WINGING IT

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For SIA AppChallenge 2018
Singapore Students Category

Who We Are

Ho Kai Lun

I am an Industrial & Systems Engineering student at the National University of Singapore. My skill include Python, MySQL and data analysis (Tableau, Pandas etc.). I am learning Systems Dynamics Modelling and Operations Research as part of my curriculum. I am in charge of developing the food waste management system for this project.

James Gover

I am a third year university student on exchange to the National University of Singapore from Brisbane's University of Queensland studying software engineering. I have a variety of skills, most relevantly to this project; skills in using python including pandas and sklearn for machine learning applications and experience working in software projects with a human computer interaction(HCI) focus.

Wang Shiyao

I am a Computer Science freshman at the National University of Singapore. I am able to build interactive websites and provide artistic visualisations for solutions. I am in charge of developing the inventory management interface for this project and doing up charts and drawings.

Problem statements & Value proposition

Our project aims to tackle simultaneously the challenge statements
      4) Tracking Inventory Usage &
      5) Tracking F&B Consumption.

Our proposal is a system of inventory management integrating the management of food and crockery through automated means that seek to increase counting accuracy, reduce manpower and management overhead, and provide the potential for greater customer satisfaction through data analytics.
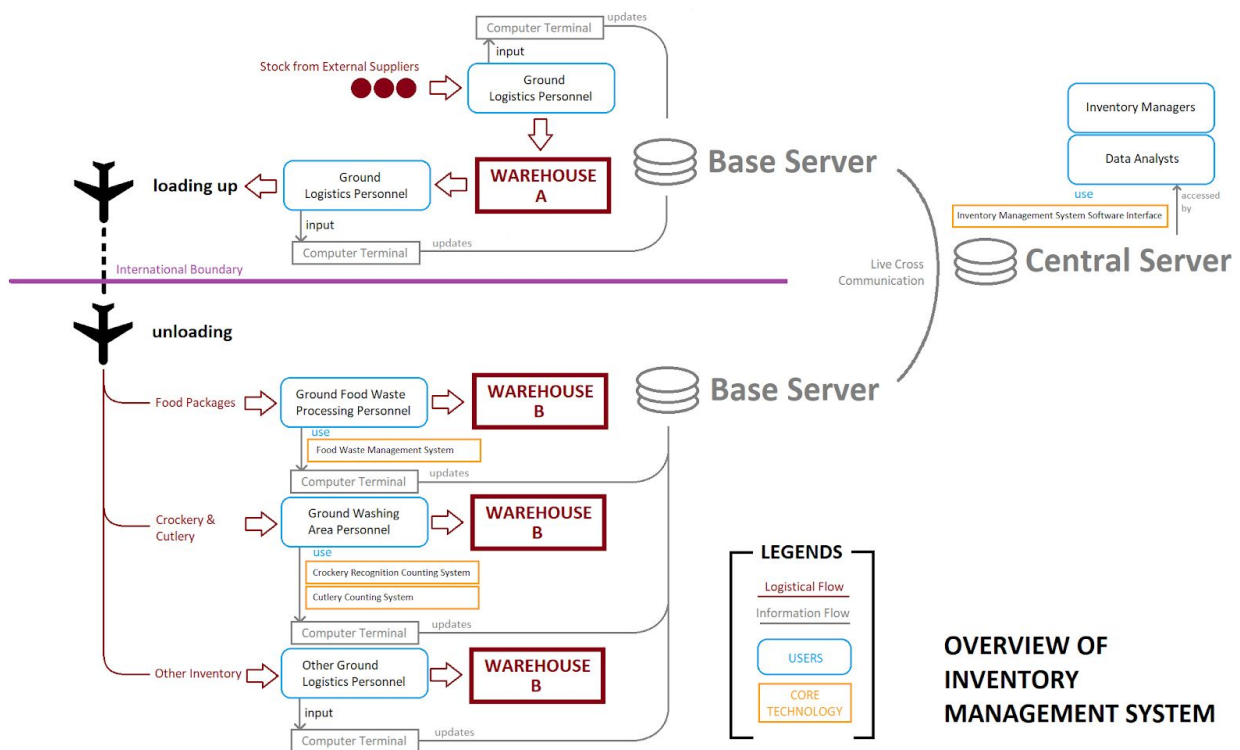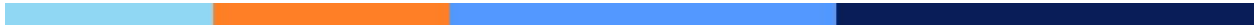
Overview

