Smart and Integrated Mobile Application Service for Community Waste Handling Using Image Processing

SCANNER

Smart Waste Management Solution for Green Environment

Team from Sultan Qaboos University

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TEAM Name: **SCANNER** (**S**mart **C**ommunity w**a**ste ha**n**dling usi**n**g imag**e** p**r**ocessing)

Project Name: Smart and Integrated Mobile Application Service for Community Waste Handling Using Image Processing

Keywords: Waste classification, notification by mobile application, smart system, reducing human use by AI and ML

1. Introduction

The municipal waste management sector relies heavily on community participation. In Oman, communal waste collection containers are used in most residential neighborhoods. Containers are placed in a convenient location and close to homes, although there are still challenges as a large percentage of waste is disposed incorrectly and outside the containers. In addition, it includes improper disposal of green waste resulting from afforestation operations, large waste such as household furniture, or throwing municipal waste generated from the house out of the container or other waste (such as construction and demolition waste, expired tires, etc.). Thus, these practices require more resources than labor and equipment so that the company can provide service at a high level.



2. Problem Statement

Large waste or green waste cannot be loaded on the garbage compactor truck. There is no mechanism to know the quantity and quality of waste outside the containers. There is no mechanism for weighing the waste outside the containers. There is no mechanism for reporting or requesting an automatic service for transporting green or large waste. There is no mechanism for the population survey served by containers.

3. Proposed Solution Statement

This project idea proposes an integrated and smart mobile application/service that works on close-circuit camera-induced image processing based on waste classification algorithm and notification. The waste-collection authority can get the notification via a systematic and smart integrated mobile application, which can provide them better management and decision-making mechanism.

4. Innovation/ creativity of the project

- **Project Innovation**

This project will be a smart solution package which integrates internet of things (IOT), machine learning (ML), artificial intelligence (AI) and mobile application for a real life problem related to environmental management. Using this kind of smart solution package will be the first time in Oman to be used for such problem. The project also is integrating the multi-skilled students to take part in a real problem for practical solution.

- **Description of the logo**

The logo can be divided into two parts or shapes. One is the shape of the eye, which indicates camera, scanning and capturing. Another is the shape of a green leave, which indicates the environment. The gear inside represents the image processing by the camera, machine learning and mobile application. The green color signifies the cleaning of environment by a circular and sustainable process**.**

3. Objective

- To capture images from designated bin location using internet protocol close circuit camera (IPCCC)
- To process the captured image in PYTHON program using image processing library to segregate large waste and filter unwanted objects. The accuracy of the image processing will be tasted and improved.
- To use the output data as input in application servers like Google Firebase etc. to process for the mobile application.
- To create an application portal which can be used as notification platform for BEAH.
- To use the same platform for sending request to the concerned section for waste handling

4. Scope of this project

The project proposal initially (first phase) wants to deploy the internet protocol close circuit camera (IPCCC) on the waste bin site to capture images of large wastes scattered around the collection bins. The waste bin location will be selected on the reports which is based the frequency of large waste seen around those bin. IPCCC will capture the image twice a day and send it to a server and store there. An algorithm based image processing unit will analyze the images and create an input database for mobile application processing in google firebase. A notification mobile application will be made which is connected with google firebase. The mobile application will be able to read google firebase database and generate notifications in real-time. Anytime Google firebase receives output data from image processing will read it and notification will be immediately generated for BEAH. This notification can be seen in a mobile application through the output as the location map (google map), time, date and image of the location of the large waste. Thereafter BEAH or vendors can take decision

and collect the waste on time. The application may also integrate the notification service to notify the collection vendors after deciding the waste should be collected or not.

5. Future Project Phases

The **project's second phase** will embed the waste classification algorithm in the application so that the type of waste and approximate quantity can be known based on machine learning (ML). To minimize the cost of cameras, the second phase of the project wants to check the feasibility of using portable camera unit to capture images. The portable camera units will be attached with the collection trucks and once the collection trucks will reach any bin to collect waste, the camera unit will capture the images surrounding the bins and send to the cloud for the rest of the processing. It may potentially increase the efficiency of the image capturing and reduce cost of individual camera maintenance.

