GOVERNMENT COLLEGE OF ENGINEERING[IRTT]

ERODE :: 638 316 Computer Science and Engineering

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PROJECT DOMAIN: ARITIFICIAL INTELLIGENCE

PROJECT TITLE: INTELLIGENT GARBAGE CLASSIFICATION USING DEEP LEARNING

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BONAFIDE CERTIFICATE

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ABSTRACT

Intelligent garbage classification plays a crucial role in promoting sustainable waste management and reducing environmental impact. Traditional waste sorting methods often suffer from inefficiencies and inaccuracies, leading to suboptimal recycling and disposal practices. In recent years, deep learning techniques have emerged as a promising approach to automate and improve the accuracy of garbage classification. This abstract presents a comprehensive overview of an intelligent garbage classification system based on deep learning.

The proposed system leverages convolutional neural networks (CNNs) to extract meaningful features and model temporal dependencies from garbage images and data. A large-scale dataset comprising diverse garbage samples is collected and used to train the deep learning models, allowing them to learn intricate patterns and make accurate predictions.

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CHAPTER 1

INTRODUCTION

1.1 Project Overview

Garbage classification plays a crucial role in waste management and environmental sustainability. Traditional methods of garbage sorting can be time consuming and error-prone, which has led to the exploration of automated solutions. Deep learning, a subfield of machine learning, has shown great potential in addressing this challenge by leveraging artificial neural networks to classify garbage items accurately.

The process of garbage classification using deep learning typically involves several steps:

1. **Data collection**: A diverse and representative dataset of garbage items is collected. This dataset should encompass various classes of waste, such as paper, plastic, glass, metal, organic waste, and so on. It is essential to have a well-labelled dataset, where each garbage item is associated with its corresponding class label.
2. **Data pre-processing**: The collected dataset undergoes pre-processing to ensure its quality and suitability for training a deep learning model. This step may involve resizing images, normalizing pixel values, removing noise, and performing data augmentation techniques like rotation, flipping, and scaling to increase the diversity of the dataset.
3. **Model architecture selection**: A suitable deep learning model architecture is chosen for garbage classification. Convolutional Neural Networks

(CNNs) are commonly used for image-based classification tasks. CNNs are effective at automatically learning relevant features from images and have been successful in various computer vision applications.

4. **Model training**: The selected deep learning model is trained using the preprocessed dataset. During training, the model learns to map the input garbage images to their respective class labels by adjusting its internal parameters through an optimization process. The model is exposed to the training data in multiple iterations (epochs), gradually improving its performance.
5. **Model evaluation**: Once training is completed, the model is evaluated using a separate validation dataset. The evaluation metrics, such as accuracy, precision, recall, and F1-score, are calculated to assess the model's performance. If the model's performance is not satisfactory, further iterations of training and fine-tuning may be required.
6. **Deployment and inference**: After successful training and evaluation, the trained model is deployed for real-world garbage classification tasks. New garbage items can be fed into the model, and it will predict their respective class labels based on the learned patterns. This allows for automated garbage sorting and facilitates effective waste management practices.

1.2 Purpose

The purpose of intelligent garbage classification using deep learning is to improve waste management and recycling processes. Traditional waste management systems often rely on manual sorting and classification of garbage, which can be time-consuming, labour-intensive, and prone to human error.

Intelligent garbage classification powered by deep learning techniques aims to automate and enhance this process.

Here are some key purposes and benefits of intelligent garbage classification:

1. **Efficient Waste Sorting**: Deep learning algorithms can be trained to accurately classify different types of waste, such as plastic, paper, metal, glass, organic waste, etc. By automatically identifying and categorizing garbage, intelligent systems enable more efficient waste sorting, reducing the need for manual intervention.

2. **Increased Recycling Rates**: Intelligent garbage classification helps improve recycling rates by ensuring that recyclable materials are properly sorted and separated. This allows for more effective recycling processes, minimizing waste that ends up in landfills or incineration facilities.

3. **Resource Recovery**: Deep learning-powered systems can identify valuable materials within the waste stream, such as specific types of plastics or metals, that can be recovered and recycled. By optimizing resource recovery, intelligent garbage classification contributes to a more sustainable and circular economy.

4. **Environmental Conservation**: Effective waste management is crucial for environmental conservation. By accurately classifying and sorting garbage, deep learning systems can reduce environmental pollution caused by improper disposal and encourage responsible waste handling practices.

5. **Cost Reduction**: Intelligent garbage classification can help reduce waste management costs in the long run. By automating the sorting process, it

minimizes the need for manual labour and streamlines waste treatment operations, potentially leading to cost savings for municipalities, recycling facilities, and waste management companies.

6. **Data-driven Insights**: Deep learning-based systems generate valuable data and insights about waste composition, patterns, and trends. This information can be utilized for urban planning, policy-making, and designing more effective waste management strategies.

Overall, the purpose of intelligent garbage classification using deep learning is to enhance waste management practices, increase recycling rates, reduce environmental impact, and promote sustainable resource usage. By leveraging advanced technologies, we can address the challenges associated with waste handling and move towards a more efficient and environmentally friendly waste management ecosystem.

CHAPTER 2 IDEATION & PROPOSED SOLUTION

2.1 Problem Statement Definition

The problem at hand is to develop an intelligent garbage classification system using deep learning techniques. The goal is to accurately categorize different types of waste items, such as organic waste, recyclables, and nonrecyclables, based on visual information obtained from images or video streams. However, several challenges need to be addressed to achieve this objective effectively.

1. **Insufficient Labelled Training Data**: The availability of a comprehensive and accurately labelled dataset is crucial for training deep learning models. The lack of a sufficient amount of diverse and properly annotated garbage samples poses a significant challenge. Obtaining a large-scale dataset that covers various waste categories and different environmental conditions is essential to train a robust model.

2. **Handling Regional Variations**: Garbage classification practices and waste management systems can vary across regions and countries. The model needs to be adaptable to these regional variations and capable of accurately classifying waste items according to the specific guidelines and regulations in each area.

Developing a system that can handle these variations presents a challenge.

3. **Handling Complex and Dynamic Waste Scenarios**: Garbage items can exhibit variations in shape, size, texture, and appearance. Additionally, waste items may be partially damaged, incomplete, or present in cluttered environments.

The intelligent garbage classification system should be able to handle these complex scenarios and accurately classify waste items despite their conditions.

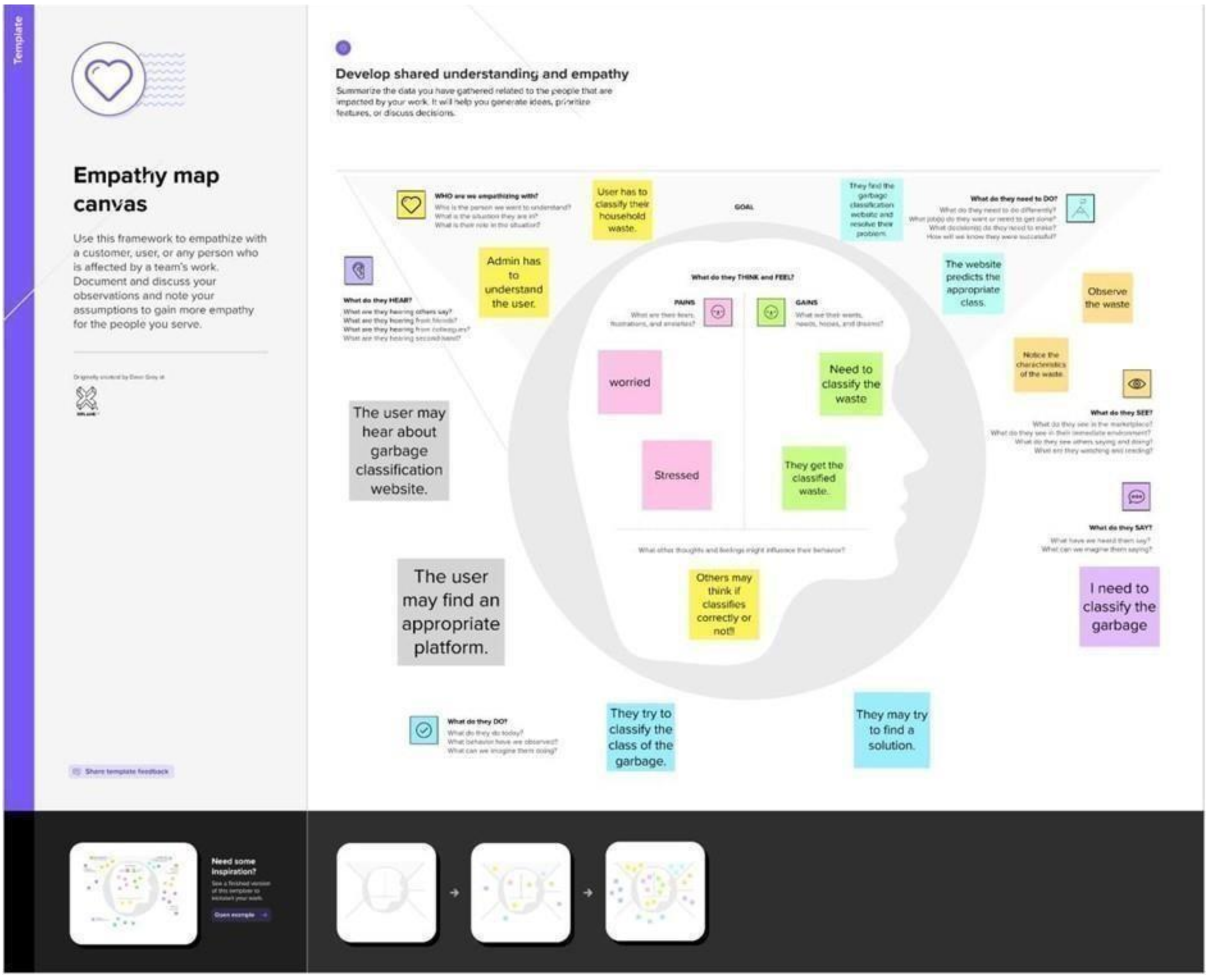
4. **Real-time Implementation**: Deploying deep learning models for intelligent garbage classification in real-time scenarios, such as waste management facilities or on resource-constrained devices, presents computational challenges. The model should have efficient inference speed, low memory requirements, and minimized energy consumption to enable practical and realtime implementation.

5. **Generalization and Scalability**: The developed deep learning model should be capable of generalizing well to unseen waste items and exhibit scalability to accommodate a wide variety of waste materials. The system should be able to handle different waste categories, adapt to new waste types as they emerge, and provide accurate classification results in real-world scenarios.

