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A Human Centred Study on Smarthome Based Food Detection System

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Dear Professor Abbosh,

In accordance with the requirement of the Degree of Master of Interaction Design in the School of Information Technology and Electrical Engineering, I submit the following thesis entitled

"A Human Centred Study on
Smarthome Based Food Detection System"

The thesis was performed under the supervisor of Peter Worthy and Jacki Liddle. I declare that the work submitted in thesis is my own, except as acknowledge in the text and footnotes, and has not been previously submitted for a degree at the University of Queensland or any other institution.

Yours sincerely
Liqian YOU

To ….

I would like to express the sincere and deep gratitude to my father Zhenjian YOU who has been the most incredible financial and mental support throughout this year.

Without his assistance, patience and understanding, I would not have been capable of completing this thesis, or indeed my program.

Abstract

In the information technology age, smart home technologies have been increasingly penetrating people's everyday life. Modern technologies may pave an avenue for smart home devices such as audio and video entertainment systems, home security systems, smart kitchen appliances and healthcare monitoring systems. With the revolution of internet and computer, smart homes have made people's life more efficiency and wellbeing. Currently, dietary related diseases such as obesity, diabetes and cerebrovascular diseases brings the awareness of food intake and dietary care. Whereas nutrition from dietary plays a fundamental role in people's health, the number of people with medical conditions with specific dietary requirements are relatively increasing.

The smarthome based food detection system has been emerging and changed people's attitude towards dietary care and nutrition monitoring by using mobile applications. A variety of mobile applications can be used to support dietary, but they have a considerably poor uptake for general publics. Researchers and technologies developers are focusing on the pressing issues related to privacy, security, and accuracy of the food detection system. Besides, many researches in terms of human computer interaction exploring the user experience of food detection and nutrition monitoring apps, but few studies have explored the acceptability of novelty from the early adopter. Therefore, we need further investigation on the acceptance consideration rather than usability on smarthome based food detection systems through user involvement evaluation.

In this project, a smarthome based food detection system — FoodCare was developed for special groups with specific dietary requirements including seniors, vegetarians and pregnant women to detect food and monitor health diets. This thesis focuses aims at exploring the usability and acceptability consideration of a novel smart home system for the early users. Quantitative and qualitative research approaches including online survey and interview are employed to address domain problems and establish requirements in the early design process. Conceptual design such as mind mapping and personas are used to identify the target audience and their requirements for idea generation. Digital prototyping is designed for user experience evaluation. In the iterative design process, evaluation methods such as TAM and SUS survey are employed to access its usability, functionality and acceptance. More results and outcomes related to the human based interaction are presented in the final sections.

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Chapter 1 Introduction

In the era of information and technology, the rapid development of hardware and software leads to the innovation of smart homes including IoT (Internet of Things), information and communication technologies (ICTs), AI(artificial intelligence) and a variety of technologies integrating into human's everyday life[1]. Smart home technologies have been leading to a series of technological innovations in the past few decades. A variety of smarthome based electrical appliances integrating with smart elements bring more remarkable and fascinating life experiences, which become increasingly popular to the general publics[6]. According to the statistics, there are over 175 million smart homes worldwide[33]. Regarded as modern homes, smart homes are associated with household smart devices and appliances connected with one other, allowing users to remote control[33]. Smart home technologies can be generally divided into four categories, which are smart entertainment systems, monitoring and security systems, smart kitchen systems and home automation systems. These smart home systems focus on improving people's wellness and fitness, bringing more efficiency and convenience as well as creating a wellbeing lifestyle. Smart homes have several benefits of energy and cost efficiency, customization and ease of mobility, but they are facing diversity of issues as well. The pressing challenges are related to the privacy and cyber security in the technology aspect[4], as well as the usability and acceptance in the user perspectives[1].

Dietary is essential in people's daily life and adequate nutrition from dishes plays a fundamental role in our body health. Unhealthy diet and junk food intake may cause dietary-related diseases including overweight, obesity, heart diseases, cancers, osteoporosis, and diabetes are becoming one of the most pressing issues[10]. The awareness of food detection for health dietary has been raising in recent years, and a variety of people monitor their diet for different reasons[10]. Dietary care and food detection technologies may provide an approach for people to monitor diet and nutrition. However, these novel technologies are considerably poor uptake due to their uncertainty privacy, security or accuracy, and it is inevitable to understand how these early adopters consider and accept them. According to the literature review, there are a wide range of studies related to food detection techniques such as deep learning method of Convolutional Neural Network (CNN) and Deep Neural Network (DNN)[17-18], as well as mobile applications with nutrition monitoring and dietary recommendations, while few researches are relevant to the usability and acceptance of food detection systems. Therefore, further investigation on the smarthome based food detection system is a necessity.

This thesis project aims at further exploring the requirements on the smarthome based food detection system accept smarthome based food detection system and manage their expectations through human-centred research. This project is wholly completed following these four steps: research, design, development and evaluation. At the beginning, quantitative and qualitative research methods are used to identify target audience and investigate their needs on smart home technologies. Next, conceptual design approaches including mind mapping and personas are applied for specifically setting the potential users and establishing requirements for consequent participants involvement research. Afterwards, the interactive interface is designed by considering the data of functionality, colour styles, user experience, usability and acceptance collected from the users. The smarthome based food detection system—*FoodCare* is developed to identify food from online shopping and to ensure a healthy diet for those who are in medical conditions with specific dietary requirements including pregnant women, vegetarians and seniors. Besides, digital prototypes are evaluated for investigating

the acceptance considerations rather than usability on the smarthome based system through various user testing approaches, such as TAM and SUS surveys. Results from the human-centered research indicated that accuracy, privacy and security are the key issues of the smarthome based food detection system.

This thesis is divided into six sections. The first section of this thesis summarizes the literature reviews, which provides several scientific inspirations in the project. The consequent section is related to the project overview, which presents the approaches, design process, project plan, milestone, outcomes and limitations. The research methods including inquiry and interview aim at discovering the support of smart kitchen application to the smartphone users in healthcare. Then, the analysis of the project is demonstrated following the results of the research. Finally, it discusses the findings, limitations and further improvement of the whole project.

Chapter 2 Literature Review

1. Smart home IoTs

Innovation in information and technology leads to the smart technologies pervading in people's everyday life. Smart homes, regarded as the initial practice in the aspect of Internet of Things (IoT), are embedding smart services, products and applications including smart kitchen appliances, home based detection system, healthcare monitoring devices and so on. A smart home consists of a bunch of information and communication technologies (ICTs) that allows a variety of IoT services control and monitor refrigerator, heater, cooler, air-conditioner, lights, oven, washer and almost every electrical appliances with multiple connectivity to the internet[1].

Global leading technology companies devote to a more promising market in terms of marketability and user accessibility, which allows users to control smart devices through voice or gesture interaction such as the Amazon Alexa[1]. Technology globalization under the evolution of cloud commuting, machine learning and artificial intelligence made home based IoTs entering millions of households and integrating into daily life[1]. Results from the global smart homes statistics reveal that the smart homes penetration rate is hitting 10.6% in 2020 and the revenue in the Smart Home market is dramatically increasing from $46,252m in 2018 to $77,280m in 2020[2]. According to the study, however, the smart homes household penetration rate in 2020 is growing 3.1% from 7.5% in 2018, with exactly slower increase than researchers expected[1]. Existing scientific and technological studies on smart home based IoTs demonstrate their chanting of improving our lifestyles, and "making life more comfortable than ever" seems as a common sense[3].

Despite the bump up potential profits, there is a chasm between the former users and the smart home market, which represents the requirements of investigation on smart homes from user perspectives[1]. According to Avast, nearly 69% smart homes are vulnerable to cyber-attack risk because of weakness access to the credentials[33]. Approximate 35% of US broadband households faced a data security issue in 2019, which brings about one in four consumers in six of the biggest markets refusing to purchase smart home devices[33]. Trust in smart home technologies is another initial problem that seems to go different extremes[33]. According to the smart home statistics, 20% participants would trust Alexa to take care of their children, while over 2 in 3 surveyed opposite because they consider that "their smart devices are being used by businesses and the government to spy on them"[33].

Currently, the privacy and security traces one of the significant hurdles for the adoption of home based IoTs[4]. On hardware barriers, the IoT devices with limited processing capacity and storage amplify the risk of security mechanism to be attacked[5]. The software approaches to exploit the vulnerabilities of IoT focus on optimizing algorithms and certifying technologies for user acceptance[4]. Since smart homes have considerably poor uptake recently, user centric researches need to be conducted for further investigation[1]. A small group of technology developers and researchers persist in contributing to the challenges of who are the potential users; what are users intention, requirements and usability consideration; how to build trust on latest techniques; and why privacy, security and accuracy is the priority in technology development[3].

Therefore, the primary issue that researchers and technology developers should focus on is not merely trust in data privacy and security, but that the technology does what it states it does. Whereas smart

devices are becoming even smarter in the future, unintended consequences are assumed to be emerging[6]. Smart home technology is not just a novelty but an uncertainty and what should be seriously considered is what should we do if this is Pandora's box. Open it or keep it? And in what ways?

2. Smart kitchen appliances

Smart kitchens refer to those homebased kitchen designed IoTs aims at providing sustainable and efficient lifestyle. They are combined with "cooking", electronics, human-centric design, environmentally friendly appliances[6]. The global smart kitchen market is dramatically expanding with the value of $14.5 billion in 2019 and it is expected to $43 billion by 2027, according to the *Statista, Forbes*[33]. With the incredible development of the market, smart kitchens will become more intelligent, for instance, smart refrigerators and smart ovens can scan food and make dishes themselves[33]. Various smart kitchen appliances can be remotely controlled and monitored via applications and programs on mobile devices and wearables. Despite the popularity of the smart kitchens to the general public, occurring limitations have become the obstacle for widely employment in household, including cost, dependency on networks and professionals[7].

According to the research, approximately 80% of smart devices are vulnerable to the DoS attacks[6]. As Austin presenting in the article[7], smart devices may be hazardous to your health that "Privacy is not private any more under your unconscious permission". Employing these appliances may increase the risk of hacker entry into smart homes and steal personal data[6]. One of the World Health Organization (WHO) departments--the International Agency for Research on Cancer (IARC) has indicated non-ionizing radio frequency radiation (NRFR) from laptop, mobile devices, smart kitchen appliances and any homebased smart technologies may create hazard of physical and mental health[7]. Despite the convenience and necessity of the smart appliances, how to balance the relationship between technological benefits and security remains uncertain[6]. Perhaps, reducing the frequency of using mobile phones or other smart technologies will be a best choice.

According to the literature review, the initial factors that prevent people from adopting smart kitchen technologies are the uncertain hazards on physical and mental health due to the limited authoritative research on uncertain techniques[6]. Besides, vulnerable to the hackers and security breaches are the challenge that technology developers still need to address.

3. Dietary care and health care

Dietary takes a pivotal role in everyday life. Food intake and dietary care are the key component of physical and mental health that need to be investigated in the medical and clinical studies[8]. Unhealthy dietary may cause a series of chronic health complications, including obesity, cardiovascular diseases, cancer, diabetes and food hypersensitivities[9]. According to the report from the World Health Organization (WHO), diet-relevant diseases make up 41% among all clinical diseases from 2014[9]. The medical therapy and prevention of diet-relevant diseases is currently one of the most emergent issues that dietary care researchers and healthcare professionals need to put emphasis on[13]. The growth in overweight and obesity has become a serious health crisis worldwide in recent decades. Obesity is normally related to the high intake of unhealthy food with low nutrition and low vitamin, high fat, high energy, high sugar or high salt[11].

According to the research, evidence determined that maternal junk food intake have the negative consequences on fetal and suckling health during pregnancy[11]. Other risks of dietary care including invasive listeriosis in pregnant women is nearly 20 times greater than non-pregnant women, which may cause spontaneous abortion, preterm birth and intrauterine fetal death during pregnancy[12]. These issues associated with food intake and dietary care are relatively beneficial to raising awareness of healthy dietary habits, dietary assessment, food patterns and intake behaviors, healthcare, food identification for specific medical conditions and explicit dietary needs[10].

Since nutrition diet aids to reduce the risks of overweight, heart diseases, cancers, osteoporosis and so on, dietary care technologies become increasingly popular to the general public. According to Statista, the global mobile Health market will increase from $21 billion in 2016 to $100 billion in 2021[15]. The demands for dietary care technologies are rising dramatically, due to their several benefits on supporting daily intake, mentoring calories and consumed, guiding healthy and nutritious food, managing individual diet schedule and detecting ingredients in your diet[15].

According to the study *Promising approaches of computer-supported dietary assessment and management—Current research status and available applications*, researchers reviewed 41 articles and 29 applications and generally divided dietary care technologies into four sections: nutrition assessment, food monitoring, dietary management and social community[9]. Study indicates among 176 mobile applications related to the nutrition and dietary in the iTunes and Google play market, few of them are well adopted with careful designed interface and user-friendly interaction, while half of them are in a low rating due to the lack of useful datasets, scientific validation, privacy and security policy, legal and ethical requirements, functionality and usability[14].

Since adequate nutrition from everyday meals play a vital role in people's physical health, it is necessary to assessing dietary for different reasons. Diverse mobile applications probably provide an approach to nutrition monitoring and dietary recommendations. Some apps related to nutrition monitoring are well-accepted, while others are poor adopted according to the research[14]. A variety of studies have investigated the usability of these applications, but few of them explore the acceptability and adoption from consumers. Therefore, it is necessary to further research the acceptance consideration on dietary care technologies on user perspectives.

4. Food detection technologies

With the increasingly concentration on dietary care in modern world, food detection has become one of the primary sections that researchers and technology developers are getting involved in[16]. Current technologies of nutrition monitoring and food detection are mostly associated with mobile phones, laptop and wearable devices[16]. Wearable and non-wearable technologies with different electronic sensors (such as AI camera) for dietary monitoring and food detection provide a quick response, simple operation and instant feedback to the users[16].

Due to the various of diversity of food, image identification is particularly a challenge, which is the main reason of low accuracy performance in food detection systems[17]. Convolutional Neural Network (CNN), as one of the most powerful methodologies to deep learning techniques, is widely employed in food image recognition tasks[17]. Research exploits CNN to a higher accuracy comparing with the conventional approaches through parameter optimization[17]. Besides, Deep

Neural Network is another novel method applying to the food and beverage recognition and identification tasks[18]. According to the research, this well-performed solution uses a latest deep convolutional neural network—NutriNet, which can recognize dataset with images of 520 types of food and beverage, achieving a classification accuracy over 80%[18].

Researchers present in *Food identification by barcode scanning in the Netherlands: a quality assessment of labelled food product databases underlying popular nutrition applications* that barcode scanning is a simple and quick approach to food detection via mobile phones[19]. According to the study, researchers selected 24 apps that allow nutrition and ingredients detection via bar scanning on Google plays and iTunes market and evaluating their functionality in the Netherlands supermarket. Results indicated that most applications achieve well performance, while some have the barriers on limited dataset, invalidation scanning and identification, availability and accuracy of nutrition data[19].

Food detection related to biosensors techniques is a novelty and promising field, which have a great impact on healthcare[20]. Electrochemical biosensors such as enzyme-based biosensors and affinity biosensors have particularly used for food contaminants detection for several years[20]. Moreover, food allergen detection on smartphone-based immunoassays has been another improving technique in the food detection research recently[21].

According to the literature, current researches on the food detection technology are typically related to the aspect of information technology, including artificial intelligence and deep learning (CNN and DNN)[17-18]. Others may provide a novel avenue on biosensors techniques for contaminants and food allergen detection[20-21]. Considering artificial intelligence and deep learning are leading techniques for image detection, they will be applied to the food detection system and to test if they have a well performance.

5. Human centred study on smart homes

Human Computer Interaction is a discipline (HCI) with respect to the design, evaluation and interaction to the computing technologies, such as mobiles phones, laptops or PCs, which is to transform information from human to digital devices through a series of communication approaches[23]. HCI generates a chronic cumulative design approaches, providing a principle guideline for human centred design process[23]. According to the research, building smart environment based systems set to become increasingly challenging to ensure its usefulness and usability[28]. To bring more benefits to consumers, innovators and developers have to depend on a combination of technical components, which are complicated to every single part and effectively more when mixed together[28]. The employment of HCI methodology to the development of intelligent environment such as smart homes probably leads to a continuous user-centred aspiration and outcomes during the embarking process[28].

Human-centred design is an important methodology of problem resolution, normally applied in design process, which aids to build solutions to problems associated with the human perspectives rather than exclusively documenting them[25]. This approach leads to interaction technology innovation that focuses on making technical products or services usable and useful based on users

expectation and requirements, improving effectiveness and efficiency, as well as creating well-being, satisfactory, accessible and sustainable life to general publics[25].

Human centred research upon participatory motivation typically involved in the initial stage of inquiry, interview and observing the domain problems, which requires designers and developers immersion to the community and problem space[25]. Following stages aims at brainstorming, conceptualizing, implementation, and evaluation of the problem solution[26]. Integrating information technology into smart home products or services, human centred design support the innovation on ensure smart home technologies to alleviate barriers and deal with problem spaces, particularly around topic of health and fitness[27].

According to the literature review, there are numerous studies and researches with respect to the smart home IoTs and food detection technologies. However, very few investigate the usability and acceptability of food detection system for specific dietary requirements. Smart homes have become increasingly common feature to the general publics in recent years, but commercial objectives on novel smart home products and services rather than specific and explicit requirements from users usually drive the innovation of smart home based technologies[24]. Whereas lack of user experience brings about smarthome based novel technologies predominantly poor uptake, it is necessary to further explore the acceptance consideration rather than usability of the early potential user. This project is to understand what is required for people to accept smarthome based food detection system and manage their expectations through human-centred research.

Chapter 3 Project overview

The focus of this project is to identify the user acceptance of novel smart home technologies. To go through the research, a smarthome based food detection system called FoodCare is developed. The aim of FoodCare is to satisfy the food detection requirements for people with a specific dietary. This section presents an overview of the thesis project, which integrates the research objectives and the analysis of domain problems, insights from users, design space and technologies.

1. Research Objectives

This research project explains the process of developing a smarthome based food detection system through a series of research, design and evaluation. Results in literature review indicated that the initial challenge prevent early user adoption of the smart home technologies may be associated with privacy, security and accuracy. Researchers and technology developers should focus on the trust building of technologies in the aspect of data privacy and security, as well as the confidence of employing technologies. Therefore, this thesis attempts to investigate the acceptance rather than usability consideration of the novelty through the people involvement research.

The general objective is to identify main issues that affects the acceptability of smarthome based food detection system and to assess users attitudes, behaviours and motivations towards food and dietary care and support for people living with smart home technologies. The specific objectives are to assess the techniques, attitude and practice of the users towards smart home technologies; to identify barriers and concerns associate with smarthome based food detection system and its uptake; to assess the cognition and consciousness of the study based on human-centred regarding food care and dietary support for people living with smart home technologies.

This project involves in three main steps, which are quantitative and qualitive research, conceptual design, digital prototyping and user experience evaluation. Quantitative and qualitive research aims at collecting non-numerical and numerical to investigate the design space, establish requirements as well as define the target users of the smart home technologies. Conceptual design and digital prototyping focus on presenting a visual information and developing a model for users to experience its functionality and evaluate its usability. User evaluation is to gain more feedback on the acceptance of the novel technology for next iterative design. The accomplishment of this research may provide a direction to the future study on the usability and acceptance on food detection system.

2. Design Scope

Potential users: those with medical conditions and need a specific dietary, including
Design space: smarthome based smart kitchen appliance
Technology: food detection system

FoodCare is a smarthome based food detection system, with a mobile interface and a food detection system. The detection system (see Figure 1) is developed by a Raspberry Pi 4 RAM Board with an AI camera and two servos for horizontal and vertical rotation to follow objects. It is also connected with an MP3 module for voice feedback. OpenCV and TensorFlow lite model is used to establish its food detection function.

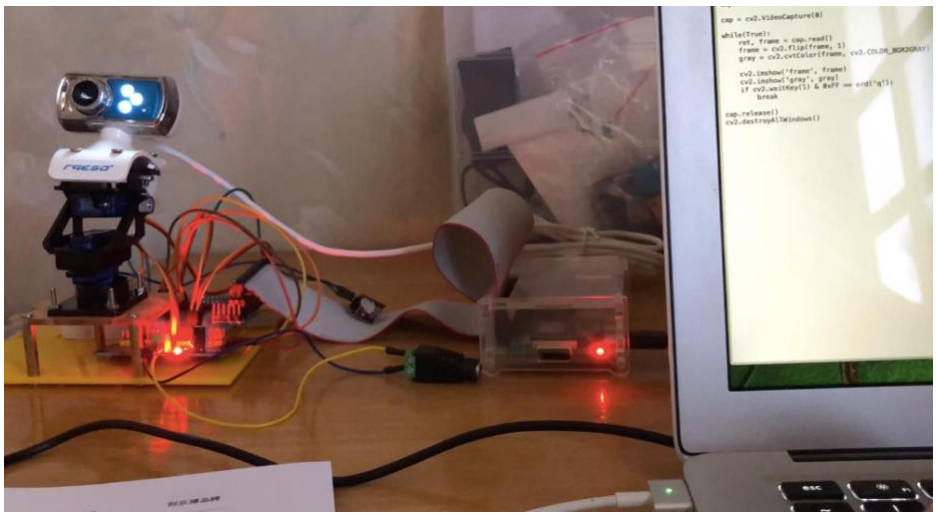


Figure 1: Food Detection System--FoodCare

The mobile app is designed by InVision, which allows users to select one mode from pregnancy, vegetarian and seniors to reach the food care dataset on specific group. Users can also login and link to user's Costco account to upload online shopping list. When parcel delivery, users can put food into the crisper and the AI camera behind the crisper can identify food category and give a positive voice feedback to users. Meanwhile, it can also monitor the expired data and get dietary recommendation from mobile application.

