

## PROJECT REPORT

Date	20 May 2023
Team ID	NM2023TMID01793
Project Name	Intelligent Garbage Classification Using Deep learning.

**PROJECT TITLE: Intelligent Garbage Classification Using Deep learning.**

### 1.Introduction:

The project aims to develop an intelligent garbage classification system using deep learning techniques. The goal is to create an automated system that accurately identifies and categorizes different types of waste, facilitating efficient waste management and promoting sustainable practices. Intelligent garbage classification using deep learning represents a ground breaking approach to revolutionize waste management. By harnessing the power of deep neural networks, we can automate the process of garbage sorting, optimize recycling efforts, reduce landfill waste, and promote sustainable practices. While challenges persist, the potential benefits of this technology offer hope for a cleaner, greener future, where waste is managed intelligently and with utmost efficiency.

#### 1.1 Project Overview:

By implementing this project, we can pave the way for more efficient and sustainable waste management practices, ultimately contributing to a cleaner and healthier environment. Develop a deep learning model capable of accurately classifying various types of waste, such as recyclable materials, organic waste, hazardous substances, and non-recyclable items. Improve recycling rates by ensuring the correct identification and separation of recyclable materials, reducing contamination and increasing their reuse. Enhance waste-to-energy processes by efficiently segregating organic waste for composting or bioenergy production. Reduce landfill waste and minimize environmental pollution by optimizing waste management practices.

#### 1.2 Purpose:

The purpose of using intelligent garbage classification using deep learning is to transform waste management practices, increase recycling rates, reduce landfill waste, and promote sustainability. By leveraging advanced technology, we can optimize waste sorting processes, conserve resources, and mitigate the environmental impact associated with improper waste disposal. The main purpose of using intelligent garbage classification using deep learning is to revolutionize waste management practices and promote sustainability.

### 2.Ideation Phase and Proposed Solution:

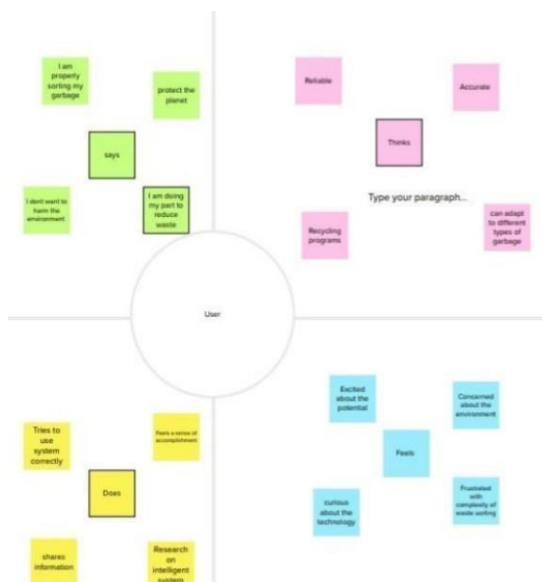
#### 2.1 Problem Statement Definition:

The problem addressed by intelligent garbage classification using deep learning is

the inefficiency and limitations of traditional waste management systems, which rely heavily on manual sorting and are prone to human error. These systems struggle to accurately identify and categorize different types of waste, leading to suboptimal recycling rates, contamination, and environmental consequences. The challenge lies in developing a robust and automated garbage classification system that can accurately classify diverse waste items, including recyclable materials, organic waste, hazardous substances, and non-recyclable items.

## 2.2 Empathy Map Canvas:

An empathy map is a tool used to understand and empathize with the needs, thoughts, feelings, and behaviours of a target user or stakeholder group. In the context of intelligent garbage classification using deep learning, an empathy map can help gain insights into the perspectives and challenges of various individuals or groups involved in waste management.



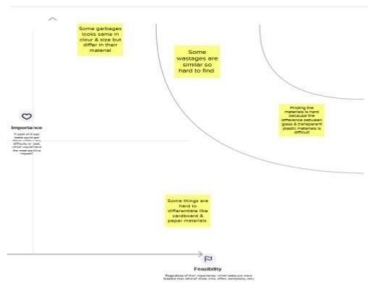
## 2.3 Ideation and Brainstorming:

Ideation and brainstorming are techniques used to generate creative ideas and potential solutions for a specific problem or project. In the context of intelligent garbage classification using deep learning, ideation and brainstorming sessions can help explore different approaches, algorithms, features, and system components.

