WeWasteNoMore: A Mobile Food Waste Management & Food Aid Application

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ABSTRACT

According to the Food and Agriculture Organization (FAO), almost half of all food produced will never be consumed in our society. The outcome of wasting food might bring significant impacts to the environment as well. This is due to the lacking of proper food waste management. Therefore, the goal of this project is to design and develop a mobile application, namely, WeWasteNoMore, with Waterfall model. The proposed application also can reduce food waste by providing a platform for users to donate or receive food from others. The project received satisfactory user experience from the respondents.

Keywords: Food waste, food aid, mobile application

INTRODUCTION

For many years, people have been concerned about food quality. Food appearance, taste, and ingredient standards are all aspects of how customers feel about food quality. United States Department of Agriculture, also known as USDA, sets "grades" based on appearance, including size, shape, texture and ripeness of fruits and vegetables (Kenny, 2018). This standard has also led to a significant increase in food waste. USDA has categorized the grades of tomatoes into 3 grades, which are Grade A, Grade B, and Grade C. The appearance of Grade A tomatoes is fairly smooth, Grade B is roughly smooth and Grade C tomatoes are probably mishappen. This standard has caused the customers to be more willing to buy a higher grade of tomatoes. Similarly in Malaysia, Grade A, Grade B, and Grade C eggs are most found in the grocery store. The Grade A eggs are graded as having the best appearance, Grade B is slightly stained, and Grade C is more stained and smallest size compared to Grade A and Grade B eggs (Egg Sizes and Comparison, 2020). By categorizing the eggs, middle or high-income people will not be likely to choose lower-grade eggs and this may directly result in more lower-grade eggs in the market.

Food waste is defined as products that are consumable but are wasted (Lipinski et al., 2013). It is becoming a global issue to which farmers, food wholesalers, food outlets like restaurants, families, and individuals all contribute. Food and Agriculture Organization of the United Nations (FAO, 2011) stated that every year, almost 1/3 of the world's food, around 1.3 billion tons is lost or wasted. Admittedly, COVID-19 has caused havoc on food availability, food security, and food loss and waste (FLW) since the outbreak began (ReFED, 2020). Research done by Rodgers et al. (2021) showed a trend of decreased food waste from the period of 8th April to 28th April 2020 with a survey involving a sample of 479 individuals from the United States, and 476 individuals from Italy. The survey mainly questioned the respondents about their awareness of food waste before and during the pandemic. From the results obtained, more people tend to cook at home, avoid going to public places such as supermarkets, and have more concerns about food health.

According to the Food Aid foundation, Malaysians waste about 15,000 tonnes of food everyday, including 3000 tonnes of edible food (Sulaiman & Ahmad, 2018). Food waste happens not only the leftovers from the restaurants, also from the leftovers from households. This can be caused by several factors, including improper food management. Most people do not record the amount of the foods stored in the fridge and this causes food quality degraded. Manual recording the food purchasing can lead to data redundancy, data loss, and time consuming. It is also not an environmentally friendly method as it may need paper printout.

Thus, the main objective of this project is to design and build a food waste management and food aid application (app) through mobile device. The application will be implemented on Android platform using Android

Studio. The output of this project is a prototype of waste food management system and will be evaluated by randomly chosen users.

LITERATURE REVIEW

This section briefly reviews the three existing systems that have comparable features. Besides, the comparison of WeWasteNoMore and the existing systems is also under this section. Lastly, the tools and technologies used for the implementation of WeWasteNoMore are discussed in this section.

1) **Existing Systems**

   a) **Smart Kitchen**
      Smart Kitchen (2020) is a food inventory management app that allows users to create inventory lists. This app was developed by ITR Solutions Ltd. It can be accessed on both Android and iOS devices. This application is mainly used to manage the food inventory issue. With this application, users can list down the products purchased, categorize, and create a shopping list quickly and easily.

   b) **KitchenPal**
      KitchenPal (2019), developed by iCuisto Pte Ltd, is mainly a pantry management app that allows users to organize the kitchen, find recipes, and create shopping lists. The app is to keep track all the expenses related to kitchen. It is currently available on both Android and iOS platforms. Similar to Smart Kitchen, users will first be directed to an authentication screen, which will allow users to either login, register, or use the app without requiring credentials. Without an account, it is not possible to sync or export the data across multiple devices.

   c) **NoWaste**
      NoWaste (2020) is also a food inventory management app that allows users to create inventory lists. This app was developed by KH Creations IVS. It can be accessed on both Android and iOS devices. Users must choose the preference such as language and database for the region country that is required to retrieve item details when scanning the barcode of items. Users are required to have an account to access the application.

2) **Comparison of existing systems and WeWasteNoMore**

Table 1. Comparison of Features Between Existing and WeWasteNoMore

Application / Features	Similar Existing Mobile Application			Proposed Application
	Smart Kitchen	**KitchenPal**	**NoWaste**	**WeWasteNoMore**
Login Access	✓	✓	✓	✓
Manage data items (Add, Edit, Delete)	✓	✓	✓	✓
Purchase cost (Free)	✓	✓	✓	✓
Check Expiry Date	✓	✓	✓	✓
Expiry Date Reminder	✗	Only Premium	Only Premium	✓

Based on Table 1, the proposed mobile application includes all the features that should be included in the application. Users can use the proposed application to manage their food inventory for creating shopping lists, checking the expiry dates, and preventing overbuying to save daily expenses. It is good practice to manage food inventory wisely starting from using the proposed application. The most important part is the proposed application is free and does not contain premium features.