In the **third phase**, the project wants to integrate a user interface where the mobile application will be on the cloud for public use. The user (waste generator) community around the waste collection bin can also send images of large size waste and location via that app directly to BEAH or concerned authority for further collection.

The **third phase** wants to quantify the number of users for each bin using the captured image proposed in this proposal. The captured images can be used in PYTHON programming to quantify user numbers for each bin using machine learning. This project also can identify whether the bins are filled or not and when; the status of the bins so that it can notify to BEAH ahead for real time collection to avoid waste spill. BEAH can schedule their waste collection based on the bin status. It may minimize a big cost for manpower and transportation.

6. Project Feasibility Check

The project team has visited some of the waste bin location where they found construction and large wastes. Those observations gave the baseline to formulate the project in terms of capture dimension, image capturing feasibility, scheduling and possible locations. The observed data helped to make the image processing and provide a dummy application preparation for this project. The following sections discuss the detail of the progress of the application prototype-

7. Project Tools

- Image capturing – Internet protocol close circuit camera
- Image processing – Python programing using machine learning libraries: OpenCV, TensorFlow, CV2 for opening camera

- Mobile Notification- Google firebase, google maps, dart language, flutter platform to create application for IOS and android.

8. Brief workflow

The workflow is divided into two parts:

1. Image capturing and processing
2. Mobile Notification

Image capturing and processing

Camera Location and Image Capturing

Most of the waste collection bins are located near to the road lights. Therefore, the IPCCC can be mounted with road lights or sidewalls of the nearby buildings where road lights are not available. The power source can be either grids or solar power. The following schematic (fig 1) shows presentation of the image capturing.

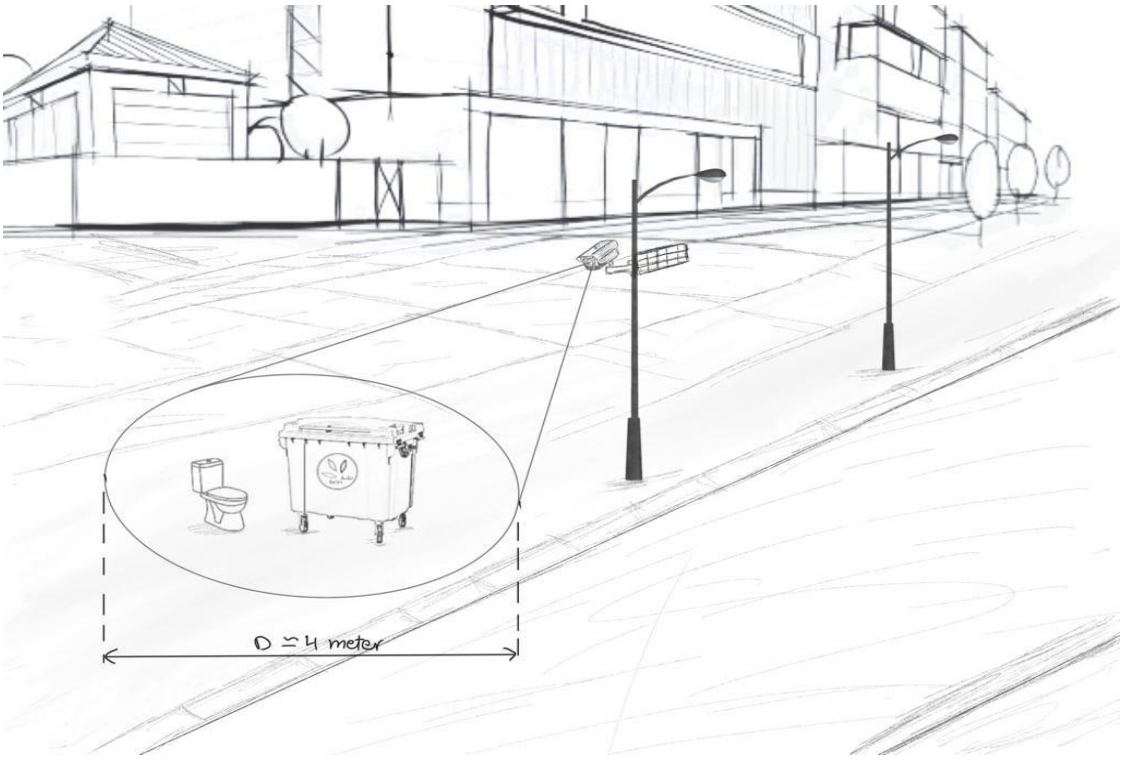


Figure 1 Schematic of the camera mounting in a typical waste bin site

After that, the following steps will be carried out to do further processing of the images-

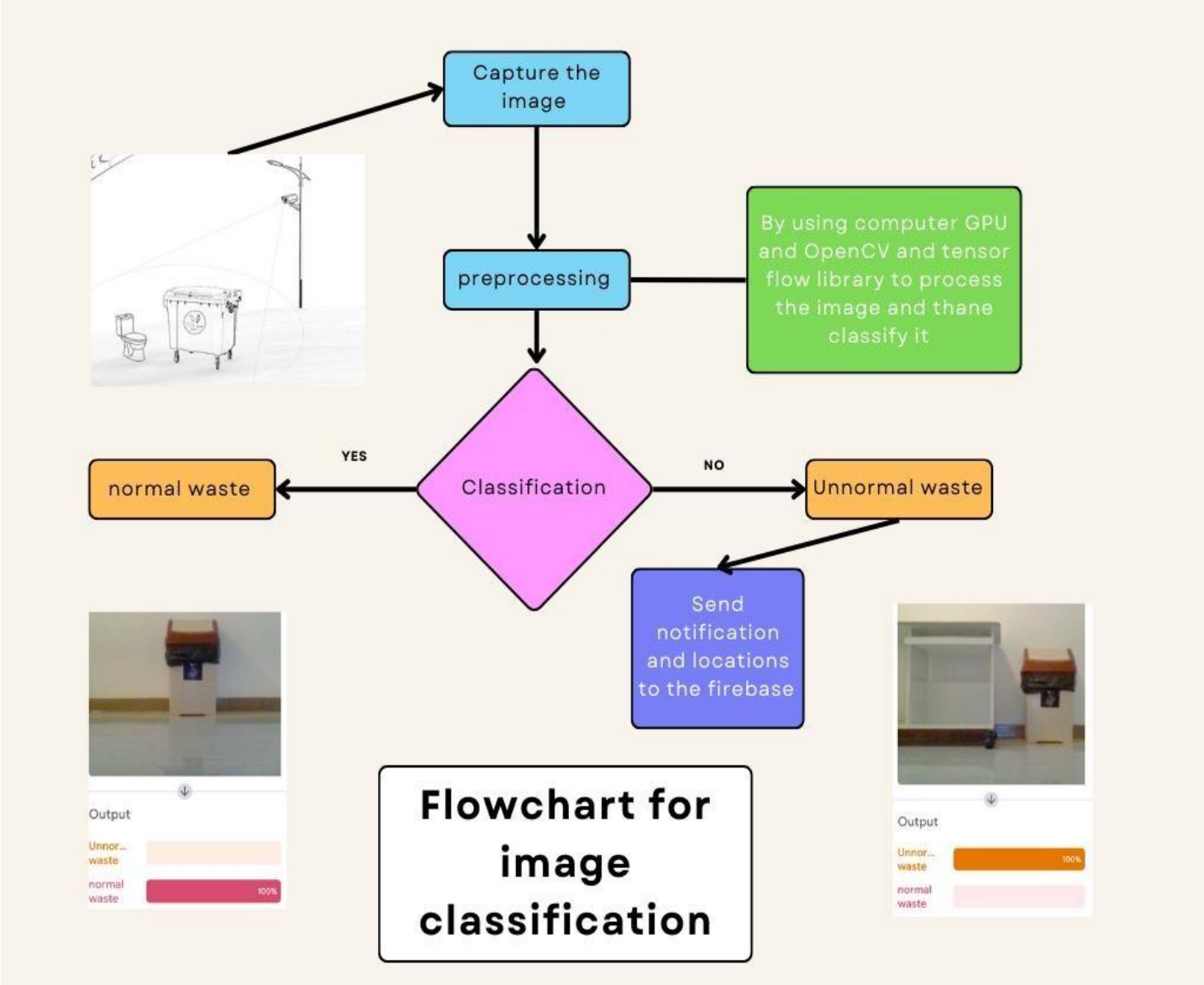
- Each IPCCC will contain a camera, memory and an internet protocol mechanism.
- The IPCCC will capture images of the real bin with different waste (includes large and normal waste)

- The images for real bins with waste will be captured multiple times. These images will be used to build an image classification model for better precision so that it can automatically decide the type of waste.
- The output of the captured image includes- waste images, bin IDs, longitude and latitude, date and time
- At first, the image-processing model will be built using the different waste image alongside the bin and generate the initial data for classification based on normal waste and large waste or un-normal waste.
- The model is embedded in the internet server so that it can receive the captured image, process it and then classify it automatically to build output for the next step of application processing
- The employed cameras has to be connected with the server so that the model can receive the captured images directly.

Image Processing Unit Workflow

- The embedded model in server initially receives the images. The received image will be sent to the designated library i.e. OpenCV and TensorFlow. These libraries can classify the images using their default algorithms. To adjust the image processing for this project, some simple tools can be used to import the library and declare the image processing statements depending on the type of waste.
- The output of the image processing will be initially classified as normal and abnormal or large waste
- The testing phase will evaluate the accuracy of the model and ascertain the reliability of the model. The image, which contains abnormal or large waste, will be shown as near to 85-99% accuracy, which will be accepted for the next step for notification.
- The other images will be ignored and rejected.
- The output from image processing model will include - the classified image, waste bin ID, longitude and latitude, date and time
- The accepted output will be sent directly to google firebase to do further processing for application.

The following workflow shows an idealistic model, which shows image processing using PYTHON. The output data below shows that it is feasible to classify the large waste (abnormal waste) from other types of object around the large waste.



Mobile application

The mobile application includes the google firebase processing and building application.

Google firebase is a platform, which will give the necessary tools to grow this application. The processed images will be exported to google firebase to build the application. The necessary steps are as follows-

- To create the database for waste bin as shown in fig 2.
- To add columns to waste bin database which will include waste bin ID as string values, image as string values, location as longitude and latitude forms, date as date series values and time as time series values

