

A Smart Diet Framework for Promoting Healthy Eating Habits and Nutrition in Mauritius

Yuvna Goorwappa, Ajitesh Sharma Sreeneebus and Soulakshmee D. Nagowah*

Software and Information Systems Department, University of Mauritius

Phone Number: +230-4037831

**Corresponding Author's E-mail: s.ghurbhurrun@uom.ac.mu*

Abstract

Non-communicable diseases such as diabetes, overweight, obesity and physical inactivity have been on a significant rise over the years and are affecting people of all age groups and countries. This is mainly caused due to bad eating habits and lack of exercises. In order to prevent these diseases and since Mauritius is very limited on diet platforms, a framework that fits the Mauritian context has been proposed using intelligent techniques. Additionally, the paper presents Smart Diet Consultant, an Android application which acts as a customized consultant and generates diet plans based on user's data and preferences. It also allows users to measure and calculate their calorie intake per day. Smart Diet Consultant additionally includes a recommendation module where alternative diet plans are provided, in cases where users dislike the initial proposed plans. This application motivates users to lead a healthy lifestyle by being conscious of what they are consuming and keeping track of their daily diet and physical activities.

Keywords: *Smart health, machine learning, mobile application, diet plan*

1. Introduction

The concept of healthcare has evolved throughout the years. Long ago, there was the classic healthcare where patients visit doctors, and they are consulted using traditional tools [3]. In 1999, the electronic healthcare was first introduced at the 7th International Congress on Telemedicine and Telecare in London [56]. According to Gunther Eysenbach [26], "*e-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies*". It is a subcategory of traditional healthcare and is distinguished by the use of Information and Communication Technologies (ICT). It includes the use of electronic health records (EHR) and databases that save medical data of patients [3]. In 2003, the mobile healthcare was first found [21]. Robert Istepanian, the first scientist to coin the phrase m-health defined mobile healthcare as "*emerging mobile communications and network technologies for healthcare*." [50]. It is a subcategory of e-health since it uses mobile devices to obtain medical data [3]. In 2014, the smart healthcare was introduced [17]. "*Smart Health is the supply of health facilities by using the context-aware network and sensing infrastructure of smart cities*" [17]. Smart healthcare can also be defined as "*the technology that give*

rise to better diagnostic tools, better treatment for patients, and devices that ameliorate the quality of life for anyone and everyone" [4]. It is a subset of electronic health and mobile health [3].

In today's time, people have busy work schedules that they barely have time to take care of their health. Nevertheless, despite being occupied, people are becoming more health-conscious and want to adopt healthy cultures [13]. By incorporating healthy lifestyle applications in their daily routine, people can easily keep track of their health. Now, since everything is digitized, with smart health, people are exposed to multiple applications which use the latest technologies and with different services provided [52]. They can register their profile on the applications which allow them to track and organize the data about their health. Hence, with smart health, they are able to access their data anywhere and anytime around the world. They can personalize the applications according to their preferences. Thus, people can have a better quality of life and independence, while their treatments become more efficient and cheaper.

According to [8], at the end of 2010, more than 200 million health-related mobile applications have been downloaded and around 70 % of inhabitants around the world were keen to access to, at least, one mobile health application. Some mobile applications in healthcare assist people to track their calorie consumption and to manage their weight. Other applications developed have interesting features such as taking photos of meals with the phone camera and send them directly to professionals [31]. There are also some mobile health games which have been developed where "players learn how to make healthier meal choices". According to a study, while playing these games, people learnt more about healthy eating and were more health-conscious about the foods they consumed [2]. Moreover, since mobile applications are user-friendly and portable, they can be used and accessed anytime and anywhere [45]. Information can be rapidly accessed, thus making people more knowledgeable [12]. However, the main drawback of these mobile health applications is that there is no federal standards that these applications need to follow. Hence, accuracy of information provided is not guaranteed [51].

The rest of the paper is structured as follows: Section 2 presents an overview an eating habits of Mauritians along with systems adopted in the country and relevant measures taken by the government to promote good eating habits. Section 3 describes some existing systems in the field. Section 4 proposes a smart diet framework for promoting healthy eating habits in Mauritius. Section 5 presents the system prototype. Finally, section 6 concludes the paper.

2. Status in Mauritius

This section describes the eating habits of Mauritians, the currently used systems in the country and the measures taken by the government and at school levels to enhance eating habits.

2.1. Eating Habits

Mauritius is a small island of two thousand and forty square kilometers and is located in the southwest Indian Ocean [54]. It has a population of approximately 1.3 million which consists of people of Indian, African, European and Chinese origin, hence making Mauritius a poly-ethnic and multicultural island [10]. Its exotic cuisine, which is an amalgamation of European, Indian and Chinese flavors, is another evidence of the rich variation of the Mauritian culture which reflects the eating habits of its inhabitants [54]. According to the Mauritius Non-Communicable Diseases survey in 2015, Mauritius has experienced rapid industrialization and economic growth over the past several decades, and this has brought in its wake a shift in the disease pattern [37].

As the world is evolving, the standards of living continue to rise in terms of work, family, technology and health. There are various health issues in Mauritius which are posing a growing threat to health, among which is the non-communicable diseases (NCD). In 2016, according to the World Health Organization (WHO), 14.2% of Mauritians had diabetes, 46.8% were overweight, 18.8% were obese and 25.4% were not doing any physical activity [60]. In developing countries like Mauritius, non-

communicable diseases are on a rise due to risk factors such as physical inactivity and unhealthy diet which comprises of uncontrolled salt, fat, and sugar intake [30]. Currently, the major health issue in Mauritius is Diabetes and according to a survey conducted by the Ministry of Health and Quality of Life in 2015, 22.8 % of adults are affected by Diabetes [41]. Diabetes mellitus is also ranked first in the Top 10 causes of deaths in Mauritius [39] as shown in Figure 1.

