Title	Nutrito : a smartphone application provides users suggested exercise amount through the image recognition of nutrition facts labels
Sub Title	
Author	Huang, ShengWen(Sugiura, Kazunori) 杉浦, 一徳
Publisher	慶應義塾大学大学院メディアデザイン研究科
Publication year	2020
Jtitle	
JaLC DOI	
Abstract	
Notes	修士学位論文. 2020年度メディアデザイン学 第824号
Genre	Thesis or Dissertation
URL	https://koara.lib.keio.ac.jp/xoonips/modules/xoonips/detail.php?koara_id=KO40001001-00002020-0824

Master's Thesis
Academic Year 2020

Nutrito: A Smartphone Application Provides Users Suggested Exercise Amount through the Image Recognition of Nutrition Facts Labels

Keio University
Graduate School of Media Design

ShengWen Huang

A Master's Thesis
submitted to Keio University Graduate School of Media Design
in partial fulfillment of the requirements for the degree of
Master of Media Design

ShengWen Huang

Master's Thesis Advisory Committee:

Professor Kazunori Sugiura	(Main Research Supervisor)
Senior Assistant Professor Chihiro Sato	(Co-Advisor)

Master's Thesis Review Committee:

Professor Kazunori Sugiura	(Chair)
Senior Assistant Professor Chihiro Sato	(Co-Reviewer)
Senior Assistant Professor Junichi Yamaoka	(Co-Reviewer)

Abstract of Master's Thesis of Academic Year 2020

Nutrito: A Smartphone Application Provides Users Suggested Exercise Amount through the Image Recognition of Nutrition Facts Labels

Category: Design

Summary

When humans reach their age 30s, the daily metabolism slowly decreases until the end of our life. With the metabolism slowing down, it becomes more easier for humans to gain body weight. Some of the existing researches points out that gaining weight can be a cause of mental illness, but when people are in their 30s, their workload or the responsibility to their families may lead to less exercise time and pressure sometimes can drive people to eat more food.

On the other hand, image Recognition technology now becomes more powerful and supports people's life in different aspects. In the area of nutrition smartphone apps, the IR has been applied for scanning the barcode to add the food's nutritional facts into the app. Currently, none of the app provides exercise suggestions in terms of calories toward the scanned foods.

In this research, Nutrito, a prototype of nutrition app which provides suggestions to amount of exercise to users through IR feature will be introduced. Many of the existing nutrition apps and research paper of design an nutrition app will be detailed. After explained the design concepts of Nutrito, several user tests will be conducted to measure the effectiveness and accessibility of this design.

Keywords:

Smartphone application, Design, Nutrition, Metabolism, Image recognition, Education

Keio University Graduate School of Media Design

ShengWen Huang

Contents

Acknowledgements **viii**

1 Introduction **1**
1.1. Background 1
1.1.1 Obesity 2
1.1.2 Metabolism 3
1.1.3 Mechanism of gaining weight 4
1.1.4 Calorie Restraint 6
1.2. Hypothesis 6
1.3. Purpose of research and Contribution 8
1.4. Thesis Structure 9

2 Related Works **11**
2.1. Nutrition applications in the market 11
2.1.1 Nutrients - Nutrition Facts 11
2.1.2 MyFitnessPal 12
2.1.3 MyPlate Calorie Counter 12
2.2. Image Recognition 13
2.2.1 Principle 13
2.2.2 Application: Calorie Mama 14
2.2.3 Application: MyFitnessPal 14
2.3. A relevant research paper of designing an educational nutritional app 16

3 Design Concept **19**
3.1. Background 19
3.2. Design Environment 20
3.2.1 Learning from tutorial videos 21

3.3. Interface Design of Main Page 23
3.4. User Portrait 26
3.5. Scanned food objects 27
3.6. SAE database settings 30
3.6.1 Average weights in height intervals by age and gender . . . 30
3.6.2 Calories burned by exercises in terms of weight 34
3.7. Image recognition model training 37
3.8. SAE Result Page in completed prototype 39
3.9. The novel points of the prototype compared with the other nutrition apps 40

4 Evaluation **41**
4.1. Background 41
4.2. First user test 41
4.2.1 Evaluation 42
4.2.2 Lessons after Nutrito preliminary prototype test 43
4.3. Second user test 45
4.3.1 Objective 45
4.3.2 Test environment 45
4.3.3 Questionnaire design 46
4.3.4 Analysis before experiment 49
4.3.5 Experiment procedures 53
4.3.6 Final test result and discussions 56
4.4. User survey and interview feedback 58

5 Conclusion **60**
5.1. Validation of concept 60
5.2. Limitations 61
5.3. Future work 62

References **63**

Appendices **68**
A. MIT App Inventor resources 68
A.1 MIT App Inventor 2 68

A.2 Personal Image Classifier 68
A.3 Personal Image Classifier tutorial videos 68
B. First User test questionnaire 69
C. Preliminary questionnaire 72
D. General questionnaire 72
E. Post-test questionnaire 77
F. User survey 80
G. Preliminary questionnaire Results 82
H. General questionnaire Results 83
I. Post-test questionnaire & User survey Results 84

List of Figures

1.1 An example of existed nutrition application 3
1.2 Chart of metabolic rate by ages 5
1.3 Smartphone penetration at Japan among population by age group, 2017 7

2.1 Nutrients - Nutrition Facts 12
2.2 MyFitnessPal 13
2.3 Calorie Mama 15
2.4 Scanner mode of MyFitnessPal 15
2.5 Pre-test and post-test questionnaire of M. Juan, J. Charco, I. Garcia and R. Molla's research 17
2.6 Phases of M. Juan, J. Charco, I. Garcia and R. Molla's research 18

3.1 MIT App Inventor 2 20
3.2 User interface of Scratch 21
3.3 Happy face example from the tutorial video and the IR result . . 22
3.4 Angry face example from the tutorial video 22
3.5 Main page of Nutrito 23
3.6 Blocks of Main page 24
3.7 Nutrito is a possible solution for people who care their shape . . 26
3.8 A same size Essence of Chicken used in prototype test 27
3.9 A same size Digestive Biscuit Oat flavor used in prototype test . 28
3.10 A same size Original flavor chips used in prototype test 29
3.11 Average Weight for Men by Age 32
3.12 Average Weight for Women by Age 33
3.13 An example of Calories burned exercising calculator result 35
3.14 Add training data 37

3.15 Ran the model 38
3.16 Results 38
3.17 SAE Results 39

4.1 Data of average weights in age and gender, MHLW 43
4.2 Preliminary version of Nutrito 44
4.3 Preliminary questionnaire results 50
4.4 Testee M in her step 2 examined the nutrition labels 53
4.5 Testee A in her step 3 shown the IR detection result 54
4.6 Testee F in his step 4 was using the IR scanner to scan Digestive biscuit 55
4.7 Testee B in his step 5 was finishing his post-test questionnaire . 55

C.1 Questions of preliminary questionnaire in Section 4.3.4 72

D.1 Questions of General questionnaire in Section 4.3.4, Part A . . . 73
D.2 Questions of General questionnaire in Section 4.3.4, Part B . . . 74
D.3 Questions of General questionnaire in Section 4.3.4, Part C . . . 75
D.4 Questions of General questionnaire in Section 4.3.4, Part D . . . 76

E.1 Questions of Post-test questionnaire in Section 4.3.6, Part A . . 77
E.2 Questions of Post-test questionnaire in Section 4.3.6, Part B . . . 78
E.3 Questions of Post-test questionnaire in Section 4.3.6, Part C . . . 79

F.1 Questions of User survey in Section 4.4, Part A 80
F.2 Questions of Post-test questionnaire in Section 4.4, Part B 81

List of Tables

3.1 Average weights in each height interval by gender 31
3.2 Average exercise time for burning 3 test foods in minutes, in the order of ESC, Digestive biscuit and Original chips, by height and gender 36

4.1 Testees' data in first user test 42
4.2 Testees' data in second user test 49
4.3 Responses of General questionnaire 51
4.4 Responses of amount of exercise estimation, Q10 - 12 51
4.5 Average rates from Q13 to Q15, in both groups without Nutrito test 52
4.6 Group A Responses of amount of exercise estimation, Q10 - 12 . 56
4.7 Group A and Group B's contrast of intention to buy or eat scanned foods (Nutrito V.S. Nutrition facts label) 57
4.8 Group A's rate of "After I receive the SAE of the scanned food from Nutrito, I will stop to purchase or eat it." before and after test 57
4.9 Responses of feedback survey 58

B.1 Responses in 1st user test questionnaire 71

G.1 Preliminary questionnaire Results 82

H.1 General questionnaire Results 83
H.2 Amount of exercise estimation Results (Walk min, Run min) . . 84

I.1 Post-test questionnaire Results 85
I.2 User Survey Results 86

Acknowledgements

As a management student in my undergrad, I entered KMD for a desire to learn design methodology of something new and special. The two and half years spent in KMD expanded my knowledge of designing thinking and taught me the spirit of Disruptive innovation. I would like to give my best appreciation to my parents and all my family members, who strongly gave me best mental supports before, during and after my research.

I would like to thank to my supervisor Professor Kazunori Sugiura, who gave me creditable advises for my researches even under the issue of distance. He guided me the attitude for how to appropriately think, design and conduct an objective academic research, which would continually bring positive influences throughout my future career and my life. I would also thank to my sub-supervisor Chihiro Sato, who put her kind concern to the schedule of my research and motivated me to finish the research and this thesis on time.

Finally, I would like to thank to all 13 testees who spent their precious time to help me for the user tests; My kind CREATO! members, especailly Mr. Xu Cong, who tirelessly provided many good advice to me before and during this research.

Chapter 1
Introduction

1.1. Background

To most of humans, their body shapes are not unchangeable through their life. Start from a certain moment of our age, we can find that our bodyweights start to increase without a clear reason. Gaining bodyweights may be a very depressing thing toward life: Pressure and discrimination toward obese people can cause numerous consequences for their physical and mental health. Rebecca M. Puhl and Chelsea A. Heuer pointed out the concept of disease stigma, which means groups of people are blamed for illness because they are viewed as unnormal or lazy. Obesity stigma, among these disease stigmas, is that overweight and obese individuals suffered from stereotypes from public that obesity relates to overeating and lack of self-control. [1]

To stop the trend of gaining weights, we may start to examine every food and beverage we take, checking their nutrition facts label if possible, calculating the relationship between calories and body weight. Eventually, we realize that calorie is one the main reasons to increase our weight, but there has no clear hints of how can we do to burn out these foods' calories from their nutrition facts labels. Today, we already have several smartphone applications that use Image Recognition (IR) mechanism to capture food images and distinguish the food ingredients, providing nutrition information such as carbohydrates, fats and sugars, then calculate the whole calories of that meal. A figure of existing model in the market, retrieved from Azumio Inc, shown as Figure 1.1. [2] However, even the users realize the calories of the foods, they cannot get further information or directions of what do those calories mean to their body, or related to what they should do get rid of obesity.

The Community Research and Development Information Service (CORDIS) of

European Commission believes that the current nutrition facts labels don't not provide enough motivation for people to choosing food based on their level of healthfulness. With the average attention to nutrition labels was between only 25 and 100 milliseconds by customers, it is not enough time for consumers to process the information. [3]

As the possible solution, the prototype smartphone application (app) created in this research called Nutrito, which provides users information of suggested amount of exercise through the image recognition of nutrition facts labels. By scanning the nutrition facts label from the packaged foods, Nutrito analyzes the relations based on food calories and user's profile (Age, height and gender). After examining through the created database,it will provide information of how much exercise the user suggested do to burn out the calories of one unit of the scanned food. Though the expectation for the completed version of Nutrito would be an app that can analyze through all kinds of nutrition facts, the prototype is limited to the calories by technical lackness. The following subsections will give medical explanations of why the analysis of food calories intake could be beneficial to the users.

1.1.1 Obesity

When talk about the importance of calories or consider the necessity of nutrition-related apps (Figure 1.1), the theory of obesity should be explained. According to Harvard school of public health, Dr. A. Hruby and Dr. F. Hu defined the obesity is a multifactorial, largely preventable and complex disease, which affecting, along with overweight, over the third of population today. If the worldly trend continues, it is estimated that 20% of the world's adult population will become obese and another 38% of the population will be overweight. [4]

Obesity often lead to discrimination, as the society attributes the cause of obesity to those obese people in the perception of lack of personal control or laziness. [1] Based on an experimental research, if providing individuals information that underlines the personal responsibility of obesity (such as they should control themselves to eat less or exercise more without laziness), will increase their negative stereotypes toward obese person. [5] In Asian culture, the desire to lose body weight or to have a skinny body has became a norm. The body dissatisfaction of

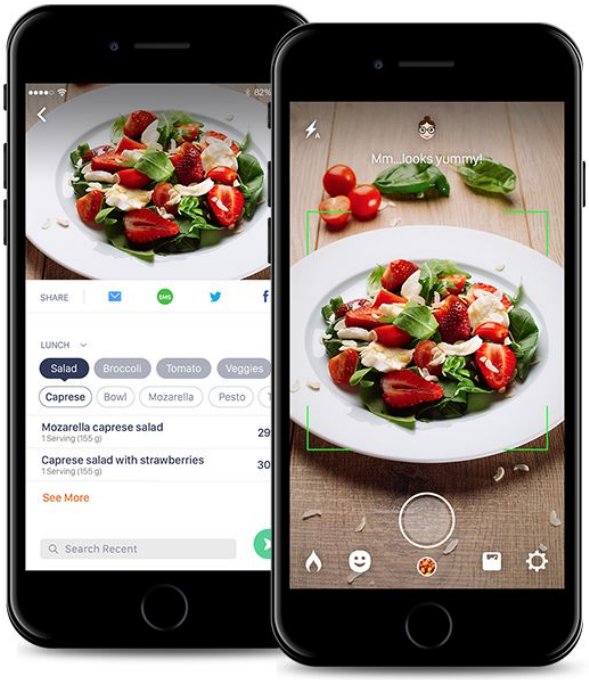

Figure 1.1 An example of existed nutrition application

Asian women group is more serious than other countries. A study across 22 countries pointed out that the Asian women (from Japan, Korea and Thailand) tend to consider the body thinness as a more important value than other ethnicities. [6]

Obesity usually is defined as the excess body weight of height, but this definition is too simple to belie an etiologically complex phenotype, primarily associated with excess adiposity, that can manifest metabolically but not just in terms of the growing size of the body. [4]

1.1.2 Metabolism

By Harvard medical school's definition, metabolism is the series of chemical reactions in a living organism, which creates and breaks down energy necessary for life. It's the rate at which humans' body expends energy or burns calories. [7] The better a person's metabolism is, the more food he or she can intake without gaining weight, as most of the calories will be burn into the energy of living without

being stored as fat cells.

Other than hormone, age, height and muscle mass, the speed of metabolism is related to four key factors: [8]

- **Exercise**: The amount of exercise that burns food calories. A regular exercise habit could induce loss of fat mass by increasing fat oxidation. [9]
- **Thermic effect of food (TEF)**: The amount of calories humans burn through food digestion and absorption, which is usually 10% of humans' daily calories burned.
- **Resting metabolic rate (RMR)**: The amount of calories humans burn while resting or sleeping. It is the minimum amount of metabolism to keep a human alive and functioning.
- **Non-exercise activity thermogenesis (NEAT)**: The amount of calories humans' burn through non-exercise activities, such as standing, laying or sitting.

Unfortunately, studies show that human's metabolism starts to drop at the average age of 25. It is a linearly decrease, within a average speed of 2% or more per ten years. The drop of metabolism results in an inevitable change to human's weight. [10] In another term, an inevitable increase of body weight, since the same amount of food calories we take at our 20s no longer can be burn out fully by or body mechanism, as the chart of metabolic rate by ages retrieved from online medical forum FitnessHealth101. (Figure 1.2) [11]

1.1.3 Mechanism of gaining weight

Human body is full of mysteries, and the mechanism of gaining or losing body weight is complicated. The rise of body weight cannot fulling be blamed to the heredity issues or the slower metabolism, but sometimes just related to mental pressure, endocrine disorders caused by insomnia, a period of time for overeating, or a less amount of exercise due to cold weather or a lockdown for Covid-19. A note from Harvard Medical School (2015) explained how body gains weight:

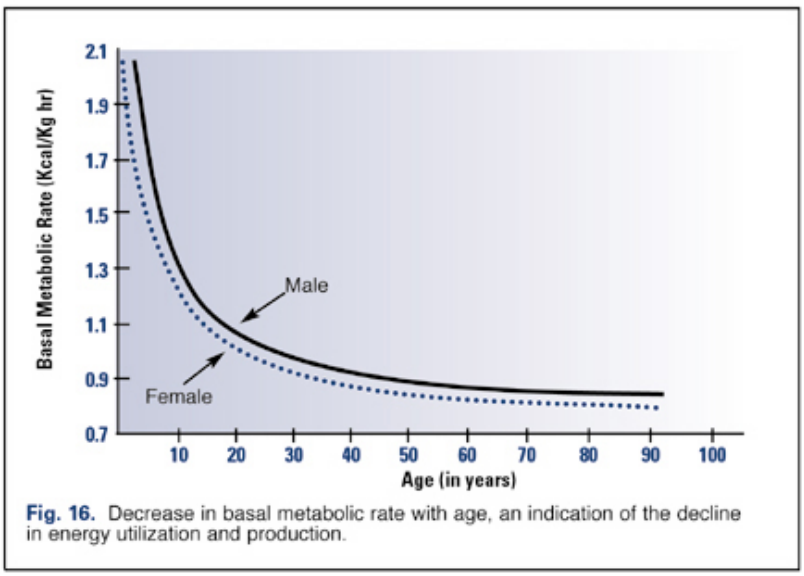

Figure 1.2 Chart of metabolic rate by ages

> Regardless of whether your metabolism is fast or slow, our bodies are designed to store excess energy in fat cells. So if you eat and drink more calories (energy "intake") than your body expends (energy "output") you will gain weight. On the other hand, if you eat and drink fewer calories than are burned through everyday activities (including exercise, rest and sleep), you'll lose weight. Our bodies are also programmed to sense a lack of food as starvation. In response, our BMR slows down, which means fewer calories burned over time. That's one reason why losing weight is often difficult. [7]

When it comes to the relations between weight and calories, a frequently used measurement in the textbook is that a pound (454g) of gaining weight, or fat tissue, comes from the 3500 kcals of calories intake. It seems like not that easy to eat extra 3500 kcals of food a day, but when it turns to monthly, an extra pack of Original flavor Lays chips (552 kcals, 97g) per day can bring 2 kg extra weight a month. Of course, it only happens when a person exceeds his or her energy output everyday, and generally speaking, it is not a easy thing for a person orderly records his or her energy intake and energy output every single day. Most

of the people doesn't realize their daily maximum energy needed, too. Yet, to decrease the unnecessarily food intake other than three meals can prevent people from gaining extra weights. Based on Harvard's claim, we start to gain weight only when the calories intake exceeds our daily needs, so the less we eat out of normal meals, the possible our calories intake will not surpass our metabolism speed, which can lead to a good shape of body even aging.

