An Android Application for Detection and Collection of Solid waste

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Abstract - *The increasing urbanization and population growth have resulted in a surge in solid waste generation, posing significant challenges to existing waste management systems. We propose a smart waste detection android system to enhance communication between users, collectors, and officers. This system allows users to capture images of their waste and submit them, then it detects the waste in the submitted image using YOLO algorithm. Collectors, equipped with their system, receive real-time notifications of new waste submissions in their assigned areas. Upon accepting a collection request, the system provides navigation assistance to guide collectors to the users' locations effectively. Once the waste is collected, the collector confirms the task completion and the user gets a reward in terms of baggage. This system also enhances communication between garbage collectors and waste management officers. After completing the waste pickup, collectors can notify officers about their successful collection activities, providing real-time updates on the waste management process. This ensures efficient coordination, reduces response time, and enhances the overall effectiveness of the waste management system.*

Key Words **- Android, Waste Management System, YOLO, CNN, Rewards System.**

1. INTRODUCTION

In Indian streets we might have seen the improper disposal of solid waste which has a dangerous impact. The Garbage thrown in the streets or in open spaces has a large impact on the people living around them. Everyday garbage collectors try to collect waste from various places, but they don’t know the place where the waste is disposed of or the places where there are overflowing garbage bins. Such problems are common in India, where vast amounts of solid waste remains uncollected in the streets, in empty plots of land and in illegal dumps. At the end of the day, the collectors end up by collecting waste from the same places or by collecting small quantities of waste. Hence, the traditional way of collecting waste is complex which utilizes more human effort, time and cost and it is not compatible with the present technology. Since with the rise of new technologies, we should use these technologies for waste management systems. So, in this paper we propose a solution for the waste management system. This system introduces a user-friendly mobile application to create an efficient and sustainable waste management ecosystem. The primary objective of this system is that it automates the process of waste detection and introduces a rewarding mechanism to encourage responsible waste disposal practices. Through this system users can submit images of waste and the system detects the waste through the yolo algorithm. If the system detects waste in the image then it is assigned to the collector. On the collector's end, the system ensures that real-time notifications of new waste submissions are delivered with the details of the user and location of waste. Upon accepting a collection request, the system provides navigation assistance to guide collectors efficiently to the users' locations. Once the waste is successfully collected, collectors can confirm task completion through the system. This system also contains implementation of points-based reward systems for users as well as collectors.

2. RELATED WORK

[8] M. Kalpana and J.Jayachitra proposed a system where individual users send bin details to the server through an Android app when the bin is full. Once received, the server shares this information with authorized users. However, their approach has some drawbacks. It relies solely on users to report bin status manually, which could lead to delays or inaccuracies in waste management processes. Additionally, the system lacks automatic detection methods, meaning it may not be able to identify filled bins without user intervention. This limitation not only increases the burden on users but also raises concerns about the system's reliability and efficiency. Furthermore, the system has limited user engagement features, which may result in decreased user participation and less accurate reporting. The requirement for users to register before reporting bin status adds an extra step to the process and may deter some individuals from participating. Moreover, the system relies heavily on a centralized monitoring approach, which may face challenges with scalability as the user base grows. Additionally, the lack of environmental sensors means the system cannot effectively monitor environmental factors such as air quality or temperature, which are important considerations in waste management. To address these issues, we suggest a new solution. We're introducing a user-friendly mobile app for reporting bin status, which will streamline the reporting process and make it more accessible to users. To prevent false reports and ensure data accuracy, we're implementing a verification mechanism where collectors can review and validate submissions. Moreover, we're introducing a reward system to incentivize both users and collectors for their contributions to waste management. By incorporating these enhancements, we aim to improve the efficiency, accuracy, and user engagement of waste management processes, ultimately leading to a cleaner and more sustainable environment for all.

[10] Krishna Samdani, Shaunak Varudandi, Raj Mehta, Jahnavi Mahetalia, and Harshwardhan Parmar have proposed an innovative Waste Management system with two versions. While their solution utilizes advanced sensors and technology, it faces a common limitation: ineffective coordination between users and collectors, leading to inefficiencies in waste collection. To address this challenge, our solution integrates a seamless communication platform within the mobile application. This allows users to report waste easily, ensuring collectors receive instant notifications for swift action. Improved communication streamlines waste collection, promoting timely and effective disposal. The system features separate bins for wet and dry waste, each equipped with sensors, servo motors, and Wi-Fi connectivity managed by an Arduino Uno R3. Version 2 enhances waste segregation accuracy with a camera sensor and enables citizens to upload waste pictures for classification. The mobile app also facilitates prompt reporting of waste mismanagement. However, a significant limitation of current waste management systems is the lack of effective coordination between users and collectors. Our solution addresses this by providing seamless communication, streamlining garbage collection.

