AUTOMATED TRASH DETECTION SYSTEM USING IMAGE PROCESSING.

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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JANUARY 22, 2024

APPROVAL

This Project titled "**Automated Trash Detection System using image Processing**", submitted by Md Yeakub, ID No: 201-15-14113 to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 22th January 2024.

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I hereby declare that, this project has been done by me under the supervision of **Abu Kaisar Mohammad Masum, Lecturer, Department of CSE** Daffodil International University. I also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ACKNOWLEDGEMENT

First, I express my heartiest thanks and gratefulness to almighty God for His divine blessing makes my possible to complete the final year project successfully.

I am really grateful and wish my profound indebtedness to **Abu Kaisar Mohammad Masum**, **Lecturer**, Department of CSE Daffodil International University, Dhaka. Deep Knowledge & keen interest of my supervisor in the field of "computer vision" to carry out this project. His endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior drafts and correcting them at all stages have made it possible to complete this project.

I would like to express my heartiest gratitude to Dr. Sheak Rashed Haider Noori, Head**,** Department of CSE, also to other faculty members and the staff of CSE department of Daffodil International University.

I would like to thank my entire course mate in Daffodil International University, who took part in this discussion while completing the course work.

Finally, I must acknowledge with due respect the constant support and patience of my parents.

ABSTRACT

In this modern world any type of detection is an important task. The reason is that in this 20th century anything can be easily found through detection. Among the several types of identification, trash detection is one of the best tasks. Through trash detection, we can easily find what kind of trash or unused items are present in our environment. Through detection, we can also protect our environment from pollution very easily because through detection, we can easily tell what kind of trash service has what kind of impact on our environment and how we can take steps against this pollution. Trash products may now be strictly found and categorized by trash detection systems by using advanced sensors, machine learning algorithms, as well as computer vision techniques. These intellectual technologies act as protectors as our cities spread, making sure that responsible trash management and better-informed decision-making pave the way for a future that is greener. Although various models have been used for trash Detection, YOLO v5 and YOLO v6 perform well. One of the reasons is that we know that in trash detection we always deal with real life or real time data and the YOLO model works very well for real life data. This model provides us with a balance between accuracy and speed and creates them useful for applications. Finally, we can say that using technology we can easily keep the trash objects in separate categories and by using any type of complex category we can clean our environment and find any type of unused things around us. As a result, environment meets the genuine use Artificial intelligence.

Keywords: Trash; Detection; Recycle; Categories; Computer; Vision; Image; YOLOv5; YOLOV6.

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CHAPTER 1
Introduction

1.1 Introduction

There are diverse types of pollution in our present society but among them environmental pollution is one of the biggest problems. Due to environmental pollution, there are several types of adverse effects on people, such as people suffering from various diseases and people becoming physically weak. It has an unbelievably adverse effect especially in the rural areas and not less in the cities as well. One of the main causes of environmental pollution is that trash is left anywhere without dividing it into distinct categories properly. The big garments, factories and industries of our country often make this kind of mistake. As a result of which our environment is getting badly polluted constantly and the amount of this pollution is increasing regularly. But we can solve this problem very easily through trash Detection. This is because with trash Detection we will include each trash in the distinct categories and place them accordingly. As a result, there will be no adverse impact on our environment and there will be no negative impact on people, which is a greatly beneficial and very productive step for our present society. In this case, by using image processing to detect each trash separately, we will separate them into distinct categories. One of the best advantages is that through imaging we will get particularly good accuracy which will be particularly good for our application as well as for those who are involved in trash management. Finally, it can be said that using technology in trash detection, we can easily solve one of the problems of today's society and bring back the greenness of our environment and make people's daily lives healthier.

1.2 Motivation

In this contemporary era trash detection is one of the most important works and there are several advantages available. But in every work, there are some specific reasons and all of them are given below:

- **Protecting the environment:** Air, water and soil are crucial elements of our environment and important for humans. Unused and unnecessary trash are too

dangerous for the environment. Especially hazardous trash and other trash make all the elements polluted for this human and animals are suffering a lot in this century. But using trash detection systems can help us and trash management people to reduce the amount of pollution and makes our environment healthier and livable.

- **Safety of the public:** Trash is spread distinct types of chemicals into the air which basically mixed with the air as a result several types of dangerous gas are produced which is so much harmful for the human eye especially for the children's. The main reason is management people are basically gathering them in a specific place, that's the reason this problem occurred. But trash detecting system can help to understand where to gather which type of trash by which kind problem can easily be solved and easy to save the life of local people.
- **Easy to recycle things:** In trash there are enormous number of things available which can be easily recyclable and use them once again. On the other hand, recyclable things can also help to save the financial amount in a good figure. So, it's clear to say that trash detection systems can easily be used to find recyclable things and save the company's financial condition.
- **Reduce dangerous gases:** We can easily find recyclable and non-recyclable things in trash. If we burn non-recyclable things, it produces a vast number of black gases which basically increase the amount of carbon-dioxide in our environment by which it can cause big problem for humans breathing. But using trash detection systems can easily find the non-recyclable things as a result the gases production will be reduced day by day and save humans life.
- **Reduction of global warming:** We all know that when trash is burnt it produces diverse types of dangerous gases which basically make the environment warm and as a result trees are facing a huge problem. Tress is the only way by which humans are getting oxygen. But using trash detection system can let us know which trash is producing dangerous gases. As a result, management can separate them in other places and burn them in an alternative way which cannot damage our environment.

1.3 Research Question

When doing research on a subject, we must face various problems or face various questions. In this case, some questions based on my research “automated trash detection system using image processing” are presented below:

- Data is an especially valuable element for any research. In this case, what kind of problems have I met while collecting data during this research?
- Have I met any problems in safely storing data collected for research?
- Based on what is the accuracy of two models YOLO V5 and YOLO V6 used in trash detection system compared?
- What improvements or modifications have helped the YOLO V6 model perform better than the YOLO v5 model?
- How does the diversity and size of the dataset affect the ability of YOLO models to accurately detect types of trash items while also being able to generalize and handle scenarios effectively?
- How well do the Yellow V5 and Yellow V6 models perform in real-life scenarios?
- Are there any classes or bins where the model fails to accurately predict?
- What are the limitations of the YOLO V5 and YOLO V6 models in terms of trash detection?