1.1.4 Calorie Restraint

Although there has many debates toward the pros and cons of controlling diet, a 2019 new research published [12] in "The Lancet", one of the oldest (since 1823) and best-known general medical journals in the world, found that after 2 years of 25% calorie restrictions diets, 218 participants shown good outcomes such as lower blood pressure, significant improvements for their metabolic syndrome score, and weight reduction of 7.5 kg (versus the 0.1 kg increase for the control team) of which 71% resulted from fat tissue loss. The authors described the result [12] as:

> "...the findings suggested potential for a substantial advantage for cardiovascular health of practicing moderate calorie restriction in young and middle-aged healthy individuals, and they offer promise for pronounced long-term population health benefits."

1.2. Hypothesis

The Hypothesis of the research will defined as such:

If the suggested amount of exercise exceeds users' estimation, they will consider to stop buying or eating the scanned food object. In this research, the term "users" will be limited to people who ages between 30 to 39, based on the claim of Dr. Holly Lofton, director of medical weight management at NYU, that the 30 decade means the first decade that human no longer increased bone production, thus we don't increase muscle mass production, resulted to overall metabolism goes down. [10] The drop of metabolism means to gain weight year after year, even the active adults feel that their habits of eating or lifestyle haven't changed that much. [10] Medical anthropologist E. Brodwin also

claimed that " Our metabolism does begin to grind a bit slower every year from age 30 onward." [13] Thus, in terms of the first age decade of metabolism drops, people between 30 to 39 years old may start to aware their food intake and weight increases, making their feedback more creditable to collect for Nutrito. In another concept, the statistic figure retrieved from Statista [14] shown the 30 decade has a relatively higher smartphone penetration by age, which means they are more likely to be the users of smartphone applications like Nutrito, comparing to elder decades. (Figure 1.3) [14]

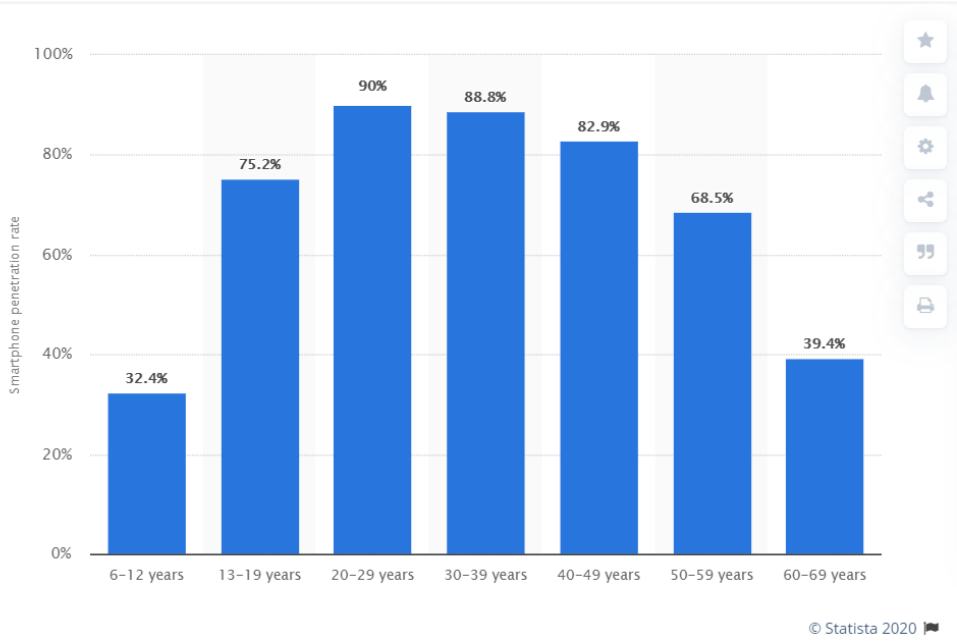

Figure 1.3 Smartphone penetration at Japan among population by age group, 2017

In addition, the "suggested amount of exercise" is the amount of exercise suggestion calculated by Nutrito to burn the calorie of scanned objects when their calories intake exceeds their daily metabolism, based on individual variations. The types of "exercise" used here will be defined as Walking and Running, based on M.Forgione [15] and an index collected from over 1 million users of fitness tracker

maker Fitbit [1], the primary form of fitness around globe is walking, then the second most-popular exercise is running.

Last but not least, the objects used in the research are defined as packaged foods with nutrition facts labels. According to the U.S Food and Drug Administration (FDA), food labeling is required toward most of the prepared food, such as frozen foods, breads, snacks and drinks. The raw produce food which are fish, fruits and vegetables are voluntary. [16] Due to the image recognition used in this research can only detect nutrition labels, this research only focus on testing objects with labels on.

1.3. Purpose of research and Contribution

This research aims to design a new kind of nutrition smartphone application, which can provide users a speedy and clear information of how much exercise they should do, based on their age and gender, to burn the calories toward the foods they scanned.

By definition, only when the intake calories exceeds human's needs, then the weight starts to gain. However, the mechanism of human body gaining and losing weight is much more complicated. Currently, the world hasn't came out clear academic claim to prove that eat less can definitely lead to lose weight. Thus, the goal of Nutrito is not to let users lose their weight. **The primary goal of this research is to provide information to users, making them understand the relatively meaning of calories of scanned objects to the amount of exercise based on individual variation.**

The expected contributions for Nutrito would be to motivate users think twice before they choose to eat the scanned objects, or prevent them from consuming unnecessarily calories (The extra foods intake other than three meals) with those especially reflected to high suggested amount of exercise. In addition, Nutrito also aims to bring changes into humans' life style. In the future, Nutrito could have different influences to people in different age intervals. For people under

1 Determined using aggregated and anonymized data from more than 1 million Fitbit users between January 2010-July 2016. `https://www.fitbit.com/global/us/activity-index`

30, humans are still in better metabolism and less worries for obesity, Nutrito might be focused by the athletics or workout populations to have reference for how extra foods they eat may impact to their training, because those people tend to eat more than their daily metabolism amount to gain muscle. For people around 30 to 39, which is the target group of this research, who start to aware of the change of their metabolism, Nutrito becomes a early warning for them to check out the relationships between their extra food intakes and exercise amount. Though it may not be concerned by many people to build a habit of checking each packaged food they eat, Nutrito would benefit to the small group of users, and their change in body shape or health status could encourage their relatives and friends, becoming more users to join this app. Last but not least, for the people over 40, which might be less possible to do intense exercise for the aging and stiffer of their joints, Nutrito would provide different suggestions than the exercise amount. For example, the % change rate of user's body cholesterol based on the calories / fat of the scanned food, or how the food's sodium lead to the increase dangerous of dialysis. Eventually, more and more users who used Nutrito could be possible to have a light and healthier diet lifestyle than non-users.

1.4. Thesis Structure

- **Chapter 1: Introduction**

  This chapter mainly introduces the research background, hypothesis with the terms definitions, contributions and the structure of the whole thesis.

- **Chapter 2: Related Works**

  This chapter will analyze the existing nutrition applications. Some of them may use image recognition features. A paper of designing the image recognition related augmented reality nutrition application model with its experiment will also been discussed.

- **Chapter 3: Design Concept**

  This chapter will introduce the design methodologies of the prototype application "Nutrito". The logic of experiment variables settings and the features

of Android application development system: MIT App Inventor 2 will be explained.

- **Chapter 4: Evaluation**

  This chapter will explain the experiment scenarios, the 1st user test discussion, preliminary, general and post questionnaire design, records of testees (Group A: Experimental team and group B: Control team) during the 2nd user test, and the evaluation of experimental statistics.

- **Chapter 5: Conclusion**

  This chapter will conclude the results of experiments, discussing the limitations, possible improvements and future developments of the research.

Chapter 2
Related Works

2.1. Nutrition applications in the market

In order to understand what features Nutrito should have to be diverse from other nutrition applications, it is necessarily to analyze those existing models. The background and advantages of applying image recognition into such app will also be discussed in this section.

The first 3 selected nutrition apps are been ranked as The best Nutrition APP 2020 by Healthline Media [17], the online medical information forum which has averaged 200 million users every month, based on Google Analytics. [1]

2.1.1 Nutrients - Nutrition Facts

Nutrients - Nutrition Facts, launched by Pomegranate Apps LLC since 2011, is the app which allows users can search for nutrition facts from over 200,000 kinds of food.[2] (Figure2.1) [18] Their nutrition facts are based on the USDA National nutrition database which guaranteed to provide the accurate data to their users. The users can make their own recipes with choosing each of the ingredients and serving size, understanding the whole nutrition facts and make adjustments to their customized meals.

1 `https://www.healthline.com/about`, July 2019.

2 `https://apps.apple.com/us/app/nutrients-nutrition-facts/id396836856`

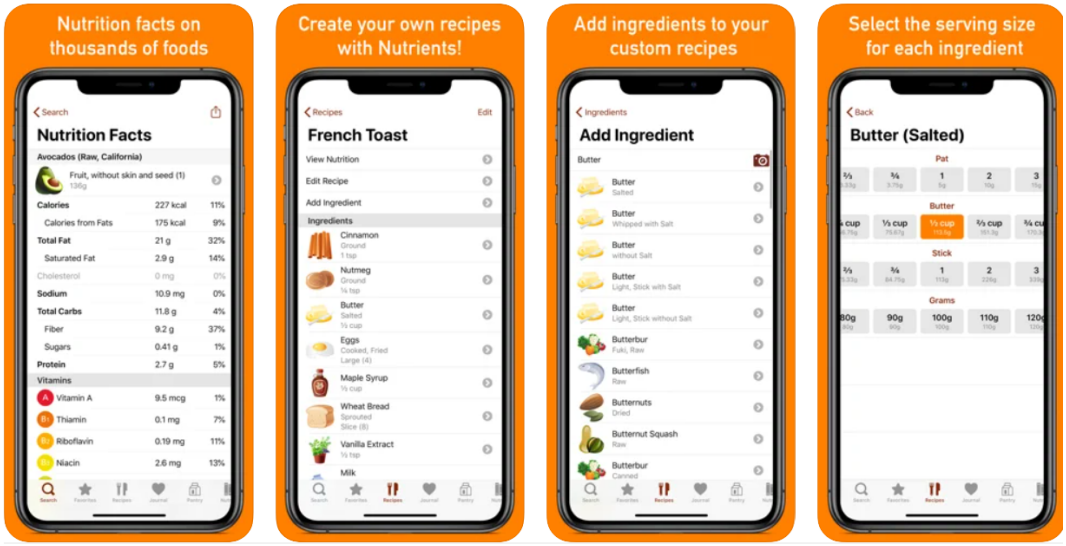

Figure 2.1 Nutrients - Nutrition Facts

2.1.2 MyFitnessPal

MyFitnessPal, owned by UnderArmour then sold to Francisco Partners, is a smartphone app which uses gamification features for users to trace their exercise accomplishments and diets. About the gamification, MyFitnessPal applies image recognition system that users can scan the barcode of foods and beverages. If the scanned objects information matches with MyFitnessPal's pre-existing database, the nutrition facts will be shown in the screen. Except for diet tracking system, MyFitnessPal also has the challenge mode, which app will record users' daily steps for them to challenge if they can reach 6,000, 9,000 or more steps per day. Last but not least, the app has an online social networking site similar to Twitter, where users can view, like or comment on the other users' diary diet and fitness accomplishments. (Figure 2.2) [19]

2.1.3 MyPlate Calorie Counter

Having most of the similar features with its competitors, the MyPlate Calorie Counter has a workout interface that the users can select different kinds of the workout. Depends on how hard the workout is, the users can earn a medium level,

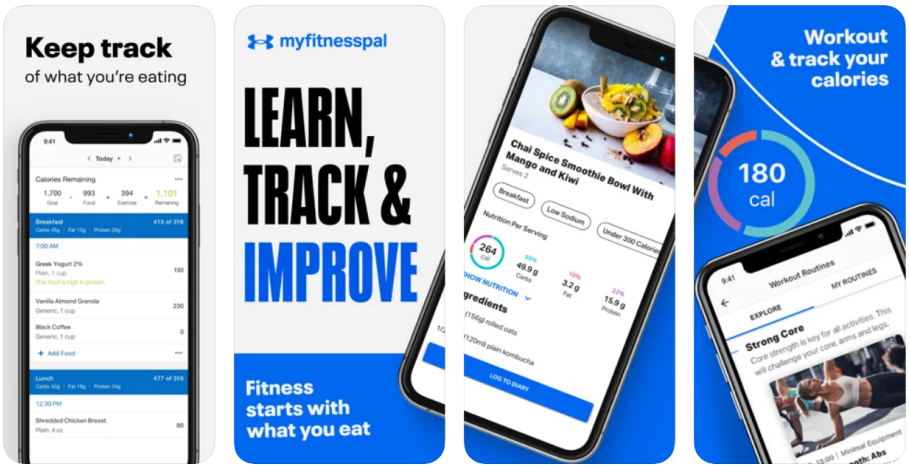

Figure 2.2 MyFitnessPal

high level or gold level medal that will be shown on the online community interface. To earn medals and share off to community friends, as winning the trophies in the games or clear a video game, gamification (The practice of making activities more like games in order to make them more interesting or enjoyable) [20] is a common goal for most of the nutrition apps want to reach.

2.2. Image Recognition

Machine learning is one of the most focused research topics in recent years. It relates to many of the applications in artificial intelligence field, such as Virtual Reality (VR), Augment Reality (AR), and Image Recognition (IR). Among these fields, the IR has been broadly applied in many kinds of smartphone apps, so as the nutrition apps, for its convenience. In this section, the principle of IR and a practical example of smartphone nutrition apps applied image recognition will be introduced.

2.2.1 Principle

Image recognition is the subcategory of the AI and Computer vision (A scientific field which teaches computers to recognize digital images and videos with high-

level understanding). With a set of methods, IR helps machines to detect and analyze the captured images with objects, colors, texts, places and people, then comes with an analyzed conclusion for what the image is about. Mostly, the image recognition is powered by machine learning, or deep learning. By the definition of IBM, it means a branch of AI creates applications which focuses on learning from data and improves their accuracy without programming them to do so. [21] The algorithms in machine learning are made to "learned" from data for finding their patterns or features in order to make better predictions and decisions for the next new data. As IBM pointed out, as the big data collected by machine learning growing bigger, humans can expect the working and personal future lives supported by the machine learning will be more efficient. [21] Like it mentioned, now more and more IR applications are created to make a more efficient lifestyle, as the following example.

2.2.2 Application: Calorie Mama

Calorie Mama featured for its image recognition system. According to its information page, the Food API has been trained from meals all around the world, and is confident to be the most culturally diverse food identification system in the market. It keeps updating newest food images and adding to its database. Once users took the photo of a meal, the food categories will been detected, its nutrition facts will be added into the nutrition facts charts. (Figure 2.3) [2]

2.2.3 Application: MyFitnessPal

Similar to Calorie Mama, MyFitnessPal applies image recognition system for its barcode scanning mode. Unlike the previous one which is take a picture then analyze the image, MyFitnessPal shortens the progress in one barcode scan then logs food information. As the company claimed, over 4 million kinds of barcodes can be recognized[3] . Close to many of other competitors, once the food information been detected, it adds to the nutrition facts charts. (Figure 2.4) [19]

3 `https://apps.apple.com/jm/app/myfitnesspal/id341232718`

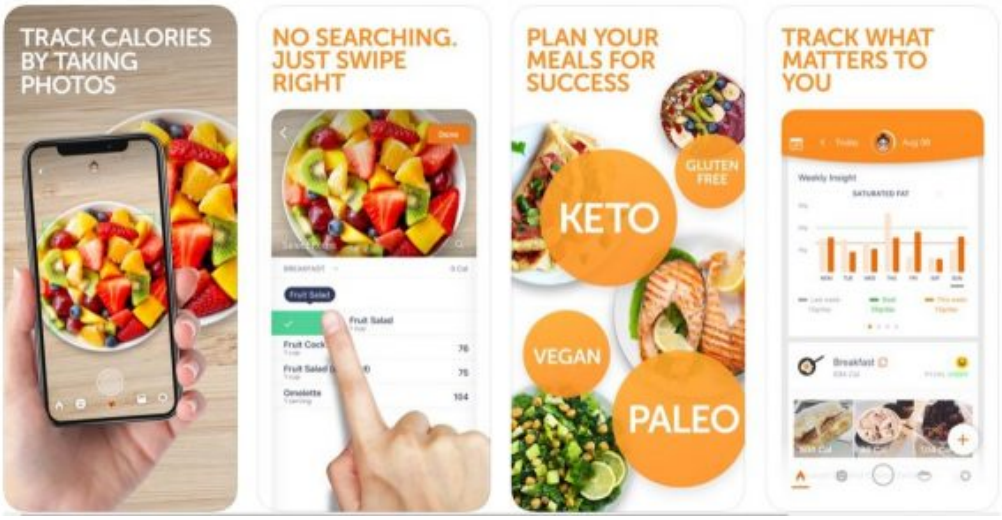

Figure 2.3 Calorie Mama

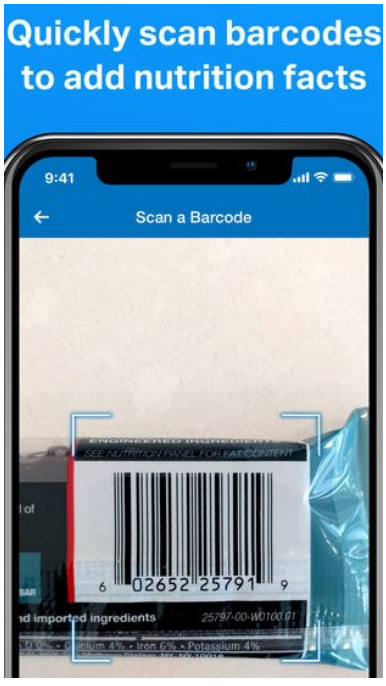

Figure 2.4 Scanner mode of MyFitnessPal

2.3. A relevant research paper of designing an educational nutritional app

At June 2019, M. Juan, J. Charco, I. Garcia and R. Molla from Universitat Politècnica de València wrote the paper: *An Augmented Reality App to Learn to Interpret the Nutritional Information on Labels of Real Packaged Foods* [22] , which has some similar goals with this research that provides users clearer information behind the traditional nutrition facts labels.

