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Sustainability of GreenMed: a physical activity monitoring application

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ABSTRACT

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Sustainability of GreenMed a physical activity monitoring application

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Abstract:
Evidence suggests that physical activity brings substantial health benefits while its absence causes several health issues. As people become more aware of the negative health outcomes associated with physical inactivity, the shift from sedentary lifestyles to healthier ones occurs, and physical activity tracking apps may help in this regard. While mobile applications for tracking physical activity are abundant, most of them fail to deliver evidence-based recommendations. This is a major drawback especially when these apps are designed to guide users towards healthy lifestyles. This thesis presents a prototype application that (1) keeps track of physical activities, (2) visualizes this data to the user and (3) provides evidence-based recommendations according to user's current activity level. Additionally, a new visualization approach is proposed which uses animal representations for activity levels in order to enhance user's experience, increase motivation and create a good base for further integration of gamification principles. Test users found the prototype useful and showed great interest towards the animal representations.

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TABLE OF CONTENTS

LIST OF SYMBOLS AND ABBREVIATIONS

AR Activity Recognition

UI User Interface

UX User Experience

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX

1 INTRODUCTION

Time and again, scientific evidence has proved that engaging in physical activity and exercise has enhanced the quality of life and brought positive health outcomes. According to J Kruk [1], physical activity helps reduce mortality risks by preventing several chronic diseases such as cardiovascular, cancers, diabetes, hypertension and obesity. Additionally, improving physical well-being through exercise also helps generate more positive emotions while significantly reducing anxiety and depression [2]. These health benefits are applied for both genders of all ages from all over the world [3] [4].

Physical inactivity on the other hand, is associated with many health problems. Each year, this “fourth leading underlying cause of death” [5] killed more than 3.3 million people around the globe [6]. Along with morbidity and premature deaths, this lifestyle also presents a large burden on the health-care system. In 2013, it cost the worldwide health-care system approximately 53.8 billion US dollars on both public and private sector [7].

Although people are aware of benefits brought by physical activity and consequences of sedentary lifestyles, a large part of the world population are still physically inactive. According to the Eurobarometer survey [8], approximately 59% of Europeans never or rarely play sports and these figures had not experienced any significant changes since 2009. When it comes to the intensity of exercise, more than 44% of all respondents admitted that they did not perform any moderate or vigorous activity within the current week and roughly 13% of them did not walk for at least 10 minutes in most days. In Asia, the proportion of physically inactive citizens is even higher, accounting for 40% to 80% of the population [4].

At the same time, the world also experienced a rapid growth in the mobile phone market. There were approximately 7.5 billion mobile subscriptions worldwide in 2016 with slightly more than half of them being smartphones [9]. Within a relatively short period of time, ubiquitous mobile devices have reinvented our daily lives by providing not only standard facilities (e.g. calls, messages) but also advanced functionalities (e.g. GPS tracking, sensing ability), offering an enormous opportunity to tackle many social challenges in including the physical inactive problems.

When these two trends converge [10], the desire of having a mobile application that can guide user towards healthy lifestyles is now made possible [11]. Since the very beginning, this area has received a tremendous amount of attention and continuously grows over time. In 2013, there were approximately 23,490 and 17,756 apps in both Apple store and Google Play, respectively, categorized in health and fitness section [12]. Most applications provide tracking of physiological variables (e.g. physical activity, calories in-take, and sleep quality) while detecting behaviour patterns changes and inform users of the changes [11]. Measurements provided by fitness apps are deemed to be more accurate compared to self-reported ones [13] [14], giving user a comprehensive view about their activity pattern.

1.1 Problem Definition

While the number of mobile applications for health and fitness has spiked quickly over the past few years, two major gaps in the functionality remain.

- Firstly, research pointed out that while studies on the sufficient amount of physical activity/exercises are abundant, most of available applications failed to deliver evidence-based recommendations [15]. This is a major drawback especially when these apps are designed to guide users towards more healthy living styles.
- Secondly, available apps on the market primarily focused on improving accuracy and making the app more appealing to users while paying much less attention on the long-term usage and its sustainability. When these apps run continuously for a long period of time, a large burden on data storage and energy consumption is generated if sustainable designs are not being carefully considered.

This research attempts to address the two aforementioned shortcomings by incorporating latest research results on physical activity and sustainable designs into an application called GreenMed. This app (1) delivers evidence based recommendations about how much physical activity users should do to stay healthy based on their current physical activity levels; (2) provides comprehensive views on their activity patterns through statistical data; and (3) reflects sustainable designs through implementation choices.

The research also proposes a new approach to visualize physical activity levels, using animal representations. The new visualization approach makes the app more appealing to users, brings fun while creating a good platform for further incorporation of gamified elements and behaviour changing techniques.

1.2 Motivation

Living in a world where physical inactivity is the main contribution of many health issues such as diabetes, heart disease and depression, developing an application that motivates and guides people towards healthy living styles will help change this trend for the better, hence reduce the burden on the healthcare system. Going out for a walk, having a little fun while meeting people are good ways to cultivate new relationships and improve life qualities. Incorporating sustainable designs also helps avoid the data burden for the long run as well as promote the reusability and sustainability. The animal representations of physical activity levels brings a little fun to the visualization but also opens an opportunity to raise user's awareness about the animals around them by give them knowledge about these animals.

1.3 Objective

To fulfil the research gaps, this thesis was set out to build a physical activity tracking prototype that can/will:

- Provide evidence based recommendation on how much activity an adult should do to stay healthy regarding user's physical activity levels.

- Show users how much physical activity they have done during the day and how are their activity levels compared to the recommended ones (to gain health benefits)
- Effectively visualize their daily/weekly/monthly physical activity patterns, incorporate the new visualization method using animal representations
- Encourage users to cultivate and maintain active lifestyles.
- Carefully consider and integrate sustainable design into the app.

1.4 Delimitation

This research focuses on giving research-based recommendations based on user's physical activity levels while effectively extracting insights from user's physical data before presenting it to the user. The sustainable designs will be carefully considered during the development process, reflecting clearly on technology choices. Due to time constraints, the prototype only provides evidence based recommendation on how much exercises an adult should do to stay healthy in four main actives including walking, biking, jogging and running. Statistics derived from physical data will be given through hourly, daily, weekly and monthly data. The gamification elements are mentioned in the research but they are just an introduction for the potential extension of animal representations and not the main focus.

1.5 Methodology

The project consists of three main phases illustrated in Figure 1

- Phase 1: Critical literature review to identify the research gaps
- Phase 2: Identify research topic, the objective and the delimitation
- Phase 3: Collect requirements and design the system architecture
- Phase 4: Iterations within time limitation, starting with implementation, evaluation

and followed by optimization.

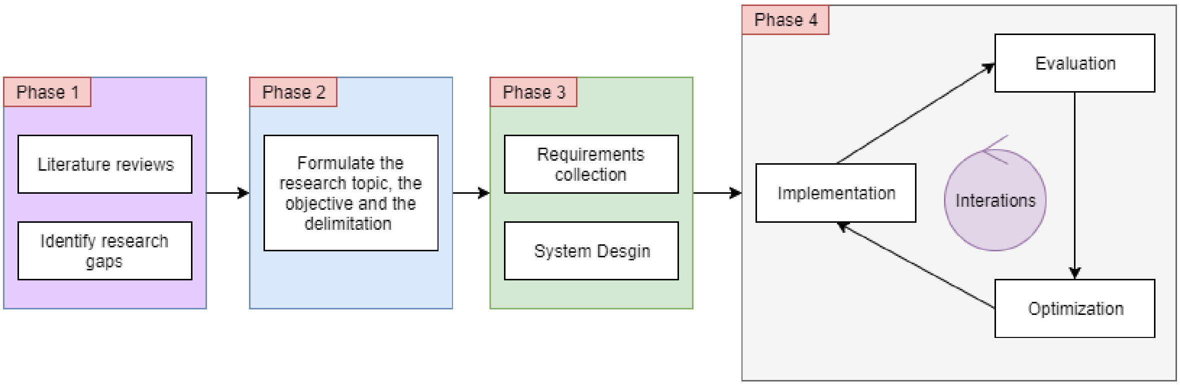

Fig. 1. Methodology

1.6 Structure of the thesis

The report is structured as follows:

- The ***Introduction*** section furnishes information on existing Android physical activity tracking application and the need to develop the GreenMed prototype. Objective that the thesis seeks to explore is also discussed in this chapter.
- The ***Literature Review*** section covers various relevant work on the current research on physical activity, the motivation for exercising and similar apps working on physical activity monitoring.
- The ***GreenMed Application*** chapter outlines the application's skeleton which provides a glimpse on the application overview, target users, requirements and the system architecture.
- The ***Implementation*** chapter describes in detail about the development of the application which could be largely divided into three main phases, including Data Acquisition, Data Interpretation and Data Visualization.
- The ***Evaluation*** section presents results of the thesis and critical analysis as well as discussion around users' feedback for the prototype. This chapter also describes

relevant future work.

- The ***Conclusion*** section covers a summary of the conducted research work.

2 LITERATURE REVIEW

In this chapter, we survey the health benefits of physical activity and how does current technology help track and encourage people to cultivate/maintain healthy lifestyles. We will also take a look at the motivation that drives people to be active or keep them in the sedentary lifestyle. Finally, relevant technologies that support the GreenMed prototype will also be discussed.

2.1 Health benefits from Physical Activity

Irrefutable evidence suggests that physical activities and exercises bring a wide range of health benefits by reducing or preventing several chronic conditions such as diabetes, obesity, hypertension and cardiovascular diseases [1] [16]. Living a physically active life also reduces depression and anxiety, improves moods [2], and increases productivity in performing daily tasks [17]. Different activities with different duration, frequency and intensity bring different health impacts, however, more is likely to be better than less [18].