Chapter 4 Research Methods

According to the literature review, Human Centred Interaction (HCI) investigates the design and application of information technologies with respect to the users and technologies[23]. HCI research approaches aim at solving problems and developing novel technologies[23]. These methods also aids to identify the problem spaces of improvement and create more efficient and effective products or systems[23]. Whereas primary concerns on technologies, HCI has consequently expanded to involve nearly all types of human centred interaction design. According to the *Peter Morville's User Experience Honeycomb*, HCI studies should place more awareness on usefulness, usability, findability, accessibility, credibility, desirability and value[29]. Therefore, researchers and innovators should focus on developing a technologies that is easy to use, trustworthy, originally fulfil the requirements, inspire emotions and appreciation, as well as accessible to vulnerable groups.

Besides, 7 fundamental HCI design principles introduced by Don Norman in *The Design of Everyday Things* (1998) are discoverability, feedback, conceptual Modelling, affordances, signifiers, mappings, and constraints, which refers to utilize knowledge in the world as well as in the mind, make the structure in simple frameworks, make things visible, get the mappings responses, explore the power of constraints in reality and artifact, design for faults, standardize the rules in failure[30]. These principles are considered most important that should be followed in practicing the consequent human centred research approaches in my project, which are: objective on potential users and problem spaces in early stage; understand the users by investigating their characteristics on cognition, motivation, performance and attitudes; observe users involvement activities and study their behaviour on domain problems in the design process.

In the research phases, user experience and context of utilization are recorded and investigated, while the system is developed to support user characteristics and requirements. All design decisions are determined from user behaviours on their problem spaces. Users consultation and feedback throughout from earliest to the latest and their output needs to be severely taken into account. Users reflection and performance to the digital prototypes are documented and analysed. To satisfy specific usability and user experience goals, designers need to select one or several different demos (low-fidelity or high-fidelity prototype) to develop. Iterative Design is a process of finding and solving problems in user evaluation. Here are the four basic activities conducted in the research and design process of my project:

1. Identifying expectations and establishing requirements: find out who are the potential users and what smart home technology can specifically support them
2. Developing conceptual and physical design: consider what the product looks like and what is the function, colours, shapes, navigation, icon design, etc.
3. Creating interactive interface: unnecessarily establish a smarthome based system, but digital prototypes include main interaction pages are essential
4. Evaluating digital prototypes: identify usability and acceptance of the smarthome based system via user involvement throughout the whole design process

This section introduces the various research methods employed in the project according to the human centred design principles. At the beginning, quantitative and qualitative research strategies including survey and interview was applied for idea generation. Conventional approaches such as onsite

observations and face-to-face inquiries are inconvenient and time consuming to put into practice. Therefore, to ensure data collecting from the traditional method with a high quality, accuracy and validation, all quantitative and qualitative research would be conducted online.

1. Quantitative Research

Quantitative research seeks to interpret domain problems through numerical and broad data such as age, gender and region, as well as analyse these data from usable statistics[22]. It is a structured research approach, which can be applied in the early research stage to find the domain concepts on average data, make assessment and prediction, as well as generate ideas from wider sample populations[22].

Online survey is a quantitative research strategy applied in the early stage of design process. It aims at exploring what kind of smart home technologies people are well-accepted and expected to use in the future. The survey was created on Google Form with 5 multiple choice questions, which is related to their age, gender, the smart home technologies they have used, or they are expecting to use and which group of people (senior, pregnant women or children) they consider the smart home technologies are mostly beneficial to. The survey link is published on the Facebook group and WeChat group. Participants are mostly from my colleagues, friends, families as well as UQ schoolmates. 10 responses are received within 3 days. There are 9 participants age from 18-34 and 80% are female. Considering smart home technologies are popular with youth, I set young adults as the target audience.

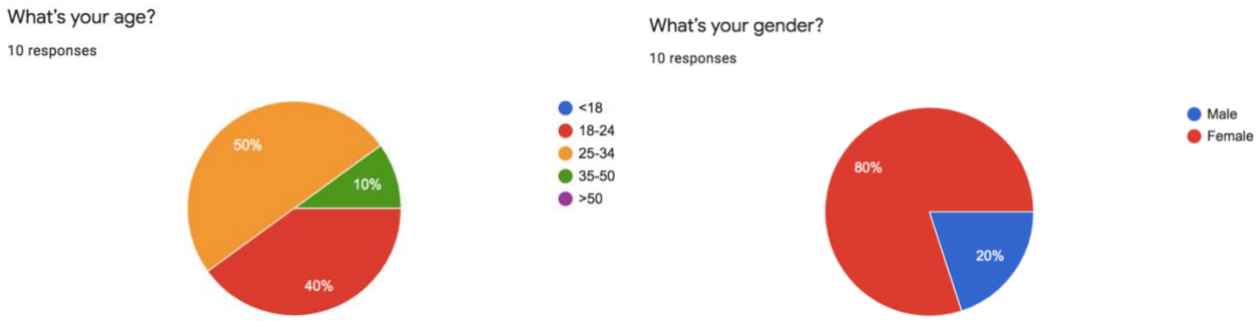


Figure 2: Online Survey

According to the diagram, kitchen appliances and AV entertainments are the top two smart home technologies participants have used in their daily life, while kitchen appliances and health monitor are the top two smart home technologies they expect to use in the future. They consider these smart home technologies are mostly beneficial to pregnant women. Therefore, the consequent qualitative research will emphasize on investigating participants attitudes towards smart kitchen appliances and health monitoring for pregnant women.

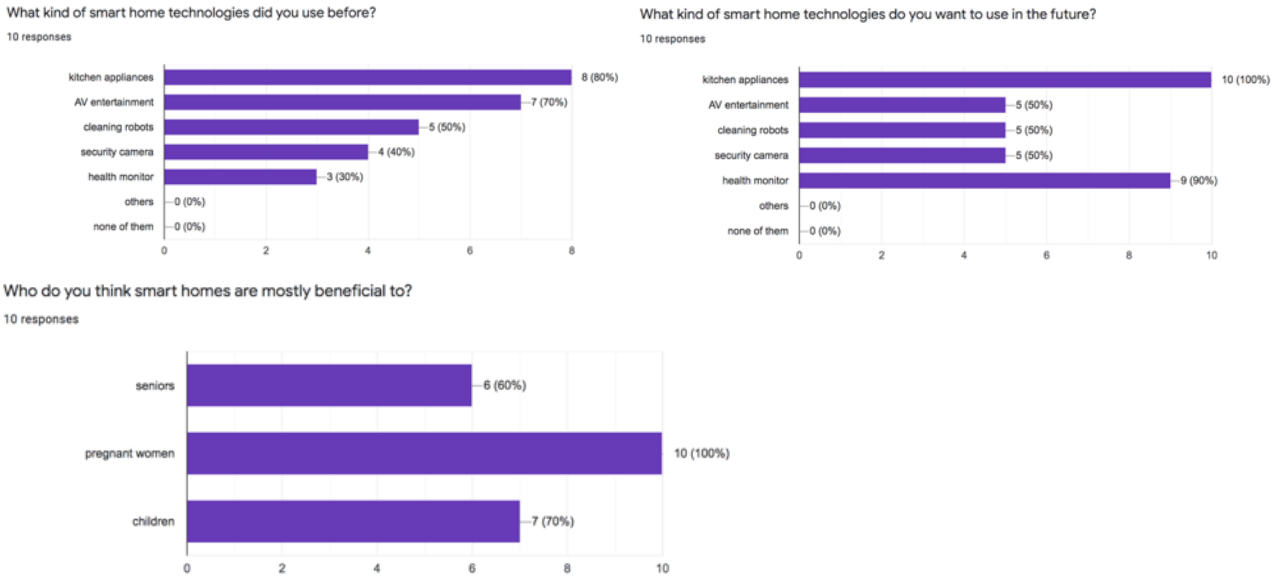


Figure 3: Online Survey

2. Qualitative Research

Qualitative research focuses on collecting non-numerical and in-depth data such as why and how they behave in this way as well as exploring their idea and thoughts on domain by using unstructured or semi-structured approaches[22]. The purpose of qualitative research in the HCI design process is to understand people's opinions, objections, reasons and motivations on smart homes IoTs, smart kitchen appliances and smart homebased food detection systems.

Interview is a qualitative research method follow-up the online survey. The purpose of interview is to investigate people's attitude towards smart home and smart kitchens and food detection system. According to the online survey, 6 participants (there UQ students major in hotel and management, information technology and interaction design, one nurse, one government officer and one international company staff) including 5 female and 1 male, age from 18-40 are selected and invited to this activity. There were two interviews during the design process. Due to the special situation, all interview activities were conducted via zoom meeting. The initial interview questions are related to people's intention and behaviour of smart homes and smart kitchens.

Initial interview questions:

1. What do you think a smart home looks like currently and what it attempts to be in the future?

2. Have you tried some smart kitchen technologies? If so, what are they?

3. Why or why not using this kind of smart kitchen technology?

After analysing the data collecting from the first interview, I found it is necessary to conduct second interview to insist on investigating participants requirements and narrowing down the target audience. The second semi-structured interview focus on exploring participants pregnancy experience and their ideas on food detection systems for specific dietary care.

Semi-structured interview questions:

4. Have you, or your friends, relatives around you been pregnant?

5. When your friend is expecting, how diets have changed?

6. What types of food do you think are good for pregnant women?
7. What food should pregnant women avoid? Why?
8. How do you get the information on foods good or bad for pregnancy?
9. Why do you get information in this way?
10. If there is a technology to help you (or expectant mothers) detecting food to ensure a healthy diet, would you like to try? Why?

From two interviews, a variety of valuable feedback were gathering from the participants, which are presented as follows:

Participants 1: Female, 24 years old, UQ Student major in hotel and management
She is an optimistic girl and an "apple enthusiast". The smart home she imagined is like a scene in the science fiction movie with different kind of electrical appliances and automatic machines. She is willing to use smart home technologies due to their efficiency and convenience and she attempts to try any novel, fashion and interesting technologies. Her older sister was pregnant last year. She thought family support are relatively important during pregnancy. She cares about the accuracy of food detection system and false information may be harmful to the baby during pregnancy.

Participants 2: Female, 25 years old, UQ Student major in interaction design
She like to use smart speaker such as Amazon Echo with voice interaction during cooking. She is not a smart technologies fan and she won't use mobile apps on smart phones to control different smart kitchen appliances such as oven, microwave or refrigerator. Currently, her high school best friend has been pregnant for 6 months. She believes the food detection system usefulness to pregnant women, but she has no idea whether to use it or not because she doesn't know what kind of technology it is.

Participants 3: Male, 28 years old, UQ Student major in information technology
As an IT student, he loves to explore new technologies. He has used housekeeping robot and it is convenient and easy to use. He wants to use food monitoring technologies in the fridge because he always a lot of food in the fridge and forgets to eat them before expired date. His neighbourhood was pregnant last year and born a baby girl. He tends to use the food detection system to remind of food category and expired date in the fridge.

Participants 4: Female, 28 years old, Senior Nurse work at Shanghai Huadong Hospital
Her imaginary smart home seems like automatic breakfast cook, automatic wash dishes, automatic cleaner, morning greeting from smart speaker, automatic broadcast news and weather report from smart TV, etc. She was pregnant two years ago and has a baby boy. She had changed dietary habits during pregnancy. She is not a vegetarian, but she loved to eat vegetables rather than meat due to the serious morning sickness during pregnancy. She considers smart phone may be bad for the baby due to its radiation. She would try to use the food detection system if she is not pregnant.

Participants 5: Female, 39 years old, Officer work at Government Organization
As a vegetarian, she is interested in the food and dietary monitoring. She considers smart home in terms of smart kitchen appliances, such as smart microwave, and self-control oven

that can adjust temperature itself based on what you want to cook. The smart refrigerator can recommend food menu and nutrition dietary based on what kind of the food is stored in the refrigerator. She was pregnant ten year ago and her boy is currently going to the elementary school. She believes nutrition dietary is very important to pregnant women. She not used smart technologies frequently, but she seems to use the food detection system to identify its ingredients and make sure she can eat. This may help to separate vegetarian diet from normal diet in her family.

Participants 6: Female, 32 years old, Staff work at International Company
Her idea on smart home is mostly related to the kitchen appliances. She wants to have a smart cook that may remind her cooking time and temperature when baking a chocolate cake, because she is not good at cooking. Since she is an employee and always sit in the office. She is worried about her overweight. She is on diet and need to detect nutrition and calories of the food. She is also preparing for the pregnancy next year and want to detect which kind of food is good for baby. She has no idea about what kind of food detection system it is but would like to try it if it is useful.

Results from the interview indicated that every participant has a pregnant woman around (or one had experienced pregnancy before). Pregnancy is a long and hard period with bad appetite, morning sickness, physical and mental issues. Nutrition is essential for both pregnant women and their baby. Therefore, it is necessary to develop a food detection system for them. Food care and monitoring should focus on those with medical conditions need special diet, particularly for the expectant mothers. Besides, vegetarians may also have specific dietary requirements and seniors may require technology support such as voice interaction and simple interface.

According to the interview, participants who have requirements on specific dietary are willing to use the food detection system. However, most of them doubt its accuracy and functionality. As a novel technology, their considerations are also associated with privacy, security and usefulness. For example, participant 2 had no idea about uncertain technology and participant 4 declared that she attempted to use the food detection system if she is not pregnant. Of course, “No one puts their children in a boat unless the water is safer than the land.”[34] Therefore, I consider in the conceptual design and user evaluation stage, the tangible product (or prototype) with detailed introduction of functionalities, credential of proven techniques, and instructions of application may increase their confidence in adopting this novel technology. These issues will be further investigated in the prototype evaluation process.

Since participant 4 demonstrated that it would be better not to use too much mobile phone during pregnancy, I consider developing a food detection system, including a Raspberry Pi mainboard with a camera inside the crisper, which can save users time for food detection; and a mobile application just for uploading e-shopping list from Costco and checking their food which has been detected and stored in the fridge.

Here are the transcript excerpt and insights summarised from the interview:

Source (from interview transcript excerpt)	Insights
Participant 1: I think smart kitchen, or we can say smart life is like wake up in the morning with an automatic coffee machine and a self-cooked breakfast. Enjoy a wonderful day with a nutrition-aware meal. That's cool.	experience automatic and smart electrical appliances to make kitchen life smarter
Participant 4: It is nice if something could remind me the use of date of food because I always forget what food is in the fridge.	have something to reminder of food storage
Participant 6: During the lockdown period, my husband has bought a lot of things online. It is convenient to buy daily necessities. But my concern is online shopping for food and drinks. For me, I don't like to eat snacks or drinks from online shopping because I don't know if it has some ingredients that is bad for my health. We are preparing for a baby and to accurately identify what kind of food is good to eat is incredibly time consuming.	detect healthy food for pregnancy accurately in an efficient way
Participant 1: I think family support is very important for me during pregnancy and I believe my husband will be a good father. I hear from my older sister who has born a girl baby last year that it is really a tough journey during pregnancy. She experienced seriously morning sickness and doesn't want to eat any food in the first 3 months. She felt upset about physical reaction. But her husband is very caring person and he made special dishes every day. The delicious food provided a huge support to my sister.	need family support and enjoy delicious meals during pregnancy
Participant 2: I really enjoy music when I am cooking, a voice-controlled sounder would be better rather than a remote-controlled rice cooker, refrigerator or oven. I will never use them in a bunch of applications. It is so ridiculous.	voice interaction with smart kitchen appliances
Participant 1: I use mobile phone but not very frequently, just for calling and message. Although it takes much time to learn to use apps on mobile phone, I am still willing to learn new technology… For my mum, she may be hard to read too much words clearly on the mobile phone screen, because she always asked me to help her read the message on the mobile phone.	older people use smart devices with less mobile screen interaction
Participant 5: I am also a vegetarian, but my families are not. I need special diet individually and the food storage separately from others. When I buy something online, I will read the ingredients list carefully, avoid eating meat or meat products.	know about food ingredients easily and monitor vegetarian friendly diet
Participant 3: I want to have some machine that could remind me of the time or temperature of baking a banana cake. It will be much better if it can give me some idea of what to eat everyone. Due to my overweight, I should go on a diet.	require food care suggestions to maintain a healthy diet
Participant 5: Usually, there are a lot of same food in the fridge. Last week, I bought some apples online and my mon bought fruits again few days later. Sometimes, I am confused about mon not check fridge and buy a lot of doubled food. If there is a smart device for food storage and monitoring from online shopping, I would like to use.	notice what kinds of food my family have bought online

The following research will be focused on the group of people with specific dietary requirements including pregnant women, older people and vegetarian and investigate their expectations on the smarthome based food detection system. Consequently, a digital prototype of the food detection and monitoring system with AI camera and mobile interface will be developed for user experience evaluation. The design and development process, as well as the evaluation results will be presented in the next sections.

Chapter 5 Design Process

In the design process, several design methods are applied including conceptual design and digital prototyping. Mind map and personas are designed to create a user image and summarize the insights gathering from the former research. While prototyping is relatively applied to build experience with potential users through a design concept or demo, this strategy can provide an accessible and real empathy for investigation and evaluation. Lo-fi and hi-fi prototypes are created for design iteration based on HCI design process. Evaluation methods such as TAM survey and SUS focus on testing usability and user experience, providing more data on structured consideration of user requirements.

1. Conceptual Design

Conceptual design is an essential approach among the various human-centred design methods, which includes the design of user experience, interaction flows, interfaces and strategies. Typically, it is the early stage of the design process focusing on identifying the domain research, drawing outlines of the function, finding appropriate design principles and establishing design and development structures. Conceptual designs help to create a clear user interface which is easy to understand and interpret. Moreover, it assists to describe a variety of users in a specific user image and portfolio, as well as determine their requirements to better understand the intention of establishing the smarthome based system.

In the conceptual design stage, mind mapping is the first and useful conceptual model applied to analyse the insights gathering from the former research. Mind mapping is hierarchical approach relying on a diagram to visually presenting information and connection between related ideas and products. It is an effective method for taking notes, documenting insights and generating ideas. The mind map (see Figure 2) in this project is basically related to a design concept of a smarthome based mobile application that generated from former research.

Figure 4: Mind Map

The previous research indicated people have a strong requirement on smart kitchen technologies with the function of nutrition monitoring and food detection. Therefore, based on the data collecting from the online survey and interviews, this mind map is combined with insights, prototype outline, functionality, research methods, user requirements, potential users, interaction modes, etc. The general idea is about a mobile app named FoodCare, which can provide food detection and storage, dietary recommendation and healthy diet monitoring for those with medical condition and have specific dietary requirements including pregnant women, seniors and vegetarians. The purpose of this mobile app is to keep healthy diet habit through food detection from online shopping and food monitoring in fridge. The conceptual design is following the guideline of simplicity interface, warm color theme, link with Costco account with permission and so on. More details can be seen on Figure 3 above.

Based on the interview, fiction characters, also regarded as personas are created to represent the different types of users who may experience the smart home system. Consequent approach in this project is persona, which focuses on creating the image of potential users by analysis of their characteristics and behaviours. It can also help to understand user requirements, intentions, experience and behaviours.

Persona one: Alice is a warm-hearted and creative artist and she is pregnant. She has a strong awareness on dietary care for pregnant women. She has a requirement on food detection for specific medical condition. However, she can't find any useful apps or systems that could help her identify food categories in an effective and efficient way from online shopping. One day, her best friend recommended her to use FoodCare app, which can link to the Costco online account and uploads the shopping list to identify what kind of food is good for her and her baby. This app can also remind her of the food expired date and provide dietary recommendations to support a healthy diet during pregnancy.

Figure 5: User Persona One

Persona two: Tom is a retired worker and he lives happily with his family. He likes to read newspaper everday to learn knowledge and latest technologies. As a vegeterian, he have a specific dietary requirements. He wants to detect food in a more efficent way from online shopping. He attenpts to use FoodCare to find the vegetables and fruits which is suitable for him. He would like to search the vegetarian recipe to keep on a healthy diet on FoodCare app.

