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GarbageGo – City Waste Management System with Garbage Reporting and Garbage Truck Tracking

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***Abstract*—** India's waste management infrastructure is plagued by serious issues, such as irregular garbage collection and unattended street waste, resulting in hygiene and environmental problems. GarbageGo is an intelligent mobile app that aims to make waste collection more efficient by offering real-time tracking of garbage trucks and enabling users to report uncollected garbage via images. The app classifies users into three roles: general users (residents), garbage collectors, and municipal administrators, to facilitate smooth coordination.

A TensorFlow and YOLO-driven machine learning model is applied to scan images of garbage that have been uploaded, deciding whether the trash has to be picked up. A profile area is also present in which users can view their contributions and receive badges as a reward for their work done in cleaning up the city. Predictive analytics in the future involves optimizing waste pick-up routes to make the operations more efficient.

***Keywords*—** Smart waste management, real-time tracking, garbage collection, mobile app, machine learning, YOLO, TensorFlow.

I. INTRODUCTION

Waste management is an important urban sustainability factor, but most cities, including those in India, have inefficient garbage collection systems. Untended street waste, uncertain timing of garbage truck arrivals, and the inability to track waste in real time lead to unsanitary conditions and environmental pollution. Several studies have emphasized the need for intelligent waste management using IoT, GPS tracking, and artificial intelligence for efficient waste collection operations. Yet most current solutions consider only smart bins or fixed routes, which do not solve the problem of littered, uncollected trash in public areas.

This research seeks to propose GarbageGo, a smart waste management mobile app that combines real-time garbage truck tracking, machine learning waste classification, and user-initiated garbage reporting. The main goals of this study are:

To create a real-time tracking feature that alerts users when the garbage truck is on its way.

To deploy a machine learning model (YOLO + TensorFlow) for image-based waste sorting.

To create a structured reporting system for users to report missed garbage.

To improve municipal waste management efficiency through data analysis and route optimization.

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To track garbage truck location everyday and send alerts to the users.

Our solution focuses on making contributions to smart city projects through waste collection efficiency and cleaner cities. The use of AI and real-time monitoring makes the model efficient and scalable for other cities that have similar issues with waste management. While letting the citizens to be more responsible in keeping the city the clean. And letting citizens, collectors, and municipal officials interconnect for a smooth process.

The rest of the paper is structured as follows: Section II has the related work presenting past waste management technologies. Section III outlines the system architecture and design of GarbageGo. Section IV gives the methodology,

such as real-time tracking, ML-based garbage detection, and the reporting system. Section V explains the results and discussion of the research. Section 6 concludes the study and presents future directions.

I.I. Types of Collectable Wastes

Waste picked up in urban spaces is categorized as Municipal Solid Waste (MSW), encompassing household, commercial, and institutional waste. MSW comprises numerous types of waste that have different disposal mechanisms. GarbageGo's machine learning algorithm analyzes and categorizes the following types of waste for effective collection and disposal:

Organic Waste – Contains food waste, yard trimmings, and other materials that are biodegradable and can be composted.

Plastic Waste – It identifies bottles, bags, packaging materials, which need proper recycling.

Metal Waste – Identifies cans, aluminum foil, scrap metal, to ensure that they are separately processed.

Electronic Waste (E-Waste) – Identifies disposed mobile phones, batteries, electric parts, that need special disposal because of the toxic content.

Paper Waste – Makes newspapers, books, and office paper accessible for recycling.

Hazardous Waste – Paint cans, medical waste, and chemicals are termed hazardous.

Figure 1. Municipal Solid Waste

I.II. Urban Waste Management Challenges

Notwithstanding the advances in waste management technology, the cities still grapple with numerous challenges:

Unpredictable Collection Schedules: Residents miss waste collection due to the irregularity of garbage truck arrival times.

Lack of Public Awareness: Citizens throw away waste without segregation, resulting in inefficient recycling.

Unreported Uncollected Garbage: Street garbage tends to go unreported, resulting in pollution and sanitation problems.

Inefficient Garbage Collector Routing: Without optimization based on data, garbage trucks travel inefficient routes, wasting fuel and time.

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GarbageGo seeks to solve these problems by using real-time location tracking, AI-based garbage sorting, and a built-in user reporting system.

II. RELATED WORK

Al Mamun et al. in article [1] states that IoT-based smart waste management systems enhance the efficiency of garbage collection through sensor-based monitoring of waste levels. The article explains how real-time data collection can be utilized to optimize waste collection routes in cities. It does not address user-reported scattered garbage, which GarbageGo does.

Gupta et al. in [2] confirms that deep learning models like TensorFlow can efficiently automate waste sorting. The paper discusses an AI-powered sorting system for intelligent bins but does not take into consideration trash lying outside marked waste zones. GarbageGo builds on this by enabling the reporting of uncollected trash through images, incorporating real-time AI-powered detection.