[2] Arghadeep mitra in his paper stated that the waste management in present time is known to everyone but unfortunately it is neglected by numerous people that utilized to perform exercises for waste segregation to take care of issues brought about by wrong garbage disposal. Many neural network and support vector machine based image classification projects are being done previously. A comparison study was performed byMind Yang et al to classify garbage between AVMs with scale-invariant feature transform and eleven-layer CNN design like AlexNet. The result is that SVM beats CNN. The accuracy level was 63% The process of segregating waste prompts the generation of energy out of waste, diminishing landfills, recycling, and reduction of waste. Incorrect disposal of waste leads to recycling contamination. Pollution is a big problem for the recycling industry, but it can be solved by automated separation of computer waste. The existence of models and strategies that help people to separate their wastes has become very important for proper disposal of these wastes. Although there are many different types of recycling categories, many people are still confused and do not understand how to choose the right bin to manage each type of waste. Waste management and its systematic separation play an important role in the development of ecosystems around the world. The goal of this project is to create an automatic garbage

detection system that uses deep learning algorithms to collect garbage images or videos from object detection cameras. Identify, predict and classify waste such as cardboard, glass, metal, paper, plastic and garbage to ensure proper disposal of waste in recyclable and non-recyclable bins. This paper basically uses the Faster-RCNN model for garbage detection. However, this model does not work well with images from your phone's gallery. And I got more accurate results. To limit the impacts of improper garbage disposal, this project introduced an automatic garbage detection framework using deep learning algorithms and image processing techniques. The diagnosis of lesions is done accurately and with higher accuracy.

[6] Haris Imran Karim Fathurrahman , Alfian Maarif , Li-Yi Chin have proposed that the problem of garbage in the world is a serious issue that must be solved. Good garbage management is a must for now and in the future. This study aims to create a mobile-based application that can select the type of garbage and enter the garbage data into a database. With economic development, the total amount of waste in the world increases year by year. Separation of waste is essential. As you know, one of the trends in the development of waste separation is automatic separation, which can significantly save labor. However, traditional vision-based automatic garbage separation systems use simple manual operations, and the generalization performance is not satisfactory. There are still many challenges in the automatic separation of complex and diverse wastes. In recent years, deep learning has shown explosive development. Compared with traditional visual characteristics extraction methods, the advantage of deep learning is that it does not need to select in advance which features or design features to extract, but allows the model to learn from large-scale data. So deep learning has a stronger learning ability and adaptability. This paper proposes a visual sensor-based method, according to deep learning, in order to achieve automatic garbage classification, which greatly improves the garbage collection rate. This paper also browses through the model called denseNet which is Dense convolutional Neural network. And also tell us about the various disadvantages and advantages of it. A real-time mobile garbage detection using deep learning and a simple database has been successfully developed.

3. SYSTEM DESIGN

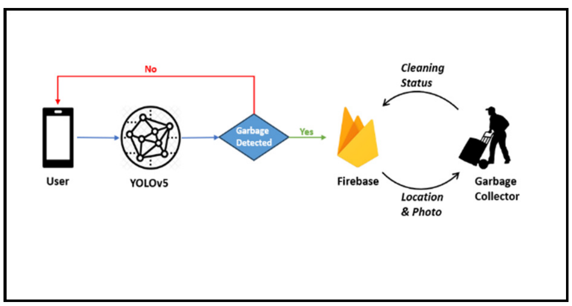

Fig-1: Architecture Diagram

Above diagram shows the architecture of smart waste management system that leverages technology to optimize waste collection and minimize costs. It starts with user who captures the photo of the garbage through camera within app, then this image is passed through garbage detection algorithm (here, we are using YOLOv5) which detects the presence of garbage. If the garbage is present, then the image is stored at the firestore along with the location of the garbage, if not the request gets cancelled. After that the garbage collector driver gets notified with the request which consists of the image and location of the garbage. Once the driver gets the request, he/she travels to the location with the help of a route which is provided with Google maps provided in the app. Then, the driver cleans the garbage and marks the request. After the request gets marked, the user gets notification from the driver, then the user confirms the cleaning process. After completion of the whole process the report is submitted to the officer in charge.