1.4 Expected Outcome

Before starting any kind of work, we must think about its blueprint or what outcome we will get through this work. The main reason is that we want to create the system for the reason, whether our system can sustain that work or that result or what kind of Ricks will be generated. The hope we have with this system is that through it we can easily detect the kind of trash that is lying around us, and we can very well detect which trash we can recycle, and which can't. Moreover, we will be able to detect what kind of chemicals are released from what kind of trash. Moreover, through this system, we can divide the trash into distinct categories, and we can easily tell which type of trash is through the image. Which will play an especially significant role for our society and companies.

1.5 Project Management and Finance

The project management and pay up aspects of my thesis on " Trash detection system By Applying Image processing (YOLO V5 and YOLO V6 model) Approach" involve the below key or main considerations:

- **Distribution of resources:** In the trash detection system we need massive amounts of data or resources for smooth work or smooth output and need some special hardware for smooth processing.
- **Budgeting:** Create a proper budget planning for the system and prepare clear system aims, milestone and working zone.
- **Funding and acceptance:** Create a document for the total cost and take opportunities from the university to manage funding for the future work.
- **Risk management:** Discuss with the supervisor about the possible risk of the system and try to mitigate them.
- **Reporting and Documents:** Create a proper document for every work about the progress of the system.

After ensuring the above demands I can ensure the successful implementation of my system in a broad way in some specific area.

1.6 Report Layout

This report discusses six discrete chapters in order to make the study report more compact and efficient for readers and researchers.

In chapter number 1, we get the overview of my project. Various types of sections like 1.1 present the Introduction, 1.2 represent the Motivation, 1.3 highlight the Research Question, 1.4 pointed out the Expected Outcome, 1.5 narrate the Project Management and Finance, 1.6 describe Report Layout.

In chapter number 2, I basically Discuss about the background history and my system related works. Diverse types of sections like 2.1 present the Preliminaries, 2.2 describe the Related work, 2.3 represent the Tools and software, 2.4 narrate the extent of the issue, 2.5 pointed out the using model's limitations.

In chapter number 3, I basically discuss about the research methodology, adding its subdivision, the topics Chapter 3 covered are 3.1 represent the introduction, 3.2 pointed out the Data collection, 3.3 present the Data selection, 3.4 narrated the Data Labeling , 3.5 represent the Apply Image Preprocessing Techniques, 3.6 highlighted the Verification, 3.7 described the Data split, 3.8 represent the Proposed Model,3.8.1 described about the YOLOV5, 3.8.2 narrated the YOLOV6.

In chapter number 4, I basically describe the Experimental results and discussion. The topics covered in this chapter number 4 are, 4.1 described the Introduction, 4.2 narrated the Evaluation Metrics, 4.3 represent the Result and analysis, 4.4 pointed out the Performance analysis.

In chapter number 5, I originally Discuss about the Impact on Society, Environment & Sustainability. Diverse types of sections like 5.1 represent the Impact on Society, 5.2 described the Impact on Environment, 5.3 pointed out the Ethical Aspects, 5.4 described the Sustainability Plan.

In chapter number 6, I originally Discuss about the Summary, Conclusion, Recommendation, and Implication for future Research. Diverse types of Subsections 6.1 pointed out the Summary of the Study, 6.2 narrated the Conclusion, 6.3 represented the Implication for Further Study.

CHAPTER 2

Background Study

2.1 Preliminaries

During the preliminary phase, a literature review will be conducted to thoroughly examine relevant literature to find the most precise trash detection models and the factors that influence our trash management system. This can set up a fundamental basis for my research and aid in finding deficiencies in current knowledge that my research can tackle. Subsequently, the components are extracted from the data collection. I collect pertinent trash data from distinct types of bins and secondary trash management facilities, as well as from my own residence. Upon gathering data, I must engage in data pre-processing. Performing pre-processing and cleaning on the gathered data to guarantee its integrity and appropriateness for training and evaluating deep learning models. Next, the process of model selection involves choosing proper deep learning models by conducting a thorough review of existing literature and conducting experiments to figure out the most precise model for the task at hand. Categorize the trash into different classifications. Utilizing the curated and pre-processed data, the chosen model will undergo training, followed by an evaluation of its accuracy using an independent dataset. This process may entail adjusting the parameters of the model to perfect its performance and assessing its effectiveness by employing suitable metrics. This section can be referred to as the model training and testing phase. Examining the outcomes of the deep learning models is necessary to find the most precise model and discern the factors that influence the detection of trash. This process may entail the use of visualization techniques to examine and interpret the outcomes, specifically referred to as result analysis. Thus, these are the first steps of my thesis project.

2.2 Related Works

In paper number [1] the author Qiuhong Sun 1 used the YOLO V5 and the best accuracy ratio with algorithm was 77.3%. On the other hand, the author Amruta Hingmire1 in paper number [2] used the YOLO V4 model as well the best accuracy with algorithm amount was 90%. The author Martin Streicher-Portea, et al. Used the algorithm MFA in paper

number [3] where the best accuracy with algorithm percentage was 89%. In paper number [6] the best accuracy with algorithm rate was 90% where the author Jenilasree Gunaseelan used the ResNetXt. In the [7] number paper the author EUNICE LIKOTIKO used the Naive Bayes, Random Forest, Xgboost algorithms where he got the accuracy with algorithm exactly 88%. The author Teoh Ji Sheng,et al used the SSDMobileNet V2 algorithm in paper number [10] where he got the accuracy with the algorithm around 86.23%. In paper number [14] the author Vishal Verma got 92% accuracy using the CNN1 model. The author Tomáš Ferdan1. et al got 90% accuracy with the algorithm using the (GWP), (WTE), (MBT), GHG, LCA models in paper number [15]. In the paper number [16] the accuracy was around 89.82% where the author Xingshuai Yang was used the YOLOv5_CBS model. In paper number [17] the author Dilara KARACA1*, Süleyman UZUN2 used the YOLO V3 model and got the accuracy around 86.45%. The author Zhao Lun1 got 89.67% accuracy where he used the YOLO V3 model in paper number [18]. In paper number [19] the author A. R. Abdul Rajak. et al used AlexNet Convolutional Neural Network (CNN) and got accuracy exactly 80%.74.70% accuracy was taken by using ResNet50, VGG16 by the author Faisal S. Alsubaei in paper number [20]. Exactly 80% accuracy was taken by the author Farnaz Fatovatikhah1, et al. In paper number [21] after using (3D-DWT), SVM. In paper number [23] the author R. Bauer. et al. Used UV and/or visible light, TiO2/UV, the Photo-Fenton reaction algorithms and got 90% accuracy.