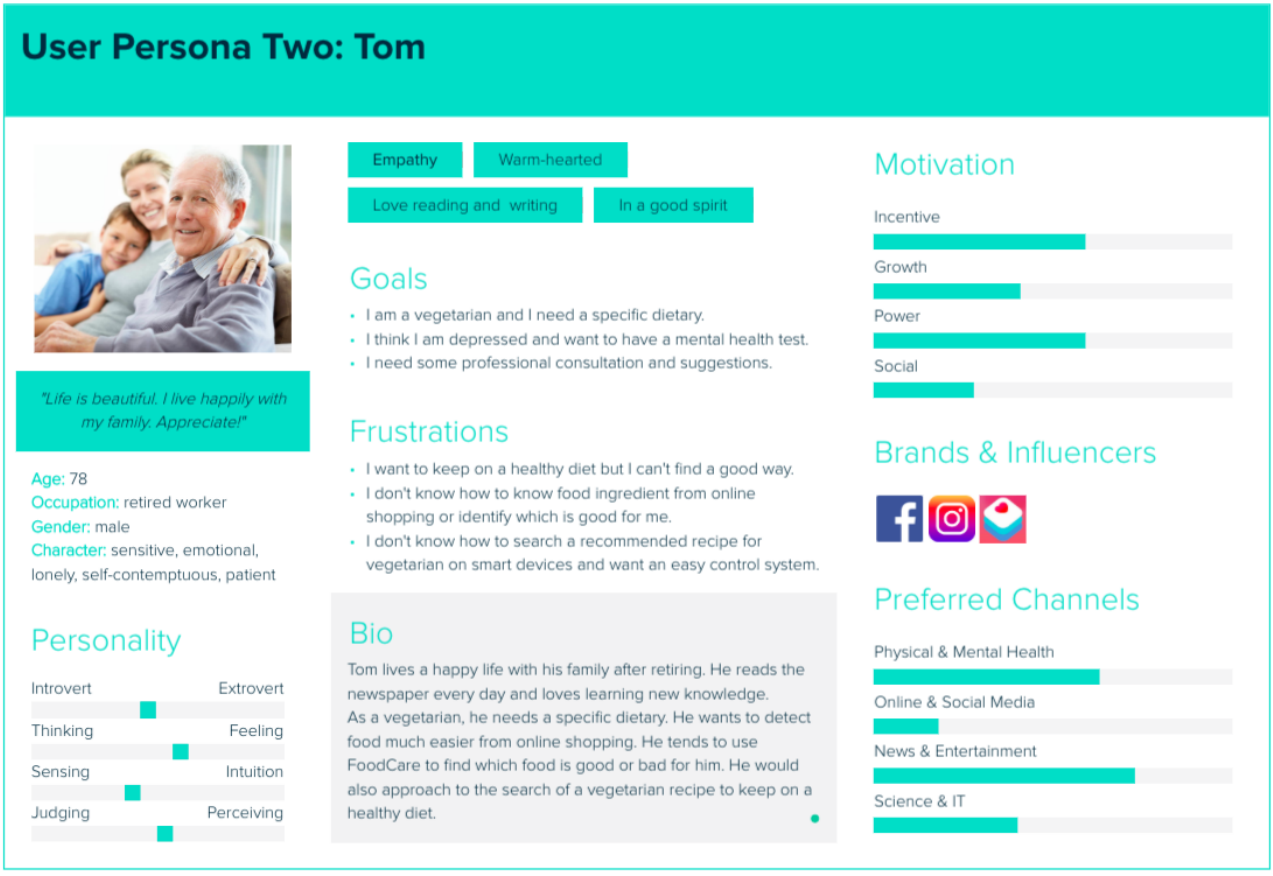


Figure 6: User Persona Two

From the analysis of mind map and persona, I found that users have requirements on the smart home food detection system. So, in the following stage, I focus on developing a digital prototype for investigating their usability and acceptance.

2. Digital Prototype

Prototyping is an essential design stage with a demo of the food detection system to present the design concept as well as evaluate its functionality and usability. Digital prototype is an experimental design approach, allowing designers to implement ideas into physical styles from empirical to conceptual model. To build tangible forms of prototypes, various classifications of fidelity is necessary in the design process, which is to capture design concepts and evaluate on target audience.

With different fidelity prototypes, the design can be refined and validated to satisfy users requirement. Most importantly, a digital prototype of the food detection system is real simulated system that may be developed in the near future. Designers and developers can test its accuracy and practicability as well as discover design errors through a draft version of the system. It is an early demo or model

which allows designers to further investigating user experience and usability for the improvement of system to a well-adopted final product.

In this project, two iterative prototypes including low-fidelity prototype and high-fidelity prototype were designed for user experience evaluation.

2.1 Low-fidelity prototype

Low-fidelity (lo-fi) prototyping is an effective and efficient approach to make conceptual design into a simple, tangible and testable wireframe. The most important objective of lo-fi prototypes is to evaluate its functionality and gather feedback from users rather than interface design. It focuses on the design concept with less technical and sketched prototyping that can save much time and allow designer to pay more attention on ideation.

At the beginning, a wireframe of the system is designed to make the idea concept visualized. My general idea on food detection system is combined with two parts, a mobile application and an AI camera system. The interaction flows are as follows (see Figure 7):

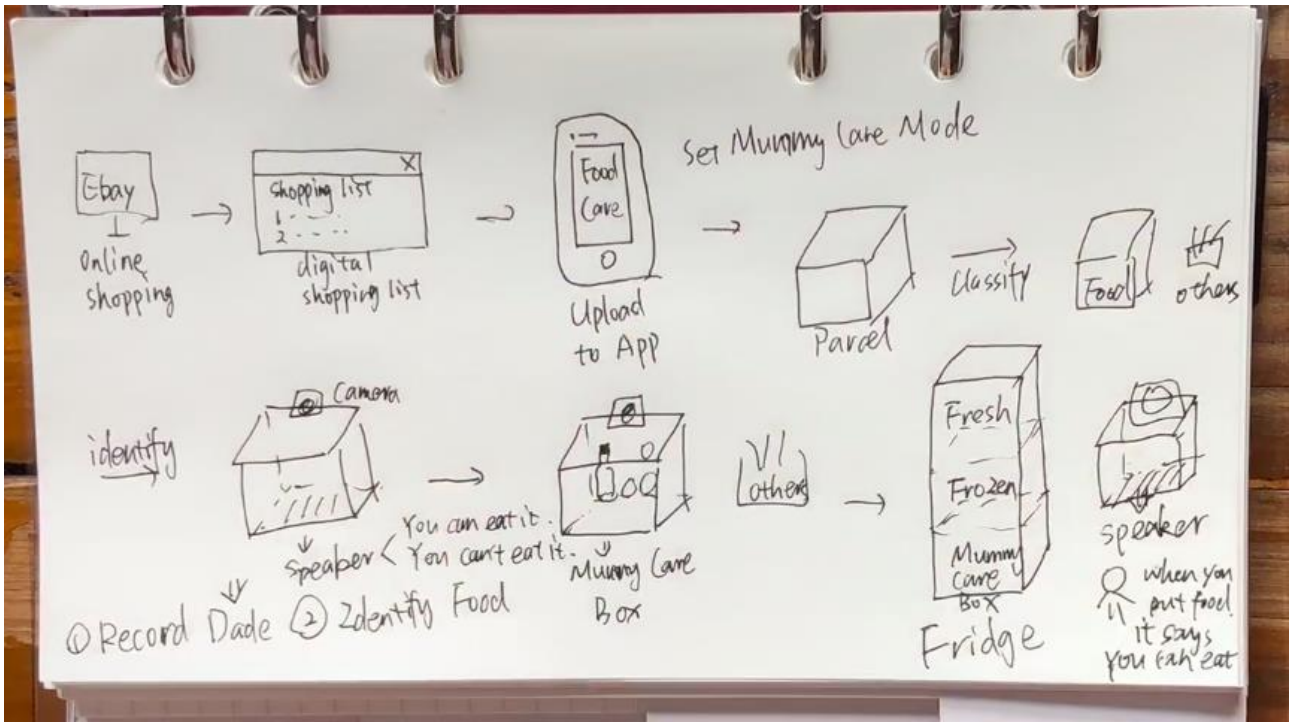


Figure 7: Paper Prototype

Based on the paper prototype, the lo-fi prototype of FoodCare mobile app with 8 interfaces is created by InVision (Figure 6). Users can follow the instruction to browse the food information (the storage place, good or bad for target users) and upload a shopping (from mobile phone or online). The interaction flows are:

1. *select one mode for specific dietary care*
2. *click pregnant button and enter the food storage page*
3. *browse food & recipe page*
4. *click add button to upload a shopping list*

5. choose one approach among "Link to Costco account and upload online shopping list", "upload a shopping list image from photo library" and "scan QR code from shopping list"

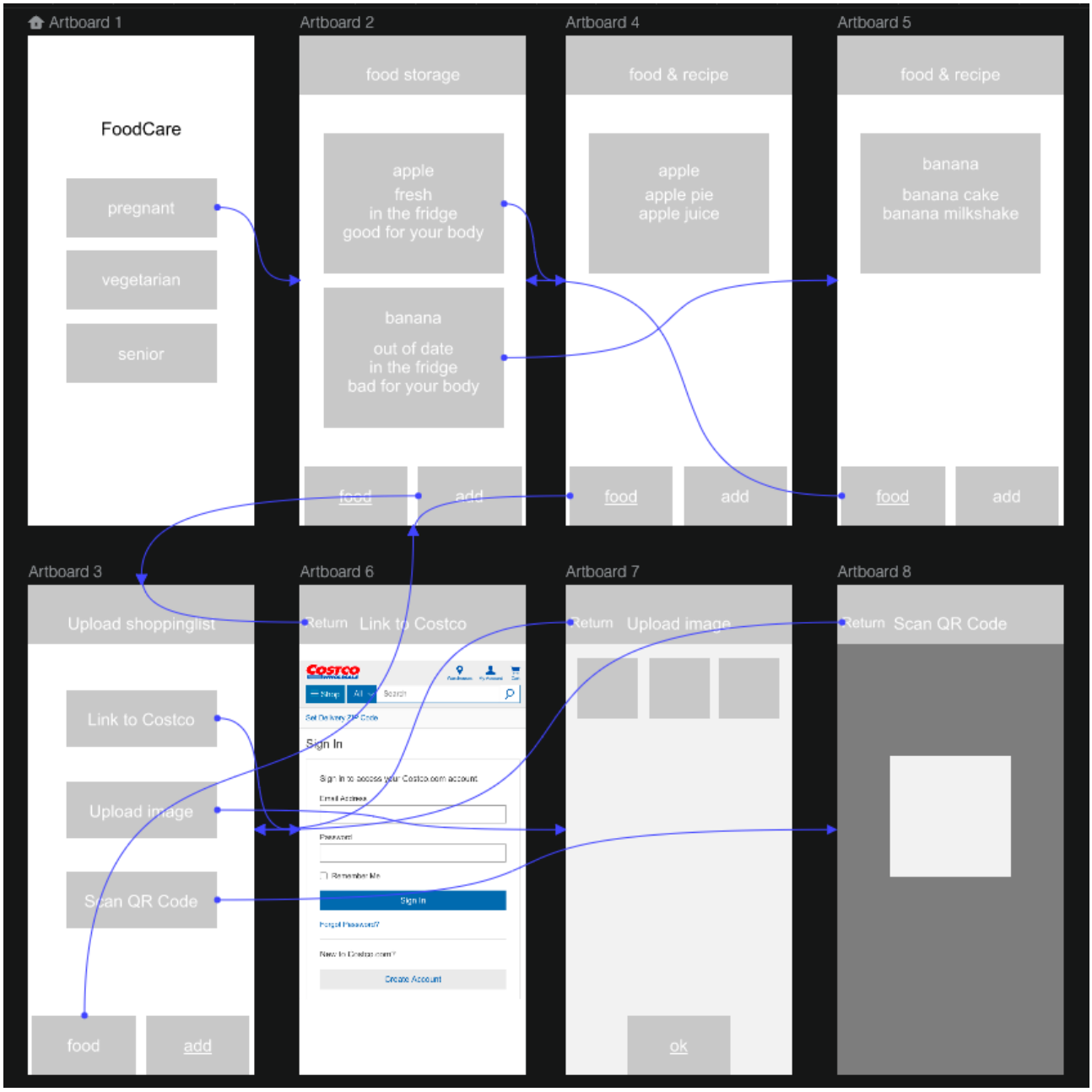


Figure 6: Low-fidelity Prototype Interface

2.2 High-fidelity prototype

High-fidelity (hi-fi) prototype is considerably similar as the final system with high-level functionalities, interactions, complex design assets and components (such as interaction flow, visualization and navigation system), which is often applied in the latest design stages to evaluate usability and identify technical problems.

The hi-fi prototype of the smarthome based food detection system is combined with an AI camera system and a mobile application. The mobile interface is designed by InVision, which is the iterative design of the lo-fi prototype. I choose green and orange as the main colour of the app interface,

because it represents the health and fitness. Compared to the lo-fi prototype, there are some changes (see Figure 7):

1. *add recipe recommendation page*
2. *create design metaphor: smile and sad icon*
3. *add food search function*
4. *design consistent colour style, font size and colour, image size and icons*

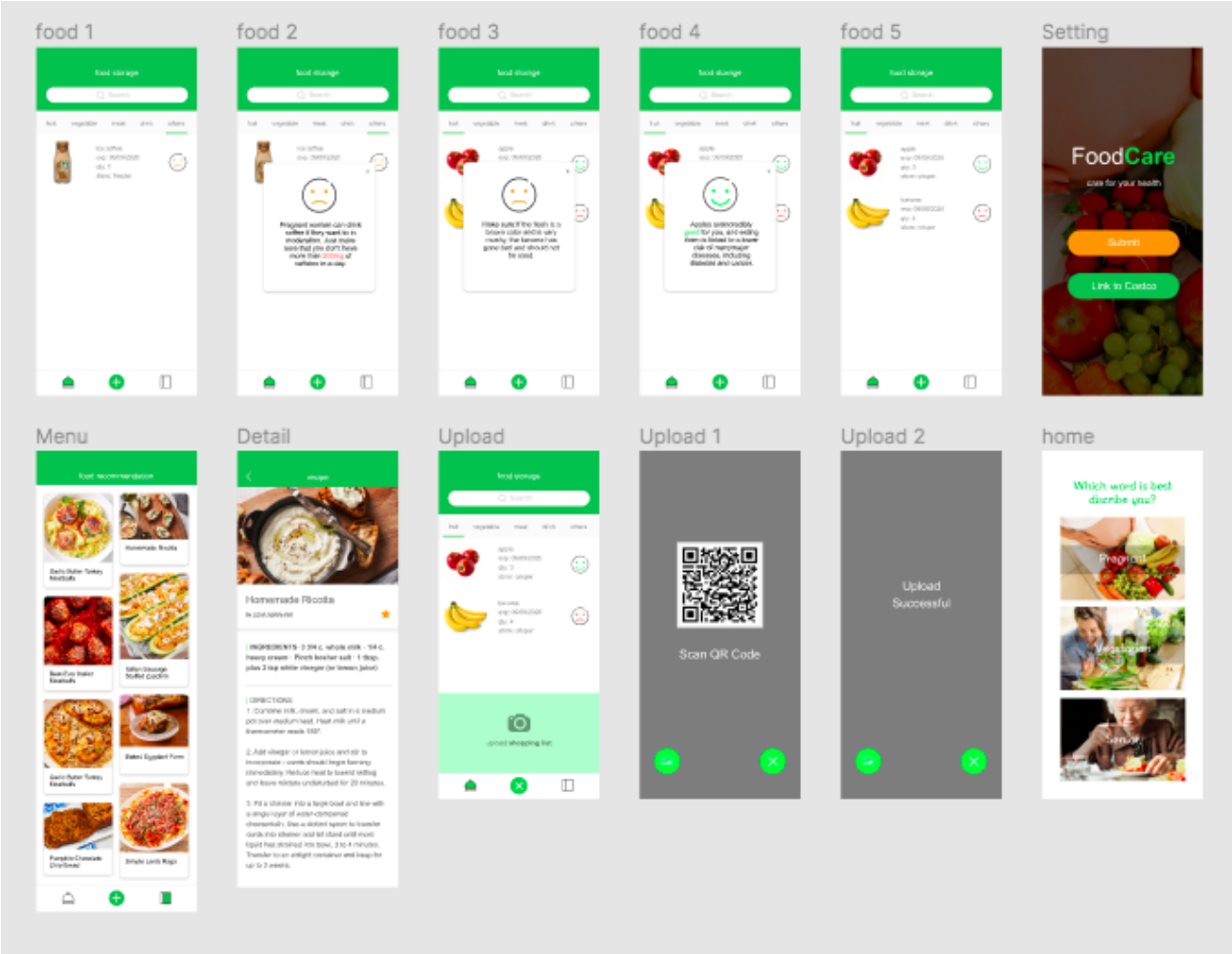


Figure 7: High-fidelity Prototype Interface

The AI camera system is developed by Raspberry Pi 4 RAM Board. At the beginning, I downloaded Raspbian desktop remotely wrote down the program through VCN Viewer. There is a camera and two servos for Horizontal and vertical rotation. The MP3 module is used for voice feedback. I try to use Google Cloud Speech API for transform text into voice but failed because of the network barriers. The OpenCV and TensorFlow lite framework is used for developing food detection function. Due to the time limitation, I haven't developed the deep learning methods for potential users. The dataset of dietary for pregnant women is referred from *Food safety during pregnancy on Queensland Government Publications and data.world* (see Appendix 11). The voice feedback was downloaded into the MP3 module beforehand. When the camera identifies the food, it will give a signal to the MP3 module and play the relevant audio.

For example: when users put an apple into the criper, it will say *Apples are incredibly good for you*. These feedback is just the dietary suggestion for preganant women. It may save user's time to search and record every products from online shopping. Users can choose to follow it or not.

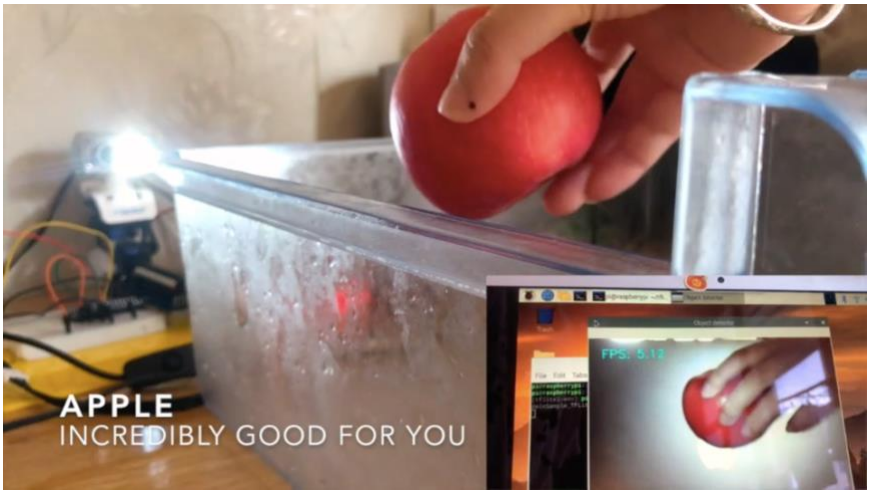


Figure 8: AI Camera

Users select one mode from pregnancy, vegetarian and seniors. Login and Link to the Costco account to upload my online shopping list. When parcel delivery, user can put them in the crisper. the AI camera can identify the food category and give voice feedback to user. Users can also browse the expired date, quantity and storage on the mobile phone. Recipes recommendation allows user to follow the directions and make healthy diet. Users can upload a shopping list by scanning the QR Code as well.

3. User Experience Evaluation

User experience (UX) is emotions and attitudes from the potential users on utilizing a specific product, system or service, which contains human–computer interaction with respect to the practice, effectiveness, experience, meaningfulness and value[31]. UX plays a vital role in interaction design because it attempts to satisfy the user's needs and to make technologies usable and useful. It focuses on providing positive and meaningful experiences that allows users to well uptake a product or service.

User experience evaluation, also regarded as user-based assessment, is a collection of approaches through user involvement. It is employed to reveal user's perception of the home-based food detection system in the process of interaction with it. User experience evaluation techniques include experimental and observational research methods, Surveys and Interviews, System Usability Scale (SUS), Think aloud, Time on Tasks and so on.

In the evaluation process, 6 participants, five females and one male, who had attended the former survey and interview, were invited to conduct the following user experience evaluation activity, including TAM survey, Time to complete and SUS survey. They are UQ Business and ITEE students, nurse, government officer and international company staff. They are selected to join this activity due to their interests on smart home technologies. Besides, pregnant women are the potential users as their feedback and attitudes towards the system is much valuable for consequent iteration. Therefore, women who have been pregnant or plan to have a baby are the key research objects. UQ students

major in IT and interaction design are considered as the expertise respondents and the heuristic evaluator. They support to identify the usability and interaction problems during evaluations. My cousin is a senior nurse, who is expert in healthcare, and she can provide her professional suggestions on food care and food detection for pregnant women.

