Lipid Profile Self-Monitoring Application Using Recommender Approach

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Abstract
The recent healthcare transformations emphasize the importance of individuals maintaining a healthy lifestyle through proper nutrition and physical activity to reduce the risk of severe illnesses. Patients often search for information on their own, leading to uncertainty about appropriate diets or fitness activity. Consequently, many individuals cross-check information or health advice from various sources. However, some people hesitate to verify online health-related information with their clinicians, fearing that it may be per-ceived as a challenge to their expertise and authority. The aim of this study was to determine a useful way to monitor a patient's lipid profile and provide recommendations for meal plans and fitness activity. A content-based approach that utilizes a vector space model is employed in the development of a recommender method. The vector space model employs meal plans keywords to suggest similar items, and selection rules are used to identify relevant meal plan and fitness activity options. This approach has been incorporated into a mobile application for healthcare, allowing patients to receive personalized recommendations based on their lipid levels. To assess the usability of the mobile application, an initial user study was conducted, which showed that most respondents had a positive opinion of the application. In the future, the application could be integrated with a wider variety of meal plans and additional features.
Keywords:
lipid profile, self-monitoring, recommender, mobile application,

1. Introduction

Lipid profile refers to a blood test that provides information about the levels of different types of lipids. The different types of lipids include total cholesterol, low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL-C), triglycerides and non-HDL cholesterol [1]. The higher-than-normal levels of total cholesterol, LDL and triglycerides and lower-than-normal levels of HDL can increase the risks factors for the development of cardiovascular disease (CVD)[2].

Several studies have highlighted the importance of the lipid profile in the progression of CVD [3]–[6]. Elevated levels of triglycerides and total cholesterol have been observed to impact the narrowing and hardening of heart vessels, factors closely associated with CVD risk. Additionally, higher levels of low-density lipoprotein cholesterol (LDL-C) have the potential to trigger the development of arteriosclerosis, as they lead to the buildup of LDL-C within the inner layers of artery walls, thus promoting the formation of blood platelets, leading to serious health complications [7]. However, clinical findings demonstrated that self-monitoring lipid level is apparently beneficial not only for secondary prevention of CVD but possibly for primary prevention [8]. Therefore, patients with lipid disorder should focus on maintaining a healthy lipid profile to protect against the risk of CVD.

Lipid management serves the purpose of preserving a balanced lipid profile within healthy parameters. To achieve this, individuals are encouraged to participate in self-management practices, which involves adopting a nutritious diet, engaging in regular physical activity, consistently monitoring lipid levels, adhering to prescribed medications, employing problem-solving skills, and minimizing risk factors for cardiovascular disease [9]–[11]. Past research demonstrated that tailored interventions for self-management practices were effective in encouraging self-regulation behaviors related to dietary fat consumption, engagement in physical activity, and adherence to screening practices among patients dealing with chronic diseases [8], [12]–[14]. Consequently, offering personalized interventions to patients with lipid disorders could possibly enhance their ability to manage their lipid levels more effectively.

Information and communication technology improvements have permitted tailored interventions for self-management practices in health management. This implies that healthcare solutions can be personalized to individual needs, increasing their effectiveness in monitoring various aspects of their health, ranging from diet and weight to fitness activities. Smartphone applications allow users to access information on the Internet at their convenience. This connectivity also enables users with other services such as voice delivery services, location-based services, and camera and recording features. These services make smartphone applications useful and convenient, empowering individuals for managing chronic disease[15]–[17].

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Several smartphone applications are available that cover a wide range of healthcare, from fitness and nutrition to mental well-being for health improvement. Some applications related to cardiovascular have included lipid profile for general information that is not tailored to the user's data. Therefore, developing a tailored smartphone application for patients with lipid disorders to manage their lipid profile, nutrition, and physical activity can have significant benefits for user health.

This study introduces an approach to enhancing patients' self-management practices through a mobile application and a recommender system, and a lipid profile tracker. The resulting application is referred to as CoLipid. This paper outlines the design and development of CoLipid, an application that possesses the ability to suggest meal plans and physical activity and to monitor lipid profile in accordance with predetermined health information. The construction of a vector space model serves as a content-filtering technique for the purpose of recommending meal plans and physical activity to patients based on their similarity score to previously preference information. A preliminary assessment was carried out on CoLipid usability, involving a sample of 32 participants.

The remainder of this paper is organized as follows: Section 2 present our proposed methodology to develop the lipid application. Section 3 depicts the development. In Section 4, we discuss the evaluation findings. Finally, we conclude the paper in Section 5.