2.3 Tools and Software

In this case I am using python because python is easy to use and learn for many reasons. Here I used to google collab for the coding implementation and using google drive for the data store and other helping purposes.

2.4 The extent of the issue

The trash detection system described in the thesis paper has several remarkable back draws. Firstly, in this case using Raspberry Pi is very normal but they use the older version 3, which may the reason of slow or limit its processing power as well as capabilities compared to the more recent iteration or the most recent version. Additionally, the system does not

count the trash from landfill venues as well as Mulli grabs sites, thus extruding a serious source of strong data. The research targeted exclusively on flood trash and employing only two schemes as well as comparing them with a single algorithm, which basically imposes a restriction on research scope and comprehensiveness. On the other hand, here using a limited range of data or limited range of trash, which is the main drawback of the research and using a limited number of methods. These negative sites are the main obstacle for further research and creating a more comprehensive as well as a perfect trash detection system.

2.5 Challenges

Challenges of the models: In my thesis project "Trash detection system" using YOLO v5 and YOLO v6 has several amounts of challenges throughout its execution time as well as all the challenges are highlighted in the below:

- Quality of training data: Plentiful and disequilibrium training data can lead to poor model results. Background, condition of light can affect the model's judgement.
- Size and speed of the model: Larger and more correct models need more or complex resources and that is the reason the models are getting slow or slower inference time as well as imposing a limitation real-life application.
- Adjusting and Transferring Knowledge: In this case YOLO models have specific domains as well as some novel classes which may create a very tough challenge when dealing with limited annotated data.
- Detection of small object: We know that YOLO models are too good to deal with big objects but in the case of small objects the performance is not so good.
- Object detection of multi-scale: In terms of effective detection across a wide range of scales and size of objects may occur a challenge for the YOLO models.
- Deployment of real world: YOLO model is dealing with real-time data as a result some deployment challenges occur like hardware challenges as well as power consumption and compatibilities.
- Maintenances and updates: The latest or up-to-date version of the model arise some issue over time in the ongoing work.

Perfect planning, best method choice can easily overcome the above challenges and contribute to correct and reliable results in the specific work filed.

CHAPTER 3

Research Methodology

3.1 Introduction

Distinct types of trash are present in our area but although it is difficult to deal with all the trash, we have tried to deal with some specific types of trash. One of them is plastic trash, food trash, leather trash, metals trash, ashes trash, paper trash. Moreover, in this case, we will be able to divide the trash into various categories by using images. The first essential element needed for our detection system is data and these data we collected from physical environment for our next work. We have outlined all the stages of our work here and we have divided our stage of work into different steps so that it is possible to complete our tasks very easily. Included in this are the data collection, preprocessing, training, testing, description of the suggested model, and, in the end, performance evaluation. The overview or the job flow broken down in the figure number 3.1:

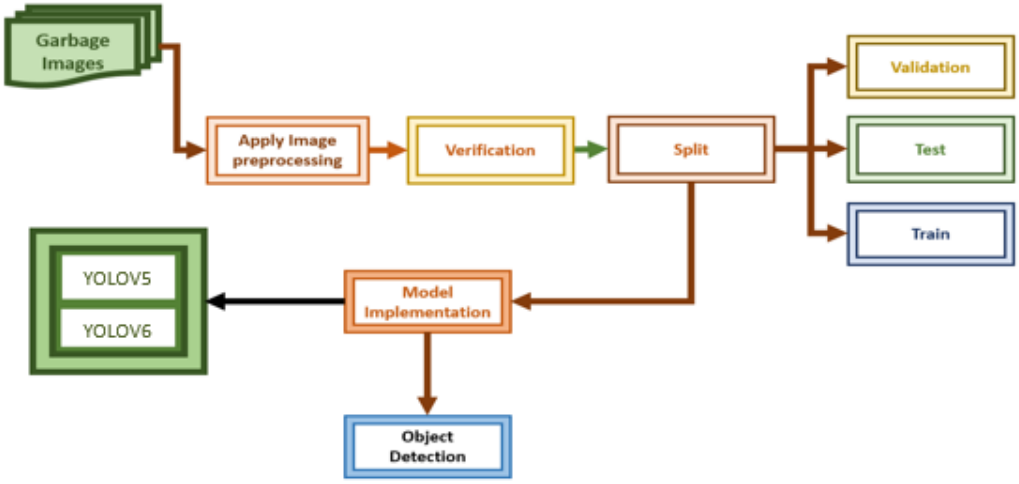

Figure 3.1: Overview of the whole study

3.2 Data Collection

In this case, we have selected the trashes that are most abundant in our neighborhood and will be very easy to use for our system. In this case we have collected pictures of trashes through our mobile phones and stored the pictures by uploading them to Google Drive.

3.3 Data Selection

In this case we have selected plastic trash, food trash, leather trash, metals trash, ashes trash, paper trash. The main reason is that these trashes are around us in abundance and we can easily collect them and use our trash detection system to get a good result. On the other hand, if we select such trash that it will be difficult for us to collect images, then our system will not be able to work properly because there is not enough data for our system. So, it is wise to take data that is easily available. The below table number 3.1:

Table 3.1: Illustration of dataset parameter

Classes	Illustration
leather trash	This column mainly covers almost all types of leather related stuff. We get leather trash very easily in and around our house and leather trash collection is comparatively easier than other trash collection.
metals trash	All types of metals trash are basically included in this column. There are some new big buildings coming up in our area and basically, we collected the metals trash from those places. Moreover, we have been able to collect different types of metals trash from nearest working places.
food trash	This column mainly highlights the types of trash that are used or generated in local food stores. In particular, the unused parts of various types of leftover fruits and vegetables are basically included in this.
ashes trash	Through this column we have mainly included the trashes that are generated by burning woods and many others stuff. Basically

	we have collected the ashes trashes physically from nearest working places.
paper trash	In this column we mainly describe the characteristics of paper related trash. In paper related trash we include newspapers, books, notebooks and other paper like items.
plastic trash	This column mainly highlights the characteristics of all plastic trash. In terms of plastic trash, we mainly take various water bottles and various plastic boxes used in homes, industries as well as many stores, besides various plastic-wrapped items.