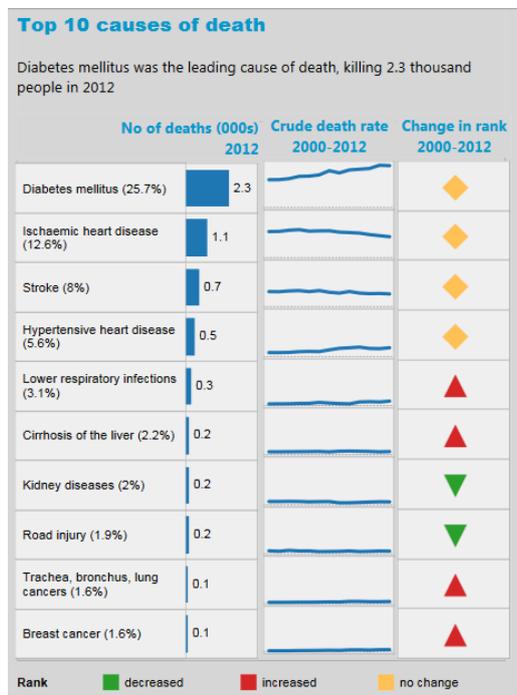


Figure 1. Top 10 causes of death in Mauritius [39]

In Mauritius, since people live at a fast pace, rather than cooking their own meals, they would opt for fast foods and according to [53], there is a high preference of processed food such as burgers, pizzas, french fries, chips, cakes, biscuits and sweetened breakfast cereals. Also, their lives are sedentary with the same routine everyday that they do not have time for physical activities [53].

In recent years, awareness and sensitization campaigns were carried out to show to the population the negative impacts of consuming unbalanced diets and not doing any physical activities [38]. They encourage people to eat less fat and more fiber and to improve their fitness. An example is that often on Mauritius Broadcasting Channels (MBC), a message is displayed encouraging Mauritians to eat 5 fruits and vegetables per day, to do exercise and to drink water [32].

2.2. Currently used systems

In Mauritius, people are becoming conscious of the importance to eat healthy and stay healthy. There are some websites available and some hardcopy books offered by dieticians to help Mauritian follow a healthy diet.

One of the famous book is Weigh-Less [59]. The book describes the importance of a good eating habit and the importance of sports in our lives. Weigh-Less has for objective to make people lose weight while still being able to eat food of their preference. Also, Weigh-Less has adopted the No diet pills, No strenuous exercises, No shakes and No meal replacement plan, that is, this diet plan consists of only healthy eating and simple exercises to lose weight and stay in shape. All these details are also available on the official website of Weigh-Less Mauritius [59]. On the website, recipes which have low calories are available to give an idea of healthy food. There are some motivational stories about weight loss which may inspire people browsing the website to lose weight and stay healthy.

The vegetarian society website [57] is also well-known in Mauritius, where healthy lifestyles have been explained clearly. It gives an insight of the ingredients of some renowned fast foods which may not be healthy and good for us. The vegetarian society of Mauritius promotes vegetarian eating habits with several recipes which are both tasty and good to maintain a healthy lifestyle. Moreover, there are additional information on people suffering from different ailments such as diabetes. It shows how to eat while controlling diabetes. This society also adopts the no diet pills and no strenuous exercises. Only regular exercises and good eating habits can help lose weight and stay healthy. (Vegetariansocietymauritius.org, 2017) [57].

Compared to other countries, Mauritius lacks smart mobile application that can enhance the lifestyle of Mauritians and track their eating habits to help them improve their health.

2.3. Measures taken by government

On the Ministry of Health and Quality of Life's side, NCD screening programme is carried out for early identifications, preventions and treatments of NCDs. It also comprises of thorough health promotion campaign and is also being carried out in secondary schools for students [39]. Furthermore, to create better awareness about the importance of physical activities at national level, the Ministry is implementing a National Action Plan on Physical Activity, where people have the opportunity to learn about Yoga exercises [40].

In 1998, the introduction of school canteen instructions was made by the Ministry of Education and Human Resources in collaboration with the Ministry Of Health and Quality of Life. In 2006, the Government of Mauritius passed a law stating the prohibition of sale of soft drinks in primary and secondary schools [33].

Following a regulation which was passed in 2009, soft drinks and unhealthy snacks were prohibited from canteens of pre-elementary, elementary and secondary schools [44]. Moreover, according to the Food (Sale of Food on Premises of Educational Institutions) Regulations 2009 [25], this regulation was to be implemented in 2010 and it provides a list of foods which are allowed to be sold on schools' properties.

Nevertheless, consuming a healthy diet is considered as one of the core of preventive health strategies that is effective [30]. Healthy eating means consuming nutrient-dense foods in the right quantities from all the food groups [1]. Nutrients are essential to maintain good health, to feel good and to have energy. These nutrients comprise of protein, carbohydrates, fat, water, vitamins and minerals [9]. A healthy diet is a diet low in saturated and trans fats and high in fruits, vegetables and grain foods [30]. Diabetes and obesity can be controlled by consuming healthy food. Positive changes in dietary behavior may lead to a reduction in the risk of disease [30].

3. Existing systems for Smart Diet

In many developed countries and evolving ones, people are seeking for new technologies to help combat health issues such as obesity, overweight and hypertension amongst others. Many mobile applications have already been developed while many more are still being developed with some extra features for the betterment of people. Some of the existing applications are described below. The systems are further categorized in terms of different features in Table 1.

▪ HealthAware

HealthAware is a smart application which prevents obesity by using the mobile components such as an embedded camera used to monitor the food intake, an accelerator to extract daily physical activities through the built-in accelerometer readings and GPS to index pictures in the health database. There is an on-device database which all contains specific data about the user and food information. Moreover, this application has a feature which enables the user to connect to social platforms to share the relationship between their food intake and physical activities. HealthAware consists of four

components: user interface, on-device database, physical activity analysis system, and food item classification system [11]. Figure 2. and Figure 3. show user interfaces of the application.



