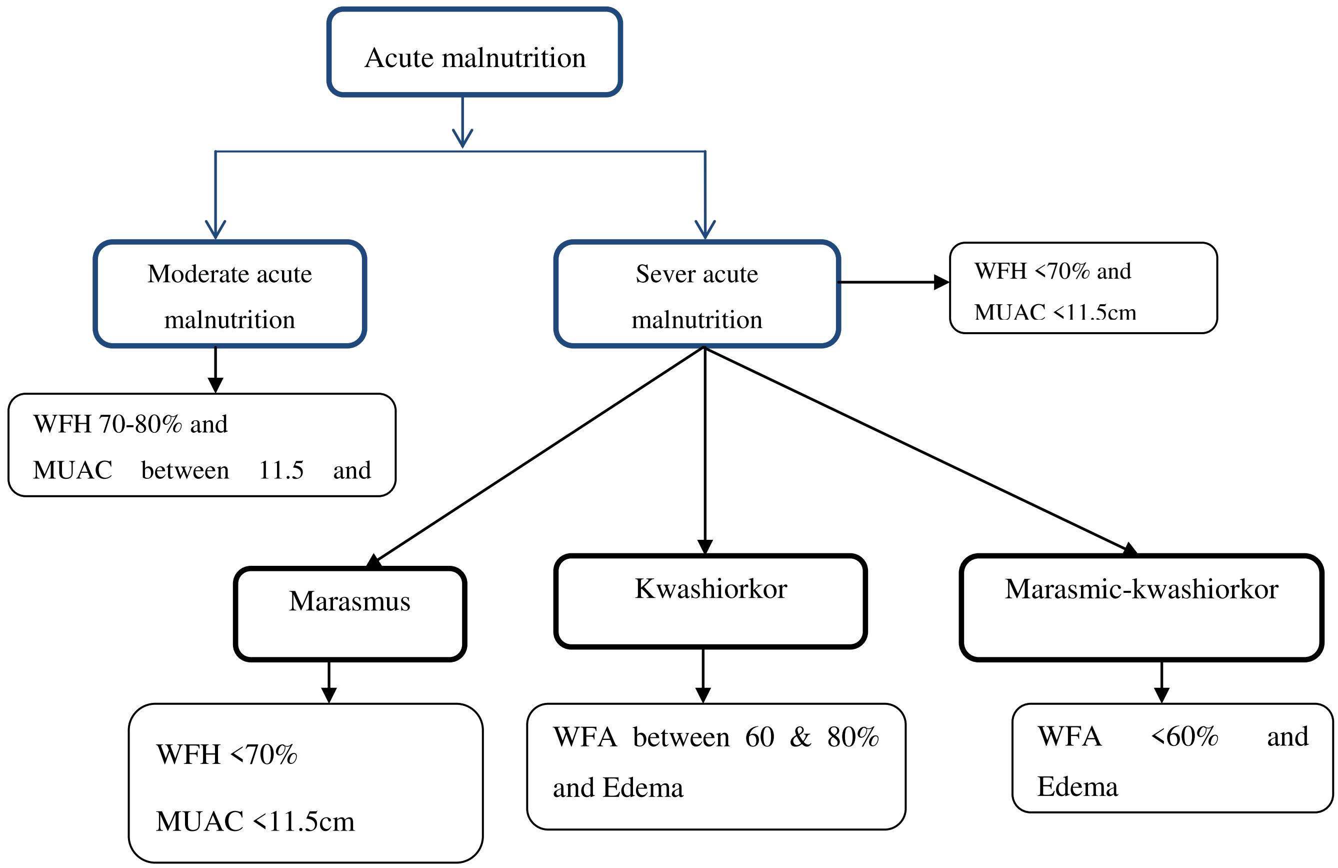


Figure 3. 1: Classification of malnutrition adapted from (Arare, 2007)

3.2.2.2. Chronic malnutrition

Chronic malnutrition is a long-term consequence of undernourishment that may begin before birth and goes into adulthood (HTP, 2008). Stunting is the result of chronic malnutrition, where a child's height-for-age is shorter than normal (HTP, 2008). A child's body will be of proportional size, but compared to a child of the same age, will be shorter in height; hence, the classification measurement of height-for-age (HTP, 2008). In some cases, a child can be both wasted and stunted (both short and thin); an issue that increases their susceptibility to morbidity and mortality (HTP, 2008).

3.2.3. Diagnostic tools/measures of malnutrition

Malnutrition is diagnosed by anthropometric measurements and physical examination. According to Schaible and Kaufmann, (2007), Correlation of malnutrition and growth retardation allows assessment of the individual nutritional state, which is usually measured as body mass index. Body mass index are given as weight-for-height. Acute and chronic malnutrition are measured by body measurements, height, and weight.

The mid-upper arm circumference (MUAC) and weight-for-height Z-score (WHZ is specifically for 'wasting') are the most efficient and cost-effective measures used for diagnosing under-nutrition in children. Other measures have proven to be more accurate; however, they require more time and are a bit complex to use.

A. Mid-Upper Arm Circumference (MUAC)

MUAC is used as an alternative measure of "thinness" to weight-for-height. It is particularly used in children from one to five years: however, its use has been extended to include children of over 65cm in height – or children of walking age.

MUAC values are acquired using a tape that measures the muscle mass of the mid-upper arm (HTP, 2008). It is fast and effective measure of malnutrition for children aged for under-five, although it has showed increasing use in measuring adult nutritional status (HTP, 2008).

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

WFH Z-score is a combination of weight and height measurement that allows a comparison of children of different ages. WHZ uses the WHO Growth Standards to compare the individual's weight to the average weight of an individual of the same height to assess whether the individual is "wasted" (HTP, 2008).

C. Checking For Bilateral Edema

Bilateral edema is the sign of kwashiorkor. Kwashiorkor is *always* a severe form of malnutrition. You do not need to take anthropometric measurement of children with bilateral edema as they are directly identified to be acutely malnourished. Those children are at high risk of mortality and need to be treated in a therapeutic feeding program urgently. In order to determine the presence of edema, normal thumb pressure is applied to the both feet for three seconds. If a shallow print persists on the both feet, then the child presents edema. Only children with bilateral edema are recorded as having nutritional edema.

D. Weight-for-Age (WFA)

Reflect body mass relative to chronological age; Often used if the child is normal, under or over weight. It is a simple index but does not consider height. It is influenced by both the height (height-for-age) and weight (weight-for-height) of a child and its composite nature makes interpretation complex. For example, weight-for-age fails to distinguish between short children of adequate body weight and tall, thin children.

E. Height-for-Age (HFA)

Reflect height relative to chronological age; It is used to tell if a child is the normal height for age. Stunted growth (shortness) is reflects failure to reach linear growth potential (pre and postnatal). as a result of sub-optimal health or nutritional conditions. On a population wide basis, high levels of stunting are associated with poor socio-economic conditions and increased risk of frequent and early exposure to adverse conditions such as illness and/or inappropriate feeding practices.

3.2.3.1. Symptoms and signs of malnutrition

The stamp of chronic malnutrition is stunted growth, while in acute malnutrition the most common symptoms are: there is wasting, with or without the presence of symmetrical bilateral pitting edema, Weight-for-height (WFH) <70%, Mid-upper arm circumference (MUAC) <11.5

cm and other signs, such as the presence of medical complications Like;, Hypothermia (feeling cold), Dehydration, Electrolytes, Infection, shock, High grade fever and skin lesions.

Symptoms of sever acute malnutrition

In addition to the general symptoms of malnutrition for under-five year children, patients with severe acute malnutrition present with damaged different bodies part. The most common forms of SAM and the common presentations include: Marasmus, Kwashiorkor and Miasmic-Kwashiorkor.

In Marasmus, growth is reduced to conserve energy; nonetheless, this alteration has adverse effect on the body's immune response to fight infection(s) (HTP, 2008). Thus, a wasted person is highly susceptible to "liver, kidney, heart, and gut infections and/or failure of major organs" (HTP, 2008). Marasmus at its more severe stages is physically apparent where the bones are easily seen and the skin becomes very thin (HTP, 2008). Common symptoms are WFH <70%, MUAC <11.5cm, No edema, WFA <60% & Baggy pants' loose skin around the buttocks.

Kwashiorkor: WFA between 60 and 80%, Edema, body swelling, weight loss, cough, depression, moon face, swollen hand and feet, hair color change and shedding of the skin.

Miasmic- Kwashiorkor: WFA <60% & Edema Loss of appetite, vomiting, diarrhea, skin lesion, skin rash, weakness, fast breathing.

3.2.4. Treatments of malnutrition

Every patient with SAM should be assessed to decide whether in- or outpatient management is best. In developing countries, with the highest incidence of under nutrition, lack of resources limits the ability to admit every child. Effective screening to correctly enroll patients in outpatient programs has been shown to improve survival. Classifying patients according to anthropometry, presence or absence of symmetrical bilateral pitting edema and complications, i.e. (Vomiting, severe diarrhea, weakness, Infection, fever, skin lesions and skin lesions and feeling cold), then checking their appetite test. If the patient passed appetite test assists with decision-making with regard to out-patient management but failed appetite test treats as in-patient. In line with this, according to the study by the Ethiopian- federal ministry of health (MOH, 2007), the principles of management of severe acute malnutrition, whatever the programmed setting, are based on 3 phases.

Phase I: Patients without an adequate appetite and/or a major medical complication are initially admitted to an in-patient facility for Phase I treatment. The formula used during this phase or F75/ 170ml Q3 hr8x/d(F75) promotes recovery of normal metabolic function and nutrition-electrolytic balance Gentamycin 25mg IV BID, folic acid 5mg PO state, vitamin A if non edematous, ampicillin 400mg IV BID and Give vaccine (measles) if not vaccinated & age >9months Monitoring and follow up. Rapid weight gain at this stage is dangerous, that is why F75 is formulated so that patients do not gain weight during this stage.

Transition Phase: A transition phase has been introduced for in-patients because a sudden change to large amounts of diet, before physiological function is restored, can be dangerous and lead to electrolyte disequilibrium. During this phase the patients start to gain weight as F100 or RUTF (130ml = 130kcal) is introduced, Child gain weight 8 meals per day or 5 or 6 feeds of F100 during the day 3 or 2 feeds of RUTF during night. The quantity of F100 given is equal to the quantity of F75 given in Phase I or an equivalent amount of RUTF. As this is resulting in a 30% increase in energy intake the weight gain should be around 6 g/kg/day; this is less than the quantity given, and rate of weight gain expected, in Phase II.

Phase II: Whenever patients have good appetite and no major medical complication they enter Phase II. Many patients who present with a good appetite are admitted directly into Phase II. This can occur in both in-patient and out-patient settings. In Phase II they are given RUTF (used in both in-patient and out-patient settings) or F100 (used in in-patient settings only) according to look-up tables and Albendazole/mebendazole-syrups 100mg/5ml. Those formulas are designed for patients to rapidly gain weight (more than 8 g/kg/day).

Routine Medicines

Vitamin A

There is an adequate amount of vitamin A in the F75, F100 and RUTF to manage mild vitamin A deficiencies and to replete liver stores of vitamin A during treatment. 10 On the day of admission (day 1), give vitamin A for all children except those with edema or those who received vitamin A in the past 6 months. Give vitamin A to every patient on the day of discharge11 (in-patient care) or at the fourth week of the treatment for those in out-patient care.

Folic Acid

There is sufficient folic acid in F75, F100 and RUTF to treat mild folate deficiency. On the day of admission, one single dose of folic acid (5mg) can be given to children with clinical signs of anaemia.