3.1 Low-fidelity prototype evaluation

Davis's Technology Acceptance Model (TAM) firstly promoted in 1989 is now widely applied in the research process[32]. It has been one of the most predominant research models for evaluating technology acceptance, with elementary factors including perceived usefulness (PU), perceived ease of use (PEOU), attitude towards technology (ATT) and intention to use (ITO) for rating and evaluating users intention, motivation and attitude on novel technology[32].

In the process of low-fi prototype evaluation, TAM survey is employed to discover and hypothesize the mutual relationship between acceptance of technology and actual behaviour, as well as the perceived usefulness and perceived ease of use from the target audience.

TAM Survey (see the form below) was created on Google Form based on Davis's Technology Acceptance Model[32]. 6 participants who had attended the former research activities were invited to attend this evaluation activity. The evaluation activity was conducted in one hour through zoom meeting. Participants were asked to interact with the lo-fi prototype, complete the following tasks and fulfill the TAM survey. Evaluation protocol can be seen in Appendix 14.

1. *Select one mode and click into the main interface*
2. *Browse Food Storage page*
3. *Click the fresh fruit and read recipe*
4. *Go to add page and read the information*
5. *Select one way to upload shopping list*

Construct	Items	Rating
Perceived usefulness (PU)	[PU1] I can accomplish my [food detection] more quickly using FoodCare [PU2] I can accomplish my [food detection] more easily using FoodCare [PU3] FoodCare enhances my effectiveness in utilizing [food & recipe] [PU4] FoodCare enhances my efficiency in utilizing [food & recipe] [PU5] FoodCare enables me to make better decisions in utlizing [food detetion] [PU6] Overall, I find FoodCare useful	Disagree 1 2 3 4 Agree
Perceived ease of use (PEOU)	[PEOU1] Learning to use FoodCare is easy for me [PEOU2] It is easy to use FoodCare to accomplish my [food detection] [PEOU3] Overall, I believe FoodCare is easy to use	Disagree 1 2 3 4 Agree
Attitude towards technology (ATT)	[ATT1] In my opinion, it is desirable to use FoodCare [ATT2] I think it is good for me to use FoodCare [ATT3] Overall, my attitude towards FoodCare is favourable	Disagree 1 2 3 4 Agree

Intention to use (ITO)	[ITO1] I will use FoodCare on a regular basis in the future [ITO2] I will frequently use FoodCare in the future [ITO3] I will strongly recommend others to use FoodCare	Disagree 1 2 3 4 Agree

3.2 High-fidelity prototype evaluation

In the process of high-fi prototype evaluation, Time to Complete and SUS survey are conducted for testing functionality and usability of the food detection system.

Time to complete is an evaluation approach often conducted in the middle design process, which is to record the amount of time that participants spend on specific tasks during the interaction with the system. It is an efficient and effective approach to discover the usability problems of the system. This evaluation activity aims at measuring three events including average task completion time, mean time on failure task and average time on task.

6 participants were invited to conduct the online evaluation. 4 participants went through this activity remotely and 2 of them were offline. When start and complete every task, they are asked to raise the paper and the time they spent on every task was recorded. Participants were asked to complete the following tasks:

1. *Choose one mode, click button to link to the Costco account*
2. *Browse food storage page and find the expired date of iced coffee*
3. *Browse food recommendation page and read detail information on recipe page*
4. *Click add button to upload a shopping list*
5. *Open the parcel and pick an apple and put in front of the camera for detection (face to face testing only, participants from zoom testing please skip this step)*

Here is the screen shoot of the zoom meeting:

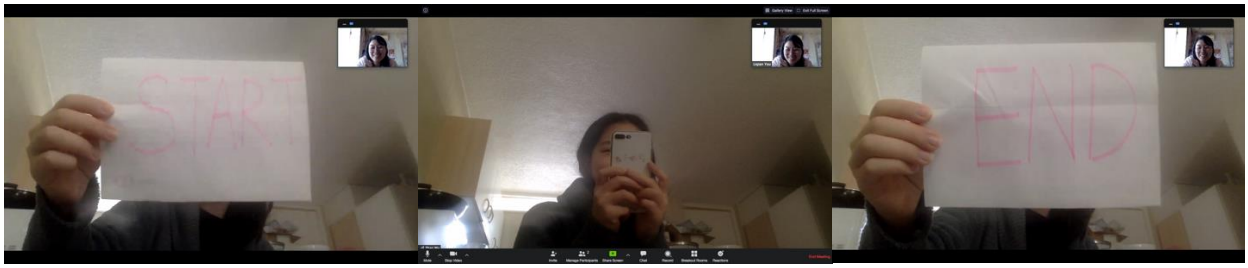


Figure 9: High-fidelity Prototype Evaluation Zoom Meeting

System Usability Scale (SUS) regarded as a “quick and dirty” evaluation method usually applied for testing functionality and usability. It is a survey with 10 questions with five response options for respondents. This evaluation method was conducted after the Time to Complete activity, which aims at collecting users feedback on acceptability of the food detection system. Here are the six responses:

SUS Raw Data	Resp1	Resp2	Resp3	Resp4	Resp5	Resp6	Average
I think that I would like to use this system frequently.	3	4	4	4	4	5	4
I found the system unnecessarily complex.	1	1	2	2	2	2	1.66666667
I thought the system was easy to use.	5	5	5	4	4	4	4.5
I think that I would need the support of a technical person to be able to use this system.	1	1	2	2	2	3	1.83333333
I found the various functions in this system were well integrated.	4	4	4	4	5	5	4.33333333
I thought there was too much inconsistency in this system.	1	1	1	2	2	2	1.5
I would imagine that most people would learn to use this system very quickly.	4	4	4	4	5	5	4.33333333
I found the system very cumbersome to use.	1	1	1	2	2	2	1.5
I felt very confident using the system.	4	4	4	4	5	5	4.33333333
I needed to learn a lot of things before I could get going with this system.	1	1	2	2	2	2	1.66666667

	Resp1	Resp2	Resp3	Resp4	Resp5	Resp6	Average
I think that I would like to use this system frequently.	2	3	3	3	3	4	3
I found the system unnecessarily complex.	4	4	3	3	3	3	3.33333333
I thought the system was easy to use.	4	4	4	3	3	3	3.5
I think that I would need the support of a technical person to be able to use this system.	4	4	3	3	3	2	3.16666667
I found the various functions in this system were well integrated.	3	3	3	3	4	4	3.33333333
I thought there was too much inconsistency in this system.	4	4	4	3	3	3	3.5
I would imagine that most people would learn to use this system very quickly.	3	3	3	3	4	4	3.33333333
I found the system very cumbersome to use.	4	4	4	3	3	3	3.5
I felt very confident using the system.	3	3	3	3	4	4	3.33333333
I needed to learn a lot of things before I could get going with this system.	4	4	3	3	3	3	3.33333333

Total for each respondant	87.5	90	82.5	75	82.5	82.5	
	A	A	A	B	A	A	

Figure 10: SUS Survey

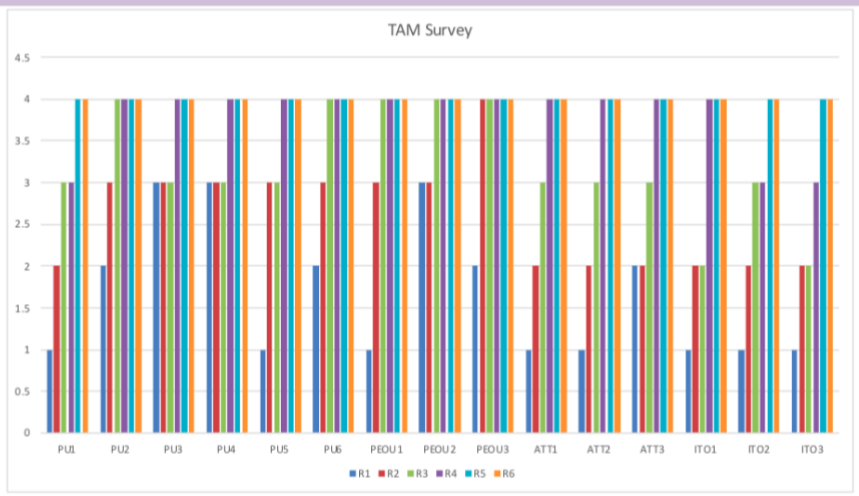
Chapter 6 Evaluation Outcomes

This section analyses the data gaining from the research and presents the results of evaluation.

1. Low-fidelity prototype Evaluation

The first evaluation TAM survey is conducted on the lo-fi prototype. Here is the result:

Dimension	R1	R2	R3	R4	R5	R6	R8	R9	R10
PU1	1	2	3	3	4	4			
PU2	2	3	4	4	4	4			
PU3	3	3	3	4	4	4			
PU4	3	3	3	4	4	4			
PU5	1	3	3	4	4	4			
PU6	2	3	4	4	4	4			
PEOU1	1	3	4	4	4	4			
PEOU2	3	3	4	4	4	4			
PEOU3	2	4	4	4	4	4			
ATT1	1	2	3	4	4	4			
ATT2	1	2	3	4	4	4			
ATT3	2	2	3	4	4	4			
ITO1	1	2	2	4	4	4			
ITO2	1	2	3	3	4	4			
ITO3	1	2	2	3	4	4			



	Av	
PU1	2.833	
PU2	3.5	
PU3	3.5	
PU4	3.5	
PU5	3.167	
PU6	3.5	3.3
PEOU1	3.333	
PEOU2	3.667	
PEOU3	3.667	3.6
ATT1	3	
ATT2	3	
ATT3	3.167	3.1
ITO1	2.833	
ITO2	2.833	
ITO3	2.667	2.8

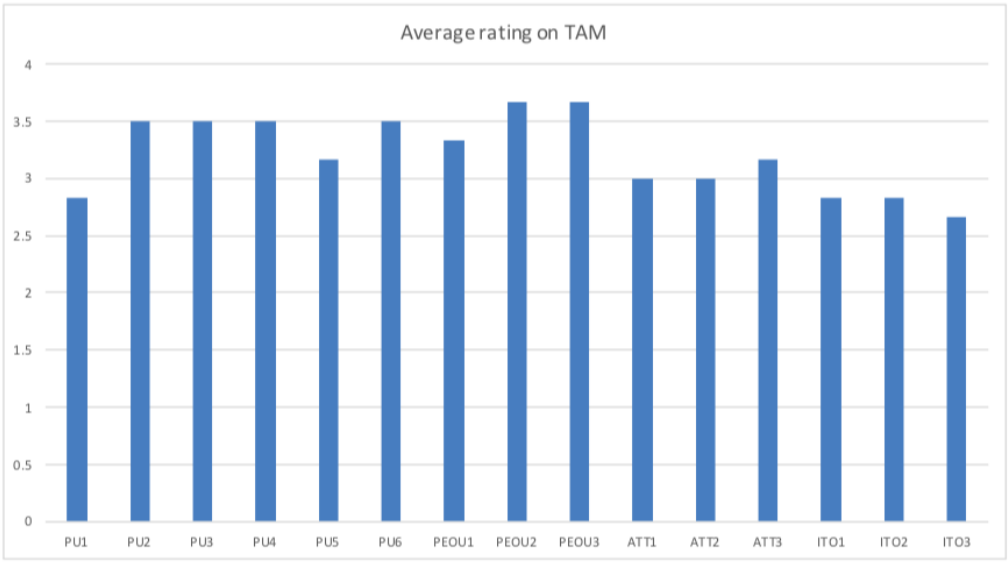


Figure 11: TAM Results

The average score is:
PU (perceived usefulness) =3.3
PEOU (perceived ease of use) =3.6
ATT (attitude towards technology) =3.1
ITO (intention to use) =2.8.

According to the diagram above, there is a narrow gap among the six participants on ITO. One participant has a totally different opinion from others with low motivation to use this system. In addition, the score of PEOU is far beyond my expectation, which means users can follow the instruction and succeed in interacting with the application. They can also generally understand how the system works. The moderate PU and ATT rate indicates that users consider this system is part of usefulness and most of them have a positive attitude while few of them would attempt to adopt it.

Feedback

1.What's your general idea about FoodCare?

A: It is like a food identification app with diet suggestion. It's cool. I would like to try.

B: I don't exactly understand what it is for. For food detection, I probably use my knowledge or search the Google rather than using app.

C: For specific groups, it is extremely useful. I am looking forward to it.

D: I know what it is. I am wondering if it can work well, but I would expect to use it.

E: I think it's different from some food and diet apps. They used for nutrition detection to every people, but this is only used for special groups with special diet requirements. It may be not as popular as them.

F: Really a good system for pregnant women to have a healthy diet.

2.Where are you confused about or what do you think should be improved?

A: Privacy and security is very important. When I upload my shopping data online, I don't want anyone to know what kinds of food they are.

B: How does senior people interact with it? I just worried about if there is a mode for senior groups, it should be considered more understandable and easy-controlled interaction.

C: Make sure the food detection data is correct, because it is fairly important for pregnant women's health.

D: I am confused if it can be used without WIFI. My parents live in a remote village and they don't use internet in their house, but I can use my mobile data.

E: I use a lot of laptop and iPad every day, I don't want to use smarter phone any longer after working. It is very harmful to my eyes. So, I am wondering if I can use this system without mobile phone.

F: Voice control will be more fantastic rather than screen touch.

3.Do you consider FoodCare is helpful? Why?

A: Yes, I think it is helpful. Because there is no such system for pregnant women and if it can work well, it will be used widely.

B: I am not sure, and I am worried about its safety and accuracy for food detection.

C: Well, I have no idea about it. I don't use smart phone regularly just calling to someone.

D: I believe it is helpful to my future life (during my pregnancy). I think it is very convenient for me and my families to know what kind of food I can eat and what I should avoid. It is really saving time to identify food and not to search one by one on the internet.

E: No. I don't think it is helpful because I believe I can read the ingredients list and identify food much more accurate than the system. And if the system goes wrong detection, it will harm to pregnant women and the baby.

F: I consider it is useful to some extent when developer could solve all technique problems.

Reference from the feedback and reviews on lo-fi prototype, I made some changes in the hi-fi prototype. The UX Goals are summarised as follows:

Source (feedback)	UX Goal	Measure	Requirement	Changes in hi-fi prototype
Response A: Privacy and security is very important	I want to have a sense of security when using this system	1. login and register (High priority) 2. privacy and security policy (Medium) 3. user instruction to keep security (Low)	· login page interface · logo design · policy text · instruction and using flows	I created a login page link to the Costco account in the landing page because I want to let people understand what this app is used for at the first time. Consider privacy and security policy is redundancy, I haven't designed the page in the prototype.
Response B: How does senior people interact with it	I want to experience senior mode	1. simple design (Medium) 2. big picture (Medium) 3. less words (Medium)	· video or audio direction · easy-understanding image and text	I have changed the design simplicity by using several icons such as smile to represent good for health.
Response C: How to ensure the food detection is correct	I want to use an accurate food detection system	1. instruction on techniques (such as how to use AI detection algorithm) (High priority)	· video prototype	I have created a video prototype to briefly introduce the functionality and application of this system. (see Appendix 11)
Response D: If it can be used without internet	I want to use this system offline	1. keep data in local memory devices (Low) 2. save the image and upload when there is internet around (Low)	· storage or sensor · instruction	Consider there is a technical issue on developing this function, I haven't made this change.
Response E: If I can use this system without mobile phone	I want to use this system without the mobile app	1. develop another system with camera (Medium) 2. use mobile app as subsidiary (Medium)	· Raspberry system	I developed the AI camera system on Raspberry Pi because user would prefer not using mobile phone frequently during pregnancy.
Response F: Voice control	I want to use voice control system	1. develop voice control function (Low)	· google API (speech to text)	Consider there is a technical issue on developing this function, I haven't made this change.

2. High-fidelity prototype Evaluation

The second evaluation Time to Complete and SUS Survey are conducted on the hi-fi prototype. Here are the results:

2.1 Analysis of Time to Complete

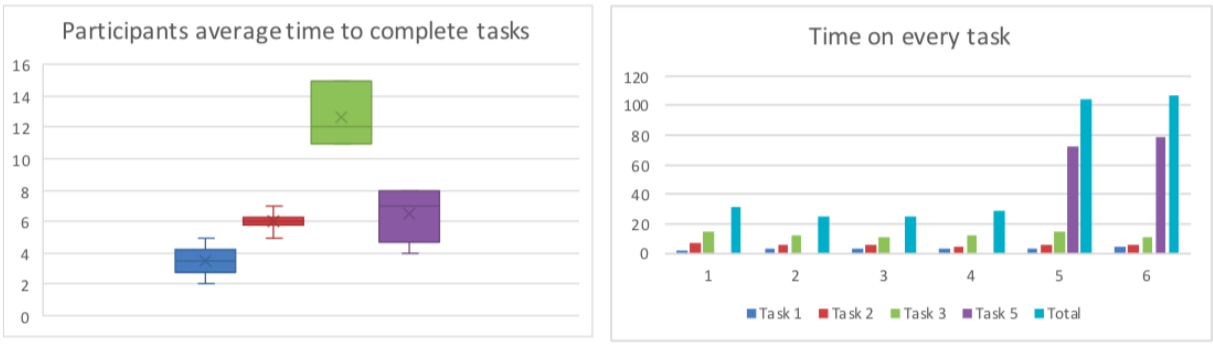


Figure 12: Time to Complete Result

According to the diagram, participants spent nearly 30 seconds on the previous 3 tasks. While task 4 was only conducted by two onsite participants, so it is hard to find the problems on food detection and voice feedback. There is a narrow gap on complete time of task 1 and task 2. According to the evaluation note, participant 1 didn't link to the Costco account when log into the food detection application. Other participants were following the task instructions and login with Costco account, so they use more time on task 1. Participant 1 also spent a little bit long time on task 2 because he attempted to click the wrong button on finding the information of ice-coffee but finally he found the mistake and click to the right page. Based on the evaluation note, participant 2 didn't know what is QR code scanning used for. Therefore, in the future design iteration, shopping list upload function need to be improved.

2.2 Analysis of SUS

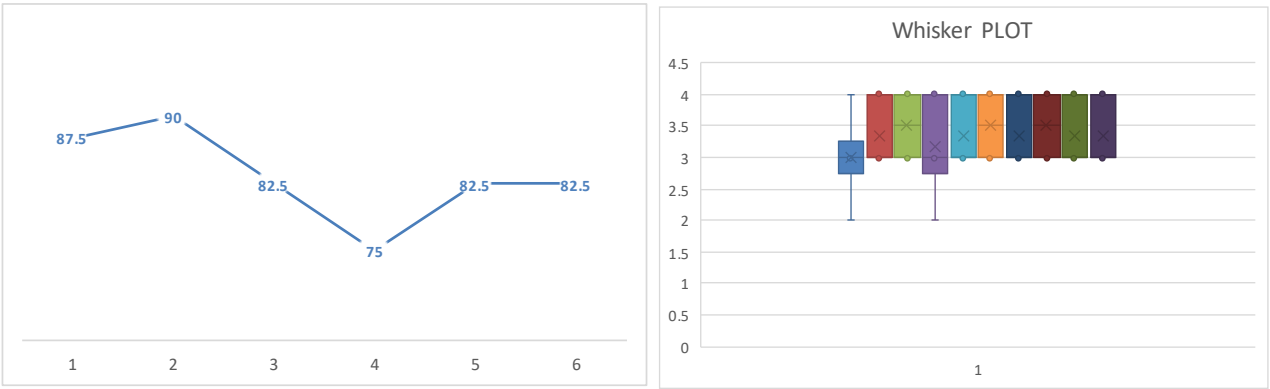


Figure 13: SUS Analysis

According to the SUS analysis rules, the score from odd numbered responses should subtract 1, and even numbered response subtract 5, and afterwards, sum up all converted values and multiply by 2.5[35]. The six scores get from the previous calculation need to be changed into percentile ranks[35]. We can see from the diagram above, five responses are above 80 which means they consider the usability and acceptance of the food detection system is in A grade, and one score is 75, which means this participant consider the system is in B grade. The results indicated that the system's NPS is positive and it is acceptable for most users.

The diagram of box plots provides a visualization of the characteristic of responses from participants. All box plots are relatively short except the second and the fourth plots, which represents that

participants agreed on the utilization of the food detection system. They believed this system has a well performed function and easy to use. However, the second box plot is short, which represents that participants hold the opposite opinion on “use the system frequently”. The fourth box plot is also short, which means some consider it “need a support of a technical person”, while other don’t need a technical support. Besides, the size of fourth box plot is uneven. Based on the feedback from participants, young adults (below 35 years old) tend to be easier to accept the novel technology, while older people need more time and support to adopt it. Most surveyed not to receive any technical support and they can learn to use it in a very fast way.