MATERIALS & METHODS

The Waterfall (Definition of 'Waterfall Model', n.d.) model methodology as shown in Figure 1 was used to perform software development of WeWasteNoMore. This project is inspired by the existing systems as stated before. The Waterfall model consists of five project lifecycles which are planning, requirement analysis, system design, implementation, and testing.
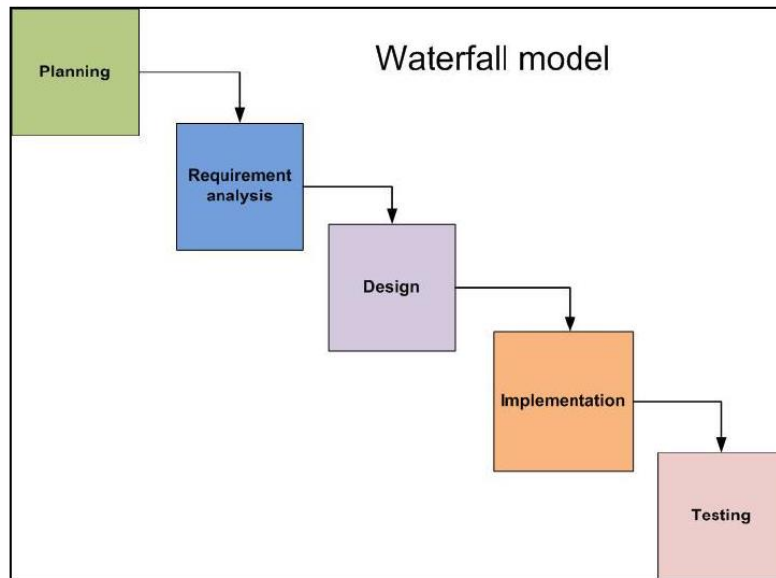
Figure 1. Project Lifecycle

1. **Planning**
    At the first of the planning phase, the target of WeWasteNoMore is determined, that is for everyone in the community. Hence, problems faced by the community will be collected and identified. Next, the goals or purposes for the proposed system are defined. The main problem faced by the community is that food waste happening everywhere due to several factors. Therefore, the main objective of the proposed system is to develop a food waste management mobile application that helps to manage personal food inventory and reduce the food waste problem starting from the housing area. Besides, the scope and limitations of the proposed system will be discussed too.

2. **Requirement analysis**
    In the requirement analysis phase, the requirements of WeWasteNoMore are collected. The main functionality of WeWasteNoMore is similar to the existing systems, which allow users to manage food inventory and reduce food waste. Besides, WeWasteNoMore has features that allow users to add a shopping list, check their monthly expenses, and donate or receive items. Besides, the functional requirements and non-functional requirements of WeWasteNoMore are listed in the following.

    Functional requirements for WeWasteNoMore
    *   Create user account
    *   Login with email address and password
    *   Logout
    *   Update personal information
    *   Reset password
    *   Manage shopping items
    *   Manage kitchen items
   *   View expenses
    *   Donate or receive donation items

    Non-functional Requirements for WeWasteNoMore
    *   User friendly user interface (UI)
    *   Highly secure application

Gather requirements

To gather requirements, a questionnaire was given out to a total of 20 respondents consists of randomly chosen. The purpose of this questionnaire is to ensure that the proposed application is well-understood by potential users. The questionnaire is distributed to the respondents through WhatsApp. 17 of the respondents were between 18 to 24 years old, 1 respondent was between 25 to 30 years old and another 2 respondents fell in the age range of 31 and above. Among these 20 respondents, 12 of them are male, and 8 are female.

Figure 2 shows the responses of reasons that may cause food waste in households. among these 20 respondents, most of the respondents think that the reason of food waste is due to the food going off before the "use by" or "best before" dates, which contributes 14 responses. This is followed by the reason of some household members don't always finish their meals, contributing 13 responses. Next, food left too long in the fridge or freezer, contributed 12 responses. Buying too much food contributes to 11 responses, and the remaining possible reasons have fewer responses. Besides, none of these respondents used a food waste management mobile application before. Therefore, the actions done by respondents to prevent food waste have been obtained too. Table 2 lists the questions in detail.
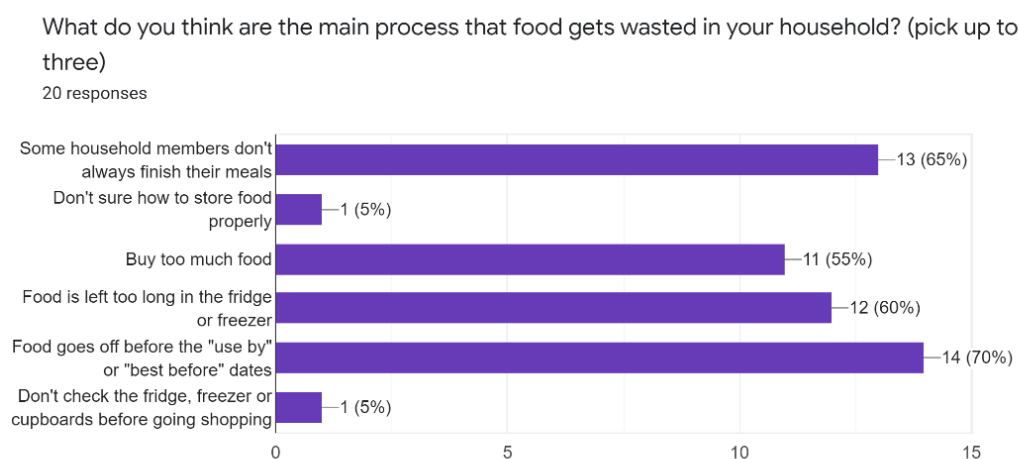
Figure 2. Analysis of Possible Reasons that Food Get Wasted

Table 2. Summary of the Possible Reasons of Food Waste

No.	Questions	Vote
1	Some household members don't always finish their meals.	13
2	Not sure how to store food properly.	1
3	Buy too much of food.	11
4	Food is left too long in the fridge or freezer.	12
5	Food goes off before the "used by" date.	14
6	Don't check the fridge before going shopping.	1

Software requirements

The following software (as listed in Table 3) are open-source and can easily be obtained. Thus, this meets the minimum requirements for this project.

a. Android Studio

Android Studio (Meet Android Studio, n.d.) is the official Integrated Development Environment (IDE) that is built on IntelliJ IDEA, and it is specifically designed for Android development. It is cross-platform friendly as it is available on Windows, macOS, and Linux-based operating systems. Android Studio, as

a code editor and developer tool, has even more capabilities that improve productivity when developing Android applications.

b. Firebase Cloud Firestore

Firebase (Anoshyna, 2016) is a Backend as a Service (BaaS) platform that offers RTDB (real-time database) services to developers of mobile apps and web applications. The company was founded in 2011 and purchased by Google in 2015. Using the real-time database, developers can easily set up and configure a back-end database as a service. As a result of its low barrier to entry, low maintenance costs, and fast queries, Real-time Database is still popular among developers.

c. Android

Android is one of the most commonly used mobile operating systems. The Android mobile operating system is based on the Linux kernel and was developed by Google (Singh, 2014). Compared to other platforms, Android app development is a lot more cost-effective because it is compatible with Windows, Mac, and Linux. According to Spencer (n.d.), 90 billion Android apps were downloaded while only 25 billion iOS apps were downloaded in 2016. This is one of the reasons why more developer chooses the Android platform for development.

d. Flutter with Dart

Flutter (Rahman, 2019) is an open-source framework released by Google for developing multi-platform, natively-built applications from a single codebase. Dart is the programming language used to develop the Flutter application. The Dart programming language makes the Flutter application have more advanced features. Dart not only runs Flutter apps with its language and runtimes, but it also helps developers with formatting, analyzing, and testing code (Dart overview, n.d.).