Antibiotics

Antibiotics should be given to every severely malnourished patient, even if they do not have clinical signs of systemic infection. Nevertheless, despite the absence of clinical signs, they are nearly all infected, particularly if they require Phase 1 treatment (poor appetite) – these infections are treated blindly. Small bowel bacterial overgrowth occurs in all these children (including those with moderate, and some with good appetites). These enteric bacteria frequently are the source of systemic infection by translocation across the bowel wall. They also cause malabsorption of nutrients, failure to eliminate substances excreted in the bile, fatty liver, intestinal damage and can cause chronic diarrhea. The antibiotic chosen for routine treatment must be active against small bowel bacterial overgrowth. Because the children with kwashiorkor have free iron in their blood, bacteria that are not normally invasive, such as Staphylococcus epidermises and "exotic bacteria" can cause systemic infection or septicemia. If staphylococcus is suspected then an antibiotic active against staphylococcus should also be used.

The antibiotic regimen:

First line treatment: oral amoxicillin13 (if amoxicillin not available use oral ampicillin) second line treatment: add chloramphenicol (do not stop amoxicillin) or add gentamycin (do not stop amoxicillin)or change to amoxicillin/clavulinic acid (Augmentin) In some in-patient settings where severe infection is common this is used as the first line antibiotic combination Third line: individual medical decision. Frequently a systemic anti-fungal (Fluconazole) is added for any patient who has signs of severe sepsis or systemic candidiasis. Chloramphenicol should never be used in babies less than 2 months of age and with caution in infants less than 6 months of age.

Measles

In in-patient settings, all children from 9 months without a vaccination card should be given measles vaccine both on admission and discharge after Phase II. In out-patient settings, all children from 9 months without a vaccination card should be given measles vaccine on the 4th week of treatment (including those that have been initially treated as in-patients).

Deworming

Albendazole or Mebendazole is given at the start of Phase II for patients that will remain as inpatients. For both those transferred from in-patients to Phase II as out-patients and those admitted directly to OTP de-worming is given at the 2nd out-patient visit (after 7 days). Worm medicine is only given to children that can walk.

Table 3.1: 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 anaemia	- 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 7 days at home
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)

3.3. Case modeling

After the case is acquired from malnutrition cases, domain experts (health professionals) and other relevant documents, the next step is modeling the case. The case modeling involves organizing and structuring of the knowledge gathered during case acquisition. This activity provides an implementation independent specification of the knowledge to be represented in the knowledge base. Case Modeling is the concept of representing information and the logic for purpose of capturing, sharing and processing knowledge to simulate intelligence (Makhfi, 2011). Here, the basic concepts that reveal the main activities and decisions that are made to solve cases in the domain are modeled. Conceptual modeling is a vital step in case acquisition process so as to understand well the problem domain and to prepare for the case representation phase. Although there are different case modeling techniques the researcher used decision tree structure to model case that is acquired through the case acquisitions and for modeling diagnosis of malnutrition under-five year children.

3.3.1. Concepts of clinical diagnosis of malnutrition

Malnutrition for under-five year children health diagnosis involves many steps beginning with asking questions about the patients' signs and symptoms, Anthropometric measurements like: measuring weight, height, MUAC, weight-for height, checking edema and performing physical examination along with the different risk factors. Even though there are no laboratory tests to diagnose specifically malnutrition illness, the physician may use various tests to make sure that the absence and presence of medical complications. According to experts' response during interviewing, the main information for the physician is the dialogue between the patient families and by observing the attitudes, food preparation (feeding style) and breast feeding practice, how many family members are live with together at home (how many sisters & brothers have)and the signs observed by the physician during diagnosis time. According to Guidelines for the Management of Acute Malnutrition (Government of Ethiopia, 2014 and EFMH, 2007), the following steps are used in order to give diagnosis for the suspects of malnutrition for under five year children.

3.1.1.1. Concept of symptoms and signs of malnutrition

In diagnosis of malnutrition for under-five year children there are common symptoms and signs to be identified in the first course. These are weight-for-height (WFH) <70%, Mid-Upper Arm Circumference (MUAC) <11.5cm and Bilateral pitting edema. If the patient has most of these symptoms she/he considered to have suggestive symptoms of malnutrition to go for further steps of diagnosis, so the health professional check for medical complications. If most of the symptoms couldn't observe on the child other diagnosis need to be performed.

If the child shows the above suggestive symptoms and signs then the health professional has to consider if additional symptoms or medical complications observed on the suspect. These additional symptoms and signs help to identify if the child has symptoms of admit patients for in-patient treatment or treat as an out-patient. If the patients have additional complications like: Hypoglycemia, feeling cold, diarrhea, Vomiting, weakness, severe anemia, High grade fever and skin lesions then the suspect considered to have in-patient or acute malnutrition.

If a child shows additional symptoms and signs on other parts of the body, it may encounter sever acute malnutrition. These specific body parts which can be infected by the deficiency macronutrient malnutrition can be skin bone legs and feet. So, in addition to the symptoms of sever acute malnutrition, if a person shown signs like: WFH <70%, MUAC <11.5cm, no edema, WFA <60%, Baggy pants' loose skin around the buttocks, she/he may encountered Marasmus, or if shown WFA between 60-80%, Edema, body swelling, weight loss, cough, depression, moon face, hair color change, swollen hand and feet, shedding of the skin She/he encountered kuwashikor; or if shown symptoms of both Marasmus and kuwashikor or; WFA <60% & Edema Loss of appetite, vomiting, diarrhea, skin lesion, skin rash, weakness, fast breathing, she/he encountered Miasmic-kwashiorkor.

Malnutrition for under-five year children Diagnosis Case Structure

Malnutrition for under-five year children Diagnosis case structure has two important parts. The first one is the problem descriptions or situation and the second one is the solution. **Problem Description/Situation**: It is the part of the case structure that is consisted of attributes which describes the problem to be solved.

Solution: This part of the case structure provides the recommended diagnosis given to patients based on the problem descriptions.

Therefore, the researcher identified the different description and solution attributes with the help of malnutrition experts and guidelines for the management of sever acute malnutrition manual. Short descriptions of attributes that are used for building the case structure are presented as follows:

Age: Is the age of the patient

Gender: is the term used to refer to a persons' self-representation as male or female,

Weight: Is refers to a person's mass or weight

Height: Is the distance from the bottom of the feet to the top of the head in a human body, standing erect.

Mid-upper arm circumference (MUAC): is a measurement of nutritional status by determining the mid upper arm circumference in cm.

Bilateral pitting edema: is presence of edema on both feet.

Loss of appetite: a decreased appetite occurs when somebody has a reduced desire to eat

Hair color change: is the change in hair color (yellow/orange and brown).

Skin lesions: is a part of the skin that has an abnormal growth or appearance compared to the skin around it.

Fever: an abnormally high body temperature.

Moon Face: is a medical sign in which the face develops a rounded appearance due to fat deposits on the sides of the face

Skin rash: is a change of the human skin which affects its color and appearance

Body swelling: is swelling in different areas of body

Fast breathing: is the process of fast moving of air into and out of the lungs.

Diarrhea: is an increase in the frequency of bowel movements or a decrease in the form of stool

Vomiting: dislodging the food in stomach through mouth

Cough: an unremitting cough that is not improving and has been present for more than two or three weeks

Weakness: Is a decrease in the strength in one or more muscles.

Weight loss: the decrease in weight

Swollen hands and feet: Is caused by buildup of fluid in the body.

Feeling cold: is a perception of decreased body temperature or the feeling that your body is colder than usual

Depression: is a common mental disorder, characterized by persistent sadness and a loss of interest in activities that you normally enjoy

Body sweating: is the occurrence of excessive sweating.

Diagnosis: is a solution attribute and recommends the type of malnutrition based on the similarity of input case and the old cases in the case base.

Recommended Treatment: is a solution attribute and provides a recommendation of treatment based on the similarity of cases.

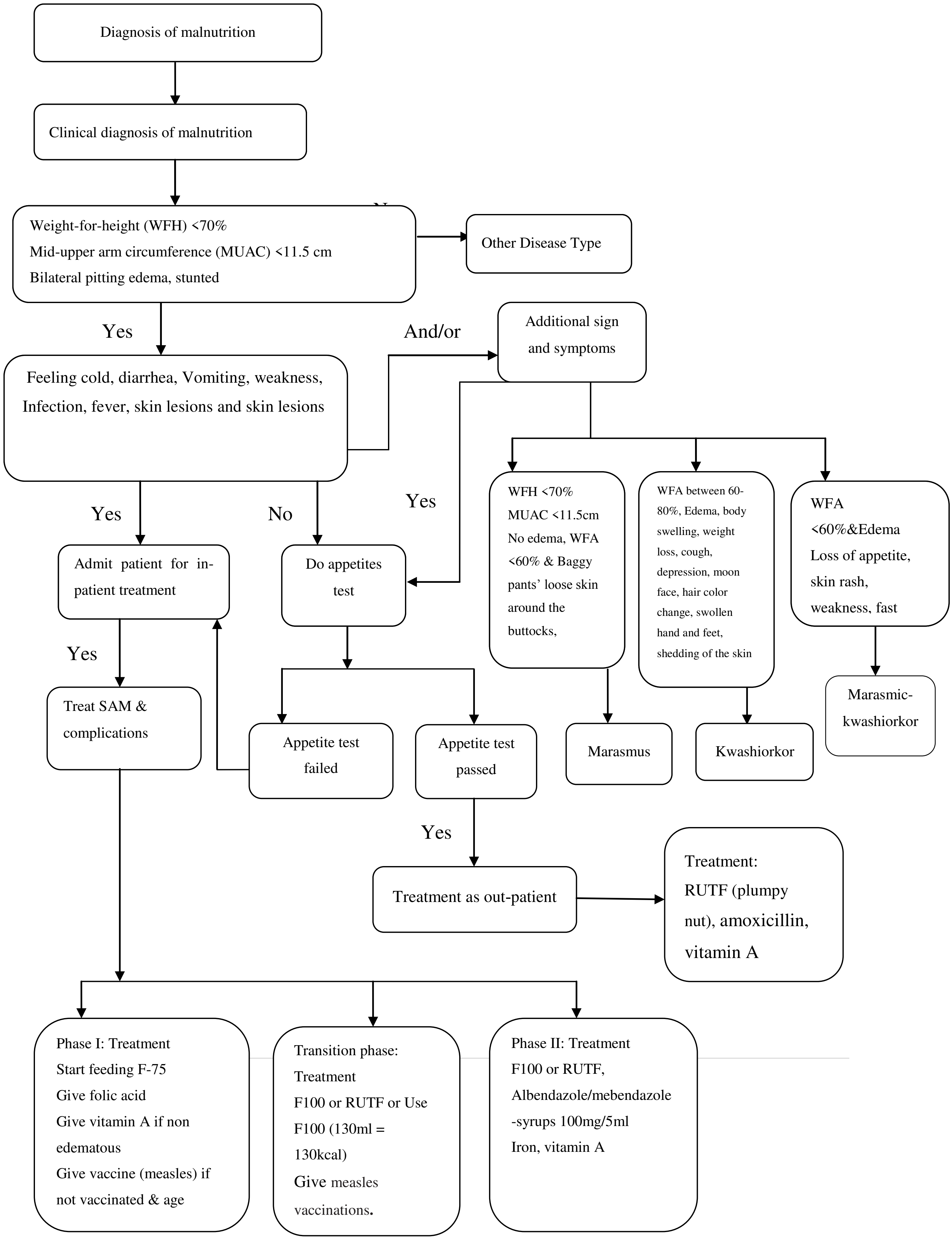

Diagnosis of malnutrition
Clinical diagnosis of malnutrition
Weight-for-height (WFH) <70%
Mid-upper arm circumference (MUAC) <11.5 cm
Bilateral pitting edema, stunted
Other Disease Type
Yes
And/or
Additional sign and symptoms
Feeling cold, diarrhea, Vomiting, weakness, Infection, fever, skin lesions and skin lesions
Yes
No
Yes
Admit patient for in-patient treatment
Do appetites test
WFH <70% MUAC <11.5cm No edema, WFA <60% & Baggy pants' loose skin around the buttocks,
WFA between 60-80%, Edema, body swelling, weight loss, cough, depression, moon face, hair color change, swollen hand and feet, shedding of the skin
WFA <60%&Edema Loss of appetite, skin rash, weakness, fast
Yes
Treat SAM & complications
Appetite test failed
Appetite test passed
Marasmus
Kwashiorkor
Marasmic-kwashiorkor
Yes
Treatment as out-patient
Treatment: RUTF (plumpy nut), amoxicillin, vitamin A
Phase I: Treatment
Start feeding F-75
Give folic acid
Give vitamin A if non edematous
Give vaccine (measles) if not vaccinated & age
Transition phase: Treatment
F100 or RUTF or Use F100 (130ml = 130kcal)
Give measles vaccinations.
Phase II: Treatment
F100 or RUTF,
Albendazole/mebendazole -syrups 100mg/5ml
Iron, vitamin A

Figure 3. 2: Decision Tree for Diagnosis of Malnutrition

3.4. Case Representation

After case is acquired and modeled the next step is case representation with the suitable case representation technique. CBR is a type of case representation which uses previous experiences in form of cases to understand and solve new problems. For the prototype is CBR system for diagnosis of malnutrition for under-five year children. System knowledge is represented in the form of cases. For the prototype CBRSDMUFYC system knowledge is represented 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; as the problem and solution features. As it is easy to represent the cases collected using attributes with their characteristic values.

