Milestone 3: Design Document Report

Abstract:

This project proposal aims to establish a comprehensive Smart Waste Management and Classification System to enhance waste management practices. By using sensor data, the system will keep track of the fill levels and weights of trash bins, which will aid in predicting future fill rates and determining the frequency of pick-ups. The project aims to streamline collection routes and reduce operational costs by concentrating on bins that are over 50% full, thereby promoting cleanliness in the community.

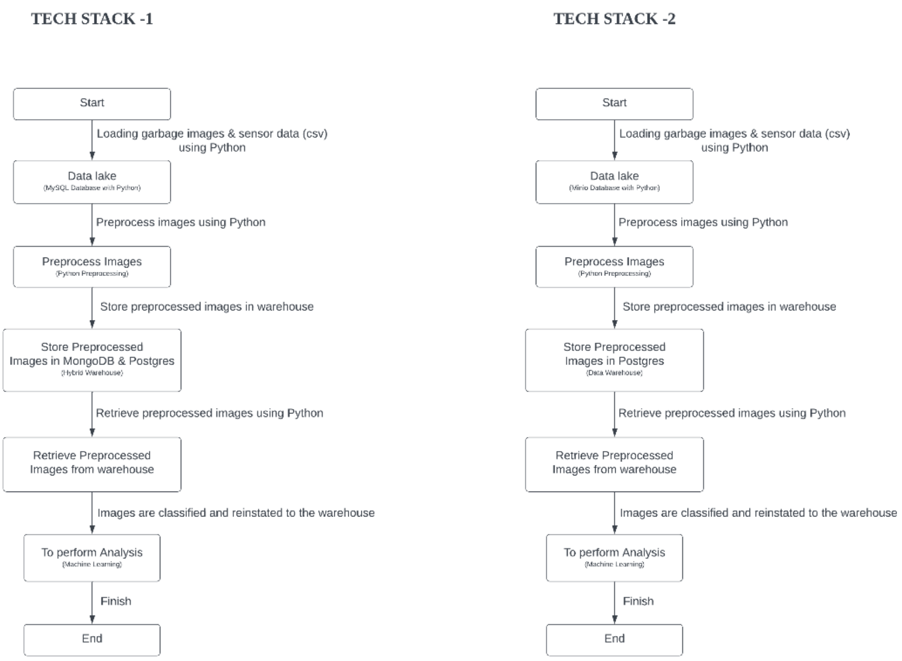
The system will also generate waste collection notifications based on bin levels, effectively reducing waste overflow. An integral part of the project is an automated waste classification system that uses image recognition technology to classify waste as recyclable or non-recyclable, with data stored in the cloud. This feature not only improves segregation and disposal but also prevents unhygienic accumulation of waste around bins.

In addition to these, the project will gather a comprehensive set of real-world images to improve model generalization. It will also focus on data visualization for detailed analysis of air quality, bin fill levels, and waste weights. The goal is to improve waste collection efficiency, reduce waste overflow, and encourage recycling in the community, thereby making waste management more efficient and cost-effective.

Project Design:

The figure 1 below shows the UML design diagram of the 2 different tech-stacks implemented in this project.

Figure 1



Technology Stack 1:

1. Data Collection: The process initiates with sensors placed inside garbage bins gathering diverse data such as fill levels, trash weight, and the air quality in the surrounding area.
2. Garbage Level Check: The sensors generate an alert if the garbage level in the bin is overfilled. Otherwise, no alert is issued, thereby reducing the frequency of unnecessary pickups.
3. Data Storage: Python scripts are employed to ingest the collected sensor data and image data, storing them in MySQL database acting as the Data Lake.
4. Pre-processing: The image data undergoes pre-processing, encompassing tasks such as de-brightness, resizing, outlier detection, and image scaling. Similarly, the sensor data is also cleaned to extract important features.
5. Storing Pre-processed Data: The pre-processed images are then stored in the data warehouse, utilizing MongoDB and Postgres as the chosen Data Warehouse solutions. MongoDB is a NoSQL database known for its flexible and schema-less data model. It excels at handling unstructured or semi-structured data, making it suitable for certain types of data, while PostgreSQL, being a relational database, enforces a structured schema.
6. Waste Classification: Python scripts were employed to retrieve pre-processed images from the data warehouse, which were subsequently input into the classification model for image categorization. The deep learning algorithm MobileNet V2 is utilized to classify the waste images into distinct categories such as Plastic, Paper, Glass, Trash, E-waste etc.

Technology Stack 2:

1. Data Collection: The process begins with sensors placed inside garbage bins collecting diverse data, encompassing fill levels, trash weight, and air quality in the vicinity.
2. Garbage Level Check: Sensors generate an alert if the garbage level in the bin gets overfilled. If it doesn't, no alert is issued, reducing the frequency of unnecessary pickups.
3. Data Storage: Python scripts are used to ingest the collected sensor data and image data, storing them into the MinIO database, functioning as the Data Lake.
4. Pre-processing: The image data undergoes pre-processing, involving tasks like increasing the brightness, resizing, outlier detection, and image scaling.
5. Storing Pre-processed Data: The preprocessed images and the trash can sensor data are then stored in Postgres, serving as the Data Warehouse.
6. Waste Classification: Python scripts retrieve preprocessed images and sensor data from the data warehouse, subsequently loading them into the classification model for image categorization. The deep learning algorithm MobileNet V2 is employed to classify the waste images into various categories such as Plastic, Paper, Glass, Trash etc, and further medical waste classification into 11 categories.

Use case Diagram:

The use case diagram depicted in figure 2 outlines the garbage collection and disposal process:

Data providers, interacting with the system—be it a smart garbage bin or a waste management application—are tasked with importing and preprocessing the data.

The system plays a pivotal role in coordinating the entire process, facilitating communication with the user, the garbage truck, and the sensors.

Sensors, strategically positioned within the garbage bins, gather data related to fill level, weight, and the surrounding air quality. Upon reaching a specific threshold, they trigger alerts to authorities, prompting the dispatch of a garbage truck for bin clearance.
The garbage truck is responsible for the collection and transportation of garbage.
An authorized individual, potentially a waste management official, oversees the process by ensuring the timely dispatch of the garbage truck.
Public users can access data visualizations and image classifications through the waste management application.

Figure 2