Fig 1. Overview of Inventory Management Solution

Our solution is an efficient process of digitising all inventory records across all SIA destination airports. A central server will be used to track all inventory at every airport, which inventory managers and data analysts can then access through our proposed Inventory Management System (IMS) Software Interface. The interface will provide a broad overview of all inventory item quantities and shortfalls, which will make tracking easy.

Referring to the top of Fig 1, when stock from external suppliers enter the SIA airport warehouse, ground logistics personnel will log the quantity of stock through a terminal, which will be sent to the base server.

When inventory is pushed out of the airport warehouse and uplifted onto any SIA flight, ground logistics personnel will verify the respective items and quantities uplifted, before sending that information to the base server as an update.

After a flight has arrived at its destination and has begun unloading, different inventories will be sent to different parties.

> I. Unconsumed Food packaging will be sent to Ground Food Waste Processing Personnel, who will be able to count the leftover amount of food packages quickly using our Food Waste Management System (FWMS). Using either QR codes or the packaging colour, the FWMS will automatically count the food packages. The leftover quantity (by meal option) will then be uploaded into the database, which is used to compute wastage statistics.

> II. Crockery and cutlery will be sent to ground washing area personnel, who will be able to count the amount of crockery and cutlery unloaded from the aircraft using our Crockery Recognition Counting System (CRCS) & Cutlery Counting System. The information is, again, passed on to the base server.

> III. Other logistics will be handled by logistics personnel, who will verify the quantities unloaded from the flight before uploading the data onto the base server through a connected computer terminal.

Note: All counting systems are conceptualised to maximise efficiency. For more info, read the section on 'Presentation of Users' Experience'.

Differentiation

Inventory Management System

Our system is designed to leverage a central database that will provide all users with real-time updates of inventory. The software interface for this system will provide a holistic big-picture view of all inventory across all airports. It will also automatically flag inventory shortfalls to alert users for the forecasting of demand-planning with suppliers and other follow-up action. We envision it to be easily integrated into existing logistical processes and workflows.

Food Package Counting System & Food Waste Management System

Our system provides a fast and rather automated food waste counting solution. Help enlisted from caterer can be minimised. The system will allow for convenient data collection, which can be used for further data analysis to bring up customer satisfaction and cut down wastage.

Crockery Counting System

Our system provides a fast and accurate crockery counting system through computer visual recognition.

Cutlery Counting System

Last but not least, we envision an accurate cutlery counting system using a combination of human labor and weighing machines.

Core Technologies

Inventory Management System (IMS)

Software

Demo coded as an interactive front-end website (simulating user interface) with:

HTML, CSS, Javascript, jQuery, PHP,

managing constant live data stream from back-end mySQL database (simulating central server)

Food Waste Management System (FWMS)

Software

Back-end Database: mySQL
Front-end App:
    Built in Python
    Additional Packages used: PyMySQL, PyZBar, Requests, PyQt5, OpenCV, SciPy, NumPy
Dashboard/ Data Analytics:
    Tableau and Python

Hardware (Food Package Counting System)

Food Package Counter Terminal (See Appendix)
    Camera (30 - 60fps, High Definition)
    LCD Display + Computer (Surplus computer/ Minicomputer e.g. Raspberry Pi)

Crockery Recognition Counting System (CRCS)

Software

Machine learning models:
    K Nearest Neighbours
    Logistic Regression
    Neural Network Classifier
Object isolation in an image:
    Otsu threshold to create a binary mask
    Image regions
Video analysis
Implemented using sklearn NumPy and pandas

Hardware

Camera (30 - 60fps, High Definition) mounted on top of dishwashing machine conveyor belt.