For this research, the acquired cases are represented using one of the different case representation methods that are appropriate for the researcher. Among the different case representation methods, the researcher selected feature-value case representation method. Other case representation methods like relational database case representation, predicate based representation and soft computing case representation methods have their own advantages and disadvantages. But, for this study feature-value representation method is suitable. The reason for representing cases using feature-value representation is that this approach supports nearest neighbor retrieval algorithm and it represents cases in an easy way (Salem *et al*., 2005; Bergmann *et al*., 2005). This approach also uses old experiences to understand and solve new problems. In addition to this representation of cases, case indexing is another important issue in CBR systems to facilitate the retrieval of cases. Cases are selected and retrieved in a ranked order based on their similarity for the given new case query. For this research nearest neighbor retrieval algorithm were used to measure the similarity of input case with cases in the case base.

So for representing the knowledge with feature-value pair format, case structure was constructed for diagnosis of malnutrition for under-five year children. The case structure has two important parts: problem descriptions and solution. Problem description, as part of the case structure consisted of attributes (symptoms and signs) which described the problems to be solved as depicts in table 4.1. The solution part provides the recommended diagnosis given to malnutrition for under-five year children patients based on the problem descriptions.

Therefore, the researcher identified the different problem description attributes and solution with the help of domain experts, national guidelines, manuals and other materials. The attributes which were used for diagnosis of malnutrition for under-five year children were: 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, Weakness, Weight loss, Swollen hands and feet, Feeling cold, Depression, 'Baggy pants' loose skin around the buttocks, Body sweating, Diagnosis and Recommended Treatment.

Most attributes selected have Boolean data types and some others have string, age and height has integer value, weight and Mid-upper arm circumference (MUAC) has double value. Age of the patients is difficult to represent because time has different units of measurement to represent like: day, weeks, months, year and also difficult to use different unit, so the researcher changed in similar unit (months) to be used as an attribute.

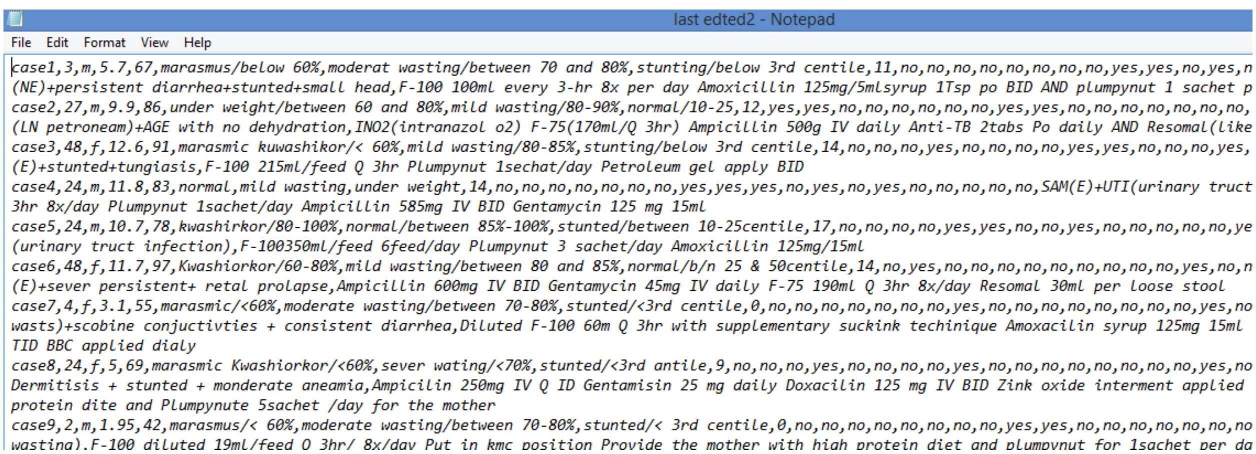
Sample case representations (Case 2):

To easily show the case representations working mechanisms, the researcher selected randomly selected case from the notepad plain text connectors.

Case2:27,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 using note pad as depicted on figure 3.3.below.



```
last edted2 - Notepad
File  Edit  Format  View  Help
case1,3,m,5.7,67,marasmus/below 60%,moderat wasting/between 70 and 80%,stunting/below 3rd centile,11,no,no,no,no,no,no,no,no,yes,yes,no,yes,n
(NE)+persistent diarrhea+stunted+small head,F-100 100ml every 3-hr 8x per day Amoxicillin 125mg/5mlsyrup 1Tsp po BID AND plumpynut 1 sachet p
case2,27,m,9.9,86,under weight/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,
(LN petroneam)+AGE with no dehydration,INO2(intranazol o2) F-75(170ml/Q 3hr) Ampicillin 500g IV daily Anti-TB 2tabs Po daily AND Resomal(like
case3,48,f,12.6,91,marasmic kuwashikor/< 60%,mild wasting/80-85%,stunting/below 3rd centile,14,no,no,no,yes,no,no,no,no,yes,yes,no,no,no,yes,
(E)+stunted+tungiasis,F-100 215ml/feed Q 3hr Plumpynut 1sechat/day Petroleum gel apply BID
case4,24,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(urinary truct
3hr 8x/day Plumpynut 1sachet/day Ampicillin 585mg IV BID Gentamycin 125 mg 15ml
case5,24,m,10.7,78,kwashirkor/80-100%,normal/between 85%-100%,stunted/between 10-25centile,17,no,no,no,no,yes,yes,no,no,yes,no,no,no,no,no,ye
(urinary truct infection),F-100350ml/feed 6feed/day Plumpynut 3 sachet/day Amoxicillin 125mg/15ml
case6,48,f,11.7,97,Kwashiorkor/60-80%,mild wasting/between 80 and 85%,normal/b/n 25 & 50centile,14,no,yes,no,no,no,no,no,no,no,no,no,yes,no,n
(E)+sever persistent+ retal prolapse,Ampicillin 600mg IV BID Gentamycin 45mg IV daily F-75 190ml Q 3hr 8x/day Resomal 30ml per loose stool
case7,4,f,3.1,55,marasmic/<60%,moderate wasting/between 70-80%,stunted/<3rd centile,0,no,no,no,no,no,no,no,yes,no,no,no,no,no,no,no,no,yes,no
wasts)+scobine conjuctivties + consistent diarrhea,Diluted F-100 60m Q 3hr with supplementary suckink techinique Amoxacilin syrup 125mg 15ml
TID BBC applied dialy
case8,24,f,5,69,marasmic Kwashiorkor/<60%,sever wating/<70%,stunted/<3rd antile,9,no,no,no,yes,no,no,no,no,yes,no,no,no,no,no,no,no,no,yes,no
Dermitisis + stunted + monderate aneamia,Ampicilin 250mg IV Q ID Gentamisin 25 mg daily Doxacilin 125 mg IV BID Zink oxide interment applied
protein dite and Plumpynute 5sachet /day for the mother
case9,2,m,1.95,42,marasmus/< 60%,moderate wasting/between 70-80%,stunted/< 3rd centile,0,no,no,no,no,no,no,no,no,yes,yes,no,no,no,no,no,no,no
wasting).F-100 diluted 19ml/feed Q 3hr/ 8x/day Put in kmc position Provide the mother with high protein diet and plumpynut for 1sachet per da
```

Figure 3. 3:Case representations using notepad.

CHAPTER FOUR

DESIGNING AND IMPLEMENTATION OF THE PROTOTYPE SYSTEM

4.1. Introduction

The design and implementation part of this section involves the actual development of a scaled down workable CBR system for malnutrition under-five children diagnosis. Therefore, having all the necessary cases and the knowledge from the domain expert and different relevant documents, the next task is coding the knowledge into computer using appropriate and efficient knowledge representation methods. For this research, jCOLIBRI 1.1 CBR frame work is used to develop the prototype. The retrieval algorithm used in this research is nearest neighbor retrieval algorithm. This is because jCOLIBRI uses this algorithm for retrieval task. Nearest neighbor retrieval algorithm is also suitable when there are attributes which have numeric (continuous) value (Fang and Songdong, 2007).

4.2. Designing the architecture of the proposed Case Based Reasoning System

In designing the prototype case based reasoning system the CBR cycle (Aamodt and Plaza, 1994) which includes four Re‘s processes such as Retrieve, Reuse, Revise and Retain were taken as a base by the researcher (see Figure 4.1). When a case or query (problem) was inserted to the system by using the query window, it would be matched with the previous solved cases from case base. If the retrieved case exactly matched with a query in a case base then the new case has been solved in the reuse stage and so got a proposed solution. Otherwise, if there was no exact match, relevant cases were retrieved based on the global average similarity measurement and if the similarity value resulted within the threshold value of greater than 80%, the best similar case from retrieved cases were taken as a solution for adaptation in reuse stage. For a given query, when there is no relevant similar cases retrieved with the given threshold, or need to change the problem attributes or to update a solution, revision of them was taken place by the domain experts for the confirmation of both the problem and/or solution. If the updated or incremented is confirmed to be valid by the domain experts, then the new learned case stored to the case base in retain phase for future use. So the case base might be updated by the new learned case. The

Knowledge engineer is expected to collect data for the case base and mange case structure to incorporate with the appropriate connectors that fit to the cases written as text. For the purpose of this study, the prototype CBR system named as Case Based Reasoning System for Diagnosis of malnutrition for under-five year children (CBRSDMUFYC).