The paper aimed to stress the importance of "Healthy diet", which means a habit of eating different categories of food in order to absorbing different nutrients to supply for daily lives. [22] The prototype has been positioned as an educational application which can make users learning about the portions of carbohydrates (Refers to **carb servings**) contained in the real packaged foods. Based on the authors' researches, most of the processed foods are now consist of high-calorie foods, which contain saturated and transgenic fats, more sugar and carbohydrates are consumed by people. Other than obesity, diabetes is one of the most common diseases of affluence, or diseases of rich people, resulted from the lack of education for balanced and healthy diet.

Juan, Charco, Garcia and Molla pointed out that many literature claimed that Augment Reality (AR) is useful to help in the learning process, thus they decided to make an educational app with AR features. [22] In their app test, the user need to first fill out a pre-test questionnaire, which measures the knowledge of the users about the number of carb servings contained in the 5 foods. The participants would fill out the answers to indicate their predictions of carb servings for each food. (Figure 2.5) [22]

After the pre-test, users would move to customization phase to customize their individual variations (Age and Gender). The app then shown their daily recommend carb servings. In training phase, the users were asked to use camera to search 5 packaged foods one by one. Once the device camera detected a food (The front side image), the arrow would shown to ask users rotate the food to catch the nutrition label. An oval appeared at the label to guide users to touch it with the nutritional information of the food would shown on the left side. Af-

Figure 2.5 Pre-test and post-test questionnaire of M. Juan, J. Charco, I. Garcia and R. Molla's research

ter reading the carb servings of 5 tested foods, users then moved to test phase for taking another multiple choices test of asking their understanding of the carb servings, with 2 foods already shown in the training phase and 3 new foods. The authors' expectation was if the users already been educated for the knowledge of carb servings at the training phase, they should be able to select the correct carb servings choices for the other 3 new foods as well. (Figure 2.6) [22]

After 40 tests, the 4 researchers collected satisfied outcome that the participants shown to be more knowledgeable about how to interpret the nutritional information on packaged foods. As they mentioned:

> The initial knowledge about carb choices of our participants was very low (a mean of 0.12 on a scale from 0 to 5). This indicates that people do not know how to interpret the labels of packaged foods...the results indicated that our app has proven to be effective for learning about the nutritional information that is on the labels of packaged foods. [22]

Juan, Charco, Garcia and Molla's conclusion is a pilot of this research, which specified people may not earn enough information from the nutrition facts label

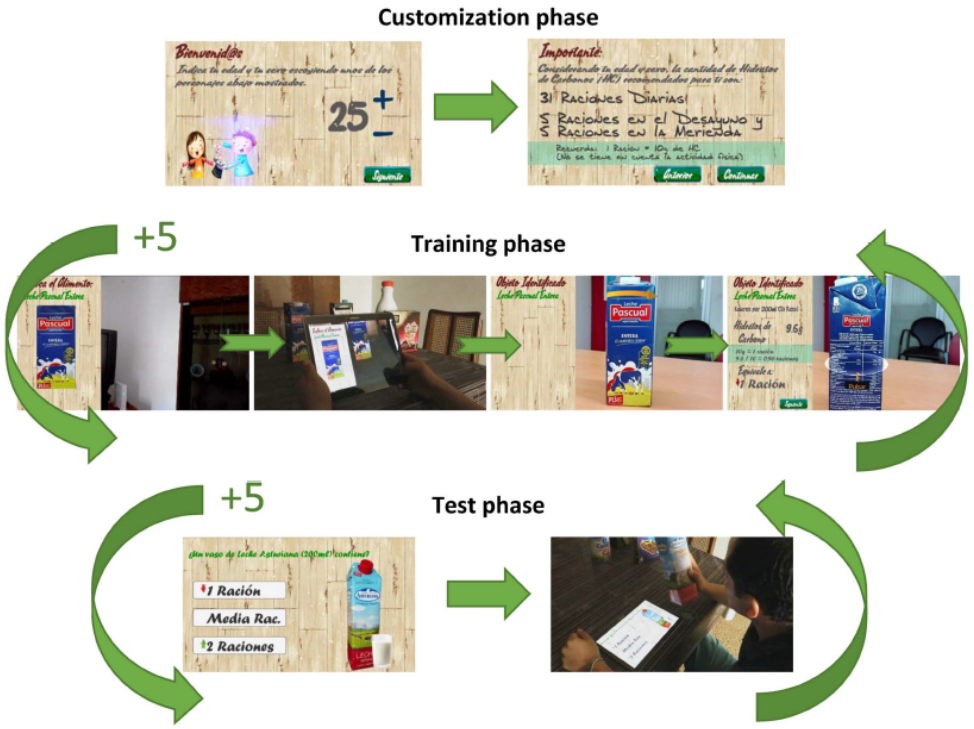

Figure 2.6 Phases of M. Juan, J. Charco, I. Garcia and R. Molla's research

on packaged foods as many of them don't know how to explain it. Yet, people can be educated through the help of a designed nutrition app.

Chapter 3
Design Concept

3.1. Background

After examination through some of the existed model in the market, we can find out that most of the nutrition apps have similar features. From the early designed nutrition app: Nutrients - Nutrition Facts, users need to type each ingredients' names, servings by hand to search the nutritional facts and add them into the calculation system. Then, the idea of gamifcation and convenience came. The implementations of barcode scanner, IR food detection, daily sports challenges, medal collection, online community, and AR educational feature, all related to an idea of creating additional values for users to choose these apps.

So far, none of the nutritional app in the market has the feature of interpreting the calorie information on nutrition facts labels to relative amount of exercise of burning out its calories. Possible reasons could be that every person's metabolism speed is vary from their variations, from their gender, age, height, weight, to their mental health, current diseases, genetic facts, and hormone. It is not impossible to do so, through, comparing to do such complicated calculations and building a database of each variations, with their influences toward the calorie people could burn from different kinds of exercise plus kinds of food. Compare to these, create a nutrition app which can simply tell people the nutrition facts of ingredients (Which tends to be fixed data) seems to be easier to achieve in business perspective. However, regardless the complex of providing an 100% perfect, accurate interpreted results of amount of exercise, collecting the reactions from users of using such functional app and their next actions after receiving these information will be interesting to research.

In the section, the design concept of Nutrito will be introduced. Nutrito is a

prototype nutrition smartphone app with the functionality of IR nutrition label scanner and detector, with a built database which can provide Suggested Amount of Exercise (SAE) in measured degree of accuracy by variations from individuals and the scanned packaged foods' calories.

3.2. Design Environment

The choice of design environment for Nutrito was from two Youtube introduction films: How to create Image classifier App in Mit app inventor 2 [23] & How To Create Personal Image Classifier App In MIT App Inventor 2 (AI App) [24], which teach viewers to build a basic model of image recognition app through the Android application design environment called MIT App Inventor 2. (Figure 3.1) [25]

Figure 3.1 MIT App Inventor 2

MIT App Inventor 2 or MIT APP Inventor in common, created by Google and maintained by Massachusetts Institute of Technology (MIT), is an integrated and intuitive web application development software which allows programmer rookies to create their apps without coding skills. It uses similar user interface and logic with another programming language Scratch (Figure 3.2) [26], that all programming commands are been categorized by different "blocks". Users pull blocks into the palette interface and set commands from what they want the app achieve. For example, in MIT APP Inventor, a possible command blocks setting for asking

phone to take a photo after pressing a button will be "When button 1. Click" "do""call Camera 1. Take Picture".

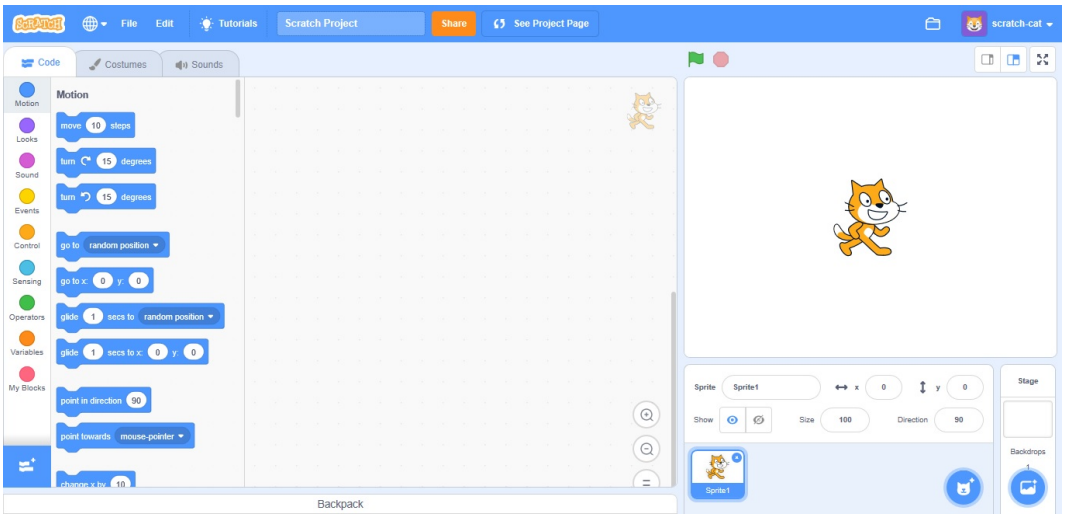

Figure 3.2 User interface of Scratch

3.2.1 Learning from tutorial videos

In the tutorial films [24], the author guided viewers how to create image classifier app model. He created an personal image recognition model that detects people's facial expressions. As his suggestions, the viewers should apply Personal Image Classifier training engine created by MIT into their apps. The author then added different expressions into the model, for Happy face, Angry face and Sad face, each took 5 examples for the model to do machine learning. In the Happy examples, he smiled with a obvious corners of mouth curved up and sometimes shown his tooth; in Angry face, he popped out his eyes, opened his mouth with tooth shown as well; in Sad face, he closed his eyes with mouth closed tightly.

After training phase, the model could detect facial expressions in a good level of accuracy. For the author's self test, the system detected his smile at 0.78952 points of Happy, 0.15112 points of Sad and 0.06017 points of Angry. (Figure 3.3) [**?**] In his 3 tries, his Angry face had lowest accuracy that the system may misunderstood 2 different expressions both shown tooth, which is ["Angry", 0.41727, "Happy",

0.41281, "Sad", 0.17075]. (Figure 3.4) [?] Sad face had a higher level of accuracy for ["Sad", 0.50381, "Happy", 0.36395, "Angry",0.13454], as the closed mouth could a clear identification. Through the author's tests, it was learned that if Nutrito wants a high level of accuracy for IR results, the scanned food label objects need to be clearly distinguishable. The choices of the food objects will be discussed in section 3.5, with green, red and yellow package and label colors.

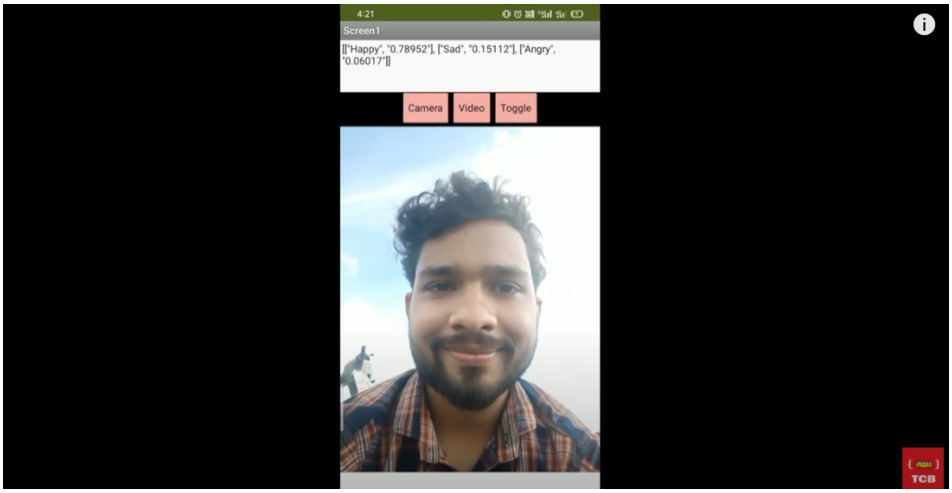

Figure 3.3 Happy face example from the tutorial video and the IR result

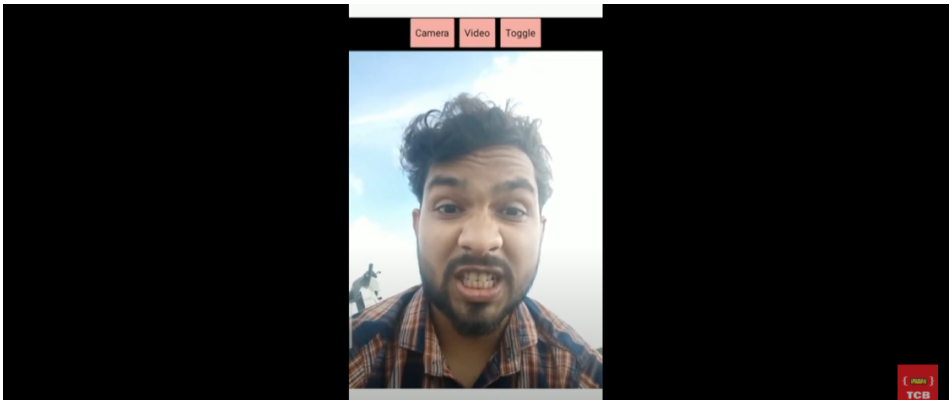

Figure 3.4 Angry face example from the tutorial video

3.3. Interface Design of Main Page

Considering the convenience of users, the prototype disposed the design of introduction page. When users open Nutrito, the main page (Figure 3.5) named Screen 1 shown up with 5 different buttons. Pressing the Scan button, the prototype directly calls out the camera of Android phone, and users can then take a picture of nutrition facts label to detect the object. The Video Scan button allows Nutrito to capture nutrition labels during the phone's camera recording, for instance, if a user holds the packaged good object, Nutrito can also capture the label and get the analyze result of what kind of food it probably is, but the accuracy came out to be extremely low after a few tests. Thus, in the tests, users were asked to use Scan button for using camera to take a clear photo of label, in order to get accurate results.

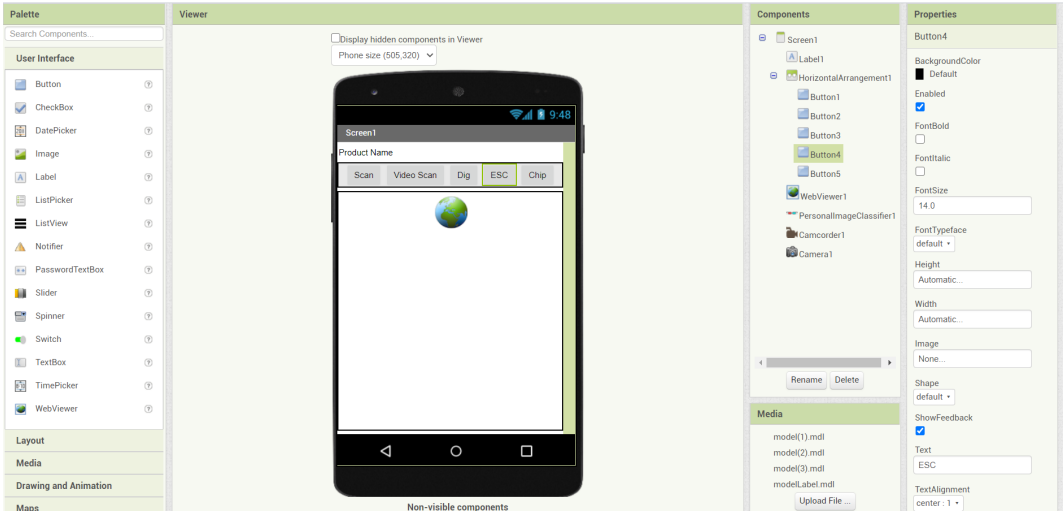

Figure 3.5 Main page of Nutrito

In the middle part of the page is the Webviewer. WebViewString can communicate between the app and Javascript code running in the Webviewer page. In this prototype, the Webviewer is controlled by an import extension "PersonalImageClassifier" which can apply trained IR model to detect the images shown in the Webviewer screen. More details of IR model of Nutrito will be explained in

the section 3.7.