Several guidelines such as The Global Recommendations on Physical Activity for Health (2010) [19], The Physical Activity Guidelines for Americans (2007,2008) less [18] [20], The British Association of Sport and Exercise Sciences (2010) [21] confirmed that 150 minutes of moderate-intensity activity (e.g. walking, biking) or 75 minutes of vigorous-intensity activity (e.g. jogging, running), or an equivalent combination of these two bring substantial health benefits. Consistent evidence also suggests that even exercising under recommended levels still results in health benefits. A 15-year study on 55,137 adults carried out by Duck-chul Lee at the Cooper Clinic in Dallas, Texas [22] shows that running during leisure time with a minimum of 5 to 10 minutes per day (30 to 59 minutes per week) even at slow speeds could significantly reduce risks of mortality and cardiovascular diseases (up to 30% and 45%, respectively). Similar finding [4] also links 90 min a week or 15 min a day of moderate-intensity physical activity with reduced mortality risks by 14% and expanding life expectancy. This research also stated that with every additional 15 minutes beyond the minimal recommendation, up to 100 min per day (no additional health benefit will be generated after which), all causes mortality risks will be cut down by 4% more. Figure 2 illustrates the relation between the exercising duration (minutes) and the reduction of all causes of mortality (percentages).

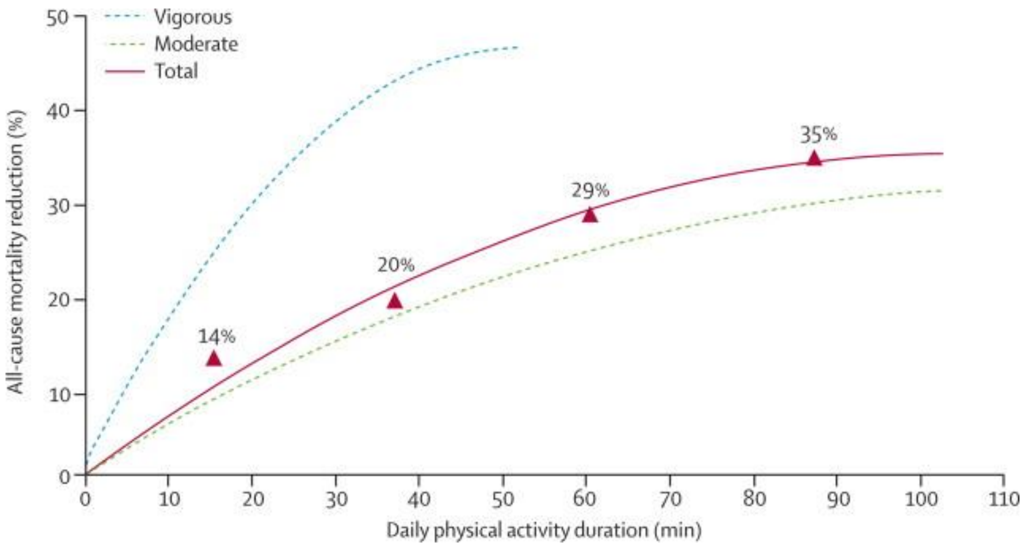

Fig. 2. The relation btween duration and the reduction of all causes of mortatlity **[4]**

Research also suggests that vigorous-intensity activities generate more reduction in mortality and disease risks than moderate-intensity ones [23]. According to Wen et al. [24], running could generate a two-fold or a four-fold more positive health influence compared to walking. Figure 3 illustrates the comparison of influences generated by walking and running on reducing all-causes mortality. As shown in the graph below, 5 minutes walking is equivalent to 15 minutes walking; 25 minutes running is as good as 100 minutes walking. Although people can choose running to save time, caution should be exercised when choosing running, particularly for older adults since more intensive physical activity is usually associated with risks of injuries [21].

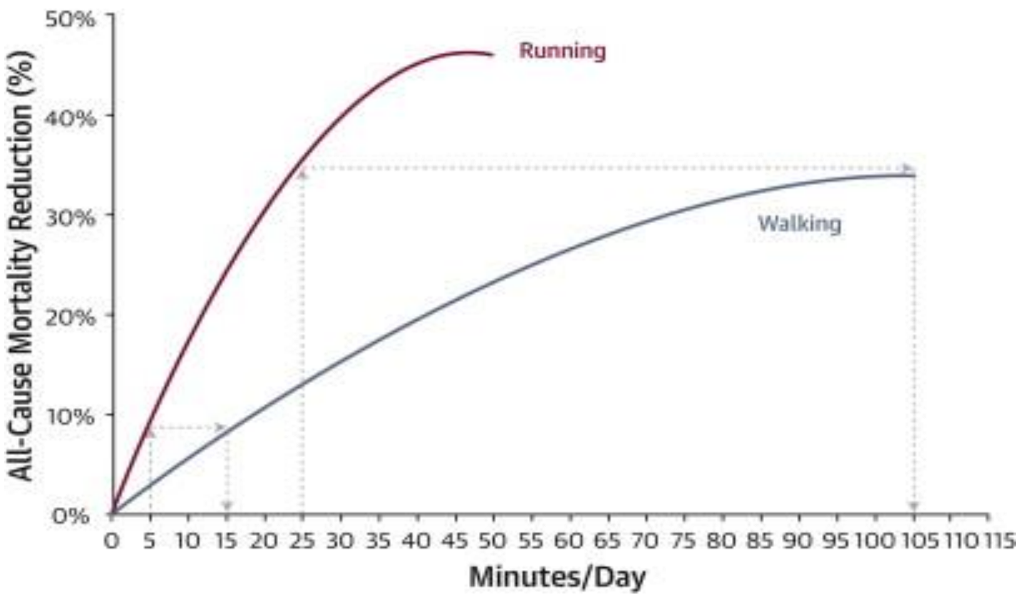

Fig. 3. Comparing the benefits of walking and running **[24]**

2.2 Motivation for doing exercises

While motivation for engaging in physical activity depends on several factors such as gender, age, education, etc., maintaining good health condition remains the most common motivation. Special Eurobarometer Survey on Sport and Physical Activity conducted in Europe showed that improving health was mentioned by 62% European participated in the survey [8]. Similar study in Denmark (2014) [25] also confirmed the previous finding with more than 70% of the respondents cited staying healthy for their driven cause on both men and women.

Other motivations include relaxing, having fun, socializing, appearance and weight control purposes. Out of 76,101 participants in Denmark, having fun was the second most common reason for doing exercises/sports among men with 25.3%, followed by losing weight (22.7%) and socializing (22.7%). Women, on the other hand, are more motivated by losing weight with 29.6% than socializing with 18.2% and having fun with 17.8% [25]. The main driven cause can be different in different country. For examples, health consideration is a significant contribution in Sweden (81%), Denmark (76%), and Spain (73%) while relaxation is more compelling to Netherlands (56%) and Belgium (53%) [8].

The barriers to exercising and physical activity are also diverse but lack of time and motivation are the top causes. In Europe, the main reasons preventing people from exercising or doing sport were that they did not have time (40%) or due to their lacked interest (20%) [8]. Again, these numbers may vary at country levels.

2.3 Health and fitness application

As health awareness improves, the need for personal tracking tools that can reflect daily physical activities also grows. Traditionally, activity assessments are carried out through subjective methods such as diary, questionnaires and surveys. Although these methods are simple and inexpensive, they are prone to bias since the data qualification depends primarily on self-observation and individual interpretations [13] [14]. Technological interventions, on the other hand, provide more objective measurements through various methods. Mobile applications are increasingly useful in this area [26] thanks to the ubiquity and growing capability of personal devices. With a wide range of built-in sensors (e.g. accelerometer, gyroscope and GPS), smartphones are very effective in delivering physical activity information [27] while maintaining user’s sense of privacy.

Various mobile applications support tracking of user’s physical activity. The common goals are usually to determine types, duration and intensity of user’s motion during a period of time while generating feedback in forms of notification or statistics based on the collected data. Many of these apps aim for promoting fitness/weight loss [28] [12]. MyFitnessMap (free version) [29], for examples, allows users to record a workout session in various measures (e.g. duration, distance, pace, speed, calories burned and travelled route). The app encourages users to work out more for weight management purpose but failed to give evidence-based recommendation for those exercise to stay healthy as many other apps [15].

To improve the activity recognition results, additional wearable devices [30] such as hip/wrist band or smartwatch are sometimes required. Although these devices are still on its early stage of diffusion, various research [31] [32] suggested that users have very strong interests for them. However, when it comes to supporting health and fitness apps, these devices are considered more of facilitators than drivers [33].

Gamification are very common among health and fitness applications [34]. Game-liked rewards and incentives are added as ways to improve users' motivation and engagement [35]. When the use gamification are linked with desired behaviours, potential changes may appear in user's behaviour [36].

Applications in this category also adopt various behaviour changing techniques [12] [37] [38], aiming for establishing and cultivating healthy lifestyles. The most common technique is providing instructions or demonstrations of specific physical activities [37]. Other techniques such as providing feedback on performance, goals setting/reviewing and social supports are also very popular although some of them only appear in paid apps.

2.4 Tracking Physical Activity

This section explores the common approaches for tracking physical activities as well as the strength and the drawback of each methods. The new approach using Android Fitness APIs is introduced before the chapter explains why it is suitable for the thesis.

2.4.1 Traditional approach

Initially, tracking physical activity was a very complex process. Firstly, activity must be recognized from sensing data using activity recognition (AR) algorithms, following by knowledge extraction process where information such as duration, types of activity and time during which users perform these activities were obtained. Typical AR procedures consists of four main phases, including Data Collection, Feature Extraction, Activity Modeling and Activity Recognition. Although Data Collection can be done by vision-based [39], sensor based approach [40] is preferred when it comes to human activity recognition because it is more effective, inexpensive and less privacy concern [41]. In Feature Extraction, Activity Modeling and Activity Recognition phase, there are two major trends, including ontology based and machine learning based approach [42]. While different approaches are suitable for different applications, machine learning based approach has been received more and more attention especially supervised learning. In this method, patterns will be extracted and annotated (online or offline) from collected data, which will then feed into the classifier as training data. Activity is recognized by mapping new data with the training set using a wide range of machine learning algorithms (e.g. Hidden Markov Models, decision trees, Naive Bayes classifier and support vector machines). The workflow is illustrated in Figure 4.