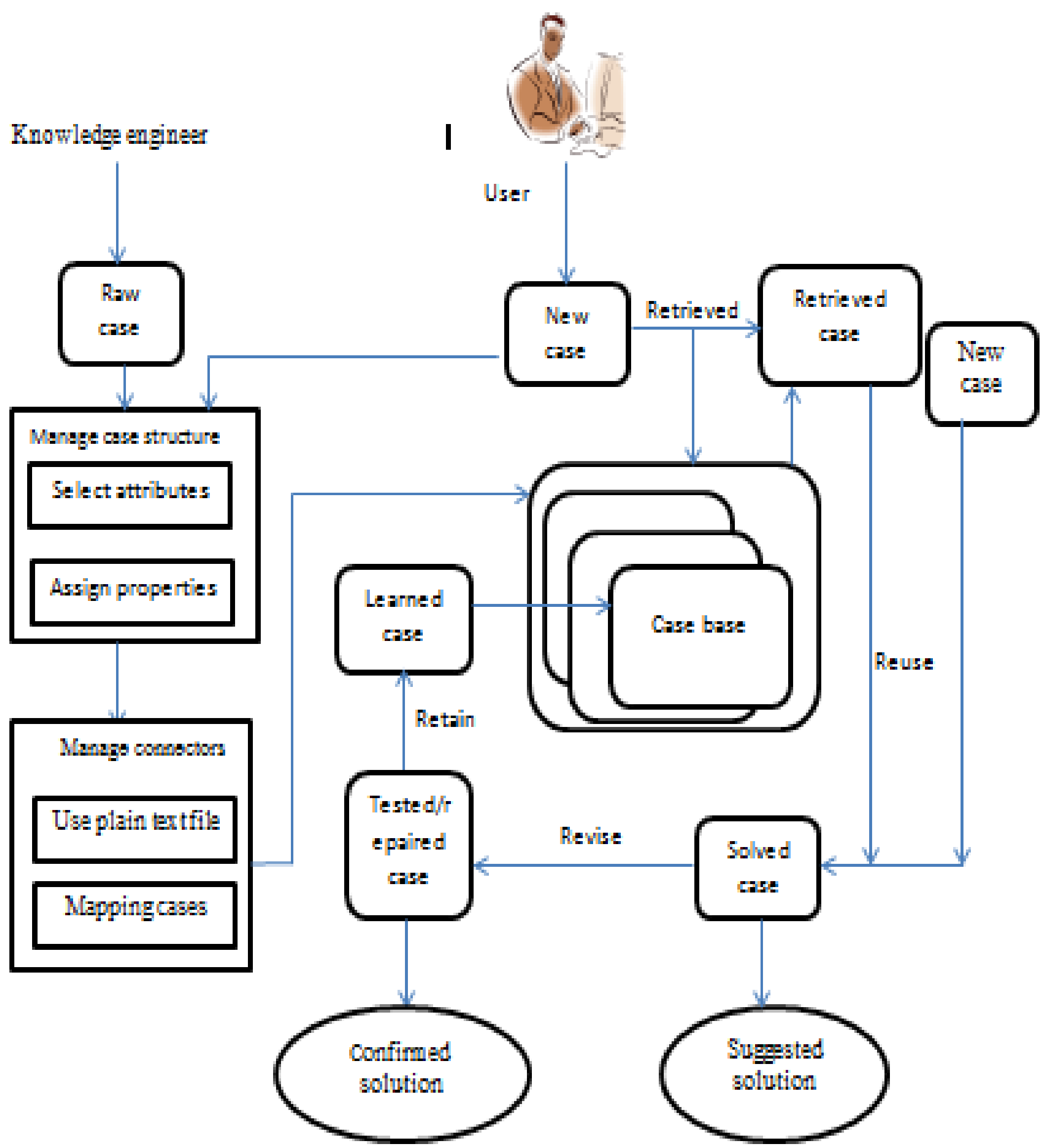


Figure 4. 1: Architecture for CBRSDMUFYC adapted from (Getachew, 2012)

4.1. Case Based Reasoning System for CBRSDMFUYC

The development of a CBR application involves number of steps, such as collecting cases and background knowledge, modeling, case representation, defining an accurate similarity measure, implementing retrieval functionality, and implementing user interfaces (Stahl and Roth-Berghofe, 2008). In this study, the researcher used the main feature of jCOLIBRI to develop the actual prototype. As Recio-Garcia, Diaz-Agudo, Recio Garcia, and González-Calero (2008) presented jCOLIBRI has been constructed as a core module to offer the basic functionality for developing CBR application. Implementing a CBR application from scratch remains a time consuming software engineering process and requires a lot of specific experience beyond pure programming skills (Stahl & Roth-Berghofe, 2008). Therefore, using jCOLIBRI CBR framework minimizes the effort to develop an application by using other programming languages.

To run jCOLIBRI for the first time, click on the JColibriGUI.bat file and it becomes ready for usage as shown in the following figure 4.2 has an upper toolbar which shows four menu lists: File, CBR, Evaluation and Help**.**

Figure 4. 2: The main windows of jCOLIBRI

Developing a CBR system is a complex task where many decisions must be made. For this prototype CBR system, a new name CBRSDMUFYC was created and core and textual extensions were used for the new application to perform all the four major tasks of CBR cycle. This tool (jCOLIBRI) allowed the researcher to build this new application by defining: the case structure, building a case base, representing the cases by using feature-value pairs, configuring the connectors to use plain text format, and applying different methods and tasks which enable to achieve the objectives of the research.

4.1.1. Building a case base

During setting up the objectives of this study, one of the objectives is collecting malnutrition patient cases in order to build a case base and represent the cases using the appropriate case representation method. So, the researcher collected malnutrition for under-five year patient cases from Jimma University Specialized Hospital and Hawasa university comprehensive specialized hospital. The cases were selected purposefully to acquire knowledge from different experienced doctors and share their knowledge for non-experienced and other first line health professionals in order to help their decision in diagnosis of malnutrition for under-five year children. The acquired cases which diagnosis of malnutrition for under-five year children.

The case base is presented as a plain text comprising of n columns representing case attributes (A1, A2, A3, ..., An) and each m rows representing individual cases (C1, C2, C3, …, Cm), in which each attribute has a sequence of possible values associated to each column attribute A= {V1, V2, V3,…, Vk}.The reason for representing cases using feature-value representation is that this approach supports nearest neighbor retrieval algorithm and it represents cases in an easy way (Salem *et al*., 2005; Bergmann *et al*., 2005).

4.1.2. Case representation

The case representation is made in a way that easily fit to jCOLIBRI. Designing of such a case structure helps easily define the features available in the case and to measure the similarity between existing and new cases. Hence, the overall application of this research is to retrieve similar cases from the case base that can guide future reasoning, problem solving and also transforming a solution retrieved in a solution appropriate to the current problems. The collections of cases are represented in the feature-value representation to make efficient retrieval process. Indexing refers to assigning indices to cases for retrieval and comparison of a query to the case base (Luzelschwah, 2007).

To represent a case in CBR systems, the simplest way used is feature-value pairs. In the study, also the researcher used feature-value pair representation which was simple to make retrieval efficient. In designing a case structure, an emphasis was given to defining the attributes available in the case and measuring the similarity values between existing and new cases. So, this research stressed on the retrieval of similar cases from the case base that can support decision in problem solving by retrieving in a solutions appropriate to the current problem.

4.1.3. Managing Case Structure

The acquired cases are saved in plaintext file format. Before creating CBR application case structure configuration was needed. As it is depicted in Figure 4.3, new window which is a visual tool used to define case structures displayed. In the left panel the structure of the case displayed as a tree and in the right panel the property values of the selected attributes are shown. A Case could have a Description, a Solution and a Result. Simple attributes were described by the following four characteristics: name, type, weight and local similarity function. Compound attributes collect other simple or compound attributes allowing complex case structures. The properties of the compound attributes are described by the name and the global similarity function.

Most of the case attributes have Boolean data type and a few attributes have string data type. Age and height has integer data type, weight and Mid-upper arm circumference (MUAC) has double data type. The reason for the use of Boolean data type for most of the attributes is, during the diagnosis of malnutrition for under-five year children the physician simply checks the absence and presence of the symptoms with respect to the significance of the attribute for her/his decision. Even the local similarity of all attributes which Boolean and double data type is equal. Age and height has interval. Global similarity of solution attributes is average.

Local similarity functions are used to compare simple attribute values. In the study Local similarity functions used are listed as follows.

Equal: If equal was selected for each attributes, the input value and the value in the case base must be exactly matched to get the result otherwise failure would be the result. In the study this equal similarity used to show weather the patient had the symptoms and/or signs or not; if a sign or symptom is seen on the particular patient similarity value would have a value of one, otherwise the similarity value be zero.

Interval: In the interval case, exact match is not required for similarity; when it is assigned to the attributes in jCOLIBRI, the interval value is valid in searching similarity from the case base.

Global Similarity is linked with compound attributes and used to get similarity of the average of all the attributes with their unique similarity value. In this research average similarity which is a type of global similarity that considers the average of all attribute local similarity values is used.

Average: It is a type of global similarity that considers the average of all attribute local similarity values. The algorithm works as follows (Watson & Marir, 1994; Salem et al., 2005; Henok, 2011).

Step 1: Find the local similarity of step for all attributes of the case which make up the case base

Step 2: Multiply the result of the local similarity of attributes with their corresponding attribute weight (importance value)

Step 3: Add the value of all attribute results of step 2

Step 4: Add all weights of attributes that represent the importance value of the attributes and multiply by the number of attributes

Step 5: Divide the result of step 3 by the result of step 4 and the result of this step is the global similarity that represents the degree of match of the old case with the new input case.

4.1.4. Description of CBRSDMUFYC Case Attributes

For the prototype CBRSDMUFYC, there were 27 description attributes and 2 solution attributes identified by the domain experts for diagnosis of malnutrition of under-five year children. Solution attributes are used after selecting best similar case and it shown the type of malnutrition and the recommended treatment. The attributes had a weighted value which was also assigned by the domain experts by assuming higher weighted values to mean more important attributes in diagnosis of malnutrition.

The main attributes used in the CBRSDMUFYC system were: 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, Weakness, Weight loss, Swollen hands and feet, Feeling cold, Depression, 'Baggy pants' loose skin around the buttocks, Body sweating, diagnosis and recommended treatment. Weighs are assigned by the domain experts by assuming to retrieve best solution for the problem at hand. So some attributes had less weighted value than others to mean less important in diagnosis of malnutrition. The description of case attributes regarding name, data type, weight value and local and global similarities are shown in the following table (Table 4.1). In developing the prototype the weight used ranges from 0 to 1; where 0 means irrelevant and 1is very important and the values difference is assumed as linear scale. The weight values are assigned by the domain experts with their importance in diagnosis of malnutrition for under-five year children.

Table 4.1: 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 buttocks	Boolean	0.7	Equal
Body sweating	Boolean	0.6	Equal
Diagnosis	String	0.9	Equal
Recommended Treatment	String	0.9	Equal

