

A Collaborative CBR Recommender System to Support Patients, its Relatives and Caregivers in Chronic and Palliative Care

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1. Introduction

In the last decades, many medical assistance systems have been developed, and the interest in computer-aided problem-solving in medical and healthcare is constantly growing. Most of the software systems in this domain focus on decision support and recommendation of effective medication for patients. The combination of statistical analysis and case-based reasoning can facilitate a better medical diagnosis [1] [2] [3]. Within the case comparison mechanism of CBR, feature selection, similarity measurement, and adaptation methods play an important role to retrieve and revise cases. In this research, DePicT (**D**etect and **P**redict diseases using **i**mage classification and **T**ext Information from patient health records) uses image interpretation and word associations for feature selection and recommendation of medical solutions [4]. All gathered patient records are stored in relational databases as structured or closed-format (e.g. parameters and statistics), or unstructured or open-format e.g. texts and images. For example, images of affected areas of a melanoma skin cancer can contribute and support early stage diagnosis. Also, further information on answering questions or writing a statement about the patient's health condition is added to the knowledge base. Domain Experts can validate and verify the collected information and also update the case-base to correct the data records of patients. In the other hand, more over than assisting for detecting and predict the disease, the Vocational Educational Training (VET) and Technology Enhanced Learning (TEL) [5] is a research field which is investigated continuously. DePicT CLASS (**D**etect and **P**redict diseases using **i**mage classification and **T**ext information in **C**ase-based **L**earning **A**ssistant **S**ystem) is a CBR system by enrichment of cases with learning materials (e.g. reference images and textbook) [6]. It is utilized smart (knowledge-based) and accessible systems to provide vocational educational learning opportunities and achieving higher education. CBR is applied in various problem-solving domains, and it is appropriate in medicine to integrate the system and for explicit experience, cognitive adequateness, the duality of objective/subjective knowledge, and to extract subjective knowledge [7]. Design and development of the DePicT and DePicT CLASS are the main contributions of this investigation. It is a case-based system which uses DePicT Profile Matrix of the association strength between title phrase and identified keywords of cases. Making experiments to validate the research and this recommender system lead us to do it in the

skin and brain diseases as patient assistance system-DePicT CBMelanom and caregiver learning assistant system-DePicT Dementia CLASS, respectively.

2. Research Questions and Aims

This section presents the research questions which have been reached by my doctoral thesis:

1. How can we extract knowledge from healthcare processes and stakeholders to find the gap in the current system to create the desired system with considering requested a change?
2. How is it possible to establish an assistant system and utilizing data from the network communication between patients, caregivers and doctors contributing to a better understanding of their challenges?
3. How can we improve user experience with using Case-based systems?
4. How to evaluate the adaptation mechanism?
 - a. A new proposal that word association profile can follow adaptation on the most similar cases. The practicalities of this will be discussed.
 - b. A system is learned which guides manual adaptation of similar references retrieved from the case base. (e.g. learner can rank the best references)
 - c. In the context of adaptation, it is compared with the:
 - i. Information extraction using domain expert & stakeholders
 - ii. Information extraction using references.
 - iii. Statistical approaches (e.g. value),
 - iv. Statistical approaches enhanced by learned knowledge. (e.g. grade of ranking)

The approaches to addressing the research questions and the explanation of how the remaining aspects of these research questions are going to be investigated are described in the next sections.

3. Proposed Plan of Research

This research divided to a preliminary concept which is DePicT and the educational concept which is DePicT CLASS recommender procedure. In these concepts, we focus on the combination of the textual and structural case based reasoning and utilizes word association method which is called CIMAWA [8] to find the word association strength between case title and case features which identified keywords.

DePicT [4] is a conception of a knowledge-based system for the identification and diagnosis of diseases. It utilizes the graphical and textual similarity measurements of non-image and image information which are Tverskey's similarity measure [9], Frucci et al.'s image dissimilarity measure [10]. So, DePicT CLASS [6] is able to search for references based on the comparison of word association profiles of identified keywords to find the best similar ones with the request. DePicT CLASS is a Case-based Learning Assistant System which is the application of the DePicT concept. To answer the research questions which are explained in the previous section, two use cases are investigated. The prototype of DePicT CBMelanom is developed which is briefly explained in the next section and DePicT Dementia CLASS is fully implemented based on the retrieval and adaptation mechanism of DePicT CLASS [6] and evaluated based on the test problems from