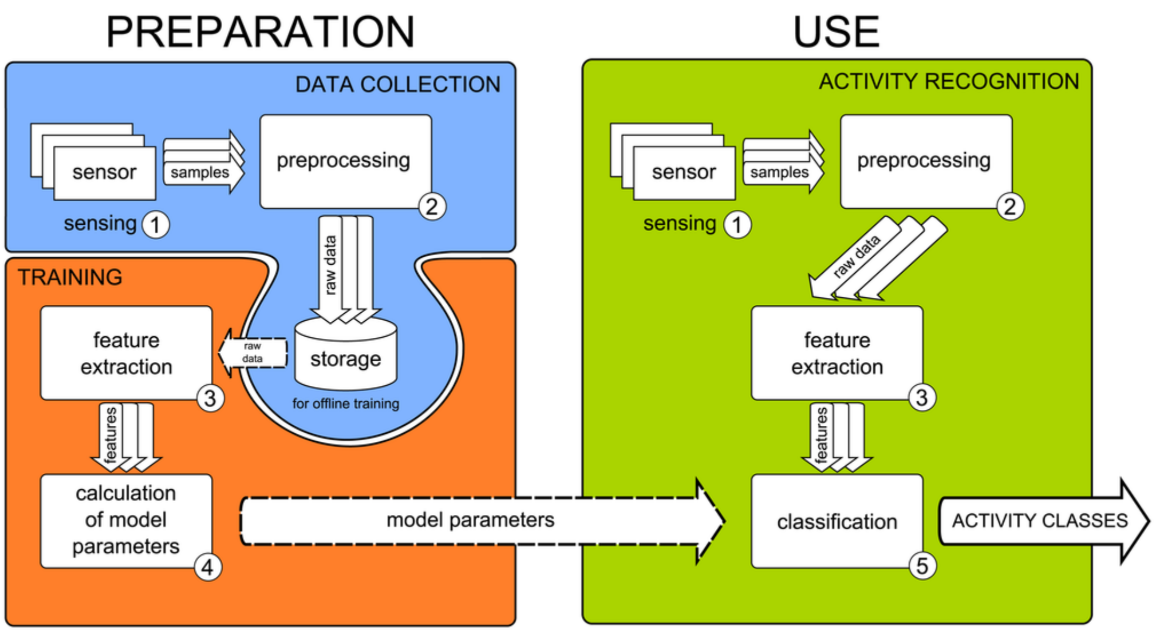

Fig. 4. Activity Recognition Data Flow [42]

2.4.2 Android Fitness APIs from Google

In May 2015 Google released Android Fitness APIs as a part of Google Play Services, allowing developers to extract physical activity information without having to build and perform complex activity recognition processes on raw sensing data.

Android Fitness APIs provided by Google help obtain and analyze data stream from built-in sensors of smartphones or wearable devices. Sensing data is aggregated and blended with other data from compatible apps to form a comprehensive look into user's health and fitness routines. With Android Fitness APIs, all sensing data generated by any compatible apps or devices in the platform will be stored in one central repository (Figure 6), instead of storing separately in several databases for different applications in traditional approach (Figure 5). User privacy are also taken care of by granting user full access permission over their personal data. This way user can (1) access (directly or indirectly via applications) to their activity data at any time from any devices and anywhere; (2) share this database with any compatible apps to increase data usability and reduce redundancy; and (3) delete it whenever they wish. The platform also ensures the persistence of user's data even when their devices are upgrade.

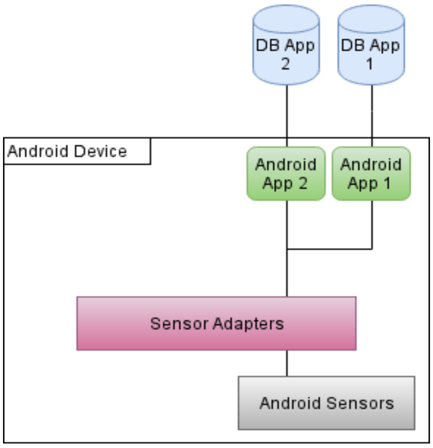

Fig. 6. Traditional apporach

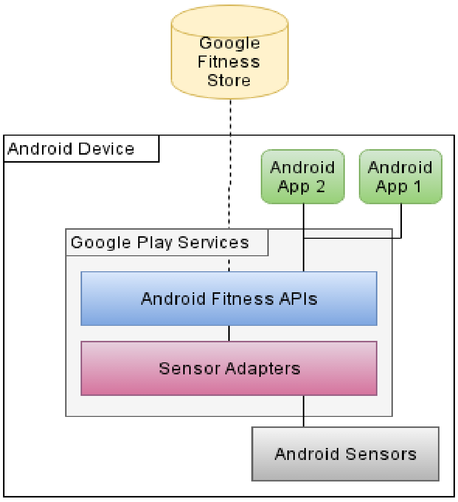

Fig. 5. New approach with Google Fit APIs

Developers can manipulate physical activity data via four main APIs:

- ***Sensors API*** allows developers to access raw sensing data from connected sensors, including sensors on Android device or any companion devices (e.g. wearables). Using this API, data freshness can be controlled by setting appropriate sampling rates. When the interval is set to 0, sensing data is updated in real time. Developers, however, should handle this metric with caution to avoid battery draining.
- ***Recording API*** enables the application to subscribe for a cloud-synced background data collection service instead of directly accessing to raw data like Sensors API. Sensing data from active subscriptions is automatically recorded in a battery-efficient manner even when the app is not running, and stored them in the user's fitness history data repository. Since ***Sensors API*** does not automatically store sensor readings and its registrations are not persisted when the system restarts, developers need to combine the ***Recording API*** together with the ***Sensors API*** if they want to use these real-time data later on (accessing through ***History API***).
- ***History API*** provides access to user's historical physical activity data which was recorded or inserted from connected apps in Google Fit Platform. If the application just requires history data, using of ***Recording API*** together with **History API** should be enough.
- ***Sessions API*** allows the app to create sessions with metadata on time intervals of activities and store them on fitness store for further uses. Additionally, under user permissions, this API allows an application to share its data with other apps or retrieve shared data from other apps.

3 GREENMED APPLICATION

This chapter gives a comprehensive look at the GreenMed application. It starts with an overview about the application and the requirements before diving deeper into the system architecture.

3.1 Application Overview

GreenMed is designed to give evidence-based recommendation on how much physical activity an adult should do to stay healthy. The recommendation was conveyed based on user's current activity levels. Users are also given an overview into their behaviour patterns through details about their daily activities (e.g. types of activity, time and duration) and statistical data.

The prototype is designed to run mainly on smartphones due to two main reasons. Firstly, users usually carry their smartphones around, making them more suitable for collecting physical activity data. Secondly, smartphones also have a wide range of built-in sensors with adequate capacity to perform data acquisition and data processing tasks which sometimes involve running computationally expensive algorithms.

This application targets users who needs recommendation on how much exercises they should do to stay healthy. Users with interests in tracking their lifestyles and getting insights in forms of behaviour patterns or statistical data on how active they are every day/week/month also can benefit from this app. Last but not least, the app may also serves users who are curious about this app or wanted to compare one with and other apps.

3.2 Application Requirements

This prototype is designed according to user requirements, functional requirements and sustainable requirements. The user requirements and sustainable requirements were extracted through literature reviews, what the author thought were appropriate and customer reviews in similar application. Functional requirements are derived from the user requirements, sustainable requirements and similar features in other physical activity tracking apps.

3.2.1 User requirements

I. The recommendation delivered by the app must maintain high reliability and reflect scientific evidence. In order to motivate users to be more active, the app must keep all these recommendations positive and avoid negativity.

II. The activity tracking feature must have high accuracy in order to be perceived as reliable by users.

III. The app must also ensure reasonable reliability, increase reusability where it is possible and eliminate conflicts (if exists) between this app and similar applications or other common applications. The reasons are (1) people who actively track their physical activities usually keep these data for a long time [43] and (2) they can also use different tools to track different activities or use more than one tools to track the same activity [44].

IV. The data visualization must be neat and effectively reflect user's activity behaviours

V. The number of required interactions should be kept at minimal levels while more data analysis results such as statistics and pattern recognition should be given since users are more motivated to maintain their habits of using application if the benefits outweigh the required effort.

VI. The app should not drain too much battery or consume a large amount of computational resources.

VII. The app settings should be initialized with technically optimized configurations but also allow users to modify these configurations if they wish.

3.2.2 Functional requirements

I. The app must deliver evidenced-based recommendation based on user's current activity level. The recommendation must stay positive and link closely to scientific research.

II. The app must be able to track user physical activity duration, on four main activities including walking, running, jogging and biking per hour, per day, last 7 days and per month. The physical activity data must be clearly and effectively visualized to users.

III. Information affects user's physical activity patterns (e.g. weather, sunrise, sunset, and temperature) should be given along with recommendation, helping users to better plan their activities.

IV. In settings, the app should initialize default configurations with technically good options but allow users to change if they wish.