Presentation of Users' Experience

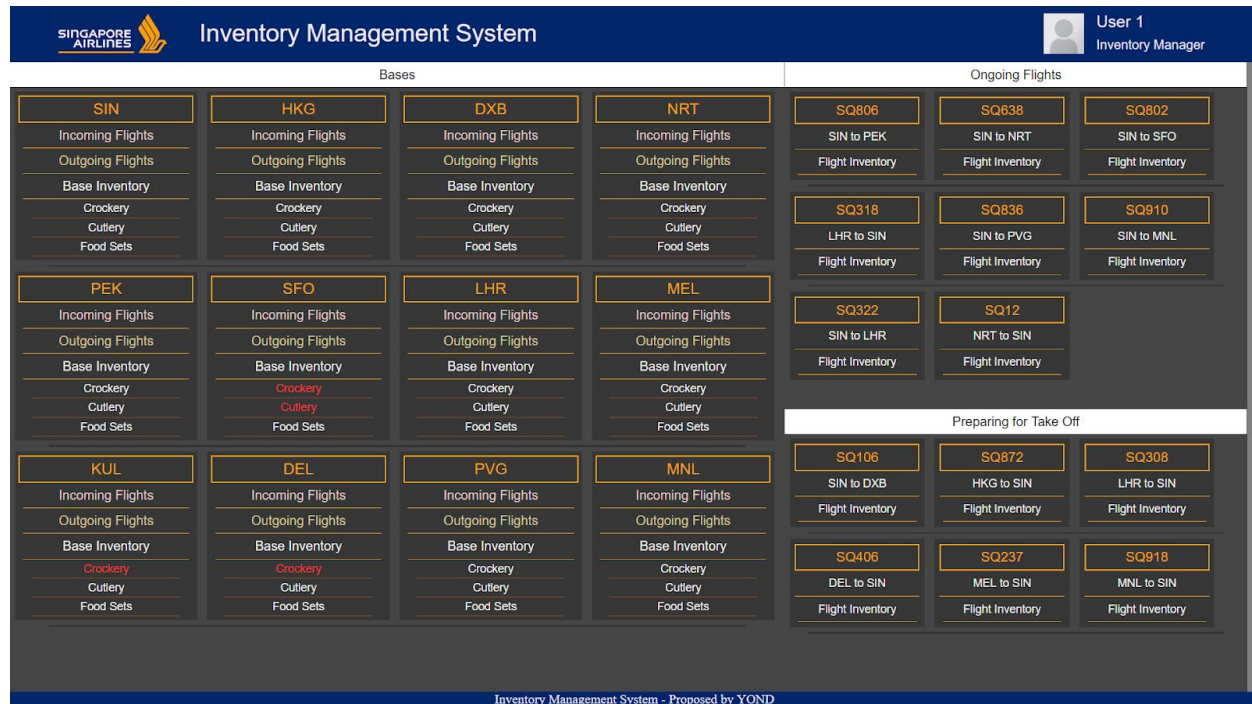## Inventory Management System (IMS) Software Interface

Fig 2-1. Screenshot of IMS Software Interface

Inventory Managers:

1. All that Inventory Managers have to do would be to log into the the software to use it
2. The interface will provide users with real-time information of all inventory line-items across all locations that SIA has a presence in.
3. Users can also set warning limits for each line-item, allowing them to be notified whenever the stock of that item falls below that limit. This provides much needed convenience to busy Inventory Managers in tracking inventory.