Table 3. Software requirements and descriptions for developers

Software	Description
Operating System: Windows 10 or above	Windows 10 is the minimum requirement used as the platform to develop and design the proposed application. The latest Windows 11 is also acceptable.
Firebase	Real time database as the backend service of the proposed application.
Android Studio	Official IDE for Android application development.
Flutter	A framework allows building cross-platform mobile application.
Dart	A programming language suitable for multi-platform development.
Android	A platform to install and run the proposed application. Requires minimum Android version: Android 7 (Nougat).

Hardware Requirements

The hardware components (as listed in Table 4 and Table 5) are accessible and there are the basics components that can be setup during the time of this implementation.

Table 4. Hardware requirements for development process of the proposed application

Developer	
Hardware	Description
Processor: Intel Core i7-7500U	Intel Core i7 in Acer Aspire F15 is used to develop the proposed application.
Memory: 16GB RAM	16GB RAM is sufficient to support the development of proposed application. Size of the RAM is important and must be larger to ensure the development process run smoothly.
Graphic card: NVIDIA GeForce 950M with 4GB	A mobile application development framework that is compulsory to develop a cross-platform mobile application.
Hard Disk: 128GB SSD + 1TB HDD	Large enough storage to store the data using development process, and SSD allows faster speed.

Table 5. Hardware Requirements and Descriptions for Users

| Hardware	Description
Octa-core Max2.32GHz	Redmi Note 9S is equipped with an Octa-Core CPU. This middle-end phone enables the proposed application to be tested and run smoothly. This is the only available device the user has.
6GB RAM	6GB RAM loads the application faster.

3. System design

During the system design phase, there exist two types of system design which are logical design and physical design. Logical designs are shown using the following diagrams as Context diagram, Data Flow Diagram (DFD), Entity Relationship Diagram (ERD), and Data dictionaries. Thus, an analysis is done to compare the features of each system and the proposed system. As for the physical design, high-fidelity wireframes are represented.
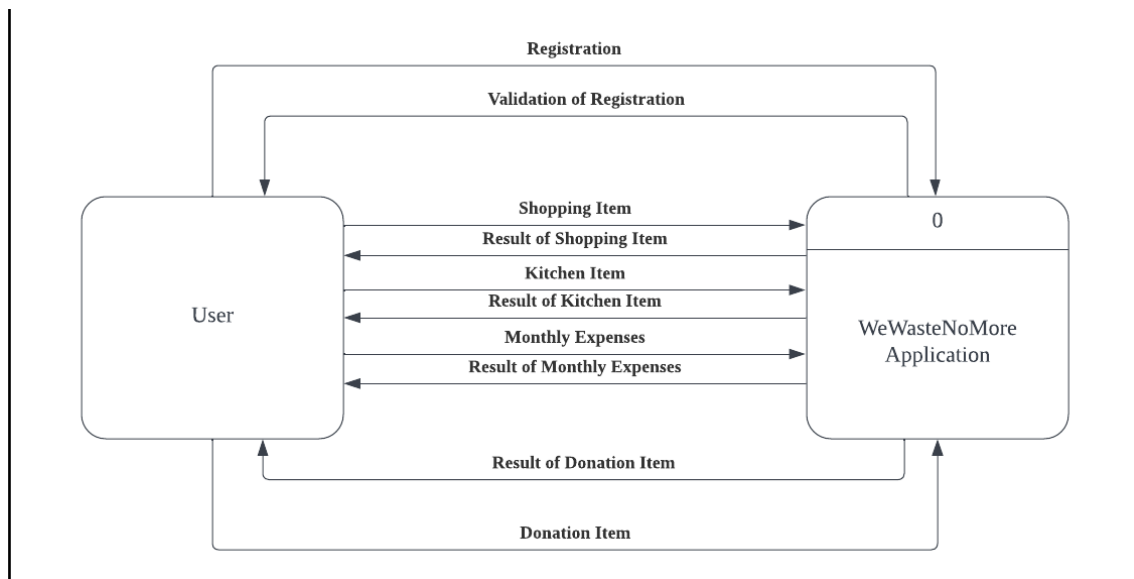
Figure 3. Context level diagram for WeWasteNoMore

