Design of Knowledge Management System for Diabetic Complication Diseases

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Abstract. This paper examines how to develop a Model for Knowledge Management System (KMS) for diabetes complication diseases. People with diabetes have a higher risk of developing a series of serious health problems. Each patient has different condition that could lead to different disease and health problem. But, with the right information, patient could have early detection so the health risk could be minimized and avoided. Hence, the objective of this research is to propose a conceptual framework that integrates social network model, Knowledge Management activities, and content based reasoning (CBR) for designing such a diabetes health and complication disease KMS. The framework indicates that the critical knowledge management activities are in the process to find similar case and the index table for algorithm to fit the framework for the social media. With this framework, KMS developers can work with healthcare provider to easily identify the suitable IT associated with the CBR process when developing a diabetes KMS.

1. Introduction

Diabetes is a complex, chronic illness that requires continuous medical care with multifactors risk reduction strategies to control the blood sugar level. Diabetes could increase the risk of developing a series of serious health problems. This happens because the high level of glucose could lead to serious diseases affecting the heart and blood vessels, eyes, kidneys, nerves and teeth. In addition, people with diabetes also have a higher risk of developing infections. People with diabetes need self-management education and they also need support for preventing and reducing the risk of other complications diseases. People with diabetes should receive medical care from a collaborative, integrated team with expertise in diabetes and also a support group from family, friends and other people that diagnose with diabetes. On the other hand, it is well known that every medical treatment has risks as well as benefits. The medical ethical principle state that a patient has the right to decide what's appropriate treatments for them, taking into account their personal circumstances, lifestyle, beliefs, and priorities. Moreover, to choose the right medical treatment is a long and confusing process. Especially if one of the options is whether to take surgery or other high risk and expensive treatments. Informed decision-making is part of process to give a relevant information regarding to the medical treatments, by making collaborative communication between patient, family and one or more medical practitioners. But sometime, this information still not enough, patient also has the need for finding and get information from another patient with similar case to make the most suitable decision. The better information and knowledge to other people with a similar case, lifestyle and treatments history, personal circumstances and lifestyle are crucial in making the decision [2].

In this digital era that we live in, its natural to gain information and knowledge regarding the disease and its medical treatment through the web and search engine. But the problem is because of the vast and complex knowledge and the overload information on the web. Especially, the information regarding diabetes risk health, complication disease and healthy lifestyle, not yet well exist, manage, share and informed. Moreover, the information regarding diabetes complication disease and treatments, is scattered with unstructured format, it makes the decision process becomes more complex and confusing.
We address this issue in this paper by presenting an integrated framework for the diabetes knowledge management system with social networks. In this paper the analysis focused on designing a model of knowledge and the system for mapping, gathering, acquisitions, filtering information and share the knowledge of diabetes complication and treatments from social media.

2. Related Work
Knowledge management systems refer to a class of information systems applied to manage and facilitate knowledge sharing among the system’s user effectively and efficiently. There are seven general techniques for knowledge management: knowledge management framework, knowledge based systems, data mining, information and communication technology, artificial intelligence, database technology and modeling, along with their implementation for different problem domains [3]. The problem is, medical and health knowledge highly related to experience and each patient has its unique condition that lead to unique treatment. There are already several research on medical and health knowledge management system. Koutkias et al designed a data acquisition mechanism for multi agent chronic disease management system to enhance homecare health service [4]. Pham et al presented research on how medical knowledge management includes patients’ information gathering, medical expert note and experiences, and tests result could be a used as critical component is diagnosis and treatment planning [5]. There also research to design the framework a knowledge management system to establish key relationships between Western Medicine and Complementary and Alternative Medicine in order to find an effective exploration of ideas and possible solutions of medical diagnosis [6]. Chen et al using machine learning techniques and propose an “Eat, Trust, and Correct” (ETC) framework to find pattern of the behavior of the diabetes patients who use insulin pumps [7]. Klenk et al presented a method to calculate similarities of patient profiles for recommending people to other members in social networks in [8]. But there is still no similar research regarding a knowledge management system of complication diseases and treatments related to diabetes condition.

Therefore, the objective of this research is to propose a conceptual framework for designing a knowledge management system of diabetes complication diseases and treatments. This proposed system will integrate the relevant enabling information and communication technology into the knowledge management process that would support informed medical decisions for diabetes patient. Parallel with the framework for a knowledge management system to organize, store, and manage the abundant data available for diabetes management, one of important output of the proposed system is the potential to give recommendations of the most suitable treatment for the patient based on their living condition and lifestyle. This knowledge gain by manage and find other patients with similar case by using a profile matching technique on the proposed system.

3. Research Approach
Given the growing prevalence of diabetic patient, especially in Indonesia, which is the seventh largest number of diabetic patients in the world. It is including both diabetes type 1 and 2 in individuals aged between 20–79 years [1]. The establish knowledge regarding comprehensive diabetes risk factors and treatment management could significantly reduce diabetes complication diseases and could also improve patient quality of life. We developed a framework of a knowledge acquisition model from social media, regarding diabetes complication diseases and treatments. This knowledge management system (KMS) will build based on diabetes management plan that would also consider the patient profile, symptoms, diagnosis and recommended treatment option.

