

Project Report: R10 Humanitarian Sustainable Project & Volunteer Training Support Fund 2024

On

“AI-Based Food Wastage Monitoring Robot”

1. Introduction

Food waste is a common problem in today’s society specifically in community meal areas like student canteens and hostel messes. This wastage is brought about not due to the people leaving food but due to various passive factors that result in degraded food quality, inedible food, food served in unhygienic conditions, and large serving sizes.

To counter this issue an innovative solution combining IOT with Computer Vision and Machine learning, A food wastage monitoring bot has been developed, this bot uses weight sensors and camera modules to input various data about used food plates and process this data to detect what and how much food is wasted, the bot being connected to the internet allows it to transfer this data in real-time to cloud-based database which is connected to a mobile application which serves as a dashboard for the concerned authorities to monitor the wastage and take action as quickly as possible.

The bot has been built with an emphasis on modularity, evident by its adjustable camera mount, and the ability to support multiple types of food dustbins, crates, and payloads. Along with this, the planned upgrades involve the use of Wi-Fi camera modules to allow for remote control of the bot from anywhere using the local area network.

2. Methodology

- **Structure:**

The bot is made using an aluminum frame to provide strength to handle multiple food plates and payload while also being very light. The bot features a vertically protruding rod with a bend at the top completing an L shape at the tip of which a camera is mounted directly at the center of the payload area to capture clear images of the food. At each corner of the payload area, 4 load cells each rated for 50 kgs of weight have been mounted using special 3d printed covers to input accurate weight data. A designated area with a base of insulative Sunboard is being used to store all the electronics, computers, microcontrollers, and batteries being used by the bot.

The camera mount features multiple aligned holes on a lower and upper section with two nuts and bolts holding the upper and lower section together. These holes allow us to adjust the height of the camera module at any time and also ensure a stable mount for the camera. Various extra supports have been added to the mounting to make the camera stable even when the bot itself is moving around.

The bot is designed to support large crates which can be used as a bin for the food plates, these crates can be covered with large trash bags that will ensure no food/liquid is spilled affecting the bot or the surrounding area. The bot's modularity allows crates of varying sizes to be compatible with the bot, and no one crate needs to be quickly reused thus a smooth-flowing cycle with the bot and the cleaning staff can be maintained.

▪ **Sensors**

The algorithm that allows the bot to conduct its primary goal requires two pieces of input from the hardware, an image of the food plate, and its weight. These inputs are given to the algorithm by the load cells and the camera module attached to the bot, the four load cells at each corner of the payload area can measure a collective weight of 200 kg, they are interfaced with an Arduino UNO through an HX711 Amplifier chip, the Arduino is programmed to check the weight at a fixed interval and if the weight is sense passes a certain threshold (the weight of an empty plate), it sends a trigger signal along with the weight measurement to the Jetson Nano module to continue with the algorithm and process the information.

Once the processing is triggered a picture of the food plate is captured and sent to the computing unit for further processing, the camera module is a Logitech C920 webcam that interfaces with the computing unit. The load cells and the camera unit communicate with different modules and thus need serial communication between the Arduino UNO and the computing unit.