3.2.3 Sustainable requirements

I. The technical choices to develop the app must be navigated towards sustainability.

II. Increase resource reusability while eliminating redundancy where it is possible.

III. Balancing the tradeoffs between sustainability and application's performance based on user's feedback.

3.3 System Architecture

The overall architecture is illustrated in Figure 7 in which physical activity data (types and durations) is fetched from Google Fitness Database (separately for each user) using Google Fitness APIs. The returned data will then be aggregated and classified into hour by hour, daily, monthly. Relevant data (such as weather, sunrise, sunset time...) will also be collected and merged with physical activity data before streaming to the next component for further analysis. In the analysis component, physical activity data will first be quantified per day/week/month, giving user a glimpse into their overall lifestyles. Then a comparison between user's physical activity level and critical thresholds/recommended levels will be given along with alternative ways to achieve it. It is worth noting that analysis is performed locally based on local data, meaning no data propagation is needed. These insights extracted from analysis component will then be visualized to user, available on request. More details will be discussed in the implementation

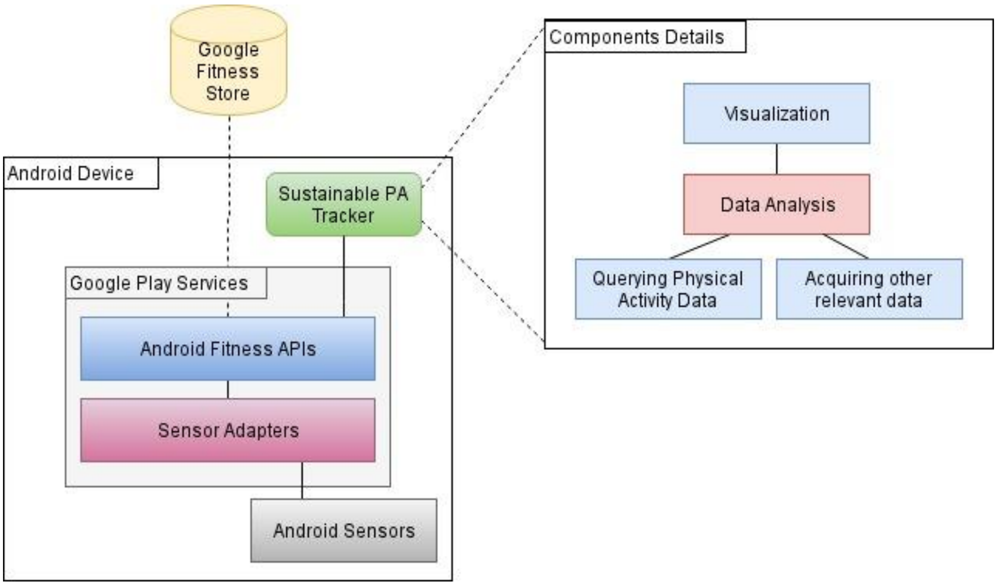

Fig. 7. System Architecture

4 IMPLEMENTATION

This chapter describes in details about the application implementation, including the data acquisition process, data interpretation and data visualization. Through analysis, the chapter also uncovers the sustainable designs lying underneath every technical choices that were made during the application development process.

4.1 Data Acquisition

To access physical activities data through Android Fitness APIs, the application has to obtain permission[1] from users and is connected to Google Play Service. After the connection with Google Play Service is initialized, activity data can be periodically polled from accelerometer, gyroscope and GPS sensors and automatically stored in one central repository (located in user's drive) via background process. The sampling rates and the choice of sensors are optimized by Android Fitness APIs to deliver highly accurate results but still keep the battery consumption at low levels. When the data is needed, the app performs data request and waits for the most up-to-date data from the central repository being delivered. This way, the data persistence is maintained even when user uses several devices or installs updates.

4.2 Data Interpretation

Different types of physical activities with different durations and intensities have different impacts on mortality reduction. Vigorous-intensity activities (e.g. cardiorespiratory fitness, running, sports) yield larger mortality reductions rate while moderate-intensity activities in daily living (e.g. gardening, doing chores) and physical activities for transportation (e.g. cycling, walking) deliver smaller health benefits. Based on several physical activity guidelines [18] [19] [20] adults should exercise at least 150 minutes of moderate-intensity

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[1] https://developers.google.com/fit/android/authorization

activities or 75 minutes of vigorous-intensity activities, or an equivalent combination of both to achieve substantial health benefits. For even greater health benefits, adults should exercise 300 minutes of moderate-intensity, or 150 minutes of vigorous-intensity activities every week. Other research also suggests that health benefits can still be found even with smaller doses of physical activity compared to the recommended levels [4] [22]. For example, with 15 minutes a day of moderate intensity activities such as walking and cycling or 5 - 10 minutes of moderate to vigorous intensity activities such as running and jogging, people can reduce mortality risks by 14% (if they can maintain the habits).

Based on types, duration and intensity of activities performed during the day and aforementioned research on physical activities, users are labeled with four activity levels:

- ***Inactive:*** Little (less than 5 minutes) or no physical activity;
- ***Slightly Active***: The user has done some physical activities but under the minimum level (15 minutes of moderate-intensity activity or 5-10 minutes of vigorous-intensity activity);
- ***Moderately Active:*** The user has done more physical activity than the minimum level but still under the recommended level (at least 30 minutes a day); and
- ***Highly Active:*** The user physical activity level is above the recommended level.

These activity levels are then used for classifying user's daily activity levels and as references for giving recommendations later.

4.3 Data Visualization

Data Visualization holds a very important role in this app. Good visualization gives users a comprehensive view about their current behaviours and motivates them to move towards healthy lifestyles. In this app, the visual information is kept as positive as possible, trying to build up user's confidence rather than causing to lose one.

4.3.1 Physical Activity Levels

Physical activity performed by user after being labeled with one of four levels will be visualized to users using different colors in which:

- Green is for Highly Active;
- Blue is for Moderately Active;
- Grey is for Slightly Active and
- Slightly Red for Inactivity (but only for Home Screen)

Using color visualizations in Home Screen along with text visualization makes it easier for users to quickly grasp their physical activity data. For similar purpose, color visualization is also used to present monthly activity data, however, Slightly Red for inactive days was not used to avoid negative feelings especially if users were inactive in several days.

4.3.2 Recommendations

The evidence-based recommendations are designed to guide users toward the next levels of their current activity state and to help them keep track of or maintain their habits if they have reached the recommended levels. Relevant information such as weather, sunrise, sunset time and current temperature will also be given, allowing user to choose appropriate activities during the day. For example, if sun sets after 8:00 PM and the weather is nice, users are recommended to go for a walk and since they are informed about when the sun will set they can plan out the time to take a walk. Recommendation will be given not only daily but also weekly, encouraging users to stay active everyday rather than being highly active in one day and then being inactive for the rest of the week.

Recommendations for users with different activity levels are different. For Inactive Users, at first the app will encourage them to be more active by giving them relevant information and the support from gamification and behaviour changing techniques. For Slightly Active

Users, the app will show them the remained time they should exercise compared ***to the minimal level*** of activities to start reaping health benefits. Similarly, for Moderate Active Users, suggestions will guide them to achieve ***the recommended level*** of physical activities. Once they pass this threshold and is classified as Highly Active Users, the app will encourage them to maintain this habits. The time during the day when users access the app also affects the recommendation. If it is in the early morning and users have not done any activity yet, the app will give some encouraging messages and provide users relevant information so they can plan out when to exercise during the day; if they have done some activities already, the app will give them the recommendation on how much more they should do. If users access the app during the night time and they have not done any activity during the day, the app will encourage them to be a little more active in the next day. Weather conditions are also considered in the recommendation; if it is sunny outside the app will recommend users to do some outdoor activities; otherwise, it will suggest users to consider some indoor activities instead. Refer to Figure 8 for more details of the workflow.

Exercises and physical activity in general, will give more health benefits if users perform it frequently during the week. Thus, along with daily recommendations, the prototype also provides weekly recommendation which informs users how many active days they have had during the week. The app also keeps track on how many consecutive active days which motivates users to be more active in the future but it is also a good reference for further integration of a reward system.

Recommendations aim to guide users to the next levels from ***Inactive*** to three different levels, including ***Slightly Active***, ***Moderately Active*** and ***Highly Active***. The purpose is to make the target on the amount time for working out become more achievable for users, therefore motivate them to be more active. Punishments when users do not reach the recommended levels are not used in this prototype since this approach may cause some negative emotion and is not good for long run.