The dataset includes columns that help us classify and find diverse types of trash, including plastic trash, food trash, leather trash, metals trash, ashes trash, paper trash making it precious for trash management and environmental inspection.

3.4 Data Labeling

First, we collected all the data physically and put each data into its distinct categories. We basically created six classes and divided the data under these six classes. Each picture or data we included in diverse groups one by one depending on the characteristic. Leveling the data is particularly important to work with the data properly and for leveling we have used an AI, and its name is Make Sense AI. One of the important advantages of Make Sense AI is that we don't need to print the name of the label repeatedly for leveling, once the name is given, it automatically becomes the name of the level in every case. Moreover, one of the important points is that through this make sense AI, it is possible to easily level how much part of an object we want to label.

3.5 Apply Image Preprocessing Techniques

Image processing technique: A variety of perspectives are used to adapt and improve digital images under the heading of image processing ability. These methods can entail adjustments to the contrast as well as image sharpening, and noise reduction to intensify the visual quality or extract precious information. In several domains, including computer

vision as well as satellite imagery analysis, and medical imaging, image processing is mandatory for tasks like diagnosis, remote sensing, and object recognition. We are doing apply image enhancement (contrast & brightness adjustment) & gaussian filter technique (gaussian noise) for our work purpose. Briefly discussed below:

- **Image enhancement (contrast & brightness adjustment):** Image enhancement: Image enhancement is an especially major step. The reason is that when we collect the images, the images may have various problems. Basically, image enhancement is done to increase the visual quality of the image, and in this case, the visual quality of the image is basically increased by noise reduction and enhancing the details. Contrast coordination or adjustment is the act of upgrading the visual contrast in the middle of the lightest and darkest areas of the image. To get a clearer as well as informative image this process helps us a lot.
- **Gaussian filter technique (gaussian noise):** Gaussian Filtering (gaussian Noise): Gaussian filtering is particularly useful when we are trying to work out the overall structure of an image or any image. The reason is that through Gaussian filtering we can minimize the noise in our image and support the image details very easily. Moreover, any image can be easily smoothed through it and preserving the crucial details of the image. Moreover, by using it, the unwanted artifacts or blur parts in the image can be reduced very easily.

The output of the above two techniques are given below in the figure number 3.2:

Before Image

After Image

Before Image

After Image

Before Image

After Image

Before Image

After Image

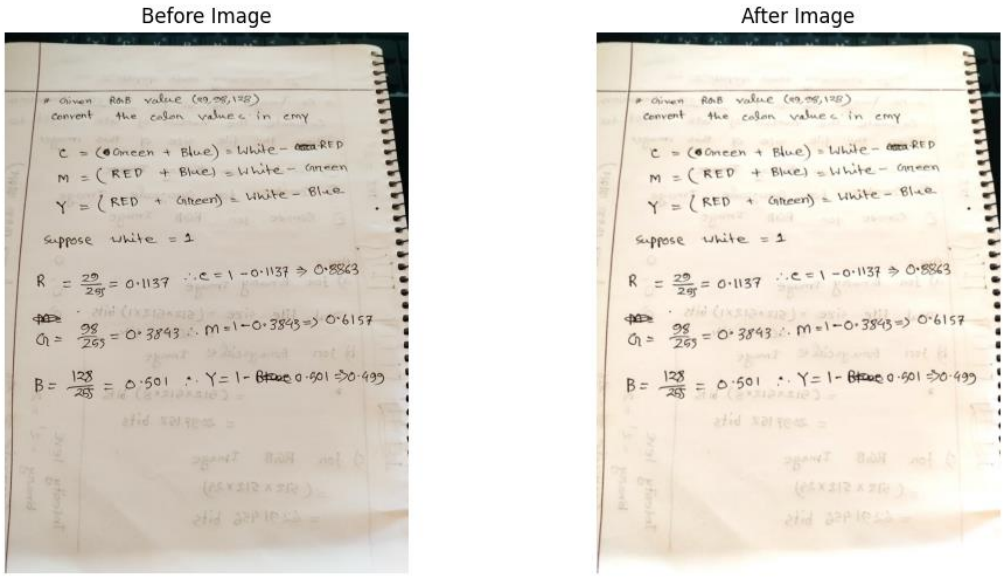

Figure 3.2: Applying image preprocessing techniques.

3.6 Verification

Verification is particularly important in the field of image processing to make sure that the accuracy and authenticity of the results are gained from several types of algorithms as well as processes. In fields such as medical imaging as well as surveillance, and computer vision, verification confirms that the expelled information is virtuous, mitigating the threat of misinterpretation or wrong conclusions.

- **SSIM:** Comparing two images, the structural similarity index (SSIM) assigns a value between -1 and 1, with 1 standing for the greatest conceivable similarity. The SSIM method is predicated on luminosity, contrast, and structural similarity.
- **RMSE:** The RMSE score is the Root Mean Squared Error between two images in image processing. The difference between two images can be figured out, in part, by dividing the mean of the squared pixel differences by one.
- **MSCE:** Mean squared error (MSCE) is a way to assess the average squared difference between two photographs. To get it, add up all the disparities in the two images' pixel counts and then multiply that sum by the total squared difference. When the MSE score is lower, it means the two images are more like one another.

The following values were obtained for a random sample of 6 trash pictures as well as one picture from every class. The value is representing in the below table number 3.2:

Table 3.2: Show the values of verification techniques.

Classes	SSIM	RMSE	MSCE
leather trash	0.94	0.095	0.0023
metals trash	0.95	0.11	0.0011
food trash	0.96	0.11	0.0004
ashes trash	0.72	0.13	0.0072
paper trash	0.91	0.159	0.0022
plastic trash	0.81	0.067	0.0019

3.7 Data Split

In this case we divided the data set into three parts. First part is train set, second part is test set and third part is validation. In this case we have taken 70% data in train set and 20% data for test set and remaining 10% data for validation.