Figure 2. User interface-monitoring screen [11]



Figure 3. User interface-monitoring screen [11]

▪ **SmartDiet**

This application is a daily tracking of nutrition intake for obese patients, for people who want to re-shape their body and for those who want to stay healthy. Compared to the already existing applications, SmartDiet is divided into 2 parts, namely the Diet planner and the Diet game. The diet planner calculates the calorie intake and the exercise level. Additionally, it provides different nutrition programmes for different patients based on their preferences. The diet game allows the users to play game which helps in broadening their knowledge on how to control calorie intake and exercises. Moreover, it allows users to download all the different diet plans in case they wish to change theirs so that they avoid accessing the internet every time [58]. Figure 4. and Figure 5. show the user management screen where the user has the choice to select the purpose for which he wants to use the application.



Figure 4. User information [58]

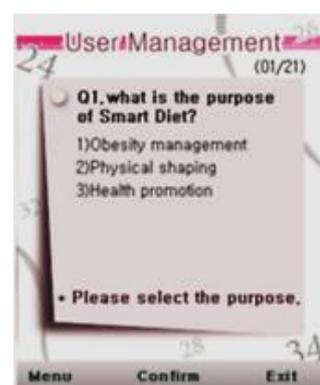


Figure 5. Purpose of SmartDiet [58]

Figure 6. and Figure 7. are screenshots from the Diet planner application.



Figure 6. Planning period [58]



Figure 7. Assessment of calorie intake for the period [58]

Figure 8. and Figure 9. show screenshots from the Diet Game application.

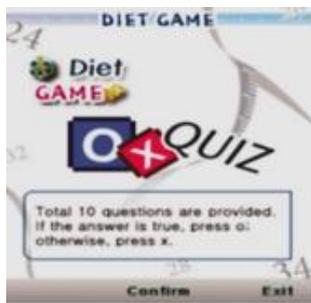


Figure 8. Title page of the Diet Game [58]

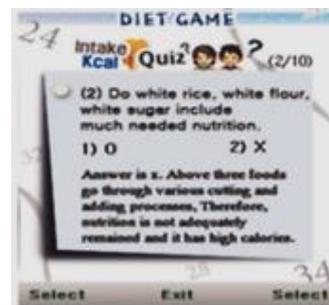


Figure 9. Diet quiz for nutrition [58]

▪ **My Meal Mate (MMM)**

My meal mate is a smart mobile application, designed to help people eat healthy and lose weight. This application has an electronic food diary in which users can select food item from a database of 40,000 food item. The database allows users to select food items from generic and branded food items. MMM allows its users to save their favorite food items, take photos to act as memory and store all recently used items. One of the advantages is that this application gives instant feedback on the calorie intake and its level of expenditure. It also gives weekly feedback via SMS. One disadvantage is that, MMM allows user to take photos which is stored for memory purposes for only 24 hours [36]. Figure 10. and Figure 11. show an overview of the application.



Figure 10. Food diary entry page[36]

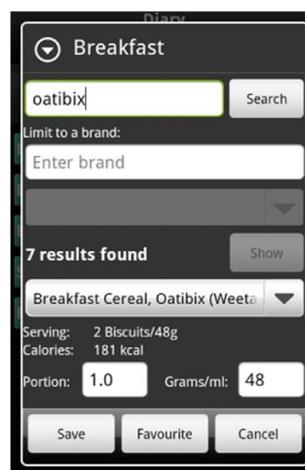


Figure 11. Search page for finding a food to add to the diary [36]

▪ SapoFitness

SapoFitness is a mobile health application which motivates constantly and challenges its users to keep a healthy diet and to always practice sports or any other physical activities. It has for objective to help obese and overweight people to get the desired physical shape they want. This application has a diary which allows the users to enter their eating habits and their diet progress. Then the diary displays how many calories the user has consumed on that specific date and time, and how much more calories he/she may consume more during the day [7]. After entering all personal details, the application prompts a user diary where several options are available. Figure 12 shows the user's diary. Then a user profile appears showing messages related to calorie intake, as shown in Figure 13.

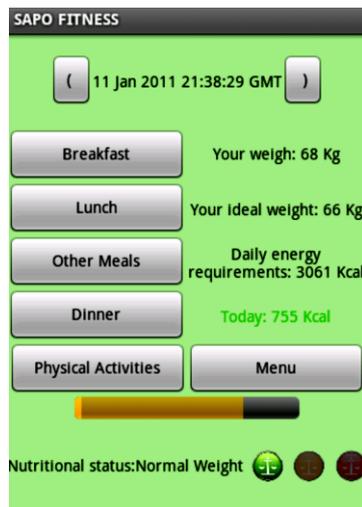


Figure 12. User diary [7]

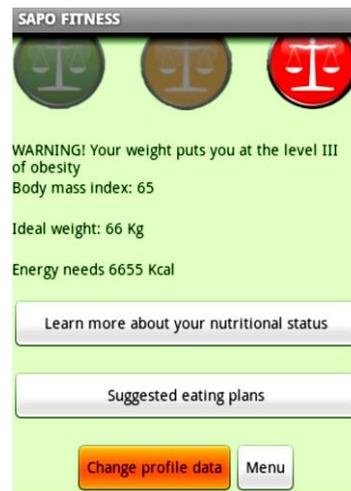


Figure 13. User profile [7]

▪ FoodEye

FoodEye is an application which helps people who want to stay healthy to see a product information and ingredients before buying it. It has a barcode reader which helps to view and to compare nutrition information. It includes food allergens and health star ratings. If there are food items which are not available on the food database, it allows the users to include it [19].

Table 1 shows a comparison of features between the different systems. HealthAware has for objective, to prevent obesity and help stay fit and healthy. The use of camera, accelerometer and GPS give a modern touch to the application, which may interest many people who are fond of modern technology. However, the accelerometer readings, which are taken when placed on the body or in a pocket while exercising, may fluctuate depending on the position that the phone has been placed. Thus, falsifying the readings. Therefore, this application is not recommended for anyone who wants to follow a strict diet.

SmartDiet was developed to manage obesity, to promote health and for physical shaping as more and more people want to look good and stay healthy. This application gives a complete detailed list of calories taken meal and calculates the total calorie intake at the end of the day as well as proposes meal plans to the user. The only drawback of this application is that all its features are available upon pay. Although it has interesting features, people will prefer to use a software that is free of charge, and as for Mauritians, since it is a rather new concept, people will prefer to use a free application instead of paying for the services of an application without even knowing its functions.