Patel and Ramesh in article [3] discuss the application of IoT and AI for monitoring waste. The research emphasizes how CNNs can enhance automated waste detection but lacks real-time citizen participation in waste management. GarbageGo builds on this by allowing direct user involvement in garbage reporting.

Kumar and Jain in [4] studied the effect of AI-based route optimization in waste collection. The research illustrates that dynamic scheduling with real-time waste buildup can enhance collection efficiency. It does not include direct communication between waste collectors and users, which GarbageGo includes to make waste pickup responsive.

Verma et al. in paper [5] says that deep learning algorithms can sort waste into organic, plastic, and hazardous types to enhance recycling rates. The paper points out the application of AI in sorting waste at recycling plants but not in real-time sorting at the source. GarbageGo addresses this by using YOLO-based AI classification on images submitted by users.

Hajito et al. in [6] examined public awareness and involvement in waste disposal. The research established that insufficient public involvement and education largely impact the success of waste management. GarbageGo addresses this through rewards and gamification incentives for user involvement.

Whittaker et al. in paper [7] looks into the position of intelligent dust bins in contemporary refuse management. According to the article, although efficiency is enhanced with sensor-based bins, uncollected garbage lying on roadsides is not managed. GarbageGo supports the system by providing users with a platform to report littered refuse, which allows for end-to-end waste monitoring.

Boonmee et al. in [8] is a discussion on facility location optimization for waste management. The paper suggests stochastic and dynamic models for enhanced garbage collection efficiency. It falls short of real-world deployment perspectives, which are supplemented by GarbageGo through real-time monitoring of garbage trucks.

Adebayo et al. in paper [9] investigates the application of AI-based image recognition for waste classification in intelligent cities. The research demonstrates the capabilities of real-time object detection without incorporating waste reporting systems. GarbageGo builds on this by enabling users to upload images of missed garbage for automatic classification.

Chen et al. in [10] remarks that predictive analytics can be applied to forecast areas of high wastes using past statistics. The research suggests an AI-driven forecasting framework for waste collection planning but is not adaptable in real time. GarbageGo improves on that by incorporating real-time dynamic waste accumulation monitoring combined with predictive analytics.

III. THEORY / CALCULATION

The theoretical background and mathematical models employed in the GarbageGo system are described in this section. The system is based on machine learning for waste classification, GPS tracking for real-time truck location, and predictive analytics for waste accumulation prediction.

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III.I. Machine Learning-Based Waste Classification

GarbageGo uses YOLOv5 (You Only Look Once), a real-time object detection model, to classify images of trash provided by users. The classification involves:

Image Preprocessing – The input image is resized and normalized.

Feature Extraction – The image is analyzed using convolutional neural networks (CNNs).

Bounding Box Detection – The AI model identifies objects and gives them a confidence score.

Category Allocation – The waste is allocated to one of six categories: Organic, Plastic, Metal, E-Waste, Paper, Hazardous Waste.

The model makes the most likely waste type prediction and assists in automating source segregation of waste for efficient collection and disposal.

III.II. Real-Time Garbage Truck Localization

GarbageGo localizes garbage trucks in real-time with GPS information. The system:

Obtains real-time GPS locations of garbage trucks.

Estimates truck speed from movement information.

Estimates arrival time (ETA) at the user's site.

Sends a push notification to the user if the ETA is 10 minutes or below. The system constantly refreshes the truck location to make precise arrival forecasts and improve waste collection scheduling.

III.III. Predictive Analytics for Waste Accumulation

Predictive analytics is utilized by GarbageGo to find areas of high waste and improve garbage collection routes. The system examines:

Historic garbage reports uploaded by users.

Time-varying waste patterns, like changes in the rate of disposal at any point in the day.

Space-varying waste density, separating commercial from residential zones.

A predictive algorithm is employed to forecast future levels of waste and suggest the optimal collection routes for the municipal agency.

III.IV. Notification Timing Optimization

Notification timing is optimized by GarbageGo to enhance collection efficiency in the following manner:

Monitoring real-time truck movement with GPS.

Computation of truck speed and predicted arrival time.

Automatically sending push notifications to users when a truck is on its way.

This feature ensures that users are alerted beforehand, minimizing missed pickups and enhancing overall waste collection efficiency.

IV. PROPOSED METHOD

GarbageGo is a comprehensive smart waste management system with integrated machine learning-based waste sorting, real-time tracking of garbage trucks, user-initiated reporting, and predictive analytics. The following discusses the methodology in building the system, including the system architecture, waste sorting process, GPS tracking, data

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processing, and notification system. Refer workflow diagram - Figure 2.