- **Train:** In image processing or any type of machine learning, we first must train the model for a particular task. That's why we need a data set of a certain size that has a level of edge and with which we can feed our model. The train is an especially important part of any system or model. Moreover, we use it for accuracy as well as speed, robustness and scalability.
- **Test:** After training a model, we check how perfectly that model is working or how accurately the model is able to output through tests. In this case, we basically test the model using our 20 percent data. Moreover, we use it for Precision, Recall as well as Accuracy and f1 score
- **Validation:** When we train our model there is a chance of over fitting and we mainly use validation to avoid that over fitting. Moreover, by using validation, we can calculate how much new data the model can generate after training.

3.8 Proposed Model

In this study, one of the reasons we mainly used the YOLO model(YOLO v5 and YOLO v6) is that we have to work with relatively large objects in the case of trash detection, and the YOLO model works relatively well in the case of large object detection, which is why we mainly select the YOLO model.

3.8.1 YOLOV5

YOLOv5 (You Only Look Once v5) The YOLO V5 model is extremely popular in current image detection and has made great progress in the image processing sector. Moreover, one of the reasons why it is so popular is its excellent speed, perfect accuracy and ease of use that make this model popular for various applications. Now let's discuss some important points of this model.

- **Real-time entity Detection:** One of the important aspects of YOLO V5 model is its inference speed and its image processing speed is amazingly fast. Moreover, it can process any image within milliseconds, making it perfect for real-time applications. The reason is that real time applications deal with real time data where processing speed plays a particularly significant role like in autonomous vehicles as well as robotics, and video surveillance.
- **Superior Accuracy:** One of the biggest differentiators of this YOLO V5 model from its current competitors is its impressive accuracy that sets this model ahead of other competitors. This model can find any object in any complex environment.
- **Ease of Use:** The YOLOv5 software was developed with the user experience in mind. Because it is built on the PyTorch framework, it is suitable for developers of varying levels of ability, and there is a wealth of documentation and tutorials available on the internet.
- **Open-source and Community-driven:** YOLOv5 is a project that is open-source and has a lively community of developers and researchers that are continually supplying new features and improvements. By doing so, the model is guaranteed to remain at the forefront of the latest breakthroughs in image processing.

YOLOv5 is not only used for object detection but also it can be used in other purposes. It can also perform:

- **Classification of Image:** Appoint the universal content of an image.
- **Case in point segmentation:** Showing as well as marking off individual objects within an image.
- **Panoptic segmentation:** Object detection and instance segmentation are combined in order to achieve a more comprehensive grasp of the scene.

These added functionalities make YOLOv5 more flexible as well as valuable for distinct types of image processing tasks. YOLOv5 stands as a notable change in the realm of image processing just because of its speed, accuracy as well as easy to use, and adaptability make it a powerful tool for developers and researchers.

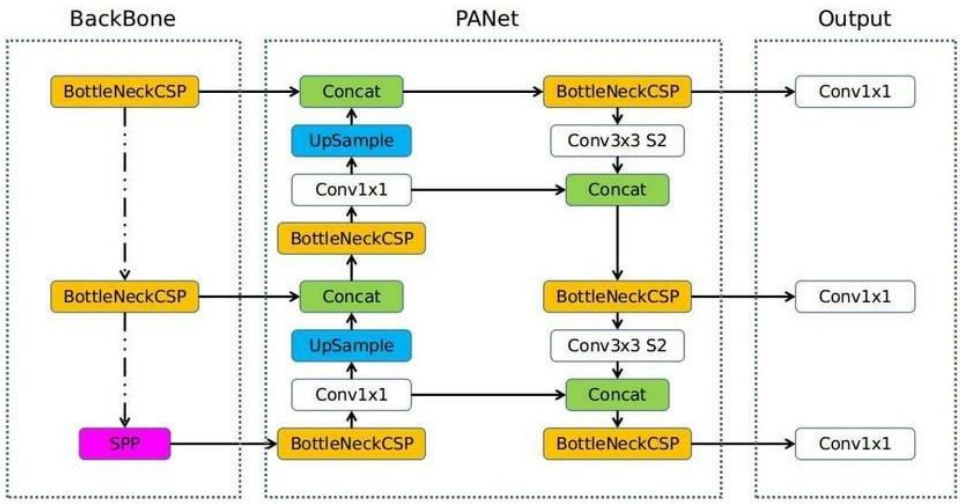

Figure 3.3: YOLOV5 Model Architecture.

3.8.2 YOLOV6

YOLOv6 although not an official continuation of the YOLO series has emerged as a competitor, in the field of object detection. Despite being relatively new it showcases some advancements compared to its predecessors:

- **Improved Speed:** In comparison to YOLOv5 YOLOv6 offers accuracy while maintaining speed during inference. This is achieved through the use of the EfficientNet L2 architecture, which is known for its efficiency and lightweight design.

- **Designed for Efficient Hardware Utilization:** YOLOv6 prioritizes utilization of resources making it well suited for deployment on devices with computational power such as embedded systems and mobile phones. This opens up possibilities for real time object detection in scenarios where resources are constrained.
- **Tailored for Industrial Applications:** The design of YOLOv6 focuses on applications in settings. As a result it performs better when dealing with images that have clutter, resolution and challenging lighting conditions often found in environments.
- **Emphasis on Objects**: YOLOv6 incorporates features specifically crafted to handle objects of varying sizes within an image. This enhances its capability to accurately detect both screws and large factory machinery.
- **Open source and Community driven:** Similar to YOLOv5 YOLOv6 is an open source project driven by a growing community.

This guarantees a progression and enhancements which're advantageous, for both researchers and developers.

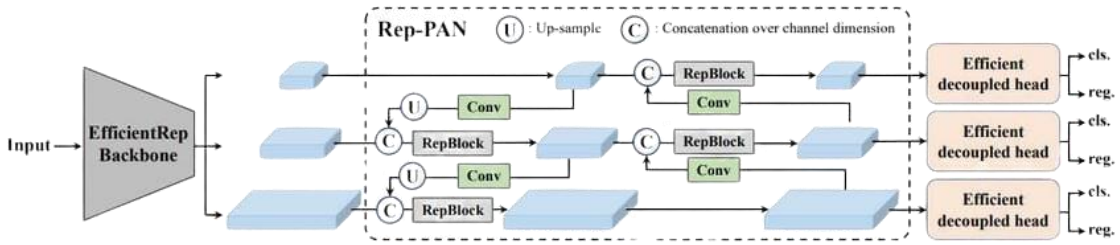

Figure 3.4: YOLOV6 Model Architecture.