MyMealMate was created to guide people on how to eat healthily and to help people lose weight. If the user does not have enough time to input his/her eating details, the application allows to take pictures which will act as a reminder to fill the details later. However, if the user forgets to enter the details within 24 hour, the picture will be automatically deleted as the pictures may only be stored up to 24 hours. Therefore for people who are normally busy and do not have much free time, this

application would not be suitable as if they forget to fill in the details, this may affect their diet as the calorie meter on the application will not be reliable.

SapoFitness promotes healthy eating to prevent all types of health issues. This application allows the user to enter his food details and then it calculates the calorie intake per meal. If an excess calorie is calculated, the application issues a warning message to the user. This application allows taking pictures for social media to make it more interesting for the users. However, all the information and pictures are saved on the phone memory which with time, will reduce the performance of the phone. Therefore, for people who use their phone for all their work, it might become a problem. Also, Mauritians might not be able to enter the foods they have consumed since this application lacks typical Mauritian food items.

FoodEye was developed to calculate the calories in a food item before purchasing it. This application helps the users to buy their food products based on the ingredients and the number of calories. However, this application does not propose any food plan nor any exercise plan which might help the user to lose weight and stay healthy. The user has to download other applications in order to help keep track of their diet and their exercises. Therefore, this specific application does not help the user in losing weight and keep track of his daily calorie intake.

Table 1: Comparative Table of the Existing Systems

Features	HealthAware	SmartDiet	MyMealMate	SapoFitness	FoodEye
Take photos	✓		✓		✓
Embedded GPS	✓				
Embedded accelerometer	✓				
Social network	✓			✓	
Internet connection	✓		✓		
User friendly interface	✓			✓	
Calorie calculator	✓	✓	✓		✓
Hybrid implementation	✓			✓	
Exercise plan	✓	✓		✓	
Customized diet plan		✓		✓	
Diet games		✓			
Electronic food diary			✓	✓	
Feedback via SMS			✓		
Alert system				✓	
BMI calculator			✓	✓	

4. Proposed Model/Framework

Based on the observations from the previous section, a framework is proposed for the smart mobile diet application. The user connects to the mobile application's interface via registration or login. The framework consists of five modules, that is, the user's profile, the BMI (Body Mass Index) calculator, the calorie calculator, the information tracking component and the recommendation for diet plan. The information tracking is further broken down into the food diary and the exercise diary. There are three databases which consists of the user database, the food database and the exercise database. The user database contains the user's personal information, that is the sex, age, weight, height, food choice, illness and allergies, if any. It also contains the BMI of the user and the number of calories he/she should consume or the calories remaining for the day. Furthermore, the user database stores the food and calories intakes of the user, the types of exercises he/she has done throughout the day and the duration of the exercises, the user's number of calories yet to be consumed and the user's weight lost. The food database contains all the food details including the number of calories and number of portions for each food items. The exercise database contains the different types of exercises, its duration and the number of calories burned for each exercise. The recommendation module is linked with the food database since it is based on the user's food preferences, allergies, diseases, calories, objective, age, weight.

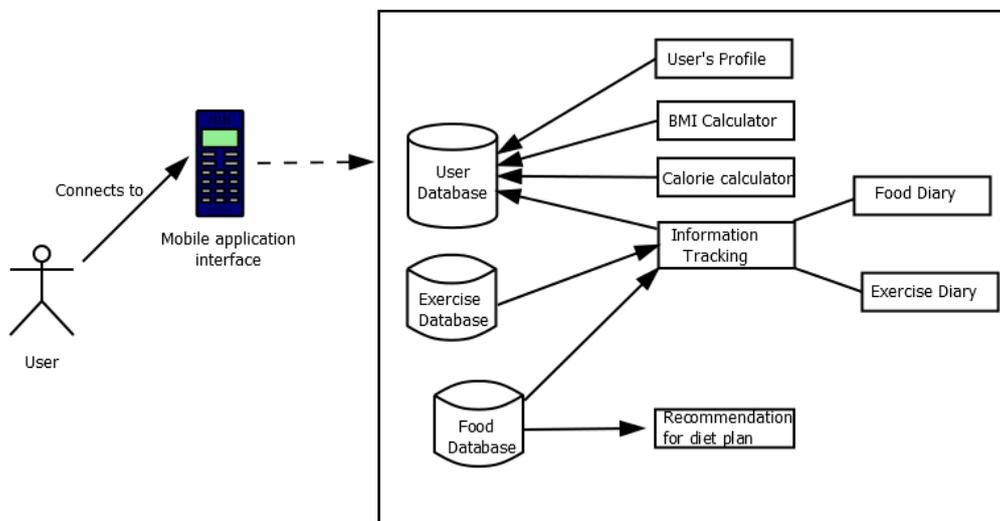


Figure 14. Proposed framework

4.1. User Profile

The user profile module displays all details concerning the user, such as his/her personal details, physical activity, health status and weight loss goals. The user also has the option to edit his/her details, in case, for example, age, weight or height increase.

4.2. BMI Calculator

BMI is one of the most widely used measures of obesity, which indicates a proportion of a person's weight to height [28]. According to [5], it is a measure used to determine whether a person is underweight, normal, overweight or obese. If a user has increased BMI, the risk of him/her having non-communicable diseases also increases. Therefore, calculating the BMI will be useful for the user to know where he/she is situated. The user can, thereafter, make the decision of whether to lose, maintain or gain weight. The formula used to calculate a person's BMI is [46]: $BMI = \text{Weight (in kg)} / (\text{Height (in m)})^2$.

Using the above formula, if a person's BMI is between 18.50 and 24.99, he/she is said to be in the normal range. Similarly, if the BMI is less than 18.50, the person is said to be underweight, if it is greater or equal to 25.00, he/she is overweight and if the BMI is greater or equal to 30.00, he/she is obese.