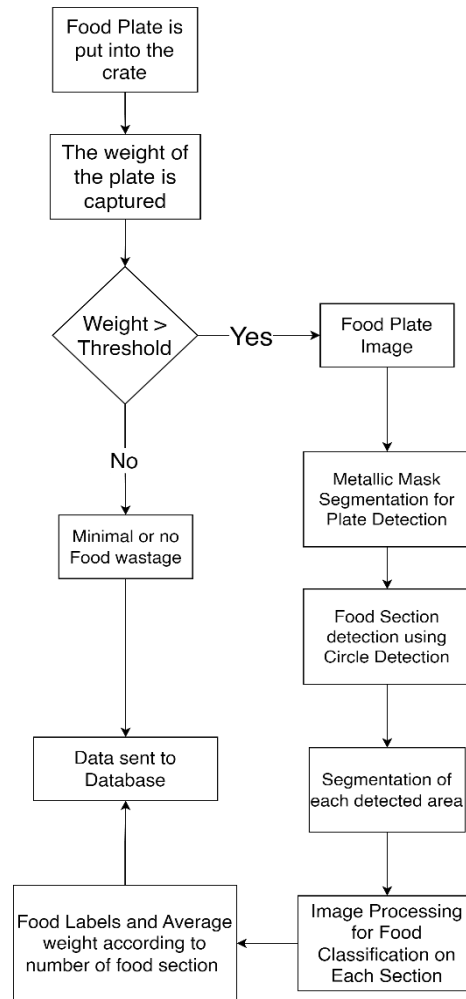
▪ **Processing and Algorithm**

Finally, as all the data has been received by the algorithm, the following process takes place –

- A. The initial image is processed and a metallic mask is created for that image to separate the plate from the extra padding that might be visible in the image.
- B. Various food sections within the plate are detected using the Hough circle detection technique in OpenCV, and the various sections are cropped and separated.
- C. Finally, a pre-trained Keras Model is fed these separated images which provides appropriate labels for each image based on the type of food item that it detects.
- D. Finally, this label data along with the weight data is sent to the server with a timestamp.

The vision model used in our bot is a fine-tuned version of the Mobile Net V2 which is a pre-trained version of VGG 19 a Convulated Neural Network with 19 layers.

The fine-tuning of the model was performed with data collected in the institute canteen and several online databases.



➤ **Database and Mobile Application:** The data after being processed is sent to a

Figure 1 Flow of the processes in the bot

Google Firebase Real-time database, which is connected to a Flutter dashboard app with a simple-to-use UI and with various important data preprocessed including the Top 5 most wasted food items of the day and graphs showing food wastage across longer periods.