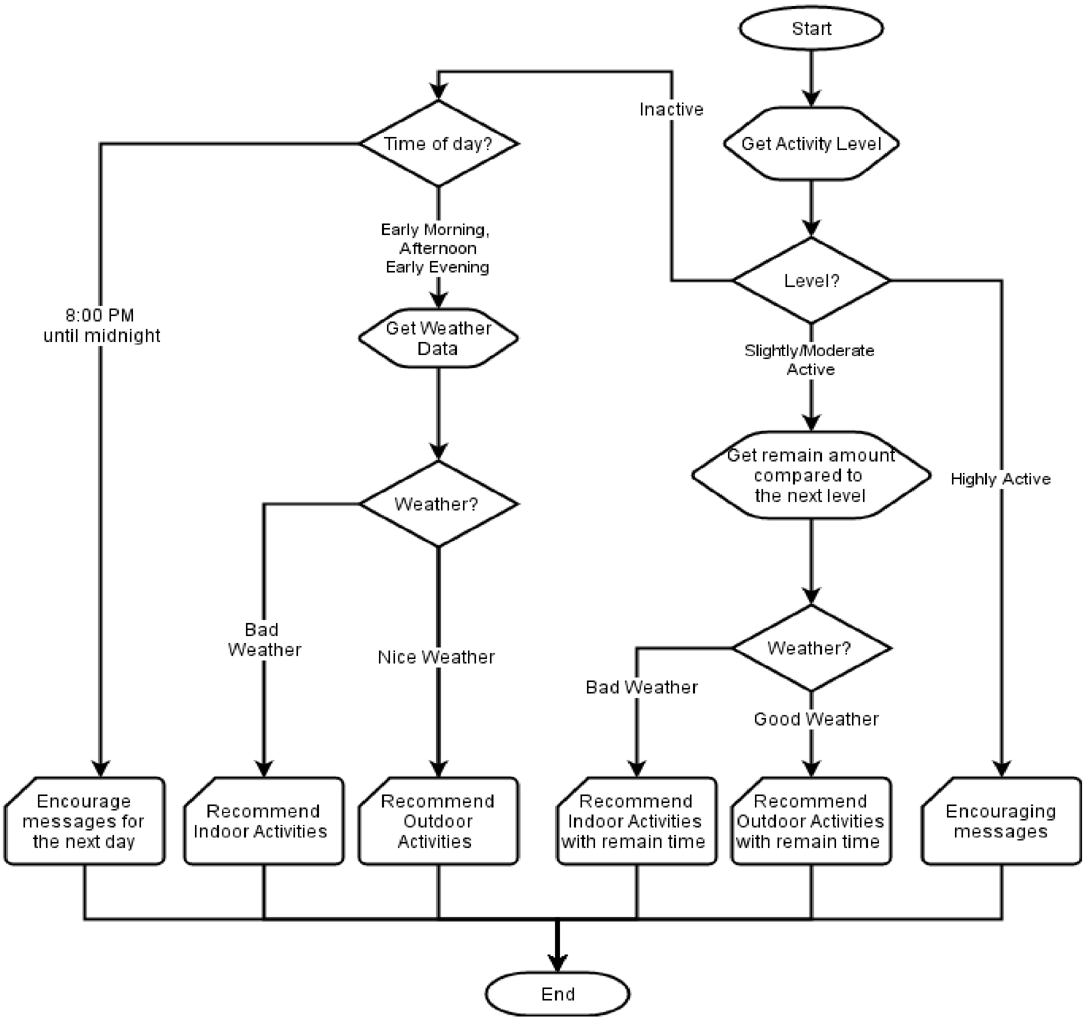


Fig. 8. Workflow of the Recommendation feature

4.3.3 Animals representations

In this prototype, we also employ animal representations for visualizing a user's physical activity levels. Depending on the activity pattern, the user will get an animal that shares similar activity pattern as avatar. When the user touches this avatar, a pop up will appear with some general information and fun facts about the animal. This way, the app helps to stimulate curiosity and improves awareness about the animals living around us. This also adds an element of gamification to using the app (achievement [34]).

The animal representation is matched with user's activity pattern if they share commons in:

- Quantity of activities (activity levels)
- Time of day when activities are performed
- Location where activities are performed

Table 1 presents how research on physical activity and the animal representations are integrated into demonstrating activity levels. For examples, if user's activity level is classified as highly active and the user workouts mainly during daytime in residence area, this user may get a bee since bees are very active during daytime and they appear everywhere (e.g. residence areas, forests, parks…). Similarly, if a user is inactive or slightly active and stays at the residence area most of the time, this user may get a cat. Users with similar activity patterns performed in different areas (e.g. forests, parks, residence areas) in different geography locations (e.g. Europe, Asia, Africa…) may have different animal representations if the animals living in the area that they are exercising in are different. For examples, two moderately active users usually workout in the wilderness, the one living near the North Pole may get a polar bear but the one living in Southeast Asia will not even if they share similar activity patterns.

Table 1. Animal representation of physical activity levels

Daily Activity Levels	***Example Animal***	***Scientific Ref***	***Example Picture***
Inactive (0 to 5 minutes)	Sloth Cat Panda	[4]	
Slightly Active (> 5 to 15 minutes)	Sloth Cat Panda	[4]	

Moderately Active (15 to 30 minutes)	Dog Sheep Cow	[21] [22] [24] [23]	
Highly Active (> 30 minutes)	Bee Humming Bird Squirrel	[3] [18] [19] [20]	

4.4 Sustainable implementations

Concerning sustainability, using Android Fitness APIs for developing physical activity tracking app is a good choice due to two reasons. Firstly, it reduces data redundancy and improves data reusability by collecting sensing data once and sharing it among compatible apps within the Google Fit Platform. Compared to traditional approaches where each application collects their own sensing data and stores them separately somewhere in the cloud, this new approach reduce a big amount of workloads while achieving the same results. Given the fact that multiple vendors such as Asus, HTC, LG, Intel and many more vendors are now joining the Google Fit Platform, using Android Fitness APIs can really make the most out of the same set of data. Secondly, Android Fitness APIs helps ease the device integration process by acting as a transparent layer connecting the application running in user space and the device hardware. Which means the application developed with Android Fitness APIs can perform its functionalities smoothly as long as its required input data is satisfied regardless where this data source came from. Google Fit Platform also enables the application to retrieve data from all the connected devices within the platform. As long as the device is connected, sensing data from these devices (e.g. smartwatch and other wearable devices) will be automatically delivered to the app with no modification needed. In case users have more than one device, as soon as these devices are online, activity data from each device will be automatically sent, merged and stored into the central database.

The app is design to show users their behaviour through days, weeks and months which mean flipping back and forth between day/week/month multiple time using next and previous buttons is a common pattern. Although sending data request and waiting for new data response every single time user clicks next or previous buttons may give fresher data, this operation is also very expensive in terms of computational resources especially data with large size such as weekly or monthly data. To mitigate the impact a buffer mechanism was implemented.

Each time Next or Previous Buttons are clicked, the app will retrieve stored data if they are available, otherwise, new data requests will be sent and current data will be buffered. Figure 9 and Figure 10 illustrate the operations when Previous or Next Button are clicked, respectively. Currently, the buffer size is relatively small (3 data units) therefore the more flipping back and forth between days/weeks/months users have made, the more effective it becomes. The buffer mechanism also becomes very effective if users are flipping between months or weeks because weekly or monthly data are very large (up to 3kB for each pulling response). By default this mode is enabled to optimize the data usage, however users can change it in settings if they wish (Figure 11).

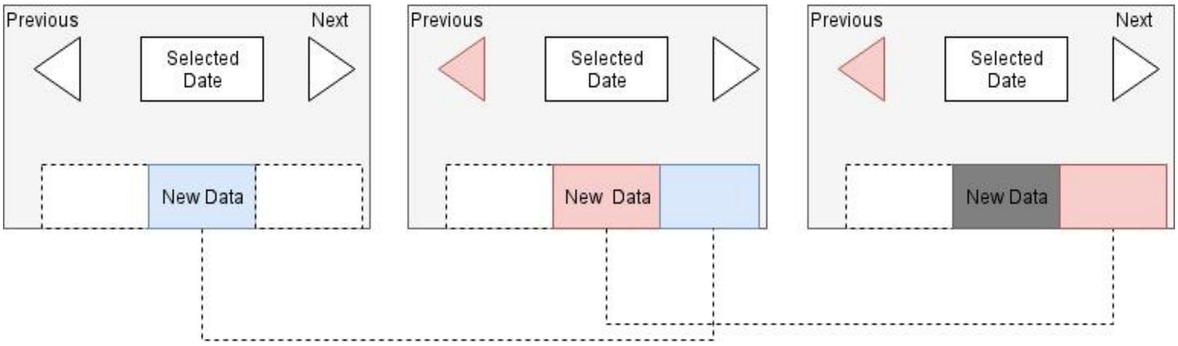


Fig. 9. Operations for Previous Button

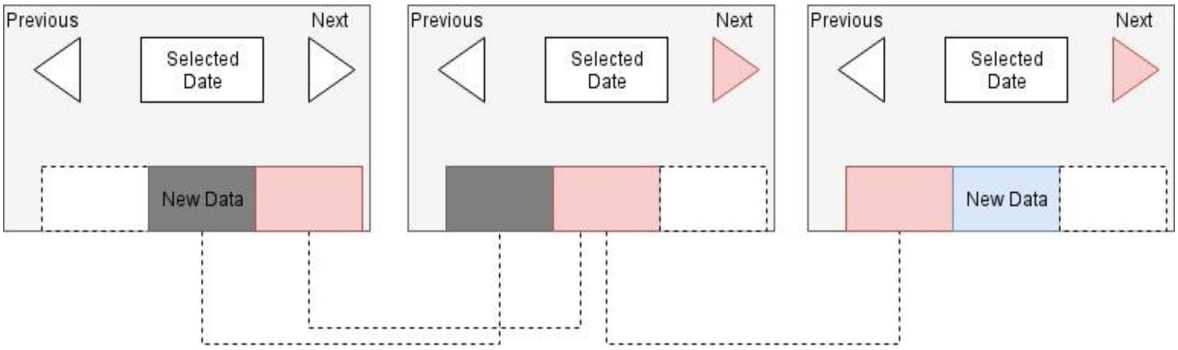


Fig. 10. Operations for Next Button (continuous action from figure 8)

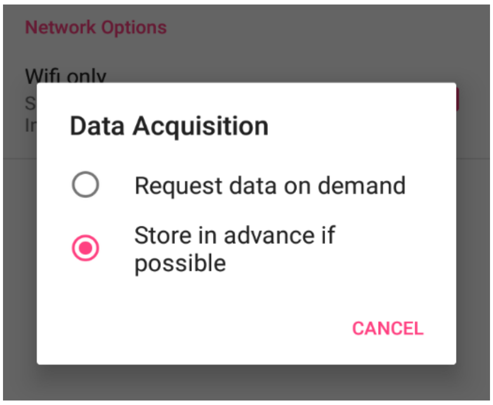


Fig. 81. Data Acquisition Settings

The Data Acquisition phase also involves pulling relevant data that affects user daily activities such as weather condition, sunrise, sunset and current temperature. These information will be very useful particularly when users want to plan out their next activities. The Internet is required to fetch these information, raising the question about whether or not the application access the Internet when users are using mobile network. Therefore, for saving cost purpose, “WiFi Only” mode is enabled by default but again users can change it if they wish (Figure 12).

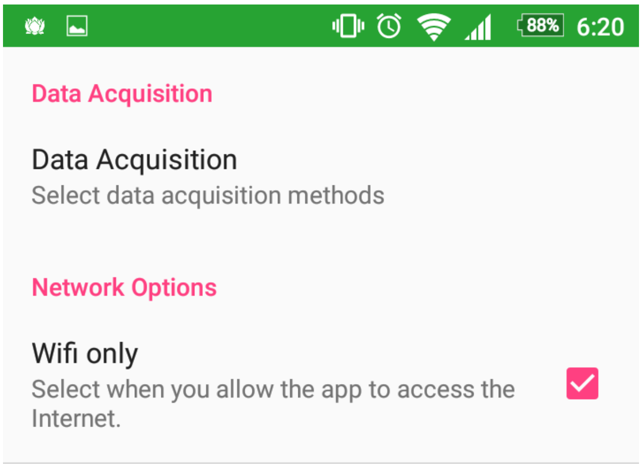


Fig. 92. Network Options

5 EVALUATION

To start with, we discuss about the preliminary results of the project. Next, the qualitative evaluation through online survey and quantitate evaluation through follow up interviews will be covered.