Chapter 7 Discussion

1. Reflection

The evaluation outcomes indicated that young adults are more likely to adopt novel food detection technology compared with older people and males have a higher expectation on the food detection system rather than females because they are more confident to command a new knowledge and using a novel technology may raise their curiosity. Compare to the acceptance consideration, males focus on the technology of the system which means they consider more about what the system can do, while females, particularly pregnant women, care about the accuracy of the food detection because they can't put their baby in the risks. Most responses have positive attitudes towards the utilization of the system with technical and professional support, which means this technology is easy to use and its functionality is easy to understand.

2. Limitation

In this thesis project, one key issue is related to participants in the research and evaluation process. Due to current pandemic situation, most research activities were conducted online. The remote assessment may gain a lot of redundant and useless feedback in a chronic research period. In addition, the number of participants attended qualitative research is quite small, for example, only ten responses received from the online survey. Low accuracy, low efficiency and low effectiveness data collecting from the users considerably increased the work of analysis and documentation.

Besides, technique limitation is another primary challenge that need to take into account. Whereas this is a remote individual project, it was a bit harder to get relevant technical support from the website. Zoom meeting is a better approach to connect my supervisor, but sometimes it was broken due to the network delay. The food detection and voice feedback mechanism were established with a negative performance. The whole product is simply a concept and more functions and algorithms in deep learning methods need to be optimized.

3. Future Direction

The consequent research would focus on developing a smarter food detection system with the function of voice control and remote monitoring to satisfy user experience goals. Semi-structured interview of potential users is necessary. More participants from different groups with specific dietary support will to be invited to the research process. More evaluation methods should be applied including heuristic evaluation, cognitive and pluralistic walkthrough to further investigate user experience, usability, and functionality from the expert and professional perspectives.

Chapter 8 Conclusions

This project focuses on investigating the usability and acceptance consideration on smarthome based food detection system. Reviewed literature related to the smart home technologies, smart kitchen appliances, dietary care and human-cantered research on food detection systems shows that the key issues on adoption of novel food detection technologies are mostly associated with accuracy, privacy and security. Therefore, a verity of research methods has been conducted to find out to what are the acceptance consideration of the novel technologies.

Based on the reflection of the literature reviews, I confirmed the domain problems are related to dietary care and food detection. Then, quotative and qualitative research methods including online survey and interviews are applied to set the research scope and potential users, focusing on providing food detection to support those with specific dietary requirements. Digital prototyping and user evaluation aim at testing usability and acceptance according to the HCI principles. Trust-building is a key issue that should be considered in the future research.

Many constructive findings and valuable feedbacks are gained from the research. Limitations including remote interview, redundancy data and long-term research period hindered the research process. Future works will focus on user experience evaluation in expert and professional perspectives for further exploring usability and acceptance of the food detection system.

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Appendix

1. Mind map

2. Persona

User Persona One: Alice

"want to have a baby boy and give him a happy family."

Age: 28
Occupation: artist
Gender: female
Character: emotional, sensitive, self-controlled, patient, warm-hearted

Personality

Introvert	Extrovert
Thinking	Feeling
Sensing	Intuition
Judging	Perceiving

Empathy | Passion for Learning | Fatigue | Trustworthiness | Creative

Goals

- I want to know which food is good for a pregnant woman.
- I think I need a special diet during pregnancy.
- I need a tool to help me monitor my fridge.

Frustrations

- I don't know where to find a platform for food detection.
- I don't know how to detect food ingredient in an efficient and effective way.
- I don't know any way to get a specific dietary during pregnancy.

Bio

As an expectant mother and an artist, Alice is a warm-hearted and creative girl, with a passion for learning physical health. She is excellent in food control for baby.
She wants to get food detection in a faster and easier way for online shopping. She tends to use FoodCare, link to the Costco online account and uploads the shopping list to see what kind of food she can eat and remind her of the food expired date.

Motivation

Incentive
Growth
Power
Social

Brands & Influencers

Preferred Channels

Physical & Mental Health
Online & Social Media
News & Entertainment
Science & IT

User Persona Two: Tom

"Life is beautiful. I live happily with my family. Appreciate!"

Age: 78
Occupation: retired worker
Gender: male
Character: sensitive, emotional, lonely, self-contemptuous, patient

Personality

Introvert	Extrovert
Thinking	Feeling
Sensing	Intuition
Judging	Perceiving

Empathy | Warm-hearted | Love reading and writing | In a good spirit

Goals

- I am a vegetarian and I need a specific dietary.
- I think I am depressed and want to have a mental health test.
- I need some professional consultation and suggestions.

Frustrations

- I want to keep on a healthy diet but I can't find a good way.
- I don't know how to know food ingredient from online shopping or identify which is good for me.
- I don't know how to search a recommended recipe for vegetarian on smart devices and want an easy control system.

Bio

Tom lives a happy life with his family after retiring. He reads the newspaper every day and loves learning new knowledge.
As a vegetarian, he needs a specific dietary. He wants to detect food much easier from online shopping. He tends to use FoodCare to find which food is good or bad for him. He would also approach to the search of a vegetarian recipe to keep on a healthy diet.

Motivation

Incentive
Growth
Power
Social

Brands & Influencers

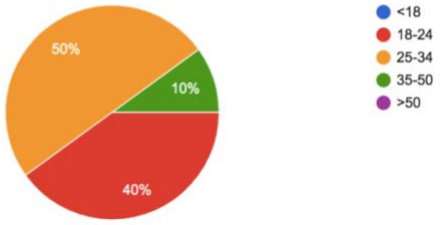
Preferred Channels

Physical & Mental Health
Online & Social Media
News & Entertainment
Science & IT

3. Online survey

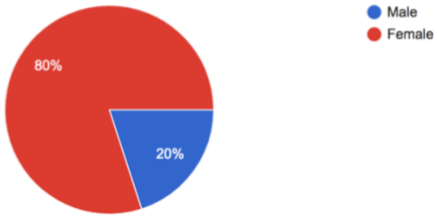
What's your age?

10 responses



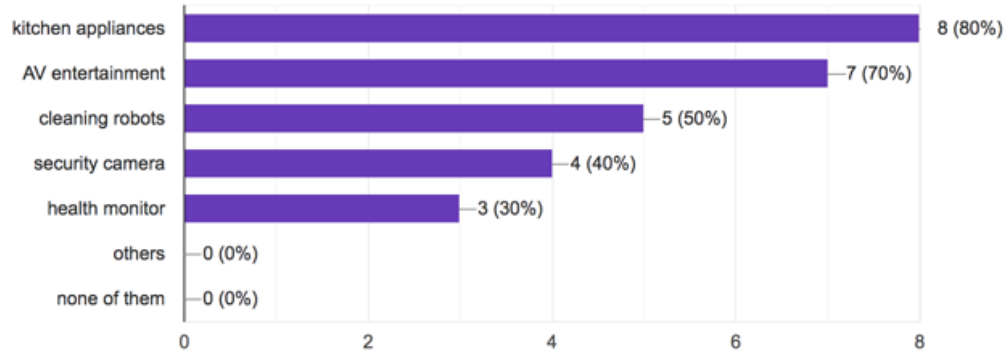
What's your gender?

10 responses



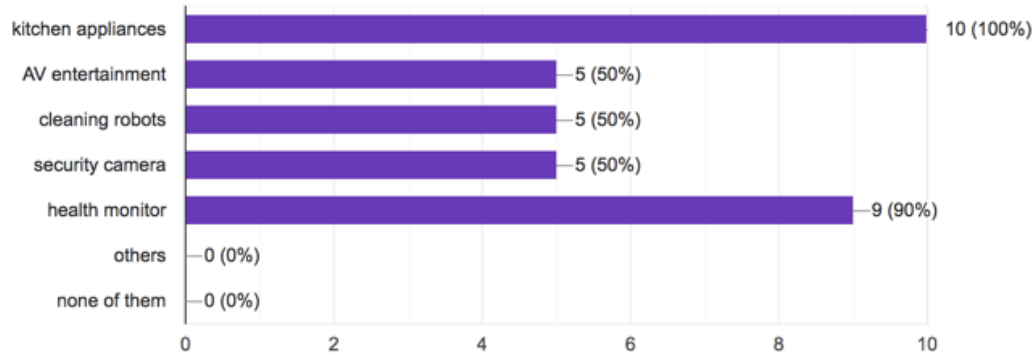
What kind of smart home technologies did you use before?

10 responses



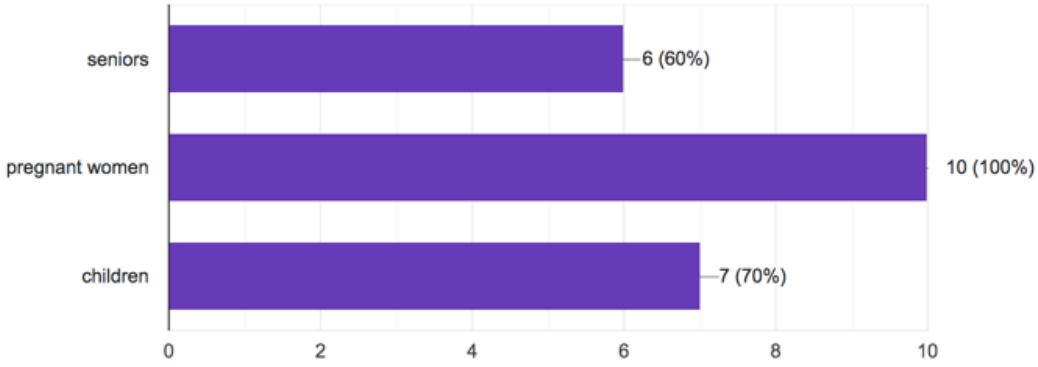
What kind of smart home technologies do you want to use in the future?

10 responses



Who do you think smart homes are mostly beneficial to?

10 responses



4. Interview transcripts

date

15-04-2020

research approach

First interview

onsite/remote

Remote

name

Participant 1

gender

F

age

24

institute and dept

UQ Business (Hotel and Event Management)

position

Student

Location

Australia

“1. What do you think a smart home looks like currently and what tends to be in the future?”

Well, in my view, smart home is like something the science fiction film. All devices are automatically, like cleaning robot, auto cooker, etc.

“2. How about smart kitchen? Have you tried any smart kitchen technologies? If so, what are they?”

I think smart kitchen, or we can say smart life is like wake up in the morning with an automatic coffee machine and a self-cooked breakfast. Enjoy a wonderful day with a nutrition-aware meal. That’s cool. I have experienced voice controlled microwave by using “Alex” to set a cooking time, really nice to say “hello” to it and it works perfectly on time, but my mum doesn’t like to use it because it is difficult to learn how to control it.

“3. Why using this kind of smart kitchen technology and why do you think your mum doesn’t like to use them?”

For me, I like to use these smart devices due to their convenience and efficiency. But for my mon, I think it may be difficult for her to learn and understand how to use it. She hardly uses smart phone or other smart technologies in daily life. As a middle-aged person, my mum told me, “I use mobile phone but not very frequently, just for calling and message. Although it takes much time to learn to use apps on mobile phone, I am still willing to learn new technology.” But for her growing age and poor eyesight, she may be hard to read too much words clearly on the mobile phone screen, because she always asked me to help her read the message on the mobile phone.

date

22-05-2020

research approach

Second interview

“4. Have you, or your friends, relatives around you been pregnant?”

Yes, my elder sister was pregnant last year, and she has born a lovely baby girl.

“5. When your sister was expecting, how diets have changed?”

She loves all types of food, especially meat. I think the types of food are as usual, not changed greatly. But she eats quite a lot,

almost twice as much as before. And she loves to eat with families. Sometimes she asked me to accompany her and share dinner when her husband was busy with job. But before pregnancy, she usually has dishes with workmates, friends and colleagues. But now, I think at this period, she wants to get more supports from the family.

"6. Why do you think family support is important during pregnancy? And what support should be provided as a family member?"

I think family support is very important for me during pregnancy and I believe my husband will be a good father. I hear from my elder sister who has born a girl baby last year that it is really a tough journey during pregnancy. She experienced seriously morning sickness and doesn't want to eat any food in the first 3 months. She felt upset about physical reaction. But her husband is very caring person and he made special dishes every day. The delicious food provided a huge support to my sister.

"7. What types of food do you think are good for pregnant women?"

Fresh fruits, fresh vegetables, beef, pork and milk, any nutrition food I think are good for mummy.

"8. What food should pregnant women avoid? Why?"

I think sea food should avoid, because it has a lot of bacteria and germs, especially raw sea food like Simon sushi. That is bad for baby and women's health.

"9. How do you get the information on foods good or bad for pregnancy?"

Online, website. When I have questions, I always search on Google. But I am not sure how accurate the information is. Maybe when I am pregnant, I would like to follow the doctor's advice.

"10. Why do you get information in this way?"

Emmm… I think professional advice with high authority will keep me and my baby healthy. They are trustful, credible, dependable, fair and scientific. Some information online maybe the advertisement or promotion that persuade women to buy useless things. So, I don't trust online information if it is not proved.

"11. If there is a technology to help you (or expectant mothers) detecting food to ensure a healthy diet, would you like to try? Why?"

I won't try any technology during my pregnancy unless it is approved by the authorities. I am not sure what it would be and what technology would add additionally. I didn't have trouble Googling if I was unsure about something. I am worried about its accuracy of datasets and information. It would be dangerous if it is broken and provides some fake news. I would like to try new technology if I am not pregnant, because I like to reach new thing and to learn latest promising technologies. But I will never let my child involved in any risks under the unknown technology without any test or evaluation.

date

14-04-2020

research approach

First interview

onsite/remote

Remote

name

Participant 2

gender

F

age

25

institute and dept

UQ ITEE (Interaction Design)

position

Student

Location

Australia

“1. What do you think a smart home looks like currently and what tends to be in the future?”

In my imagination, smart home is related to the self-controlled devices by using some high technologies like AI, cloud computing, machine learning and so on. I think smart home will be much safer due to the advanced smart camera, face recognition, voice control and many different sensors such as smoke sensor and temperature sensor. And in the near future, I wish to open the door just say “Ali Baba, Open, Sesame” without any key.

“2. Have you tried some smart kitchen technologies? If so, what are they?”

I have tried the voice-controlled refrigerator and it can play music for me. I really enjoy music when I am cooking, but a voice-controlled sounder would be better rather than a remote-controlled rice cooker, refrigerator or oven.

“3. Why or why not using this kind of smart kitchen technology?”

There are so many apps to control different smart devices that made me feel annoying when using smart kitchen devices. I will never use them in a bunch of applications. It is so ridiculous. Look at my mobile phone. First is for air-conditioner, second is for television, third is for fridge, fourth is for laundry. Some are using Bluetooth, while others link to the home WIFI. If there is no internet in my household, I can’t use them anymore. It is really inconvenient. I want to use all in one app that I can control my electrical appliances in one device or system without connecting WIFI.

date

26-05-2020

research approach

Second interview

“4. Have you, or your friends, relatives around you been pregnant?”

Yes, my best friend was pregnant last year around December. She will have a child soon.

“5. When your friend is expecting, how diets have changed?”

I am not sure she has changed diets or not. Actually, I heard that she had a good appetite during pregnancy and eat a lot.

“6. What types of food do you think are good for pregnant women?”

Well, I think nutritious food, such as milk, fruits and vegetables.

“7. What food should pregnant women avoid? Why?”

I am not sure. Maybe coffee, wine and cigarettes should be noticed.

“8. How do you get the information on foods good or bad for pregnancy?”

From my mum.

“9. Why do you get information in this way?”

I trust my mum and can learn from her experience. I will follow her advice.

"10. If there is a technology to help you (or expectant mothers) detecting food to ensure a healthy diet, would you like to try? Why?"

Well, I think I may not use it because some smart home devices would have screen monitor and may be bad for eyes and also, I learned from healthcare website that some mobile phones and WIFI signals may have electron radiation, which may increase the risk of miscarriage in pregnant women. I don't know if it has LED screen or use WIFI, but I won't let my child be in danger if I am pregnant in the future.

date

16-04-2020

research approach

First interview

onsite/remote

Remote

name

Participant 3

gender

M

age

28

institute and dept

UQ ITEE (Information Technology)

position

Student

Location

Australia

"1. What do you think a smart home looks like currently and what tends to be in the future?"

I think it is like IoT home, everything from Internet-connected light bulbs to cameras that allow us watch out our children or kitty outside the house. Smart phone can be the controller that let us monitor everything from lights to fridge through one application, allow remote access and help make budgets and save energy.

"2. Have you tried some smart kitchen technologies? If so, what are they?"

Yes, of course. I am a smart technologies enthusiast. I have used smart camera, smoke and temperature detector, smart WIFI toaster, smart oven and microwave, smart coffee maker and Cue Smart Induction Burner & Fry Pan. These smart kitchen technologies with voice control function, monitoring the temperature and food condition under connection to the certain app. With the help of these technologies, I never over or undercook a meal again. Besides, I want to have some machine that could remind me of the time or temperature of baking a banana cake. It will be much better if it can give me some idea of what to eat everyone. Due to my overweight, I should go on a diet.

"3. Why using this kind of smart kitchen technology?"

Because these smart technologies improve the level of my life. It is a new lifestyle to use voice control system like Amazon Echo & Alexa. It enhances my home security because I can remotely lock any doors that I need and spy on every conner inside or outside my house, epically the smoke and temperature monitoring when I am cooking in the kitchen.

date

25-05-2020

research approach

Second interview

"4. Have you, or your friends, relatives around you been pregnant?"

Yes. My landlord.

"5. When you or your family or friends are expecting, how diets have changed?"

I don't know because her diet is like normal.

"6. What types of food do you think are good for pregnant women?"

Nutrition food.

"7. What food should pregnant women avoid? Why?"

Coffee and wine because caffeine and alcohol may increase the crisis of miscarriage.

"8. How do you get the information on foods good or bad for pregnancy?"

I heard from TV programme.

"9. Why do you get information in this way?"

Emmm… I think health TV show may teach us some useful knowledge from experts.

"10. If there is a technology to help expectant mothers detecting food to ensure a healthy diet, would you like to try? Why?"

Yes. I will try as long as it is friendly to use. It seems like a smart suggestion provider. It may be helpful and convenient. For pregnant women and her families, it is important to keep a healthy diet. This may aid to save time of searching information on the internet because not everyone can remember clearly which food is good or bad for pregnant women as doctors.

date

14-04-2020

research approach

First interview

onsite/remote

Remote

name

Participant 4

gender

F

age

28

institute and dept

Shanghai Huadong Hospital

position

Nurse

Location

China

"1. What do you think a smart home looks like currently and what tends to be in the future?"

Under the development of IoTs, 5G and WIFI technologies, smart home become increasingly popular in our daily life. Home based smart healthcare is what I expected in the future. Mobile phone and wearable devices can provide a healthier lifestyle through monitoring heart rate, sleep quality and food nutrition.

"2. Have you tried some smart kitchen technologies? If so, what are they?"

Yes, I have used the Amazon Basics Microwave and refrigerator that is connect with Alexa voice commands.

"3. Why using this kind of smart kitchen technology?"

Because they are very convenient and simplify my cooking process. The smart microwave can automatically cook food when I set a specific time on my application. And the smart fridge can remind me the expired date. It is nice if something could remind me the use of date of food because I always forget what food is in the fridge.

date

23-05-2020

research approach

Second interview

"4. Have you, or your friends, relatives around you been pregnant?"

Yes. I have been pregnant and now I have a one-year-old boy.

"5. When you are expecting, how diets have changed?"
---
2 biggest changes for me were that I could eat (avoiding the required foods) that I have extreme nausea/vomiting and couldn't handle certain food. I did also have some cravings but these are not major.

"6. What types of food do you think are good for pregnant women?"

Dairy Products, eggs, chicken, fruits, juice, etc…

"7. What food should pregnant women avoid? Why?"

Raw meat, frozen sea food, food with uncertain ingredients and those may have bacteria pollution. Cigarette and wine are also bad for health.

"8. How do you get the information on foods good or bad for pregnancy?"

I followed advice from my gynaecologist and view online articles from professional BBS.

"9. Why do you get information in this way?"

Emmm… these are evidential suggestions. I only believe proven and professional information because I am a medical carer and a mother, I understand why pregnant women so care about their diets. We want to keep our baby safe and health. I think the professional advice will be helpful and trustful. It must be suitable for my own condition.

"10. If there is a technology to help you (or expectant mothers) detecting food to ensure a healthy diet, would you like to try? Why?"

Yeah. Why not? It is interesting. I may follow its suggestion, but I will continue my own diet habit according to my physical condition and my doctor's advices if I need specific diets.

date

15-04-2020

research approach

First interview

onsite/remote

Remote

name

Participant 5

gender

F

age

39

institute and dept

City Council

position

Government Officer

Location

China

“1. What do you think a smart home looks like currently and what tends to be in the future?”

Smart home is like voice controlling TV, remote monitoring camera, food detection fridge, automatic cleaning robot or AI face identification door gate.

“2. Have you tried some smart kitchen technologies? If so, what are they?”

I haven’t tried any smart kitchen technologies yet. In my house, the home electrical appliances are very traditional, they can’t connect internet or WIFI.

“3. Why not using this kind of smart kitchen technology?”