4.3. Calorie Calculation

The calorie calculation is done for two parts : the daily calories estimate to be consumed by a person per day and the calories consumed and yet to be consumed during the day.

(i) Calculation for the daily calories estimate

The user's Basal Metabolic Rate (BMR) is calculated using the Mifflin St Jeor formula below [47]:

$$\text{BMR} = (10 * \text{weight in kg}) + (6.25 * \text{height in cm}) - (5 * \text{age in years}) + 5, \text{ if male and,}$$

$$\text{BMR} = (10 * \text{weight in kg}) + (6.25 * \text{height in cm}) - (5 * \text{age in years}) - 161, \text{ if female.}$$

After computing the BMR, the daily calorie intake is estimated using the user's physical activity and the BMR, and it is based on the following calculation [6]:

If physical activity = Sedentary

$$\text{Daily_calorie_intake} = \text{BMR} * 1.2$$

Else if physical activity = Lightly active

$$\text{Daily_calorie_intake} = \text{BMR} * 1.35$$

Else if physical activity = Moderately active

$$\text{Daily_calorie_intake} = \text{BMR} * 1.55$$

Else if physical activity = Very active

$$\text{Daily_calorie_intake} = \text{BMR} * 1.75$$

(ii) Calculation of calories consumed and yet to be consumed

Throughout the day, the user enters his/her food consumption and exercises done in the food and exercise diary respectively. When the user enters his/her food details in the application, he/she also has to input the quantity that he/she has eaten since in the food database, the number of calories mentioned is based only per portion. If the user has eaten more than one portion, the system will calculate his/her total calorie intake based on proportion. Moreover, the exercise database consists of various exercises along with their respective amount of calories, duration, weight and speed. The number of calories burnt during workouts, based on the user's weight and the speed at which he/she will perform the exercises, are calculated and counted in the total calorie intake.

After each user input for meal consumed and exercise practiced, the application calculates a total of calories intake and calories lost, based on data from the food diary and exercise diary, in order to find out how much more calories can the user have for the rest of the journey and if the number of calories based on the user's selection is more than required, a message is sent to the user informing him/her about it.

4.4. Databases

The user database is one where all the data input by the user and the computed values such as the BMI, BMR and daily calorie intake are stored. The food database, based on the well-known Weigh-Less book [59], consists of all the food items along with their specific number of calories and quantity. The calories of the food items were based from the popular USDA Food Composition Databases [55] and the FatSecret food database [24]. Furthermore, the exercise database comprises

of all the exercises along with their specific number of calories burned and the amount of time, which were taken from the FatSecret fitness database [23].

4.5. Algorithm Design

In Smart Diet Consultant, a multiclass neural network using back-propagation learning algorithm is used to generate a neural network model which can forecast an output that has numerous data values [18]. "A neural network is a set of interconnected layers, in which the inputs lead to outputs by a series of weighted edges and nodes" [18]. It is a network built as a computational design, which is a replica of how the brain processes information [16]. The network consists of nodes (neurons) and connections which are interlinked through several layers, namely the input layer, the hidden layers and the output layer, to resolve a particular problem. While training the network on data input, the weights on the connections are learnt. Figure 15. shows a general architecture of the neural network.

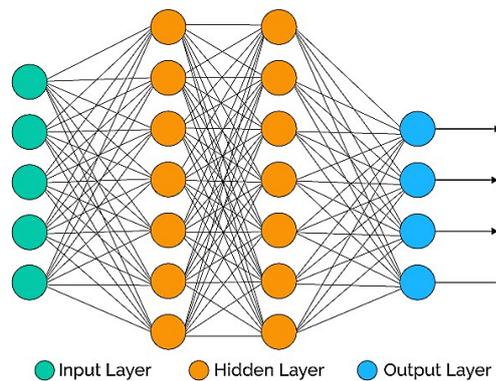


Figure 15. Neural network architecture [27]

The back-propagation algorithm makes use of the gradient-descent algorithm, where the difference between actual output and target output are discovered and weights of the network are changed to minimize the difference [27].

The multiclass neural network with back-propagation algorithm is used to intelligently develop the diet plan generator based on the user's allergies, diseases and food preferences. It is also used for the supervised classification of diet plans, using feed-forward networks, where it is trained to categorize given pattern or data set into predefined class [27].

The back-propagation algorithm has 5 main steps [34] :

1. Datasets are inputs and the relative activation is set in the input layer. The diet plan database is broken down into 3 datasets namely breakfast, lunch and dinner. In the application, the diet plan database is used as the dataset which contains several training sets.
2. The data is feed-forwarded to next layers such as hidden layers and output layers.
3. If the actual weight and the target weight are different, the error is output.
4. The error is then back-propagated from output layer to the input layer through hidden layer.
5. An output is generated, which is the user's meal ID.

In addition to the neural model, a scoring model is added to see how well it functions. An evaluating model is also added to see its execution.

Afterwards, a web service, which is a function in the Cloud that allows programs to communicate (www.tutorialspoint.com, 2018), is set up to save the model into a complete trained model. The software provides the web service with data about the user, such as his/her food

preferences, allergies and diseases, expecting as output a meal plan ID based on the input, and the service responds with a value and of percentage of accuracy.