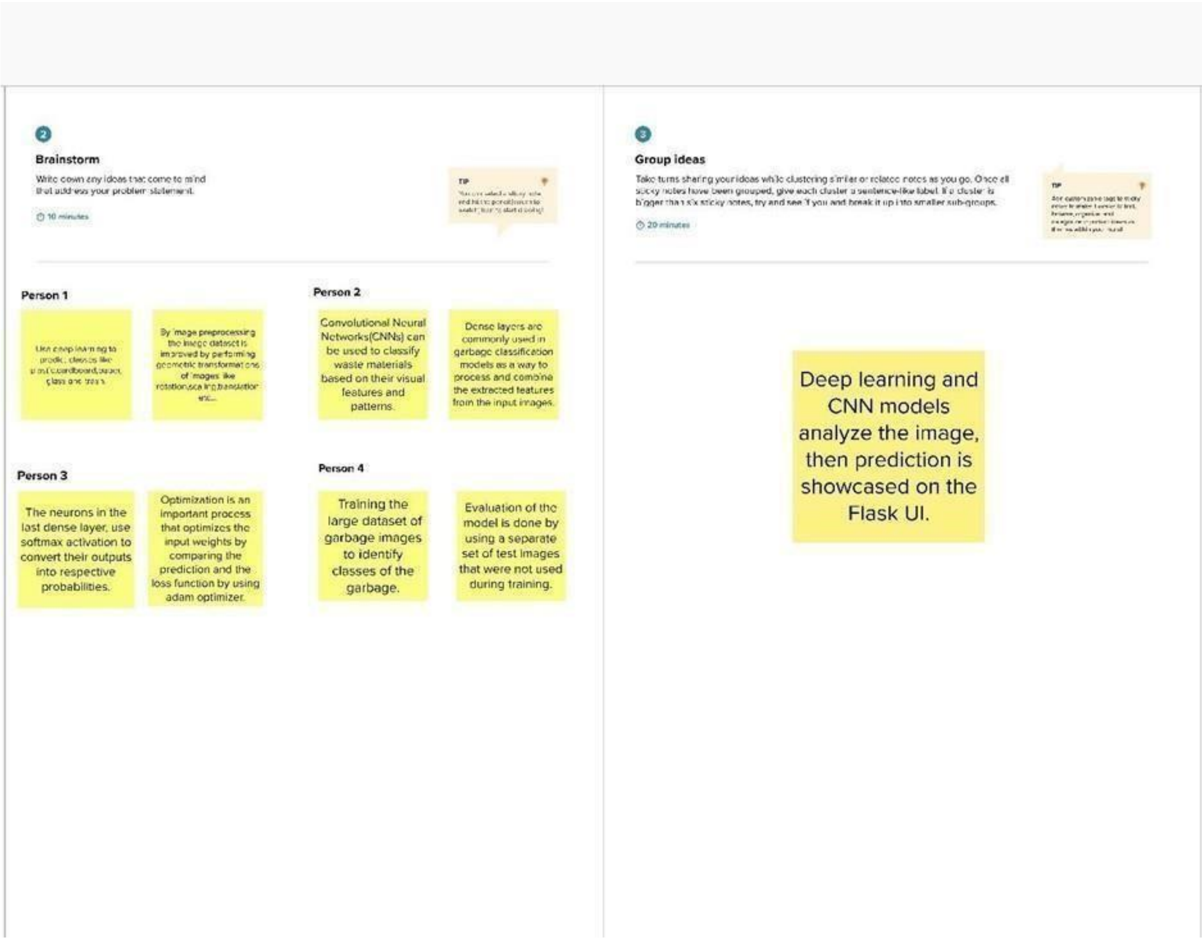
By addressing these challenges, the intelligent garbage classification system can provide an automated and efficient solution for waste management, promoting recycling and proper waste disposal practices, and contributing to environmental sustainability.

2.2 Empathy Map Canvas

Developing a Garbage Classification Prediction Model using Artificial Intelligence



2.3 Ideation and Brainstorming



2.4 Proposed Solution

Here's a proposed solution for implementing an intelligent garbage classification system using deep learning:

1. **Data Collection**: Collect a large dataset of garbage images representing different categories such as paper, plastic, glass, metal, organic waste, etc.

   This dataset should cover various lighting conditions, angles, and backgrounds to make the model robust.

2. **Data Preparation**: Pre-process the collected data by resizing the images to a consistent size, normalizing pixel values, and augmenting the dataset by applying transformations such as rotation, flipping, and scaling. Split the dataset into training, validation, and testing sets.
3. **Model Selection**: Choose a suitable deep learning model architecture for image classification tasks, such as Convolutional Neural Networks (CNNs). Popular CNN architectures like VGG, ResNet, or Inception can be used as a starting point. Consider the trade-off between model complexity and accuracy.
4. **Transfer Learning**: To leverage pre-trained models and accelerate training, use transfer learning. Initialize the selected model with weights from a pre-trained model trained on a large dataset such as ImageNet. Finetune the model to adapt it to the specific garbage classification task using the collected dataset.
5. **Training**: Train the model using the prepared dataset. Implement a suitable optimization algorithm such as Stochastic Gradient Descent (SGD) or Adam, and define an appropriate loss function such as categorical crossentropy. Monitor the training process using the validation set and apply techniques like early stopping to prevent overfitting.
6. **Hyperparameter Tuning**: Experiment with different hyperparameter settings such as learning rate, batch size, and network architecture. Utilize techniques like grid search or Bayesian optimization to find the best combination of hyperparameters for optimal performance.
7. **Evaluation**: Evaluate the trained model using the testing set to measure its performance metrics such as accuracy, precision, recall, and F1-score.

Analyse the confusion matrix to identify any specific challenges or misclassifications.

8. **Deployment**: Once the model achieves satisfactory performance, integrate it into a practical system. Develop an application or API that accepts images of garbage as input and returns the predicted class label. Consider scalability, response time, and user interface design.
9. **Continuous Improvement**: Regularly update the model with new data to improve its performance and adapt to evolving garbage classification requirements. Implement feedback mechanisms to collect user input and incorporate it into the training process.
10. **Public Awareness and Education**: Promote public awareness and educate individuals about proper waste management practices. Encourage participation in waste sorting and recycling programs to support the effectiveness of the intelligent garbage classification system.

CHAPTER 3

REQUIREMENT ANALYSIS

3.1 Functional Requirements

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form Registration through Gmail Registration through LinkedIn
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	User authentication	The system must require users to provide valid credentials (such as user name and password) in order to access certain features or data.
	Data Input and validation	The system must allow users to input data in a specific format (image).
FR-4	Data storage and retrieval	

FR-5	Reporting and output	The system must be able to store and predict the input data in a way that is efficient, secure and reliable.
FR-6		The system must be able to identify the class of the input data (image)

Table 3.1 Functional Requirements

3.2 Non-functional Requirements

FR No.	**Non-Functional Requirement**	**Description**
NFR-1	**Usability**	A system that is easy to use and understand can encourage proper waste disposal practices and improve overall waste management outcomes.
	Security	

NFR-2		The security of the garbage classification system is important to protect the confidentiality, integrity and availability of sensitive information related to waste management activities.
NFR-3	**Reliability**	A reliable system that is well-maintained, has consistent collection schedules and has contingency plans in place can encourage positive waste disposal practices and contribute to more effective waste management outcomes.
NFR-4	**Performance**	A well-designed and well-managed system that is accurate, efficient, costeffective can help to minimize environmental impact, promote
		sustainable waste management practices and improve overall waste management outcomes.
NFR-5	**Availability**	The availability of garbage classification systems is increasing worldwide as more and more people become aware of the environmental benefits of reducing waste and recycling.
	Scalability	

NFR-6		The scalability of garbage classification system will depend on various factors such as the population density, the available infrastructure and the resources allocated to the system.

Table 3.2 Non-Functional Requirements

CHAPTER 4 PROJECT DESIGN

4.1 Data flow Diagrams

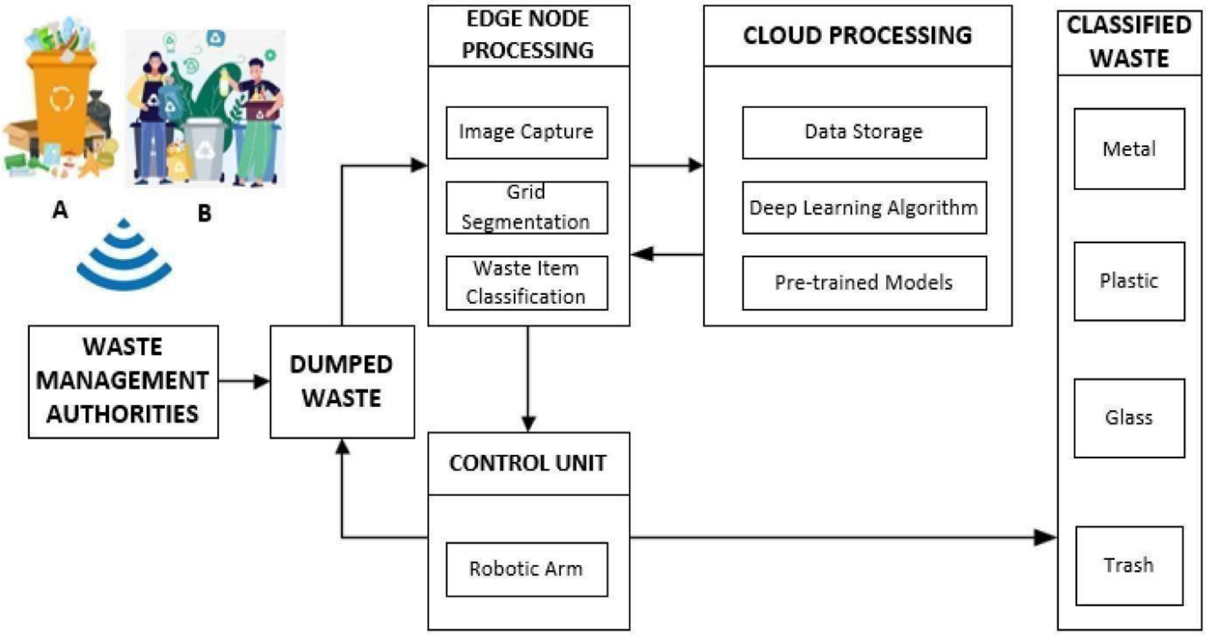
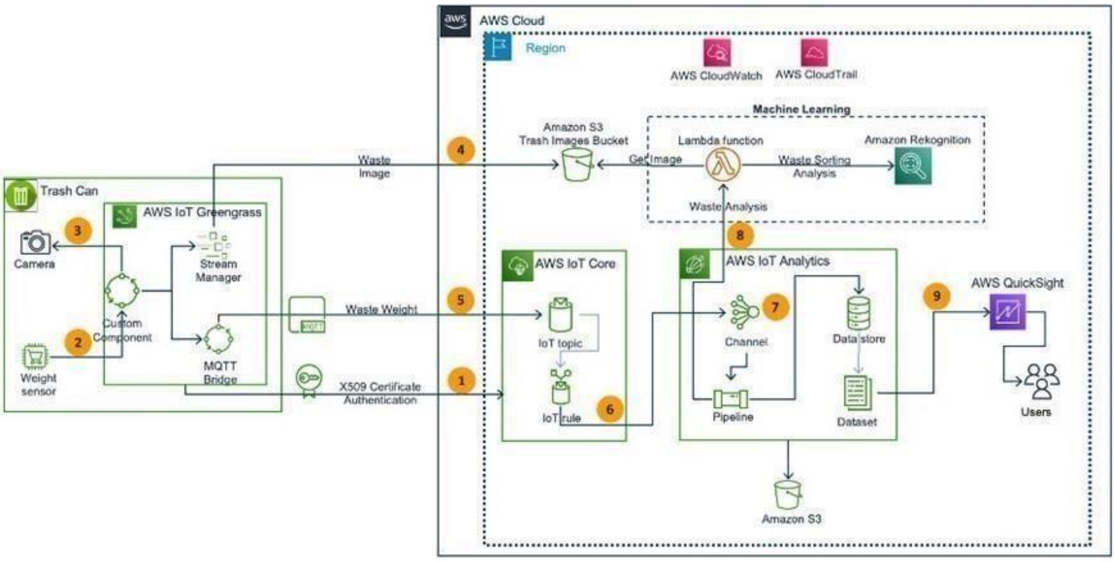


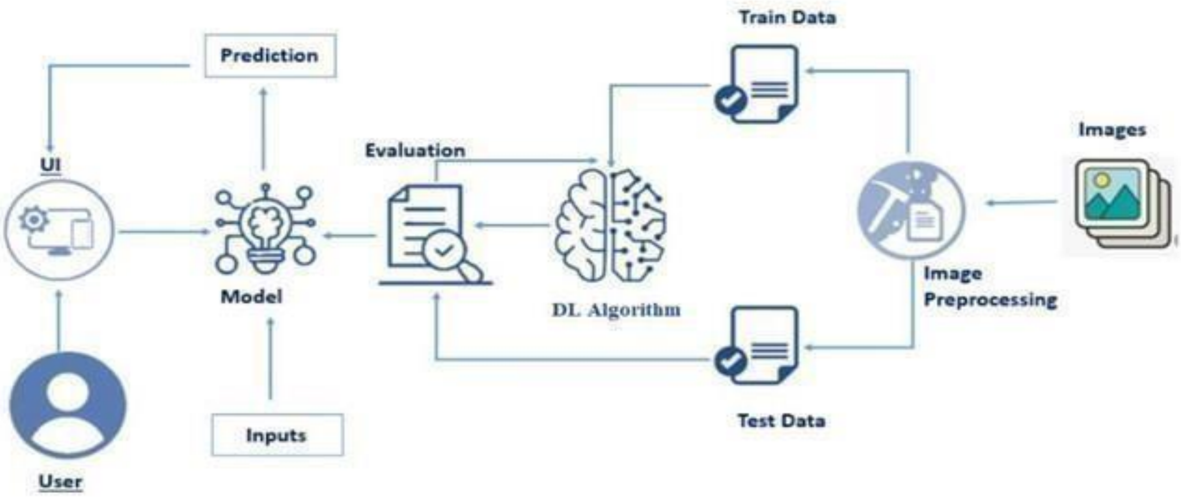
Figure 4.1 Data Flow Diagram

4.2 Solution & Technical Architecture

Solution Architecture:



Technical Architecture:



4.3 User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Team Member
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Gayathiri.T

		USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Harinee.S
		USN-3	As a user, I	I can register &	Low	Sindhumathi .S

			can register for the application through Facebook	access the dashboard with Facebook Login		
		USN-4	As a user, I can register for the application through Gmail	I can register & access the website with gmail	Medium	Subapriya.K

	Login	USN-5	As a user, I can log into the application by entering email & password	I can login to the application by entering the password	High	Gayathiri.T

	Dashboard	USN-6	As a user, I can navigate to home page, about page, contact us page, prediction page,	I can navigate throughout the website	High	Harinee.S
			feedback page.			
Customer (Web user)	Prediction page	USN-7	The user can upload the image of their waste	I can upload all types of images	Medium	Sindhumathi .S

Customer Care Executive	Contact us	USN-8	As a user, I can contact the customer care executives for any queries	I can call the customer care services	Low	Subapriya.K
Administrator	Admin	USN-9	As a admin, I can manage the entire website.	The admin can access the users details.	Medium	Gayathiri.T

CHAPTER 5 CODING AND SOLUTIONING

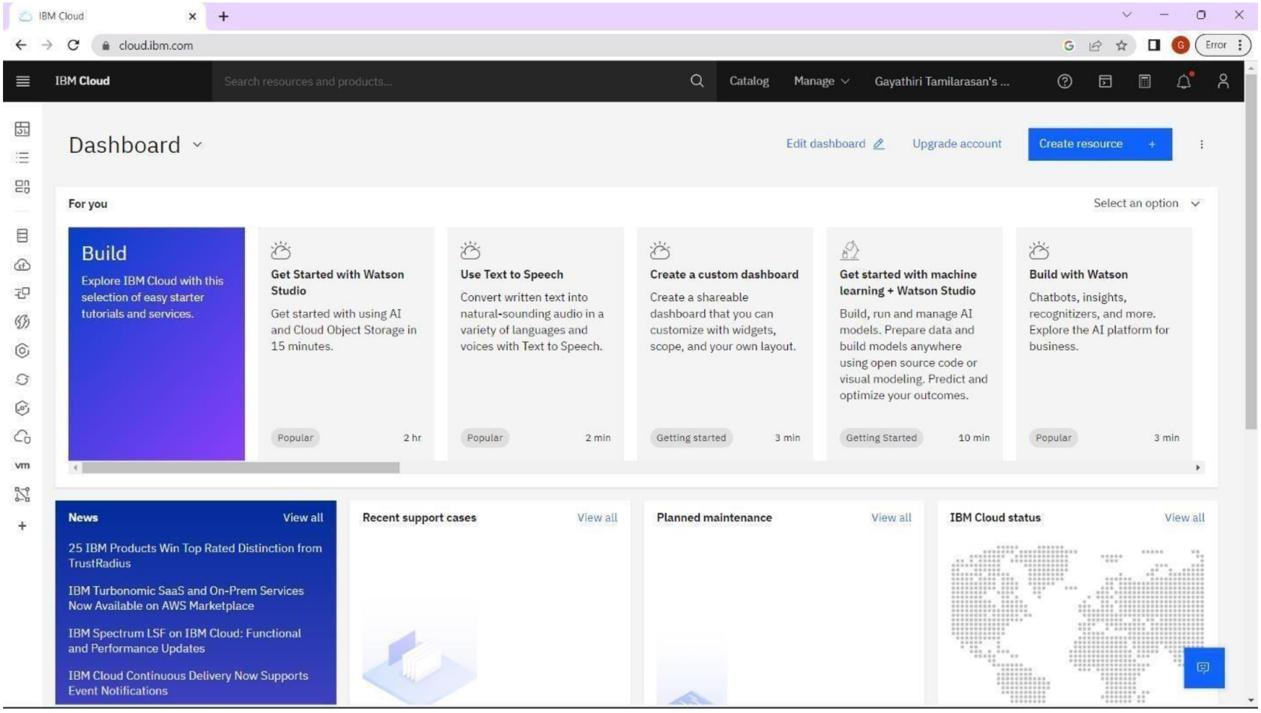
During the Project Development Phase, we have done 2 feature they are Feature 1, Feature 2. In Agile product development, a feature is a set period of time during which specific work has to be completed and made ready for review

5.1 Feature 1

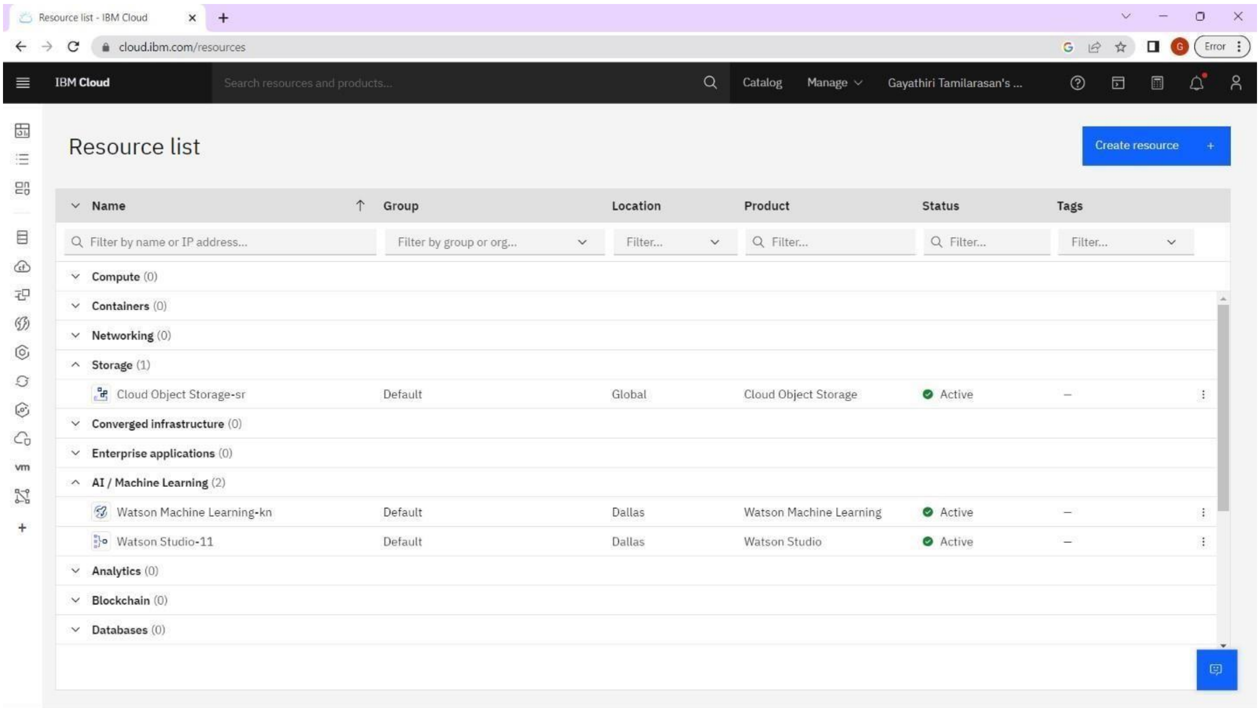
During Feature 1 we have planned for Downloading the dataset, import the libraries, Read the data set understanding data types and summary the feature. And the initializing the models are completed in feature 1

5.2 Feature 2

During Feature 2 we have planned for training the model and IBM where we will register for IBM cloud, train the model on IBM and Integrate flask with scoring end point. Registered on IBM cloud and activated . Training and testing are completed in feature 2.



IBM CLOUD RESOURCES:

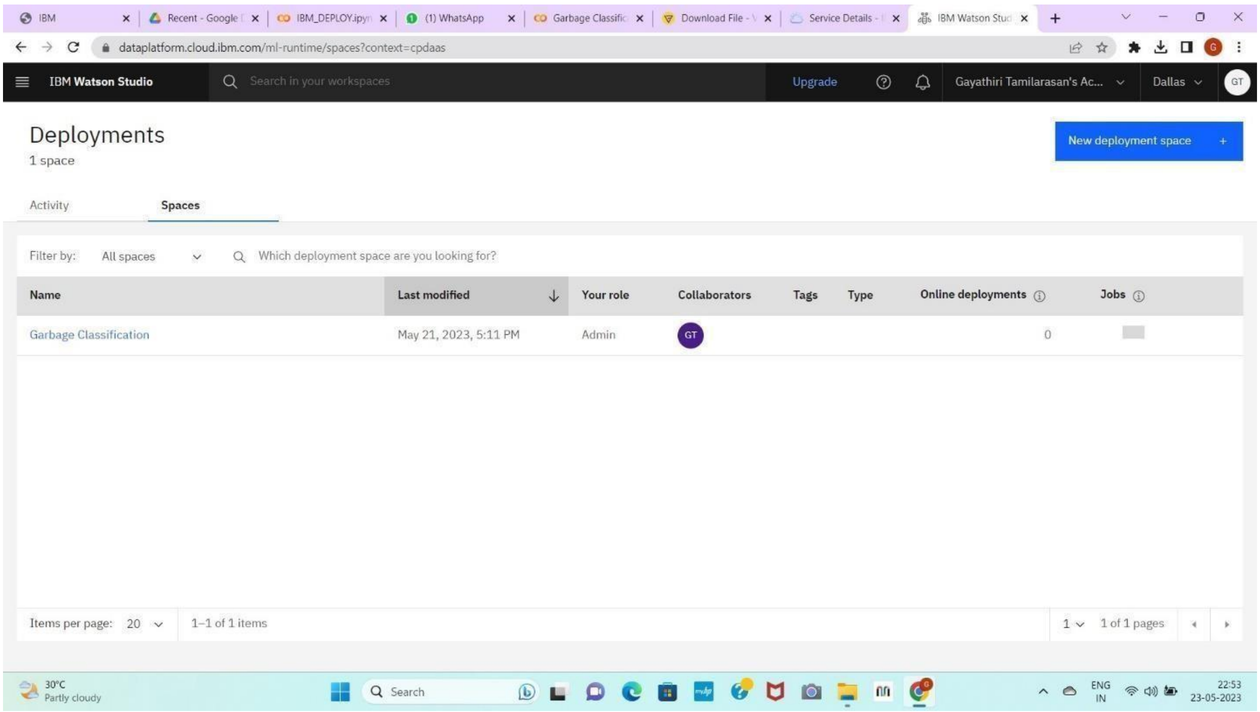


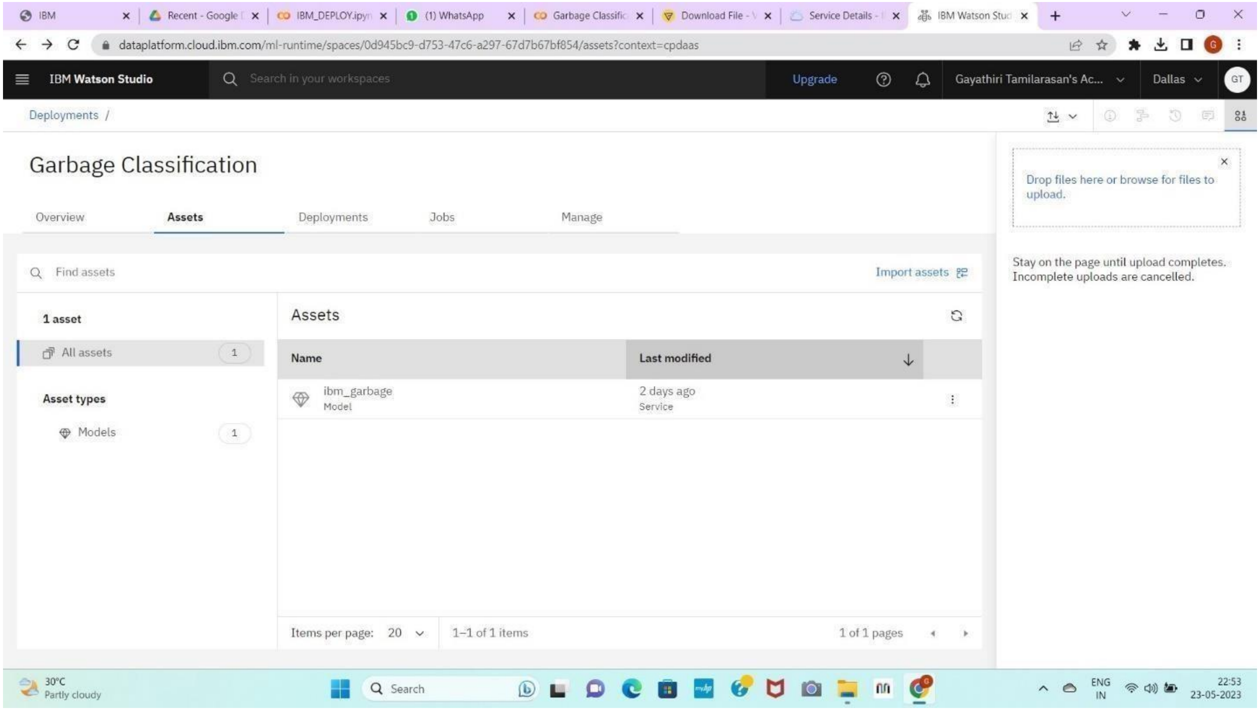
DEPLOY THE MODEL ON IBM WATSON STUDIO:

```
model.save('ibm.h5')

!tar -zcvf ibm.tgz ibm.h5

!pip install watson-machine-learning-client !pip install

ibm_watson_machine_learning from ibm_watson_machine_learning

import APIClient wml_credentials

= {

   "url":"https://us-south.ml.cloud.ibm.com",

   "apikey":"Pk642Xd79L530ZU8ki0yu_O9WPDFl4KsIM-0kZ-0suS9"

} client =

APIClient(wml_credentials) client   client.spaces.get_details()

client.spaces.list()      space_uid   =   "db804cd5-c21e-4d56-

8ed3a36643ccd341"                              space_uid

client.set.default_space(space_uid)

client.software_specifications.list()

software_space_uid         =

client.software_specifications.get_uid_by_name("runtime-  22.2-py3.10")

software_space_uid model_details =

client.repository.store_model(model="ibm.tgz",meta_props={

client.repository.ModelMetaNames.NAME:"ibm",

client.repository.ModelMetaNames.TYPE:"tensorflow_2.9",

client.repository.ModelMetaNames.SOFTWARE_SPEC_UID:software_space_
```

u id }) model_details model_id = client.repository.get_model_id(model_details) model_id client.repository.download(model_id,'ibm_1.tgz')

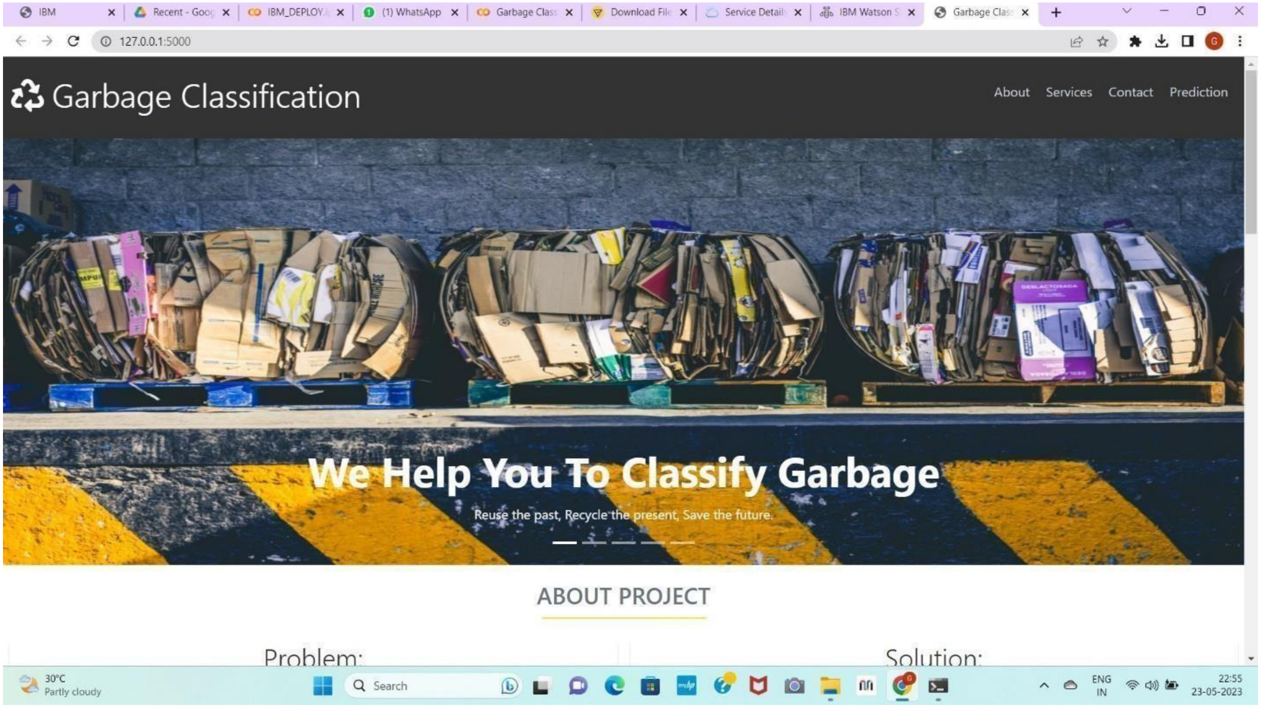
DEPLOYMENT THE MODEL:

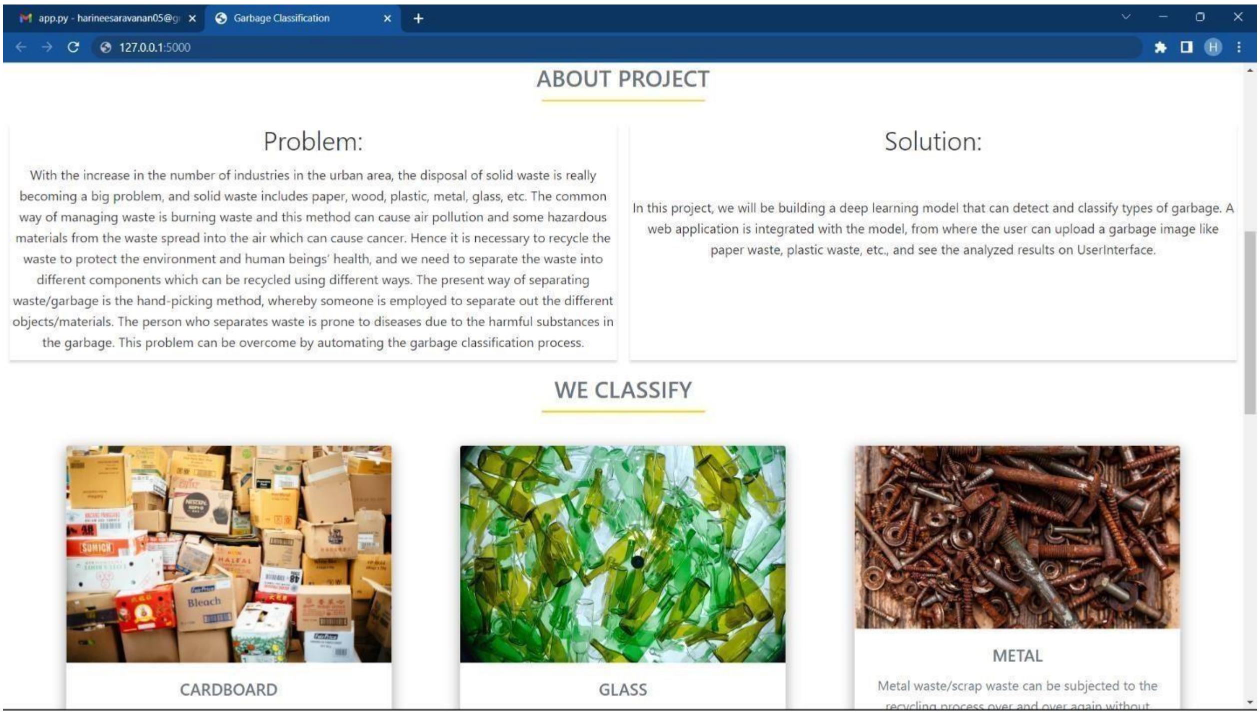



dataplatform.cloud.ibm.com/ml-runtime/spaces/0d945bc9-d753-47c6-a297-67d7b67bf854/assets?context=cpdaas
IBM Watson Studio
Search in your workspaces
Upgrade
Gayathiri Tamilarasan's Ac...
Dallas
Deployments /
Garbage Classification
Overview
Assets
Deployments
Jobs
Manage
Find assets
Import assets
1 asset
All assets
1
Asset types
Models
1
Assets
Name
Last modified
ibm_garbage
Model
2 days ago
Service
Items per page: 20
1–1 of 1 items
1 of 1 pages
Drop files here or browse for files to upload.
Stay on the page until upload completes. Incomplete uploads are cancelled.
30°C
Partly cloudy
Search
ENG
IN
22:53
23-05-2023

5.3 Feature 3

During Feature 2 we have planned for HTML files, Build Python code and run the app