I don’t like to use many applications on the mobile phone to control these smart technologies. And it is very time consuming to learn how to use them. I even don’t like to use smart phone just for communicating with others.

date

24-05-2020

research approach

Second interview

“4. Have you, or your friends, relatives around you been pregnant?”

Yes, a lot. My best friend, colleagues, my young sister and so on. They were pregnant several years before. Also, I have a boy. He is twelve.

“5. When you or your family or friends are expecting, how diets have changed?”

Most of them don’t change their diets greatly, but they focus on taking more nutrition food. For me, I only eat vegetables, so when I was pregnant, I had taken some Vitamin D pills, had more milk and fresh juice. One thing need consideration that I am also a vegetarian, but my families are not. I need special diet individually and the food storage separately from others. When I buy something online, I will read the ingredients list carefully, avoid eating meat or meat products.

“6. What types of food do you think are good for pregnant women?”

I think fruits and vegetables are good for pregnant women.

“7. What food should pregnant women avoid? Why?”

Uncooked or raw fish and meat. For example, sushi, Listeria bacteria can be passed to baby and lead to miscarriage, stillbirth, and other health problems.

“8. How do you get the information on foods good or bad for pregnancy?”

I always follow the advices from the doctor.

“9. Why do you get information in this way?”

I was under the care of a doctor and she advised current guidelines and also amended recommendations based on my current needs (such as anaemia).

“10. If there is a technology to help you (or expectant mothers) detecting food to ensure a healthy diet, would you like to try? Why?”

I think I will, but I am not sure about its functionality same as what it is in my brain. Usually, there are a lot of same food in the fridge. Last week, I bought some apples

online and my mon bought fruits again few days later. Sometimes, I am confused about mon not check fridge and buy a lot of doubled food. If there is a smart device for food storage and monitoring from online shopping, I would like to use.

date

15-04-2020

research approach

First interview

onsite/remote

Remote

name

Participant 6

gender

F

age

32

institute and dept

International company

position

Staff

Location

Australia

“1. What do you think a smart home looks like currently and what tends to be in the future?”

It looks like automation and artificial intelligence. With automatic cooked coffee and toast in the morning, curtains automatically open, smart mirror can tell me what to dress today, Amazon Alexa broadcast weather and temperature.

“2. Have you tried some smart kitchen technologies? If so, what are they?”

I don’t know what kind of kitchen devices can be regarded as smart technologies. I only used the fridge link with Bluetooth that I can set its temperature remotely on the mobile application.

“3. Why or why not using this kind of smart kitchen technology?”

I think this kind of technology is very convenient, but it is only accepted by young adults. Senior groups such as my parents cannot use it smoothly because they never use smart phone for other functions despite calling and messaging.

date

26-05-2020

research approach

Second interview

“4. Have you, or your friends, relatives around you been pregnant?”

Yes, many people I know have been pregnant in recent two years, including my high school classmate, my young cousin and my boss’s wife.

“5. When you or your family or friends are expecting, how diets have changed?”

Well, speak to my cousin for example, the category and the amount of food they eat is changed greatly. She had a good appetite when she was pregnant and loved to eat sweet deserts that she didn’t like before. Maybe she wanted to lose weight and keep fit before. But when she was pregnant, she need more nutrition to keep her baby healthy.

“6. What types of food do you think are good for pregnant women?”

Low sugar, low calories, no caffeine, no seafood, high protein.

“7. What food should pregnant women avoid? Why?”

Raw egg has Salmonella bacteria. Organ meat and caffeine are harmful to baby and may cause miscarriage.

“8. How do you get the information on foods good or bad for pregnancy?”

From the internet, search on Google and some popular mummy care applications.

“9. Why do you get information in this way?”

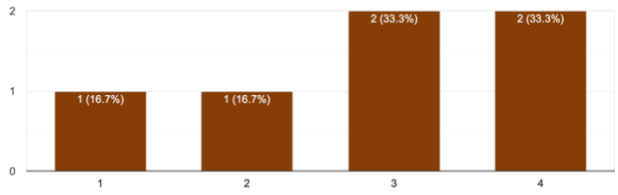
I think online social community can provide a platform to know more pregnant women and share our experience easily. Some are very professional with many experts and gynaecologist to answer the questions and give us advices. I can also set up the antenatal care date and expected date of confinement on the app.

“10. If there is a technology to help you (or expectant mothers) detecting food to ensure a healthy diet, would you like to try? Why?”

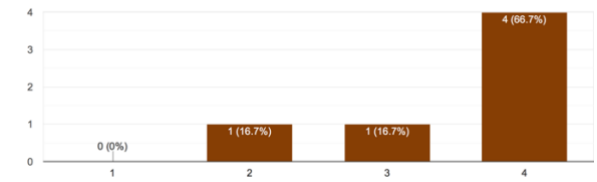
Yes, I will try if it is helpful to my body. During the lockdown period, my husband has bought a lot of things online. It is convenient to buy daily necessities. But my concern is online shopping for food and drinks. For me, I don't like to eat snacks or drinks from online shopping because I don’t know if it has some ingredients that is bad for my health. We are preparing for a baby and to accurately identify what kind of food is good to eat is incredibly time consuming.

5. TAM Survey

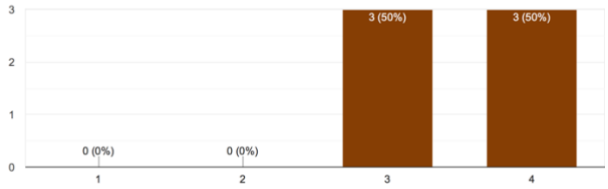
[PU1]I can accomplish my [food detection] more quickly using FoodCare
(6 条回复)



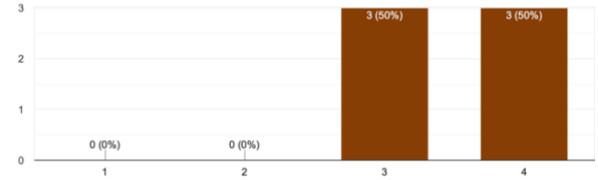
[PU2]I can accomplish my [food detection] more easily using FoodCare
(6 条回复)



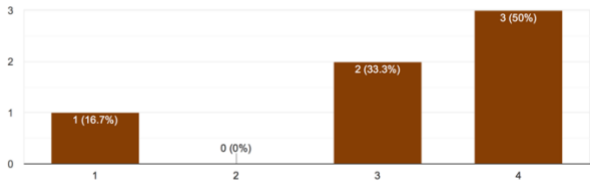
[PU3] FoodCare enhances my effectiveness in utilizing [food & recipe]
(6 条回复)



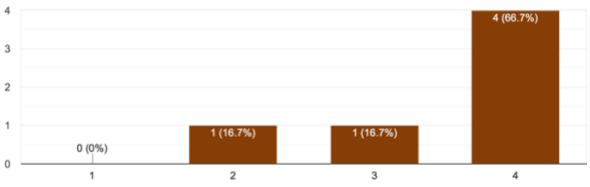
[PU4] FoodCare enhances my efficiency in utilizing [food & recipe]
(6 条回复)



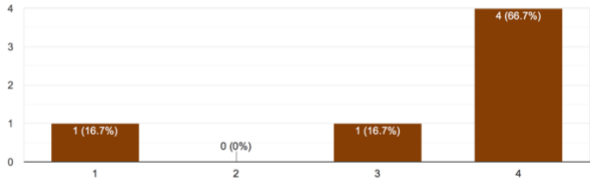
[PU5] FoodCare enables me to make better decisions in utlizing [food storage]
(6 条回复)



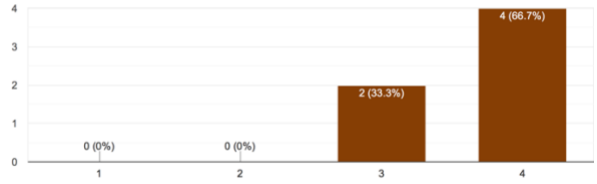
[PU6]Overall, I find FoodCare useful
(6 条回复)



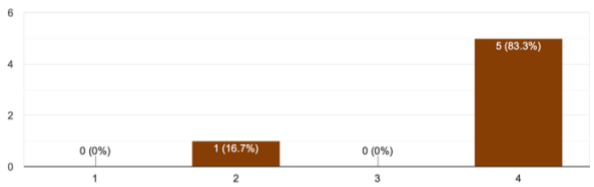
[PEOU1]Learning to use FoodCare is easy for me
(6 条回复)



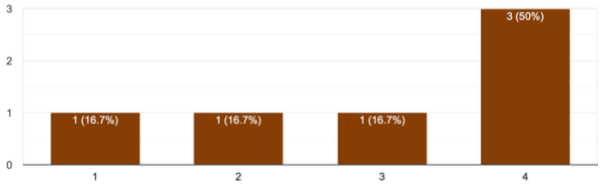
[PEOU2]It is easy to use FoodCare to accomplish my [food storage]
(6 条回复)



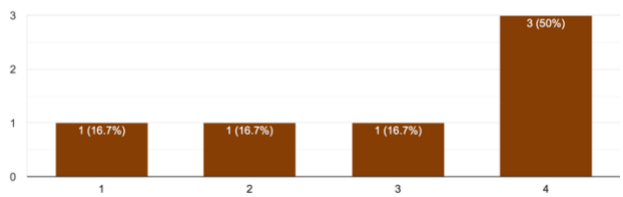
[PEOU3]Overall, I believe FoodCare is easy to use
(6 条回复)



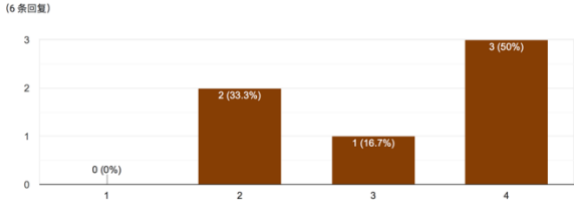
[ATT1]In my opinion, it is desirable to use FoodCare
(6 条回复)



[ATT2]I think it is good for me to use FoodCare
(6 条回复)

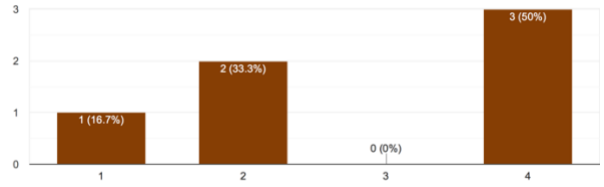


[ATT3]Overall, my attitude towards FoodCare is favourable
(6 条回复)



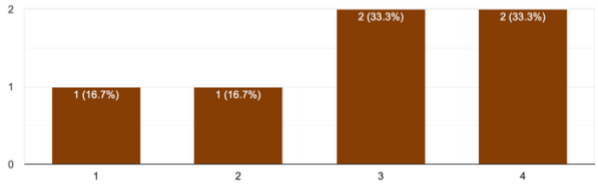
[ITO1]I will use FoodCare on a regular basis in the future

(6 条回复)



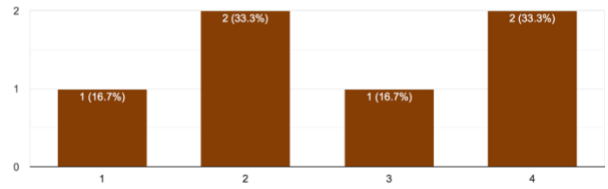
[ITO2]I will frequently use FoodCare in the future

(6 条回复)

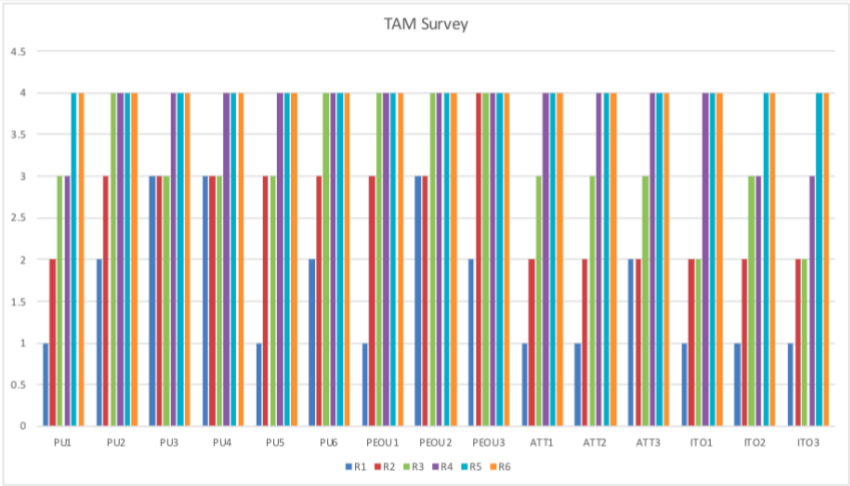


[ITO3]I will strongly recommend others to use FoodCare

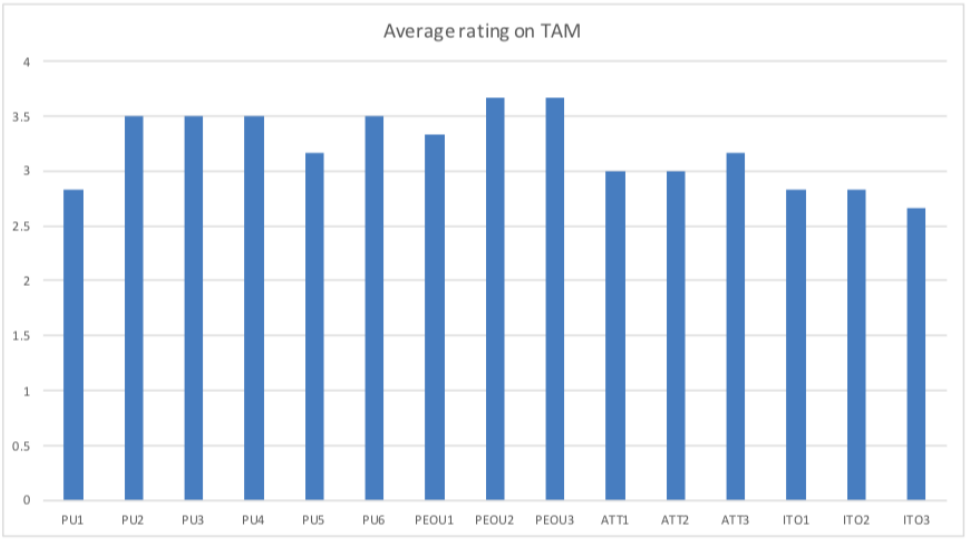
(6 条回复)



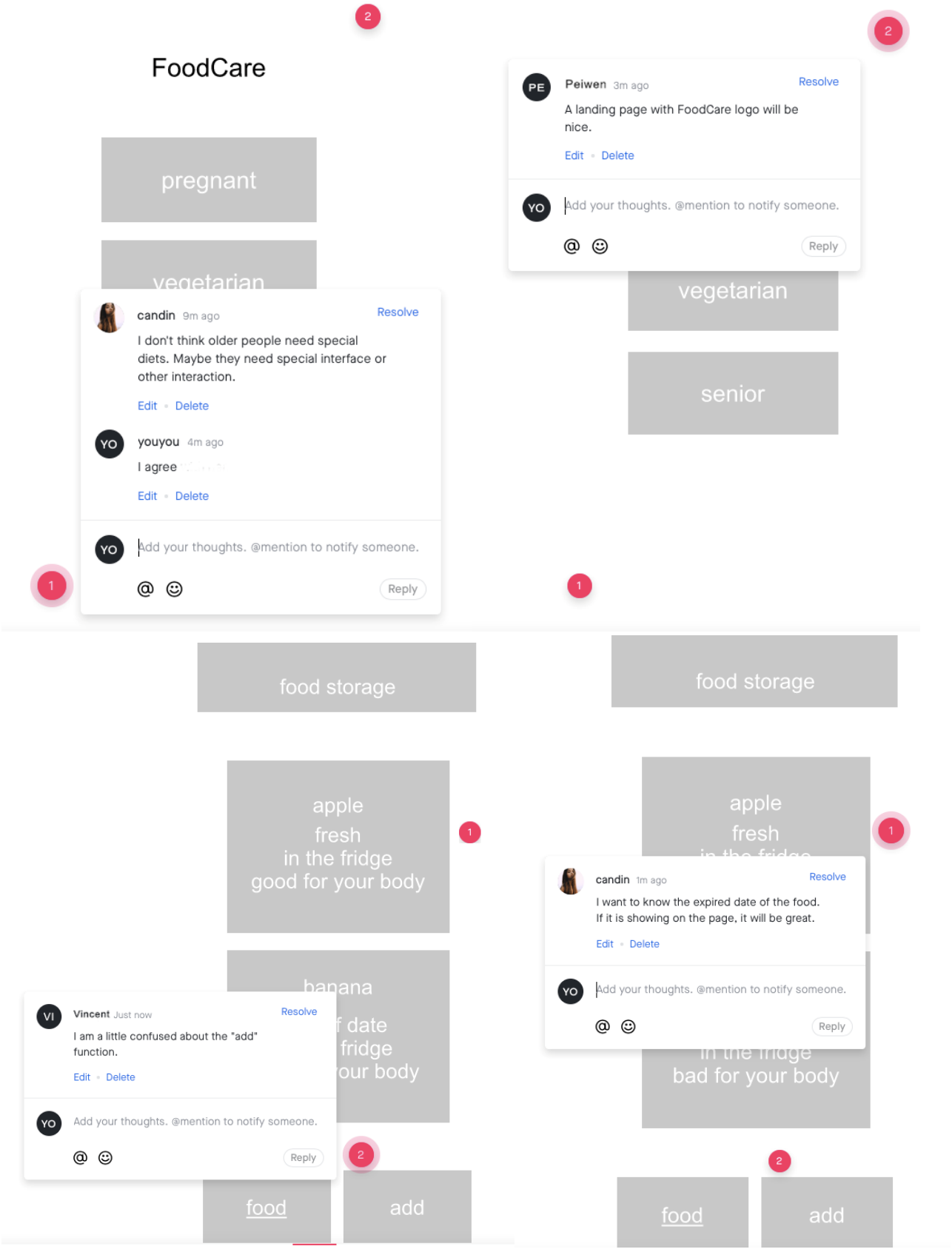
Dimension	R1	R2	R3	R4	R5	R6	R8	R9	R10
PU1	1	2	3	3	4	4			
PU2	2	3	4	4	4	4			
PU3	3	3	3	4	4	4			
PU4	3	3	3	4	4	4			
PU5	1	3	3	4	4	4			
PU6	2	3	4	4	4	4			
PEOU1	1	3	4	4	4	4			
PEOU2	3	3	4	4	4	4			
PEOU3	2	4	4	4	4	4			
ATT1	1	2	3	4	4	4			
ATT2	1	2	3	4	4	4			
ATT3	2	2	3	4	4	4			
ITO1	1	2	2	4	4	4			
ITO2	1	2	3	3	4	4			
ITO3	1	2	2	3	4	4			

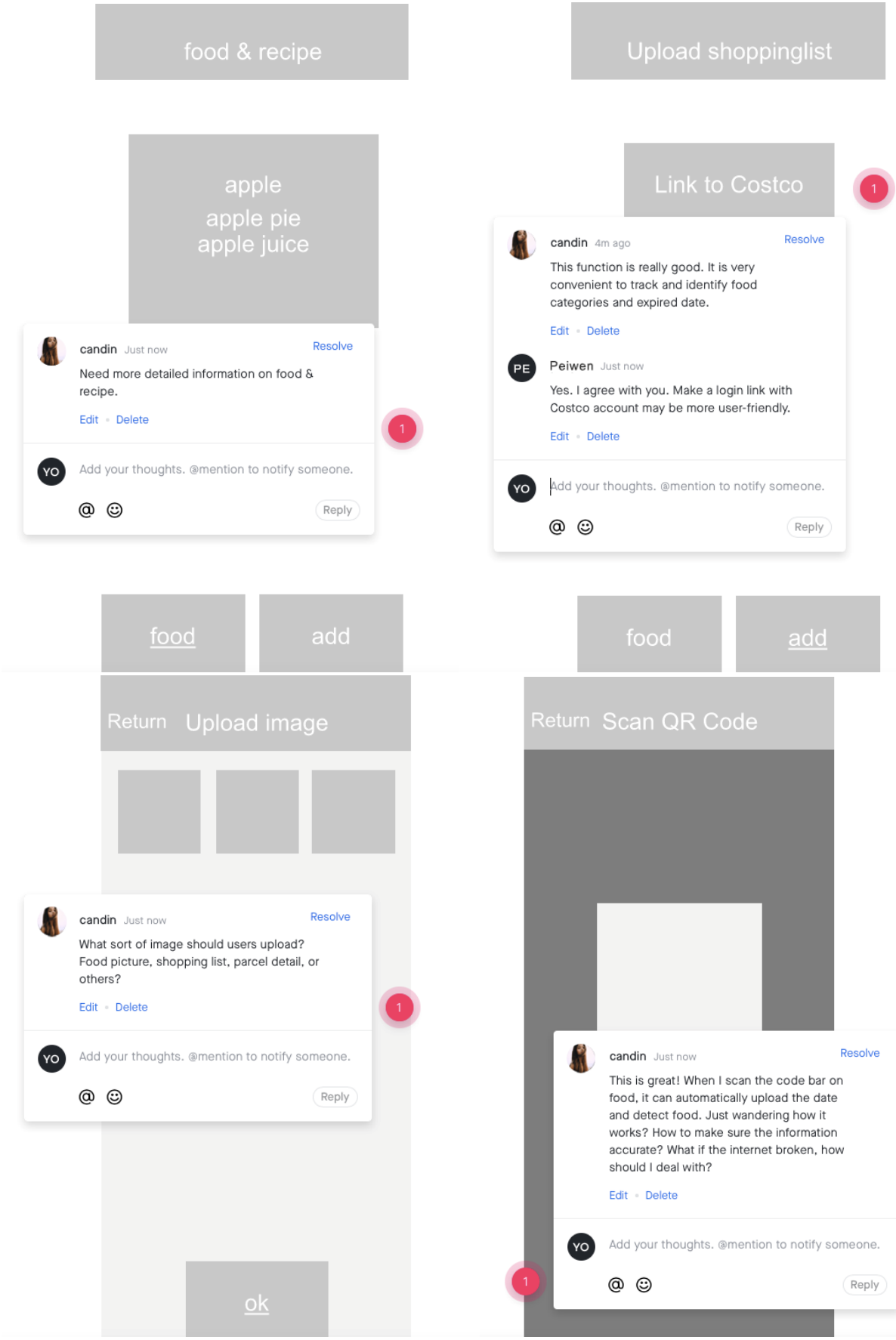


	Av
PU1	2.833
PU2	3.5
PU3	3.5
PU4	3.5
PU5	3.167
PU6	3.5 3.3
PEOU1	3.333
PEOU2	3.667
PEOU3	3.667 3.6
ATT1	3
ATT2	3
ATT3	3.167 3.1
ITO1	2.833
ITO2	2.833
ITO3	2.667 2.8