4. SYSTEM MODULES

4.1 User Module

When a user enters the application, they are prompted to authenticate with Firebase. Once authenticated, they are directed to the main page where they can access the interface. Here, guidelines for using the app are displayed along with a camera button. On the left-hand side, there is a navigation drawer containing options such as profile, support, and help/report. Users can report any issues they encounter, and there is an option to contact us via email for queries. When the user clicks the camera button, they are prompted to grant permission for camera and location access. After granting permission, the user can take a picture. The image, along with user data, is stored in Firebase. YOLO (You Only Look Once) is then applied to classify the garbage. If the classification indicates the garbage is plastic, the request is considered as valid and stored in Firebase. Additionally, the request is sent to the collector for further action.

4.2 Collector Module

When the user sends the request for the collection of garbage the image of garbage and his location goes to firebase. Firebase provides backend as a service to various mobile apps. So here we create a realtime database in firebase. To store the image of garbage that is clicked by the user and the location of the garbage. To detect the current location of the user while clicking the photo we have used Fused Location. To detect the location of the user first we take the permission of the user to access his location. After the user has allowed all permissions. And have turned on his GPS location his location is detected and then it is sent to the firebase in the form of latitude and longitude. Now the collector gets the request from the user and he accepts it. The garbage location that was on the firebase in the form of latitude and longitude is mapped on map and then the route is drawn from collector's current location to the location where garbage is not disposed properly. After the collector collects or cleans the garbage user gets the notification that his request has been successfully completed and his reward for that request will get credited in 24 hrs.

5. METHODOLOGY

5.1 Dataset

To build any deep learning model , the most important part is preparing the dataset. Dataset should contain all possible diverse scenarios. Since we have implemented convolutional networks (YOLO v8) model for that , we need labelled images constituting the ground truth data for training the neural network. We have collected various images of street garbage having various possibilities.
There are two classes in our dataset –

Fig-2: Non Garbage

Fig-3: Garbage

Figure 2 represents the sample image of non garbage class which contains very less amount of garbage and it should not be collected by the collector.

Figure 3 represents the sample image of garbage class which contains the large amount of street garbage and it should be collected by the collector. Hence, the algorithm will detect the garbage and it will be assigned to collector.
Hence, we annotated the images of two classes in roboflow.

The structure of the dataset follows ;

Training :- 70 % i.e 123 images

Testing :- 20 % i.e 35 images

Validation :- 10 % i.e 18 images

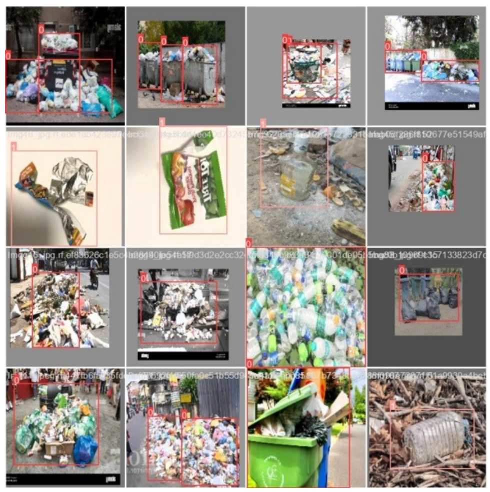

Fig-4: Sample Dataset Images

Figure 4 represents the annotated images which are used by the YOLO algorithm for training purpose.

5.2 Comparison yolov8 with other models

Since there are many computer vision models available for object detection, it is difficult to select and analyze the model which best suits our dataset. Hence ,taking into consideration various models , a comparative study was performed to identify the features of YOLOv5 , Faster RCNN , Efficientdet and YOLOv8.

Architecture	mAP@50	GPU Latency
YOLOv8	0.62	1.3 ms
Efficientdet	0.47	-
Faster RCNN	0.41	54 ms
YOLOv5	0.58	2.8 ms

Based on these results presented, it is clear that YOLOv8 is the most accurate and fastest of the four architectures evaluated, achieving a mAP50 of 0.62.