5.1 Results

The physical activity tracking prototype was completed. The installation file is at https://goo.gl/xuTFJq Video demo for the app can be found at https://youtu.be/AdRmF1SbkN4. The overall evaluation on objective is illustrated on Table 2.

Table 2. Overall evaluation

No.	***Objective***	***Evaluation***
1	Provide evidence based recommendation on how much activity an adult should do to stay healthy regarding user's physical activity levels.	Completed
2	Show users how much physical activity they have done during the day and how are their activity levels compared to the recommended ones (to gain health benefits)	Completed
3	Effectively visualize their daily/weekly/monthly physical activity patterns	Completed
4	Incorporate the new visualization method using animal representations	Completed
5	Encourage users to cultivate and maintain active	Completed

	lifestyles.	
6	Carefully consider and integrate sustainable design into the app	Completed

5.1.1 Tracking and Visualization

The prototype was able to track four main activities including walking, jogging, running and biking. In Home Screen (Figure 13), activity data is presented to a user by hours per day, giving the user a detail insight into their activity patterns. Besides the hourly activity logs and the activity summary, users also get an animal that shares similar activity patterns as users' avatar.

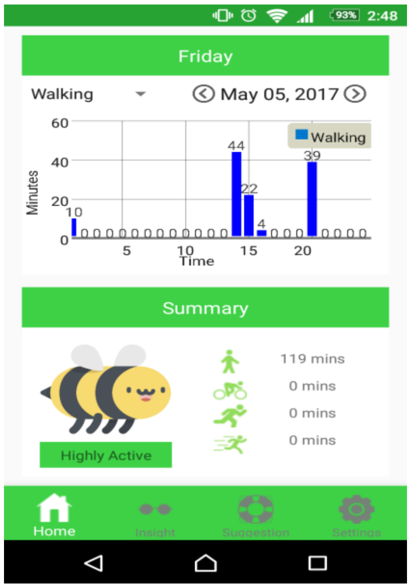


Fig. 10. Home Screen

More insights on activity patterns will be given through statistical data. Users can check their activity logs during the past 7 days (Figure 14) or

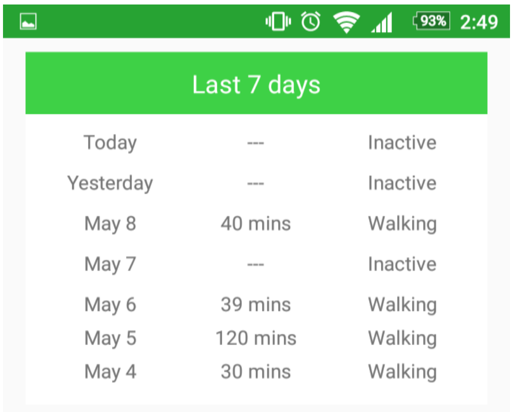


Fig. 11. Last 7 days activity log

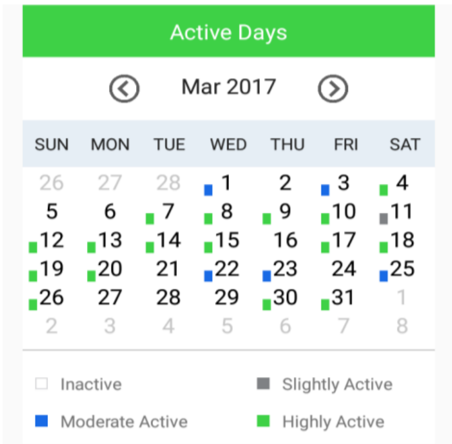
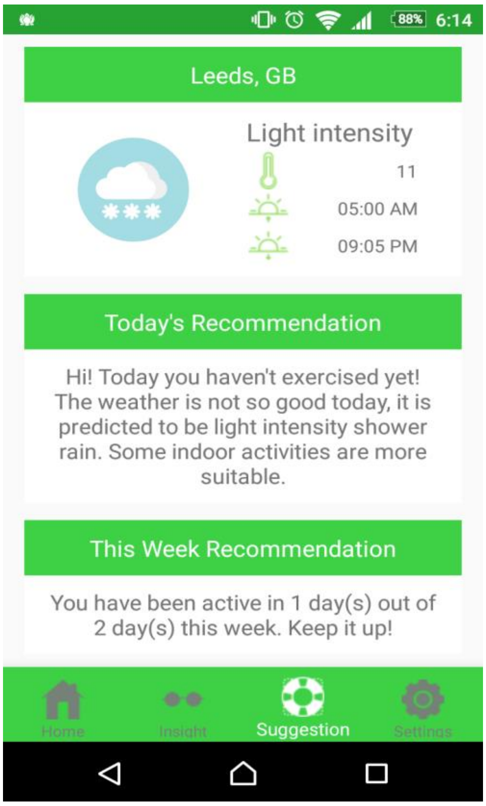


Fig. 12. Monthly activity log

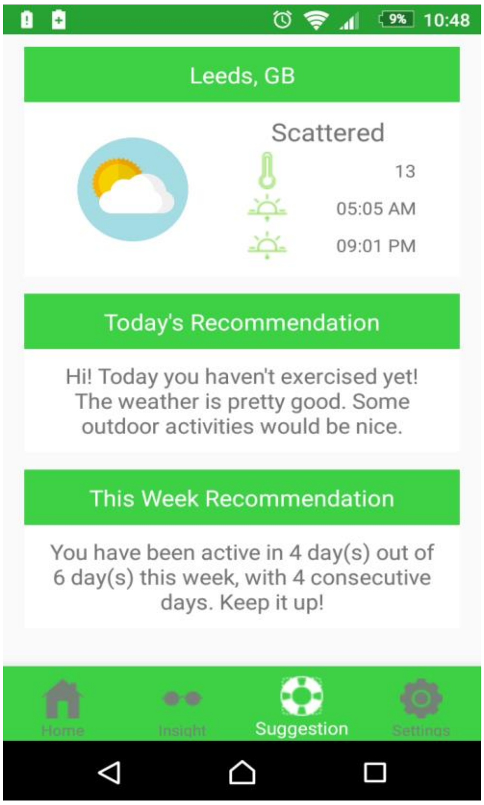
in a month (Figure 15). Based on the statistical data, they can then adjust their behaviours to suit their purposes (stay healthy, gaining rewards from the application, etc.).

5.1.2 Recommendation

As mentioned in the implementation chapter, a recommendation was conveyed based on user's current activity level and related information. The suggestion given by the app aims to encourage and support users to cultivate and maintain their healthy living lifestyles. Users can get both daily and weekly recommendations from the app (Figure 16).



(a)



(b)

Fig. 13. Recommendations with **(a)** Rain Weather and **(b)** Sunny weather

5.2 Quantitative evaluation

5.2.1 Survey Design

For quantitative evaluation, an installation file, a video demo and an online survey about the application were published on social media for a week. If people showed interest in the video, volunteers were asked to install and try using the app for at least a day to understand the functionality of the prototype before completing the survey for feedback. The survey focuses on evaluating user experience with the prototype, the accuracy of the activity recognition and power consumption. Users were also asked about their satisfaction levels, suggestions for further improvements, and if they would like to use the app when it is publicly launched. See Appendix I and II for survey questionnaire and responses.

5.2.2 Results

11 volunteers (22 to 35 years old) participated in testing the application with 4 females and 7 males. Most participants have a computer science background with 5 out of 11 people having working experience in mobile development. Testers mainly came from Asia Countries (Vietnam, Cambodia, Philippine) and European Countries (Finland, Romania, Sweden, Finland and UK). Before volunteering in testing the app, most of testers have already had interests in exercising and tracking their physical activities.

In terms of functionality and usefulness, the information delivered by the app was perceived as very useful by the majority (i.e. 73% of the respondents (Figure 17)). Participants also showed great interest in the animal representations, where some users even cited them as the most inspiring thing in the app. When users were asked about how likely they would be willing to try this software again when it is ready for public usage, 10 out of 11 respondents ranked their likelihoods from 7 to 10 (the respondents could reply between 1 and 10, where 1 is the lowest likelihood and 10 is the highest likelihood) with more than 50% of the answers falling into 9 and 10 category. Similar ratios were found when users were asked how likely they would recommend the app to their friends and loved ones.

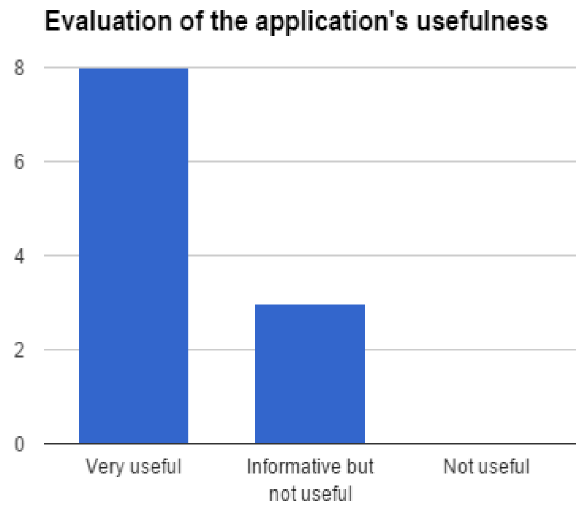


Fig. 14. Evaluation of the application's usefulness

When it comes to sustainability, the application has to balance between the accuracy of physical activity classification and the battery consumption, so volunteers were asked about their experience with these two metrics. For the accuracy of activity classification, 55% of respondents reported that they were very satisfied while the rest claimed that they were somewhat satisfied. Battery consumption also received positive feedback with 64% users stating that they barely noticed any battery drain while the remaining 36% said that the battery consumption was acceptable.