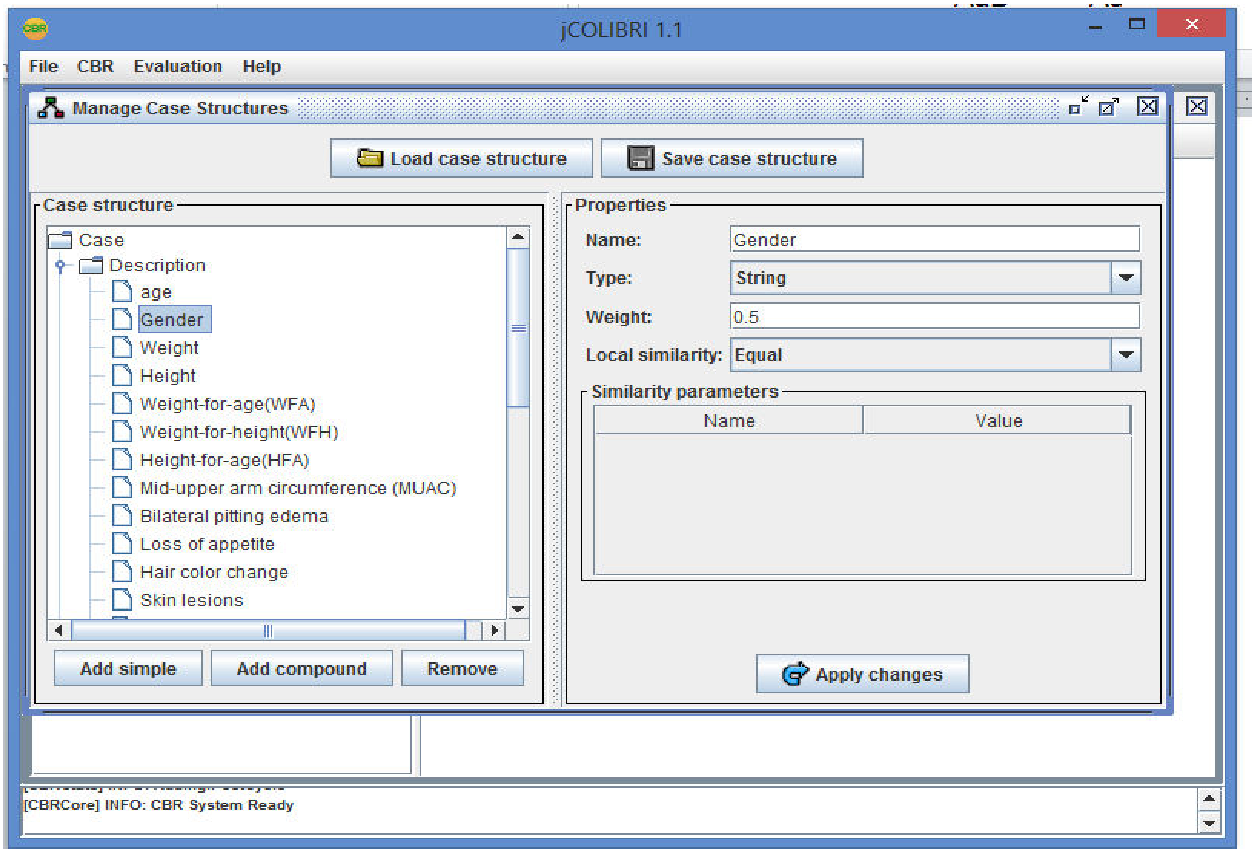


Figure 4. 3: Defining the case structure for CBRSDMUFYC

4.1.5. Managing connectors

Once case structures are configured in jCOLIBRI, CBR systems must access the stored cases in an efficient way. jCOLIBRI, splits the problem of case base management in two separate although related concerns: persistency mechanisms through connectors and in-memory organization. Cases are often derived from legacy databases, thereby converting existing organizational resources into exploitable knowledge. To take advantage of these previously existing resources, facilitate intelligent access to existing information, and incorporate it as seed knowledge in the CBR system (the case base), jCOLIBRI offers a set of connectors to manage persistence of cases.

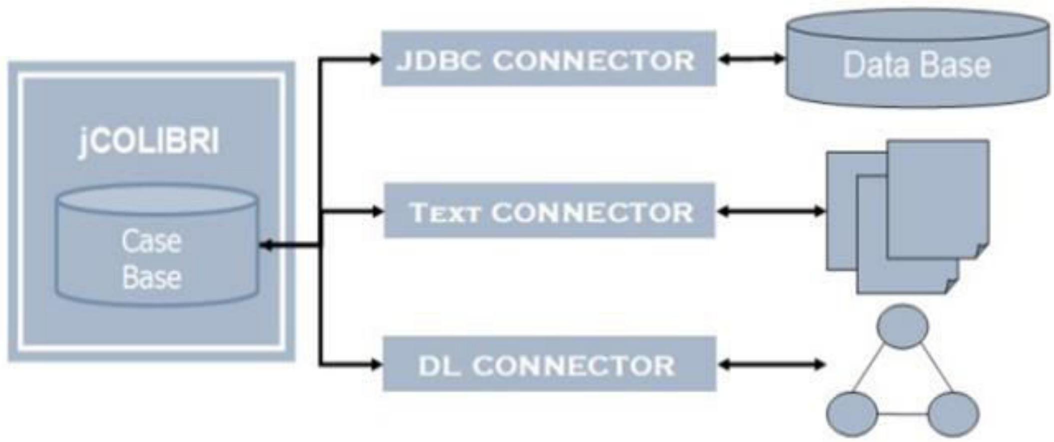


Figure 4. 4: jCOLIBRI connector architecture

Connectors are objects that show how to access and retrieve cases from the storage media and return those cases to the CBR system in a uniform way. Therefore connectors provide an abstraction mechanism that allowed users to load cases from different storage sources in a transparent way. As shown in figure 4.4, jCOLIBRI includes connectors that work with plain text files, relational databases and Description Logics systems. In developing the prototype system with jCOLIBRI, connectors that work with plain text files, XML files were used.

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

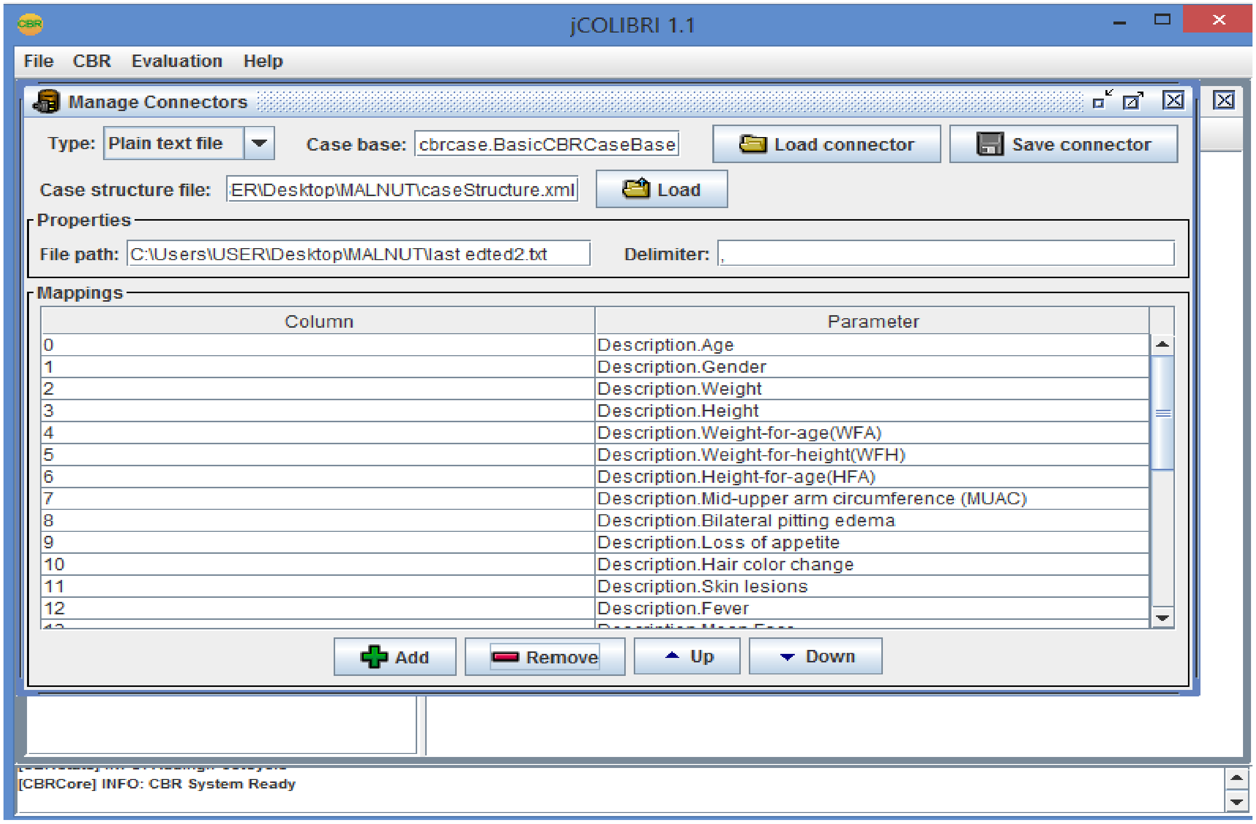


Figure 4. 5: Managing connector for the prototype CBRSDMUFYC

4.1.6. Managing Tasks and Methods

4.1.6.1. Managing Tasks

Tasks were set up by the goals of the system, and a task is performed by applying one or more methods. For a method to be able to accomplish a task, it needs knowledge about the general application domain as well as information about the current problem and its context. The set of subtasks of a task are intended to be sufficient to be accomplished the task at their level. In development of the prototype CBRSDMUFYC, the researcher used core package tasks which have three main parts of CBR system; namely: PreCycle, main CBR cycle and PostCycle.

In PreCycle the main task performed was Obtain cases task, which checked up and displayed the number of cases present in the case base using plain text connector. For the prototype CBRSDMUFYC 56 cases were stored and displayed in preparing for the next tasks.

In the main CBR cycle, there were five basic tasks performed. They were: Obtain query task, Retrieve, Reuse, Revise and Retain tasks. For each major task there were numbers of sub tasks to be performed and are described as follows.

Obtain query task: used to obtain the case attributes from the case base and a query windows interface displayed to be used for the entrance of cases. Signs and symptoms (attributes) for a suspect of malnutrition marked on the displayed query window for the process of diagnosis of malnutrition for under-five age children.

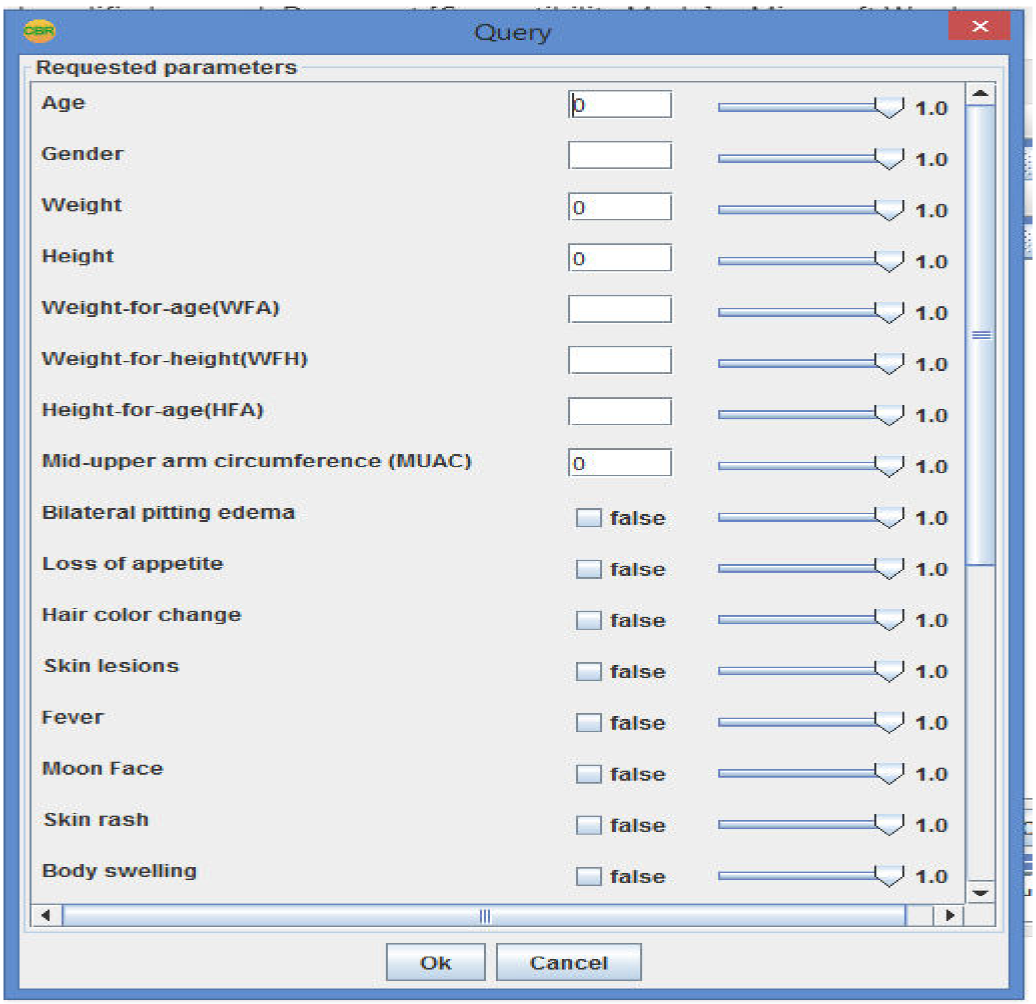


Figure 4. 6: jCOLIBRI Windows for the case entry

Retrieve task: there are three sub tasks performed here; the first sub task-Select working cases sub task used for retrieving all working cases from the case base, the second sub task-Compute similarity sub task used for calculating similarities using average nearest neighbor similarity for each cases available and the third sub task-Select best sub task used for selecting the best similar case from all listed cases for diagnosis of malnutrition for under-five age children.