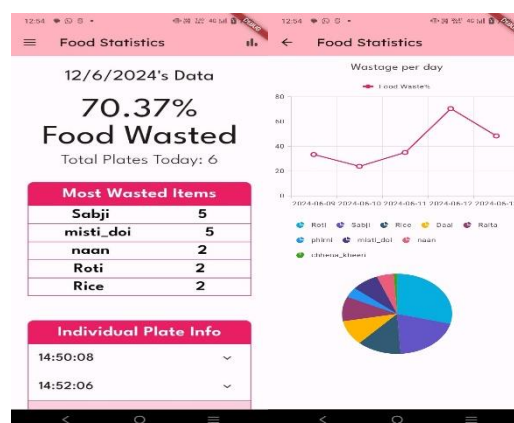


Figure 2 Mobile based dashboard application

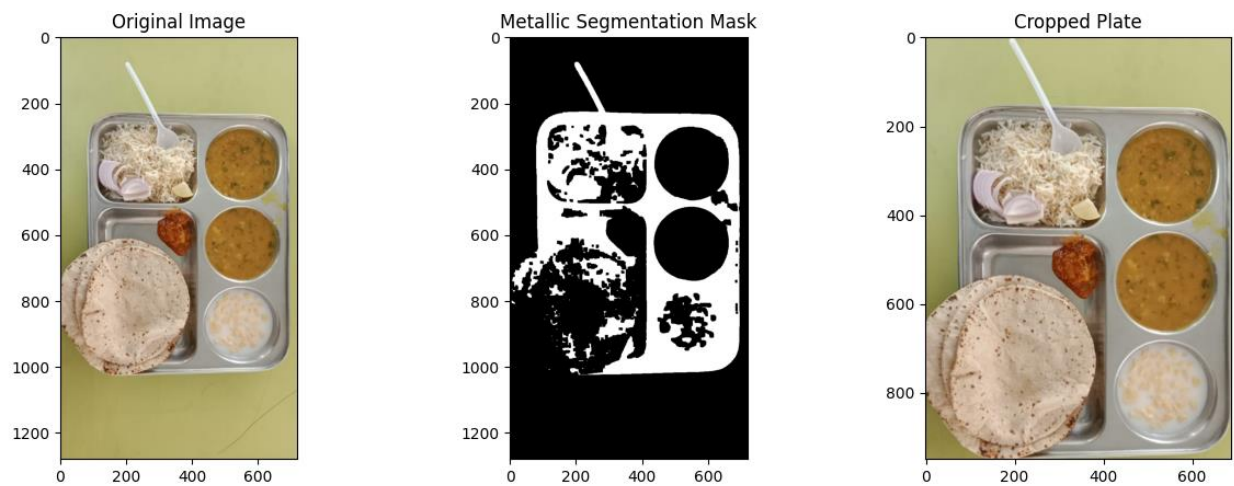
3. Results

The working of the bot is show below –