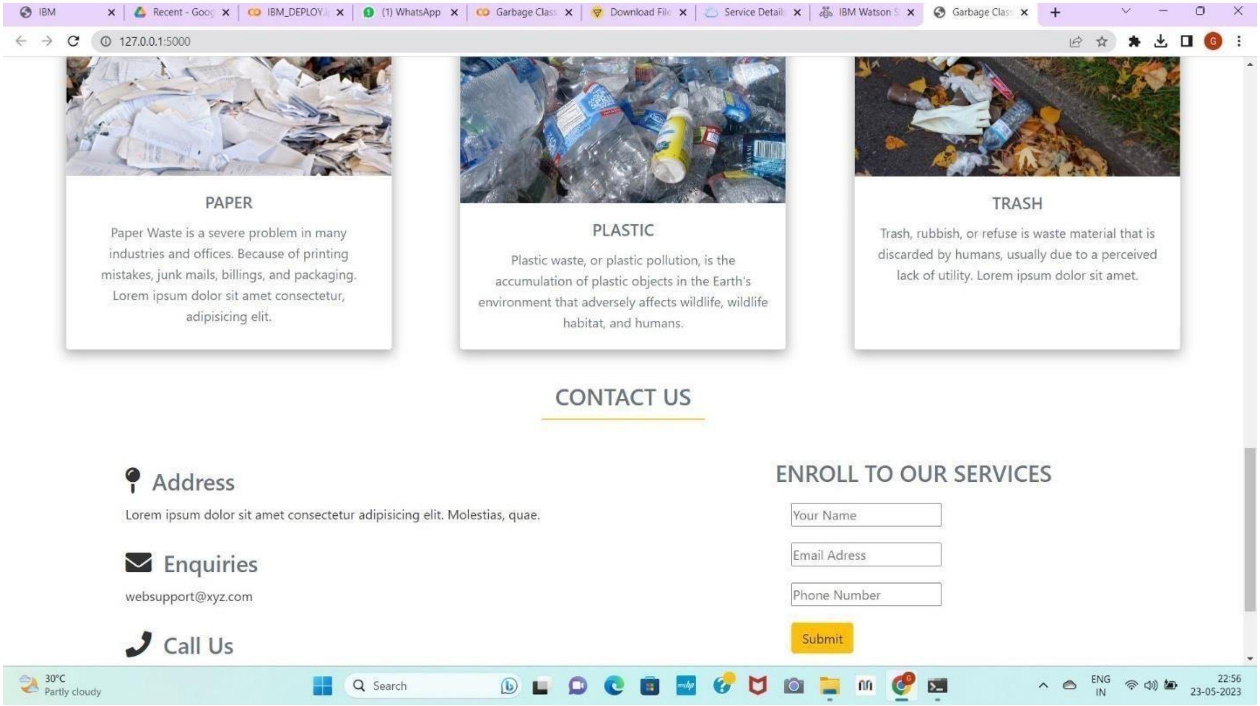
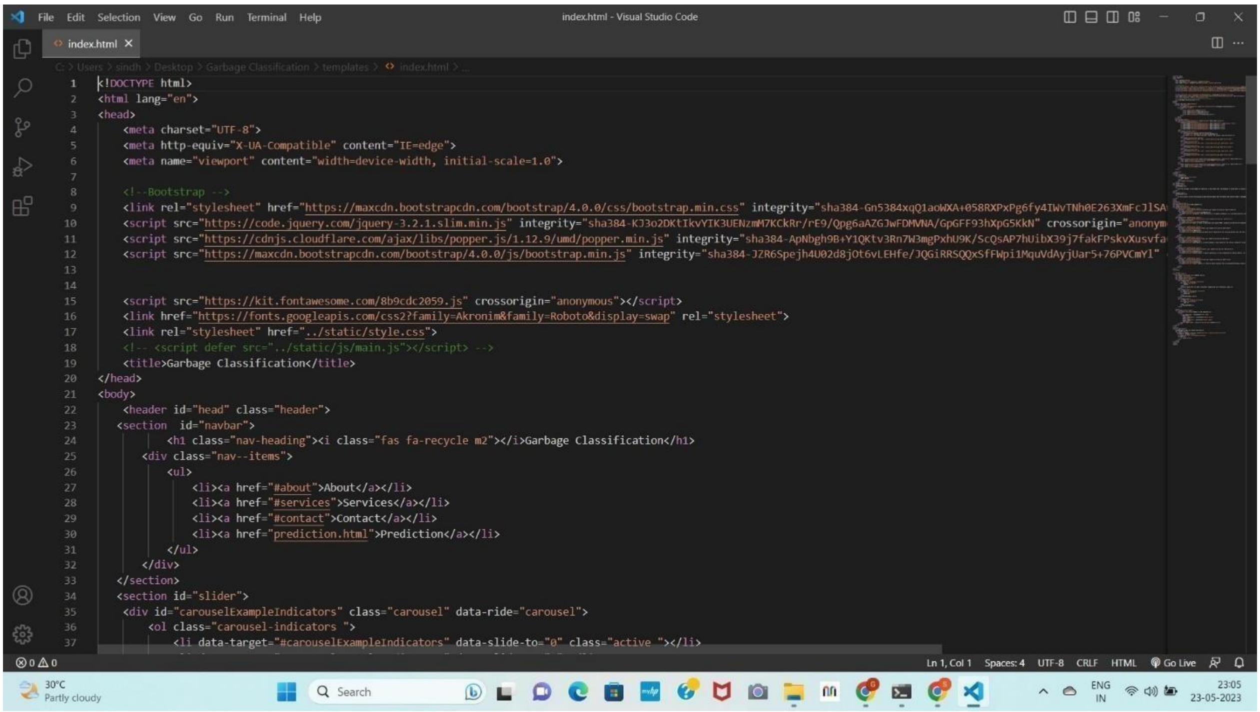
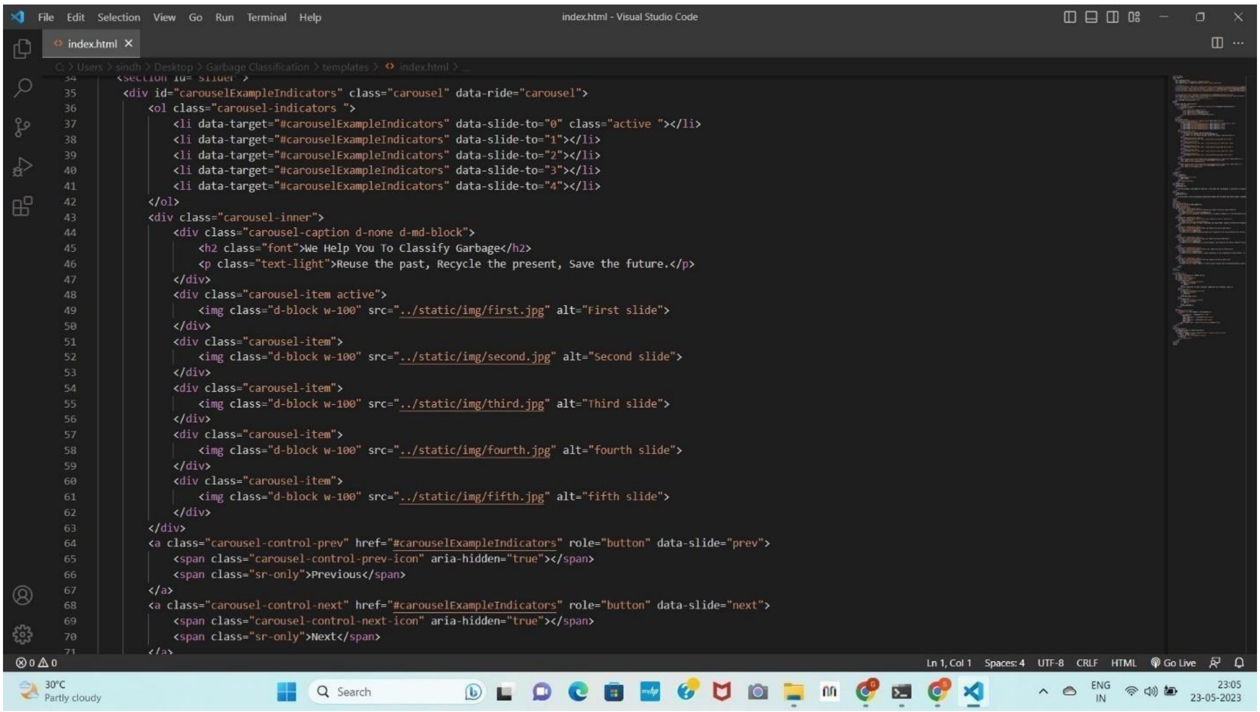


Figure 3.5 Website for Garbage Classification

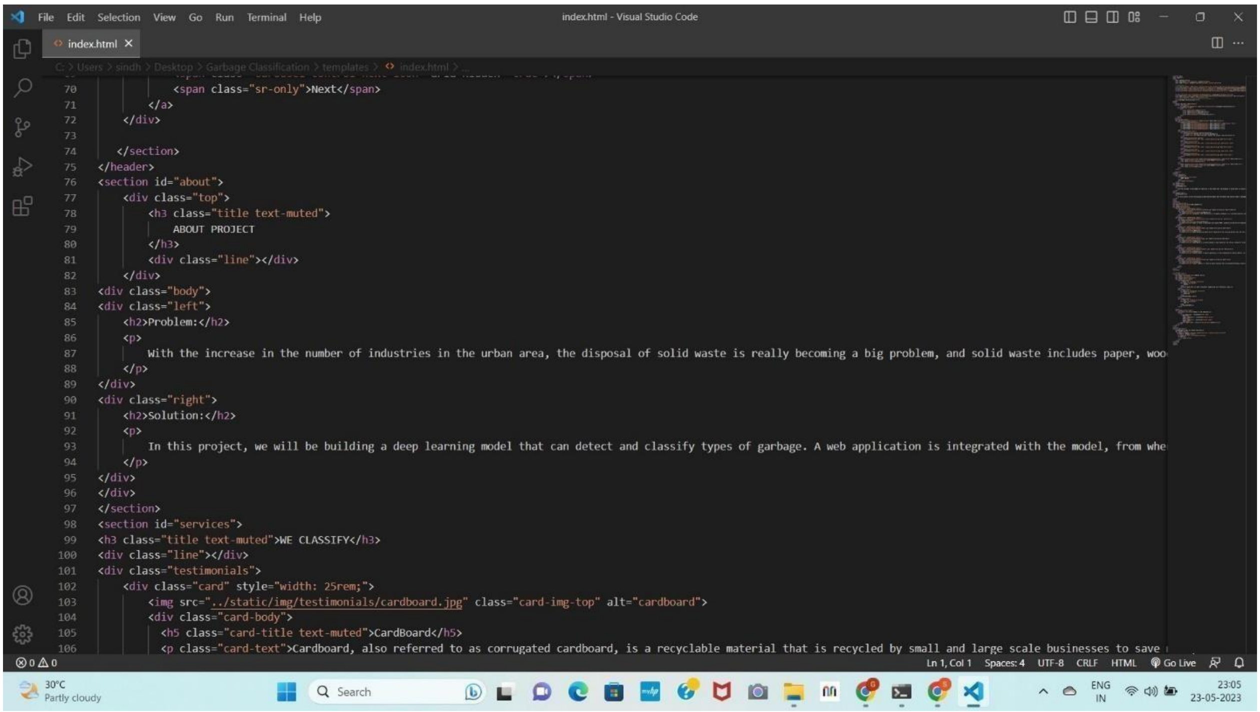
5.3.1 index.html



```html
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">

    <!--Bootstrap -->
    <link rel="stylesheet" href="https://maxcdn.bootstrapcdn.com/bootstrap/4.0.0/css/bootstrap.min.css" integrity="sha384-Gn5384xqQ1aoWXA+058RXPxPg6fy4IWvTNh0E263XmFcJlSA
    <script src="https://code.jquery.com/jquery-3.2.1.slim.min.js" integrity="sha384-KJ3o2DKtIkvYIK3UENzmM7KCkRr/rE9/Qpg6aAZGJwFDMVNA/GpGFF93hXpG5KkN" crossorigin="anonym
    <script src="https://cdnjs.cloudflare.com/ajax/libs/popper.js/1.12.9/umd/popper.min.js" integrity="sha384-ApNbgh9B+Y1QKtv3Rn7W3mgPxhU9K/ScQsAP7hUibX39j7fakFPskvXusvfa
    <script src="https://maxcdn.bootstrapcdn.com/bootstrap/4.0.0/js/bootstrap.min.js" integrity="sha384-JZR6Spejh4U02d8jOt6vLEHfe/JQGiRRSQQxSfFWpi1MquVdAyjUar5+76PVCmYl"


    <script src="https://kit.fontawesome.com/8b9cdc2059.js" crossorigin="anonymous"></script>
    <link href="https://fonts.googleapis.com/css2?family=Akronim&family=Roboto&display=swap" rel="stylesheet">
    <link rel="stylesheet" href="../static/style.css">
    <!-- <script defer src="../static/js/main.js"></script> -->
    <title>Garbage Classification</title>
</head>
<body>
    <header id="head" class="header">
   <section  id="navbar">
          <h1 class="nav-heading"><i class="fas fa-recycle m2"></i>Garbage Classification</h1>
      <div class="nav--items">
          <ul>
              <li><a href="#about">About</a></li>
              <li><a href="#services">Services</a></li>
              <li><a href="#contact">Contact</a></li>
              <li><a href="prediction.html">Prediction</a></li>
          </ul>
      </div>
   </section>
   <section id="slider">
    <div id="carouselExampleIndicators" class="carousel" data-ride="carousel">
        <ol class="carousel-indicators ">
            <li data-target="#carouselExampleIndicators" data-slide-to="0" class="active "></li>
```



```html
    <div id="carouselExampleIndicators" class="carousel" data-ride="carousel">
        <ol class="carousel-indicators ">
            <li data-target="#carouselExampleIndicators" data-slide-to="0" class="active "></li>
            <li data-target="#carouselExampleIndicators" data-slide-to="1"></li>
            <li data-target="#carouselExampleIndicators" data-slide-to="2"></li>
            <li data-target="#carouselExampleIndicators" data-slide-to="3"></li>
            <li data-target="#carouselExampleIndicators" data-slide-to="4"></li>
        </ol>
        <div class="carousel-inner">
            <div class="carousel-caption d-none d-md-block">
                <h2 class="font">We Help You To Classify Garbage</h2>
                <p class="text-light">Reuse the past, Recycle the present, Save the future.</p>
            </div>
            <div class="carousel-item active">
                <img class="d-block w-100" src="../static/img/first.jpg" alt="First slide">
            </div>
            <div class="carousel-item">
                <img class="d-block w-100" src="../static/img/second.jpg" alt="Second slide">
            </div>
            <div class="carousel-item">
                <img class="d-block w-100" src="../static/img/third.jpg" alt="Third slide">
            </div>
            <div class="carousel-item">
                <img class="d-block w-100" src="../static/img/fourth.jpg" alt="fourth slide">
            </div>
            <div class="carousel-item">
                <img class="d-block w-100" src="../static/img/fifth.jpg" alt="fifth slide">
            </div>
        </div>
        <a class="carousel-control-prev" href="#carouselExampleIndicators" role="button" data-slide="prev">
            <span class="carousel-control-prev-icon" aria-hidden="true"></span>
            <span class="sr-only">Previous</span>
        </a>
        <a class="carousel-control-next" href="#carouselExampleIndicators" role="button" data-slide="next">
            <span class="carousel-control-next-icon" aria-hidden="true"></span>
            <span class="sr-only">Next</span>
```