Alzheimer and dementia forums and homepages [11]. This research proposes a new adaptation method for dementia vocational educational training which uses the WHO Framework for the International Classification of Functioning, Disability, and Health (ICF) [12] word association strength of the DePicT Profile Matrix [6], [11]. It is utilized abstraction adaptation to characterize each case by an identified keywords list which is associated with each dementia disease and compositional adaptation to computing a value for each reference from the most similar cases. Based on the definition of Kolodner [13], DePicT CLASS adaptation is also categorized as a particular type, while it is considered the collaborative recommendation of users by ranking the references, adding the images tags, suggesting images impact factors, sending the feedback to contribute to the reference collection. Therefore, the DePicT CLASS adaptation mechanism has a combination of value comparison based on the requested word association profiles and manual adaptation based on user collaborative recommendation e.g. learner can rank the best references and learning materials based on their understanding and requirements. In future, the other parameters of caregiving e.g. their challenges and task's difficulties will be considered. Moreover, for completing the evaluation phase, it will be tested with a domain of informal caregivers. For further development of an application of the DePicT concept, DePicT CBMealnom will be developed based on the 7-point checklist (7PCL) which has been recommended by NICE (2005) and the case base is modifying based on the Melanoma Datasets. The future work is addressing the fourth research question in this use case.

4. Description of Progress to Date

DePicT CBMealnom is utilized by patients who has skin problems. While a user can not necessarily be able to formulate the question in a machine-readable form which is ready for the CBR system, Conversational Case-Based Reasoning provides a question dialog to guide users to describe their problem incrementally through an answering procedure [14, 15]. Its prototype utilizes myCBR tool [16] to create the CBR system for early detection of skin cancer. Based on the report of American cancer society's cancer facts and figures 2016 [10], "Melanoma accounts for only 1% of all skin cancer cases, but the vast majority of skin cancer deaths. In 2016, an estimated 10,130 deaths from melanoma and 3,520 deaths from other types of skin cancer (not including KC) will occur." Therefore, early detection is crucial in this kind of cancers and "the best way to detect it early is to recognize new or changing skin growths, particularly those that look different from other moles [10]." Even after treatment, it is imperative that patients keep their medical history and records [11]. Therefore, DePicT Case-based Melanom (DePicT CBMealnom) illustrates how Melanoma is detected and predicted utilizing conversational case-based reasoning.

DePicT CLASS of Dementia is used and updated by caregivers and domain experts. It enables caregivers and patients' relatives to find their learning materials and references which address the problems that they are looking for. Although the increasing prevalence of dementia poses a major challenge for global health at multiple levels [17], CBR is applied in the care of Alzheimer's disease patients from 2001 [18]. "Dementia encompasses a range of neurological disorders characterized by memory loss and cognitive impairment. In 2015, almost 47 million people worldwide were estimated to be affected by dementia, and the numbers are expected to reach 75 million by 2030, and 131 million by 2050, with the greatest increase expected in low-income and middle-income countries [19]. Since the development of ICF [12], several projects for specific health

conditions and disabilities are defined to develop core sets of ICF codes. DePicT CLASS uses DePicT Profile Matrix weights of the association strength between title phrase and identified keywords of cases (including references) which are dementia related diseases and ICF parameters, respectively. In this analysis, the references and learning materials with high valued keywords in word association profiles from the most similar cases are recommended to the selected case. This research proposes a new abstraction, compositional and collaborative adaptation method for medical vocational educational training which uses the calculated word association strength of the DePicT Profile Matrix [6]. DePicT Dementia CLASS is used and updated by caregivers and domain experts. It enables caregivers and patient's relatives to find their learning materials and references which address the problems that they are looking for. Case formation identifies the requested keywords and assigning their values based on DePicT Profile Matrix. These 111 ICF parameters are searched in 40 dementia and caregiving books and handbooks to create the large document as a reference of DePicT Profile Matrix. DePicT Dementia CLASS experimentally evaluated adapted references compared to the retrieval only references using its similarity measurement [6]. We have used two rates to investigate the hypothesis which is DePicT Dementia CLASS is able to select cases (three most similar ones) which can be adapted more related to the user request in comparison with the retrieval only references. The attract rate is defined based on the ratio of the value of references to their rank. In this way, DePicT CLASS compares reference ranking which is enhanced by learned knowledge of users. Besides the attract rate, for evaluating the adaptation results, the adaptation rate (adapt rate) is defined based on the ratio of retrieval only references to the total number of associated references. Thus, the recommendation of selected case is arranged based on the combination of high-value and ranked references.

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