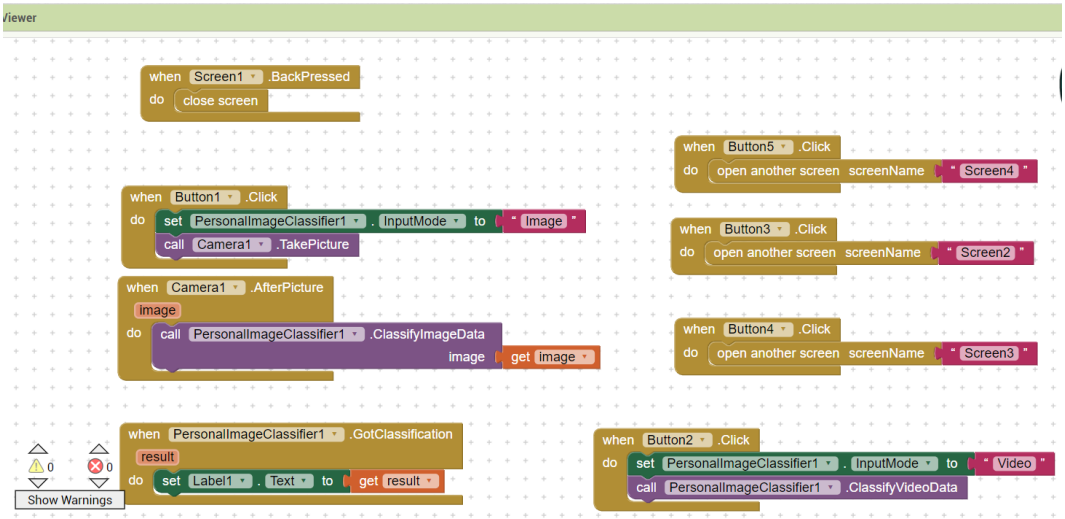

Figure 3.6 Blocks of Main page

The built-in blocks of the main page (Figure 3.6) separated in different purposes. The browns related to "control" commands; dark greens are "setting" a component to do something; pinks are capturing the component named in a certain "text"; purples are the "procedure" commands and the oranges indicate the "variables" results what we want the App to get after a certain action. The explanations of the blocks are listed below:

- **when Screen 1 BackPressed, do "close screen"**:

  If user clicks back button during scan mode and video scan mode, the screen will stop all actions and back to the Screen 1 (Main page).

- **when Button 1 click, do "set PersonalImageClassifier1. InputMode to 'image'", call camera 1 "Take picture"**:

  If user clicks Button 1 (Scan), Nutrito will set the input mode ready for classify the image user took from camera. The app will then automatically

turn into camera screen and ready to take a picture by user.

- **when Button 2 click, do "set PersonalImageClassifier1. InputMode to 'video'", call PersonalImageClassifier1 "ClassifyVideoData"**:

  If user clicks Button 2 (Video Scan), Nutrito will set the input mode ready for classify the video recording from selfie lens. The app will then automatically capture any possible food label objects from the video and turn out the result at Label1 (Product Name).

- **when Camera 1 AfterPicture, do "call PersonalImageClassifier1. ClassifyImageData", image "get 'image'"**:

  When user takes a picture, Nutrito will get the image and use PersonlImageClassifier to classify this image using a user trained model from the image classification explorer.

- **when PersonalImageClassifier1 GotClassification, do "set Label1. Text" to "get 'result'"**:

  Once Nutrito got result from image classification, the Label 1 (Product Name) will show the result and following identification points of each possible food objects.

- **when Button 3/4/5 click, do "open another screen screenName 2/3/4"**:

  When user got the image classification result, press the corresponding button 3 (Dig), 4 (ESC) or 5 (Chip) in order to go to each screen of food's Suggested Amount of Exercise (SAE) page.

3.4. User Portrait

The possible users of Nutrito will be defined with following portrait:

People who enter their 30s (30-39 years old), and realize that the same food amount they used to eat in their youth now easily turns into gaining weights. However, people in their 30s usually become the mainstay of their companies or their families, thus it's not that popular for such people to have a regular exercise habit. Not all people wants to stay in a good body shape, since the joy from food and calories is hard to resist. But for those people who look forward to having a healthy diet habit or miss their shape in youth (Figure 3.7) [27] , Nutrito can help them to identify which packaged foods may become the obstacle for achieving those goals, with relatively high calorie and the SAE. Though many users may not able to accomplish SAE if they eat those foods, they can understand those extra calories intakes in terms of exercise times and make adjustment of the following food intake it that day.

Figure 3.7 Nutrito is a possible solution for people who care their shape

3.5. Scanned food objects

The scanned food objects used in the experiments of this research are the:

BRAND'S® Essence of Chicken 68ml (ESC), McVitie's® Digestive (or "Hob-Nobs" in the U.K.) Oat flavor 300g (20 biscuits), and Lay's® Original (or "Classic" in the U.S.) potato chips 97g. These objects are chosen as ideal tested objects for the following reasons:

- **Essence of Chicken** (Figure 3.8) [28]:

  Essence of Chicken is a popular health product which keeps producing in the last 180 years [1]. Made of an all-natural extract of fine quality chicken, the ESC is considered as one of the good foods that benefits people's energy and fat-free, with only 21.6 kcal per can. In the test of this research, the ESC plays a role of one of the **Low Calorie and Healthy food choices.** The SAE result provided by Nutrito should not bring much influence on people's consideration to buy and eat such foods.

Figure 3.8 A same size Essence of Chicken used in prototype test

1 https://www.brandsworld.com.sg/en/products/essence-of-chicken-original.html

- **Digestive Oat flavor** (Figure 3.9) [29]:

  Digestive biscuit, a famous dessert in British afternoon tea culture, is a hidden "Bomb food" in term of calorie. A biscuit of oat flavor Digestive has 70 kcal calories, which means merely 3 biscuits can easily overpass the calorie of a bowl of white rice (160 kcal). [2] In addition, the name Digestive gives people a myth that it is good for digestion, but actually it is nothing related to health. Digestive biscuits contain sugars, refine flours, fats and sodium, but on the package, the slogans hint the biscuits are rich in fiber, abundant oats added, and non artificial food coloring or flavours, which may mislead customers these products are healthy choices and can replace 3 meals. The Digestive is an instance of **Hidden bomb food choices** in this research, which related to high calories packaged foods with a popular myth of healthiness.

Figure 3.9 A same size Digestive Biscuit Oat flavor used in prototype test

- **Original flavor potato chips** (Figure: F.2) [30]:

  Eating potato chips has researched to be one of the main dietary causes of gaining weight. Based on a research of D. Mozaffarian, T Hao, E B. Rimm, W C. Willett and Frank B. Hu [31], 120,877 American participants categorized by different dietary habits and researched in 4-year period, with the result of gained 3.35 lb in average. Among all kinds of food intakes in the research, Weight change was mostly correlated to the intake of potato

2 https://www.myfitnesspal.com/nutrition-facts-calories/rice-bowl

chips, with consuming a serving of potato chips each day leaded to a 1.69 lb weight gain over a 4-year period. [32] However, the global consuming of the potato chips is still growing, with a predicted CAGR (Compound annual Growth Rate) of 4.40% in 2020 to 2025. [33]

In this research, the Original flavor chips with 552 kcals calories is defined as the **Food guilt choices**. Food guilt means people already know to have such kinds of food will lead be negative impact, but often continue to eat them. Those guilt foods usually have the best tastes and are hard for people to resist their temptation. With the help of Nutrito, would users consider stop buying or eating those foods is worthy to be observed.

Figure 3.10 A same size Original flavor chips used in prototype test

3.6. SAE database settings

3.6.1 Average weights in height intervals by age and gender

To provide Suggest Amount of Exercise (SAE) precisely, the data used for Nutrito to calculate for the results are retrieved from creditable resources. Mentioned in the Introduction section, human's mechanism of metabolism in terms of gaining weight is complicated and varied by each individuals, but mostly related to age, gender, weight and height.

The range of height used in this research is limited to 151 cm to 180 cm, both male and female. The height data from each individual can connect to average weight data researched and collected by areppim AG, an online Swiss database founded by Nokia RD Manager & Professor of University Geneva and Dr. E. Casais Jr and Management Centre Europe consultant E. Casais Sr, which provides many health-related statistics in decades. The collected statistics of Average Weight for Men and Average Weight for Women by age intervals are listed in Figure 3.11 [34] and Figure 3.12 [34] retrieved from areppim. (The Men data was collected from 153 cm and Women data was from 148 cm.)

Since Nutrito's target user group in Prototype test is from 30 to 39 years old, the data retrieved here are the average weight in 30-39 interval in both gender. In the Suggested Amount of Exercise result page, the user can select from 151-155 cm, 156-160 cm, 161-165 cm, 166-170 cm, 171-175 cm, and 176-180 cm. As one of the technical limitations, Nutrito can only calculate the amount of exercise by one average weight in each height intervals. Thus, each average weight is defined as the sum of weights in 5 heights and divided by 5. In Men's 151-155 cm interval, the number is sum of weights in 153 cm, 154 cm and 155 cm divided by 3. The result table is listed below (Table 3.1):

Table 3.1 Average weights in each height interval by gender

Height(cm)	Men avg Weight(kg)	Women avg Weight(kg)
151-155	60.3	54.8
156-160	62.6	57.4
161-165	66.2	60.2
166-170	69.6	63.2
171-175	73.2	66.4
176-180	77.2	70.2

Average Weight for Men

(in kg, wearing clothes)

Height (in cm, wearing shoes)	Age interval							
	15-16	17-19	20-24	25-29	30-39	40-49	50-59	60-69
153	44.9	51.7	55.7	58.4	59.7	61.1	62	60.7
154	45.6	52.1	56.2	58.9	60.3	61.6	62.5	61.2
155	46.3	52.6	56.7	59.5	60.8	62.2	63.1	61.7
156	47.2	53.2	57.2	60	61.3	62.7	63.6	62.2
157	48.1	53.7	57.8	60.5	61.9	63.2	64.1	62.8
158	49	54.3	58.4	61.2	62.5	63.9	64.7	63.3
159	49.9	55.1	59.1	61.9	63.2	64.6	65.2	63.9
160	50.8	55.8	59.9	62.6	63.9	65.3	65.8	64.4
161	51.7	56.5	60.6	63.1	64.7	66	66.5	65.1
162	52.6	57.2	61.3	63.7	65.4	66.7	67.2	65.8
163	53.5	58	61.9	64.2	66.1	67.5	67.9	66.6
164	54.4	58.7	62.5	64.8	66.8	68.2	68.6	67.3
165	55.3	59.4	63	65.3	67.5	68.9	69.4	68
166	56.1	60.1	63.5	66	68.2	69.6	70	68.7
167	57	60.8	64.1	66.7	68.9	70.3	70.8	69.4
168	57.9	61.6	64.6	67.3	69.7	71.1	71.5	70.2
169	58.8	62.2	65.1	67.9	70.4	72	72.4	71.1
170	59.7	62.9	65.7	68.4	71.1	72.9	73.3	72
171	60.6	63.6	66.4	69.1	71.8	73.6	74.1	72.7
172	61.5	64.3	67.1	69.8	72.5	74.3	74.8	73.4
173	62.4	65.1	67.8	70.5	73.2	75	75.5	74.2
174	63.3	65.8	68.5	71.2	73.9	75.8	76.2	75.1
175	64.2	66.5	69.2	71.9	74.7	76.5	76.9	76
176	64.9	67.2	69.9	72.6	75.5	77.3	77.8	76.9
177	65.7	67.9	70.6	73.4	76.4	78.2	78.7	77.8
178	66.4	68.6	71.4	74.1	77.3	79.1	79.6	78.7
179	67.1	69.3	72.1	74.8	78	79.8	80.5	79.5
180	67.8	70.1	72.8	75.5	78.7	80.5	81.3	80.4

Figure 3.11 Average Weight for Men by Age

Average Weight for Women

(in kg, wearing clothes)

Height (in cm, wearing shoes)	Age interval							
	15-16	17-19	20-24	25-29	30-39	40-49	50-59	60-69
148	44.4	45.3	46.6	48.9	52.4	55.6	56.9	57.8
149	44.9	45.8	47.2	49.4	52.8	55.9	57.3	58.2
150	45.4	46.3	47.7	50	53.1	56.3	57.7	58.6
151	46	46.9	48.2	50.5	53.7	56.9	58.2	58.9
152	46.5	47.4	48.8	51	54.2	57.4	58.8	59.3
153	47.1	48.1	49.4	51.6	54.8	57.9	59.3	59.8
154	47.9	48.8	50.1	52.1	55.3	58.5	59.8	60.3
155	48.6	49.5	50.8	52.6	55.8	59	60.4	60.8
156	49.3	50.2	51.3	53.2	56.3	59.5	60.9	61.3
157	50	50.9	51.9	53.7	56.9	60	61.4	61.9
158	50.6	51.5	52.4	54.3	57.4	60.6	62.1	62.5
159	51.1	52.1	53	54.8	58	61.1	62.8	63.2
160	51.7	52.6	53.5	55.3	58.5	61.7	63.5	63.9
161	52.2	53.3	54	55.9	59	62.4	64.2	64.7
162	52.8	54	54.6	56.5	59.6	63.1	64.9	65.4
163	53.4	54.8	55.2	57	60.1	63.8	65.7	66.1
164	54.1	55.5	55.9	57.7	60.7	64.3	66.4	66.8
165	54.8	56.2	56.6	58.5	61.2	64.8	67.1	67.5
166	55.5	56.7	57.3	59.2	61.9	65.5	67.8	68.2
167	56.2	57.3	58.1	59.9	62.6	66.2	68.5	68.9
168	56.9	57.8	58.7	60.5	63.2	66.9	69.2	69.7
169	57.4	58.3	59.2	61.1	63.8	67.6	69.9	70.4
170	58	58.9	59.8	61.6	64.3	68.4	70.6	71.1
171	58.6	59.6	60.5	62.3	65	69.1	71.3	71.8
172	59.4	60.3	61.2	63	65.7	69.8	72.1	72.5
173	60.1	61	61.9	63.7	66.4	70.5	72.8	73.2
174	60.8	61.7	62.6	64.4	67.1	71.2	73.5	73.9
175	61.5	62.4	63.3	65.1	67.9	71.9	74.2	74.7
176	62.2	63.1	64	65.8	68.6	72.8	75.1	75.4
177	62.9	63.8	64.7	66.6	69.3	73.7	75.9	76.1
178	63.6	64.6	65.5	67.3	70	74.6	76.8	76.8
179		65.5	66.4	68.2	70.9	75.5	77.7	
180		66.4	67.3	69.1	71.8	76.4	78.6	

Figure 3.12 Average Weight for Women by Age

3.6.2 Calories burned by exercises in terms of weight

As the average weights of each age intervals from both genders are determined, now we have to consider the amount of exercise to burn out the scanned foods' calories. As the Introduction section mentioned, the types of exercise used for Nutrito SAE are Walking and Running, based on M.Forgione [15] and fitness tracker maker, as the primary and popular exercise in the world is walking and the second is running.

To calculate how many calories users can burn out through these 2 exercises, this research refers to the calculator model provided by Verywell Fit. Verywell Fit is a medical publication online forum dedicated to empowering users with credible and up-to-date advice on all diet, weight loss, and exercise topics. Its library has been written by more than 100 healthcare professionals and industry experts in the past 20 years. [3]

The "calories burned exercising" calculator uses the formula: Total calories burned = Duration (in minutes)*(MET*3.5*weight in kg)/200, according to American College of Sports Medicine and Dr B.Bushman. [35] By input the exercise category, time duration and weight, the calories burned exercising calculator can come up with an estimated calories burned after doing the exercise, as an example of Figure 3.13 retrieved from Verywell Fit. [36].

According to Catrine Tudor-Locke1, Ho Han, Elroy J Aguiar, Tiago V Barreira, John M Schuna Jr, Minsoo Kang and David A Row, a minimum speed for walking in moderate intensity is near 100 steps per minute for adults under age 60. [37] Thus walking (moderate) is defined as 100 steps per minute in Nutrito system. For the speed of running, healthline collected 10,000 runners who ran in a 5K race in United States and came up with the statistics that people in age 30 to 39, men run in average 11 minutes per mile (Rounded), with women averaging 12 minutes per mile. [38]

By applying 3 scanned foods calories (ESC 21.6 kcals, Digestive biscuit 70 kcals and Original chips 552 kcals), weight and exercise time in the model, the final data Nutrito uses to calculate SAE are listed in the Table 3.2.