### Brainstorm:



### Ideation :



## 2.4 Proposed Solution:

The proposed solution for intelligent garbage classification using deep learning aims to develop an automated system that accurately identifies and categorizes different types of waste, revolutionizing waste management practices. The system will leverage the power of deep learning algorithms to achieve efficient and accurate garbage sorting.

By implementing this proposed solution, we can achieve efficient and accurate garbage classification, enabling optimized waste management practices, improved recycling rates, reduced landfill waste, and enhanced environmental sustainability. The intelligent garbage classification system will contribute to creating a cleaner and greener future, while also promoting the adoption of deep learning techniques in waste management domains.

## 3.Requirement Analysis:

### 3.1 Functional Requirements:

The functional requirements serve as a foundation for developing an intelligent garbage classification system using deep learning. They address the key functionalities necessary to achieve accurate and efficient garbage classification while considering usability, integration, scalability, and data security.

#### 3.1.1 Pre-processing:

- The system should pre-process input images to enhance their quality and standardize lighting conditions.
- Noise reduction techniques should be applied to improve image clarity.

#### 3.1.2 Deep Learning Model:

- Utilize a trained deep learning model (e.g., CNN) for garbage classification.
- The model should be capable of accurately categorizing different types of waste.
- Support for different network architectures and pre-trained models should be available.
- The system should allow for model training and updating as new data becomes available.

#### 3.1.3 User Interface:

- Develop a user-friendly interface that allows users, such as waste management personnel, to interact with the system easily.
- The interface should support image upload, display classification results, and provide feedback options.

#### **3.1.4 Documentation and Support:**

- Provide comprehensive documentation and user guides for system installation, configuration, and usage.
- Offer technical support and assistance to users for troubleshooting and addressing any issues that arise.

### **3.2 Non- Functional Requirements:**

The non-functional requirements ensure that the intelligent garbage classification system is accurate, efficient, scalable, robust, adaptable, user-friendly, secure, reliable, maintainable, integrated, and ethically sound. They define the desired qualities and characteristics of the system beyond its core functionality, ensuring its effectiveness, usability, and compliance with relevant standards and regulations.

#### **3.2.1 Accuracy:**

The system should achieve a high level of accuracy in garbage classification, minimizing misclassifications and false positives/negatives. The accuracy should be specified based on the specific requirements of the waste management application.

#### **3.2.2 Scalability:**

The system should be designed to handle a large volume of garbage inputs, accommodating potential increases in data and user demand. It should scale efficiently in terms of computational resources required for model inference and the storage capacity for managing datasets.

#### **3.2.3 User-Friendly Interface:**

The system should have an intuitive and user-friendly interface, enabling easy interaction for users, such as waste management personnel. The interface should provide clear instructions, feedback, and classification results in a visually understandable manner.

#### **3.2.4 Reliability and Availability:**

The system should be reliable and available for use during operational hours, minimizing downtime and ensuring continuous availability. Measures should be in place to handle system failures gracefully and provide appropriate error handling mechanisms.

#### **3.2.5 Maintainability:**

The system should be designed and developed using modular and well-documented code, enabling easy maintenance, troubleshooting, and future enhancements. Regular updates, bug fixes, and improvements should be supported to address emerging issues or advancements in deep learning techniques.