CHAPTER 4

Experimental results and discussion

4.1 Introduction

A thorough evaluation of the provided model's implementation is provided in the result exploration section. It also included the evaluation metrics—accuracy, precision, F1 score, and recall—that were used to determine the model's performance. In order to evaluate the model's effectiveness in precisely finding each class, the impact on its execution is also emphasized, in addition to the confusion matrix. In order to determine which model is better, the performance of the proposed model is also contrasted with that of another model.

4.2 Evaluation Metrics

The outcome analysis investigates each of the two models' accomplishment instructions. The optimal model is selected based on its performance analysis, which considers recall, F1 score, accuracy, and other pertinent factors. This comprehensive review can help identify the best trash identification model and provide insights into its overall performance. The optimal model was selected by precision, recall, and F1-score. Models are found with respect to precision, recall, F1-score, and confusion matrices. . Below the equation for this:

$$\text{Recall} = \frac{\text{TP}}{\text{TP+FN}}$$

$$\text{Precision} = \frac{\text{TP}}{\text{TP+FP}}$$

$$\text{F1 score} = \frac{2 \times \text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

4.3 Result and Analysis

Table 4.1 adorned the two models' training accuracy and loss.

Table 4.1: Train result.

Models	trainAcc	train box loss	train obj_loss	train cls_loss
YOLOV5	62%	0.03	0.02	0.006
YOLOV6	63%	0.36	0	1.075

In the above table 4.1 we see that, in terms of accuracy YOLO V6 has the best ratio, and it was exactly 63% but on the other hand in YOLO V5 it was exactly 62%. In case of accuracy YOLO V6 supplied me with the best accuracy rate. In terms of train_box_lose, YOLO V5 has a minimal amount around 0.03 while in YOLO V6 it was around 0.36. It means that the train_box_lose is higher in YOLO V6 compared to YOLO V5. Now in case of train_obj_lose YOLO V6 has exactly 0 where in YOLO V5 it was 0.02. That means that in train_obj_lose YOLO V6 supplied me the minimal result. In terms of train_cls_lose YOLO v5 has a low amount of it and it was 0.006 but in YOLO V6 it was 1.075 which means that train_cls_lose is slightly higher in YOLO V6.

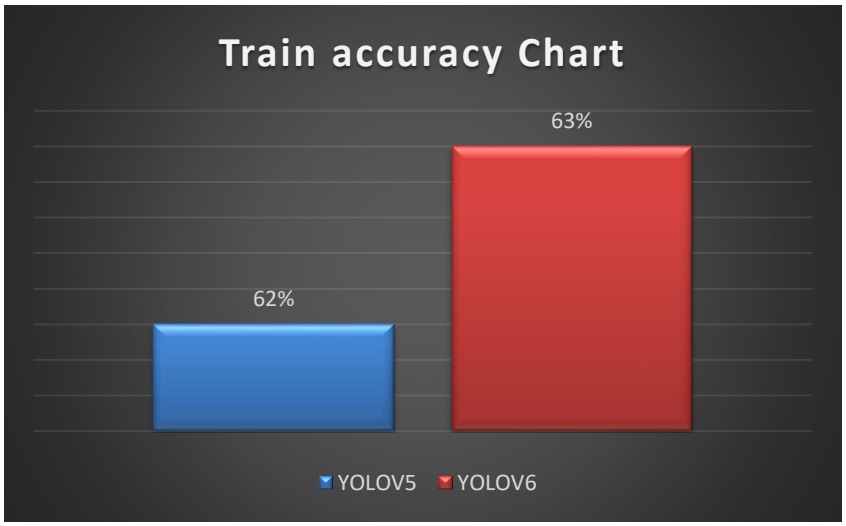

Figure 4.1: Train accuracy Chart of yolov6 and yolov5.

In this part I will compare YOLO V5 with YOLO V6 using some random pictures. Mainly all the pictures are taken randomly for the comparison. We see that in terms of ashes, the accuracy was 68% in YOLO V5 model but in YOLO V6 it was 84%. On the other hand, in YOLO V6 the accuracy was 90% in class of food but in YOLO V5 it was 72%. In the

field of plastic, the accuracy was 92% in the model of YOLO V5 but in YOLO V6 it was 85%. In the case of paper, the accuracy was 82% in YOLO V6 but in YOLO V5 it was 83%. The accuracy was 90% in the class of leather using YOLO V6 model but in YOLO V5 it was only 66%. In terms of metal the accuracy was 52% in the YOLO V5 but in YOLO V6 it was 84%.