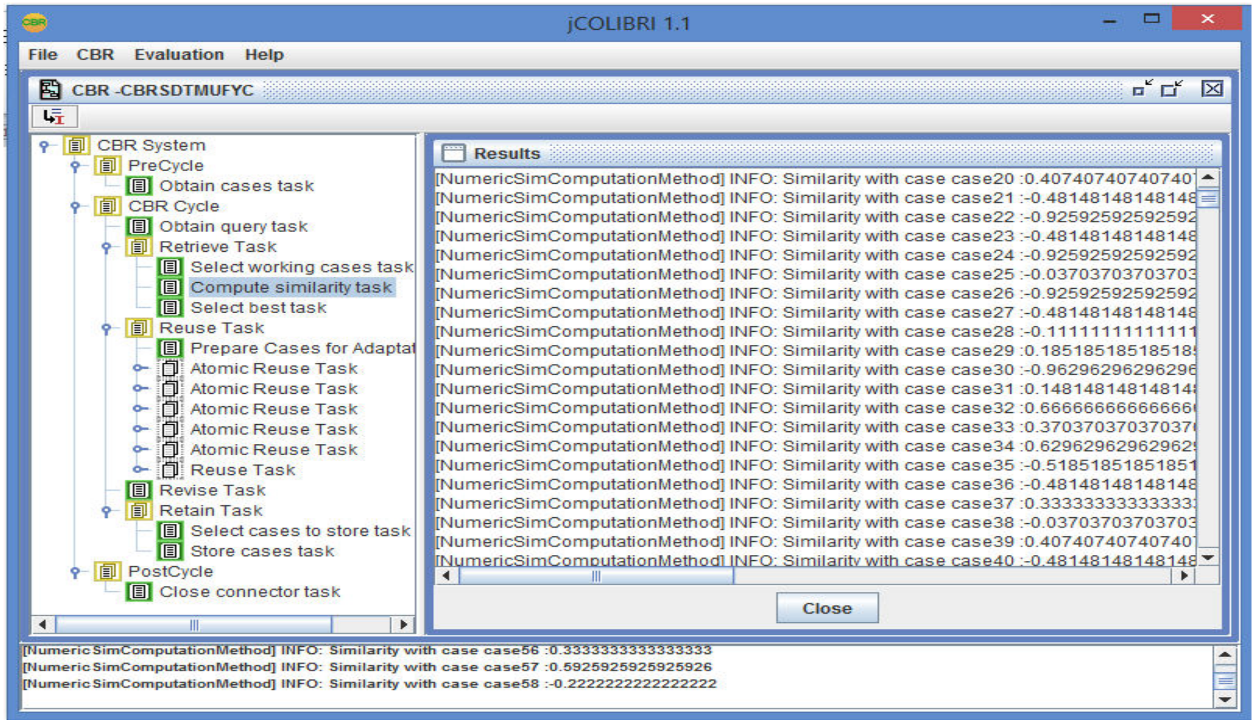


Figure 4. 7: Case similarities for the query from the case base

Reuse / Adaptation task: Selects working cases from case base and stores them into current context for the requirement of the new solution. The reuse stage generates the proposed solution for the problem. The reuse step (also named adaptation step) adapts the solution of the retrieved cases to the requirements of the query.

Revise task: This is the evaluation stage for the selected solution in the Reuse phase. After selecting the most similar case by applying nearest neighbor similarity, the solution for the problem should be confirmed and validated by domain experts before stored in a case base.

If the retrieved best case did not satisfy to diagnose and treat the new case/Query, the retrieved best case is ready for adaptation. So, this new case could be updated and stored in the case base and be used to diagnose and treat malnutrition for the future new case. This can show that the prototype CBRDMUFYC could learn at each entry of new cases and users reuse this knowledge for diagnosis and solution process.

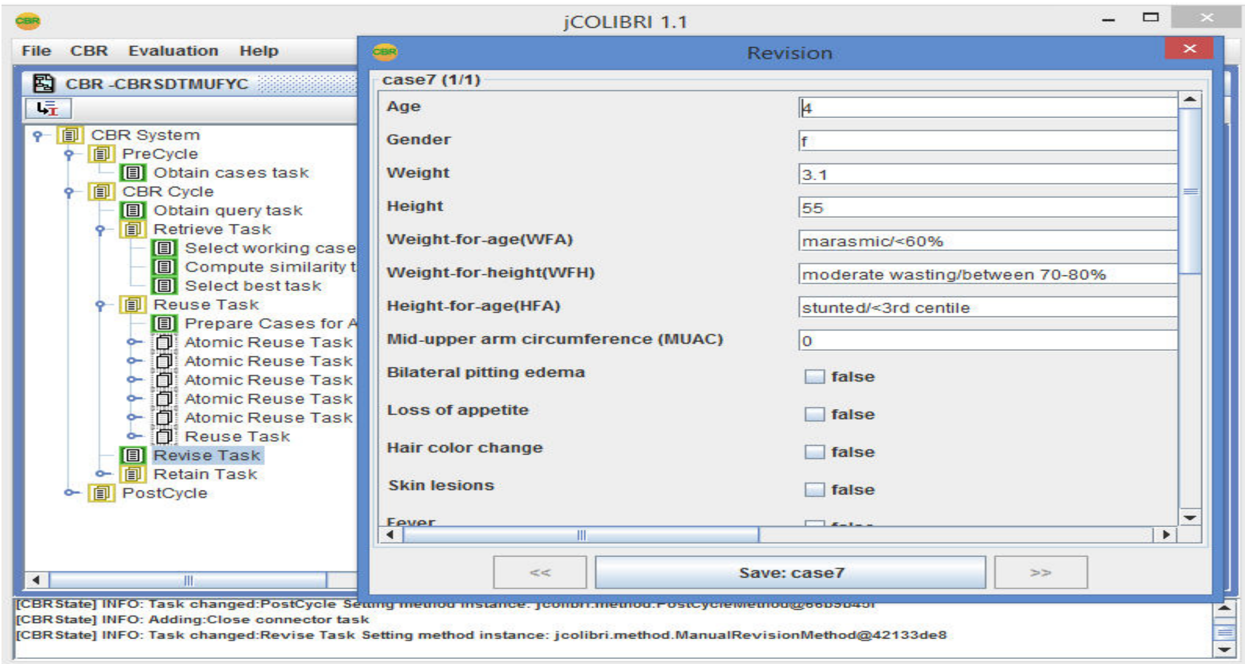


Figure 4. 8: Revision task

Retain task: After the revision is confirmed by the domain experts, the problem with its solution could be stored in a case base by using Select cases and Store cases subtasks.

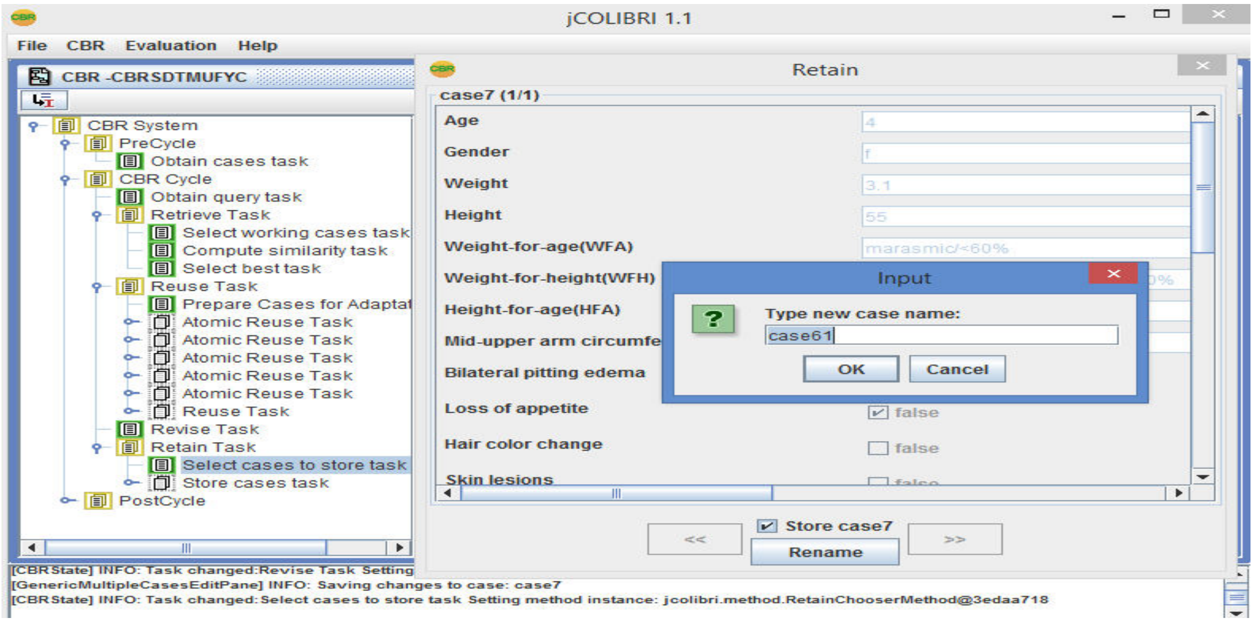


Figure 4. 9: Retain task

At this stage; confirmed, validated and learned case prepared for permanent storage in a case base. And when confirmed it prepared to be stored permanently for the next task.

PostCycle Task: This task executed after CBR cycle. Here the Close connector task closes the connector by saving permanently the learned case to store in a persistent layer of a case base.

Case Similarity, Matching and Ranking

The primarily goal of CBR system is to retrieve best similar cases by using some similarity assessment of heuristic functions. The similarity function involves in computing the similarity between the stored cases in the case base and the query, and selects nearest similar cases to the query. Therefore, jCOLIBRI uses the nearest neighbor algorithm as a cases retrieval technique. Nearest neighbor algorithm used to measure the similarity between the stored and the new queries, and return the search results within their ranked order. For each attribute in the query and case, local similarity function measures the similarity between two simple attribute values. Based on the matching weighted sum features from those simple attributes, the similarity score between the queries and stored cases for each simple attribute is assigned.

Finally, the average score (global similarity) of each attribute between the case and the query are computed and the result is assigned to the object (the similarity between the stored case and the query). The maximum degree of similarity among the retrieved cases is displayed according to their ranked order.

4.1.6.2. Managing Methods

The method library stores classes that actually resolve the task. These classes can resolve the CBR cycle using in programming or using GUI. All the tasks mentioned above should have their own methods which help them to achieve the tasks goal. A method specifies the algorithm that identifies and controls the execution of subtasks, and accesses and utilizes the knowledge and information needed to do this. In the implementation and application of CBRSDMUFYC, the main methods used for the application of the tasks are described as follows.

LoadCaseBaseMethod: This method returns the whole available cases from the case base to designer. This method use plain text connector to retrieve the case from the case base.

ConfigureQueryMethod: displays the GUI window in which the user can enter query to retrieve cases from the case base. It uses case structures as input parameters.

SelectAllCasesMethod: This method allows displaying all available cases from the case base to the result window, by holding attributes.

SelectBestCaseMethod: This method selects the best similar case among the displayed cases, by prioritizing the similarity results.

NumericSimComputationMethod: This is used to compute similarity between the query and cases that are stored in the case base. It uses nearest neighbor similarity for the computation.

CopyCasesforAdaptationMethod: Selects working cases from case base and stores them into current context. It uses case structure as an input.

CombineQueryAndCasesMethod: CBR case reuse atomic task. This task must be solved by a reuse resolution method.