Through the survey, some interesting suggestions were proposed by the volunteer testers. One person thought the app should allow users to manually add their activity records, since some users do not wear their phone while going out for a run, for example. Users with strong mobile development background suggested improvements in user experience (e.g. notifying users with new recommendations, better exceptions handling), and some users mentioned adding information about calories.

5.3 Qualitative evaluation

A week after the online survey, volunteers were asked if they were still using the app. 7 out of 11 users gave positive responses. In order to gain more insight into the user experiences, some follow up interviews were also conducted with these 7 volunteers. Through data analysis, user's feedback from the interviews were coded into 5 main themes, including Activity detection, Functionality, The animal representations, User experience, and Learning and behaviour changing.

5.3.1 Activity detection

This theme focuses on how well the app performed in recognizing physical activities such as walking, running, jogging or cycling from users' perspective. The activity recognition engine was developed by Google using machine learning and heuristics to extract details about the activities (e.g. types, durations and time). Various factors can affect the recognition results such as: the performance of the machine algorithm, the quality of the sensing data (decided by types of sensors, sampling rate, sampling size, the phone's position while user exercises, etc.) and how different these activities are (the larger the difference, the easier the recognition). These assumption were tested and proven through the interviews.

When the sensing samples are good (users put their phone in the pocket [45]), the application can differentiate between walking, running and biking with a very high accuracy. Evidence was found in the following excerpt:

"*The activity detection works quite well. The application always correctly identify my walking and biking activities*". (Person 2)

Jogging activity on the other hand is sometimes confused with walking or running, depending on the speed (tested by the authors) since jogging activity is like the transition between walking stage and running state.

When users put their phone in other places, it directly affect the sensing samples which may lead to more incorrect recognition. For example, Person 1 said that, when he was lying in a swinging hammock with the phone on his hand, the application said that he was biking. Similarly, the excerpt for Person 5 is as follows:

"*The accuracy was quite good when I put my phone in the pant pocket or jacket pocket. However, when I put it in my bag, it [the app] sometimes says that I am biking even though I was walking*". (Person 5)

These errors are understandable because based on the accelerometer data, these activities were somewhat similar.

To raise the accuracy, we can either improve the quality of the sensing samples or optimize the activity recognition algorithm. The former can be achieved by doing data pre-processing on the sensing samples before pushing it into the activity recognition algorithm, adding wearable devices or simply allowing users to modify the result if they think it is incorrect (need careful consideration to avoid cheating). The latter could be achieved by replacing the current activity recognition algorithm with a more robust one. In both cases, researcher should take into consideration the tradeoff among accuracy, user experience and sustainability.

5.3.2 Functionality

This theme intended to examine user perceptions about the functionality provided by the application including showing insights through statistics and giving evidence-based recommendations. Users can check their activity logs per day, a summary of activities during the past 7 days and activity levels for each day per month. Recommendations are given for the current day and current week, guiding users to reach the recommended level or at least the minimal level of physical activity to start reaping health benefits.

Through the interviews, the majority of respondents agreed that the statistics and recommendations are very informative. Some users checked it in the morning to plan out their day. Person 1, for an example, said:

"*I usually check it in the morning before going to work so I can plan out what to do*". (Person 1)

Some others like checking it in the evening to review their exercising goals or getting recommendation for the next day. Person 7, for an instance, said that:

"*I usually use it [the recommendation feature] in the evening or after work to see if I have reached my target*". (Person 7)

Interestingly, although giving research-based recommendations is the main focus of the app, some users found the statistics feature is the most useful for them. Person 2 said that:

"*I like checking the statistics to see how much physical activities I have done during the day*". (Person 2)

Person 7 said:

"*I like the statistics feature because it helps me keeping track of my activity so I can adjust my activity plan to stay healthy*". (Person 7)

There are two possible explanations for it. The first reason, the visualization for the recommendation feature is unsuccessful in capturing user's attention due to the simple design in the early stage of development. This assumption matched with some feedback on UI (will be discussed in the user experience sections). The second reason relates to users' awareness of the importance of physical activity. On one hand, if users have already been made aware, they would maintain the active lifestyle on their own. Thus, concentrating on giving them information about *how much* they should do (in the prototype) becomes less useful than helping them to plan *what* and *how* to do to stay active. On the other hand, if users were unaware of the health benefits brought by physical activities, they are unlikely to change changing their behaviour [34]).

To enhance the effectiveness of the recommendation feature, more improvements should be made on UI and UX. The application also can incorporate gamified elements, a very new and promising approach, to attract more user's attention [15]. However, information giving in the recommendations should be well anchored on high quality research because these recommendations may directly affect the user's behaviour and health.

5.3.3 The animal representations

This theme focuses on user feedback on the animal representations of physical activity levels in the prototype. Depends on how active users are, an animal that shares similar activity pattern will be presented to users as their avatar for that day along, accompanied by with some general information and fun facts related to the animal. When the activity level is inactive or slightly active, users cannot change their avatar. They can only change it if their activity level is moderately active or highly active.

The prototype received many positive feedback for the animal representations. Person 5 stated that:

"*I like the animals. Fun facts and general information about them are also very interesting to me*". (Person 5)

Users also reported learning something new about the animals: "*it [the animal representations] is cool. Some fun facts come along with the animal I didn't know before*" said person 1. There are also behaviour changes driven by the animal representations. Person 5, for example, said:

"*I sometime took a small walk to be able to change the avatar, I like to keep my favorite animal*". (Person 5)

Some users suggested commercializing the idea due to its business potential.

The interviews also revealed limitations in UI/UX design when one user reported that she did not aware about general information and fun facts attach with the animal avatar before she was asked if she liked it or not: *"Oh, I didn't expect anything will appear when I touch the avatar so I didn't bother to try"* she said. The next release of the prototype should fix this limitation by making the visualization explaining itself or creating a small introduction on how to use the app.

5.3.4 User experience

This evaluation concentrates on user experience of the UI, reliability and battery consumption with the prototype. A majority of the responses confirmed the assumption that battery usage will be kept at a very low level thanks to Android Fitness APIs (more details were discussed in the implementation chapter). Person 1 said *"I barely notice any battery drain"* when he was asked about the power usage. In terms of the reliability, the majority reported random crashes while using the app. Although these crashes did not happen frequently and worked well after users restarted, it could cause unpleasant experience. Exceptions may come from permission requests, incompatible devices, APIs, unhandled rare cases or unexpected usage patterns due to the early stage of development. After a few iterations in the development lifecycle, the reliability will be improved. Similarly in UI/UX evaluation, users expressed a certain level of satisfaction but also suggested many improvements such as *"improving UI/UX design"*, *"sending notification messages"*, and *"adding audio effect"*.

5.3.5 Learning and behaviour changing

The animal representations are used in the app to bring fun and raise awareness about the animals living in our surrounding environment. Although the number of animals used in the prototype were very limited and the design was still very simple, users showed strong interest in the ideas and some even reported learning something new about these animals. Person 1 said:

"*It [information about the animal including general information and fun facts] is cool, I like it. Some facts I didn't know before. If the app has more animals, it would be very nice because I can learn more about them [the animals]*". (Person 1)

Respondents also illustrated behaviour changing which was not expecting in this stage of development. According to the interviews, reasons for behaviour changing came from the animal representations of physical activity levels and the statistic information. Although the app has not incorporated any reward elements, users picked up some features of the application as ones. Person 3, for example, said that:

"*I usually check my activity logs, if I have not reached the highly active level, I may go out for a small walk. I like to keep all of the days in green color [in the monthly summary]. I have not missed a day since I installed this app*". (Person 3)

The prototype also stimulated curiosity and brought fun to users. Person 1 said:

"*It [the animal representations] affects my decision sometimes. For examples, when I want to go to the store, if I have not been so active that day, I may choose to walk to the further store instead of the nearby one. Besides, I also want new animals and see what fun facts they have*". (Person 1).

Although more research is needed to validate the real impact of gamified elements, positive feedback from users present a large potential for incorporating gamification and behaviour changing techniques into cultivating and maintaining healthy lifestyles for users.

5.4 Sustainability evaluation

Throughout the development process, several technical choices were made in order to make the app more sustainable for the long run. First, Android Fitness APIs was chosen to increase the data reusability, reduce data redundancy while maintaining the high performance (accuracy and data processing speed). Secondly, the buffering mechanism was implemented in order to reduce the numbers of unnecessary requests and responses generated by common usage patterns from users. Finally, the app also supported WiFi Only mode which helps minimizing unnecessary costs.

Through user's feedback, the prototype sustainable designs were highly appreciated by testers. The majority of the participants agreed that the battery and data storage demand of the app are acceptable and the accuracy are very high.

The successful of the prototype will help individuals and society to cultivate and maintain healthy lifestyles, thus, prevent diseases and enhance the quality of life. Preventing diseases by leaning toward healthy lifestyles also means less demand on healthcare resources (e.g. less hospital visits, less hospital beds, less ambulance rides) and human resources spending on taking care of sick people and human resources on operating the demand healthcare services. As ageing population are rapidly happened across the globe, this approach will helps healthcare become more sustainable from a personnel perspective. Details analysis on the economical, technical, individual, environmental and social impacts of the prototype are illustrated in Figure 18.