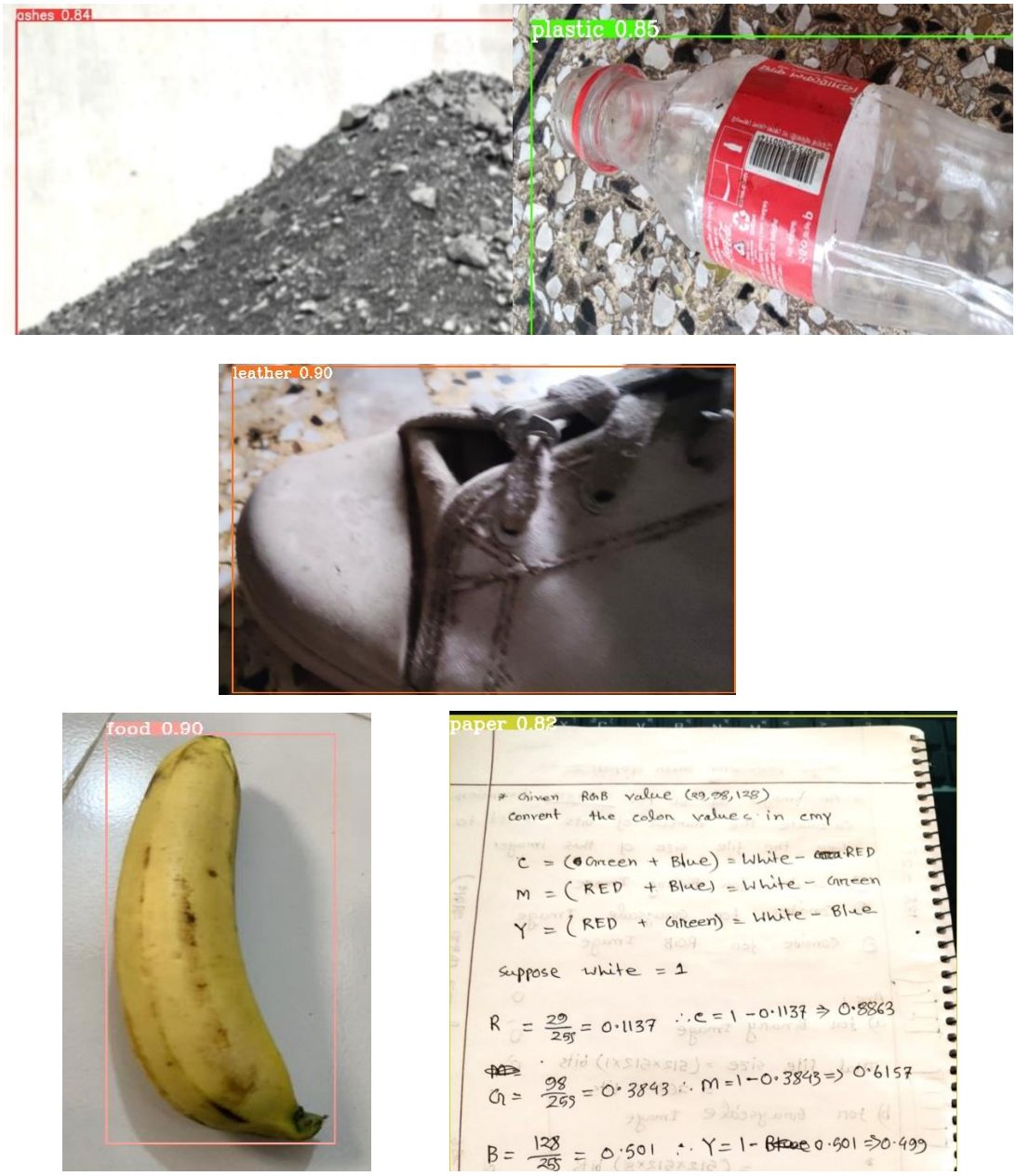

Figure 4.2: Test images for YOLOV6.

4.4 Performance analysis

In the below table 4.2 we highlight the Precision value as well as Recall and F1 score by which I can compare the both models:

Table 4.2: Performance analysis.

Models	Precision	Recall	F1 Score
YOLOV5	1.0	0.76	0.64
YOLOV6	0.63	0.63	0.51

In trash detection we used two models. These models are YOLO V5 as well as YOLO V6. Among them we see that YOLO V5 has the better precision value as well as Recall value and F1 score. That is the reason YOLO V5 is better here. But my focus or my system target is to detect trash perfectly. So, in this case we see that in figure 4.2 and table number 4.1 that the YOLO V6 model captures or detects the trash perfectly and the detection rate or accuracy rate is better than YOLO V5. Lastly, according to my requirements I can easily say that YOLO V6 is the perfect model for my trash detection system.

CHAPTER 5
Impact on Society, Environment & Sustainability

5.1 Impact on Society

Trash detection play an especially significant role in our society and exact detection has many positive effects as well as all the effects are highlighted in the below;

- **Security of food and Agriculture:** With proper trash detection, anyone can keep any type of trash in a specific place. Through which the soil will not lose its fertility and as a result the farmer will be able to do agricultural work properly and will be able to produce better- and better-quality crops. Because we know that trash destroys soil fertility, by safely storing trash, soil fertility will be fine and good production will be possible.
- **Preparedness for Natural Disaster:** We know that the temperature of our world is constantly increasing and one of the reasons for that is plastic. When plastic is burned, various chemicals mix with the air and heat our atmosphere. As a result, distinct types of natural disasters occur at contrasting times. Due to rising temperatures, large areas of ice are melting, and many low-lying areas are sinking due to this. So, if we separate the plastics properly, it will be possible to recycle them in other ways which will be of great benefit to our environment and our trees.
- **Management of water resources:** We throw distinct types of trash into water or river at various times. As a result, diverse types of trash mixed with water destroy the nutrients and purity of water. Which can be very scary for people because water is an essential thing for people. Especially in rural areas, various big factories dump their trash around the river or in the river, due to which the river flow is sometimes obstructed, and the river dries up. One of them is plastic that never completely mixes with the soil and as a result it creates various problems, so anyone can keep the environment right by separating plastics or harmful trash very easily through trash detection.
- **Energy Planning and Management:** Through the trash detection system, we can easily detect unused items and we can easily understand which trash can be recycled

and which cannot. Through this, we will be able to reuse the trash that can be recycled, which will either improve our financial situation or act as a financial help for a company. On the other hand, trash that cannot be recycled can be converted into energy by processing it in an alternative way and can be used for various purposes.

- **Safety and Health:** We know that when trash is burned or stored in a place, diverse types of bacteria or several types of gases mix with the air and produce various harmful gases. Which is extremely dangerous for the human body. When people ingest such gases, various diseases or breathing problems may develop. So, this trash must be recycled in a proper place or trash in a proper manner. That's why anyone will be able to properly detect any type of garbage through a trash detection system and as a result our oxygen will be pure and incredibly good for the human body.

5.2 Impact on Environment

My thesis project on "trash detection system" has a significant impact or has a positive impact on our environment. The positive key aspects are given below;

- **Enhanced ability in recycling:** Through garbage detection, we can detect any type of garbage very accurately. As a result, we can reduce the amount of garbage by recycling the garbage that can be recycled from the environment and increase the ratio of reciting day by day.
- **Landfill waste decreased:** The amount of trash in our society is constantly increasing and people are storing the trash in unusual ways without realizing it. They are harming us in many ways, but we can use this trash in separate ways for our different purposes. Through the trash detection System, we will be able to divide the trash into distinct categories and by which we are able to reduce the amount of trash from our landfill and make the environment greener.
- **Preserve the resource:** One of the major components of trash is plastic. We know that plastic never completely mixes with soil. In this case we will be able to separate the plastics very easily using trash detection System and it will be possible to reuse

these plastics. We know that companies are improving their finances by cleaning plastic bottles through different processes and reusing them.

Finally, we can say that trash detection using image processing is an exceptionally good step and through this we can keep our environment clean. But in this case, we must work very consciously so that the amount of negative impact is extraordinarily little and there is no disruption in our work.