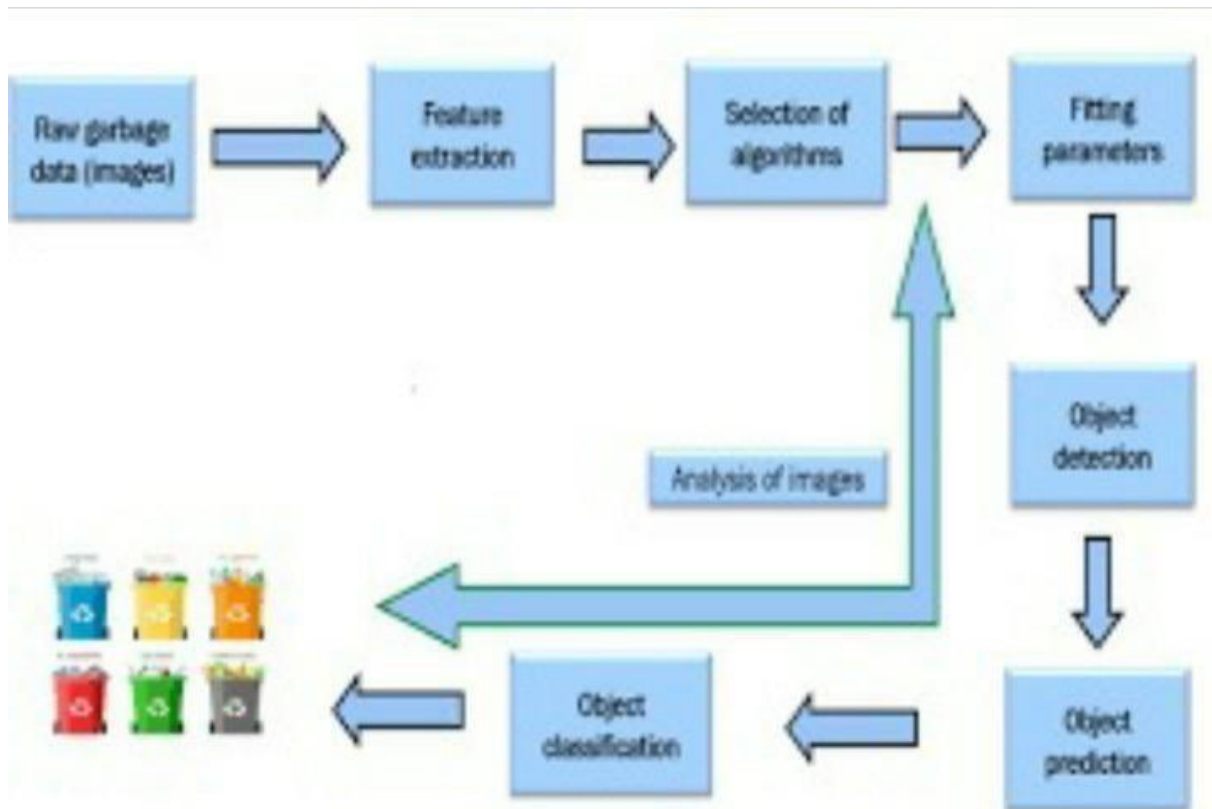
### 3.2.6 Integration with Existing Systems:

The system should seamlessly integrate with existing waste management infrastructure, such as recycling plants or waste sorting centres. It should be compatible with common data formats, databases, and APIs used in waste management.

## 4. Project Design:

### 4.1 Data Flow Diagram:

A Data Flow Diagram (DFD) for Intelligent Garbage Classification Using Deep Learning represents the flow of data and information within the system, illustrating how data is input, processed, and outputted.



### 4.2 Solution and Technical Architecture:

The solution and technical architecture for intelligent garbage classification using deep learning aims to automate the process of garbage sorting by leveraging the power of deep learning algorithms. It involves the development of a system that can accurately classify different types of waste based on input images.



### 4.3 User Stories:

The user stories capture the needs and perspectives of different stakeholders involved in the intelligent garbage classification system. They provide a user-centric focus and guide the development process to deliver a solution that meets the specific requirements and expectations of each user group.

## 5.Coding and Solutioning:

### 5.1 Feature 1:

Description of the first feature implemented in the intelligent garbage classification, such as data collection from urban areas, villages etc.

```
#Python      File
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:\Garbage Classification Project\ibm_Garbage1.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',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]])    result
    return render_template('prediction.html',prediction=result)

```

```

""" Running our application """ if
_name_ == "_main_":
    app.run(debug=False,port=8000)

```

## 5.2 Feature 2:

Description of the second feature implemented in the intelligent garbage classification, such as deep learning model training or pre-trained model (VGG, Res-Net, or Inception).