Figure 3 shows the Context Level Diagram of the proposed application with the highest-level data flow between the external components or entities and the system. The external entity is the user of the system which will provide various data into the system including email address, password, item details, and item prices into the system. The email address and password are used for users to sign up and log in to the system while the item details are details of the item that the user created in the list. The item prices are the details needed when the user checks for the current month's expenses.
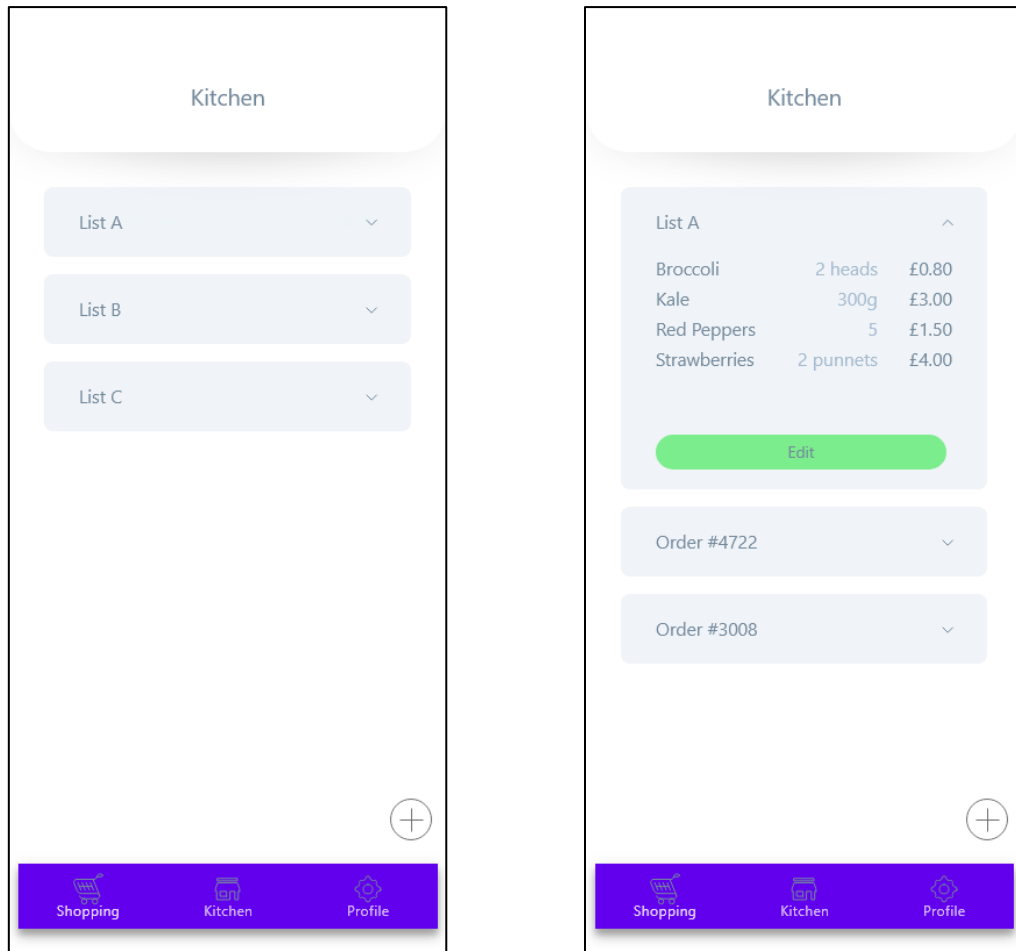
Figure 4. Wireframe of Main Page

Figure 4 represents the output examples of the wireframe design that is the main page of the proposed system, which is the Inventory List. The user will be directed to the main page after register or login to the application. In this main page, users are able to view the inventory list created before, perform action to add new inventory list by clicking on the "+" button at the bottom right, navigate to shopping list or go to user profile using the navigation bar at the bottom. Users can also click on the list to view the items added at this main page.

4. **Implementation**

WeWasteNoMore is implemented with the requirements collected and stated in the requirement analysis phase. The entire application will be implemented using Flutter SDK with the Dart programming language, and Firebase will be used as the database. The installer of Android Studio can be obtained from the Android Studio official website. This section will present some of the final interfaces of WeWasteNoMore.
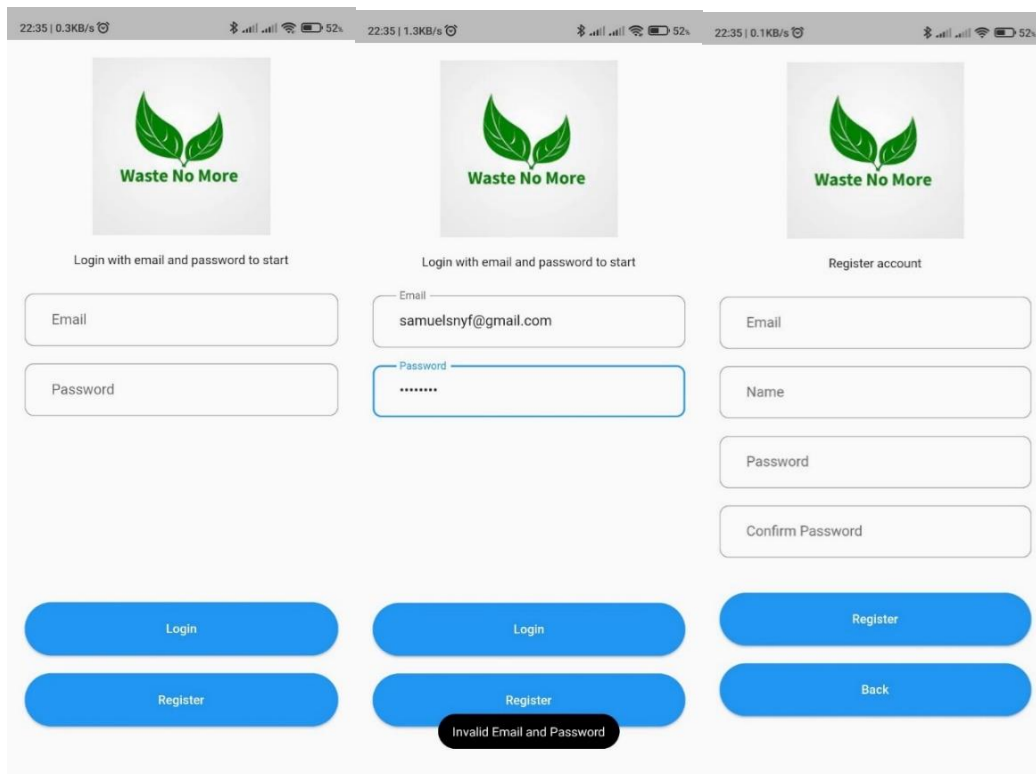
Figure 5. Authentication pages

Figure 5 shows the authentication pages. Users can log into the app by inputting their registered email and password. The user can then click the Login button after providing their email and password. If the user does not have a WeWasteNoMore account, users can create one by clicking the Register button to navigate to the Register page. The Login page also has an email validator, which requires users to input the proper email format. An Invalid Login message will pop up if the users try to login without a registered email address. On the Register page, users can create a new account by entering their email address, name, and password. Once the fields are all filled, users can proceed to register an account.

Figure 6 shows the interfaces after successful login. The user will be directed to the homepage, by default the Kitchen page. On this page, the user can view the list created before. In addition, there is a floating action button that allows user to add a new list to the application.

To add a kitchen item, users are required to input the item name, price, best before data, and amount. Category and Unit will be optional and if users leave blanks, it will automatically input as "Others". There are a few categories and units prepared in the application for users to select. The items added will be arranged based on the category, and the example of screenshot is shown in Figure 6. Users can further execute the delete action by checking the checkbox(s) to delete multiple items or swipe to the left to delete the selected items. If the expiry date of the item(s) reaches, the expiry date reminder will show a red-color text "Today Expired", otherwise if the item(s) have not expired yet, it will show green-color text with the days remaining.