File Edit Selection View Go Run Terminal Help
index.html - Visual Studio Code
index.html
C: > Users > sindh > Desktop > Garbage Classification > templates > index.html
Next

</div>
</section>
</header>
<section id="about">
<div class="top">
<h3 class="title text-muted">
ABOUT PROJECT
</h3>
<div class="line"></div>
</div>
<div class="body">
<div class="left">
<h2>Problem:</h2>
<p>
With the increase in the number of industries in the urban area, the disposal of solid waste is really becoming a big problem, and solid waste includes paper, woo
</p>
</div>
<div class="right">
<h2>Solution:</h2>
<p>
In this project, we will be building a deep learning model that can detect and classify types of garbage. A web application is integrated with the model, from whe
</p>
</div>
</div>
</section>
<section id="services">
<h3 class="title text-muted">WE CLASSIFY</h3>
<div class="line"></div>
<div class="testimonials">
<div class="card" style="width: 25rem;">
<img src="../static/img/testimonials/cardboard.jpg" class="card-img-top" alt="cardboard">
<div class="card-body">
<h5 class="card-title text-muted">CardBoard</h5>
<p class="card-text">Cardboard, also referred to as corrugated cardboard, is a recyclable material that is recycled by small and large scale businesses to save
Ln 1, Col 1 Spaces: 4 UTF-8 CRLF HTML Go Live
30°C
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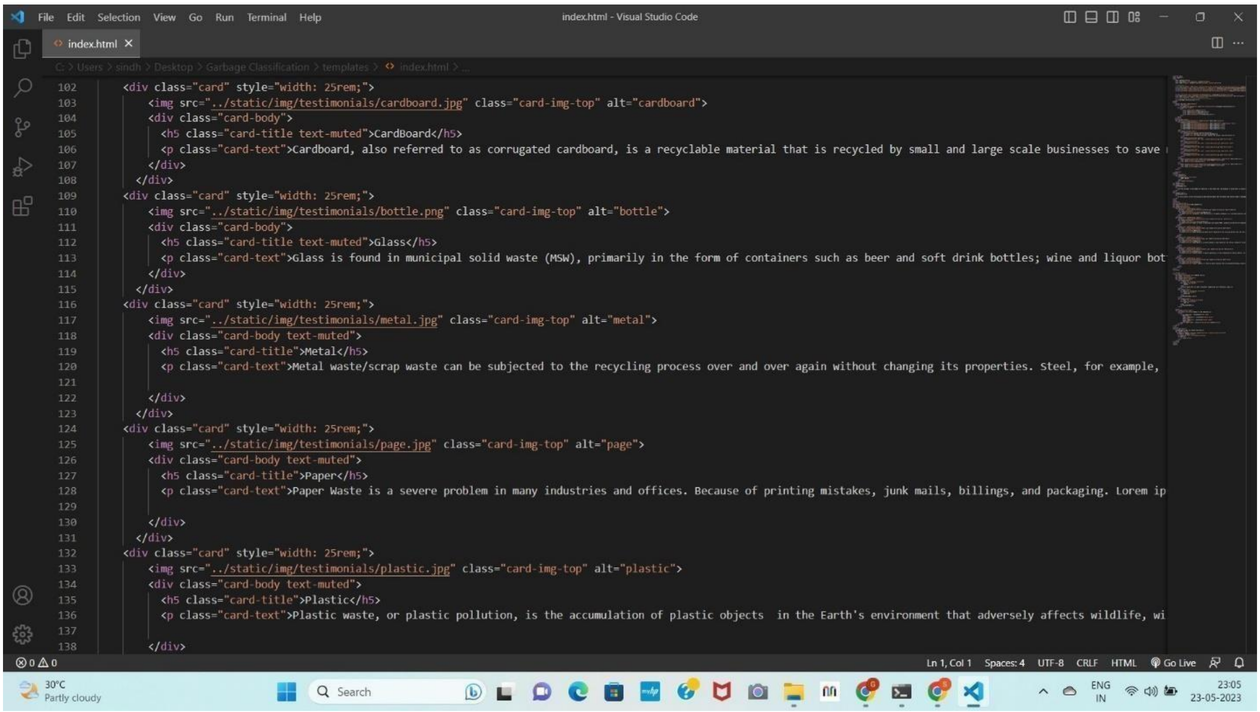
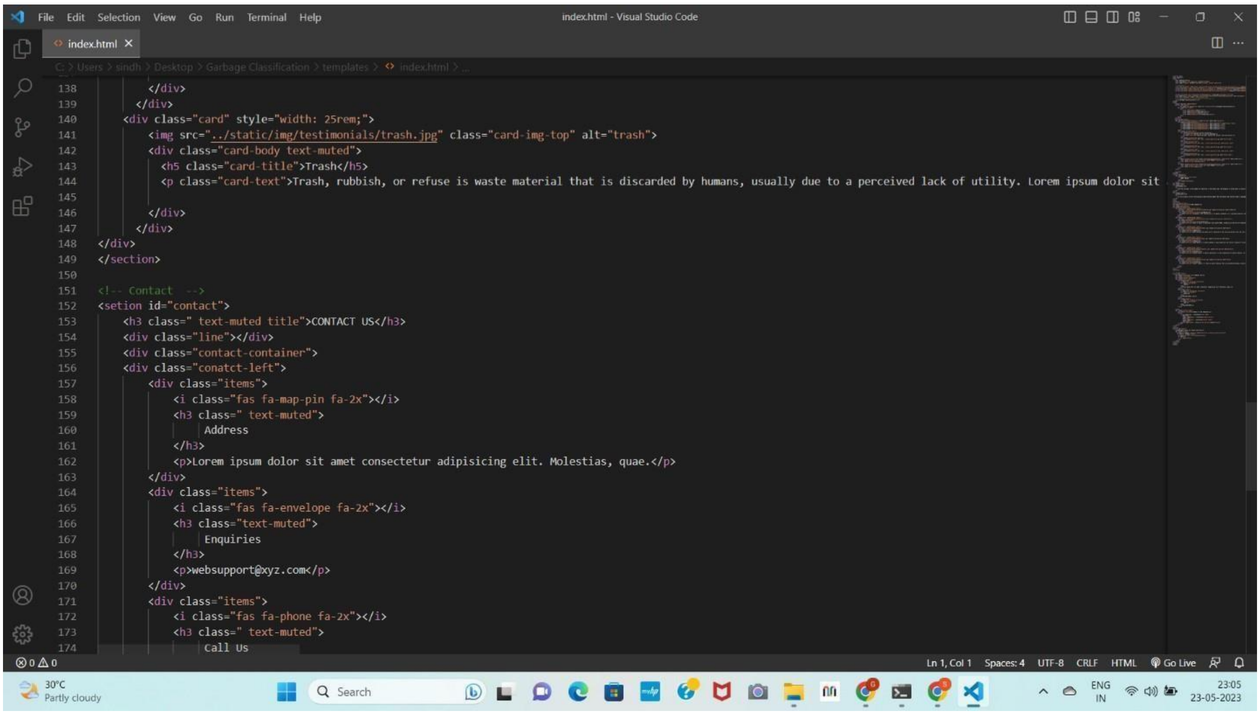

File Edit Selection View Go Run Terminal Help
index.html - Visual Studio Code
index.html
C: > Users > sindh > Desktop > Garbage Classification > templates > index.html
<div class="card" style="width: 25rem;">
<img src="../static/img/testimonials/cardboard.jpg" class="card-img-top" alt="cardboard">
<div class="card-body">
<h5 class="card-title text-muted">CardBoard</h5>
<p class="card-text">Cardboard, also referred to as corrugated cardboard, is a recyclable material that is recycled by small and large scale businesses to save
</div>
</div>
<div class="card" style="width: 25rem;">
<img src="../static/img/testimonials/bottle.png" class="card-img-top" alt="bottle">
<div class="card-body">
<h5 class="card-title text-muted">Glass</h5>
<p class="card-text">Glass is found in municipal solid waste (MSW), primarily in the form of containers such as beer and soft drink bottles; wine and liquor bot
</div>
</div>
<div class="card" style="width: 25rem;">
<img src="../static/img/testimonials/metal.jpg" class="card-img-top" alt="metal">
<div class="card-body text-muted">
<h5 class="card-title">Metal</h5>
<p class="card-text">Metal waste/scrap waste can be subjected to the recycling process over and over again without changing its properties. Steel, for example,
</div>
</div>
<div class="card" style="width: 25rem;">
<img src="../static/img/testimonials/page.jpg" class="card-img-top" alt="page">
<div class="card-body text-muted">
<h5 class="card-title">Paper</h5>
<p class="card-text">Paper Waste is a severe problem in many industries and offices. Because of printing mistakes, junk mails, billings, and packaging. Lorem ip
</div>
</div>
<div class="card" style="width: 25rem;">
<img src="../static/img/testimonials/plastic.jpg" class="card-img-top" alt="plastic">
<div class="card-body text-muted">
<h5 class="card-title">Plastic</h5>
<p class="card-text">Plastic waste, or plastic pollution, is the accumulation of plastic objects in the Earth's environment that adversely affects wildlife, wi
</div>
Ln 1, Col 1 Spaces: 4 UTF-8 CRLF HTML Go Live
30°C
Partly cloudy
Search
ENG
IN
23:05
23-05-2023