### #index.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+058RXPxPg6fy4IWvTNh0E263XmFcJISAwIGgFAW/dAiS6JXm"
crossorigin="anonymous">
    <script src="https://code.jquery.com/jquery-3.2.1.slim.min.js" integrity="sha384-
KJ3o2DKtIkVYIK3UENzmM7KCKR/rE9/Qpg6aAZGJwFDMVNA/GpGFF93hXpG5KkN"
crossorigin="anonymous"></script>
    <script src="https://cdnjs.cloudflare.com/ajax/libs/popper.js/1.12.9/umd/popper.min.js"
integrity="sha384-ApNbgh9B+Y1QKtv3Rn7W3mgPxhU9K/ScQsAP7hUibX39j7fakFPskvXusvfa0b4Q"
crossorigin="anonymous"></script>

```

```
<script src="https://maxcdn.bootstrapcdn.com/bootstrap/4.0.0/js/bootstrap.min.js"
integrity="sha384-JZR6Spejh4U02d8jOt6vLEHfe/JQGiRRSQQxSfFWpi1MquVdAjyUar5+76PVCmYI"
crossorigin="anonymous"></script>
```

```
<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>
```

```
<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">
```

```

```

```
</div>
```

```
<div class="carousel-item">
```

```

```

```
</div>
```

```
<div class="carousel-item">
```

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```

```
</div>
```

```
<div class="carousel-item">
```

```

```

```
</div>
```

```
<div class="carousel-item">
```



```

        
    </div>
    </div>
    <a class="carousel-control-prev" href="#carouselExampleIndicators" role="button"
dataslide="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"
dataslide="next">
        <span class="carousel-control-next-icon" aria-hidden="true"></span>
        <span class="sr-only">Next</span>
    </a>
</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, wood, plastic, metal, glass, etc. The
            common way of managing waste is burning waste and this method can cause air pollution and some
            hazardous materials from the waste spread into the air which can cause cancer. Hence it is necessary
            to recycle the waste to protect the environment and human beings' health, and we need to separate
            the waste into different components which can be recycled using different ways. The present way of
            separating waste/garbage is the hand-picking method, whereby someone is employed to separate out
            the different objects/materials. The person who separates waste is prone to diseases due to the
            harmful substances in the garbage. This problem can be overcome by automating the garbage
            classification process.
        </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 where the user can upload a garbage
            image like paper waste, plastic waste, etc., and see the analyzed results on UserInterface.
        </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;">
  
<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 money on waste disposal
costs.</p>
</div>
</div>
<div class="card" style="width: 25rem;">
  
<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 bottles; and bottles and jars for food,
cosmetics and other products.</p>
</div>
</div>
<div class="card" style="width: 25rem;">
  
  <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, is one of the most recycled metals
on the planet. Lorem ipsum dolor sit amet.</p>

    </div>
  </div>
<div class="card" style="width: 25rem;">
  
  <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 ipsum dolor sit amet consectetur,
adipisicing elit.</p>

    </div>
  </div>
<div class="card" style="width: 25rem;">
  
  <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, wildlife habitat, and humans.</p>

    </div>
  </div>
<div class="card" style="width: 25rem;">
  
  <div class="card-body text-muted">
    <h5 class="card-title">Trash</h5>
    <p class="card-text">Trash, rubbish, or refuse is waste material that is discarded by humans,
usually due to a perceived lack of utility. Lorem ipsum dolor sit amet.</p>

```

```

        </div>
    </div>
</div>
</section>

<!-- Contact -->
<setion id="contact">
    <h3 class=" text-muted title">CONTACT US</h3>
    <div class="line"></div>
    <div class="contact-container">
        <div class="conatct-left">
            <div class="items">
                <i class="fas fa-map-pin fa-2x"></i>
                <h3 class=" text-muted">
                    Address
                </h3>
                <p>Lorem ipsum dolor sit amet consectetur adipisicing elit. Molestias, quae.</p>
            </div>
            <div class="items">
                <i class="fas fa-envelope fa-2x"></i>
                <h3 class="text-muted">
                    Enquiries
                </h3>
                <p>websupport@xyz.com</p>
            </div>
            <div class="items">
                <i class="fas fa-phone fa-2x"></i>
                <h3 class=" text-muted">
                    Call Us
                </h3>
                <p>+911234567890</p>
            </div>
        </div>
        <div class="contact-right">
            <h3 class=" text-muted">ENROLL TO OUR SERVICES</h3>
            <form>
                <input type="text" placeholder="Your Name"
name="name">
                <input type="email" placeholder="Email Adress"
name="email">
                <input type="text" placeholder="Phone Number"
name="phone">
                <button type="submit" class="btn-warning btn">Submit</button>
            </form>
        </div>
    </div>
</setion>
<section id="footer">
    <p>Copyright © 2021. All Rights Reserved</p>
    <div class="social">
        <a href="#" target="_blank"><i class="fab fa-2x fa-twitter-square"></i></a>

```