After click on the floating action button, users are directed to the create Kitchen List page. In this page, users are suggested to input the list name such as My Kitchen, My Pantry, and My Fridge. Once the users successfully create a list, users will be directed back to the Kitchen page and the created list will be shown. The example of creating a list is shown in Figure 7.
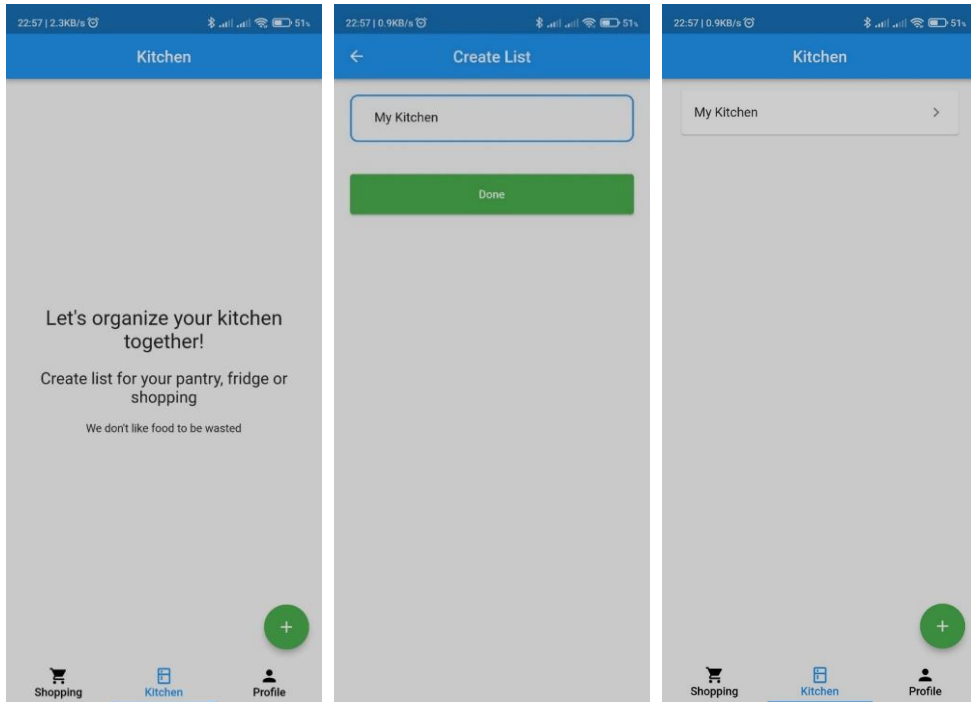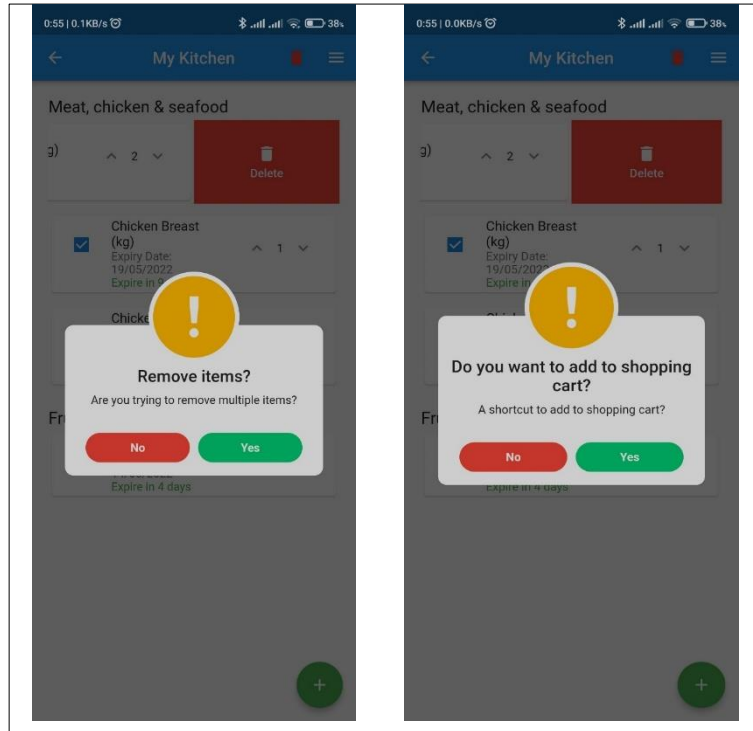
**Figure 6.** Interfaces for homepage, create list, and kitchen list
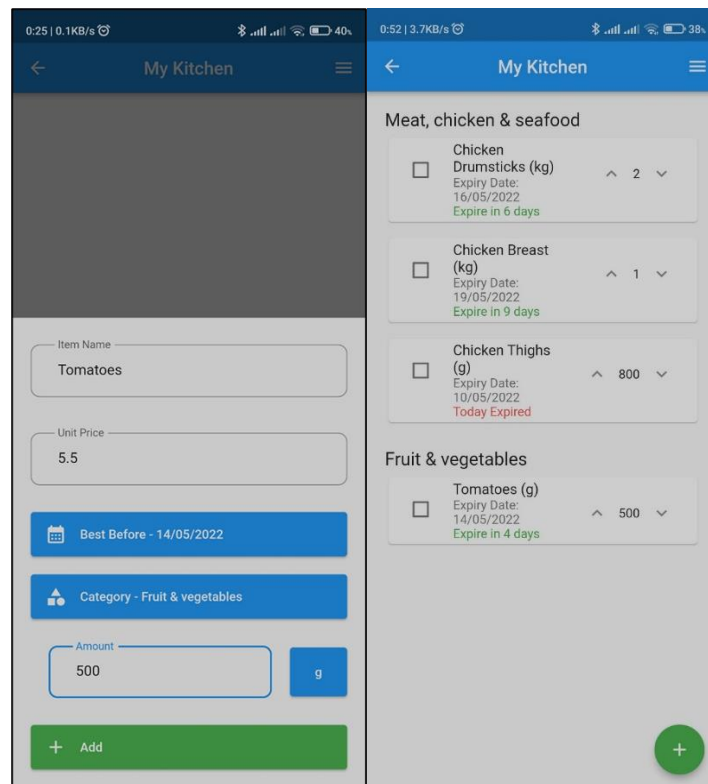
**Figure 7.** Examples of adding new kitchen item