5.3 YOLOv8 Architecture

Yolov8 is the latest version of YOLO object detection developed by ultralytics. It is an advanced model that builds on the success of previous versions and introduces new features that improve performance and flexibility. Includes new backbone networks, anchorless detection heads and lossless features. The backbone network and the neck module are based on the YOLOv7 ELAN design concept. C3 module is replaced by C2f module in YOLOv5. YOLOv8 is currently a developing open source github repository authored by Glenn Jocher and published through Ultralytics with detailed documentation. Hence, we have trained YOLOv8 model over 50 epochs to build the custom model which detects Street Garbage from the image.

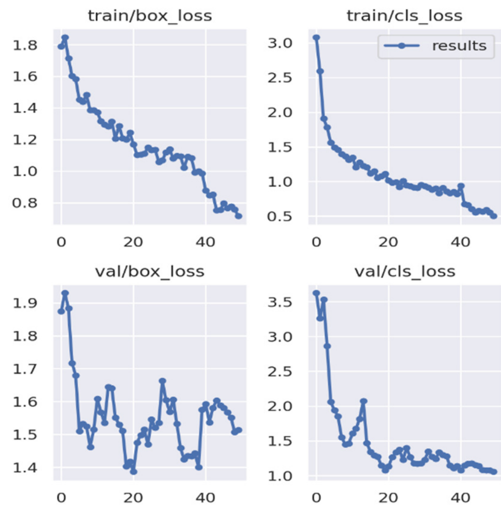

Fig-5: Training and Validation loss for classes and bounding boxes over 50 epochs

Figure 5 represents how loss is decreasing after every successful epoch. The model is trained over 50 epochs. Epoch refers to one entire passing of training data through the algorithm.

Fig-6: Test images with detections performed by yolov8 best.pt

Above figure shows the garbage detected by YOLO model. It also contains the bounding boxes with the confidence scores which classifies the images into two classes garbage and non-garbage.

6. RESULT

This section includes the evaluation of YOLOv8 model.

6.1 Precision Rate

It is defined as the ratio of relevant instances retrieved to the total retrieved instances. It is also called a Positive Predictive value.

$$\text{Precision} = \frac{\Sigma\text{True Positive}}{\Sigma(\text{True Positive} + \text{False Positive})}$$

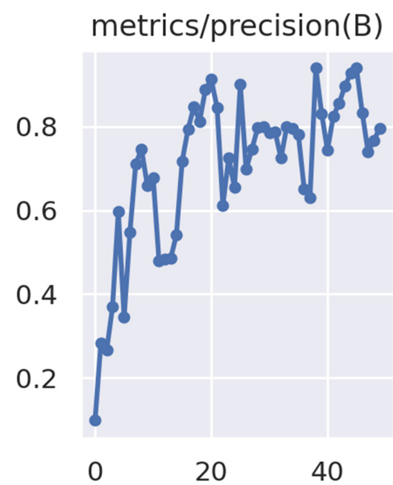

Fig-7: Precision graph of model over 50 epochs

Above figure represents increase in precision after every epochs.

6.2 Recall Rate

It is defined as the ratio of relevant instances retrieved to the total number of relevant instances. It is also called the True Positive Rate.

$$\text{Recall} = \frac{\Sigma\text{True Positive}}{\Sigma(\text{True Positive} + \text{False Negative})}$$

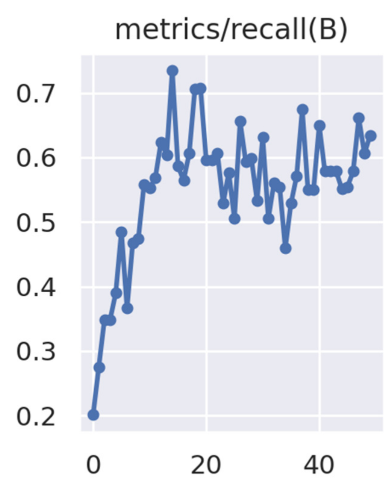

Fig-8: Recall graph of model over 50 epochs

Above figure represents increase in recall after every epochs.