Link to Inventory Management System (IMS) Overview & Software Interface demo

https://youtu.be/molcQ3sY1cI

Food Waste Management System (FWMS)
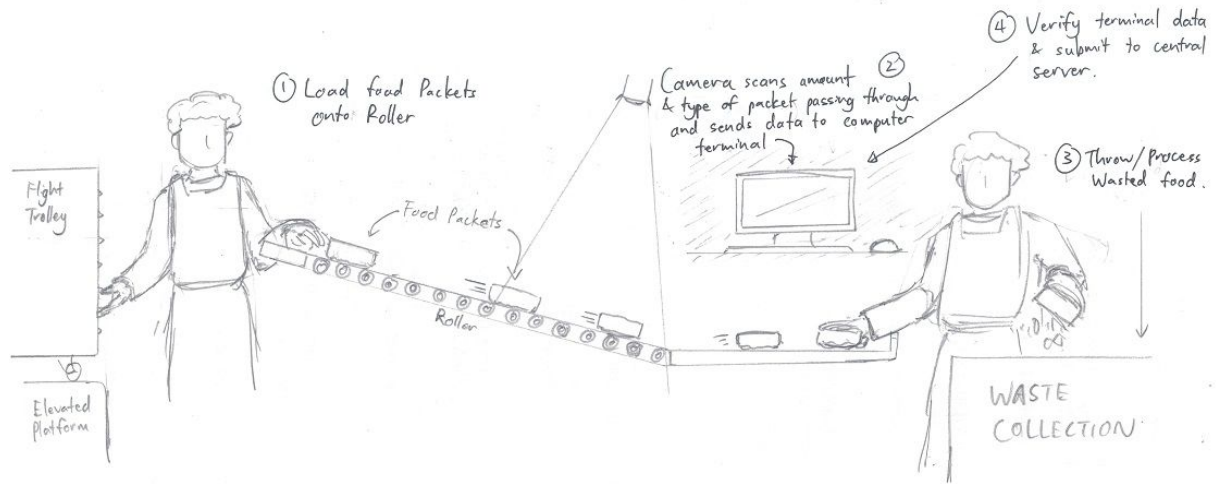
Fig 3-1. Illustration of proposed Food Package Counting System

Fig 3-2. Screenshot of FWMS Interface

Ground Food Waste Processing Personnel

1. Ground staff unload carts from aircraft. Meal carts are sent to catering partners for processing and waste disposal.
2. Catering partner staff log into the system computer terminal and indicate the flight that the carts were sent from. FWMS uses APIs to automatically obtain flight information, passenger statistics and meal uplift plan.

3. Staff unload the meal carts, placing unconsumed meals onto the conveyor. As the meals roll down the roller conveyor, the scanner automatically records the leftover meal and updates the database.
   ○ For loose items (e.g. unopened packets of bread rolls, juices): The scanner may be detached from the set up and used as a handheld scanner
4. Once scanning is complete, the personnel in-charge clicks submit, and data is automatically uploaded into the central database.
5. Wastage statistics are now accessible by HQ/ISD and ground staff.

<div align="center">

Link to Food Waste Management System (FWMS) Interface demo:

https://youtu.be/zmnFSKrJ3dI

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ISD Staff/ Data Analysts

1. Analyst logs into the database using Tableau.
2. The Tableau dashboard will automatically refresh with real-time data from the database, providing live visibility on F&B wastage and consumption trends such as:
   a. % Wastage by Time, Flight Route and Caterer
   b. % Wastage by Meal Type, Time Served and Meal Option
3. Further analyses can be conducted by analyst with Tableau. ISD staff can then build predictive models (e.g. Regression/ Principal Component Analysis) to predict food consumption on each flight.
4. ISD staff can then use these models/ analyses to optimise the quantity of meals uplifted, and make recommendations to improve in-flight catering options.
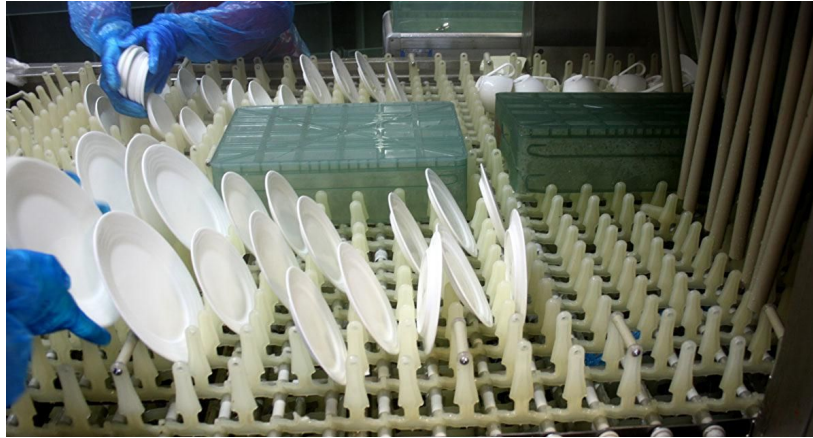
Crockery Recognition Counting System (CRCS)