3 `https://www.verywellfit.com/about-us`

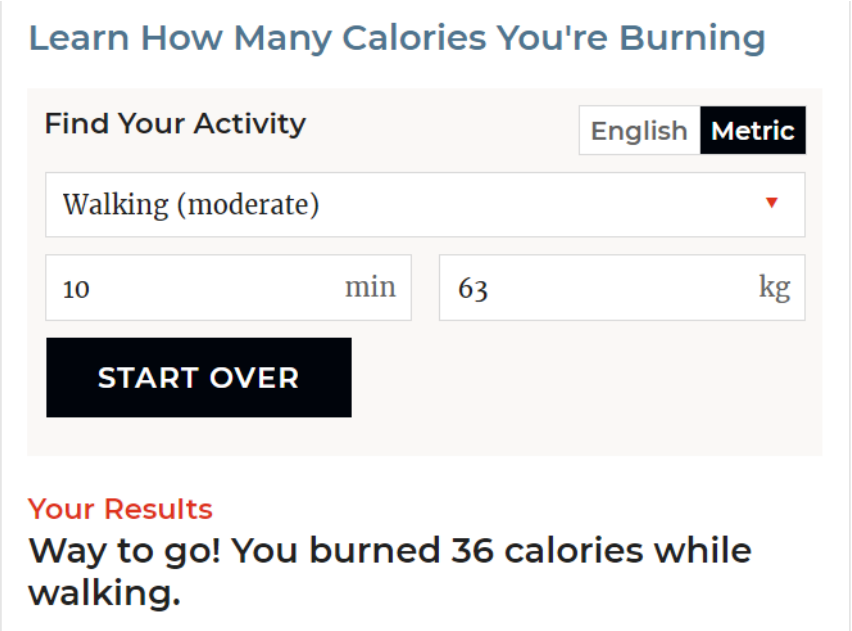

Figure 3.13 An example of Calories burned exercising calculator result

Table 3.2 Average exercise time for burning 3 test foods in minutes, in the order of ESC, Digestive biscuit and Original chips, by height and gender

Height(cm)	Men Walking	Men Running	Women Walking	Women Running
151-155	6	2	7	3
156-160	6	2	6	3
161-165	5	2	6	2
166-170	5	2	6	2
171-175	5	2	5	2
176-180	4	2	6	2
151-155	20	7	22	9
156-160	19	7	21	9
161-165	18	7	20	8
166-170	17	6	19	8
171-175	16	6	18	8
176-180	15	6	17	7
151-155	160	59	175	72
156-160	153	56	168	69
161-165	145	53	160	66
166-170	137	50	153	63
171-175	131	48	145	60
176-180	124	46	137	57

3.7. Image recognition model training

Nutrito adopts the image recognition model training extension provided by Massachusetts Institute of Technology, the Personal Image Classifier. The steps of training the model are:

- **Add training data** (Figure 3.14):

  Each food's nutrition facts label were photographed 50 pictures, some in different distance and angles, by computer and updated as the examples. (The Chinese words in the Figure 3.14 is "Select data")

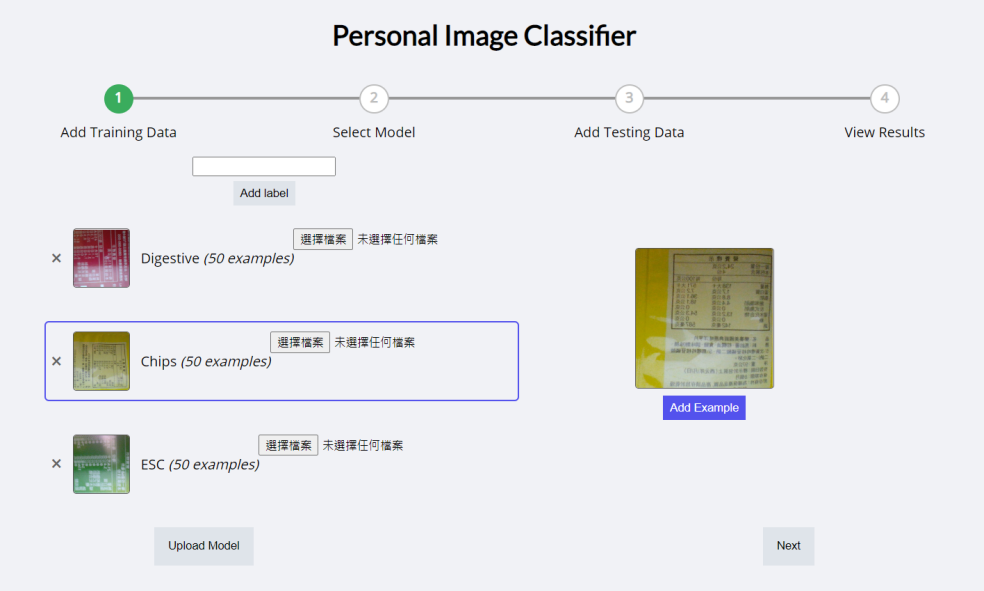

Figure 3.14 Add training data

- **Select model** (Figure 3.15) :

  After the model was ready, it was selected and trained in the default rules of Personal Image Classifier.

- **Add testing data**:

  Randomized food label pictures were taken by computer to test if the model could accurately distinguish each food corresponding with each label.

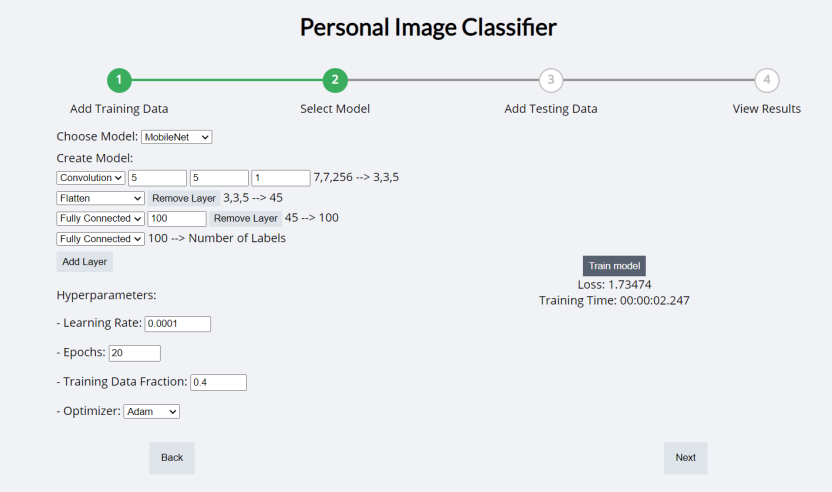

Figure 3.15 Ran the model

- **View results** (Figure 3.16):

  The result shown that this image recognition model could distinguish most of the labels correctly. The two ESC, one Digestive and one Chips labels pictures were correctly labeled. A picture of chips label was also been indicated by the model that was not Digestive label. However, a error also happened as one chip label picture didn't be correctly distinguished. Based on this, this model was trained with more label examples after.

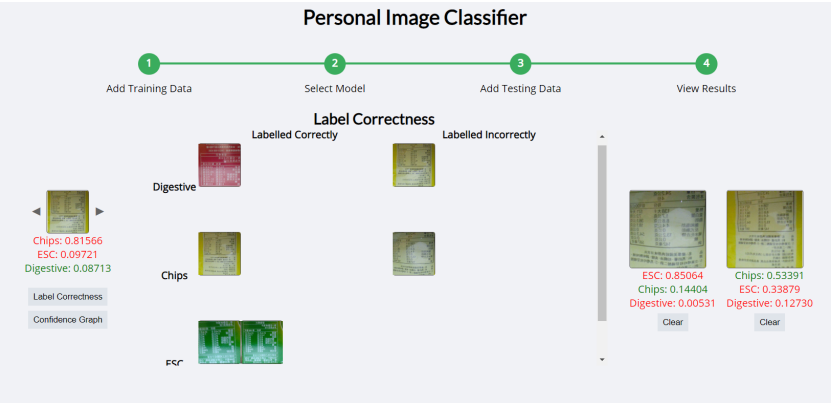

Figure 3.16 Results

3.8. SAE Result Page in completed prototype

After users received the image recognition results, they need to press the corresponded food button in the main page to enter the SAE result page. In the result page, users can input further individual variations: Age, Gender and Height. By pressing the oval, users will receive their suggested amount of exercise, based on the data of Table 3.2. Figure 3.17 shows the Nutrito SAE result of a 36 years old, 168 cm female user who scanned chips label.

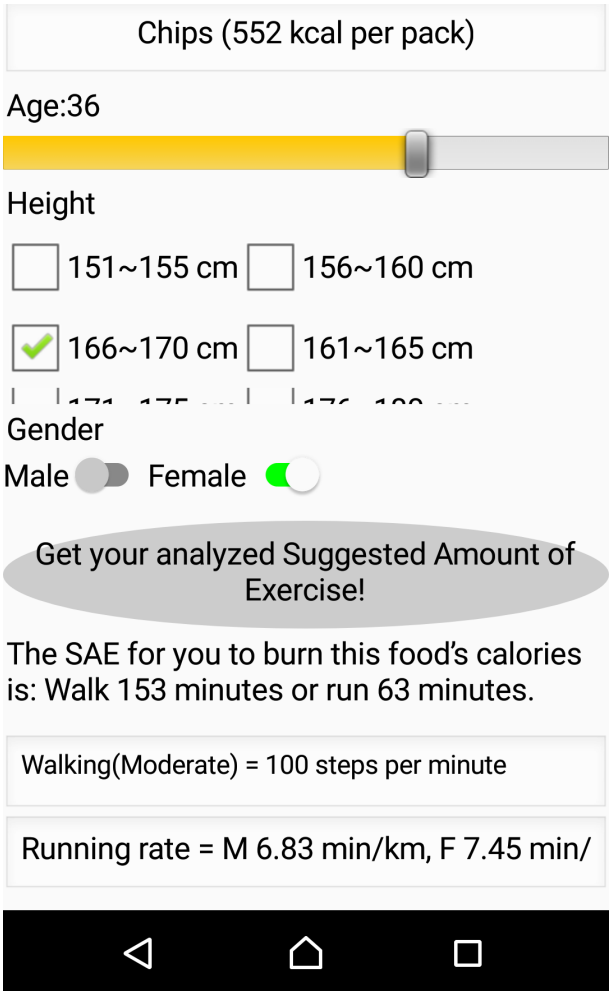

Figure 3.17 SAE Results

3.9. The novel points of the prototype compared with the other nutrition apps

Nutrito prototype provides several novel perspectives that none of the nutrition app ever has (In 2020). First is for the target that Nutrito scans: the nutrition facts label. As mentioned in section 2.1, the 3 selected 2020 Best Nutrition Apps were focusing on 3 different mechanisms: the Nutritents - Nutrition Facts emphases its database was retrieved from USDA; MyFitnessPal uses barcode scanner and MyPlate Calorie Counter focuses on gamification. However, all of these nutrition apps do not provide a further interpretation of how high Calories related to a person's exercise amount, but to focus on what portion of the foods' nutrition is in users' RDA (Recommend daily allowance). In contrast, Nutrito aims to provide a relatively meaningful interpretation of those nutrition facts portions to users' awareness. The Nutrition label scanner mechanism prompts people have another chance to read the information on the label. (As section 4.3.4, for Question 9 of the Table 4.3, the curve of answering "I examine the nutrition facts label when I purchase packaged foods" is polarization, thus near half of the users do not read the label.) By intention, people buy packaged foods with the food image on it, but a chance to read the nutrition label would make them determine if the food is healthy or a junk food. In the future, the Nutrito would be expected to analyze the other nutrition numbers on the label, and provides other health-related interpretations than the SAE.

If reading the nutrition label is not clear enough for the users to determine if the food is worthy to be purchased or taken, then the second novel point of Nutrito: the unique designed SAE would provide users a foresight of how those calories may impact on your body that you will need to exercise more to get rid of the gaining fat tissue. Even if they are not willing to do the SAE shown on, it is clear that the higher SAE is, the more possible for a scanned food's calorie would become burden and harmful to users' health. As a medical journal pointed out, high calorie intake can cause Cardiovascular Disease, Diabetes, Osteoarthritis and Cognitive Impairment [39], so the easy-understand SAE would be expected to help users stay distance from those foods and eventually have a healthier dietary habit.

Chapter 4
Evaluation

4.1. Background

In this chapter, two user tests of Nutrito will be discussed. The first user test was conducted under Nutrito's preliminary prototype, which had less features and data than the final version. The purpose of doing first user test was to understand the lacks of prototype and to improve the contents of pre-test and post-test questionnaires.

The second user test, with completed version of the prototype and questionnaires, had 13 testees who divided in to experimental group and control group. Both groups' habits of eating and exercising, mentality toward gaining weight, interpretation correctness of food labels would be evaluated. Experimental group will have post-test questionnaire and feedback survey to evaluate the effectiveness and usability of Nutrito.

4.2. First user test

The first user test attempted to test if the design of Nutrito is truly meaningful and helpful for users to think twice before buying or eating the food. If the users couldn't understand why such application is necessary to be created, this research would not match the expected goals.

In the first test, 5 testees were asked to do a pre-test questionnaire, then used Nutrito to scan food objects, and collected each of their feedback by interview. The users data are listed as below (Table 4.1):

Table 4.1 Testees' data in first user test

Testee	Age	Gender
A	39	Female
B	32	Male
C	37	Male
D	33	Female
E	30	Male

The first prototype of Nutrito only had 2 scanned food objects, the ESC and the Digestive biscuit. Before using it, 5 testees were asked to fill out the pre-test questionnaire. They answered based on their individual situations and asked to read the nutrition facts labels from 2 foods to answer question 8. The questions and responses shown at Appendix B.

4.2.1 Evaluation

The responses collected from the pre-test survey indicated that testees thought gaining weight could be a stressful thing to their life. The average rate of Q1 is 4, means generally all testees would think about the calories intake before eating the foods. However, Q2's 3.4 rate shows that testees were neutral to do exercise for buring calories in their life. Q3 and Q4 examine if the age really brings changes in weight toward them, and 4.8 and 4.4 rates shows that all testees agreed that their body weights increased after 30s. Q5 and Q6 also point out that gaining weight could or already brought mental pressure to testees. Q7's result reflects testees seldom or neutral to check nutrition labels, thus it is less usual for them to receive the calorie-related information from labels, and as the result, all testees strongly disagreed that nutrition facts label could bring them knowledge of the amount of exercise to burn out the foods' calorie in Q8. Q9's rate shows the same result of the Figure 1.3 that people in age 30 to 39 may still use smartphone a lot, as all testees use 5 or more kinds different apps per day, a high usage frequency.

4.2.2 Lessons after Nutrito preliminary prototype test

Except for less scanned food object, the preliminary prototype lacked database of heights and their relative average weights. Testees only selected their age and gender, then clicked oval button to receive Exercise Advice (Embryonic form of future SAE). The average weight of men and women was defined by the average men and women's weights in age 30 to 49 interval, which are 68.5kg and 53.0kg, based on Japanese Ministry of Health, Labor and Welfare's data. (Figure 4.1) [40]

基礎代謝基準値と基礎代謝量[2]

	男性			女性（妊婦、授乳婦を除く）		
年齢	基礎代謝基準値（kcal/kg/日）	基準体重（kg）	基準体重での基礎代謝量（kcal/日）	基礎代謝基準値（kcal/kg/日）	基準体重（kg）	基準体重での基礎代謝量（kcal/日）
1～2	61.0	11.7	710	59.7	11.0	660
3～5	54.8	16.2	890	52.2	16.2	850
6～7	44.3	22.0	980	41.9	21.6	920
8～9	40.8	27.5	1,120	38.3	27.2	1,040
10～11	37.4	35.5	1,330	34.8	34.5	1,200
12～14	31.0	48.0	1,490	29.6	46.0	1,360
15～17	27.0	58.4	1,580	25.3	50.6	1,280
18～29	24.0	63.0	1,510	22.1	50.6	1,120
30～49	22.3	68.5	1,530	21.7	53.0	1,150
50～69	21.5	65.0	1,400	20.7	53.6	1,110
70以上	21.5	59.7	1,280	20.7	49.0	1,010

Figure 4.1 Data of average weights in age and gender, MHLW

At first test, all the Exercise Advice results were same in terms of gender but not in height. Different testees would come up with same result in same gender if they scanned same object. Through this insufficient part was noticed at the end of the tests, testee C suggested that the prototype should have more variations; A 170 cm man should not have a same Exercise Advice with the other 160 cm man.

All the testees agreed that Nutrito's mechanism was not hard to understand

how to use. However, when testee B and C used the scanner, the IR model didn't accurately capture and detect the labels. Testee B's first 2 scans of ESC were detected as Digestive, and C's first try of ESC failed as well. The cause of the failure might result from a low numbers of training, as the preliminary prototype followed the guide of tutorial video (Section 3.2.1) that only added 5 examples of each food objects before trained.

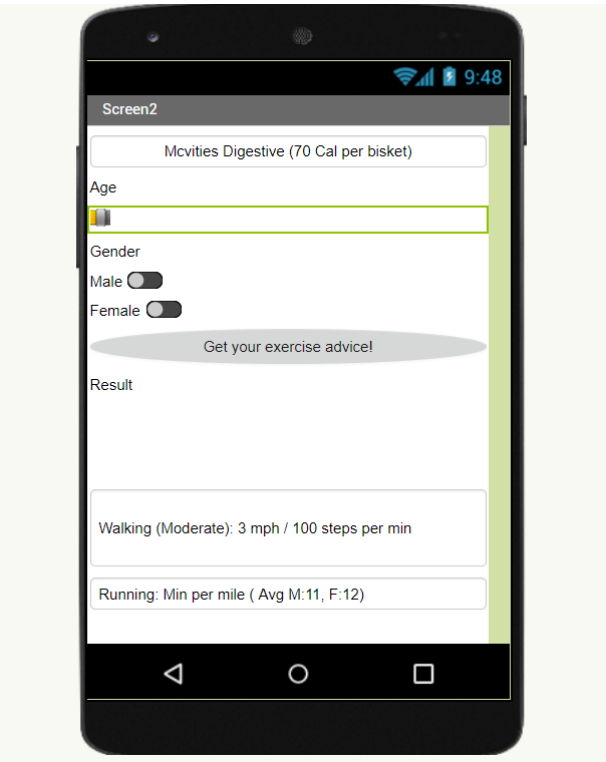

Figure 4.2 Preliminary version of Nutrito

About questionnaire questions design, testee E said some of the question contents were not clear. Q4 for instance, the decrease/ increase and slightly decrease/ slightly increase were not easy to understand without further explanation. And, did Q4 texts mean increase 2 lbs each year after turned 30s, or increased totally 2 lbs since 30 years old? He suggested this question could to be abandoned. On the other hand, testee A suggested that this questionnaire contained with different

answer options, some of them were Strongly disagree to Strongly agree, the others were Never to Always. These answer options lacked consistency, which might lead to wrong selections by careless testees. She also pointed out that the Q8 was wordy and too seductive, as all questions in questionnaire should be in neutral tone. She thought the question asked for examining if customers could receive appropriate information from physical labels, should be asked in different way.