2. Methodology

2.1 Hybrid Methodology

We employed a hybrid approach (Fig. 1) that integrates agile and waterfall development techniques. The five phases of the hybrid approach are requirement, design, develop, test, and evaluation. The agile methodology is used for the design, test, and develop phases, while the waterfall methodology is used for the requirements and assessment stages.

In the requirement stage, the knowledge for lipid profile self-management and the functions required for a lipid profile application were extracted from common practice guidelines and related literature [18]–[26]. After extracting domain knowledge and functional requirements, we collected meal plan data from nutritionist in general practice clinics. The meal plan data consists of breakfast, morning tea, lunch, teatime, and dinner. We also collected exercise activities data from common fitness guidelines. We derived common understanding and recommendations applicable to patients with lipid disorders as well as tailored recommendations to user's meal plan and physical activity from the common guidelines and nutritionist.

During the design process, we created the flowchart, graphical user interfaces, and high-level system designs. Using recommender algorithms, we created the mobile application with recommeder engine during the develop phase, testing the mobile application untill the best results were obtained. During the evaluation phase, we evaluated the mobile application prototype using a survey to measure three elements of usability. The three elements are usefulness, ease of use and satisfaction [27].

2.2 High-Level Screening System Design

A lipid profile mobile application is proposed, which allows patients to perform self-monitoring of lipid profile and receive recommendation for meal plans and physical activities using the recommender feature. Figure 1 illustrates the structure and components in the CoLipid application architecture. There are four components: (1) user input, (2) recommender, (3) report and (4) admin input. The recommender corresponds to the user input, lipid profile input and medication input and generates recommendations of diet meal plan and exercise plan according to the meal plan and exercise database using a content-based filtering approach. The report displays body mass index (BMI) and health report based on the lipid profile input and user profile input.

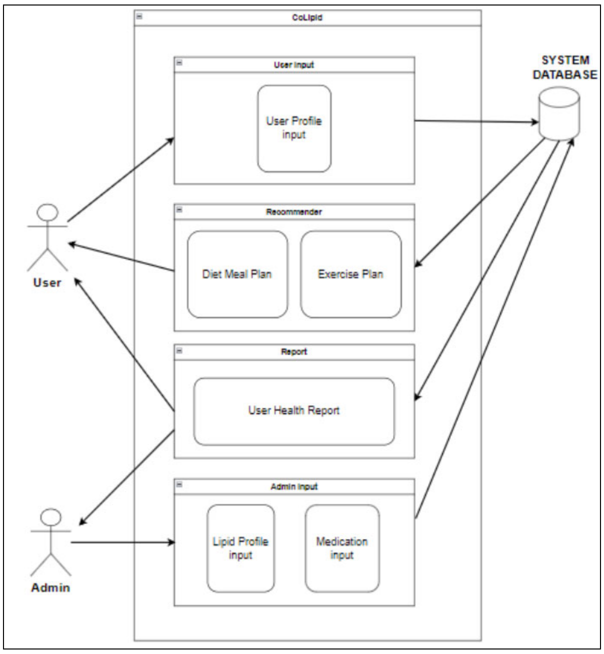

Fig. 1. System architecture

2.3 System Flowchart

The system flowchart for the lipid monitoring application is displayed in Figure 2, encompassing the login, home, plan, user profile, and settings pages. The system flowchart commences with the user logging in if they already possess an account; otherwise, the administrator must first register the user. Subsequently, they can utilize the features of the mobile application.

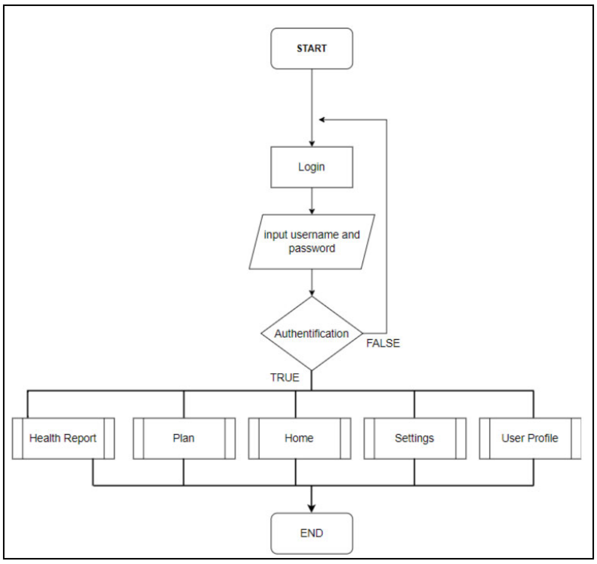

Figure 2: System Flowhart

2.4 Graphical User Interface Design

Figure 3 shows graphical user interface (GUI) for the lipid profile self monitoring application that will serve as a way for patients and medical practitioners to interact with the system. The GUI consists of application forms for inputs and tables for outputs.