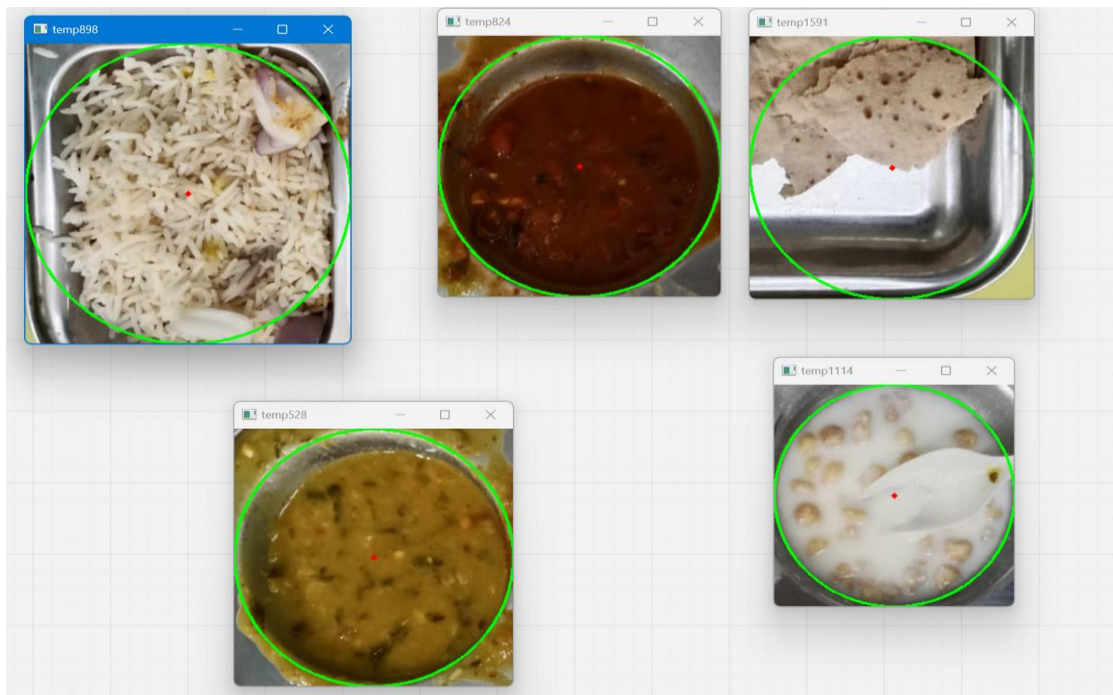
1. Original Image



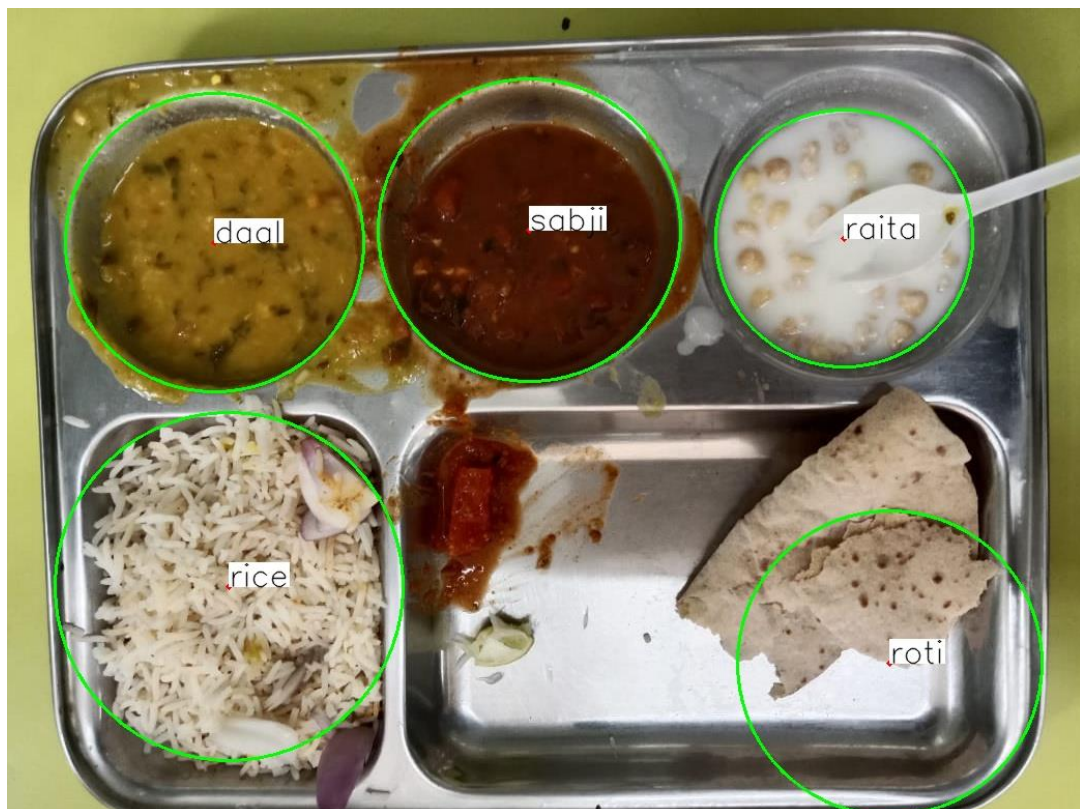
2. Metallic Segmentation



3. Detection and cropping of food items

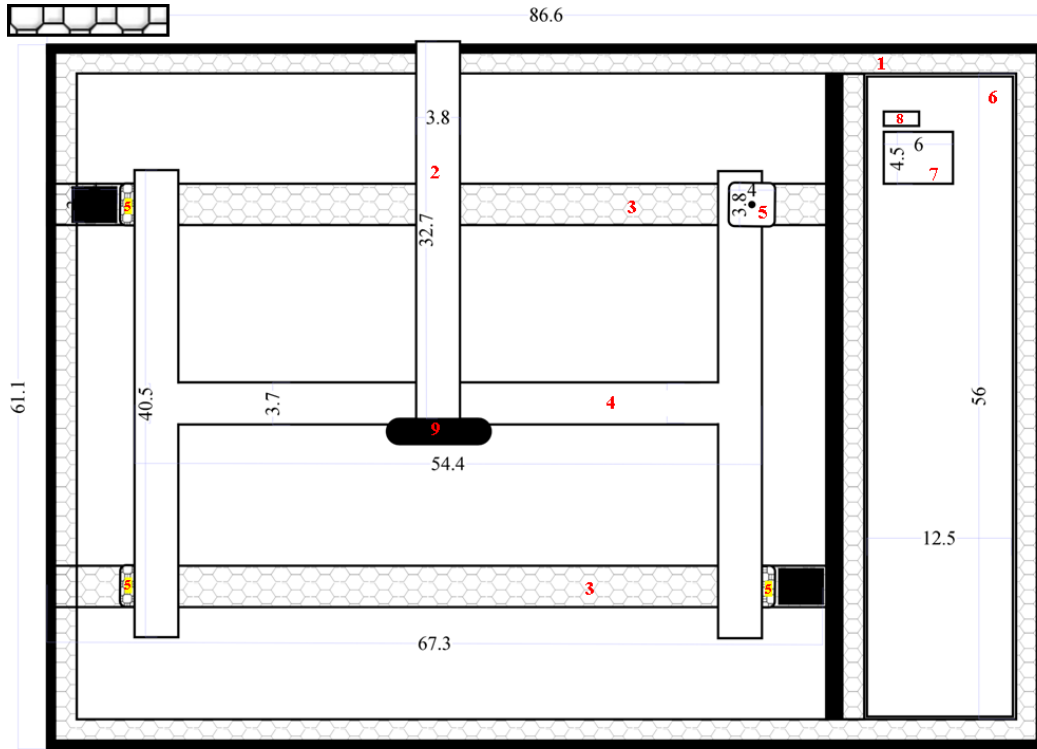