```

    <a href="#" target="_blank">
      <i class="fab fa-2x fa-linkedin"></i></a>
    <a href="#">
      <i class="#"></i>
    </a>
  </div>
</section>
</body>
</html>
#Prediction.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+058RXPxPg6fy4IWvTNh0E263XmFcJISAWiGgFAW/dAiS6JXm"
crossorigin="anonymous">
  <script src="https://code.jquery.com/jquery-3.2.1.slim.min.js" integrity="sha384-
KJ3o2DKtIkVYIK3UENzmM7KCKRr/rE9/Qpg6aAZGJwFDMVNA/GpGFF93hXpG5KkN"
crossorigin="anonymous"></script>
  <script src="https://cdnjs.cloudflare.com/ajax/libs/popper.js/1.12.9/umd/popper.min.js"
integrity="sha384-ApNbgh9B+Y1QKtv3Rn7W3mgPxhU9K/ScQsAP7hUibX39j7fakFPskvXusvfa0b4Q"
crossorigin="anonymous"></script>
  <script src="https://maxcdn.bootstrapcdn.com/bootstrap/4.0.0/js/bootstrap.min.js"
integrity="sha384-JZR6Spejh4U02d8jOt6vLEHfe/JQGiRRSQQxSfFWpi1MquVdAjYUar5+76PVCmYI"
crossorigin="anonymous"></script>

  <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/JScript.js"></script>
  <title>Prediction</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="index.html#about">About</a></li>
    <li><a href="index.html#services">Services</a></li>
    <li><a href="index.html#contact">Contact</a></li>
    <li><a href="prediction.html">Prediction</a></li>
  </ul>
</div>
</section>

```

```

</header>
<!-- dataset/Training/metal/metal326.jpg -->
<section id="prediction">
  <div class="prediction-input">
    <div class="circle">
      
    </div>
    <form id="form" action="/result" method="post" enctype="multipart/form-data">
      <input type="file" id="imageupload" name="image" accept="image/*"
class="inputimage">
      <input type="submit" class="submitbtn">
    </form>
  </div>
  <h3 class="title text-muted">
    THE PREDICTION IS
  </h3>
  <div class="line"></div>
  <div class="output-container">
    <div data-type="cardboard" class="output img1">
      
      <h3 class="text-muted">CARDBOARD</h3>
    </div>
    <div data-type="glass" class="output img2">
      
      <h3 class="text-muted">GLASS</h3>
    </div>
    <div data-type="metal" class="output img3">
      
      <h3 class="text-muted">METAL</h3>
    </div>
    <div data-type="paper" class="output img4">
      
      <h3 class="text-muted">PAPER</h3>
    </div>
    <div data-type="plastic" class="output img5">
      
      <h3 class="text-muted">PLASTIC</h3>
    </div>
    <div data-type="trash" class="output img6">
      
      <h3 class="text-muted">TRASH</h3>
    </div>

    <div class="hide" id="result">
      {{prediction}}
    </div>
  </div>

</section>
<section id="footer">
  <p>Copyright © 2021. All Rights Reserved</p>
  <div class="social">
    <a href="#"_blank"><i class="fab fa-2x fa-twitter-square"></i></a>

```

```

        <a href="#" target="_blank">
        <i class="fab fa-2x fa-linkedin"></i></a>
        <a href="#">
            <i class="fab fa-instagram-square fa-2x "></i>
        </a>
    </div>
</section>
</body>

```

</html> **#css**