In Smart Diet Consultant, the model used for breakfast prediction is also used for the prediction of lunch and dinner, except that the datasets are different for each. A sample of the breakfast prediction model is shown in Figure 16. and it shows how the model is trained. The different components are also explained as follows:

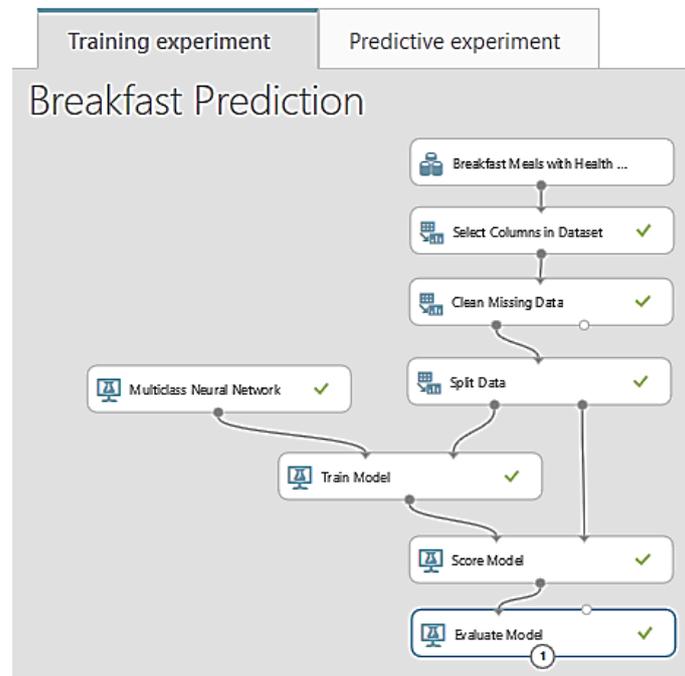


Figure 16. Training the model.

- **Breakfast Meal with Health Issues**

The dataset modules are inputs. In the application, the Breakfast Meal with Health Issues database is used as the dataset which contains several training sets.

- **Select columns in dataset**

In this module, specific columns are selected so as to predict meal ID on specific parameters.

- **Clean missing data**

This module cleans up the missing values by either removing the data completely or by replacing missing values with other values.

- **Split data**

The Split Data module is used to separate the original dataset into two modules, namely training and testing datasets. 80% of the data goes into the Train module, and 20% goes into the Score model. The different algorithms, discussed in this section, have been used so as to know which information the pattern should contain.

- **Score Model**

The scoring model is added to see how well the model functions.

- **Evaluate Model**

The evaluate model is added to see its execution, that is, view results in the form of charts.

Figure 17. shows an example of a user input, where 0 indicates that the user has no diseases, allergies and/or food preferences and 1 indicates the opposite. Figure 18. shows the output given, which is the meal ID, based on the input.

Figure 18. Screenshot of the output.

Figure 17. An example of a user input.

4.6. Lifestyle Management

The statistics, mentioned in section 2.1, regarding diabetes, overweight, obesity and physical inactivity indicate that Mauritians do not have healthy eating and dieting habits. Also, despite being a small island, there are various large surfaces where fast foods are being sold in Mauritius. This shows that instead of choosing a healthy lifestyle, Mauritians are going towards a lifestyle which is deteriorating their health.

"Mobile phones have become part and parcel of Mauritian lifestyle" [49]. According to [29], the total number of mobile phone subscriptions is 1.814 million. Since approximately 82 % of Mauritians have a smart phone [20], they will be able to properly manage their eating habits and be more health-conscious, using smart diet application. The smart diet application can also be used to change their present lifestyle into better and healthy one. The application will enhance eating habits of Mauritius.

This application is simple to use and can be understood by anyone of different age groups. It helps people to measure and calculate their calorie intake per day. Hence, they will be able to manage the amount of calories consumed. Furthermore, since the calorie calculator notifies people when they are exceeding or falling short of their daily calorie intake, proper advices will also be prompted to them. An example is that if a person exceeds his/her daily intake, the application advises him/her to exercise some more. It helps people to achieve their ideal body mass index (BMI). Additionally, the smart diet is a reliable application since it provides accurate and genuine information from the well-known Weigh-Less book. People can have timely result of the application as they will have well-defined specific periods from which they can choose for their dieting such as daily, weekly, monthly, depending on their needs and preferences.

4.7. Recommendation Engine

Recommendation engine is an approach to using intricate algorithms to determine in details large volume of data and determine what consumers may want based on their preferences, choices and based on what people with similar taste may like [42]. In the words of Steve Jobs "A lot of times, people don't know what they want until you show it to them." [48]. Likewise, while using a website

or an application, many people do not have a clear mind of what they are looking for until the system recommends the user. The basic approaches to build recommendation systems are the collaborative filtering and content-based filtering. The collaborative filtering recommends based on user ratings and on what users with similar behaviors have liked or purchased. The content-based approach makes recommendation based on previous buying histories and previous preferences [42].

The recommendation engine acts as a guide/an adviser for the user. For the Smart Diet Consultant application, the content-based approach is implemented. The system makes food recommendations based on the profile and food preferences of the user. It advises food items which the user should eat and/or prefers to eat, and also includes the items in his daily diet. Also the application helps the user to eat healthy foods and to achieve his/her goals eventually.

As shown in Figure 18. from the previous section, Microsoft Azure Machine Learning Studio outputs all the meal IDs and their associated probabilities and then selects the most accurate one based on the inputs. This means that the meal ID displayed is the one whose data best matches the user inputs.

For displaying the diet plan, the meal ID is retrieved in Android Studio where the meal plan and its calories are searched in the database and presented to the user in the application.. For a weekly diet plan, all the probabilities and their meal IDs based on user input are sorted in descending order in Android Studio. The meal ID whose data matches the user inputs is on top of the list. Hence, the top 7 meal IDs are selected for the week, and the meal plans and calories for each meal IDs are searched in the database and displayed in the application.

4.8 Data Visualization

A picture is worth a thousand words [22]. Similarly data visualization means displaying data in a visual context to help people understand its importance [35]. Since smart phones' screens are limited in size, compared to computers, data visualization becomes challenging. Data can be displayed in many forms such as text, numerical, graphics, audio, video files, charts and so on.

In the application, text and numbers are used throughout, to display user input, exercise and food items and diet plans along with their respective amount of calories. Moreover, predictions are made through graphs and charts based on the user's BMI and calorie intake. The predictions act like warnings for the user, where graphs are displayed/plotted to show different consequences of his/her choices. An example is that if a user chooses to drastically lose weight, the application will generate a graph or chart to predict how much weight should be reduced on a daily or weekly basis. Besides, it warns/prompts the user whether the choice he/she made is advisable or not.