IV.I. System Architecture

The GarbageGo system has four major components:

User Mobile Application – Enables users to report trash, be notified of trash truck locations, and monitor their contributions.

Garbage Collector Dashboard – Shows locations of user-reported trash, categories of trash, and routes of optimized collection.

Admin Panel (Municipal Authorities) – Offers a system performance overview, trash reports, and analytics.

Server & AI Model – Executes image-based trash classification, monitors truck locations, and forecasts patterns of waste accumulation.

The system architecture diagram that represents the interaction of these components is depicted in Figure 1.

IV.II. Garbage Classification Process

GarbageGo's waste classification process is driven by YOLOv5, which is an object detection deep learning model. The classification process consists of the following steps:

Image Preprocessing – Images received from users are resized and are converted to tensor format for feeding into the model.

Feature Extraction – Convolutional layers extract prominent features of the garbage item.

Bounding Box Prediction – The YOLO model predicts objects and its confidence scores.

The YOLO-based waste classification model achieved an accuracy of 94%, precision of 86%, recall of 82%, and an F1-score of 86%.

Waste Category Assignment – The system assigns the detected object to categories like organic, plastic, metal, e-waste, hazardous, or paper waste.

After classification, the image is saved in the database, and if needed, a garbage collection request is sent to the closest available truck.

IV.III. Real-Time Garbage Truck Tracking

GarbageGo includes GPS-based tracking to give real-time location updates of garbage trucks. The system keeps track of the truck's position at all times and computes its speed based on movement history. Based on this data, it predicts the arrival time at the user's location.

Once the system calculates that the garbage truck will arrive in 10 minutes, it sends a push notification to the user, who can then prepare his or her trash for collection. This helps optimize the use of collections, lower waiting time, and maintain efficient waste disposal scheduling.

The tracking system updates dynamically based on real-time GPS feeds, providing precise arrival estimates and route planning for garbage collection teams.

IV.IV. User Adoption Challenges

For tackling Human literacy barrier We shall design , I user interface that is the simplest to use and Users don't need to

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worry much about Technical terms .for example The garbage truck tracker only needs our location and the automated service will automatically send alerts before the truck arrives. And as for the garbage report section, the camera is design in such a simple way that the users don't need to send Any kin?

D of details other than the photo.

Regarding the municipal operation adoption hurdles , we shall introduce our app underswachchhabharat abhijaan.

The policy regarding the municipal authority and the app shall we first discussed with the officials and only then the apps shall Be launched.

IV.V. User Garbage Reporting System

The garbage reporting module enables users to report images of garbage that has not been collected using the app. The process is as follows:

User takes a picture of garbage and uploads it.

AI model processes the image and identifies the waste.

If the garbage needs to be collected, the system sends the request to the closest garbage truck.

User gets real-time updates on the status of the report.

This feature ensures that scattered, uncollected garbage is detected and addressed promptly.

IV.VI. Data Processing & Predictive Analytics

To improve waste collection efficiency, GarbageGo incorporates predictive analytics to forecast waste accumulation trends. The system applies a linear regression model to historical waste data to predict future waste levels:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \epsilon$$

where:

Y is the predicted waste accumulation,

$X_1, X_2, \ldots, X_n$ are independent variables (historical waste data, location, time of day, weather, etc.),

β_0 is the intercept,

$\beta_1, \beta_2, \ldots, \beta_n$ are regression coefficients,

ϵ is the error term.

The system continuously updates predictions and adjusts garbage truck routes dynamically to reduce collection delays and optimize fuel usage.

IV.VII. Reward and Notice System

To facilitate citizen involvement, GarbageGo incorporates a notification and rewards system:

Push Notifications – Notification when a trash truck is nearby or when the reported waste concern has been solved.

User Profile & Badges – Remembers how many reports the users have submitted and awards the users for active contribution.

Leaderboard System – Showcases top participants in trash reporting to encourage city cleanliness programs.

Through the inclusion of gamification features, the system encourages users to practice proper waste management.

For user motivation, we can also provide coupon's and vouchers of defend companies who sponsor our app and

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advertise in the app.

IV.VIII. Ethical & Privacy Considerations

The users will be opted for Camera, storage and location permissions before the app is completely operational to the user. And also, there will be a strict user privacy policy that the user needs to accept about the image processing and usages of location data use.

IV.IX. Methodology Summary

GarbageGo's methodology is systematic:

AI-Based Waste Categorization – YOLOv5 model categorizes images submitted by users.

Real-Time Garbage Truck Location – GPS and Haversine formula determine truck-user distance.

User Reporting System – Facilitates direct citizen participation in waste management.