```

:root{
    --main-bg-color: #fff;
    --text-color:#ced4da;
    --bs-font-sans-serif: Poppins, system-ui, -apple-system, "Segoe UI", Roboto, "Helvetica Neue", Arial,
    "Noto Sans", sans-serif, "Apple Color Emoji", "Segoe UI Emoji", "Segoe UI Symbol", "Noto Color
    Emoji";
    --navbar-bg:#333;
    --hover-color:#228B22;
    --yellow:#FFD700;
    --box-shadow:rgba(100, 100, 111, 0.2) 0px 7px 29px 0px
}

```

```

/* reset */
*{ margin:
0; padding:
0;
    box-sizing: border-box;
}
body{ background: var(--main-bg-
color); font-family: var(--bs-font-
sans-serif); color: #333;
    line-height: 1.6;
} ul{
    list-style:none;
} a{ text-decoration:
none;
    color: var(--text-color);
}

```

```

h1,h2{ font-
weight: 360; line-
height: 1.2;
}
p{
margin: 10px 0px;

}

```

```

.m2{
    margin-right: 10px;
}

```

```

/* utility */
.title{
    margin-top: 10px;
    text-align: center;
}
html {
    scroll-behavior: smooth;
}

/* Header */
#head #navbar{
    height: 100px; width: auto;
    background-color: var(--navbar-bg);
    color: #fff; padding: 10px;
}
#navbar{
    display: flex; justify-content:
space-between;
    align-items: center;
}
#navbar .nav--items ul{
    display: flex;
    align-items: center;
}

#navbar .nav--items ul li a{
    margin: 10px; text-decoration:
none;
}
#navbar .nav--items ul li a: hover{
    color: var(--hover-color) ;
}

/* header carousel */ #head
#slider .carousel-item img{
    display: block; width: 100%;
    height: 70vh;
}

.font{ font-size:
50px; font-
weight: bold;
color: #fff;
}

/* About */ #about
.top{ margin-top:
20px;
}

.line{ background-color: var(--
yellow); width: 200px; height:

```

```

2px; margin: auto; margin-
top: 10px;
}
#about .body{ margin-top:
20px; display: grid; grid-
template-columns: 1fr 1fr;
text-align: center;
}

#about .body .right,#about .body .left
{
    box-shadow: rgba(0, 0, 0, 0.15) 0px 3px 3px 0px;
margin: 0.5rem;
}

#about .body .right p{ justify-
self: center;
    margin-top: 50px;
}
/* Services */ #services
.testimonials{ display: grid; grid-
template-columns: 1fr 1fr 1fr;
grid-column-gap: 10px; grid-row-
gap: 20px; margin: 40px;
    justify-items: center;
}
#services .testimonials .card{ box-shadow:
rgba(0, 0, 0, 0.35) 0px 5px 15px;
text-align: center;
}

#services .testimonials .card h5{
text-transform: uppercase;
}

/* Contcat form */ #contact
.contact-container{
display: grid;
    grid-template-columns: repeat(2,1fr);
    justify-items: center;
margin: 3rem;
}
#contact .contact-container .conatct-left .items h3{
    display: inline;
    margin-left: 10px;
}

#contact .contact-container .conatct-left .items{
margin: 10px;
    margin-bottom: 30px;
}

```



```
#contact .contact-container .contact-right form input,
#contact .contact-container .contact-right form button
{
    display: block;
    margin: 20px
}
```

```
/* footer */
#footer {
    width: auto;
    height: 80px;
    background-color: var(--navbar-bg);
    color: #fff;    display: flex;    align-
items: center;
    justify-content: space-around;
}
#footer .social a{    margin-
left: 20px;
    text-decoration: none;
}
#footer .social a:hover{
    color: var(--hover-color);
}
/* prediction.html */
```

```
#prediction .prediction-input{
display: flex; align-items:
center; justify-content:
center;
    margin-top: 1.5rem;
}
#prediction .prediction-input form{    margin-
left: 1.2rem;
}
#prediction .circle {    width:
150px; height: 150px;
border-radius: 50%; margin-
bottom: 5px; box-shadow:var(--
box-shadow);
    transition:all ease-in 1s;
}
```