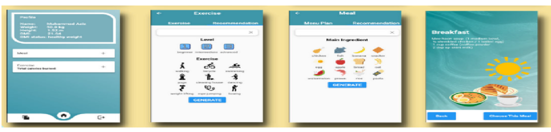

Figure 3. ColLipid User Interfaces

3. Development

3.1 Dataset

The data required for managing lipid profiles are divided into data from the first health evaluation and data from the individual's lifestyle. Weight, height, total cholesterol, low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL), triglycerides, medicine, and lifestyle information, such as categories of meal intake and physical activity, are all included in the initial health evaluation. The attributes and value sets of the data elements were used to build a total of 8 data dictionaries.

3.2 Recommender Algorithm

Algorithms were created to give personalized recommendations based on a patient's information and clinical data. A total of 6 algorithms—1 primary algorithm and 5 sub algorithms were developed. The complete lipid profile management process is included in the core algorithm. The 5 sub-algorithms are algorithms for meal plan management, physical activity management, user profile management, administration management and medication management.

The algorithms that provide individualized suggestions for meal plans and physical activities were developed using a content-based filtering strategy, which entails building a vector space model utilizing cosine similarity and the term frequency-inverse document frequency (TF-IDF) ratio. To simplify the complexity of the link between the keywords from the preference information, we used the vector space model as a computational approach to detect information similarity utilizing numerous keywords. In vector space models, TF-IDF is a weighting system that uses cosine similarity to determine similarity [28]. In order to calculate how similar two vectors are, cosine similarity divides the distance between the document and the query vectors.

Figure 4 shows how to use a variable's value that is connected to a phrase that, according to the TF-IDF weighting algorithm, denotes significance or pertinence. The frequency of a phrase in a document (tft,d), the number of documents that contain the term (dft), and the total number of documents in the collection (N) all influence the tf * idf weight, or w(t,d), of the term in the document.

$$w(t,d) = \frac{tf_{t,d}\, log\left(\frac{N}{df_t}\right)}{\sqrt{\sum_i (tf_{t_i,d})^2 log\left(\frac{N}{df_{t_i}}\right)^2}}$$

Figure 4: TF-IDF Weighting Formula [29]

In this study, the TF-IDF weighting algorithm uses the keyword of the meal plans or physical activities description and finds similar items from the meal plans and physical actvities database to recommend similar items. The weighting is often used for scoring and ranking an item’s relevance. Then, it sorts the item list according to the similarity score and sets a threshold value of 0.2.

This means that the item that is recommended needs to have at least a 20% similarity score. After that, the application implements the selection rules on the similar items to find most relevant items. Figure 5 shows the TF-IDF algorithm implemented in ColLipid.

1. Loop for word sequence text
2. Declare temporary variable
3. Check temporary variable length > 0
4. Check word fequency vector contain temporary variable
5. Declare frequency1 frequency2
6. Assign frequency1 and frequency2 with values from word frequency vector using temporary variable
7. Read values and create object values
8. Find word frequency vector with values
9. Add disctinct words to temporary variable

Figure 5. Convert Text to Vector—TF-IDF Algorithm

The frequency of the term in the meal plan or physical activities description is computed by TF-IDF to generate the frequency score. The cosine similarity algorithm uses this score to determine how similar the chosen item is to other items in the database and calculates a similarity score. Utilizing the score produced by the TF-IDF technique, the cosine similarity algorithm determines the similarity score. For each item in the database, a similarity score is generated. The meal plan or physical activities are sorted using the cosine similarity algorithm's similarity score, from highest similarity score to lowest similarity score. The recommender threshold value is set at 0.2. This demonstrates that at least a 20% similarity score between the items and the chosen meal plan or physical activities is required. The cosine similarity algorithm's similarity score is checked by the algorithm. The items that achieve the required similarity score of 0.2 are added to the selected array list. The list contains the suggested meal plan or physical activities that are shown in the output.

4. Results

This section describes the preliminary evaluation results of CoLipid. The 32 responses that are shown in Figure 6 are highly positive. Most participants responded that they agreed or strongly agreed that the CoLipid application was perceived to be highly useful, easy to use and highly satisfying in terms of usability.

All participants agreed that the CoLipid application is practical to use for lipid profile monitoring application in healthcare. Of the respondents, 95% strongly agreed that the CoLipid application met their needs in recommending suitable meal plans and physical activities based on their preferences and lipid profile. This indicates that the application helps patients to monitor cholesterol levels, taking prescription medicine as directed, and reducing risk factors for cardiovascular disease. In terms of user-friendliness, 93% of participants said the app is straightforward to use, and the majority said the application is consistent while they are using it. All participants also agreed that the application is simple to use. This suggests that the application offers simple, graphical user interfaces with easy-to-use functionalities.

All participants reported satisfaction with the user experience and said they would refer the recommender application to others. 93% of participants said they needed the app in their daily life because it might help them keep track of many elements of their health, such as their nutrition and weight as well as their exercise routines.

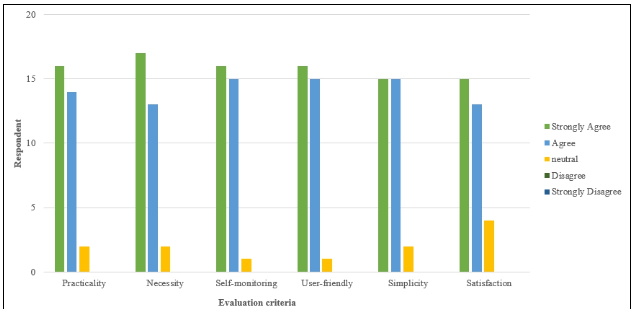

Figure 6. Responses from CoLipid User Evaluation

5. Discussions

The aim of this study was to find a practical method for recommending similar physical activity and meal plans based on lipid profiles and user preferences, in order to promote self-monitoring behaviors without the involvement of healthcare professionals. A recommender system built on the content-filtering method is incorporated into the lipid profile mobile application CoLipid. A content-filtering method was created using a vector space model that makes use of meal plans and physical activity description keywords to recommend related meals plans and physical activities and uses selection criteria to find the most similar alternatives. Two algorithms, the TF-IDF algorithm and the cosine similarity algorithm, were implemented for the recommender feature in the vector space model. The frequency score is produced by the TF-IDF algorithm utilizing the frequency of the terms used in the meal plans and physical activity descriptions. The cosine similarity method uses the frequency score to determine how similar the chosen meal plans and physical activities are to other meal plans and physical activities in the database. Meal plans and physical activities were arranged in descending order of their similarity ratings.

The CoLipid application provides users a platform to monitor their lipid profile while taking medication and receive suggestions for similar eating programs and exercises. Through the provision of knowledge, tracking tools, and resources for making wise lifestyle decisions, this ground-breaking application can enable patients to take an active role in controlling their cardiovascular health. Due to the fact that it gives users the ability to actively participate in the management of their health, provides individualized assistance, and fosters a better awareness of their cardiovascular health, this application is crucial to the implementation of self-monitoring innovation, particularly in Malaysia. It may result in better health outcomes, a higher standard of living, and a feeling of control over one's health. However, it should to be utilized in conjunction with standard medical treatment and competent medical advice.

To assess the usability of the CoLipid application, a preliminary usability evaluation was carried out with a sample of 32 people. In general, 95% of participants concurred that CoLipid is practical in terms of suggesting appropriate meal planning and physical activity. Additionally, 93% of respondents corresponded that the application is practical and user-friendly because it is quick, simple, and secure. The majority of respondents were pleased with how the application helped them track their health as well as recommend appropriate meal planning and physical activities. Overall, the evaluation study's findings show that the CoLipid application has the potential to be used in healthcare to assist individuals in better understanding their lipid profiles and the implications for their health. It informs them about lipid management, cholesterol levels, and how they affect cardiovascular health.

6. Conclusion

The main goal of this study was to determine a useful way for formulating individualized physical activity and diet recommendations based on lipid profiles and user preferences, with the intention of encouraging self-monitoring behaviors without the assistance of healthcare specialists. An important step towards reaching this goal was the addition of a content-filtering recommender system to the CoLipid mobile application. By applying pertinent keywords and selection criteria, this application, which employs a vector space model, efficiently offers meal plans and physical activities. To improve the accuracy of recommendations, the TF-IDF and cosine similarity algorithms were used, which ranked options according to how well they matched user preferences.

CoLipid application have a potential for improving healthcare by enabling users to better understand their lipid profiles and how they affect cardiovascular health. It acts as a resource for education regarding lipid management, cholesterol awareness, and general cardiovascular health. Future work will focus on improving personalisation through the improvement of recommendation algorithms and the incorporation of wearable health devices for real-time data. Predictive analytics, enhanced security and privacy protections, and long-term health monitoring are top priorities for future growth.

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