This research will focus on how to design a model of KMS that could give an informed medical option for diabetic patients. The idea is to help the diabetic patient to get, organize, and share knowledge related to factors that could worsen their condition based on each patient profile. In general, the process to decide the most suitable and correct medical decision is not easy. It is because each patient has different life condition and lifestyle that could influence on how they make decisions and the outcome of treatment they took [2]. The proposed system also designed to give a better communication and
sharing information among diabetes patients and between their medical experts, and also to help patients
to get recommended medical care based on their preference and similar condition as the form of
collaborative systems. In this research, we adopt a data mining technique to find a similar pattern of
the diabetes patient condition and treatment, to be implemented as algorithm of the proposed system.
Our proposed design of the knowledge acquisition model in diabetes medical treatments is to assist the
patient in acquiring needed information and knowledge to facilitate the process of decision making. To
achieve those goals, the proposed system should have these following characteristics:

- **Build a diabetes social network to provide collaborative ecosystem for people with diabetes and
  the medical expert to exchange thoughts, experiences and share others related medical information**
- **Store patient profile, complication disease and treatment they have taken, and other trivial information regarding the outcome of treatment and extract data mart from those data**
- **Have privacy filter, so the patient could hide their identity on other private matter.**
- **Have a knowledge management system, by combining data from user profile and diabetes information and knowledge.**
- **Allow patient to find solution to their problem by obtaining another patient(s) with similar case and conditions and weighing of personal value and similarity measurement.**
- **Inform patient of KMS limitation and mission as educational tools, clearly disclaiming the proposed system as substitutes for medical specialist diagnosis and care.**

All sixth characters of the proposed system as stated above are important to develop a diabetes complication diseases and treatment. The important characteristic of this proposed system is their ability to proposed solution on user problems, based on similar case. For instance, the fact that two diabetes patients have a different medical treatment recommendation, because they have different age, lifestyles and other medical complexity problem. This leads to a profile matching and provides better recommendations on who might have had similar experiences or who might have knowledge other patients can get benefit from. Funding relationship and extracted the knowledge is the very basis of this proposed system.

For that proposed, we adopt the Case Based Reasoning (CBR) method in this research. The CBR method is inspired by human reasoning, i.e., solving a new problem by applying previous experiences adapted to the current situation. A case (an episodic experience) normally contains a problem, a solution, and its result [9]. Today, CBR is a recognized and well-established method for research in health sciences. Aamodt and Plaza have outlined a life cycle of CBR with four main steps (retrieve, reuse, revise, and retain). There are four steps in the CBR step. first is retrieved, in this step a new problem is matched against the previous cases in the case library. The next step has reused previous case by determining how similar it is to the current case, the important process in this step is the similarity measurement that could estimate of how suitable the previous solution is for the current problem. The most relevant solutions are proposed to solve the current problem (after some adaptations if necessary). The selected solution is revised before it is reused. Then, the new problem and its solution are retained in the case library for any future use.

4. Architecture of The Proposed System

In this section we would discussed the architecture of the proposed system. Fig 2 illustrated the schematic model of proposed system. As illustrated on Fig.2, there are three main phase of this proposed system: data acquisition from social network modeling, data organization and knowledge creation.

4.1. Data acquisition and modelling.

In this phase, the system will collect two type information which are user profile and complication diseases. User profile consists data of demographic, medical condition, diagnosis and lifestyle, medical treatments (drugs, therapies and surgical options), healthcare provider and outcome of the treatment. Diabetes complication diseases consist data and information from explicit resources regarding diabetes
management and list of alternative medical treatments, a list of the treatment outcome with its degree of success, a list of health care provider histories. Information regarding diabetes complication such as retinopathy, cardiovascular, gastrointestinal, foot care management, etc. and their risk factors also recorded in this phase. The idea is to give relevant information and knowledge to diabetes patient and their health care proxy in order to reduce risk factors and increase patient quality of life.

4.2. Data organization, storage and transfer and information distribution.

This phase divided into three stages, which are feature extraction, similarity measurement, profile matching for the diabetes patient. In the first stage, because of the various and important attribute from the user profile, we need to reduce the dimensionality attribute in order to group the similar diabetes complication and treatment case.