ManualRevisionMethod: used to manually update the attributes or/and the solution when needed.

RetainChooserMethod: This method allows the user to choose the method. Chosen method will store case base. User can choose that he/she want this method to store in case base.

StoreCasesMethod: This method used to stores cases into Case base.

CloseConnectorMethod: Closes the connector by saving the case permanently to the case base.

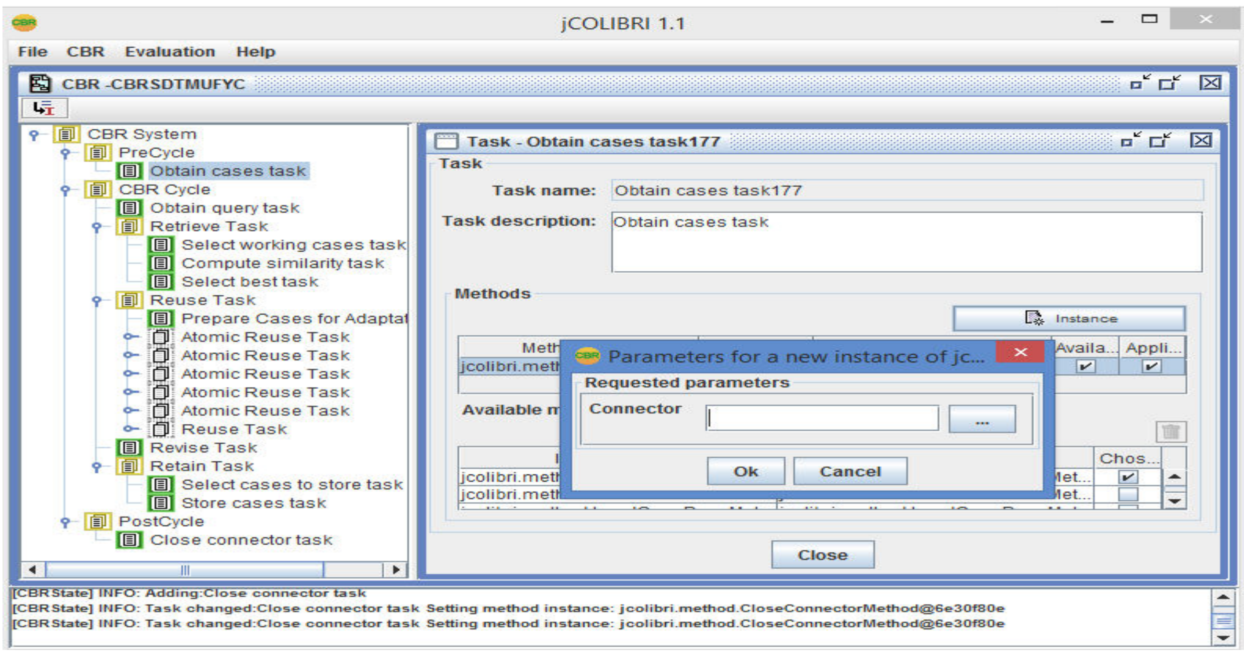


Figure 4. 10:Tasks and methods configuration

In this chapter, the researcher discussed how the prototype CBRSDMUFYC works by using jCOLIBRI. All the four CBR cycle components such as; retrieve, reuse, revise and retain were applied and discussed in the developed prototype system. The developed CBRSDMUFYC achieved the requirement of the study in giving advice for diagnosis of Malnutrition for under-five year children.

System performance testing is the process of determining whether the prototype system meets the level of accuracy as required. It confirms whether the right prototype is developed. So, in the next chapter, the results on evaluation of the system regarding system performance and user acceptance testing were discussed in detail.

CHAPTER FIVE

TESTING AND PERFORMANCE EVALUATION OF THE PROTOTYPE

5.1. Experimental Setting

For building the prototype CBR system, one of the main steps was building of previously solved cases for the case base. There were about 56 previously solved cases collected and used from Jimma University specialized hospital and Hawasa university comprehensive Specialized hospitals for developing and testing the prototype CBRSDMUFYC. The cases were represented by using feature-value pairs, in which each case represented with different number of attributes. Data cleaning like handling missing values, inconsistent data and redundant data were handled.

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

Now, this is the time to test the functionality of CBR cycles and the soundness of the prototype using selected test cases to check its validity and performance to domain experts. The effectiveness of the prototype is measured with recall and precision using test cases. In addition the performance of the system is evaluated from the users‟ side called user acceptance testing. In this user acceptance testing, potential users‟ of the system rate the applicability of the system in their day to day activities**.**

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

Retrieval of previously stored cases to solve new problems is the first step in any CBR application. Retrieval of similar cases to the new case from previously solved cases is followed by the reuse of similar solutions. In this research retrieval of cases is performed using the nearest neighbor retrieval algorithm because the implementation tool jCOLIBRI uses this algorithm. During retrieval, similar cases are retrieved to the new case with appropriate ranking. After that the user of the system can use the solution of the retrieved cases in a way that can fit to the problem at hand. Therefore, retrieval and reuse of cases is successfully implemented in the CBRSDMUFYC application as shown in figure 5.1.

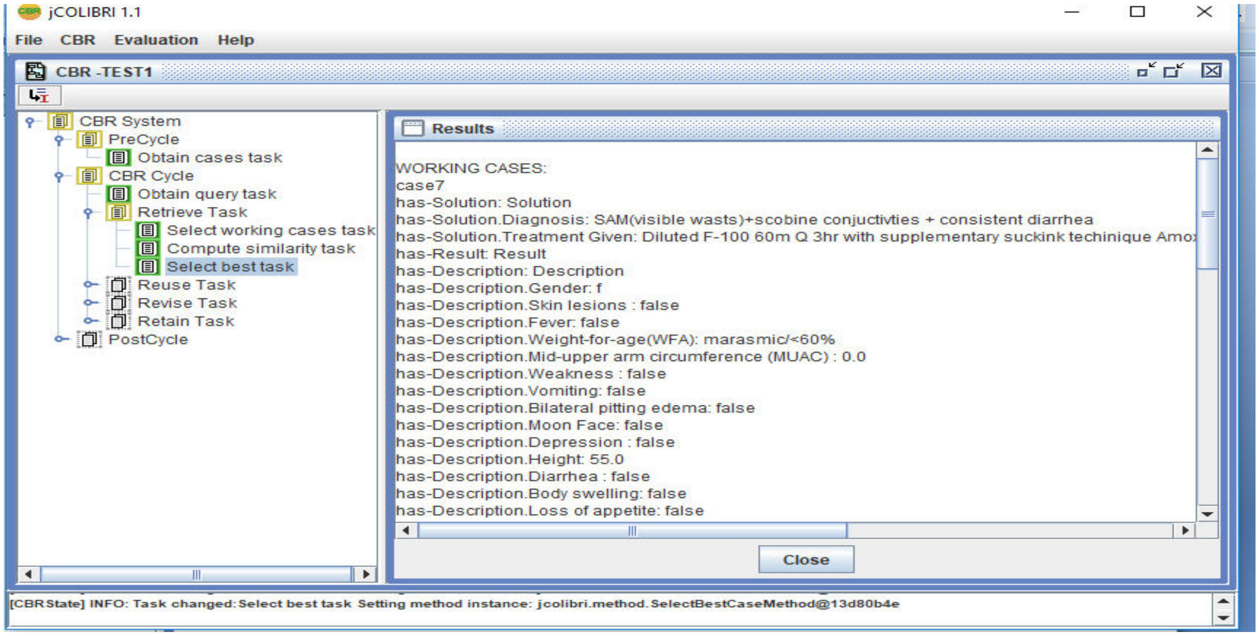


Figure 5. 1: Retrieval of Cases

The statistical analysis evaluation uses 56 malnutrition for under-five year children cases that have been collected from Jimma University specialized hospital and Hawasa university comprehensive Specialized hospitals. In this research, the effectiveness of the retrieval process of the CBRSDMUFYC is measured by using recall and precision. According to McSherry (2001) precision and recall are the commonly used measures of performance of the retrieval process in CBR. Recall is the ability of the retrieval system to retrieve all relevant cases to a given new problem (query) from the case base. On the other hand, precision is the proportion of retrieved cases that are relevant to a given query. To conduct the evaluation, for each test case the relevant malnutrition for under-five year children cases from the case base should be identified. For identification of relevant cases, test cases are given to the domain expert in order to assign possible relevant cases from the case base to each of the test cases. The domain expert uses the value of disease type and Recommended Treatment or solution attributes of the malnutrition for under-five year children case as the main concept to assign the relevant case to the test cases. After the identification of the relevant cases to the test cases by the domain expert, recall, precision and F-measure are calculated.

Test cases	Relevant cases 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

Table 5.1: Relevant cases assigned by domain experts for sample test cases

Once the relevant cases are identified and assigned to the test cases the next step is calculating the recall, precision and F-measure value of the retrieval performance of the CBR system with a threshold interval. Previous researchers used (1.0, 0.8) threshold according to Henok (2011) indicated in his research, there is no standard threshold for the degree of similarity that has been used for retrieving relevant cases in CBR. Different CBR researchers use different case similarity threshold. Henok (2011) used a threshold level of [1.0, 0.8) i.e. this means cases with global similarity score greater than 80% are retrieved. In this research, the threshold is set by the researcher. For this research, [1.0, 0.8) threshold is used.

Test cases	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**

Table 5.2: Performance measurement of CBRSDMUFYC using precision and recall

In the study, for calculating the recall value, comparison of numbers of relevant cases which were retrieved by the system and the relevant cases selected by the domain experts were used. For example for the first test case, from seven relevant cases selected by the domain experts the system retrieved only six cases so that the recall for Test case 6 is 0.86. And the rest recall values can be calculated in the similar manner as it is shown in Table 5.2.

In the case of precision, it is relevant cases retrieved by total number of retrieved cases, which total numbers of retrieved cases contains both relevant and not relevant retrieved cases within the threshold value used; i.e. [1.0, 0.8]. For example Test case6 contains six relevant cases retrieved and two not relevant cases retrieved from the case base, with a total of nine retrieved cases. And so, the precision value is 0.67; and for the rest test cases, precision values can be calculated in the same manner as shown in Table 5.2.

As it shown in table 5.2, calculated recall values for each test case were above 75%, which shows the ability of retrieval of the prototype CBR system to obtain most of the relevant cases from the case base was good. In evaluating the performance of prototype system CBRSDMUFYC, with recall values, has got an average recall value of 83%, which indicated a higher recall value that shown us the prototype system could obtain most of relevant cases from the case base. Therefore, the prototype system- CBRSDMUFYC have a capacity to retrieve relevant cases that enable to diagnose and treat malnutrition under-five year children.

On the hand the prototype system retrieved relevant cases to the system with an average of 71% precision. Although, the average precision value is good, few number of cases used are one of the limitations for the developed system. Although, it was difficult to achieve the ideal 100% precision and recall values in practice. As it is shown on Table 5.2, recall and precision values for the prototype system have been an average of 83% and 71%, respectively. The value for F-measure which was 0.76 also showed good performance of the prototype system. In general, precision, recall and F-measure average values shown us the average performance of the system as good and could be used to support health professionals for diagnosis of malnutrition under-five year children.

5.2.2. Revise and Solution Adaptation Tests

One of the main advantages of CBRSDMUFYC is its ability to update the solution whenever needed. As medical science grows faster in updating the treatment, there need to be an environment for updating itself in CBRSDMUFYC. For the query when there exist a case that exactly matches, the adaptation is null and the retrieved case is used without adaptation. But if there is no retrieval of exact matched case, the retrieved best similar case's solution can be adapted by the domain experts in time of their need. Since medicine need a great care adaptation in modifying the solution has to be done manually by the experienced domain experts. Once cases have been adapted, the domain expert could adjust the values of the working cases in a manual way, by confirmation of the domain experts.