Last but not least, testee B and E both thought the final test would need two groups to be compare, the experimental group and control group, otherwise the test could not powerfully prove the hypothesis nor to provide a creditable academically results.

4.3. Second user test

4.3.1 Objective

The second user test attempts to evaluate the usage of Nutrito completed prototype. Testees will randomly be divided into two groups, one group only collected their thoughts through questionnaires. The other group will finish the Preliminary and General questionnaires then use Nutrito. Their feedback of using Nutrito will be collected and evaluated if Nutrito can prove the hypothesis, which is it supports users to stop purchasing or eating the scanned packaged food objects if the SAE exceeds their estimation.

4.3.2 Test environment

The devices and environment settings for the second user test were:

- Personal computer (ROG Zephyrus GM 501)
- Android smart phone (Sony Z3+ Xperia)
- Scanned food objects (Essence of Chicken 70g (68ml), Digestive Oat flavor 300g, Original Chips 97g, all bought in Taiwan version packages)
- MIT App Inventor 2
- MIT AI2 Companion app, already downloaded in Android phone

4.3.3 Questionnaire design

Learned from the feedback of first user test, the design of 2nd test questionnaire modified or abandoned ambiguous questions and added some new questions. All the questions are designed to fulfill some of the research purposes. In the 2nd test, questionnaires are divided into one Preliminary questionnaire, two General questionnaire for Experimental group (Refers to Group A) and Control group (Refers to Group B), and one Post-test questionnaire.

The Preliminary survey has two questions:

- **Q1: What ' s the frequency of you eat any extra food out of 3 meals?**
  1. Zero time, 2. One time, 3. Two times, 4. Three times, 5. Four times or more extra food intakes per day
- **Q2: How many times you regularly do exercise per week?**
  1. Zero time, 2. One time, 3. Two times, 4. Three times, 5. Four times or more exercises per week

These questions aim to check testees' habit of eating extra foods and regularity of exercise. A rate in Q1 will indicate whether it's more likely or not for those people to exceed daily metabolism and thus easier to gain weight. A rate in Q2 means that those testees are more or less likely to burn out the extra calories through exercise and the possibility of gaining or losing weight. The result from both rates will represent Nutrito might be more or less likely to benefit those testees' diet and exercise habit.

The General questionnaire contains the following questions: (The term "Gaining weight" refers to weight increase through diet, not related to muscle increase through workout.)

- **Q1: When I moved to 30, compared to 20s, I feel more likely to gain weight.**

- **Q2: I want to keep the same body shape as my 20s.**
- **Q3: "Obesity" has a negative meaning in my culture.**
- **Q4: Gaining weight brings me psychological pressure.**
- **Q5: I decrease my calorie intake when I gain weight.**
- **Q6: I decrease my calorie intake even when my weight deceases or stays the same.**
- **Q7: I do exercise regularly when I gain weight.**
- **Q8: I do exercise regularly even when my weight deceases or stays the same.**
- **Q9: I examine the nutrition facts label when I purchase packaged foods.**

1: Strongly disagree 2: Disagree 3: Neutral 4: Agree 5: Strongly agree

Based on the consistency and convenience of readers, the answers of Q1 - Q9 are united to scale 1 to 5, Strongly disagree to Strongly agree. Q1 to Q4 are testing testees' mentality toward decrease of metabolism and gain weight. Q5 to Q8 are used to examine how the trend of weight makes influence to testees' diet and exercise behavior. Q9 will provide a information of do people care about the hidden calorie messages from packaged foods, or tend to eat them without thinking too much.

- **Q10: Please check the label of ESC and determine what's the amount of exercise to burn its calories.**

- **Q11: Please check the label of Digestive and determine what's the amount of exercise to burn its calories.**
- **Q12: Please check the label of Chips and determine what's the amount of exercise to burn its calories.**

For Q10 to Q12, testees will need to read 3 labels and test if they can predict the amount of exercise in Walking and Running based on the information of nutrition facts label. This question is designed for testing a critical purpose of Nutrito; if the correctness is low, then Nutrito will be meaningful to provide users further more information than traditional nutrition facts labels.

- **Q13: Based on the calorie information received from the nutrition fact labels, I won't consider to purchase or eat the ESC.**
- **Q14: Based on the calorie information received from the nutrition fact labels, I won't consider to purchase or eat the Digestive biscuit.**
- **Q15: Based on the calorie information received from the nutrition fact labels, I won't consider to purchase or eat the Chips.**
- **Q16: Nutrition facts label helps me to predict the amount of exercise I should do to burn out the calories of the food.**

1: Strongly disagree 2: Disagree 3: Neutral 4: Agree 5: Strongly agree

Q13 - Q15 examine both groups attitude toward buying or eating the scanned food only based on the Calories marked in nutrition label. In this step, group A didn't receive the SAE information. The results of Q13 to Q15 will be used in two discussions: one is Group A's choices of purchase or eat (Using app) compare to Group B's choices (Without using app), the other is the changes before and after Group A's people use Nutrito. Q16 checks if testees' made wild guesses from Q10 to Q12. Lower rate represents testees are making wild guess and proves nutrition

facts label won't help customers to receive information of amount of exercise to burn out the foods' calories.

4.3.4 Analysis before experiment

13 testees undertook the 2nd user test. 7 testees are in Group A and 6 testees are in Group B. Compared to first test, the testees' data are more detailed as below:

Table 4.2 Testees' data in second user test

Testee	Age	Gender	Height	Occupation	Group
A	39	Female	158	Senior designer	A
B	37	Male	171	Store owner	A
C	30	Male	177	Consultant	A
D	33	Female	158	Junior designer	B
E	30	Male	172	Free	B
F	32	Male	179	Bank Manager	A
G	31	Female	172	Secretary	B
H	38	Male	170	Brand manager	A
I	30	Female	173	Editor	A
J	30	Male	180	Student	B
K	30	Male	172	Car dealership	B
L	30	Female	160	Artist	B
M	31	Female	171	Company director	A

According to the Preliminary questionnaire, most of the testees have habit of eating extra foods out of 3 meals (Avg. 2.38 times for extra food intake per day). Relatively, they seldom do exercise in week (Avg. 1.08 times exercise per week). The result of preliminary is listed below (Figure 4.3):

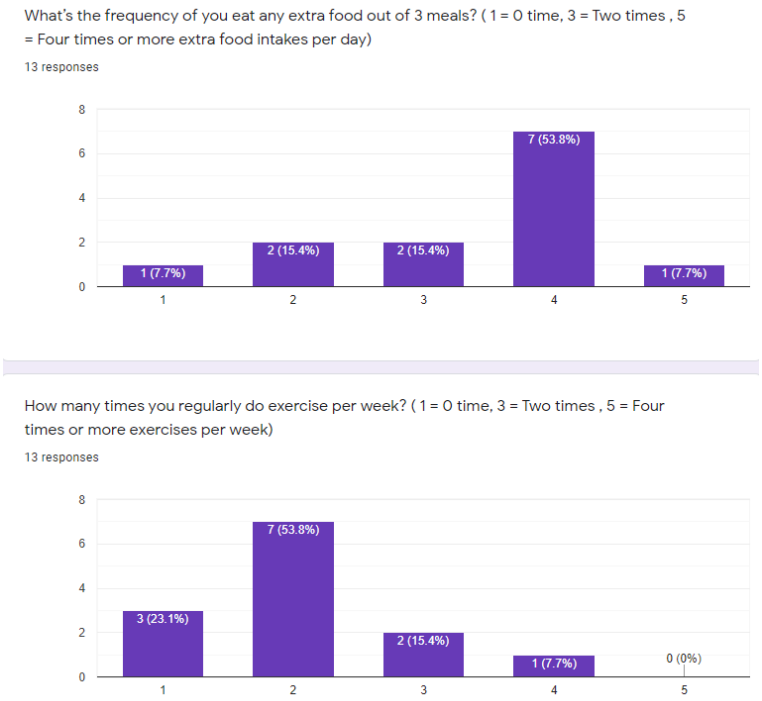

Figure 4.3 Preliminary questionnaire results

The results shows that even we can't not record the categories of extra foods from each testee, 2.38 times, or rounded as 2 extra times for eating out of 3 meals, plus merely one exercise per week can lead to gain weight, especially all testees are in the downhill of their metabolism.

The results of 13 testees' responses from General questionnaire are at Table 4.4. The correctness of all testees' estimations of amount of exercise based on their SAE shown at Table 4.5. Terms defined as:

WC (Correct) = Testee's Walking estimation matches with his / her SAE.

WW (Wrong) = Testee's Walking estimation does not match with his / her

SAE.

RC = Testee's Running estimation matches with his / her SAE.

RW = Testee's Running estimation does not match with his / her SAE.

WC rate = Rate of all testees' Walking estimation correctness.

RC rate = Rate of all testees' Running estimation correctness.

1 = Strongly disagree, 3= Neutral, 5 = Strongly agree

Table 4.3 Responses of General questionnaire

Question	1	2	3	4	5	Avg.rate
1			2	4	7	4.38
2				1	12	4.92
3				1	12	4.92
4				9	4	4.69
5		2	2	5	4	3.85
6	2	4	1	4	2	3.00
7	1	6		2	4	3.15
8	2	7	1		3	2.62
9	5	2	1	1	4	2.77
13	9		3	1		1.69
14	3	2	6	2		2.54
15	7	3		2	1	2.00
16	10	1	1	1		1.46

Table 4.4 Responses of amount of exercise estimation, Q10 - 12

Food	WC	WW	RC	RW	WC rate	RC rate
ESC	2	11	4	9	0.15	0.31
Digestive	1	12	3	10	0.08	0.23
Chips	1	12	4	9	0.08	0.31

In Question 1 to 4, most of the testees chose Agree or Strongly agree, which indicates four things: Their metabolism decreased (Q1, 4.38), they desire to keep in good body shape as their 20s (Q2, 4.92), they agreed with negative social norm toward obesity in their culture (Q3, 4.92) and they tend to have psychological pressure about gaining weight (Q4, 4.69). These results point out that people in 30s might have strong desire toward lose weight or keep in better shape, thus could more likely to use Nutrito for monitoring calorie intake.

Compare with Q5, Q6 to Q7, Q8, we can find that testees prefer to make adjustment on diet to control calories intake than to use exercise to burn out food calories. Through one of the expected goals of Nutrito is to motivate users follow the SAE to burn out the scanned foods' calories, the prevention of eating high calories foods could be more ideal to accomplish for the people in age 30s. The rate of Q9 shows that the frequency of whether testees check the nutrition labels distributes more evenly and close to neutral. (Q9, 2.77) The gamification part of Nutrito (The IR scanner) could be expected to motivate more users to aware the information of those labels.

For Q10 - Q12, testees examined the nutrition fact labels and predicted the amount of exercise based on the information of labels. Separated for Walking and Running, the correctness is low for both exercises as Table 4.5 shown. Combined with average rate of Q16 (Q16, 1.46), most of the testees agreed that nutrition facts label didn't help them to determine the amount of exercise they should do to burn out the foods. In other words, it was more likely that they did wild guess in Q10 to Q12, and could prove that Nutrito provides features that physical nutrition labels do not have.

Table 4.5 Average rates from Q13 to Q15, in both groups without Nutrito test

Question	A	B
13	1.71	1.67
14	2.86	2.17
15	2.00	2.00

The Q13 - 15 are the most important questions, aim to provide contrastive

results from Group A and Group B. The results of Q13 to Q15 will be discussed later, integrating with the answers after Group A used Nutrito. Before using it, the average rates of group A and group B in Q13 to Q15 are pretty similar. (Table 4.6) We will see how the results changed after prototype test.

4.3.5 Experiment procedures

The steps for Group A to conduct the experiment are:

- **1. Finish Preliminary questionnaire.**

- **2. Finish General questionnaire Read the information from nutrition facts labels carefully and answer Q10 to Q16, recording their selections of Q10 to 12.** (Figure 4.4)

Figure 4.4 Testee M in her step 2 examined the nutrition labels

- **3. Use researcher's Android phone which already downloaded MIT AI2 Companion, the intermediary of using app designed on MIT APP Inventor 2. Scan QR code from researcher's personal computer to login in Nutrito.**

Figure 4.5 Testee A in her step 3 shown the IR detection result

- **4. Scan each of the objects and receive SAE results based on their individual variations.** (Figure 4.5) (Figure 4.6)

- **5. Compare each food's SAE results with their predictions of Q10 to 12. Finish the Post-test questionnaire.** (Figure 4.7)

- **6. Finish feedback survey**

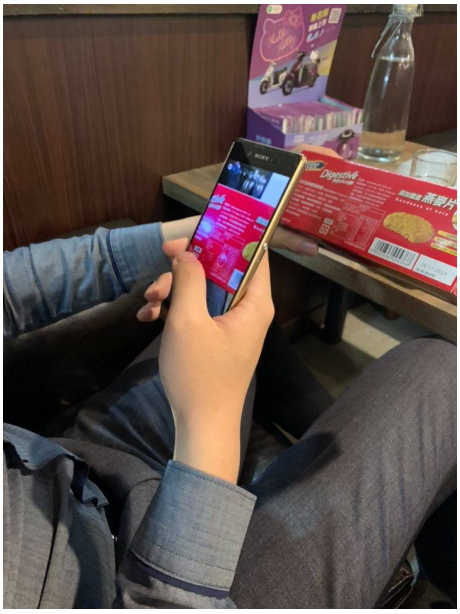

Figure 4.6 Testee F in his step 4 was using the IR scanner to scan Digestive biscuit

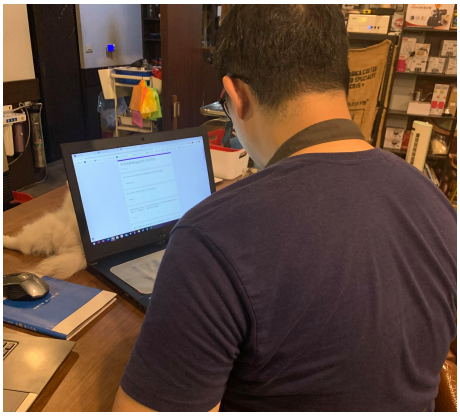

Figure 4.7 Testee B in his step 5 was finishing his post-test questionnaire

4.3.6 Final test result and discussions

(In this subsection, to distinguish from General questionnaire and Post-test questionnaire, the question numbers of Post-test will add * mark. Ex: Q1 and Q1*)

After the Nutrito experiment, Group A testees finished post-test questionnaire, which designed to contrast with Group B's attitude toward consider buying or eating the scanned objects. The result of comparison between previous estimation in Q10-12 and SAE from Nutrito shown as below:

Table 4.6 Group A Responses of amount of exercise estimation, Q10 - 12

Food	WC	WW	RC	RW	WC rate	RC rate
ESC	1	6	3	4	0.14	0.43
Digestive	0	7	2	5	0.00	0.29
Chips	1	7	3	4	0.14	0.43

Based on the results of Table 4.7, we could have the same finding as section 4.3.4 that the nutrition facts label cannot help both group's testees to determine the amount of exercise they should do in order to burn out the food's calories. With the help of Nutrito, users can receive a new form of exercise amount-related information that the traditional labels doesn't have. Combined with both results, the research proved to match the primary goal mention in section 1.3: **To provide information to users, making them understand the relatively meaning of calories of scanned objects to the amount of exercise based on individual variation** and the category of this thesis: Design.

For the evaluations of hypothesis : **If the suggested amount of exercise exceeds users' estimation, they will consider to stop buying or eating the scanned food object.**, we take a look at Table 4.8. Average rate of Q3* and Q4* indicates **the SAE of ESC didn't exceed Nutrito users' (Testees') estimation (1.86), so their intention of buying or eating the ESC didn't change. (1.29)** For Q7* and Q8*, users were neutral to agree toward the **SAE of Digestive biscuit slightly exceeds their estimation (3.86), but they**

Table 4.7 Group A and Group B's contrast of intention to buy or eat scanned foods (Nutrito V.S. Nutrition facts label)

Question	1	2	3	4	5	Avg. Rate	Group B rate
3*	4	3	1			1.86	
4*	6	1				1.29	1.67
7*		2		2	3	3.86	
8*	0			4	3	4.43	2.17
11*				2	5	4.71	
12*		1		1	5	4.43	2.00

still firmly considered to stop buying or eating it. (4.43) The claim stays coherent with Q11* and Q12*, **which most of the users strongly agreed the SAE of chips exceeds their estimation and thus agreed that they will stop eating or purchasing Original chips.** We can also find out from the rate comparison that **Group A testees tended to keep distance with scanned foods with high SAE, or high calories**, while Group B disagreed to strongly disagreed that they will stop eating or purchasing the 3 food objects after reading the calories information of nutrition labels. Based on the foregoing user test results, the hypothesis of this research should be proved.

Table 4.8 Group A's rate of "After I receive the SAE of the scanned food from Nutrito, I will stop to purchase or eat it." before and after test

Food	Before Test	After test
ESC	1.71	1.29
Digestive	2.86	4.43
Chips	2.00	4.43

In the addition, we have an extra finding with comparing Group A testees' previous answers in General questionnaire and answers after using Nutrito. The

change of two questionnaires shown in Table 4.9, which points out that after test, testees became more intentional to buy or eat ESC, the lowest SAE food. In contrast, the SAE results seemed to have strong deterrent effect to Digestive biscuit and Original chips, from 2.86 to 4.43 and 2.00 to 4.43. Thus we can also claim one of the expected contributions : **To prevent them from consuming unnecessarily calories (The extra foods intake other than three meals) with those especially reflected to high SAE** should also be accomplished.