```
.output{    width: 200px;
margin: 10rem 1.5rem;
padding: 6px; text-
align: center;
    box-shadow: rgba(0, 0, 0, 0.35) 0px 5px 15px;
}
.output-container{
display: grid; row-gap:
10px;
    grid-template-areas: 'img1 img2 img3 img4 img5 img6';
}
```

```

}

/* Hidden class */
.hidden{
visibility: hidden;
}
.hide{ visibility:
hidden;
}

```

## #JAVASCRIPT

```

'use strict'
const demo = document.querySelector('#demo'); const imageUpload
= document.getElementById('imageupload'); const dataAttributeEL =
document.querySelectorAll(`div[data-type]`); const displayAll =
function () { dataAttributeEL.forEach(el => {
    el.classList.remove('hidden')
  })
}

```

```

imageUpload.addEventListener('change', (event) => {
const fileList = event.target.files[0];

```

```

    //console.log(URL.createObjectURL(fileList));
    if (fileList) {
        demo.src =URL.createObjectURL(fileList);
    }
    displayAll();

```

```

});

```

```

const prediction = document.querySelector('#result') dataAttributeEL.forEach(el
=> {
    if (el.dataset.type !== prediction.innerHTML.trim()) {
    el.classList.add('hidden')
    };
})

```

## 6. Results:

### Performance Metrix:

Evaluation of the intelligent garbage classification using relevant metrics such as accuracy, precision, recall and f1 score. Comparison with the existing garbage classification methods to showcase the effectiveness of the deep learning approach.

```
+ Code + Text
model.summary()
Model: "sequential"
Layer (type) Output Shape Param #
-----
conv2d (conv2D) (None, 126, 126, 32) 896
max_pooling2d (MaxPooling2D) (None, 63, 63, 32) 0
conv2d_1 (conv2D) (None, 63, 63, 64) 18496
max_pooling2d_1 (MaxPooling (None, 31, 31, 64) 0
2D)
conv2d_2 (conv2D) (None, 25, 25, 32) 18464
max_pooling2d_2 (MaxPooling (None, 14, 14, 32) 0
2D)
conv2d_3 (conv2D) (None, 14, 14, 32) 9248
max_pooling2d_3 (MaxPooling (None, 7, 7, 32) 0
2D)
flatten (Flatten) (None, 1568) 0
dense (Dense) (None, 156) 235356
dense_1 (Dense) (None, 68) 18268
dense_2 (Dense) (None, 8) 414
-----
Total params: 293,136
Trainable params: 293,136
Non-trainable params: 0

Activate Windows
Go to Settings to activate Windows.
✓ Os completed at 11:44 AM
```

```
+ Code + Text
epoch_size
2/32 [=====] - 61s 2s/step - loss: 0.9052 - acc: 0.6576 - val_loss: 1.1862 - val_acc: 0.5625
Epoch 27/30
2/32 [=====] - 59s 2s/step - loss: 0.8967 - acc: 0.6700 - val_loss: 1.2840 - val_acc: 0.5339
Epoch 28/30
2/32 [=====] - 60s 2s/step - loss: 0.8053 - acc: 0.7065 - val_loss: 1.3371 - val_acc: 0.5052
Epoch 29/30
2/32 [=====] - 59s 2s/step - loss: 0.7855 - acc: 0.6971 - val_loss: 1.2713 - val_acc: 0.5288
Epoch 30/30
2/32 [=====] - 60s 2s/step - loss: 0.7881 - acc: 0.7004 - val_loss: 1.1886 - val_acc: 0.5391
Epoch 21/30
2/32 [=====] - 59s 2s/step - loss: 0.7482 - acc: 0.7213 - val_loss: 1.2187 - val_acc: 0.5807
Epoch 22/30
2/32 [=====] - 60s 2s/step - loss: 0.7163 - acc: 0.7351 - val_loss: 1.2203 - val_acc: 0.5755
Epoch 23/30
2/32 [=====] - 60s 2s/step - loss: 0.7429 - acc: 0.7321 - val_loss: 1.1206 - val_acc: 0.6016
Epoch 24/30
2/32 [=====] - 60s 2s/step - loss: 0.6485 - acc: 0.7553 - val_loss: 1.1445 - val_acc: 0.6094
Epoch 25/30
2/32 [=====] - 62s 2s/step - loss: 0.5935 - acc: 0.7726 - val_loss: 1.2991 - val_acc: 0.6036
Epoch 26/30
2/32 [=====] - 59s 2s/step - loss: 0.6107 - acc: 0.7667 - val_loss: 1.1727 - val_acc: 0.6068
Epoch 27/30
2/32 [=====] - 60s 2s/step - loss: 0.6064 - acc: 0.7741 - val_loss: 1.2812 - val_acc: 0.5573
Epoch 28/30
2/32 [=====] - 59s 2s/step - loss: 0.5207 - acc: 0.8041 - val_loss: 1.4542 - val_acc: 0.5859
Epoch 29/30
2/32 [=====] - 60s 2s/step - loss: 0.5426 - acc: 0.8032 - val_loss: 1.2504 - val_acc: 0.5921
Epoch 30/30
2/32 [=====] - 59s 2s/step - loss: 0.5077 - acc: 0.8032 - val_loss: 1.3314 - val_acc: 0.5729