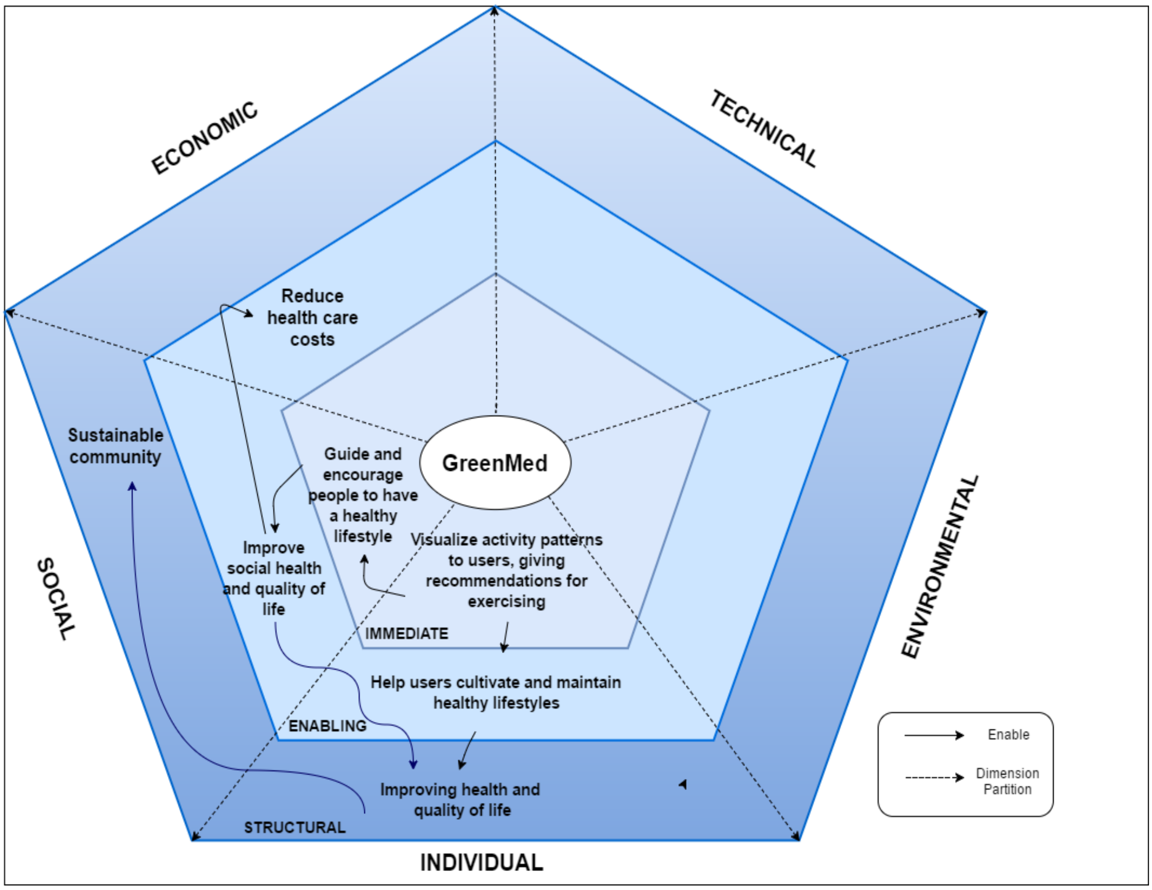


Fig. 15. Sustainability Analysis

5.5 Discussion

Compared to available health and fitness applications, our proposed prototype application addresses the shortcomings on providing evidence-based recommendations and introduces animal representations for physical activity levels to entice or inspire users. Appropriate usages of the app helps cultivate and maintain healthy lifestyle, while abusive usages may result in wasting a large amount of time without harvesting corresponding positive results.

Animal representations bring a large potential in improving visualization and encouraging further integration of gamification and behavior change techniques in physical activity tracking apps. Indeed, physical activity patterns in humans share many common characteristics with those of animals, therefore, using animal representations is a creative way to effectively show users their activity patterns. When it comes to integrating gamified elements in to the app, there are several ways to develop this idea further. One such way is to include reward systems. An example reward system can reward users for being active during the week by giving them the type of animal that matches their behaviour patterns. With this animal in their collection, they could share it on social media or even trade it with their friends if they already possessed it. Another way to further gamify the app is to develop mini games that utilize animal characters that the users gets every day.

Although the prototype addressed the lack of evidence-based recommendations in available apps, it still has some limitations. Firstly, this study had few participants, more users with various backgrounds and ages are needed to improve the generalization. Secondly, giving users information about the minimum amount of exercise they should do to gain health benefits is very useful but it is not enough for cultivating and maintaining healthy living style. Further incorporation of other aspects such as gamification or behaviour changing techniques may help in this regard. Finally, the app uses Google Fit APIs, despite many advantages brought by this approach, using APIs means having platform dependencies and very little control over the accuracy of activity detection, if at all.

6 CONCLUSION

In this project, we present a prototype application that gives evidence-based recommendations based on the user's current activity level and effectively visualize it to users. Insights are conveyed in the form of statistical data (hourly, daily, last 7 days and monthly), helping users to gain a comprehensive view of their activity patterns. The early testing obtained very positive results with a majority of volunteer users (73%) finding the prototype very useful while the remaining 27% agreed that they are very informative.

A new approach to visualization is also proposed and integrated into the prototype, using animal representations for illustrating activity levels. Through testing, the animal representations were highly appreciated by volunteer testers. Some users even reported that the prototype (with limited gamified elements) has influenced their decisions, motiving them to be more active.

In this prototype, dissatisfaction if exists, mainly came from UI/UX design and random crashes. These shortcomings will be the main focus of further improvements before publishing the app into Google Play Store for a larger scale test. Additionally, we can also incorporate more gamified elements and behaviour changing techniques to help users cultivate and maintain their healthy lifestyles.

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APPENDIX 1. Survey Questionnaires

1. How satisfied are you with the statistical function of this software?
   - ☐ Extremely satisfied
   - ☐ Very satisfied
   - ☐ Somewhat satisfied
   - ☐ Not satisfied at all

   If there is anything you are dissatisfied with, what is it?

   ----

2. How do you find the insight provided by this software?
   - ☐ Very useful
   - ☐ Informative but not useful
   - ☐ Not useful at all, totally unrelated

   If the provided information is not useful, why?

   ----

3. How satisfied are you with the reliability of this software?
   - ☐ Extremely satisfied
   - ☐ Very satisfied
   - ☐ Somewhat satisfied
   - ☐ Not satisfied at all

   Why are you dissatisfied with the reliability?

   ----

4. How satisfied are you with the accuracy of information provided by this software?
   - ☐ Extremely satisfied
   - ☐ Very satisfied
   - ☐ Somewhat satisfied
   - ☐ Not satisfied at all

   Why are you dissatisfied with the accuracy of the provided information?

   ----

5. How do you feel about the battery consumption of this software?
   - ☐ The battery drains very fast, unacceptable
   - ☐ The battery consumption is acceptable
   - ☐ I barely notice any battery drain

6. What is your overall satisfaction level with the software? (Note: 1 - lowest satisfaction level, 10 - highest satisfaction level)

1	2	3	4	5	6	7	8	9	10

7. How likely would you recommend this software to your friends and loved ones? (note: 1 - lowest likelihood, 10 - highest likelihood)

1	2	3	4	5	6	7	8	9	10

8. Do you have any suggestion for improving the software?

APPENDIX 2. Survey results

Timestamp	How satisfied are you with the visualization of this software?	If there is anything you are dissatisfied with, what is it?	How do you find the insight provided by this software?	If the provided information is not useful, why and is there any way to improve it?	How satisfied are you with the reliability of this software?	If you are dissatisfied with the reliability, why and is there any way to improve it?	How satisfied are you with the accuracy of information provided by this software?	If you are dissatisfied with the accuracy of the provided information, which part does it need improvement?	How do you feel about the battery consumption of this software?	What is your overall satisfaction level with the software?	The application is still in developing stage, how likely would you like to try this software again when it becomes more reliable?	How likely would you recommend this software to your friends and loved ones?	Do you have any suggestion for improving the software?
5/14/2017 16:53:07	Very satisfied		Very useful		Very satisfied		Very satisfied		I barely notice any battery drain	10	10	10	
5/15/2017 16:37:10	Very satisfied		Very useful		Very satisfied		Very satisfied		I barely notice any battery drain	10	10	10	
5/16/2017 2:35:15	Somewhat satisfied	The app sometimes can't load google API	Very useful		Very satisfied		Very satisfied		The battery consumption is acceptable	8	9	8	Make cute sound when clicking on adorable avatar
5/16/2017 13:07:53	Somewhat satisfied	UI	Very useful		Somewhat satisfied		Somewhat satisfied		The battery consumption is acceptable	7	8	8	UI/UX and notify when loading data
5/17/2017 8:31:30	Somewhat satisfied	the quality of icons (not smooth), the statistic isn't shown when switching between tabs	Very useful		Very satisfied		Very satisfied		I barely notice any battery drain	8	10	10	You should use svg for the icons. It's kind of vector image which we can zoom out or zoom in without break the quality :)

5/17/2017 9:03:10	Somewhat satisfied	icons resolution change from jpg to gif	Very useful		Somewhat satisfied	it crashes randomly	Very satisfied		I barely notice any battery drain	6	8	7	improve stability and resolution in icos
5/17/2017 17:13:03	Somewhat satisfied	interface looks basic	Informative but not useful		Somewhat satisfied		Somewhat satisfied		I barely notice any battery drain	7	7	7	Interface is ok but can be better. information like calories burnt could be very useful
5/18/2017 14:23:52	Somewhat satisfied		Very useful		Somewhat satisfied	Crashed a few times when trying to open it, and identified my walk as biking...	Somewhat satisfied		The battery consumption is acceptable	8	9	9	
5/18/2017 19:31:59	Somewhat satisfied		Informative but not useful		Somewhat satisfied		Somewhat satisfied		The battery consumption is acceptable	7	4	5	Gamification aspects between friends could boost usage
5/18/2017 20:27:02	Somewhat satisfied		Very useful		Somewhat satisfied	Randomly crash	Very satisfied		I barely notice any battery drain	8	9	9	Integrating mini games
5/20/2017 9:15:51	Somewhat satisfied	The UX/UI are not friendly and attractive.	Informative but not useful		Somewhat satisfied		Somewhat satisfied		I barely notice any battery drain	7	8	7	Need to improve UI/UX, also handle all uncaused exceptions.