6. UX Goal


2
FoodCare
pregnant
vegetarian
candin 9m ago
Resolve
I don't think older people need special diets. Maybe they need special interface or other interaction.
Edit • Delete
YO
youyou 4m ago
I agree
Edit • Delete
YO
Add your thoughts. @mention to notify someone.
@
Reply
1
2
PE
Peiwen 3m ago
Resolve
A landing page with FoodCare logo will be nice.
Edit • Delete
YO
Add your thoughts. @mention to notify someone.
@
Reply
vegetarian
senior
1
food storage
apple
fresh
in the fridge
good for your body
1
banana
VI
Vincent Just now
Resolve
I am a little confused about the "add" function.
Edit • Delete
YO
Add your thoughts. @mention to notify someone.
@
Reply
2
food
add
food storage
apple
fresh
1
candin 1m ago
Resolve
I want to know the expired date of the food.
If it is showing on the page, it will be great.
Edit • Delete
YO
Add your thoughts. @mention to notify someone.
@
Reply
bad for your body
2
food
add


food & recipe
Upload shoppinglist
apple
apple pie
apple juice
Link to Costco
1
candin 4m ago
Resolve
This function is really good. It is very convenient to track and identify food categories and expired date.
Edit • Delete
PE
Peiwen Just now
Yes. I agree with you. Make a login link with Costco account may be more user-friendly.
Edit • Delete
candin Just now
Resolve
Need more detailed information on food & recipe.
Edit • Delete
1
YO
Add your thoughts. @mention to notify someone.
Reply
food
add
Return Upload image
candin Just now
Resolve
What sort of image should users upload? Food picture, shopping list, parcel detail, or others?
Edit • Delete
1
YO
Add your thoughts. @mention to notify someone.
Reply
ok
food
add
Return Scan QR Code
candin Just now
Resolve
This is great! When I scan the code bar on food, it can automatically upload the date and detect food. Just wandering how it works? How to make sure the information accurate? What if the internet broken, how should I deal with?
Edit • Delete
YO
Add your thoughts. @mention to notify someone.
Reply
1

7. Time to Complete Observation Notes

Participant 1 (remote)	**Date: 03/09/2020**
Time	Observations
00:03	Start task 1: choose pregnancy mode and login (not link to Costco account)
00:05	Start task 2: accurately find the expired date of iced coffee
00:12	Start task 3
00:27	Start task 4
00:35	End
Total Clicks	12

Participant 2 (remote)	**Date: 03/09/2020**
Time	Observations
00:05	Start task 1: choose pregnancy mode and link to Costco account
00:08	Start task 2: accurately find the expired date of iced coffee
00:14	Start task 3
00:26	Start task 4: confused about scanning QR code
00:30	End
Total Clicks	14

Participant 3 (remote)	**Date: 03/09/2020**
Time	Observations
00:04	Start task 1: choose pregnancy mode and link to Costco account
00:07	Start task 2: accurately find the expired date of iced coffee
00:13	Start task 3
00:24	Start task 4
00:29	End
Total Clicks	11

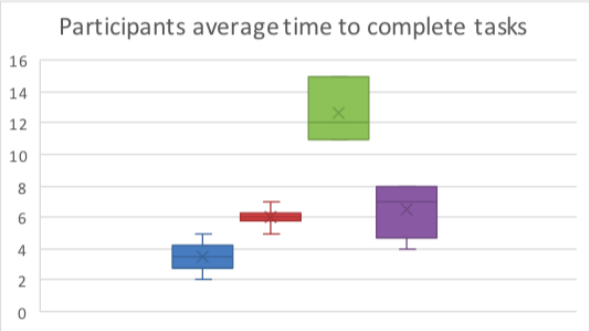
Participant 4 (remote)	**Date: 03/09/2020**
Time	Observations
00:02	Start task 1: choose pregnancy mode and link to Costco account
00:06	Start task 2: accurately find the expired date of iced coffee
00:11	Start task 3
00:23	Start task 4
00:31	End
Total Clicks	13

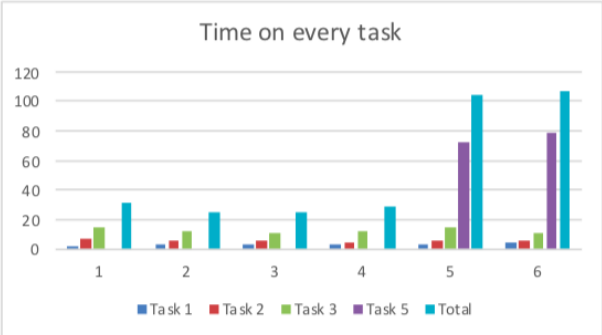
Participant 5	**Date: 03/09/2020**
Time	Observations
00:03	Start task 1: choose pregnancy mode and link to Costco account
00:07	Start task 2: accurately find the expired date of iced coffee
00:13	Start task 3
00:28	Start task 4
00:36	Start task 5
01:48	End
Total Clicks	11

Participant 6	**Date: 03/09/2020**
Time	Observations
00:04	Start task 1: choose pregnancy mode and link to Costco account
00:09	Start task 2: accurately find the expired date of iced coffee
00:15	Start task 3
00:26	Start task 4
00:33	Start task 5
01:52	End
Total Clicks	12

8. Time to Complete Analysis

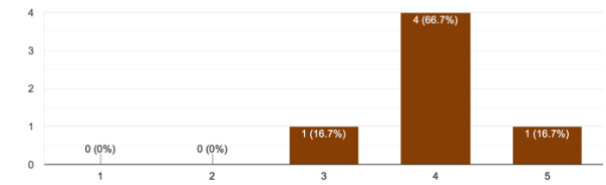
Participant/Time(S)	1	2	3	4	5	6	Average
Task 1	2	3	3	4	4	5	3.5
Task 2	7	6	6	5	6	6	6
Task 3	15	12	11	12	15	11	12.66666667
Task 4	8	4	5	8	8	6	6.5
Task 5					72	79	
Total	32	25	25	29	105	107	53.83333333



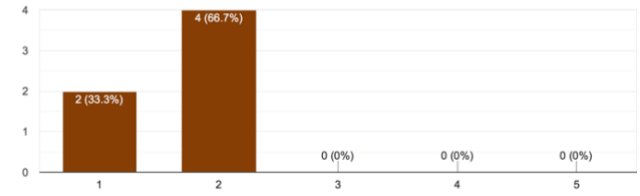


9. System Usability Scale (SUS)

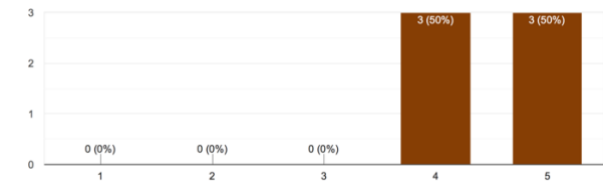
1. I think that I would like to use this system frequently.
(6 条回复)



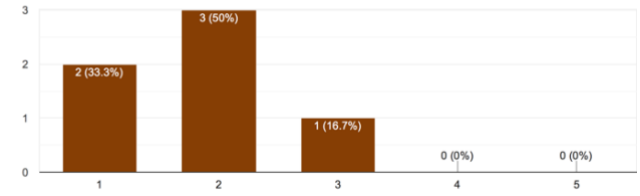
2. I found the system unnecessarily complex.
(6 条回复)



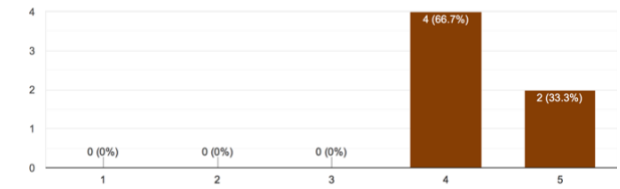
3. I thought the system was easy to use.
(6 条回复)



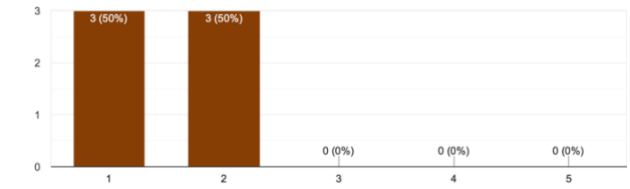
4. I think that I would need the support of a technical person to be able to use this system.
(6 条回复)



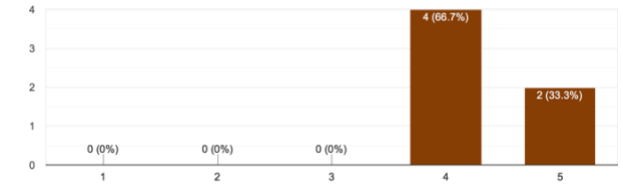
5. I found the various functions in this system were well integrated.
(6 条回复)



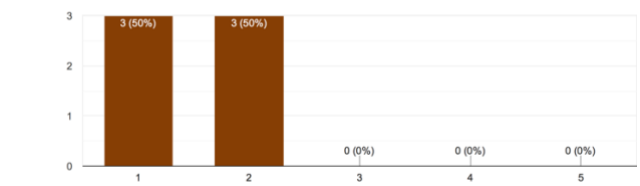
6. I thought there was too much inconsistency in this system.
(6 条回复)



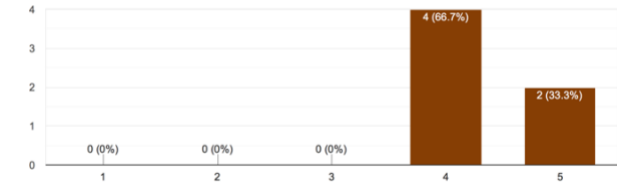
7. I would imagine that most people would learn to use this system very quickly.
(6 条回复)



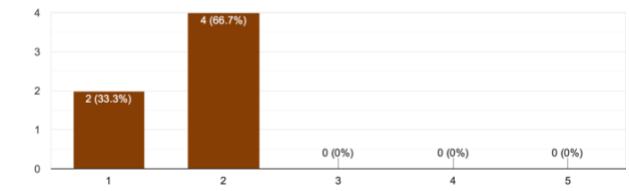
8. I found the system very cumbersome to use.
(6 条回复)



9. I felt very confident using the system.
(6 条回复)



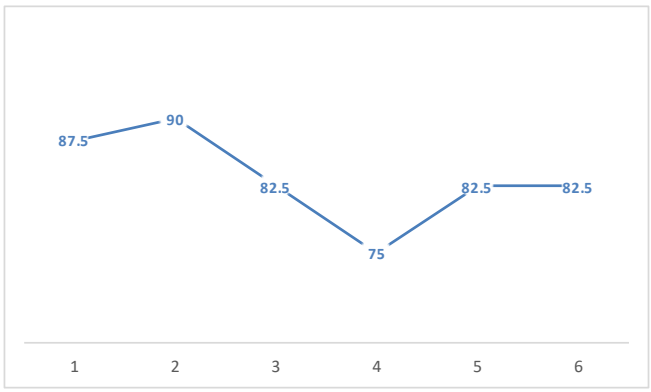
10. I needed to learn a lot of things before I could get going with this system.
(6 条回复)

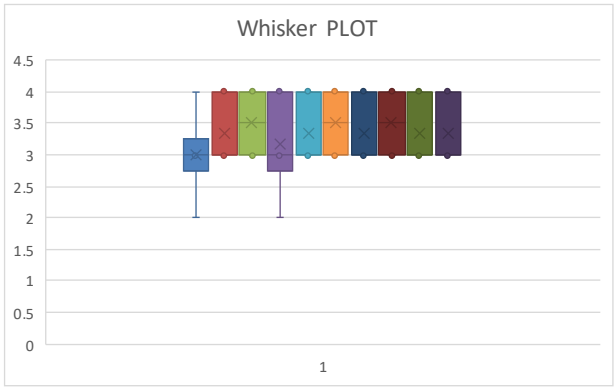


SUS Raw Data	Resp1	Resp2	Resp3	Resp4	Resp5	Resp6	Average
I think that I would like to use this system frequently.	3	4	4	4	4	5	4
I found the system unnecessarily complex.	1	1	2	2	2	2	1.66666667
I thought the system was easy to use.	5	5	5	4	4	4	4.5
I think that I would need the support of a technical person to be able to use this system.	1	1	2	2	2	3	1.83333333
I found the various functions in this system were well integrated.	4	4	4	4	5	5	4.33333333
I thought there was too much inconsistency in this system.	1	1	1	2	2	2	1.5
I would imagine that most people would learn to use this system very quickly.	4	4	4	4	5	5	4.33333333
I found the system very cumbersome to use.	1	1	1	2	2	2	1.5
I felt very confident using the system.	4	4	4	4	5	5	4.33333333
I needed to learn a lot of things before I could get going with this system.	1	1	2	2	2	2	1.66666667

	Resp1	Resp2	Resp3	Resp4	Resp5	Resp6	Average
I think that I would like to use this system frequently.	2	3	3	3	3	4	3
I found the system unnecessarily complex.	4	4	3	3	3	3	3.33333333
I thought the system was easy to use.	4	4	4	3	3	3	3.5
I think that I would need the support of a technical person to be able to use this system.	4	4	3	3	3	2	3.16666667
I found the various functions in this system were well integrated.	3	3	3	3	4	4	3.33333333
I thought there was too much inconsistency in this system.	4	4	4	3	3	3	3.5
I would imagine that most people would learn to use this system very quickly.	3	3	3	3	4	4	3.33333333
I found the system very cumbersome to use.	4	4	4	3	3	3	3.5
I felt very confident using the system.	3	3	3	3	4	4	3.33333333
I needed to learn a lot of things before I could get going with this system.	4	4	3	3	3	3	3.33333333

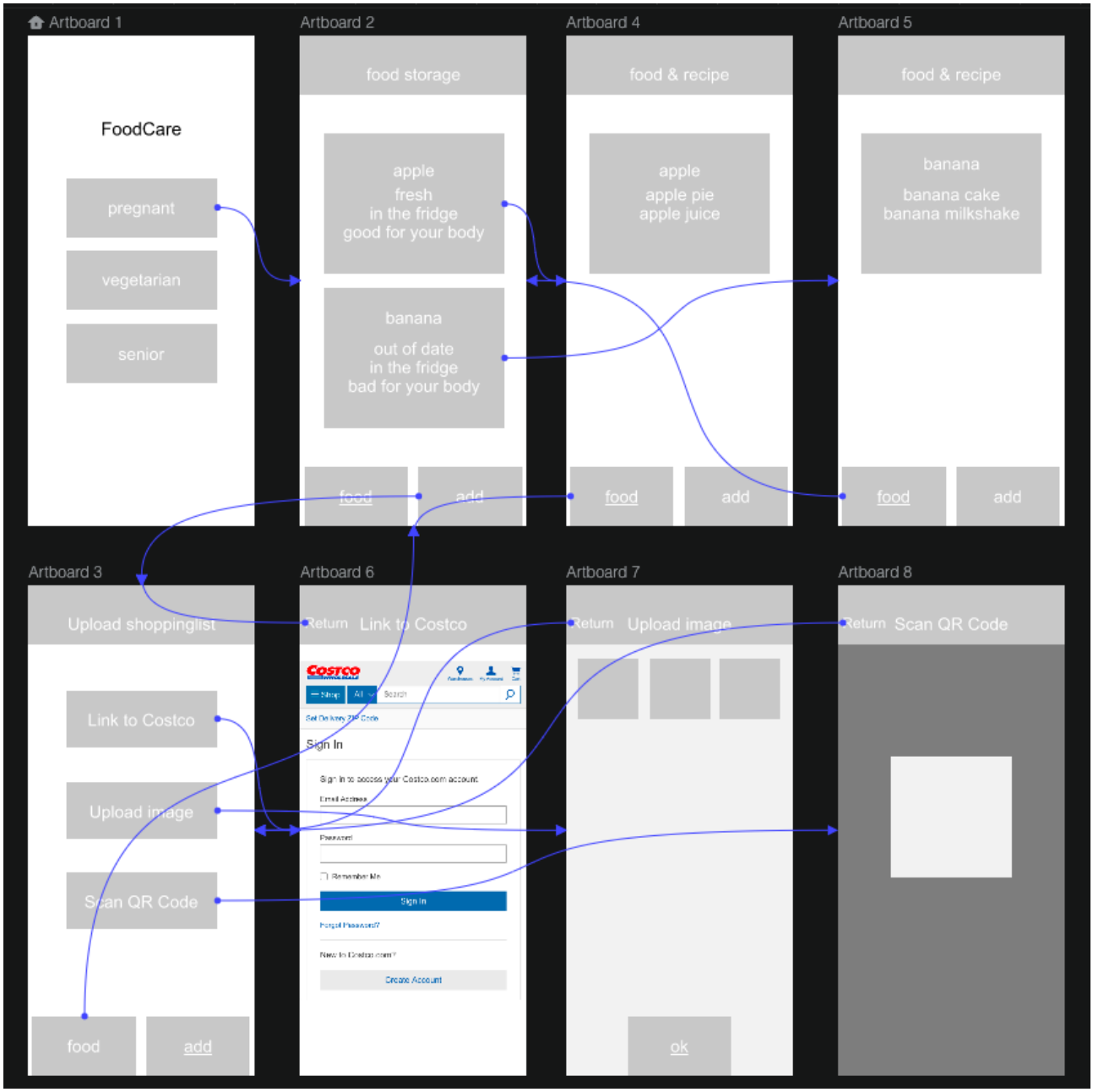
Total for each respondant	87.5	90	82.5	75	82.5	82.5
	A	A	A	B	A	A





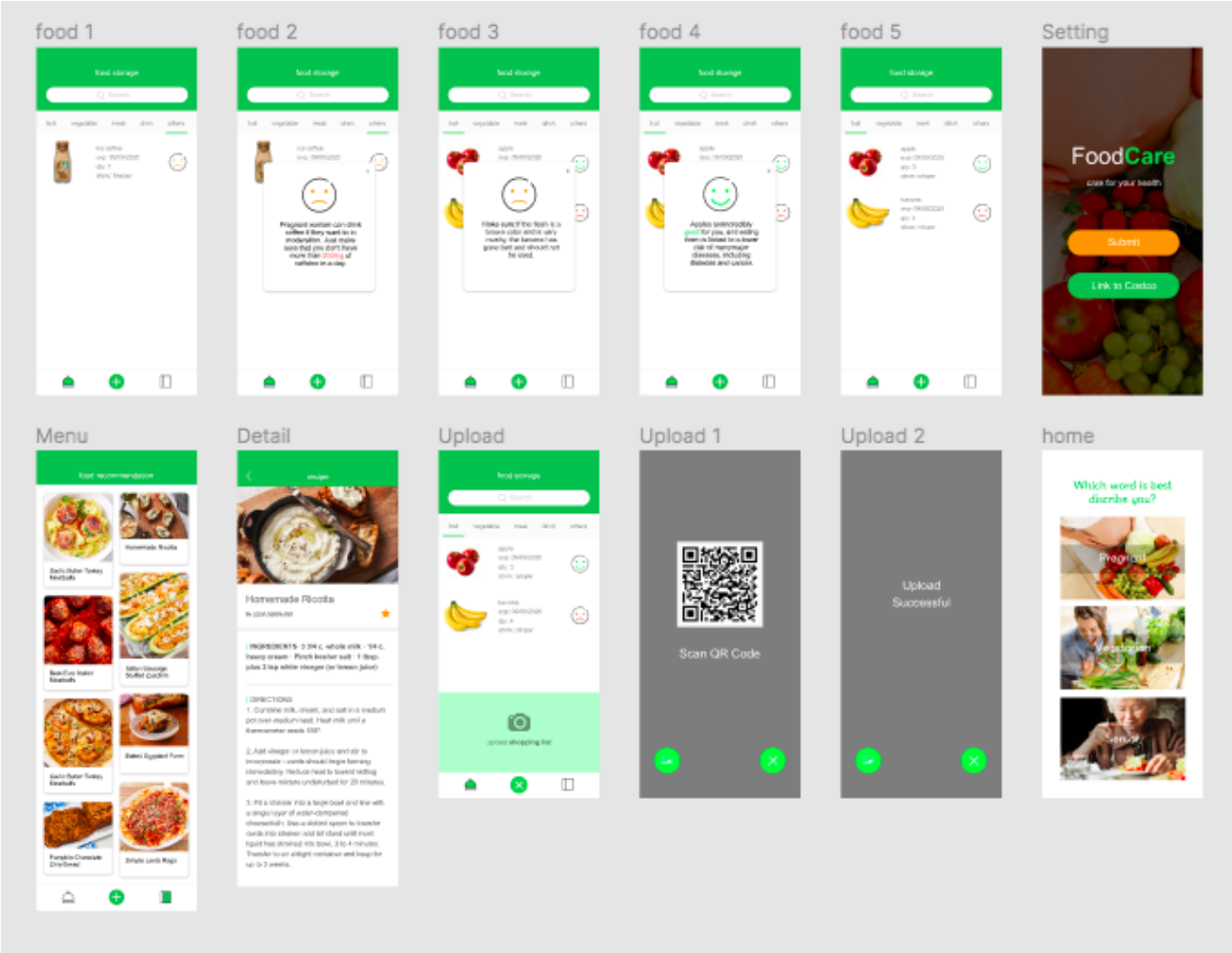
10.Low-fi prototype

Prototype link:
https://projects.invisionapp.com/prototype/ckeefkdiy0009qo01cvu29sgy/play



11.High-fi prototype

Prototype link:
https://projects.invisionapp.com/prototype/ckee2v99l00a28e01g4aehnm8/play



Food detection system video prototype: https://youtu.be/QkUEfonb4c8
Food detection system voice feedback reference from Food safety during pregnancy on Queensland Government Publications and data.world
https://www.publications.qld.gov.au/dataset/activity/food-safety-during-pregnancy
https://data.world/datasets/pregnancy

Voice feedback context:
Banana: Potassium in bananas is good for your heart health and blood pressure.
Caffeine: Pregnant women can drink coffee if they want to in moderation. Just make sure that you don't have more than 200mg of caffeine in a day.
Apple: Apples are incredibly good for you and eating them is linked to a lower risk of many major diseases, including diabetes and cancer.