6.3 F1 Score

It is a measure of harmonic mean of Precision and recall. It integrates Precision and recall into a single metric to gain a better understanding of model performance.

$$\text{F1score} = \frac{2 * \text{Precision} * \text{Recall}}{\text{Precision} + \text{Recall}}$$

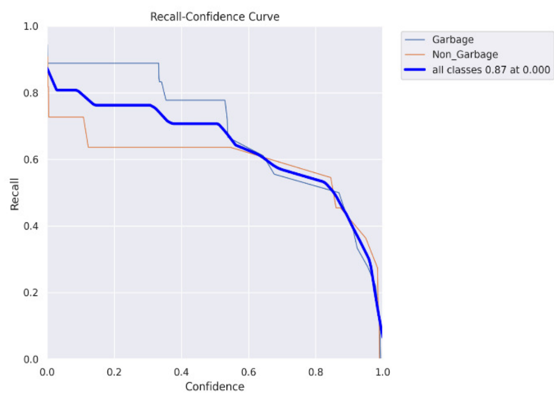

Fig-10: F1 curve of model

Above figure is the graph plot of F1 score which shows how recall is decreasing with increase in confidence.

6.4 mAP_0.5

Mean Average Precision is the metric used to evaluate the object detection model. It is calculated based on the Intersection of Union (IOU).Intersection of Union defines the ratio of area overlap to the area of union. The valueOf IOU is 1.0 when there is the exact match between the bounding boxes and it is 0.0when there is no match.mAP_0.5 is the accuracy when IOU=50 i.e. if there is more than 50% overlap, the detection is considered successful.

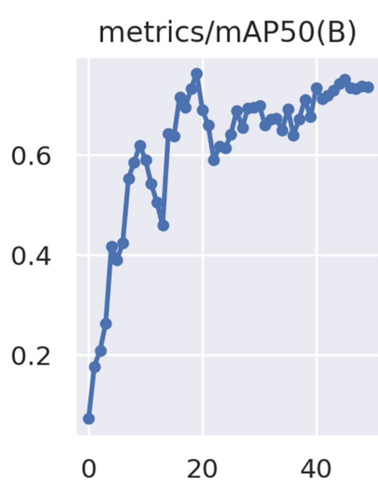

Fig-11: mAP_0.5 curve of model

Above figure shows that the Mean Average Precision is increasing with the epochs.

6.5 mAP_0.5:0.95

It is defined as the average mAP at the various IOU thresholds ranging from 0 to 0.8

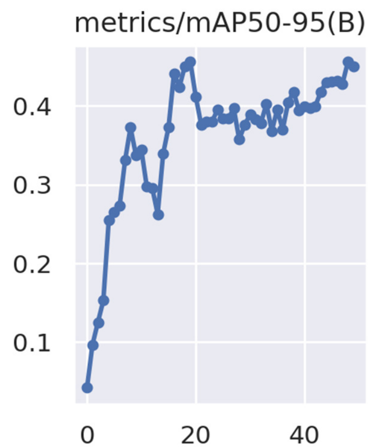

Fig-12: mAP_0.5:9.5 curve of model

Above figure shows that the average mAP is increasing with the epochs.

6.6 Confusion Matrix

It is used to measure the performance of classification models. Displays the number of accurate and incorrect samples based on model predictions. The columns show the actual values of the target variable and the rows show the predicted values of the target variable.

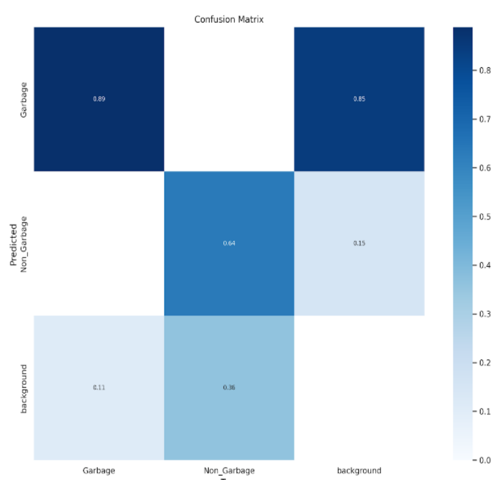

Fig-13: Confusion Matrix

Above image represents the confusion matrix of model which contains actual and predicted scores.

7. CONCLUSION

In this paper, we offered an Android application based on deep learning that can detect garbage from the image and assign it to the collector. The deep learning model (YOLOv8) can identify and detect the Street Garbage from the images and it is also able to detect the images with the least garbage so that no user could misuse the application. Since YOLOv8 has the highest accuracy as compared to the other versions of YOLO, it perfectly detects the garbage from the images and it also takes a very less amount of time. This application also encourages users to maintain their surroundings clean since every user will get rewards on the submission of complaints.

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