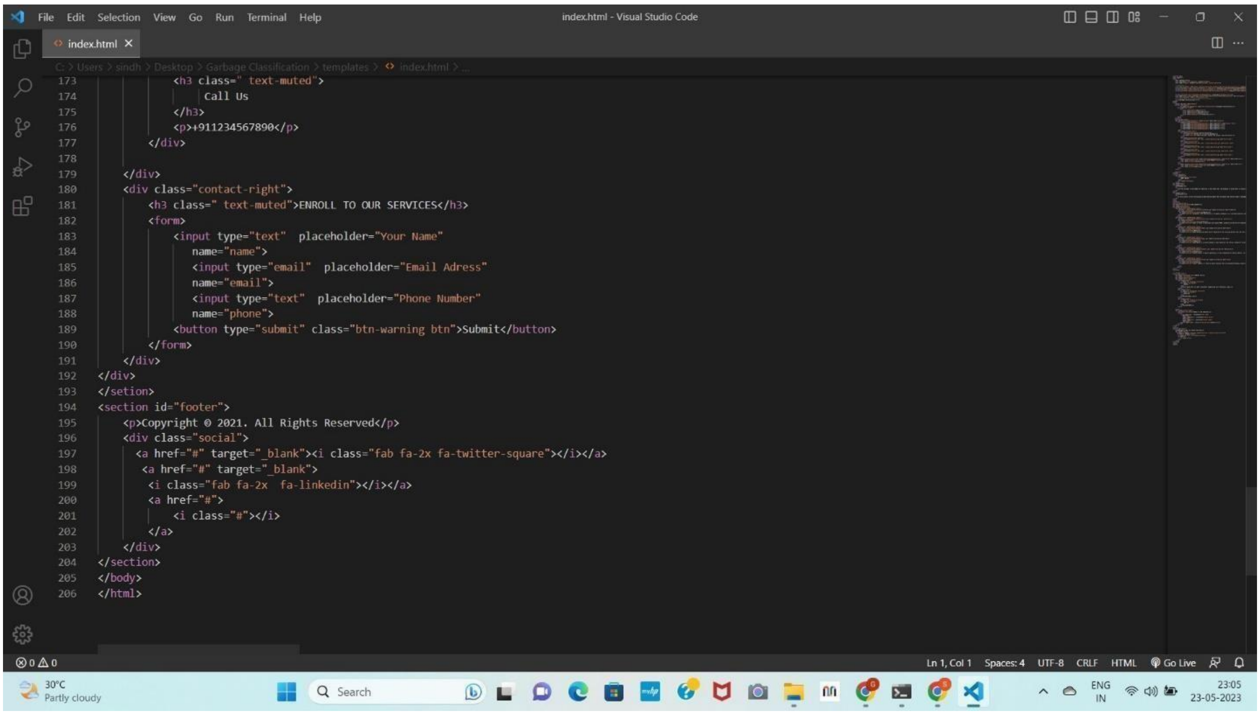
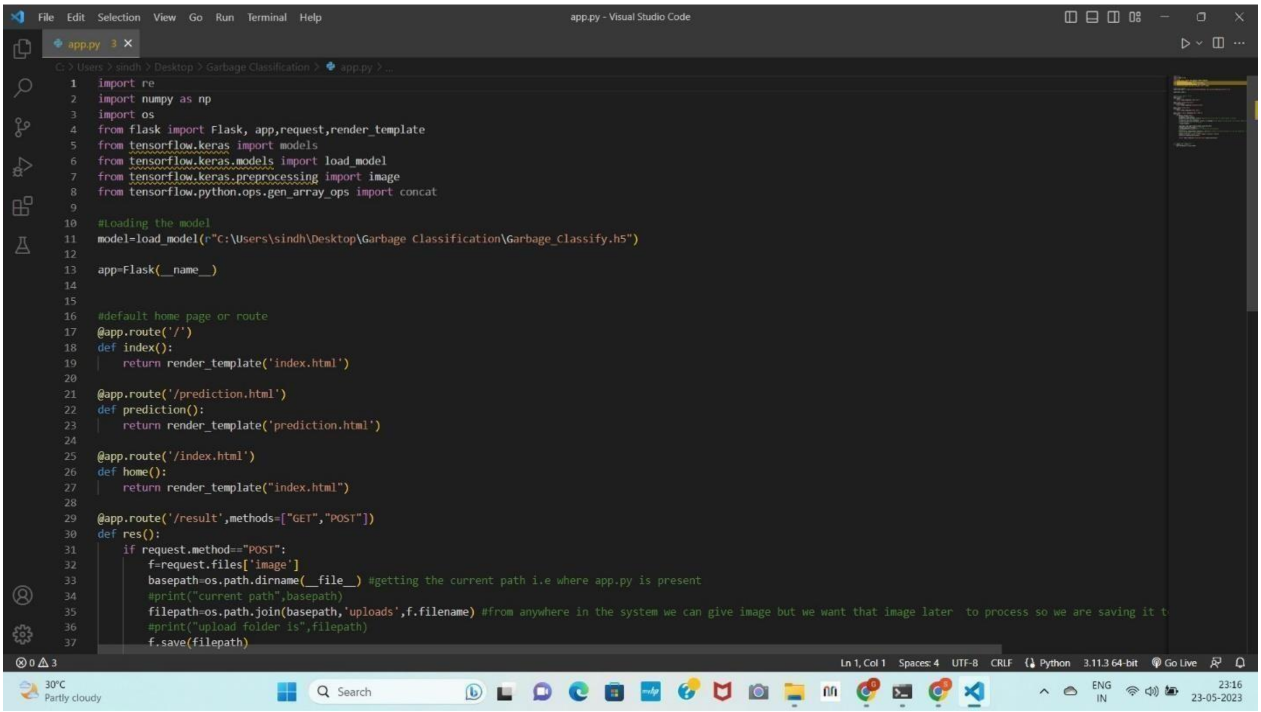


Figure 3.6 index.html

5.3.2 Building the Flask File:



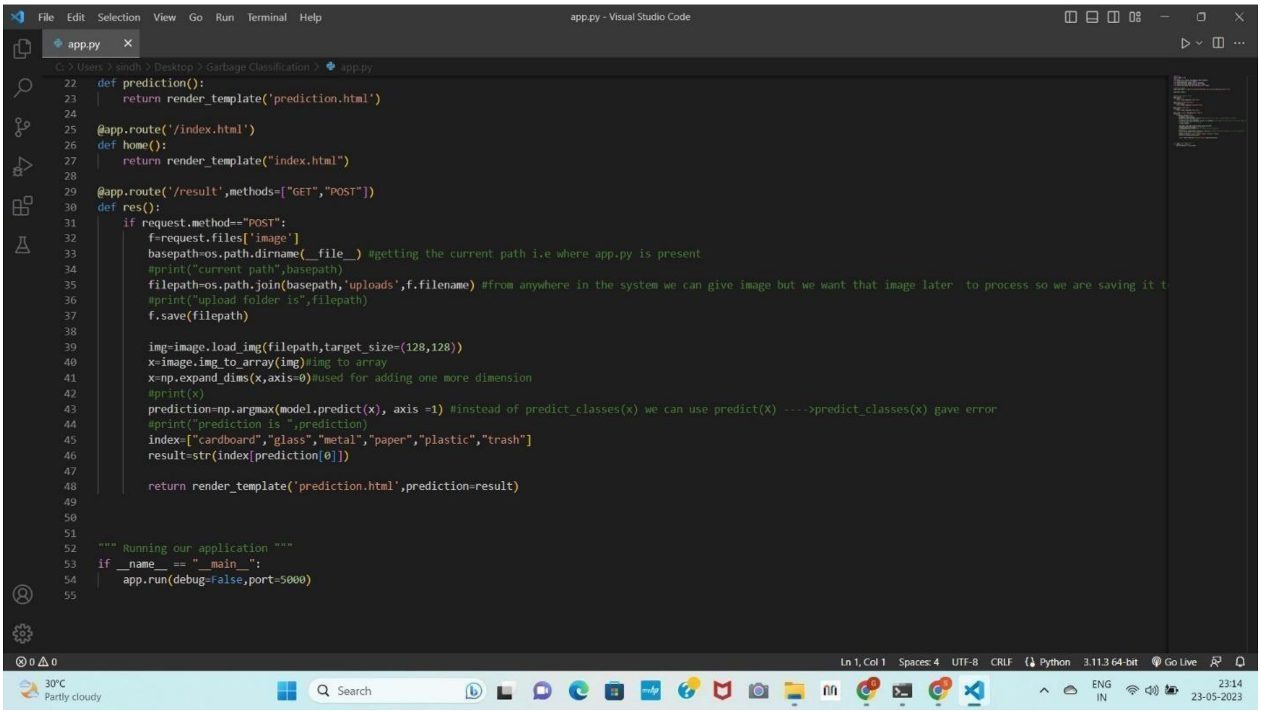
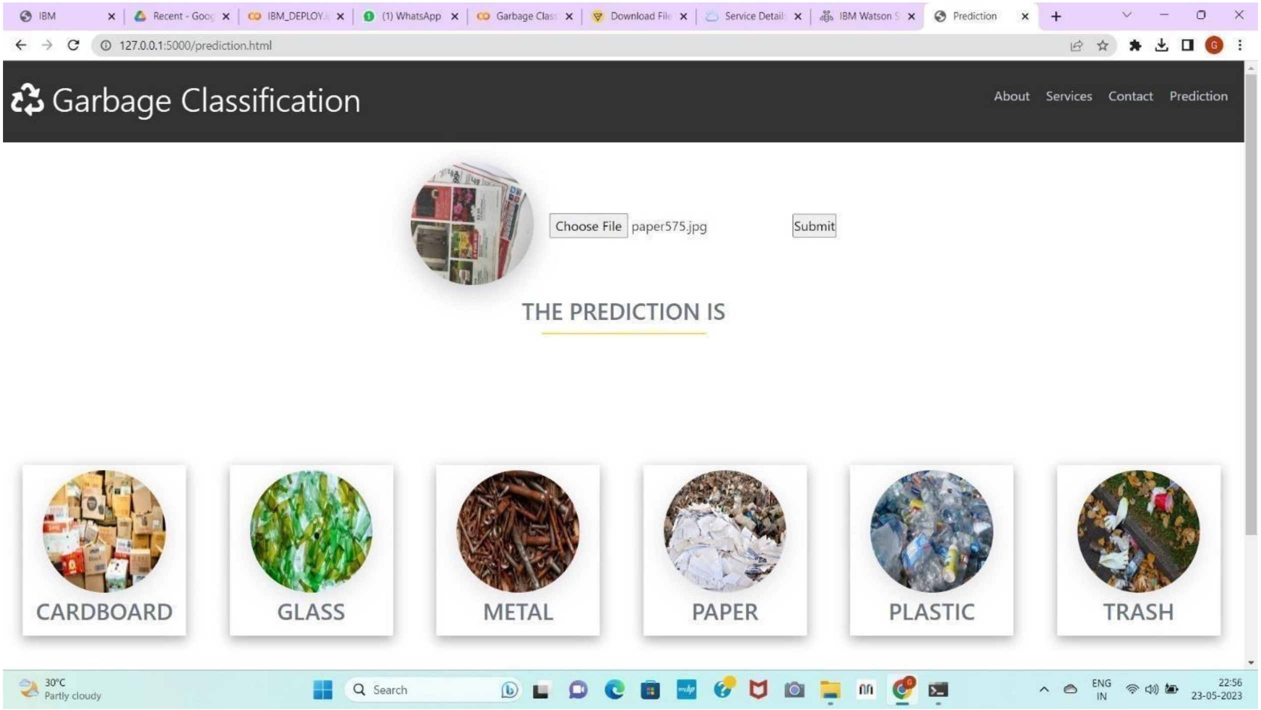


Figure 3.7 app.py

5.4 Feature 4:

During Feature 3 we have planned for asking the users to upload their Garbage Image to find the class of the image



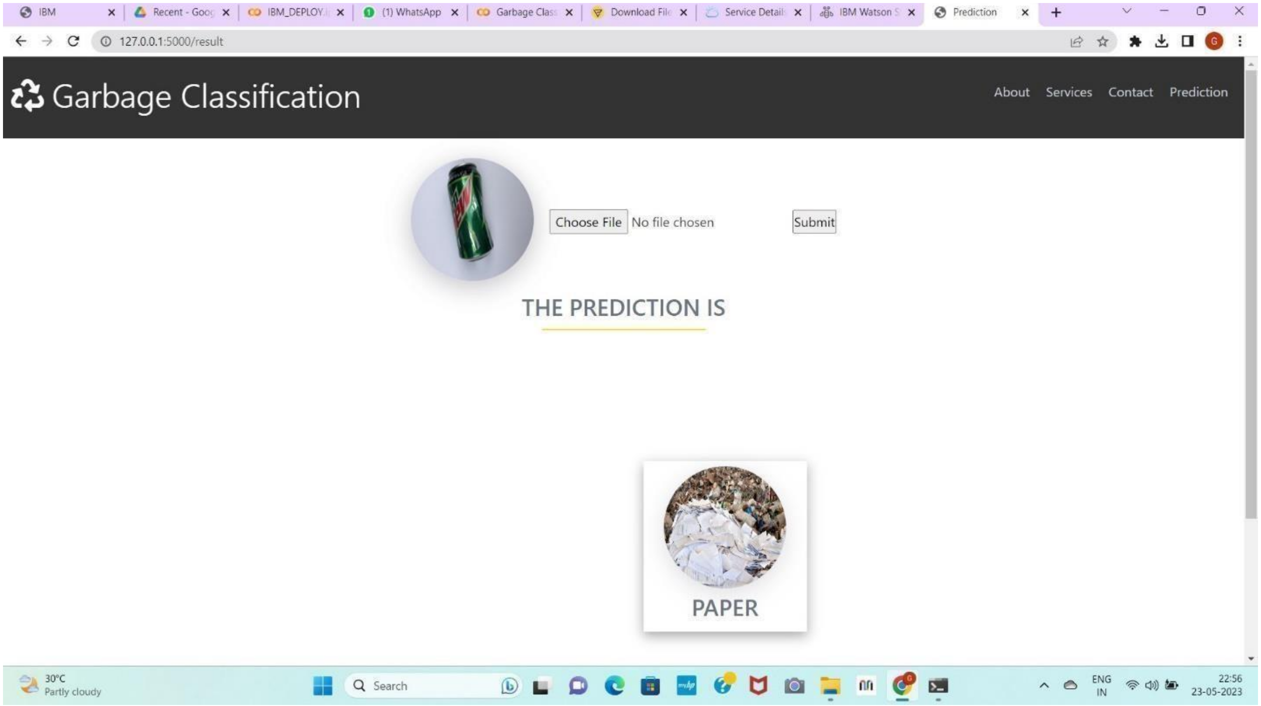


Figure 3.8 Prediction Page

CHAPTER 6
ADVANTAGES & DISADVANTAGES

Advantages:

1. **Accuracy**: Deep learning algorithms can achieve high accuracy in garbage classification, as they can analyse and classify waste items based on various features such as shape, colour, texture, and size. This accuracy helps ensure that waste is sorted correctly and can be directed to the appropriate recycling or disposal facilities.
2. **Efficiency:** Intelligent garbage classification can significantly improve the efficiency of waste management processes. By automating the sorting and categorization tasks, it reduces the need for manual labour, leading to faster and more streamlined waste management operations.
3. **Resource Optimization:** Deep learning models can analyse the composition and characteristics of different types of waste. This information can be used to optimize resource allocation for recycling and disposal purposes. It allows authorities to allocate resources effectively, reduce waste, and promote sustainable practices.
4. **Environmental Impact:** Proper waste sorting through intelligent garbage classification can have a positive impact on the environment. It enables the identification and diversion of recyclable materials from landfill sites, leading to reduced waste generation, conservation of natural resources, and lower greenhouse gas emissions.

Disadvantages:

1. **Data Requirements:** Deep learning models rely on large amounts of labelled training data to achieve accurate classification. Gathering and labelling such data can be time-consuming and resource-intensive. Additionally, the availability of diverse and representative data may pose challenges in certain contexts or regions.
2. **Cost:** Implementing intelligent garbage classification systems can involve substantial upfront costs. It requires investments in hardware, sensors, cameras, computational resources, and the development of deep learning models. These expenses may limit the adoption of such technologies, especially in areas with limited financial resources.
3. **Maintenance and Upkeep:** Smart waste management systems need regular maintenance, calibration, and updates to ensure optimal performance. Failure to address issues promptly can result in misclassification and reduced efficiency. The cost and effort associated with maintaining these systems should be considered when implementing intelligent garbage classification solutions.
4. **Limited Contextual Understanding:** Deep learning models primarily rely on visual cues for garbage classification. While they excel at recognizing specific waste items, they may struggle with understanding the context or content of waste, especially for items that don't have distinct visual features. This limitation may affect the accuracy of classification in some cases.

5. **Technological Limitations:** Deep learning models are not infallible and can make errors, especially when confronted with complex or uncommon waste items. Their performance can be influenced by factors such as lighting conditions, occlusions, or variations in waste appearances. Ongoing research and advancements are necessary to address these limitations and improve the overall effectiveness of intelligent garbage classification.

CHAPTER 7
CONCLUSION

In conclusion, intelligent garbage classification using deep learning is a promising and effective approach for addressing the challenges associated with waste management. Deep learning techniques, such as convolutional neural networks (CNNs), have demonstrated remarkable capabilities in accurately classifying and sorting different types of waste materials.

By leveraging large and diverse datasets, deep learning models can learn complex patterns and features from garbage images or sensor data, enabling them to identify and categorize various waste items with high precision. This technology can significantly improve the efficiency of waste sorting processes, reduce human error, and increase recycling rates.

CHAPTER 8
FUTURE SCOPE

The future scope of intelligent garbage classification using deep learning is quite promising. Deep learning, a subset of machine learning, has shown great potential in various applications, including computer vision tasks such as image classification. By leveraging deep learning techniques, intelligent garbage classification systems can accurately and efficiently classify different types of waste

The future of intelligent garbage classification using deep learning is exciting, with potential applications in various domains. As technology continues to advance and datasets grow, we can expect further advancements in accuracy, efficiency, and scalability, leading to more effective waste management practices and a cleaner, greener future.

CHAPTER 9

APPENDIX

9.1 Source code

Garbage Classification.ipynb

```
from keras.preprocessing.image import ImageDataGenerator import pandas as
pd    train_datagen=ImageDataGenerator(rescale=1./255,    shear_range=0.1,
zoom_range=0.1,                                 horizontal_flip=True)
val_datagen=ImageDataGenerator(rescale=1./255)    train_transform        =
train_datagen.flow_from_directory(r"/content/drive/MyDrive/dataset/Garbage
classification/training",
target_size=(128,128),
batch_size=64,
class_mode='categorical'    )    test_transform   =
val_datagen.flow_from_directory(r"/content/drive/MyDrive/dataset/testing",
target_size=(128,128),
batch_size=64,                                                    from
tensorflow.keras.models  import  Sequential  from  tensorflow.keras.layers
import  Dense  from  tensorflow.keras.layers  import  Convolution2D  from
tensorflow.keras.layers  import  MaxPooling2D  from  tensorflow.keras.layers
import   Flatten     from   tensorflow.keras.optimizers     import   Adam
model=Sequential()                               class_mode='categorical')
model.add(Convolution2D(32,(3,3),input_shape=(128,128,3),activation='relu'
))                                             model.add(MaxPooling2D(2,2))
model.add(Convolution2D(32,(3,3),input_shape=(128,128,3),activation='relu'
)) model.add(MaxPooling2D(2,2))
model.add(Convolution2D(64,(3,3),padding='same',activation='relu'))
model.add(MaxPooling2D(pool_size=2)) model.add(Convolution2D(32,(3,3),
padding='same',activation='relu')) model.add(MaxPooling2D(2,2))
model.add(Convolution2D(32,(3,3), padding='same',activation='relu'))
model.add(MaxPooling2D(pool_size=2))
model.add(Flatten())
model.add(Dense(kernel_initializer='uniform',activation='relu',units=150))
model.add(Dense(kernel_initializer='uniform',activation='relu',units=68))
model.add(Dense(kernel_initializer='uniform',activation='softmax',units=6)
) model.summary()
model.compile(loss='categorical_crossentropy',optimizer='adam',metrics=['a
cc']) res =
model.fit_generator(train_transform,steps_per_epoch=2527//64,validation_st
eps=782//64,epochs=30,validation_data=test_transform) import numpy as np
from tensorflow.keras.models import load_model from
tensorflow.keras.preprocessing import image model.save('Garbage_Classify.h5')
model = load_model("Garbage_Classify.h5") img =
image.load_img(r"/content/drive/MyDrive/dataset/Garbage
classification/Garbage classification/plastic/plastic112.jpg",
target_size=(128,128)) x=image.img_to_array(img) x=np.expand_dims(x,axis=0)
a=np.argmax(model.predict(x),axis=1) index=['0','1','2','3','4','5'] result
```

```
= str(index[a[0]]) result train_transform.class_indices
index1=['cardboard','glass','metal','paper','plastic','trash']
result1=str(index1[a[0]]) result1
```

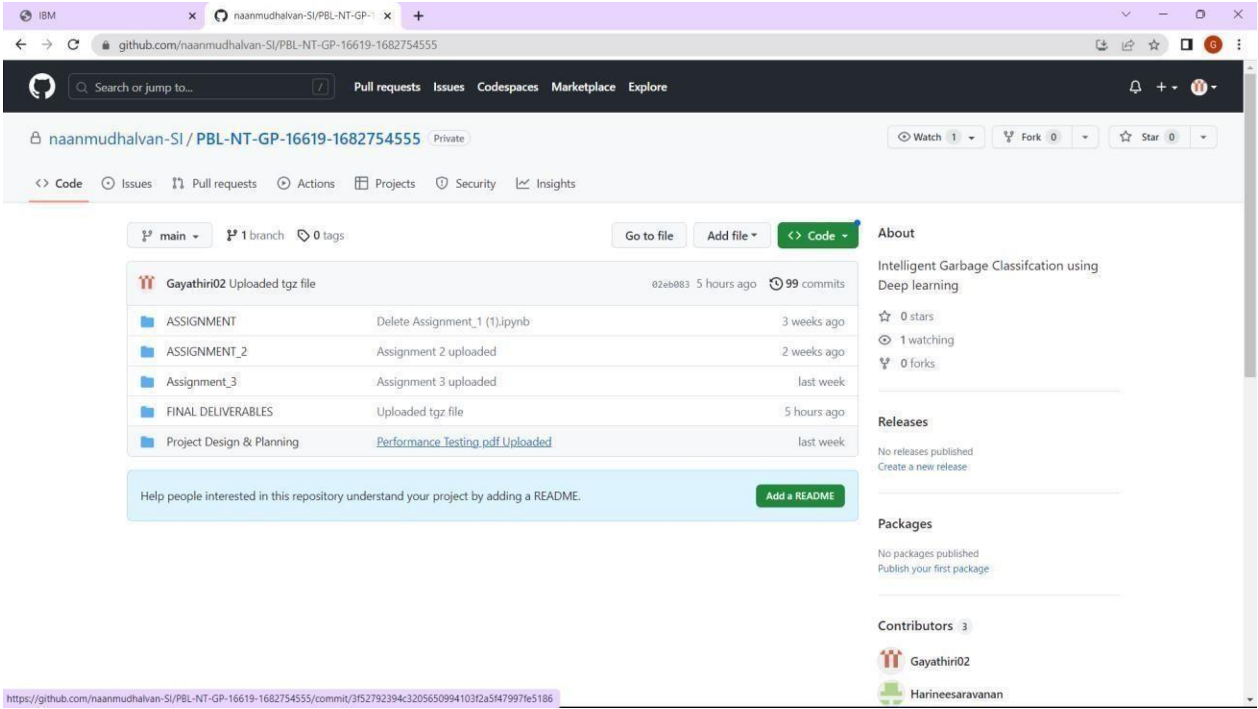
app.py

```
import re import
numpy as np import os
from flask import Flask, app,request,render_template
from tensorflow.keras import models from
tensorflow.keras.models import load_model from
tensorflow.keras.preprocessing import image from
tensorflow.python.ops.gen_array_ops import concat
#Loading the model  model=load_model(r"C:\Users\HARINEE\Desktop\Garbage
Classification\Garbage Classification\Garbage Classification.h5")
app=Flask(__name__)

#default home page or route  @app.route('/')
def index():
    return render_template('index.html')
@app.route('/prediction.html') def prediction():
    return render_template('prediction.html')
@app.route('/index.html') def home():
    return render_template("index.html")
@app.route('result.html',methods=["GET","POST"]) def res():     if
request.method=="POST":         f=request.files['image']
basepath=os.path.dirname(__file__) #getting the current path i.e where app.py
is present
        #print("current path",basepath)
filepath=os.path.join(basepath,'uploads',f.filename) #from anywhere in the system
we can give image but we want that image later  to process so we are saving it to
uploads folder for reusing         #print("upload folder is",filepath)
        f.save(filepath)
img=image.load_img(filepath,target_size=(128,128))
x=image.img_to_array(img)#img to array
        x=np.expand_dims(x,axis=0)#used for adding one more dimension
#print(x)          prediction=np.argmax(model.predict(x), axis =1)
#instead of
predict_classes(x) we can use predict(X) ---->predict_classes(x) gave error
        #print("prediction is ",prediction)
index=["cardboard","glass","metal","paper","plastic","trash"]
result=str(index[prediction[0]])                     return
render_template('prediction.html',prediction=result)
9

""" Running our application """ if __name__
== "__main__":
app.run(debug=False,port=5000)
```

9.2 Github and project video link

GITHUB LINK AND SCREENSHOT

https://github.com/naanmudhalvan-SI/PBL-NT-GP-166191682754555



PROJECT VIDEO LINK (YOUTUBE)

https://youtu.be/niS0iQc4crc

VIDEO DRIVE LINK

https://drive.google.com/file/d/1rdZ9IV9UmOqP4srybyvwzVSAuOSM3M_0