The updated case in CBRSDMUFYC, after it is confirmed by the domain experts, can be stored in the case base for future use. It is not only the solutions but also symptoms and signs can be changed with changing living conditions and new medical findings. Manuals and other relevant documents in use in today's medication could also be renewed. Therefore, the adaptation has to be performed manually by a human domain expert as shown in the figure 5.2 below.

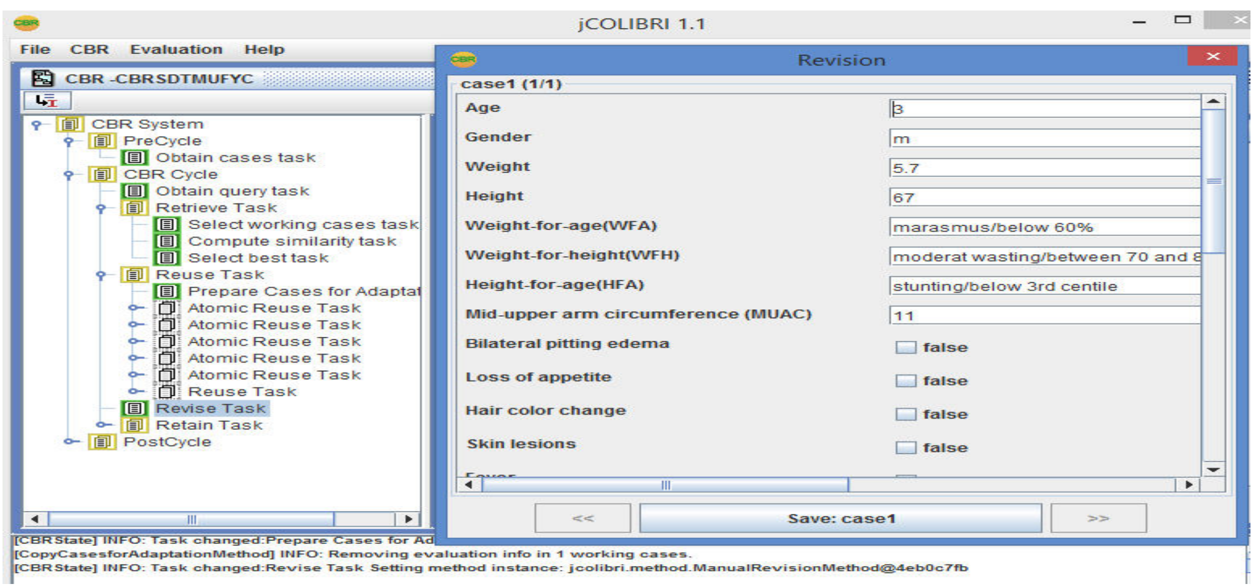


Figure 5. 2: Revision Interface

5.2.3. Testing Case Retaining

Case retaining is the last cycle in CBRSDMUFYC which is an important step in storing new cases which would use for future diagnosis. Especially, in malnutrition diagnosis, retaining cases over time is important because mostly the treatments are acute malnutrion which is mostly using nutritionist tacit knowledge and personal experience.

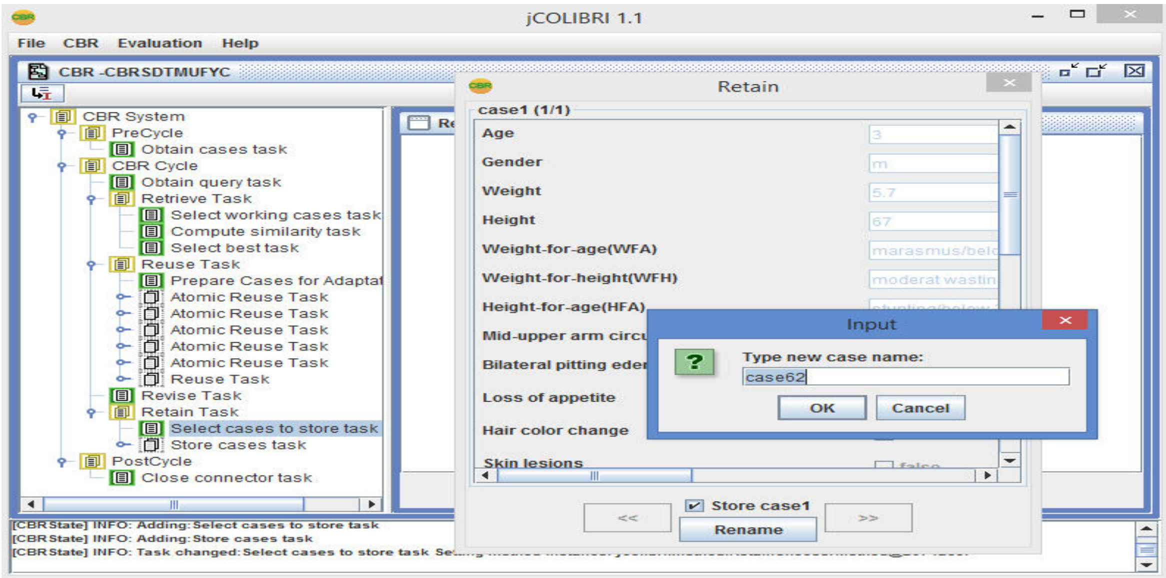


Figure 5. 3: Case Retaining Dialog Box

5.3. User Acceptance Testing

According to Abdolzade (2012) acceptance testing, as one of evaluation process, is performed to confirm that the system developed achieved its objectives. User acceptance testing consists of a process of verifying that a solution works for the user, i.e. it measures the quality of the application. Any system development is meaningless unless and otherwise the users evaluated and accepted to work with it. So the researcher tests the acceptance of CBRSDMUFYC by domain experts. For the purpose of acceptance testing of CBRSDMUFYC the researcher identified and selected six by taking six health professionals (2 medical doctor, 2 health officers and 2 nurses) purposefully from Jimma University specialized hospital.

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

No	Evaluation Parameters	Performance Value					
		Poor	Fair	Good	Very Good	Excellent	Average
1	Is the prototype system adequate and clear for decision support?			1	4	1	4
2	Is signs and symptoms are relevant in representing the malnutrition for under-five year children case?			1	2	3	4.3
3	Fitness of the final solution to the problem at hand				4	2	4.3
4	Relevancy of the retrieved cases in the decision making			1	2	3	4.3
5	Is the system efficient in time?			1	2	3	4.3
6	Is the prototype system user interface interactive?		1	1	2	2	3.8
7	Ease of use			3	2	1	3.7
8	Rate the significance of the system in the domain area			1	1	4	4.5
						Total average	**4.15**

Table 5.3: User Acceptance testing from domain experts

As depicted in table 5.3, 67% of the respondents' rate adequacy and decision support as very good, 17% of the respondent's rate as excellent and the remaining 17% of the respondents rate as good. For the case of second parameter which was "relevance of signs and symptoms for representing malnutrition for under-five year children cases', 17% of the respondent rate the system as good, 33% of the respondent rate as very good and the rest 17% of the respondent rated as excellent. In the case of fitness of the final retrieved solution to the new problem at hand around 67% of the respondents rate the prototype is very good whereas only 33% of the respondents rate as excellent. The relevance of the retrieved cases in to support users decision making rated very good by 33% of the respondents, 50% of the respondent's rate as excellent whereas the remaining 17% of the respondents rate it as good. 50% of the respondents 'rate the system as excellent, 33% of the respondent's rate as very good and the remaining 17% of the respondents' rate as good in terms efficiency in time. For the case of "interactive-ness of the user interface", 17% of the respondent rated the system as fair the reason that it is localize, other 17% of the respondent rated as good, 33% respondents rated it as very good and the rest 17% of the respondents rated the system as excellent; For the case of the seventh parameter "ease of use of the system, 33%, 17% and 50% of the respondents' rated as very good, excellent and good respectively. To this end 67% of the respondents rate the applicability of the prototype in their domain excellent, 17% of the respondent's rate as good and the remaining 17% of the respondents very good.

Generally the user acceptance testing for CBRSDMUFYC achieved a total average acceptance of 83%, which is above very good. This performance result is that showed the importance and applicability of the prototype system in decision making**.** So it can be concluded that, CBRSDMUFYC can be used in supporting decisions in diagnosis of malnutrition under-five year children. From the comments collected from the domain experts during testing, the respondents emphasized on the need for training on the CBRSDMUFYC for better understanding and usability of the prototype system. They also mentioned the need of additional cases to the case base in order to give better diagnosis of malnutrition for under five year children. They mentioned the limitation of the CBRSDMUFYC, as not having detail description whenever needed.

CHAPTEER SIX

CONCLUSION AND RECOMMENDATIONS

6.1. CONCLUSION

Malnutrition is possibly one of the predominant causes of illness and death for under- five children in Ethiopia. The possible reason for this might be that only a few health care workers have been trained on malnutrition and the poor practical performance of health professionals as nutrition education in the medical curricula has been random, uncertain and far from adequate. Additionally there is no nutritionist assigned in the health centers and it is not observed a health education session on nutritional issues. That is why this prototype CBR system is developed to share the experience of highly qualified medical professionals in order to support decision making whenever needed.

For this design science research, previously solved cases by experienced medical doctors were collected purposefully from Jimma University specialized hospital and Hawasa university comprehensive specialized referral hospitals. The acquired knowledge was organized and modeled using hierarchical tree that represents concepts and procedures in malnutrition under-five year children diagnosis. After the acquired knowledge is modeled, case based reasoning technique is used for representing the knowledge. Cases were represented with attribute-value format. In developing the prototype CBR system the researcher used jCOLIBRI, which is free and could perform all the tasks of CBR cycle such as: retrieve, reuse, revise and retain for designing the prototype system. For the problem case the system could identify past cases with their similarity values by displaying similarity values of all cases to the problem case.

For the evaluation purpose both system performance and user acceptance testing performed and got a promising result. The current study refers to a promising result towards applying case based reasoning in the health domain in general and in the diagnosis of malnutrition under-five year children in particular. One of the major challenges identified during the research was the difficulty in acquiring patients' cards and extracting features from the texts which took more time and restricted the number of cases collected. The other challenge was an assignation of weight age for the attributes depending on their importance in diagnosis of malnutrition under-five year children.

6.2. RECOMMENDATIONS

The main goal of this research is to design a prototype CBR application for malnutrition under-five year children diagnosis. At the beginning of this research, the researcher set up different specific objectives in harmony with the overall general objective of this study. To this end, almost all objectives are achieved successfully with some challenges and constraint. Therefore, there are a number of problems to be investigated by future researchers in applying CBR in malnutrition under-five year children health.

- The retrieval algorithm used for retrieval of cases for CBRSDMUFYC application is nearest neighbor retrieval algorithm. Since the case base of the system increases through incremental learning, the retrieval time increases linearly. Therefore, the retrieval performance will decrease from time to time. To overcome this problem investigating case maintenance techniques is.
- In order to increase the performance of the system a hybrid medical CBR system that incorporates the advantages of other knowledge representation techniques like rule based has to be considered so as to denote medical complications solution to a problem space.
- The prototype focused on diagnosis malnutrition only under-five year children. In order to give a better dimension, it is better to include all age group like infant and adult.
- As the prototype CBRSDMUFYC used nearest neighbor retrieval which linearly increase the retrieval time, so in the future there is a need to incorporate with other retrieval algorithms such as induction retrieval.

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APPENDICES

APPENDIX I

Interview Questions

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.	Evaluation Parameters/ criterion	Performance Value				
		1	2	3	4	5
1	Is the prototype system adequate and clear for decision support?					
2	Is signs and symptoms are relevant in representing the malnutrition for under-five year children case?					
3	Fitness of the final solution to the problem at hand					
4	Relevancy of the retrieved cases in the decision making					
5	Is the system efficient in time?					
6	Is the prototype system user interface interactive?					
7	Ease of use					
8	Rate the significance of the system in the domain area					

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

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