4. Identification and Labelling

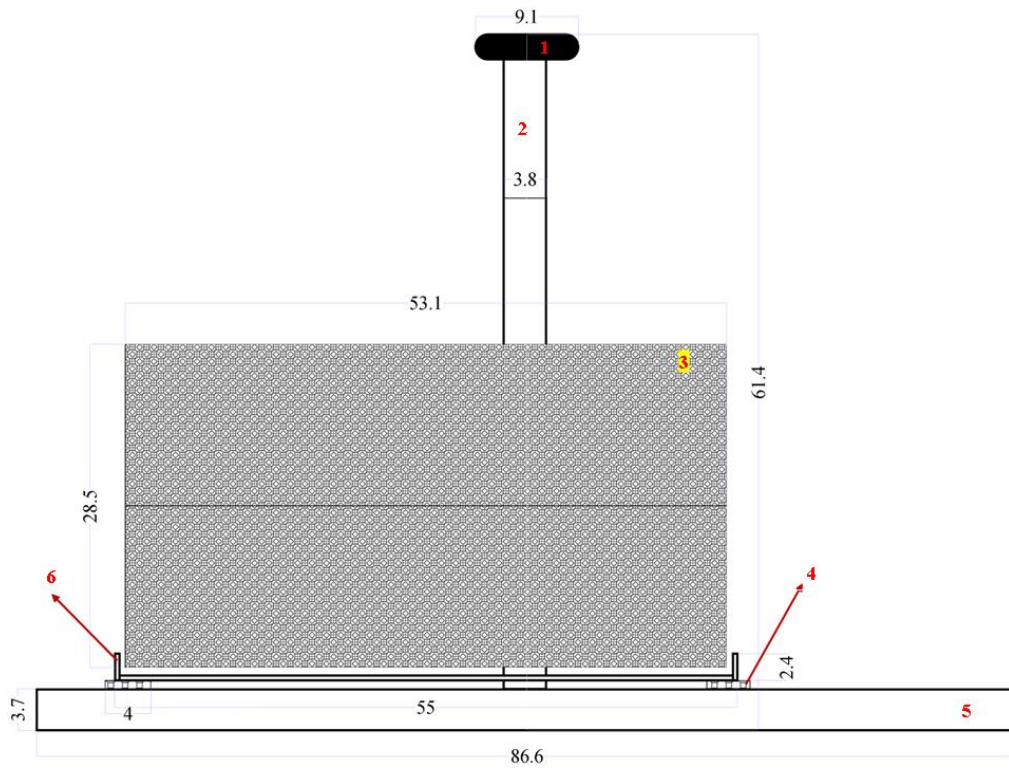


Once all these detections are done, the final labelled data is sent to the servers. Which is fetched by the mobile applications.