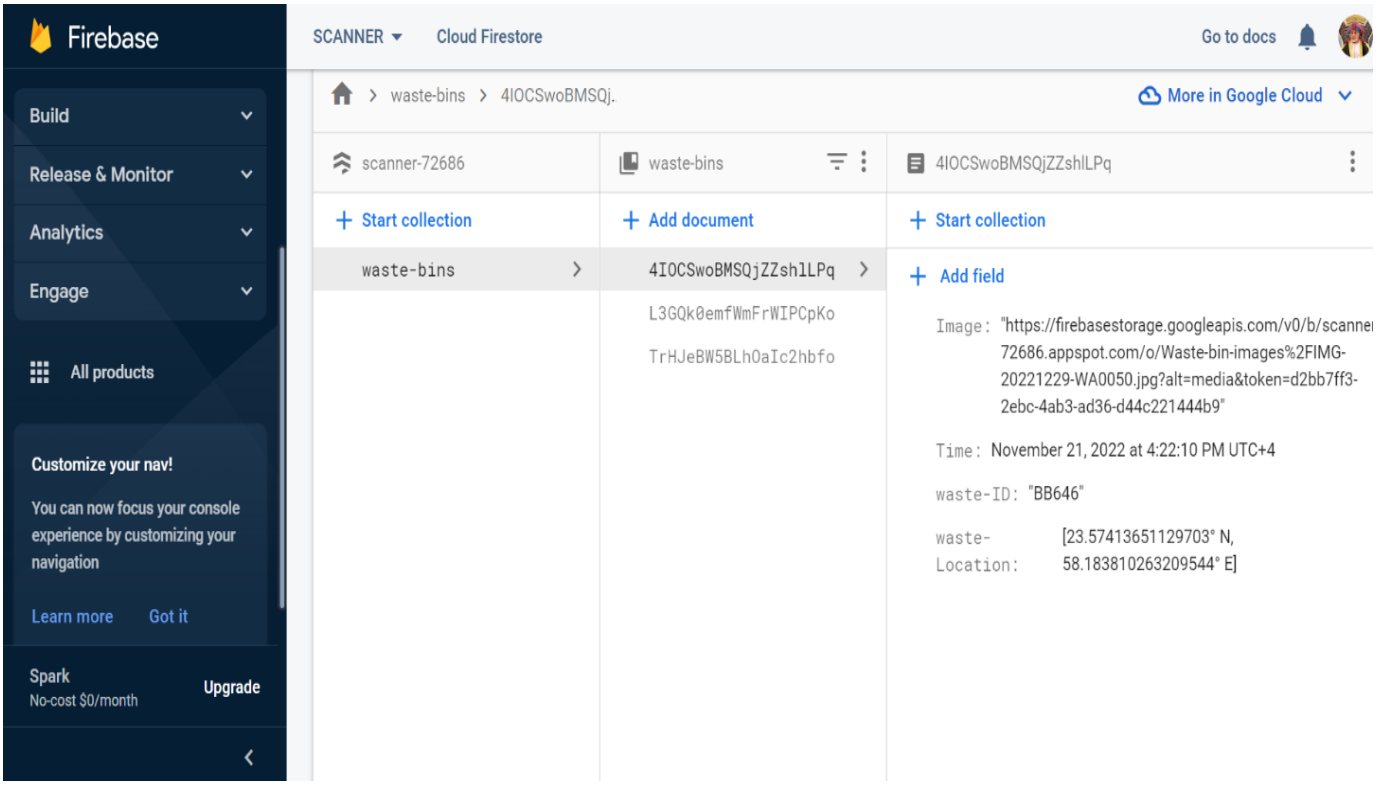


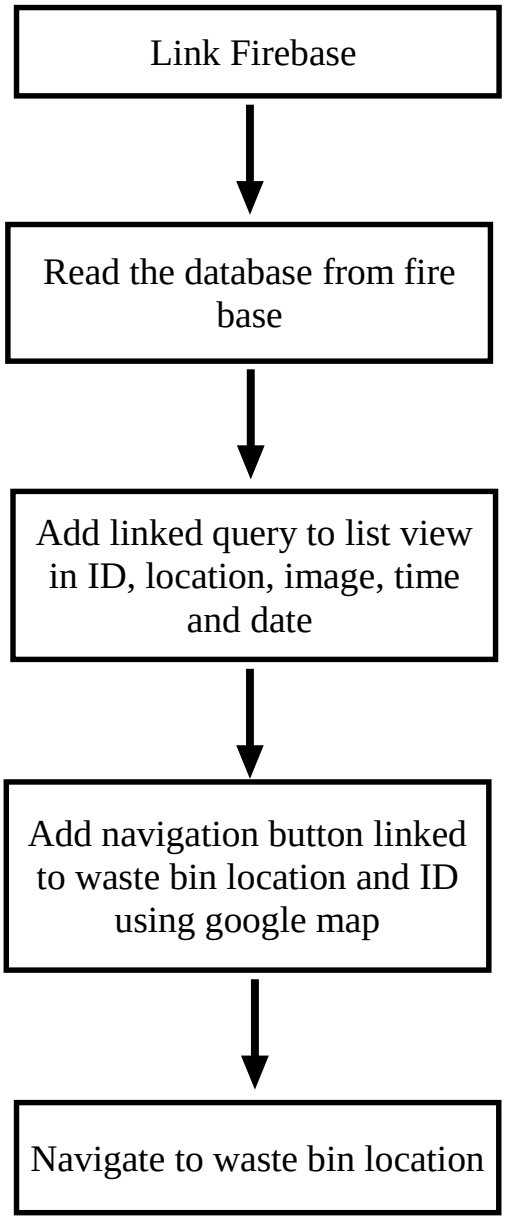
Figure 2: Google firebase platform

Mobile application processing needs the following steps before linking to google firebase-

- To create flutter project using dart language
- To link flutter project to firebase using firebase bin ID
- the waste bin database name and its columns from firebase will be linked using flutter project setting
- Need to add container / working space
- Than need to add columns to container
- list view will be add to columns
- The query will be added in list view, which contains bin ID, image, time, date, and navigation button. Need to link query with column in waste bin database.
- The application will contain a navigation button which will be linked with longitude and latitude of waste bin from waste bin database. Once the navigation button is clicked, it will take to the waste bin location using google map and show the bin's ID.

Fig 3 shows an initial view of the bin location page in the application.

The following flowchart describes the process flow for application development



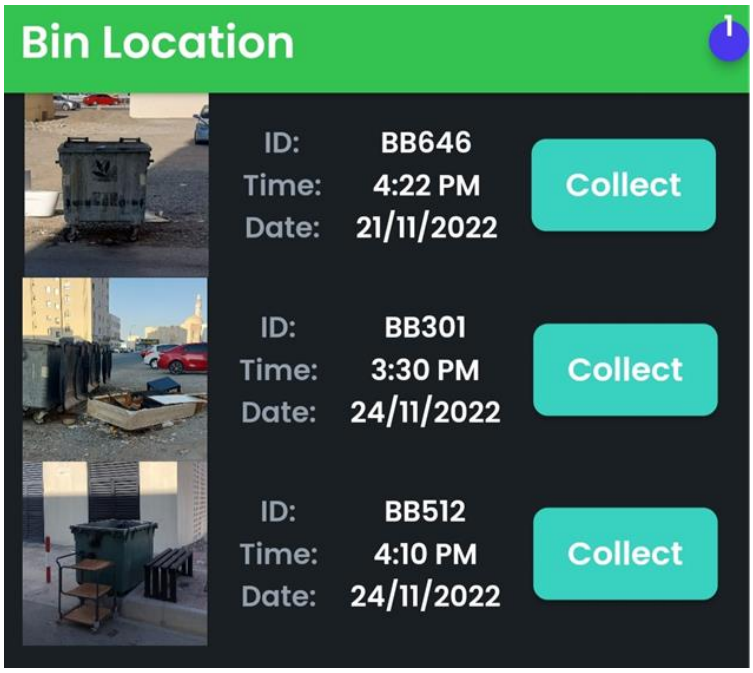
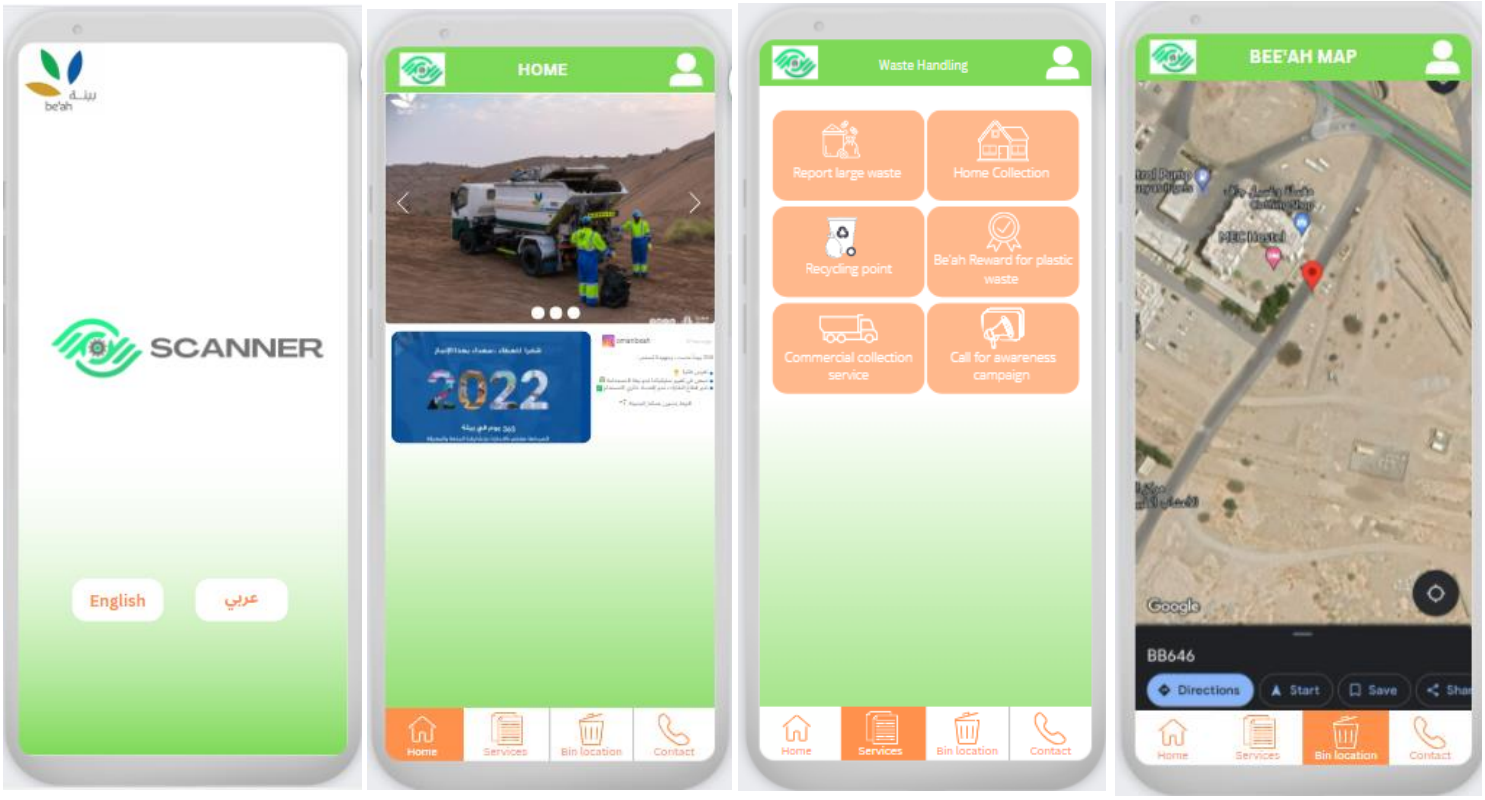


Figure 3: Initial bin location page in application

Tentative Application Outlook



The pictures above shows the application outlook, additionally showing features & services that can be added in the future. Currently, the available service is providing the user (be'ah) with image of the bin surrounding, show the ID of the bin and the location.

Initial release of application package, video demonstration of the application (Google drive link)

https://drive.google.com/drive/u/1/folders/1M3kh-8xrrHt0DC0osxBTeZziuZPSlhWS

9. Benefits of the project

- ✓ Integrated mobile application service for waste collection
- ✓ Beneficial use of image processing, machine learning and AI
- ✓ Smart way of waste handling notification for BEAH
- ✓ No handling and operational manpower needed
- ✓ Save time and reduce the cost of the labor and transportation
- ✓ Help to take more precise and effective decision
- ✓ Minimize social disturbance from annoying smell and flies by collecting the unwanted waste in proper time
- ✓ Help to maintain fresh and healthy waste management practice in the community using smart notification.

10. Budgeting

Google firebase subscription is free

- Private Commercial server per year_ rent a server: 100-200 USD/month
- For application maintenance/ administrator: Manpower cost/month
- IPCC Camera/ bin: 40 RO (Capital investment)
- Accessories: 30 RO (Capital investment)
- Data transfer/ bin/ month: 20 RO (Monthly cost)

11. Conclusion

This proposed project provides a smart solution to notify the large unwanted waste found around the waste bins in our community. The waste collection authority can get optimized notification and request facilities along with future extension services through this application for mobile and cloud usage. This application service is able to add more extensions based on the need of BEAH in its versatile platform for a sustainable waste management practice in Sultanate of Oman.