4.4. User survey and interview feedback

After the test, in order to evaluate their acceptance of Nutrito, Group A testees were asked to fill out the user survey and several of them provided personal feedback in interview. The survey questions are listed in Appendices, and the rate of each questions listed below:

Table 4.9 Responses of feedback survey

Question	1	2	3	4	5	Avg.rate
1					7	5.00
2					7	5.00
3					7	5.00
4				2	5	4.71
5				2	5	4.71
6					7	5.00
7					7	5.00
8					7	5.00

Overall, the users' feedback are positive. Q1 examines the convenience of using Nutrito, and all the users strongly agreed the mechanism of using Nutrito was simple and easy to understand. Q2 retrieved the same question in questionnaire of Juan, Charco, Garcia and Molla's research. [22] It's important to realize if the physical mechanism of using app is not troublesome to users' hands, so Nutrito could be anticipated to be user friendly and apply in all ages. Testee A suffered

from a long term wrist tendonitis based on her job, but she provided a feedback that IR scanner is speedy, so she didn't need to hold smartphone for a long time during scanning.

In Q3, all testees strongly agreed with the experience of using IR scanner was novel and interesting to them. All of the testees do not have the experience of IR detection; most of them felt surprised to see Nutrito could precisely detect the nutrition labels from different foods in 3 seconds. Testee G, who described himself as a management person who mostly work hard and lacks information for technology, said Nutrito's IR scanner was "Magical" to him. In Q4, 2 of the testees, the testee B and I failed for first time of IR scanning, thus they agree but not strongly agree with the accuracy.

Q5 and Q6 ask for users' feeling toward SAE results. Testee C and Testee H chose agree in Q5 for C wished to provide more kinds of exercises in SAE and E thought it will be better to provide accurate SAE calculation for people overweight as him since he definitely couldn't be count as a average weight person of his age. All testees strongly agreed that they got a clear direction of how much exercise in walking and running they should do to burn out the calories of scanned packaged foods.

Q7 and Q8 collect testees' thoughts for Nutrito in future reality. Testee I said even she won't give up to eating her favorite food, the chips, the SAE now taught her to consider about dividing a pack of chips in different times of eating. Testee M, a food lover, workout hobbyist and a long time user of My FitnessPal, mentioned that she will feel interesting to explore different SAE secrets behind her favorite packaged foods in the market, as she thought to scan the Nutrition labels by Nutrito will be more interesting than scanning a barcode for just adding their nutritional facts as the competitor nutritional apps.

Chapter 5
Conclusion

5.1. Validation of concept

This research presents the prototype of "Nutrito", a Image recognition featured nutrition smartphone application. The design of Nutrito involves the idea of applying image classification to the nutritional facts labels of different packaged foods, analyze their calories and provide the Suggested Amount of Exercise (SAE) to the users.

Start from age 25 and mostly be awarded around age 30, human's metabolism slowly decreases until the death. In many countries around the world, social norms, discrimination and misunderstandings are toward to overweight or obesity population. Obesity is not guilty, people have the freedom to choose the lifestyle they wish; in another concept, Nutrito could provide a possible choice for those people who feel pressure from gaining weight through aging, or wish to keep the same, healthy body shape as their youth. In addition, the SAE aim to provide users another exercise related quota, making them understand the relatively meaning of calories of scanned objects to the amount of exercise they should do.

Based on the result of final user test, the hypothesis of this research: "**If the suggested amount of exercise exceeds users' estimation, they will consider to stop buying or eating the scanned food object.**" is proved. Group A testees showed consistency of their responses that they agreed to strongly agreed (Both rated 4.33 to Digestive biscuits and Chips) that they would not buy or eat the foods which SAEs' exceeded most of their estimations. In contrast, for ESC which shows lower SAE, testees' intentions to buy or eat it also increased, thus we can also claim that if the SAE doesn't exceed users' estimation, their intention toward buying or eating it may not be influenced.

5.2. Limitations

The SAE database of Nutrito still has limitations for the nutritional theories based on the calculation of metabolism with suggested amount of exercise. In this research, the calorie defined as the only factor to influence on the amount of exercise users should do. In nutritional theories, the carbohydrate, fats and sugars can also bring different impacts on the length of exercise time, which is unable to be calculated in this research based on the lack of knowledge for professional Nutrition. The weight is also acting as a key factor of the effectiveness of burning calories through exercises. By the Table 3.2, we can observe the higher a person is, the lower SAE he or she needed to burn the calories of each foods. It would be interesting for analyzing how would different weights put influence on each individuals, if more creditable researches and related works on this topic could be referred.

In addition, the accuracy of Nutrito's IR scanner is not perfect yet. Some of the factors influenced on the correctness in the test which leaded to wrong food detects could be the light of the testing environment, the utility of the Android phone itself (The tested device Z3+ is a old smartphone), or the distance from labels to the camera. Those influences were not be discovered through this research, but the relationships of the result and environmental factors could be creditable for the IR app developers to aware in the future.

5.3. Future work

In this research, the prototype of Nutrito introduces a new possible design of nutrition apps. Due to the lack of technological coding skills and knowledge, Nutrito prototype applied relatively limited data in nutrition, metabolism and calculation formula of exercise time to represent the idea of functionality. It will be anticipate that in the future, an advanced model of Nutrito which will provide accurate nutrition label IR scanner in all kinds of packaged foods and beverages, plus a renewed database which will contain precise Suggested Amount of Exercise calculations in users' height, weight, age, gender and even their body fat percentage. As more researches will be done, the categories of SAE exercises will also be expanded. Not only just walking and running, but probably swimming, workout, basketball or any kind of sport the user prefers will be show up, in order to motivate them to do these favorite exercises to burn out the scanned foods calories. In addition, the Contribution part mentioned at section 1.3, the Nutrito would provide different suggestion to people who might be older and harder to do exercises and might less concern for keeping the skinny body shape. The replaced information or knowledge for how the nutrition of scanned food related to diseases caused by unhealthy diet would be broadly, such as fat to heart disease and stroke, sodium to dialysis, and sugar to diabetes. Last but not least, one of the further steps of Nutrito would be the new interface after the SAE result page. What if the users are eating the scanned food while using Nutrito and would like to do some exercise after they receive this SAE information? An "Exercising" page can be applied, calculating the foot steps, running speed and time length once users start to count based on the accelerometer set in smartphones, or even an action monitor combined with the smartphone as a dumbbell that teaches users to stretch their muscles in correct angles. Those future sports related features would improve Nutrito as an multi-functional (All in one), convenient and gamification nutrition app.

References

[1] Rebecca M. Puhl and Chelda A. Heuer. *Obesity Stigma: Important Considerations for Public Health*, volume 100. American Journal of Public Health, 2010.

[2] Azumio Inc. Calorie mama, instant food recognition a smart camera app that uses deep learning to track nutrition from food images. 2017. [Online; accessed Nov 24, 2020]. URL: `https://caloriemama.ai/#CalorieMama`.

[3] The Community Research and Development Information Service (CORDIS). Nutrition labelling: not as effective as you might think. European Commission. URL: `https://cordis.europa.eu/article/id/34314-nutrition-labelling-not-as-effective-as-you-might-think`.

[4] Adela Hruby and Frank B. Hu. *The Epidemiology of Obesity: A Big Picture.* 33(7). Pharmacoeconomics, 2015. `doi:10.1007/s40273-014-0243-x`.

[5] Schwartz Puhl RM and Brownell. Impact of perceived consensus on stereotypes about obese people: a new approach for reducing bias. 24(5), pages 517–525. Health Psychol, 2005. `doi:10.1007/s40273-014-0243-x`.

[6] Haase A. M. Wardle, J. and A. Steptoe. Body image and weight control in young adults: international comparisons in university students from 22 countries. 30, pages 644–651. International Journal of Obesity, 2009. `doi:10.1038/sj.ijo.0803050`.

[7] Harvard Medical School. Does metabolism matter in weight loss? Harvard Medical Publishing, 2017. URL: `https://www.health.harvard.edu/diet-and-weight-loss/does-metabolism-matter-in-weight-loss`.

[8] Ryan Raman. Why your metabolism slows down with age. HEALTHLINE, 2017. URL: https://www.healthline.com/nutrition/metabolism-and-age.

[9] MacLean P. S. Hill J. O. Melanson, E. L. Exercise improves fat metabolism in muscle but does not increase 24-h fat oxidation. 37(2), 2009.

[10] Katie Heaney. So what really happens to your metabolism after 30? THE CUT, 2018. URL: https://www.thecut.com/2018/08/how-much-does-metabolism-drop-after-age-30.html.

[11] Fitnesshealth 101. Variables that affect your basal metabolic rate (bmr). 2020. [Online; accessed Nov 24, 2020]. URL: http://www.fitnesshealth101.com/index.php?option=com_content&view=article&id=22&Itemid=33.

[12] William E Kraus, Manjushri Bhapkar, Kim M Huffman, Carl F Pieper, Sai Krupa Das, Leanne M Redman, Dennis T Villareal, James Rochon, Susan B Roberts, Eric Ravussin, John O Holloszy, Luigi Fontana, and the CALERIE Investigators. 2 years of calorie restriction and cardiometabolic risk (calerie): exploratory outcomes of a multicentre, phase 2, randomised controlled trial. volume 7 of *9*, pages 673–683. THE LANCET, 2019. doi:10.1016/S2213-8587(19)30151-2.

[13] Erin Brodwin. The biggest reason you gain weight as you age has nothing to do with your metabolism. Business Insider, 2016. URL: https://www.businessinsider.com/how-to-not-gain-weight-with-age-2016-8.

[14] Statista. Smartphone penetration rate japan 2017, by age group published by statista research department, oct 13, 2020 more than 90 percent of the population in japan aged 20 to 29 years were smartphone users as of 2017. the second highest smartphone penetration rate was measured among people aged between 30 to 39 years. smartphone penetration rate among the population in japan as of end of 2017, by age group. 2020. [Online; accessed Nov 24, 2020]. URL: https://www.statista.com/statistics/687678/japan-smartphone-penetration-rate-by-age/.

[15] Mary Forgione. What's the most popular workout in the world? Los Angeles Times, 2015. URL: https://www.latimes.com/travel/la-trb-fitbit-global-workouts-20150824-story.html.

[16] U.S Food and Drug Administration. Food labeling and nutrition. U.S Food and Drug Administration. URL: https://www.fda.gov/food/food-labeling-nutrition.

[17] HealthLine. The best nutrition apps of 2020. HealthLine. URL: https://www.healthline.com/health/food-nutrition/top-iphone-android-apps.

[18] Pomegranate Apps LLC. Nutrients - nutrition facts, recipe manager food journal. 2020. [Online; accessed Nov 24, 2020]. URL: https://apps.apple.com/us/app/nutrients-nutrition-facts/id396836856#?platform=iphone.

[19] Inc. Under Armour. Myfitnesspal. 2020. [Online; accessed Nov 24, 2020]. URL: https://apps.apple.com/mo/app/myfitnesspal/id341232718.

[20] Cambridge Dictionary. Meaning of gamification in english. URL: https://dictionary.cambridge.org/us/dictionary/english/gamification.

[21] IBM Cloud Education. Machine learning. 2020. URL: https://www.ibm.com/cloud/learn/machine-learning.

[22] M.-Carmen Juan, Jorge L. Charco, Inmaculada García-García, and Ramón Mollá. An augmented reality app to learn to interpret the nutritional information on labels of real packaged foods. Frontiers in Computer Science, 20 June 2019. URL: https://doi.org/10.3389/fcomp.2019.00001, doi:10.3389/fcomp.2019.00001.

[23] The Coding Bus. How to create image classifier app in mit app inventor 2. URL: https://www.youtube.com/watch?v=DeN0ttCSltY&list=LL&index=8.

[24] The Coding Bus. How to create personal image classifier app in mit app inventor 2 [ai app]. URL: https://www.youtube.com/watch?v=K8qsy2ftG18&list=LL&index=9.

[25] Wikipedia. App inventor for android from wikipedia, the free encyclopedia. Wikipedia, 2020.

[26] Scratch Team. The scratch 3.0 development environment on startup. March 31 2019. [Online; accessed Nov 24, 2020]. URL: https://en.wikipedia.org/wiki/Scratch_(programming_language)#/media/File:Scratch_3.0.jpg.

[27] Banner Health. Do i have body dysmorphia? Jun 09 2020. [Online; accessed Nov 24, 2020]. URL: https://www.bannerhealth.com/healthcareblog/teach-me/do-i-have-body-dysmorphia.

[28] BRAND'S. Essence of chicken 68ml.

[29] McVitie's. Digestive oat flavor 300g.

[30] Lay's. Original flavor 97g chips.

[31] Dariush Mozaffarian, Tao Hao, Eric B. Rimm, Walter C. Willett, and Frank B. Hu. Changes in diet and lifestyle and longterm weight gain in women and men. volume 364(25). The NEW ENGLAND JOURNAL of MEDICINE, 2011. URL: https://www.foodpolitics.com/wp-content/uploads/NEJMoa1014296.pdf.

[32] Jacob Schor. The potato chip study study confirms links between specific foods and weight loss or gain. volume 3(7). Natural Medicine Journal, 2011. URL: https://www.foodpolitics.com/wp-content/uploads/NEJMoa1014296.pdf.

[33] Mordor Intelligence. Potato chips market growth, trends and forecast (2020 - 2025). Research and Markets, 2020.

[34] areppim. Average weight for men. Last Updated: 11/08/2018 16:59:23. [Online; accessed Nov 24, 2020]. URL: https://stats.areppim.com/stats/stats_weight_avgmale.htm.

[35] American College of Sports Medicine. Complete guide to fitness and health 2nd edition. Human Kinetics, 2017.

[36] Paige Waehner. How to calculate the calories you burn during exercise. April 10, 2020. [Online; accessed Nov 24, 2020]. URL: https://www.verywellfit.com/how-many-calories-you-burn-during-exercise-4111064.

[37] Catrine Tudor-Locke, Ho Han, Elroy J Aguiar, Tiago V Barreira, John M Schuna Jr, Minsoo Kang, and David A Rowe. How fast is fast enough? walking cadence (steps/min) as a practical estimate of intensity in adults: a narrative review. *British Journal of Sports Medicine*, 52(12):776–788, 2018. URL: https://bjsm.bmj.com/content/52/12/776, arXiv:https://bjsm.bmj.com/content/52/12/776.full.pdf, doi:10.1136/bjsports-2017-097628.

[38] Jane Chertoff. How fast can i run one mile? averages by age group and sex. HealthLine, 2019. URL: https://www.healthline.com/health/average-mile-time.

[39] Krista Sheehan.

[40] 厚生労働省. 基礎代謝 - 厚生労働省：日本人の食事摂取基準（2010 年版）. Wikipedia, 2010.

Appendices

A. MIT App Inventor resources

The following resources were been used to created the Nutrito prototype. All these resources are free for public to use.

A.1 MIT App Inventor 2

The home page of MIT App Inventor 2. Through it is free, users need to aware that it only applies to Android system. (By the time of Nov. 2020)

http://appinventor.mit.edu/

A.2 Personal Image Classifier

An expansion that users can train their models and build their image recognition functions in MIT App Inventor 2 without complicated coding skills.

https://mit-cml.github.io/extensions/

A.3 Personal Image Classifier tutorial videos

Online tutorial classes for users to learn how to use the Personal Image Classifier.

https://appinventor.mit.edu/explore/resources/ai/personal-image-classifier

B. First User test questionnaire

- **Q1: How often you would consider if the food will gain your weight before eat it?**

  1: Never 2: Seldom 3: Neutral 4: Generally 5: Always

- **Q2: How often you do exercise for burning calories from foods?**

  1: Never 2: Seldom 3: Neutral 4: Generally 5: Always

- **Q3: After you entered your 30s, do you ever feel your metabolism decreases? (If you eat some amount of food, you become easily to gain weight compare to your 20s.)**

  1: Strongly disagree 2: Disagree 3: Neutral 4: Agree 5: Strongly agree

- **Q4: Your weight trend after 30s becomes: (Decrease / Increase = 2 lbs per year, Slightly decrease / increase = 1lb per year)**

  1: Decrease 2: Slightly decrease 3: Keep same 4: Slightly increase 5: Increase

- **Q5: Gaining weight brings me pressure.**

  1: Strongly disagree 2: Disagree 3: Neutral 4: Agree 5: Strongly agree

- **Q6: I felt angry or anxious for gaining weight.**

1: Strongly disagree 2: Disagree 3: Neutral 4: Agree 5: Strongly agree

- **Q7: Based on your online / offline experience, the frequency of you checking the Nutrition labels is:**

  1: Never 2: Seldom 3: Neutral 4: Generally 5: Always

- **Q8: Please evaluate the following statement: " I receive enough information from reading the ESC and Digestive food labels that indicates me how much exercise I should do to burn their calories."** (In this question, testees would first view ESC and Digestive nutrition labels to answer.)