Figure 8. Examples of deletion of kitchen items

Figure 8 shows the execution of the delete action of items in the Kitchen List. The alert message will be prompted before the users decide to delete the items. Next, an alert message will ask whether users want to add the deleted items to the Shopping List page as a shortcut. Figure 8 shows the Shopping List module where after a user adds items that he is going to buy, it will be stored. The user can then swipe left to the selected item to update the details and do the editing.
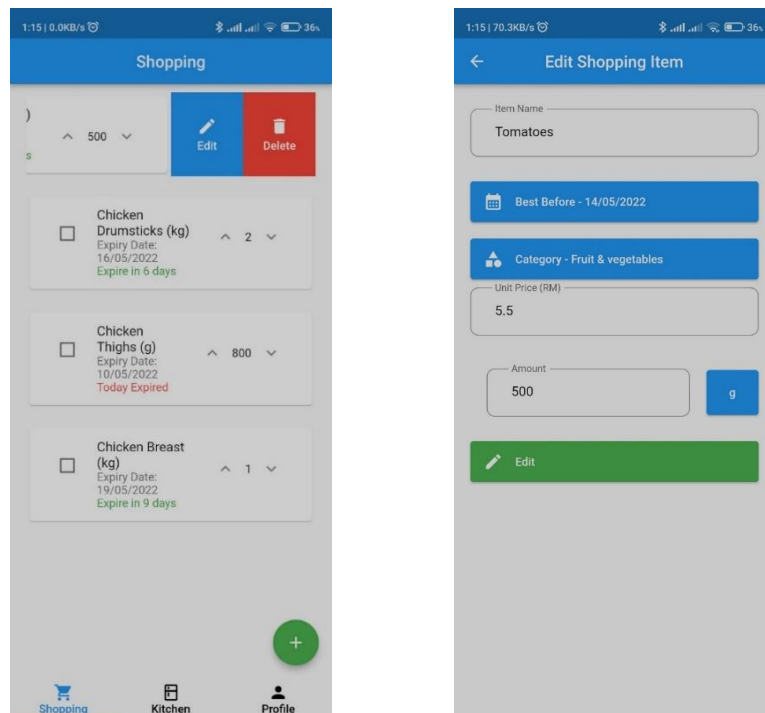

**Figure 9.** Examples of edit shopping item details of WeWasteNoMore
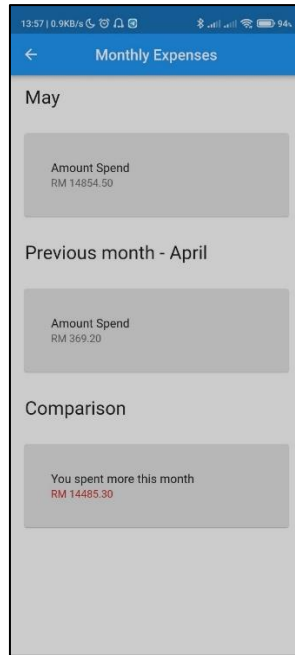
Figure 10. Monthly expenses page of WeWasteNoMore

One of the functionalities in this project is Monthly Expenses module. In this module, users are able to view the current month's expenses, previous month's expenses, and the comparison between previous and current month's expenses. The expenses are retrieved from the database, which the users previously checked out in the Shopping List module. The records of checked out products in the shopping list will be concealed and stored inside the database in order to calculate and display the money spent in a specific month. Figure 10 shows the example of monthly expense in May (Current Month) and April (Previous Month). The default values for both will be zero if the user just created an account. Otherwise, the records from the shopping items will be recorded and displayed in Monthly Expenses page.
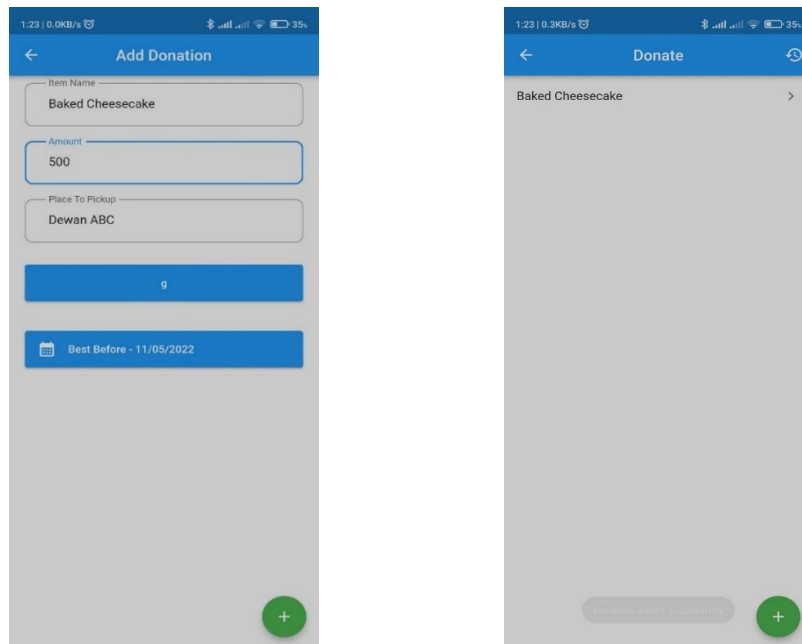
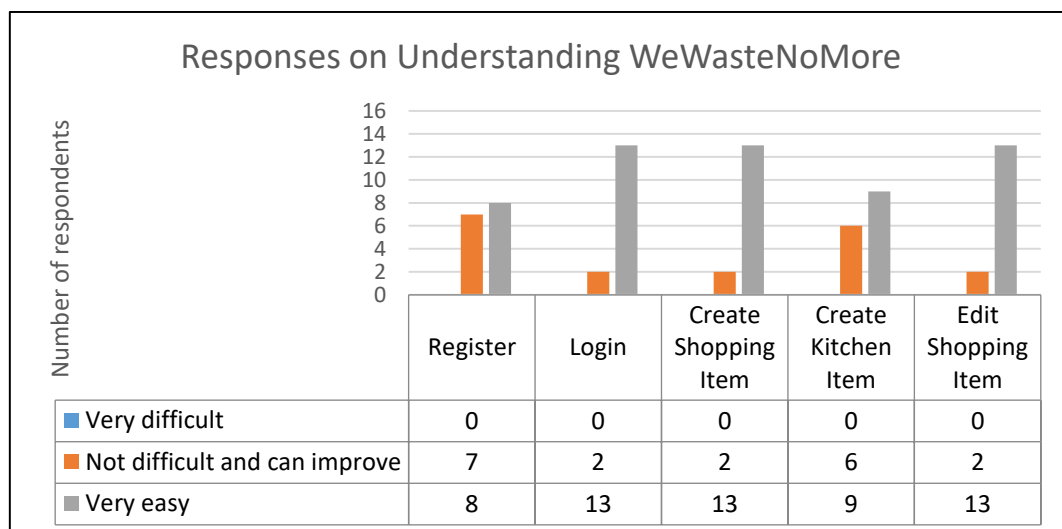**Figure 11.** Examples of adding donated item