5. System Prototype

A number of technologies have been used to implement the Smart Diet Consultant. Android Studio has been used as mobile development platform since the development language is JAVA, which is known for its high performance, independence from platform and creation of modular programs and reusable code. Android phones have been used to code and test the application. Azure Machine Learning Studio has been utilized for the generation of diet plan since it is a cloud platform and it trains the machine faster. In terms of data storage, SQLite has been used for the multiple advantages it has : It is file-based that is the database comprises of only one file on the disk, which makes it extremely portable. It makes use of SQL. It is great for both developing and testing.

Below are a few screenshots of how the application looks like. Figure 19. shows the Personal Details screen where the user enters his/her height, weight, age and gender. Figure 20. shows the Physical Activity Status where user selects between the different options provided. Figure 21. shows the Health Status screen where user selects his/her diseases,

allergies and food preferences, if any. For the Smart Diet Consultant application, only two options have been used for each section as sample.

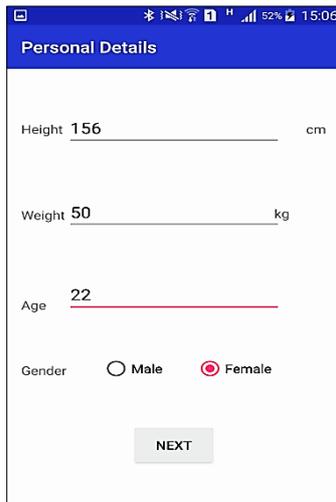


Figure 19. Personal Details

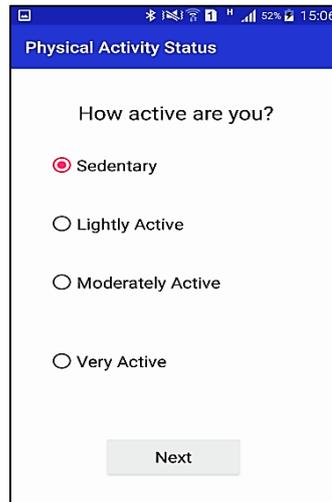


Figure 20. Activity Level Status



Figure 21. Health Status

Figure 22. shows the Weight Loss Goals screen where the user's calculated BMI, the weight and height are displayed and users selects his/her target weight and the rate at which he/she wants to lose weight. Figure 23 shows the Main Menu screen where the user's computed daily calorie intake is displayed along with the calories consumed and the calories yet to be consumed. There are also a few buttons such as the Profile, Food Diary, Diet Plan and Exercise Diary. Figure 24 shows the User Profile and buttons for the user to edit his/her details.

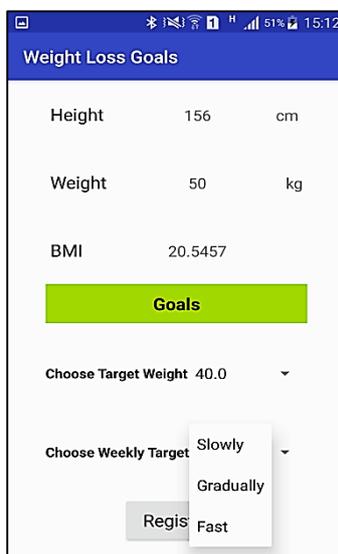


Figure 22. Weight Loss Goals

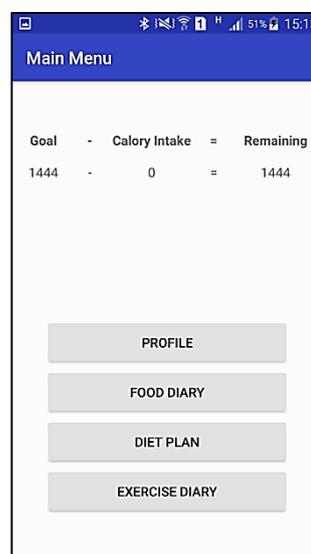


Figure 23. Main Menu

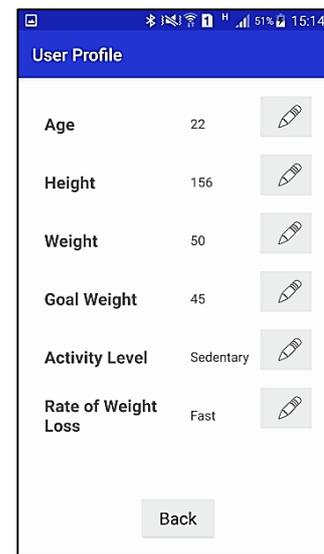


Figure 24. User Profile

Figure 25 shows the Food Diary screen. On clicking the Add button, the user is directed to the Add Food screen as shown in Figure 26. To search for food items, the user selects the Add button and he/she is directed to the Search Food screen, as shown in Figure 27, to select food items required and is redirected to the Add Food screen. The details for the item selected is displayed and he/she enters the number of portion he/she consumed.

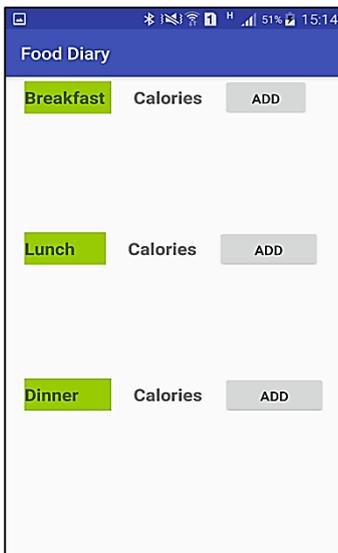


Figure 25. Food Diary

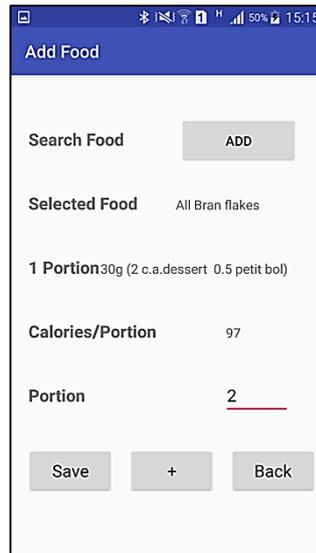


Figure 26. Add Food



Figure 27. Search Food

Figure 28. shows the Food Diary screen after the user has entered food items consumed. Figure 29. shows the Main Menu, where the total calories intake and the remaining calories to be consumed have been computed and displayed. Figure 30. shows the Diet Plan screen which displays the weekly diet plan based on information provided by the user.