[20] model.save('garbage1.h5')

[21] import numpy as np
from tensorflow.keras.models import load_model
from tensorflow.keras.preprocessing import image
model = load_model('content/garbage1.h5')

Activate Windows
Go to Settings to activate Windows.
✓ Os completed at 11:44 AM
```

## 7. Advantages and Disadvantages:

## 7.1 Advantages:

**Enhanced Environmental Sustainability:** By facilitating proper waste categorization intelligent garbage classification promotes environmentally sustainable practices. It helps divert recyclable materials from landfills, reduces contamination in recycling streams, and encourages responsible waste management behaviours.

**Real-Time Decision-Making:** The speed and efficiency of deep learning models enable real-time classification, allowing immediate decisions on waste categorization. This capability supports waste management personnel in making prompt sorting decisions, leading to improved operational effectiveness.

## 7.2 Disadvantages:

**Data Dependency:** Deep learning models heavily rely on large and diverse datasets for training. Acquiring and annotating a comprehensive garbage image dataset can be time-consuming, costly, and challenging, particularly for rare or emerging waste categories.

**Vulnerability to Adversarial Attacks:** Deep learning models can be susceptible to adversarial attacks, where maliciously crafted inputs can cause misclassifications or exploit model vulnerabilities. This poses potential risks in garbage classification systems, as adversaries could manipulate waste items to evade proper categorization.

## 8. Conclusion:

In conclusion, intelligent garbage classification using deep learning offers significant potential to revolutionize waste management practices. By leveraging advanced machine learning techniques, this approach enables automated and accurate identification and categorization of different types of waste. The advantages of this technology include improved accuracy, increased efficiency, scalability, adaptability to new waste categories, and enhanced environmental sustainability.

## 9. Future Scope:

The future advancements and developments in intelligent garbage classification using deep learning have the potential to revolutionize waste management practices, increase recycling rates, and contribute to a more sustainable and environmentally conscious society.

### 9.1 Enhanced Accuracy:

Continued research and development in deep learning algorithms can lead to even higher accuracy rates in garbage classification. This includes refining existing models, exploring new architectures, and leveraging advancements in computer vision and neural networks.

### 9.2 Integration with Robotics:

Deep learning-based garbage classification systems can be integrated with robotic systems to automate waste sorting processes. Robotic arms or conveyors equipped with sensors and cameras can work in conjunction with the intelligent classification system to sort and separate waste items efficiently.

### 9.3 Integration with Waste Sorting Facilities:

Intelligent garbage classification systems can be integrated with waste sorting facilities to automate and optimize the sorting process. This integration can improve efficiency, reduce human error, and enhance the overall effectiveness of waste management operations.

The further advancements and exploration in intelligent garbage classification using deep learning. Continued research, development, and collaboration can lead to more accurate, efficient, and sustainable waste management practices, contributing to a cleaner and greener future.

## 10. Appendix:

The source code, GitHub repository link, and a link to the project demonstration for further reference and access to the garbage classification.

**Project Demo Video Link:** <https://youtu.be/tLmY2S-43zw>

**GitHub Link:** <https://github.com/naanmudhalvan-SI/PBL-NT-GP--19520-1682578278/tree/main>