Dimensionality reduction is one of the most crucial stages of modeling data and it will also remove irrelevant and unrelated attribute. Both Feature extraction and feature selection are capable of improving learning performance, lowering computational complexity, building better models, and built an efficient storage. In this research, we used feature extraction and selection to select demographic from a user profile dataset of and then classifying them to the respective class of similar medical condition and lifestyle. So dimensionality reduction is done by selecting features that are capable of discriminating attributes (token) that belong to different classes. And then the next stage is similarity measurement. The proximity measures of these objects based on its weight of different proportion of data to find similarity are calculated. The Similarity Measurement (SM) coefficient is useful because attributes from dataset on has both positive and negative values with equal degree of information. For example, age and treatment outcome are symmetrical attributes because the number of males and female, or satisfied and dissatisfied provides an equal degree of information. Then in the last stage is profile matching of the diabetes patient in order to gain and sharing knowledge on the personalize level. Based on the previous step, convergence of patient profile, their treatments and diabetes information through profile matching to classify the similar case. These classified diabetes treatment alternative option added in extended metadata in the metadata repository. d) Proposed alternative solution. This part, determines the need for diabetes information and provides the most suitable alternative solution of the current case by finding it similarity from the profile matching algorithm. Then we build the integration and combination of alternative solutions that returned by queries on the data storage, forming set of list that gives the user a ranked list of alternative treatments.

4.3. Learning and knowledge creation.

In this phase, we built model for diabetes knowledge creation from previous organizing and storing dataset. The idea is to adopt CBR concept, so it could shown relationship between dataset properly. By adopting CBR, the initial data can be processed into meaningful information for learning and knowledge creation. This following section will explained in detail how data CBR and profile matching integrated to gather the informed medical option with its degree of satisfied outcome. The first function of this proposed knowledge management system is to build a social network of diabetes patient, with two general approaches:

- Content based KMS which uses the information and knowledge the user input into the proposed social network application.
- Relationship between information traces to find another diabetes patient with similar cases and conditions. The proximity measures of these objects based on its weight of different proportion of data to find similarity are calculated. To find the similarity we will used profile matching coefficient as state on table 1. Then, to compute different matching we used allocation scheme we used this equation [10].

\[
SM = \frac{a + c}{a + b + c + d}
\]
The proposed system is characterized by working with cases defined by the characteristics of the diabetes complication diseases and treatment outcome. Each case is divided into two main components, which are a set of attributes referred to as a target, which contains the definition of the problem and a set of attributes associated to the previous user interactions. Once the definition of the problem is formed in terms of attributes, the objective of CBR is to generate the ranking of these treatment outcome in response to user characteristics that are reflected in the characteristics of user demographic available.

The proposed KMS is initiated by a new request made by the user who is searching for medical advised related to diabetes health condition. At that moment, the CBR system is executed. The information contained in the new case at the beginning of the execution cycle of the CBR system is defined by the following tuple:

\[ c = \{ T, u_i, x_i \} \]  

Where \( T \) refers to the set of attributes defined in the target extracted mainly from the information in the markup language in accordance with standard tagged used i.e. \( T = \{ \text{age, sex, blood sugar level, years since diagnosed with diabetes,...} \} \). The user identifier is \( u_i \) and \( x_i \) is the value associated with the proposed alternative solution. Using the information defined by equation 2, the reasoning cycle for the CBR system is initiated. This process illustrated on the top area of Figure 1. During the retrieve phase the metadata for the similar case are downloaded from data storage. Profile matching algorithm applied during the reuse phase in order to predict the degree of similarity of the recovered medical case. Finally, during the revise and learning phase, information related to the user’s final decision on alternative treatment and its outcome is stored.

| Object 1 | Object 2 |
|----------|----------|
| Number of variables with categories treatment option 1 | a |
| Number of variables with categories treatment option n | c |
| Number of variables with categories treatment option 1 | b |
| Number of variables with categories treatment option n | d |
5. Conclusion

Before taking any medical treatments, patient and their medical proxy facing the biggest task, which is to decide the best treatment they would take. It not only to facilitate their success rate and risks, but also their medical and lifestyle condition. Unfortunately, they often make the decisions without completely understanding their options that could lead to choose the wrong treatments. To make decision, patient also need advice not just from medical expert but also from other people who already facing the same dilemma. There are numerous medical and health information available on the internet. But the information is scattered, overload and most of the time not related to the medical advice that needed, so instead of getting information, patient get confused and take more time in deciding the best treatment that could lead to health condition worsening.

We have presented a model of diabetes knowledge management system that could calculate similarity of patient profiles for recommending the most suitable treatment by using user data. The real power of this proposed system is to provide high-quality information to ease sharing information between patient and physician in order to make a better informed medical decision through a web-based system. In order to adopt integrating profile matching and CBR cycle on the proposed KMS, the acquisition and organizing data process used to solve the problem of binary class (satisfied or unsatisfied outcome of treatment). The result of our work offer many perspectives or further research at both the theoretical and practical level by developing models for KMS that still need detailed algorithm and social network model for medical information sharing. This study will help diabetes patients to have a better understanding of their possibility of complication diseases, its treatments option and outcome, that could lead to improvements in their medical treatment decision making. It also to identify those trigger factors and taking appropriate medical action at the right time. The future work of this research is to build the prototype system and generated data for the knowledge acquisition, storage, manage and sharing.

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