5.3 Ethical Aspects

Currently the most important thing in the field of research is data and by using this data we are performing all types of research properly. One of the key components of a trash detection system is our data. In this case, we have not collected any type of used data or any type of data from Google, each data has been collected from separate places through our own efforts, because of which it can be said that our data is the original data. When something is detected in garbage detection, we must take care of some ethics. In this case, the main moral is that our collected data should not be accessed or used by anyone else in any way, so that our collected data should be kept in maximum safety and our work should be carried forward. In trash detection, we have used different models and based on these models the system is able to detect garbage perfectly. Also, one of our biggest morals is that the models we use in our system work properly. Otherwise, our system will not be able to detect trash properly. As a result, the output in our system will not be correct, it can cause various problems and the system will fail. To ensure that the models are impartial, fair, and applicable to a variety of garbage groups, it is critical to identify and mitigate any potential bias. In addition, one of our primary responsibilities is to ensure that, from the time of system development, it is continuously targeted and maintained to prevent the emergence of any bugs or issues. The problem may have an impact on our system's output, which is the reason. Therefore, you can fix every issue with the system if you perform maintenance on it twice a week.

5.4 Sustainability Plan

A sustainability plan outlines tactics and actions to assure that a project or research endeavor spreads long-term environmental as well as social, and economic sustainability. Some key elements of a sustainability plan are highlighted below:

- **Preservation of the environment:** performance exercise that mitigates negative influence on the environment. This includes mitigating power consumption as well as promoting trash reduction and recycling and taking up sustainable resource management exercise.
- **Social Liability:** We aim to make the system very user friendly and allow the community or all types of people to engage with it. One of the aspects is that it helps the local community and does not go against any culture and can properly support the safety of all stakeholders.
- **Viability of economic:** We aim to ensure that our Trash Detection System has long-term performance and is cost-effective. Moreover, we must make sure that others are involved with this system, that is, we can easily get funding or collaborate with big companies.
- **Observation and assessment:** To keep our system sustainable we always need to check it and keep track of its performance so that our system performance does not degrade in any way. Aiming at that, we must always try to improve it so that it can always carry out our or the user's goals.
- **Always update the system**: We must always push updates to our system to keep our system as sustainable as possible. The reason is that everything is constantly being updated and things work better when they are updated. For which we need to keep our trash detection system updated. If we notice one thing, we can see that Apple company always update all their types of phones due to which there is no deficiency in their performance. So, I can say that to support the proper performance it should be updated all the time.

CHAPTER 6

Summary, Conclusion, Recommendation and Implication for future Research

6.1 Summary of the Study

My research project targets “trash detection system” using YOLO model as well as specifically YOLO V5 and YOLO V6. In this part of my report, I will mainly try my best to present the conclusion of my research project and what I think about this research project in the future. Moreover, during working on this research project, I have faced many limitations which I have considered as my future work, and I will try to solve these limitations in the future. My research project will make my system more efficient by solving its limitations.

6.2 Conclusion

The amount of trash in our modern age is increasing day by day which can be extremely dangerous for people and our environment. Basically, through a trash detection system, we can detect these trusts very easily and by including them in separate categories, we can reduce their harmful effects on people and the environment through various processes. For my system i basically use two models and the two models are YOLO V5 and YOLO V6. There are many reasons why YOLO models are working very well but in the field of image processing the YOLO model has a tremendous success rate. The YOLO model can deal with real-time data which makes this model more powerful. In this system we see many times that YOLO V5 works good in different areas but on the other hand YOLO V6 also works marvelously in many regions. There are several types of drawbacks available of these two models, but my system target is to detect any trash perfectly where the YOLO V6 works smoothly and precisely. SO, at the end I want to say that the touch of technology makes everything extremely easy for us and we can use them for any kind of purpose. So, everyone should use these types of technology in the service of humans and the environment.

6.3 Implication for Further Study

Trash detection is an especially essential and environmentally beneficial task. Because to protect our environment, our goal is to drop the types of trash in our environment. In fact, our trash Detection System is basically able to detect the unused items in the environment under which trash or in which category it will fall. But my next goal is that I will also try to figure out which trash can be recycled, and which trash cannot be recycled through this trash detection system. In addition, I will be able to measure what type of chemical is emitted from the type of trash as well as which type of gases emitted after burning them and what effect that chemical has on the environment. Moreover, I have another big goal which is that I will collaborate with big companies so that they do not allow their trash to meet the environment and when their trash is produced, they use this trash detection system to separate them in the starting as well as they can easily handle the trash and use them once again in their own purpose to generate energy or any other things. I also try to increase the train accuracy rate by using more pre-processing techniques by which I can easily make my images better than running stage and also set all the pictures in a fixed format.

Appendix

We get complete details of how we collected the data for this research and in which method we collected it through the appendix.

- **Source of data:** In this case I get data from my area and Dhanmondi. I collect all the data locally and use my own phone for the data collection.
- **Data choice:** We have selected the data which are easily available in our environment and which we can easily use for work, for example plastic, leather, food, ashes, paper as well as metals trash.
- **Classes:** In this case we have assumed six classes and worked our system accordingly the six classes are plastic, leather, food, ashes, paper as well as metals trash.
- **Check the data quality:** In this case, the quality of our data must be exceptionally good because if the quality of the data is bad then the output of our system will not be good. In this case, we have improved the quality of the data through various processes and will be able to bring good output by using the data.
- **Data Preprocessing:** We need to preprocess the collected data before analysis. In this case, we can do preprocessing in separate ways, one of them is removing outliers or errors, handling missing values and formatting the data into a structured format to process it for the next step.
- **Transform the data:** For data transformation we basically depend on our system requirements and what kind of model we use.
- **Data Documentation:** Throughout the data gathering process, broad-based documentation is kept up to date. This documentation engulfs details about the data source, classes, preprocessing footfall, as well as any transformations that have been applied. Transparency and reproducibility of the research are guaranteed by this indenture.
- **Confidentiality and protection of the data:** In this case, we must keep the collected data perfectly private so that no one else can use our collected data for

their own purposes. That's why we must save our collected data in protected Google Drive.

The data gathering method outlined in this appendix gives the surety that the acquisition of reliable and pertinent data for the analysis of the trash detection management. It ensures ethical considerations as well as emphasizes the significance of the data quality, integrity, as well as privacy.

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