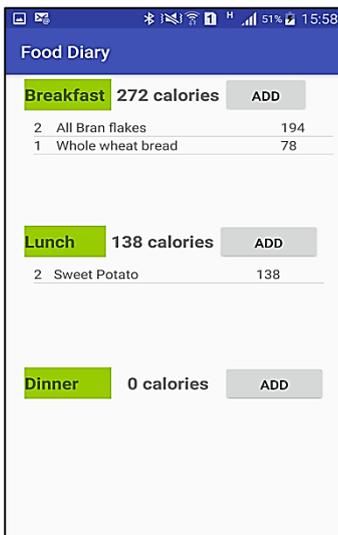


Figure 28. Food Diary after being filled

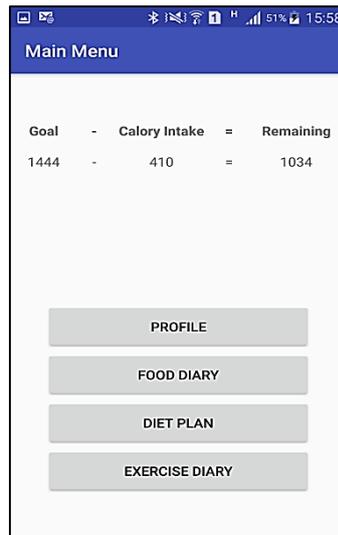


Figure 29. Main Menu after food items have been added

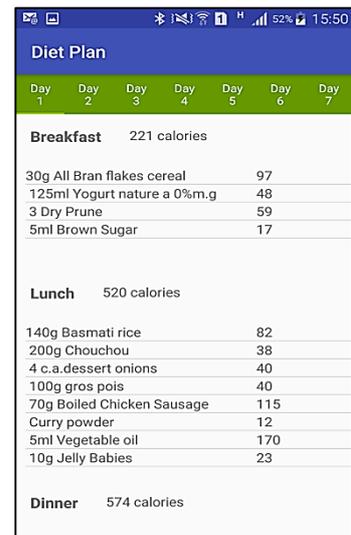


Figure 30. Diet Plan

The system proposed is beneficial to the users who want a healthy lifestyle as it has all the necessary components to help maintain the desired lifestyle. It has a food diary which enables the users to enter all their food items consumed during the day and calculate their total daily calorie intake and the number of calories left to be consumed for that specific day. This insertion of food items part differentiates the application from others as the users are able to enter specific Mauritian food items. The other component is the generation of the diet plan which generates meal plans based on the user's information and the different food items proposed are easily available in Mauritius as compared to other applications. Concerning the different diseases, allergies and food preferences in the application, only two options of each has been proposed. However, the list will include more of these in the future, to be able to target a larger number of users with different health issues. Moreover, if the user wants

to make any changes concerning his personal information, he can do so. Additionally, there are other functions which are intended to be implemented in future such as an accelerometer to help determine the number of calories lost while walking or exercising, including photos of the meal so that the system can determine the number of calories in a meal item using AI techniques and connecting to social media to share the different diet and weight loss goals.

Conclusion

This paper presents a Smart Diet framework for promoting healthy eating habits and nutrition in Mauritius. A thorough analysis of the existing systems concluded that these systems are not adapted to the Mauritian context. Also, the worldwide systems usually propose food items which are too expensive and/or which might not be available in Mauritius. Therefore, a Smart Mobile Diet Consultant application has been implemented based on the framework and the application consists of Mauritian food items consumed by Mauritians. The application uses machine learning to recommend customized meal plans based on users' allergies, diseases and food preferences. Additionally, there is a food and exercise diary where users can keep track of their calories consumption and burnt. The application has been designed with simple, user-friendly features so that it can be adopted by people of different age groups in Mauritius. If users follow the recommended diet plan, they are likely to lead a healthy lifestyle by being conscious of what they are consuming and keeping track of their daily diet and physical activities. Future work focuses on implementing more features to the system such as being able to connect to social networking sites and to be able to use an accelerometer while doing exercises. Furthermore, the application will include a wider range of nutrients and international branded food.

7. References

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AUTHOR(S)



Goorwappa Yuvna is, currently, an *Associate Software Engineer* in one of the leading and renowned IT company of the island. She has a BSc (Hons) in Software Engineering with *Second Class First Division Honours*, from the University of Mauritius. She is a very organized and motivated individual. Her goal is to continue learning and develop her skills.

E-mail: yuv_na@hotmail.co.uk

Phone Number: (+230) 5778-8693



Sreeneebus Ajitesh Sharma is a *Software Engineer* graduate with *Second Class Honours* from the University of Mauritius. He is currently working in the banking sector of Mauritius as an IT tester with a knowledge on various IT test automation tools. His passion about software development made him choose this field of education.

E-mail: adarsh22@live.com

Phone Number: (+230) 57865882



Nagowah Soulakshmee Devi, MSc, is a senior lecturer at the *Software and Information Systems Department* of the University of Mauritius. She has a BSc (Hons) in Computer Science with *First Class Honours* and an MSc Computer Science with specialization in Software Engineering. She has over ten years of teaching experience. Her research interests are directed towards Pervasive Computing, Software Engineering and Health Informatics. She has published a number of research papers in renowned international conferences and journals and has supervised projects in these areas. She has also worked on a research project entitled "A Secure Data Access Model for the Mauritian Healthcare Service" funded by the Mauritius Research Council. She has been awarded *Best Paper Award in the second place* by IEEE Software for the paper "An Automatic and Intelligent Workflow Design" for the IEEE co-sponsored ACSEAC – African Conference on Software Engineering and Applied Computing, 2011.

E-mail: s.ghurbhurrun@uom.ac.mu

Phone Number: (+230) 403-7831