Fig 4-1. Picture of an industrial dishwashing machine

Fig 4-2. Illustration of proposed Crockery Counting System

Ground Washing Area Personnel

1. Ground staff unload crockery containers from aircraft and send them to Washing Area.
2. Washing Area personnel lines up crockery onto the industrial dishwashing machine shown on Fig 4-1.
3. As the conveyor belt brings crockery into the field of view of the mounted camera (See Fig 4-2), the visual data will be processed through a pre-trained visual recognition algorithm that automatically counts the number and type of crockery.

4. Once the entire batch of crockery has passed through the dishwashing machine, the personnel in-charge will submit the processed data through a nearby computer terminal, thereby uploading the data into the central database.

NOTE: linked to a demo visual recognition algorithm found under 'Links' and a sample of the photos we trained it on under 'Appendix'

Cutlery Counting System

⑤ Every time a basket is lifted off the weighing machine, the machine sends the weight to the computer terminal

⑥ At the end of the batch, the verified data would be sent to the central server. The count of cutlery is determined by the measured weight.

② 1st worker takes out the spoons and places it in 1 basket

③ 2nd worker takes out the forks and places it in another basket.

① Pile of cutlery moves down the conveyor belt
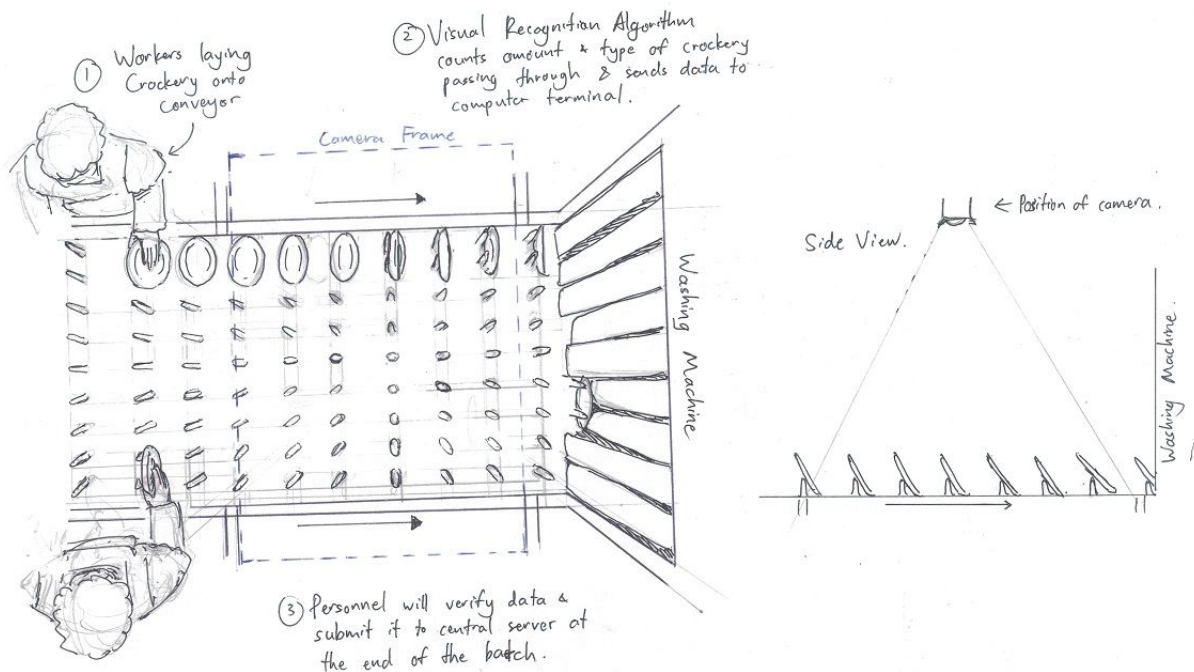
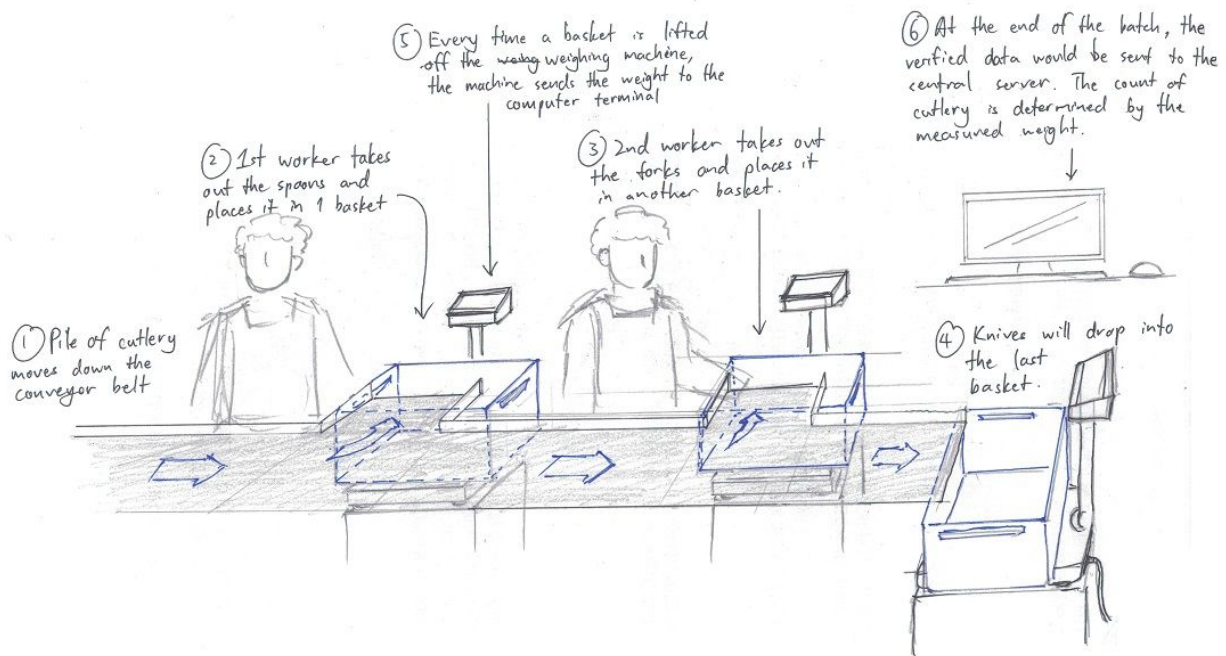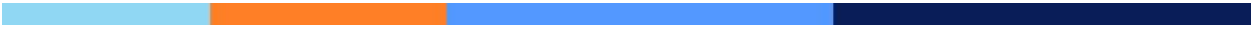④ Knives will drop into the last basket.

Fig 5-1. Illustration of proposed Cutlery Counting System

<u>Ground Washing Area Personnel</u>

1. Ground staff unload cutlery containers from aircraft and send them to Washing Area.
2. Washing Area personnel feeds cutlery into an industrial dishwashing machine.
3. After the cutlery have been washed, personnel will sort through the cutlery in the manner shown in Fig 5-1.
   a. For every type of cutlery, there will be a worker filtering that type from the moving pile into a basket.
   b. Each basket sits atop a weighing machine that feeds the recorded weight to a nearby computer terminal.
   c. Once the basket is full, the worker will replace it with an empty basket. The computer will record the weight of the previous basket of cutlery and calculate the total number of cutlery in that basket based on a precise measurement.