Figure 11 shows the view of the donated items uploaded by other users, add items for other users, and update the details of item such as expiry date, location to pick up, and amount. Figure 12 depicts an example of an user viewing items uploaded by another user. When the user clicks the "I need it" button, the user is returned to the donate list, and the selected item is removed from the list. Next, user can view the history of the items by clicking the history button at the upper right of the Donate List page, and the item name with the location to pick up will be shown. This feature is mainly used to encourage users to share food with others, thus further reducing food waste.
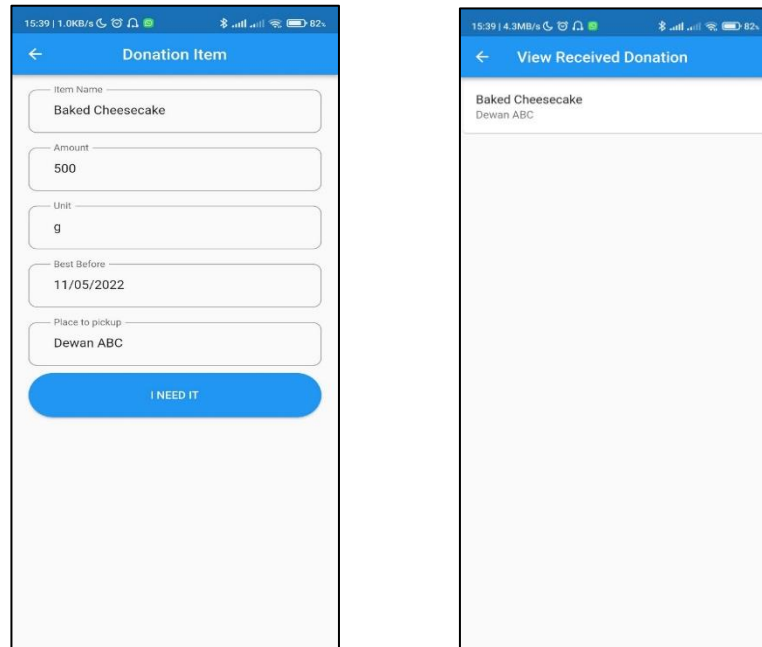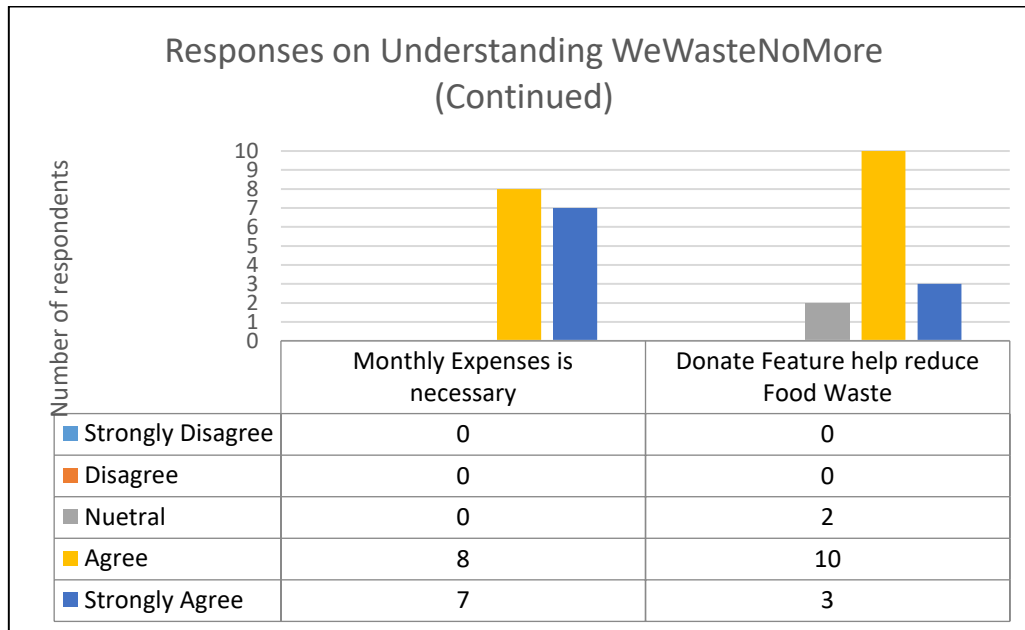

Figure 12. Example of receive donated item

5. Testing

The results of software testing and user acceptance testing are presented in this section. There are three types of software testing: functional testing (unit testing and integration testing) and non-functional testing (system testing). User acceptance testing is conducted by distributing a user acceptance form to 15 random respondents.