Predictive Analytics – AI predicts waste buildup and optimizes truck routes.

Notification and Reward System – Incentivizes user participation through alerts and rewards.

This method guarantees a cost-effective, scalable, and community-based waste management system.

V. RESULTS AND DISCUSSION

Mismanagement of waste has serious effects, including contamination of the environment, health risks, and inefficiency in the urban sanitation network. Un-collected garbage, ineffective collection time tables, and inadequate segregation of waste are widespread problems in urban areas across the globe, taking a toll on public health as well as the environment. India still grapples with garbage-filled bins, unregulated dumping, and lagging municipal garbage collection. As city populations rise, waste disposal systems need to adapt to ensure growing demands. Conventional modes of collection fail to provide live monitoring, making them inefficient with resultant waste heaps in public places.

GarbageGo resolves these issues through the incorporation of AI-driven waste sorting, live garbage truck monitoring, and predictive analytics to enhance waste collection effectiveness and user participation. The platform utilizes machine learning algorithms to sort waste, GPS tracking for waste collection vehicles, and cloud computing for efficient processing of data.

The GarbageGo workflow model, as depicted in Figure 2, shows the whole process from user garbage reporting to tracking collection. Users can upload photos of garbage that has not been collected, which the AI model identifies and determines whether immediate collection is needed. If a request is triggered, the closest garbage truck is alerted, and users are provided with real-time truck arrival times.

With data-driven optimization, GarbageGo can potentially minimize collection delays, enhance waste segregation accuracy, and enhance citizen engagement. The reward-based reporting system incentivizes users to take an active role in maintaining their environment clean, promoting a sense of community responsibility. Some challenges still exist. The AI model's capacity to categorize intricate waste types, including hazardous and electronic waste, needs to be further developed. Accuracy of real-time tracking can be influenced by traffic, and scalability testing is needed for large-scale deployment.

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The success of GarbageGo is contingent upon its ability to accommodate real-world situations. Government policy alignment, public use, and support infrastructure will play a key role in its long-term performance. Expansion of AI training sets, inclusion of traffic-aware routing for trucks, and system optimization for large cities should be areas of future development. Should it be implemented effectively, GarbageGo has the potential to revolutionize urban waste management, making cities cleaner, more efficient, and citizen-oriented sustainability practices.

This is how the GarbageGo research paper standouts from the existing research –

I. Scope of Research

Current research is on overall waste management but does not have a user-friendly mobile app for real-time waste classification and monitoring.

GarbageGo incorporates machine learning (YOLOv5) for waste classification and real-time GPS tracking, making it more efficient.

II. Technology Used

Current research is based on conventional image processing or manual sorting.

GarbageGo uses deep learning for automatic classification, making it more accurate.

III. Real-Time Features

Previous research does not prioritize real-time monitoring of garbage trucks.

GarbageGo offers GPS-based tracking with ETA estimates for streamlined waste collection.

IV. User Engagement

Current systems tend to be centered on municipal-level waste management without user interaction.

GarbageGo engages users in waste reporting and encourages community involvement.

Figures and Tables

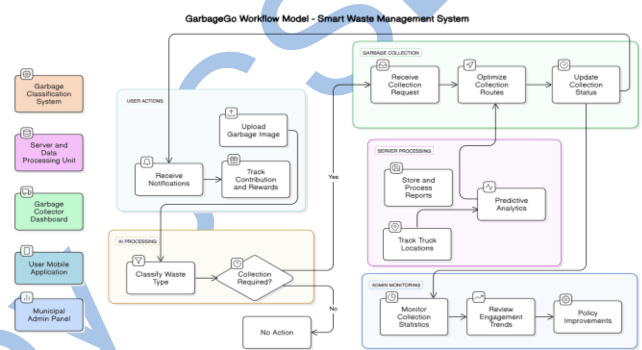

Figure 2. Workflow Diagram

VI. CONCLUSION AND FUTURE SCOPE

GarbageGo is an intelligent waste management system combining AI-based waste sorting, real-time tracking of garbage trucks, and predictive analysis to enhance urban waste collection. It allows citizens to report missed garbage, automates waste sorting, and maximizes pickup schedules via GPS tracking and data analysis. The system is intended to maximize efficiency, minimize collection delays, and foster citizen engagement via a reward system.

As the system is yet to be tested, its AI accuracy of classification, tracking reliability, and scalability are untested. The future effort will be in real-world validation, dataset increase for hazardous waste identification, and route optimization with live traffic. Further, stress testing under

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heavy user loads and integration of sophisticated gamification features can enhance adoption and efficiency even further.

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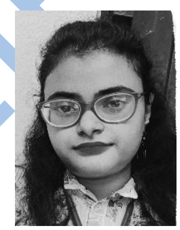

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