4. Once the entire batch of cutlery has been sorted, the personnel in-charge will submit the combined data of the batch on the computer terminal, thereby uploading the data into the central database.

Other Logistical Inputs

Ground Logistic Personnel

1. In the exact same manner as the systems above, there will be a computer terminal at every warehouse that ground logistics personnel can use to input the quantity of items going in and out of that warehouse.
2. Such a terminal may have a 2FA mechanism that allows only authorised personnel to update quantity changes on the central database.

Roadmap

The roadmap is split into three parts.

First 3 Month - Pilot & Validation Phase

In General:

1. Draft plans to integrate IMS with current workflow of all logistic departments / crew
2. Seek cooperation from all relevant industry partners

For Inventory Management System (IMS) Software:

1. Come up with multiple UI designs for IMS Software interface
2. User validation of UX and UI for the interface
3. Build interface prototype & do tests with relevant users
4. Finalise interface design

For Food Waste Management System (FWMS) :

1. Work with catering partners to understand their processes, and tailor the Food Package Counter design to their workflows.
2. Build prototypes of Food Package Counter terminal and distribute to selected catering partners for pilot testing.
3. Work with In-flight Services Department (ISD) to understand the F&B statistics that would be useful for optimising meal services. Customize Food Waste Management System and dashboard accordingly.
4. Gather feedback from catering partners and ISD to make improvements on design.

For Crockery Recognition Counting System (CRCS) at washing area:

1. Acquire industry support for getting data and testing mechanisms.
2. Obtain large scale data from an actual full scale dish washing machine.
3. Test varying learning model and select one or two best performers
4. (concurrently with 3) Develop and test a mechanism for handling live feed of data from full scale machine.
5. Optimise one of the learning models to get desired test accuracy of above .98
6. Work with industry partner identified above to implement mechanism in a pilot test facility.

Next 3 Months - Finalisation of Design & Procurement of hardware Phase

For Inventory Management System (IMS) Software:

1. Set up central server and database for all logistical items across all locations with SIA logistical presence

For Food Waste Management System (FWMS) :

1. Refine design of Food Package Counter setup and Food Waste Management System through feedback from stakeholders.
2. Work with conveyor manufacturers to finalise design of Food Package Counter terminal.
3. Procure Food Package Counter hardware setup.

For Crockery Recognition Counting System (CRCS) at washing area:

1. Refine design through feedback from stakeholders
2. Procure weighing machines, boxes and computer terminals for all other airport bases

Next 6 Months: Mass Rollout Phase

For Inventory Management System (IMS) Software:

1. Establish database links to all counting and weighing machines at washing, holding & logistic storage areas.
2. Ground testing of inventory management software
3. Staff training for IMS Software
4. Launch live running of inventory management software

For Food Waste Management System (FWMS):

1. Progressively set up FWMS in facilities of catering partners.
2. Set-up user accounts and establish database links for each terminal.
3. Staff training
4. Each catering partner can launch live independently, once staff training is complete.

For Crockery Recognition Counting System (CRCS) at washing area:

1. Set up CRCS for all other airport bases
2. Test run all systems after link with IMS
3. Staff training for CRCS

Links

Inventory Management System (IMS) Software Interface Demo

https://wangshiyao.000webhostapp.com/SIA%20Appchallenge/index.php

Github Links

Inventory Management System (IMS) Software Interface

https://github.com/shiyao821/Inventory-Manager-SIA

Food Waste Management System (FWMS)

Executable: https://github.com/hokl374/meal_scanner_compiled
(User: siauser1, Password: password)

Source Code: https://github.com/hokl374/meal_scanner

Crockery Recognition Counting Algorithm

https://github.com/jamesgover/Winging_it-crockery-recognition

Youtube Links

Inventory Management System (IMS) Explanatory Video

https://youtu.be/molcQ3sY1cI

Food Waste Management System (FWMS) Demo

https://youtu.be/zmnFSKrJ3dI

Appendix

Fig A-1. Sample pictures that we have used to train our CRCS demo