Responses on Understanding WeWasteNoMore

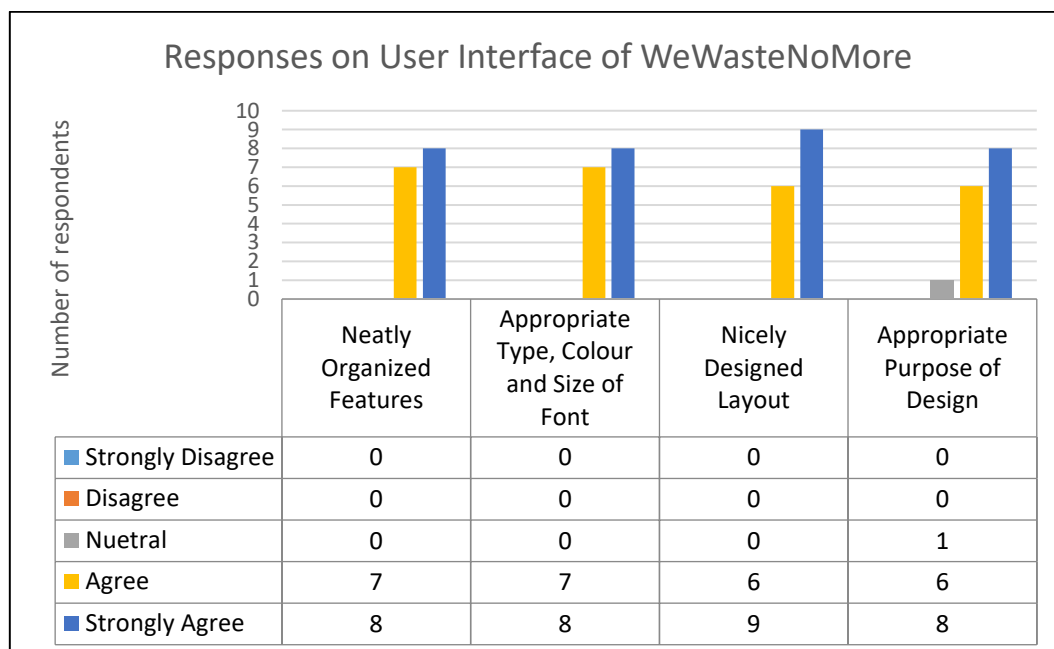|	Register	Login	Create Shopping Item	Create Kitchen Item	Edit Shopping Item
■ Very difficult	0	0	0	0	0
■ Not difficult and can improve	7	2	2	6	2
▨ Very easy	8	13	13	9	13

Figure 13. Bar chart of "Responses on Understanding WeWasteNoMore" (a)

Figure 13 shows the understanding of respondents on WeWasteNoMore. All respondents think WeWasteNoMore is easy (orange and grey colors) to use, and some think that possible improvements can be made.


Responses on Understanding WeWasteNoMore (Continued)	Monthly Expenses is necessary	Donate Feature help reduce Food Waste
Strongly Disagree	0	0
Disagree	0	0
Nuetral	0	2
Agree	8	10
Strongly Agree	7	3

Figure 14. Bar chart of "Responses on Understanding WeWasteNoMore" (b)

Figure 14 shows the understanding of respondents on WeWasteNoMore on monthly exepenses and donate feature. All respondents think that the monthly expenses feature is a must (blue color) for WeWasteNoMore. On the other hand, most of the respondents believe that the donate feature is able to help reduce the food waste in the community. Only 2 respondents doubt the feature. The respondents might think the donate feature is not necessary as the feature is not the main feature they need.

Responses on User Interface of WeWasteNoMore	Neatly Organized Features	Appropriate Type, Colour and Size of Font	Nicely Designed Layout	Appropriate Purpose of Design
Strongly Disagree	0	0	0	0
Disagree	0	0	0	0
Nuetral	0	0	0	1
Agree	7	7	6	6
Strongly Agree	8	8	9	8

Figure 15. Bar chart of "Responses on User Interface of WeWasteNoMore"

Figure 15 represents the bar chart of "Responses on User Interface of WeWasteNoMore". Each aspect is mostly agreed upon (yellow and blue colors) by the respondents. Only 1 respondent doubts the purpose of the design of WeWasteNoMore. The respondent is either not satisfied or satisfied with the design of the proposed application and give suggestions during the last section of the survey.
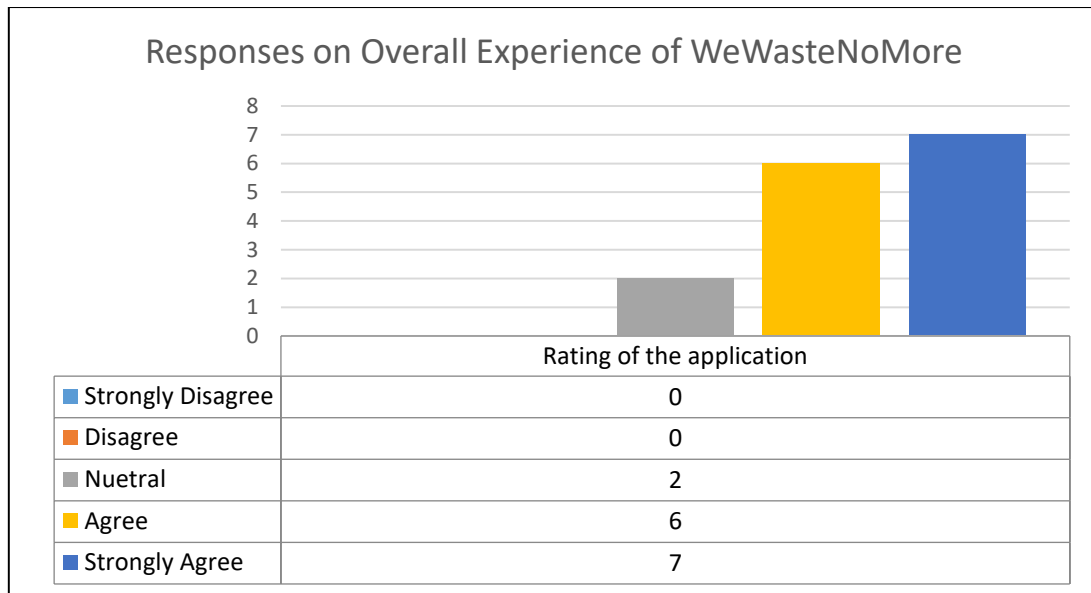
Figure 16. Bar chart of "Responses on Overall Experience of WeWasteNoMore"

Figure 16 represents the bar chart of "Responses on Overall Experience of WeWasteNoMore". Most of the respondents are satisfied with WeWasteNoMore, while 2 respondents are either satisfied or not satisfied. The feedback from the respondents are listed down and listed as future improvements of WeWasteNoMore.

CONCLUSION

Although the proposed application, WeWasteNoMore has achieved all the objectives, there are limitations and constraints encountered during the implementation process. For the time being, the proposed application is available for Android OS users. As for the feature components, the application does not allow the shopping items created automatically added to the kitchen list. The image representation of the application is too small ad it does not allow to track the live location of donated food.

With the help of the proposed application, better food waste management could be provided to the users. Users can manage the inventory items easily and can avoid wasting food by giveaway to others who are in need. However, due to the limitation of the proposed application, it will be deployed locally for now. The feedback and suggestions collected from the user acceptance survey are listed for the limitations and future works of the proposed application.

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