  1: Strongly disagree 2: Disagree 3: Neutral 4: Agree 5: Strongly agree

- **Q9: How many different kinds of apps you use per day?**

  1: Never 2: Seldom 3: Neutral 4: Generally 5: Always

Table B.1 Responses in 1st user test questionnaire

Questions	A	B	C	D	E	Avg
1	5	4	5	4	2	4
2	3	1	4	5	1	3.4
3	5	5	5	5	4	4.8
4	4	4	5	4	5	4.4
5	5	4	4	5	4	4.4
6	5	4	5	5	3	4.4
7	5	2	3	2	1	2.6
8	1	1	1	1	1	1
9	5	5	5	5	5	5

C. Preliminary questionnaire

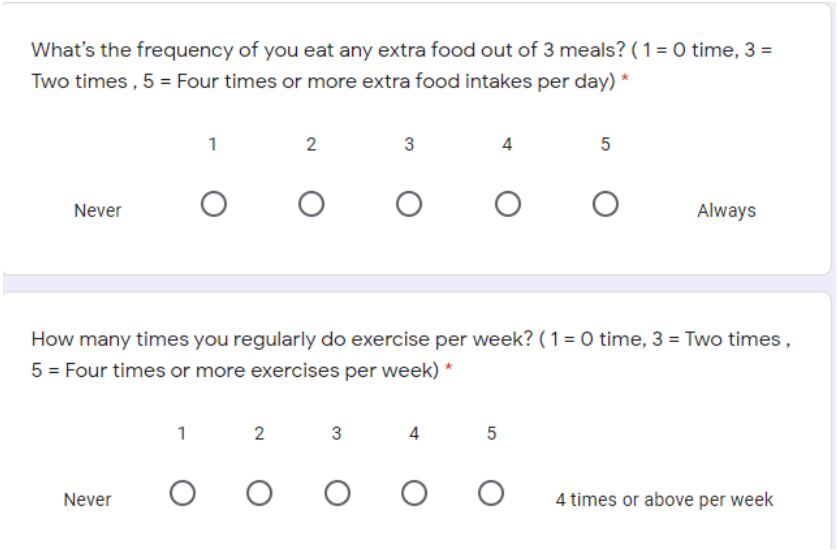

Figure C.1 Questions of preliminary questionnaire in Section 4.3.4

D. General questionnaire

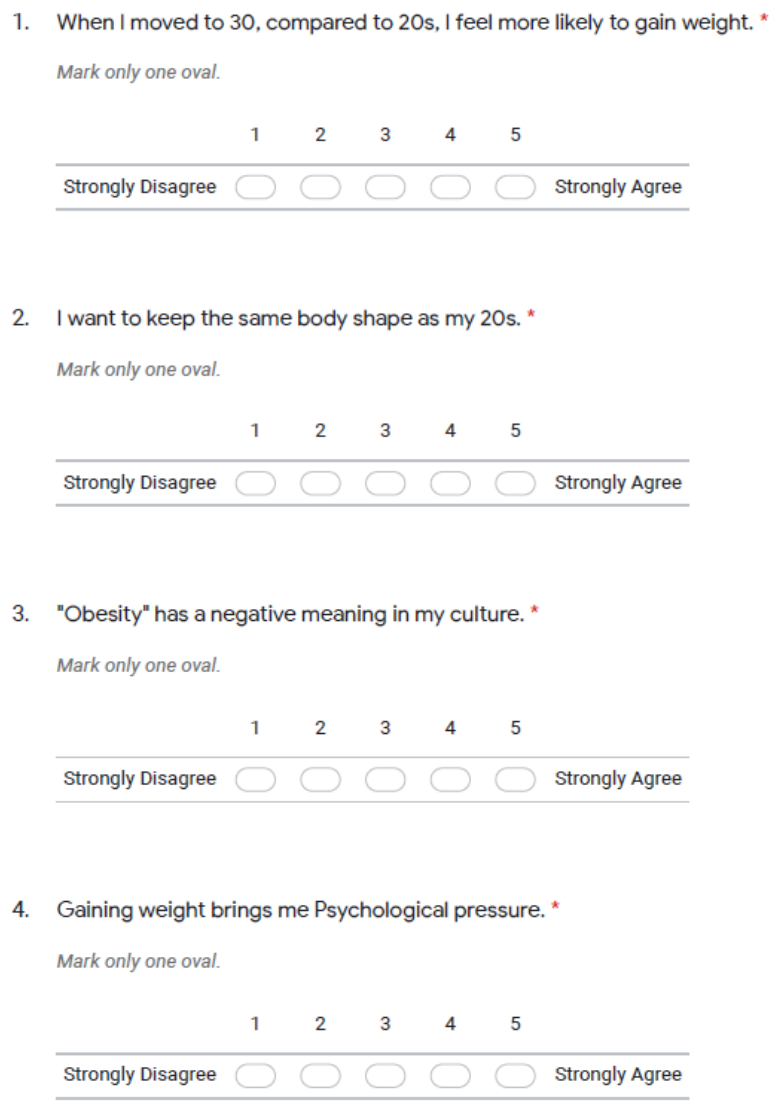

Figure D.1 Questions of General questionnaire in Section 4.3.4, Part A

5. I decrease my calorie intake when I gain weight. *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

6. I decrease my calorie intake even when my weight deceases or stays the same. *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

7. I do exercise regularly when I gain weight. *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

8. I do exercise regularly even when my weight deceases or stays the same. *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

9. I examine the nutrition facts label when I purchase packaged foods. (1 =0%, 5=100%) *

Mark only one oval.

	1	2	3	4	5	
Never	◯	◯	◯	◯	◯	Always

Figure D.2 Questions of General questionnaire in Section 4.3.4, Part B

10. Please check the label of ESC and determine what's the amount of exercise to burn its calories. *

Mark only one oval per row.

	Less than 5 mins	6 - 10 mins	11- 15 mins	16 - 20 mins	21 - 25 mins	26 - 30 mins	More than 30 mins
Walking	◯	◯	◯	◯	◯	◯	◯
Running	◯	◯	◯	◯	◯	◯	◯

11. Please check the label of Digestive and determine what's the amount of exercise to burn its calories. *

Mark only one oval per row.

	Less than 10 mins	11 - 20 mins	21 - 30 mins	31 - 40 mins	41 - 50 mins	51 - 60 mins	More than 60 mins
Walking	◯	◯	◯	◯	◯	◯	◯
Running	◯	◯	◯	◯	◯	◯	◯

12. Please check the label of Chips and determine what's the amount of exercise to burn its calories. *

Mark only one oval per row.

	Less than 30 mins	31 - 60 mins	61 - 90 mins	91 - 120 mins	121 - 150 mins	151 - 180 mins	181 - 210 mins	211 - 240 mins	More than 4 hours
Walking	◯	◯	◯	◯	◯	◯	◯	◯	◯
Running	◯	◯	◯	◯	◯	◯	◯	◯	◯

13. Based on the calorie information received from the nutritionfact labels, I won't consider to purchase or eat the ESC. *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Figure D.3 Questions of General questionnaire in Section 4.3.4, Part C

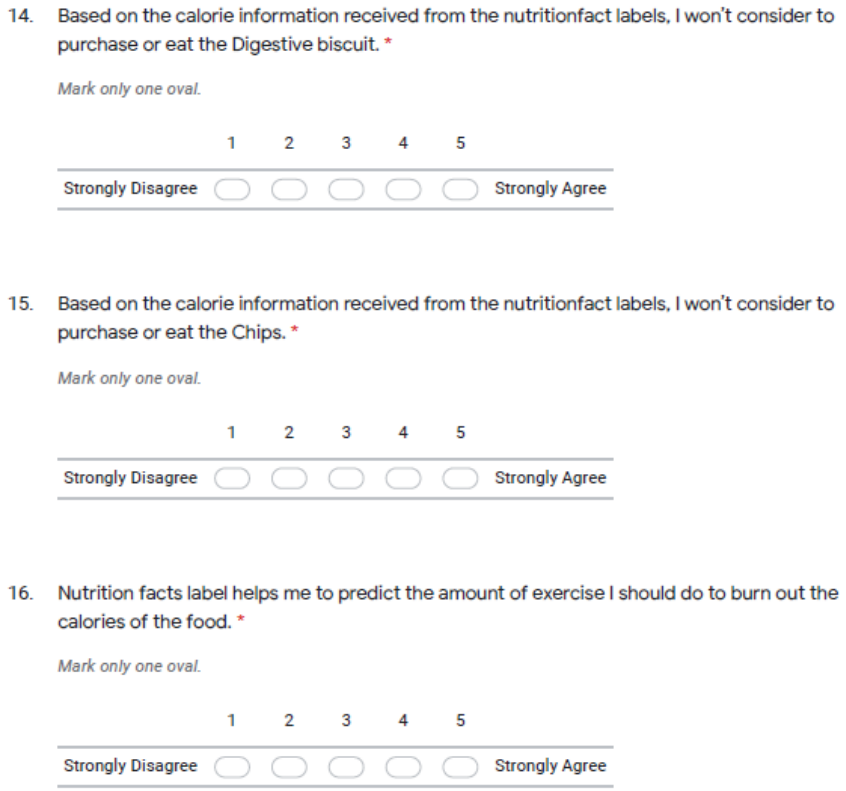

Figure D.4 Questions of General questionnaire in Section 4.3.4, Part D

E. Post-test questionnaire

1. After you scanned the ESC, does your previous prediction of walking amount match with your SAE? *

   Mark only one oval.

   ◯ Yes
   ◯ No

2. After you scanned the ESC, does your previous prediction of running amount match with your SAE? *

   Mark only one oval.

   ◯ Yes
   ◯ No

3. The SAE of burning the calories of a ESC exceeds / more than my estimation. *

   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

4. After I receive the SAE of a can of ESC from Nutrito, I will stop to purchase or eat it. *

   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

5. After you scanned the Digestive biscuit, does your previous prediction of walking amount match with your SAE? *

   Mark only one oval.

   ◯ Yes
   ◯ No

Figure E.1 Questions of Post-test questionnaire in Section 4.3.6, Part A

6. After you scanned the Digestive biscuit, does your previous prediction of running amount match with your SAE? *

   Mark only one oval.

   - ◯ Yes
   - ◯ No

7. The SAE of burning the calories of a Digestive biscuit exceeds / more than my estimation. *

   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

8. After I receive the SAE of a Digestive biscuit from Nutrito, I will stop to purchase or eat it. *

   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

9. After you scanned the Original chips, does your previous prediction of walking amount match with your SAE? *

   Mark only one oval.

   - ◯ Yes
   - ◯ No

10. After you scanned the Original chips, does your previous prediction of running amount match with your SAE? *

    Mark only one oval.

    - ◯ Yes
    - ◯ No

Figure E.2 Questions of Post-test questionnaire in Section 4.3.6, Part B

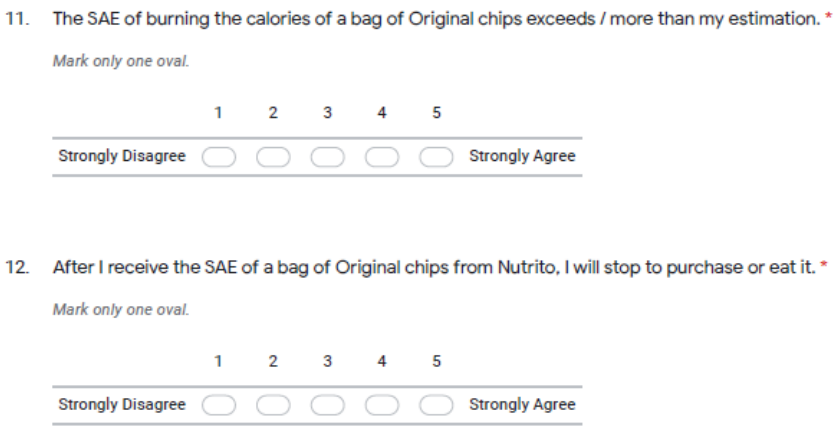

Figure E.3 Questions of Post-test questionnaire in Section 4.3.6, Part C

F. User survey

1. The usage of the Nutrito is simple and clear. *

   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

2. The movement of using the smartphone to scan the Nutiriton facts labels did not reuqire a great effort of my hands. (Fingers, wrists, arms) *

   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

3. The experience of operating the Image Recogintion (IR) scanner was novel and interesting. *

   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

4. The accurancy of IR result was high. *

   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Figure F.1 Questions of User survey in Section 4.4, Part A

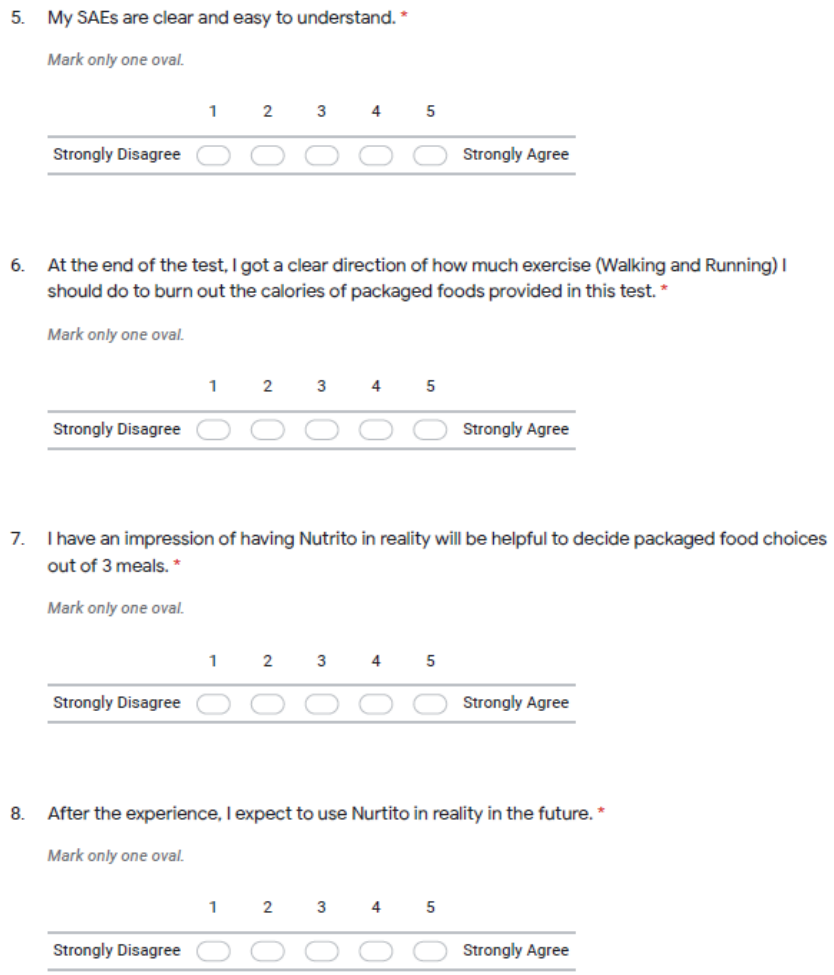

Figure F.2 Questions of Post-test questionnaire in Section 4.4, Part B

G. Preliminary questionnaire Results

Table G.1 Preliminary questionnaire Results

Testee	Q1	Q2	Group
A	4	2	A
B	4	1	A
C	2	2	A
D	2	1	B
E	3	1	B
F	4	2	A
G	3	2	B
H	5	2	A
I	4	3	A
J	4	2	B
K	4	3	B
L	4	2	B
M	1	4	A

H. General questionnaire Results

Table H.1 General questionnaire Results

Te	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q13	Q14	Q15	Q16
A	5	5	5	5	4	2	4	2	5	1	3	2	1
B	5	4	5	5	3	1	2	1	2	1	1	1	1
C	5	5	5	5	5	5	4	3	5	1	4	1	2
D	5	5	5	4	4	2	1	1	3	1	1	4	1
E	3	5	4	2	2	2	2	2	1	3	3	1	1
F	4	5	5	4	4	4	2	2	1	1	3	2	1
G	4	5	5	5	5	4	5	2	5	1	2	1	1
H	5	5	4	4	1	2	2	2	1	1	3	2	1
I	3	5	5	5	5	4	5	5	2	4	4	1	1
J	4	5	5	4	4	3	2	2	5	3	3	4	3
K	5	5	5	4	4	2	5	5	1	3	2	1	1
L	5	5	5	5	5	4	2	2	1	1	1	1	4
M	4	5	5	5	3	5	5	4	3	1	3	5	1

Table H.2 Amount of exercise estimation Results (Walk min, Run min)

Testee	Q10	Q11	Q12
A	(11-15, 6-10)	(31-40, 21-30)	(151-180, 61-90)
B	(11-15, 6-10)	(31-40, 21-30)	(91-120, 61-90)
C	(11-15, less 5)	(21-30, 1-5)	(91-120, 31-60)
D	(6-10, 6-10)	(31-40, 11-20)	(121-150, 91-120)
E	(26-30, 11-15)	(51-60, 21-30)	(91-120, 31-60)
F	(less 5, less 5)	(21-30, 11-20)	(91-120, 61-90)
G	(11-15, 6-10)	(31-40, 21-30)	(151-180, 91-120)
H	(6-10, less 5)	(21-30, less 5)	(151-180, 61-90)
I	(26-30, 11-15)	(51-60, 21-30)	(211-240, 31-60)
J	(16-20, 6-10)	(51-60, 31-40)	(181-210, 91-120)
K	(6-10, less 5)	(11-20, less 10)	(31-60, less 30)
L	(16-20, 11-15)	(31-40, 21-30)	(211-240, 181-210)
M	(11-15, 6-10)	(21-30, 11-20)	(151-180, 61-90)

I. Post-test questionnaire & User survey Results

Table I.1 Post-test questionnaire Results

Testee	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
A	N	N	3	2	N	N	5	4	Y	Y	5	5
B	N	N	2	1	N	N	5	5	N	N	4	4
C	N	Y	1	1	N	Y	5	4	N	Y	5	5
F	Y	Y	1	1	N	N	4	4	N	N	5	5
H	N	Y	2	1	N	Y	2	4	N	N	4	5
I	N	N	1	1	N	N	2	5	N	Y	5	2
M	N	N	1	1	N	N	4	5	N	N	5	5

Table I.2 User Survey Results

Testee	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
A	5	5	5	5	5	5	5	5
B	5	5	5	4	5	5	5	5
C	5	5	5	5	4	5	5	5
F	5	5	5	5	5	5	5	5
H	5	5	5	5	4	5	5	5
I	5	5	5	4	5	5	5	5
M	5	5	5	5	5	5	5	5