Introduction of the Food Detection System--FoodCare:
Raspberry Pi 4 Model B 4GB RAM Board is used to build this system. Frist Download Raspbian and copy to the SD card. Install VCN Viewer for remote control. After Raspberry Pi Desktop working, the board connects with camera and two servos for Horizontal and vertical rotation to follow objects.

The MP3 module is for voice feedback after food detection. Here I use Google Cloud Speech API. Next, I download OpenCV and TensorFlow lite in terminal and set up its environment.
There are three modes include pregnancy, vegetarian and seniors. I select pregnancy mode and login. Link to my Costco account to upload my online shopping list. Parcel delivery, there are bananas, apples and a bottle of iced coffee. When I put an apple in it, it will speak apple is safe for expectant mother to eat. And the coffee put in it, it will recommend not to take too much caffeine as it is bad for baby.. I put them in the crisper under camera with the AI system helping to identify which is good or bad for pregnant women. I put the mummy care box with apples and bananas in the fridge and the iced coffee to another crisper.
I can see the category, expired date, quantity and storage on the mobile phone. The smile or sad icon tell me which is good or bad for me. Recipes recommendation allows me to follow the directions and make dishes. I can also upload a shopping list by scanning the QR Code.

12.Food detection function

```
# Define VideoStream class to handle streaming of video from webcam in separate processing thread
# Source - Adrian Rosebrock, PyImageSearch: https://www.pyimagesearch.com/2015/12/28/increasing-raspberry-pi-fps-with-python-and-opencv/
class VideoStream:
    """Camera object that controls video streaming from the Picamera"""
    def __init__(self,resolution=(640,480),framerate=30):
        # Initialize the PiCamera and the camera image stream
        self.stream = cv2.VideoCapture(0)
        ret = self.stream.set(cv2.CAP_PROP_FOURCC, cv2.VideoWriter_fourcc(*'MJPG'))
        ret = self.stream.set(3,resolution[0])
        ret = self.stream.set(4,resolution[1])

        # Read first frame from the stream
        (self.grabbed, self.frame) = self.stream.read()

    # Variable to control when the camera is stopped
        self.stopped = False

    def start(self):
    # Start the thread that reads frames from the video stream
        Thread(target=self.update,args=()).start()
        return self

    def update(self):
        # Keep looping indefinitely until the thread is stopped
        while True:
            # If the camera is stopped, stop the thread
            if self.stopped:
                # Close camera resources
                self.stream.release()
                return

            # Otherwise, grab the next frame from the stream
```

```
            (self.grabbed, self.frame) = self.stream.read()

    def read(self):
    # Return the most recent frame
        return self.frame

    def stop(self):
    # Indicate that the camera and thread should be stopped
        self.stopped = True

# Define and parse input arguments
parser = argparse.ArgumentParser()
parser.add_argument('--modeldir', help='Folder the .tflite file is located in',
                    required=True)
parser.add_argument('--graph', help='Name of the .tflite file, if different than detect.tflite',
                    default='detect.tflite')
parser.add_argument('--labels', help='Name of the labelmap file, if different than labelmap.txt',
                    default='labelmap.txt')
parser.add_argument('--threshold', help='Minimum confidence threshold for displaying detected objects',
                    default=0.5)
parser.add_argument('--resolution', help='Desired webcam resolution in WxH. If the webcam does not support the
resolution entered, errors may occur.',
                    default='1280x720')
parser.add_argument('--edgetpu', help='Use Coral Edge TPU Accelerator to speed up detection',
                    action='store_true')

args = parser.parse_args()

MODEL_NAME = args.modeldir
GRAPH_NAME = args.graph
LABELMAP_NAME = args.labels
min_conf_threshold = float(args.threshold)
resW, resH = args.resolution.split('x')
imW, imH = int(resW), int(resH)
use_TPU = args.edgetpu
```

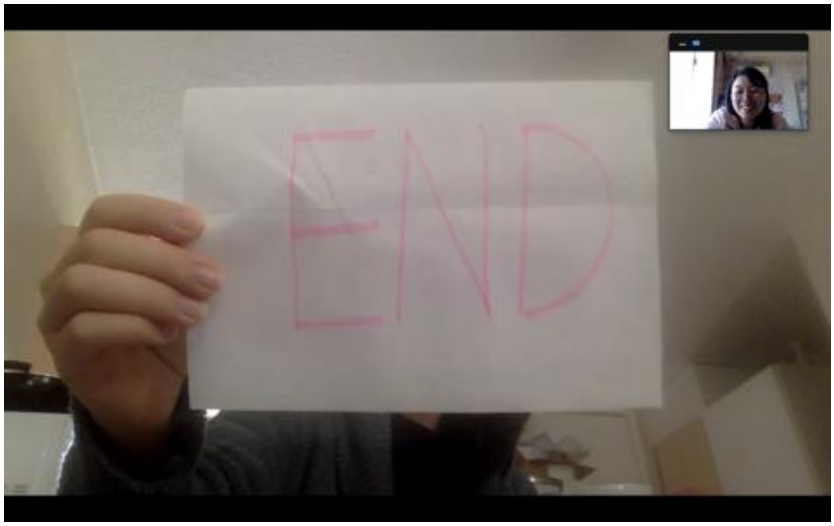
```
# Import TensorFlow libraries
# If tflite_runtime is installed, import interpreter from tflite_runtime, else import from regular tensorflow
# If using Coral Edge TPU, import the load_delegate library
pkg = importlib.util.find_spec('tflite_runtime')
if pkg:
    from tflite_runtime.interpreter import Interpreter
    if use_TPU:
        from tflite_runtime.interpreter import load_delegate
else:
    from tensorflow.lite.python.interpreter import Interpreter
    if use_TPU:
        from tensorflow.lite.python.interpreter import load_delegate

# If using Edge TPU, assign filename for Edge TPU model
if use_TPU:
    # If user has specified the name of the .tflite file, use that name, otherwise use default 'edgetpu.tflite'
    if (GRAPH_NAME == 'detect.tflite'):
        GRAPH_NAME = 'edgetpu.tflite'

# Get path to current working directory
CWD_PATH = os.getcwd()

# Path to .tflite file, which contains the model that is used for object detection
PATH_TO_CKPT = os.path.join(CWD_PATH,MODEL_NAME,GRAPH_NAME)

# Path to label map file
PATH_TO_LABELS = os.path.join(CWD_PATH,MODEL_NAME,LABELMAP_NAME)

# Load the label map
with open(PATH_TO_LABELS, 'r') as f:
    labels = [line.strip() for line in f.readlines()]

# Have to do a weird fix for label map if using the COCO "starter model" from
# https://www.tensorflow.org/lite/models/object_detection/overview
# First label is '???', which has to be removed.
if labels[0] == '???':
```

```
    del(labels[0])

# Load the Tensorflow Lite model.
# If using Edge TPU, use special load_delegate argument
if use_TPU:
    interpreter = Interpreter(model_path=PATH_TO_CKPT,
                              experimental_delegates=[load_delegate('libedgetpu.so.1.0')])
    print(PATH_TO_CKPT)
else:
    interpreter = Interpreter(model_path=PATH_TO_CKPT)

interpreter.allocate_tensors()

# Get model details
input_details = interpreter.get_input_details()
output_details = interpreter.get_output_details()
height = input_details[0]['shape'][1]
width = input_details[0]['shape'][2]

floating_model = (input_details[0]['dtype'] == np.float32)

input_mean = 127.5
input_std = 127.5

# Initialize frame rate calculation
frame_rate_calc = 1
freq = cv2.getTickFrequency()

# Initialize video stream
videostream = VideoStream(resolution=(imW,imH),framerate=30).start()
time.sleep(1)

#for frame1 in camera.capture_continuous(rawCapture, format="bgr",use_video_port=True):
while True:

    # Start timer (for calculating frame rate)
```

```
    t1 = cv2.getTickCount()

    # Grab frame from video stream
    frame1 = videostream.read()

    # Acquire frame and resize to expected shape [1xHxWx3]
    frame = frame1.copy()
    frame_rgb = cv2.cvtColor(frame, cv2.COLOR_BGR2RGB)
    frame_resized = cv2.resize(frame_rgb, (width, height))
    input_data = np.expand_dims(frame_resized, axis=0)

    # Normalize pixel values if using a floating model (i.e. if model is non-quantized)
    if floating_model:
        input_data = (np.float32(input_data) - input_mean) / input_std

    # Perform the actual detection by running the model with the image as input
    interpreter.set_tensor(input_details[0]['index'],input_data)
    interpreter.invoke()

    # Retrieve detection results
    boxes = interpreter.get_tensor(output_details[0]['index'])[0] # Bounding box coordinates of detected objects
    classes = interpreter.get_tensor(output_details[1]['index'])[0] # Class index of detected objects
    scores = interpreter.get_tensor(output_details[2]['index'])[0] # Confidence of detected objects
    #num = interpreter.get_tensor(output_details[3]['index'])[0]  # Total number of detected objects (inaccurate and not
needed)

    # Loop over all detections and draw detection box if confidence is above minimum threshold
    for i in range(len(scores)):
        if ((scores[i] > min_conf_threshold) and (scores[i] <= 1.0)):

            # Get bounding box coordinates and draw box
            # Interpreter can return coordinates that are outside of image dimensions, need to force them to be within image
using max() and min()
            ymin = int(max(1,(boxes[i][0] * imH)))
            xmin = int(max(1,(boxes[i][1] * imW)))
            ymax = int(min(imH,(boxes[i][2] * imH)))
```

```
            xmax = int(min(imW,(boxes[i][3] * imW)))

            cv2.rectangle(frame, (xmin,ymin), (xmax,ymax), (10, 255, 0), 2)

            # Draw label
            object_name = labels[int(classes[i])] # Look up object name from "labels" array using class index
            label = '%s: %d%%' % (object_name, int(scores[i]*100)) # Example: 'person: 72%'
            labelSize, baseLine = cv2.getTextSize(label, cv2.FONT_HERSHEY_SIMPLEX, 0.7, 2) # Get font size
            label_ymin = max(ymin, labelSize[1] + 10) # Make sure not to draw label too close to top of window
            cv2.rectangle(frame, (xmin, label_ymin-labelSize[1]-10), (xmin+labelSize[0], label_ymin+baseLine-10), (255, 255, 255), cv2.FILLED) # Draw white box to put label text in
            cv2.putText(frame, label, (xmin, label_ymin-7), cv2.FONT_HERSHEY_SIMPLEX, 0.7, (0, 0, 0), 2) # Draw label text
            speak(label)

    # Draw framerate in corner of frame
    cv2.putText(frame,'FPS: {0:.2f}'.format(frame_rate_calc),(30,50),cv2.FONT_HERSHEY_SIMPLEX,1,(255,255,0),2,cv2.LINE_AA)

    # All the results have been drawn on the frame, so it's time to display it.
    cv2.imshow('Object detector', frame)

    # Calculate framerate
    t2 = cv2.getTickCount()
    time1 = (t2-t1)/freq
    frame_rate_calc= 1/time1

    # Press 'q' to quit
    if cv2.waitKey(1) == ord('q'):
        break

# Clean up
cv2.destroyAllWindows()
videostream.stop()
```

13. User evaluation zoom meeting



14.Additional information

EVALUATION PROTOCOL

Evaluation ID	TEST001
Creator	Liqian YOU
Date	15/08/2020
Purpose	• Evaluation of the main functions and interaction flows • Collect information on users requirements through prototype interaction • Obtain feedback on interface and functions for improvement of the next iteration
Prototype	https://projects.invisionapp.com/prototype/ckeefkdiy0009qo01cvu29sgy/play
Participants	Shelly, Shane, Liu, Vincent, Peiwen and Wu

Preparation

1. Lo-fi prototype
2. Consent forms
3. Task sheet (PDF file)
4. Questionnaire (Google Form)
5. Observation sheet

Introduction

I appreciate your volunteering time for this evaluation activity. Today, I am going to collect your feedback on the experience of the digital prototype and the usability of this system. I will investigate how smoothly you use this system, how well you understand the process of interaction, and whether there are any struggling with the interface of the application.

First, let me introduce this system. FoodCare is a human-centered smart kitchen system to support a specific dietary for pregnant women, seniors, vegetarians, and those with medical conditions. There are three modes with different food detection datasets and interaction include pregnancy, vegetarian and seniors. Participants can select one mode and upload the online shopping list. When Parcel delivery, the food detection system is working. The AI camera on the crisper will record the food categories and expired date. When you put food in the crisper, it will remind which is good or bad for you and recommend specific dietary. In this activity, you are going to evaluate the mobile app of this system.

You are asked to complete a consent form, which tells you the purpose of this evaluation and how to use these data. This is a voluntary activity and if you have concerns or feel uncomfortable, please let me know and feel free to stop at any time. I am going to evaluate the interaction flows and functions to improve the design and development but won't evaluate you in any condition through this activity.

Consent

(Participants read through and fill in and sign on the consent form. I sign my parts.)

Thank you for your consent and just a reminder, you are allowed to withdraw this activity any time.

Task Instructions

Now, you are free to interact with the prototype and experience the main functions. Following the instruction below to complete every task. When you go through it, I will observe and record your behavior and anything you talk. I would like you to speak aloud anything you feel during the interaction. Please following the instructions below, and please feel free to ask if you have any questions about the tasks.

1. Select one mode and click into the main interface
2. Browse Food Storage page
3. Click the fresh fruit and read recipe
4. Go to add page and read the information
5. Select one way to upload shopping list

Task notes

Roles

Facilitator	Liqian YOU
Videoing of the Task	Liqian YOU
Observations of the person & discussions	Liqian YOU
Recording time and steps (interaction flow)	Liqian YOU

TAM Survey

I would like you to fill in a short questionnaire on a google form. It contains a few short questions and you should rate from 1 (strongly disagree) to 4 (strongly agree) to express your feelings and experience toward the application. Here is the link:
https://docs.google.com/forms/d/e/1FAIpQLScGELeXK_4djFEcoZ5jANfVVx0VVjwh8Y5_OXlEQ1JV-PFWpA/viewform?usp=sf_link

Feedback

You can write down any remarks on the interface through the prototype webpage or speak aloud. I will record anything you provide towards the application. Here is the link:
https://projects.invisionapp.com/prototype/foodcare-lofi-ckeefkdiy0009qo01cvu29sgy/comment/eba007a2

Other Questions

Finally, I want you to answer three questions for further analysis:

1. What's your general idea about FoodCare?
2. Where are you confused about or what do you think should be improved?

3. Do you consider FoodCare is helpful? Why?

Closing

This is the end of the evaluation, thank you again for your participation and providing valuable data. Please noted you are free to withdraw anytime in the process of activities.

EVALUATION PROTOCOL

Evaluation ID	TEST002
Creator	Liqian YOU
Date	03/09/2020
Purpose	• Evaluation the main functions and interaction flows • Gathering data on users behaviors, requirements, motivation and expectation of experience • Obtain feedback on interface, usability, functionality and efficiency
Prototype	https://projects.invisionapp.com/prototype/ckee2v99l00a28e01q4aehnm8/play
Video	https://youtu.be/QkUEfonb4c8
Participants	Shelly, Shane, Liu, Vincent, Peiwen and Wu

Preparation

1. Hi-fi prototype
2. Consent forms (Online link)
3. Task sheet (PDF file)
4. SUS Survey (Google Form)
5. Observation sheet
6. Timer to record the speed of time completion

Introduction

Today, you are going to participate an evaluation research to analyse your interaction with a smart home system. FoodCare is a human-centered smart kitchen system to monitor the food in refrigerators and storages to ensure a healthy diet for caretakers including pregnant women and those in medical conditions with specific dietary needs. Participants are allowed to select one from three specific groups and upload the online shopping list. When Parcel delivery, the food detection system can automatically identify which food is good or bad for you and give you some dietary advices. The AI camera on the crisper can also record the food categories and expired date and show on the mobile application.

You are asked to complete a range of tasks by using this hi-fi prototype, and I will observe and investigate your experience in interaction with this application. Please note that you are optional to attend this evaluation.

Consent

As a research, consent is required. Please read and sign your name on it.

Thank you for your consent and just a reminder, you are allowed to withdraw this activity any time.

Task Instructions

Please watch this introduction video: https://youtu.be/QkUEfonb4c8

Please interact with the hi-fi prototype and experience the main functions. Following the instruction below and perform tasks. When you go through it, I will observe and record your behavior, emotion and communication during the process. Feel free to ask if you have any questions.

Task notes

Roles

Facilitator	Liqian YOU
Videoing of the Task	Liqian YOU
Observations of the person & discussions	Liqian YOU
Recording time and steps (interaction flow)	Liqian YOU

Time to Complete

In this section, you are asked to conduct a “Time to complete” task to identify how smoothly your interaction with this system. When you follow the instructions and go through the task, I will record the time lapsed during the activity and observe your behaviour. I will not provide any oral instructions to you during the process, but you are free to ask if you have any questions. Here is the prototype link:
https://projects.invisionapp.com/prototype/ckee2v99l00a28e01g4aehnm8/play
Please follow the instructions below:

1. Choose one mode, click button to link to the Costco account
2. Browse food storage page and find the expired date of iced coffee
3. Browse food recommendation page and read detail information on recipe page
4. Click add button to upload a shopping list
5. Open the parcel and pick an apple and put in front of the camera for detection (face to face testing only, participants from zoom testing please skip this step)

Please go through the tasks.

System Usability Scale (SUS)

The System Usability Scale (SUS) is to measure perceived usability of the application. As completing the previous task of “Time to Complete”, now, you are asked to provide feedback from evaluation of the efficiency and usability of this application. I would like you to fill in a short survey on a google form, which contains 10 questions. Here is the link:
https://docs.google.com/forms/d/e/1FAIpQLSctBJ8I7OGPa9NELaCm-M2SggtHtJzPigmeMoEra7K3EipR4g/viewform?usp=sf_link

Closing

This is the end of the activity. Thank you for your valuable time.