A knowledge based System for Diagnosis of Malnutrition for Under-Five Year Children: A case Based reasoning Approach

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Abstract: Malnutrition is an umbrella term for the unsuitable intake of nutrients needed to sustain healthy development. It is possibly known to be one of the predominant causes of illness and death for under-five year children in Ethiopia. This is because of scarcity of specialists, practitioners and health facilities at lower level health institutions in order to diagnose and give treatment at early stage. Hence an attempt is made in this study to design a case-based reasoning knowledge based system. The cases were collected from two known hospitals in the country: Jimma University specialized hospital and Hawasa university comprehensive specialized hospitals. Stratified sampling technique was employed to select domain experts’fort 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.

Keywords: Case Based Reasoning; Malnutrition Diagnosis; Knowledge Acquisition; Knowledge Representation

Introduction
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).

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).

**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 Ecel, (2009) has shown that about one-third of deaths among children below five years of age were happened due to under nutrition.

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). 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.

Therefore, the aim of the current study is to design a case base reasoning system for early diagnosis of malnutrition. To this end, the study attempted to investigate and answer the following research questions.

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

**Objective of the Study**

The study has the following general and specific objectives.
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.

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.

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.

Methodology of the study  
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 (Philippet al., 2009). As a result, this research was followed design science model building and analysis.

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.

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.

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.

**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.

**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.

**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. Integrated knowledge base system architecture for his topopathological diagnosis of breast diseases is other study related the researcher work (Adoronke 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.

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.

Baesien (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) were 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.

Design and Implementation

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).

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 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 1: Architecture for CBRSDMUFYC

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.
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Obtain query task: used to obtain the case attributes from the case base and a query window 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.

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.

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.
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.

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.

Post Cycle 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.

**Testing and Performance Evaluation of the Prototype**

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 1.

<table>
<thead>
<tr>
<th>Test cases</th>
<th>sim</th>
<th>sim</th>
<th>rec</th>
<th>rec</th>
<th>reti</th>
<th>reti</th>
<th>eved</th>
<th>eved</th>
<th>Force</th>
<th>Recall</th>
<th>Precision</th>
<th>F-Measure</th>
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<tr>
<td>Test case6</td>
<td>7</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>0.86</td>
<td>0.67</td>
<td>0.75</td>
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<tr>
<td>Test case7</td>
<td>11</td>
<td>9</td>
<td>12</td>
<td>12</td>
<td>0.81</td>
<td>0.75</td>
<td>0.78</td>
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<td>Test case8</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>0.83</td>
<td>0.83</td>
<td>0.83</td>
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<tr>
<td>Test case9</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>0.75</td>
<td>0.6</td>
<td>0.67</td>
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<tr>
<td>Test case10</td>
<td>8</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>0.75</td>
<td>0.67</td>
<td>0.71</td>
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<tr>
<td>Test case11</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>1.0</td>
<td>0.75</td>
<td>0.86</td>
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<tr>
<td>Test case14</td>
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<td>6</td>
<td>6</td>
<td>0.8</td>
<td>0.67</td>
<td>0.73</td>
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<td></td>
<td><strong>0.83</strong></td>
<td><strong>0.71</strong></td>
<td><strong>0.76</strong></td>
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As it is shown in table1 above, the recall ability of the system is 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 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. 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.

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.

As depicted in table 2, 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.

<table>
<thead>
<tr>
<th>No</th>
<th>Evaluation Parameters</th>
<th>Performance Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Is the prototype system adequate and clear for decision</td>
<td>Poor: 1; Fair: 4; Good: 1; Very Good: 4; Excellent: 2</td>
</tr>
<tr>
<td>2</td>
<td>Is signs and symptoms are relevant in representing the case?</td>
<td>1; 2; 3; 4.3</td>
</tr>
<tr>
<td>3</td>
<td>Fitness of the final solution to the problem at hand</td>
<td>4; 2; 4.3</td>
</tr>
<tr>
<td>4</td>
<td>Relevancy of the retrieved cases in the decision making</td>
<td>1; 2; 3; 4.3</td>
</tr>
<tr>
<td>5</td>
<td>Is the system efficient in time?</td>
<td>1; 2; 3; 4.3</td>
</tr>
<tr>
<td>6</td>
<td>Is the prototype system user interface interactive?</td>
<td>1; 1; 2; 3; 3.8</td>
</tr>
<tr>
<td>7</td>
<td>Ease of use</td>
<td>3; 2; 1; 3.7</td>
</tr>
<tr>
<td>8</td>
<td>Rate the significance of the system in the domain area</td>
<td>1; 1; 4; 4.5</td>
</tr>
</tbody>
</table>

Total average 4.15

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.

Table 2: User Acceptance testing from domain experts

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

Conclusion and Results
In this study we showed the application of knowledge based system for malnutrition diagnosis. Accordingly we obtained 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. 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. 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.

References
6. Biasen, G. (2013). Application of Case Based Recommender System to Advise Students in Field of