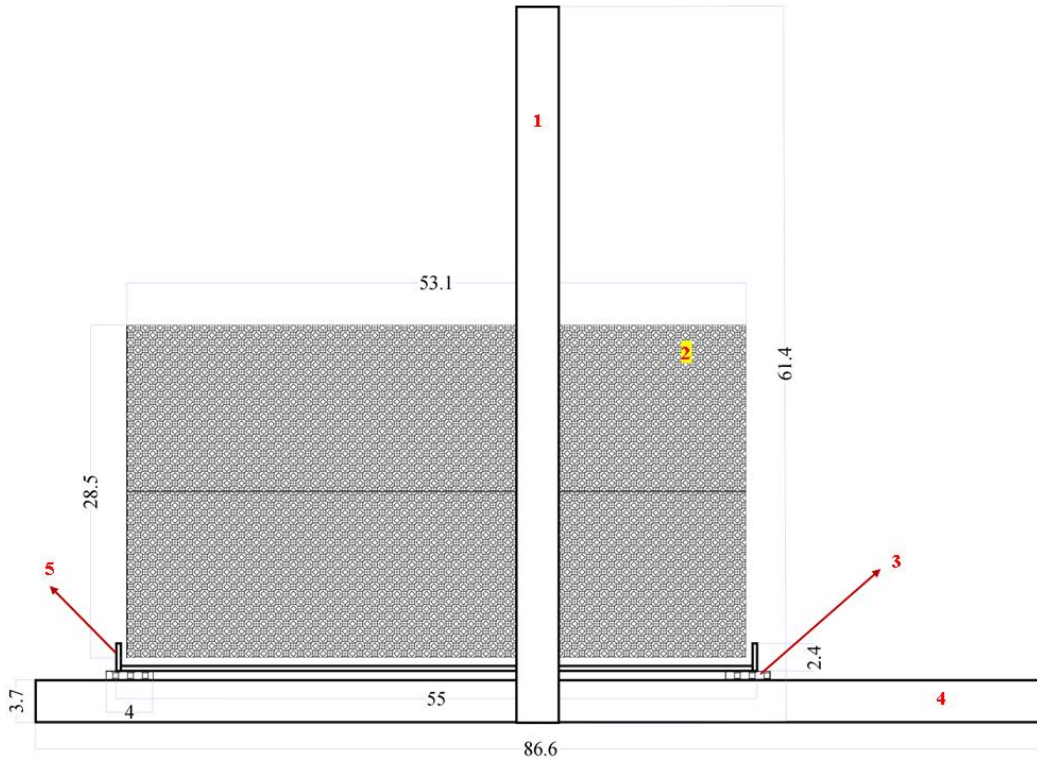
4. Diagrams



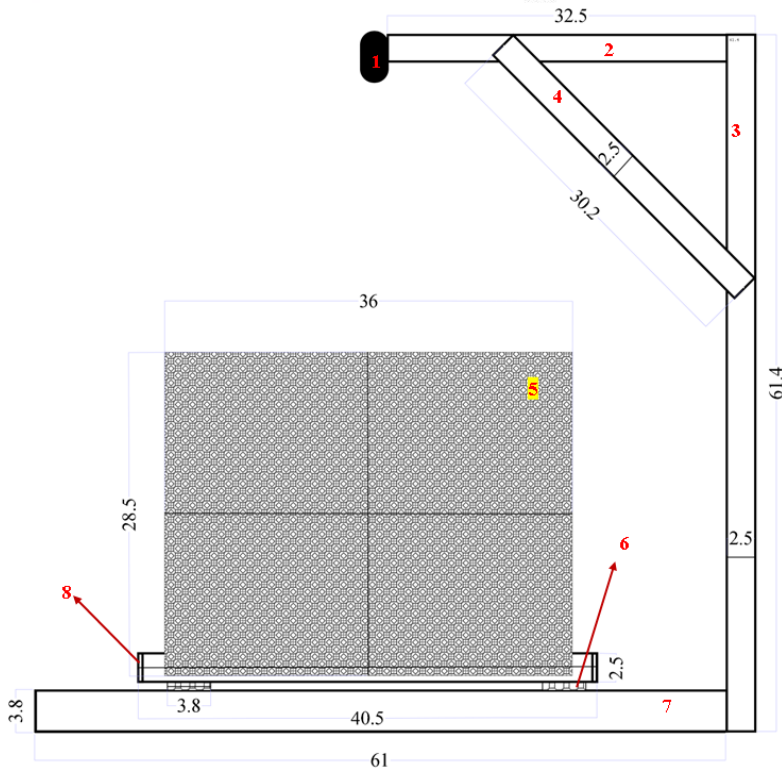
1. BASE
2. Camera Mount
3. Cross Frame
4. Base for Crate
5. Weight Sensor
6. Platform for components
7. Arduino
8. HX711 Load sensor
9. Camera



1. Camera
2. Camera Mount frame
3. Crate
4. Weight Sensor
5. Base
6. Crate mount



1. Camera Mount frame
2. Crate
3. Weight Sensor
4. Base
5. Crate mount



1. Camera
2. Camera mount
3. Camera mount frame
4. Strut support
5. Crate
6. Weight Sensor
7. Base
8. Crate mount

Project Snap:



