Project Report Format

Date	20 may 2023
Team ID	NM2023TMID17565
Project Name	Intelligent Garbage Classification on using Deep learning

1. **INTRODUCTION**

1.1 Project Overview

According to the next 25 years, the less developed countries' waste accumulation will increase drastically. With the increase in the number of industries in the urban area,the disposal of the solid waste is really becoming a big problem, and the 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.

1.2 Purpose

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. With this in mind, it motivated us to develop an automated system which is able to sort the waste. and this system can take a short time to sort the waste, and it will be more accurate in sorting than the manual way. With the system in place, the beneficial separated waste can still be recycled and converted to energy and fuel for the growth of the economy. The system that is developed for the separation of the accumulated waste is based on the combination of Convolutional Neural Network

2. IDEATION & PROPOSED SOLUTION

2.1 Problem Statement Definition

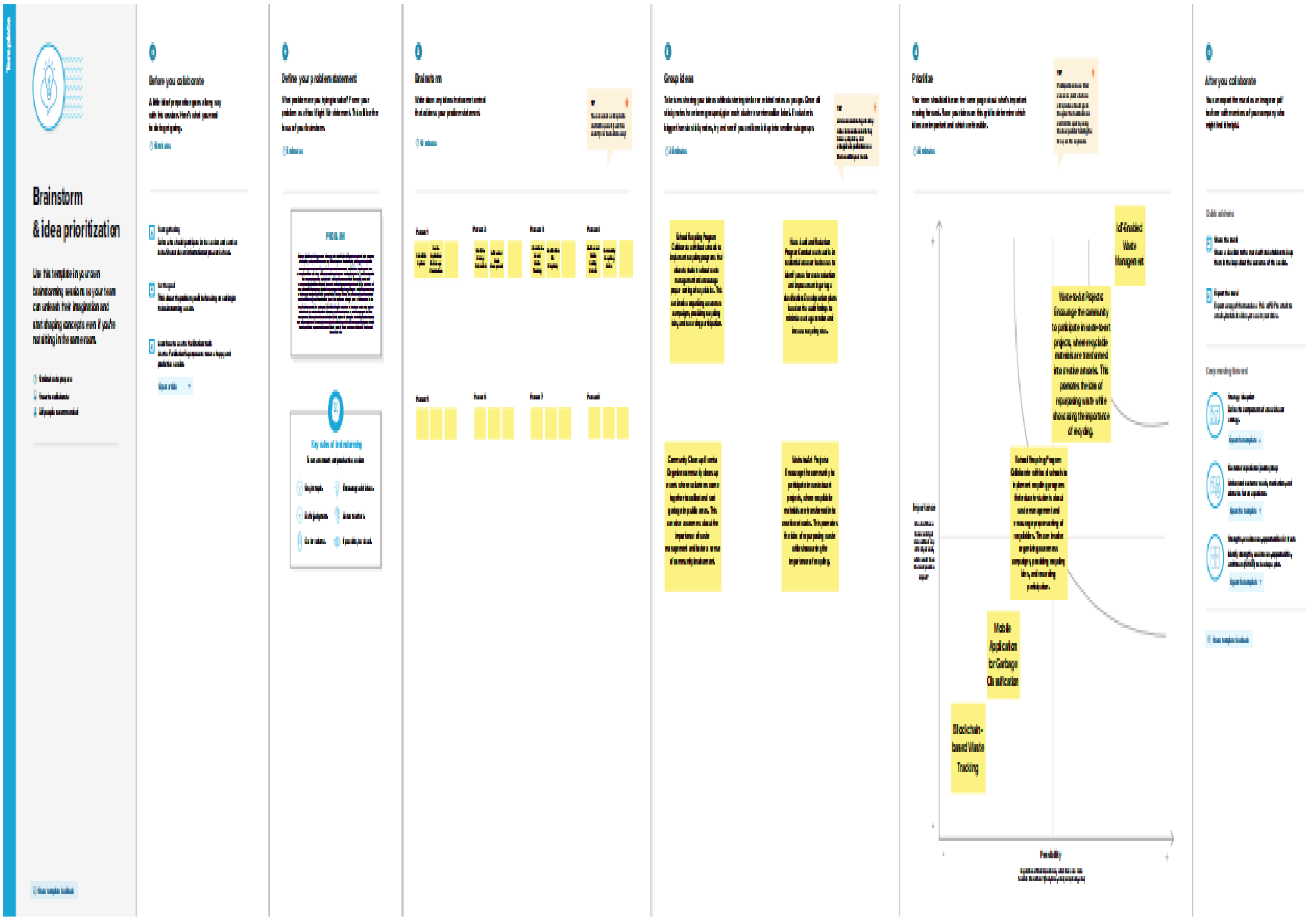
The present way of separating waste/garbage is the hand-picking method, whereby someone is employed to separate out the different objects/materials. The person who separates waste, is prone to diseases due to the harmful substances in the garbage. Hence our aim is to improve waste management practices, reduce environmental impact, and promote recycling efforts.Deep learning, a subset of machine learning, involves training artificial neural networks with multiple layers to extract features and learn complex patterns from large datasets. When applied to garbage classification, deep learning models can analyze images or sensor data to identify and categorize different types of waste.

Example:

Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	Residents	maintain a healthy body	am falling sick often	stagnation of harmful wastes	Scared
PS-2	trying to do their job	harmful chemicals	leading to health	complications	feel scared

2.2 Empathy Map Canvas

2.3 Ideation & Brainstorming



2.4 Proposed Solution

The system is developed for the separation of the accumulated waste is based on the combination of Convolutional Neural Network
If more number of data sets are provided then the accuracy can be increased further and better results can be obtained

3. REQUIREMENT ANALYSIS

3.1 Functional requirement

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Input data acquisition	The system should be able to receive input data in the form of images or sensor data representing garbage items. It should support various input sources such as cameras, sensors, or file uploads
FR-2	Pre processing	The system should pre process the input data to prepare it for the deep learning model. This may involve resizing images, normalizing pixel values, and applying other transformations to ensure consistent and standardized input
FR-3	Model training and prediction	The system should train a deep learning model on a labeled dataset of garbage images or sensor data to learn patterns and features for classification. It should then be able to predict the waste type or category based on new input data.
FR-4	Classification accuracy	The system should have a high level of accuracy in classifying different types of waste. It should be able to handle a wide range of waste materials, including but not limited to plastic, glass, paper, metal, and organic waste.
FR-5	Real-time processing	The system should be capable of processing input data and providing classification results in real-time or near real-time to ensure efficient garbage sorting.

3.2 Non-Functional requirements

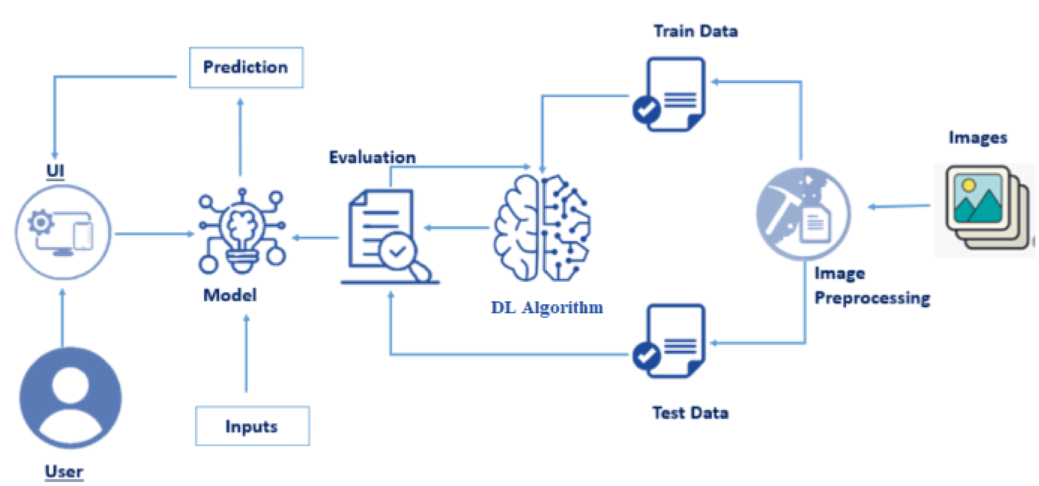
Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	Usability	The system should have a user-friendly interface that is intuitive and easy to use. It should require minimal training or technical expertise for users to interact with the system effectively. Clear and informative visualizations of classification results can enhance usability.
NFR-2	Security	The system should ensure the security and privacy of the data it processes. It should implement measures to protect sensitive information, prevent unauthorized access, and comply with relevant data protection regulations.
NFR-3	Reliability	The system should be reliable, with high availability and minimal downtime. It should have built-in mechanisms for fault tolerance, error recovery, and system monitoring to detect and address any issues promptly.
NFR-4	Performance	The system should be able to process and classify garbage items within an acceptable timeframe, ensuring real-time or near real-time results. It should have low latency and high throughput to handle a large volume of input data. The system should be designed to handle increasing data volumes and user loads. It should be able to scale horizontally or vertically to accommodate growing demands without compromising performance or accuracy.

NFR-5	Availability	**The system should be designed with redundancy and fault tolerance mechanisms to minimize downtime and ensure uninterrupted operation. This can include deploying the system across multiple servers or using load balancing techniques to distribute the workload.**
NFR-6	Scalability	**The system should be designed to handle increasing data volumes and user loads. It should be able to scale horizontally or vertically to accommodate growing demands without compromising performance or accuracy.**

4. PROJECT DESIGN

4.1 Data Flow Diagrams & Solution & Technical Architecture



- DL Algorithm - CNN (Convolutional Neural Network)
- Images - Data sets that are used

4.2 User Stories

User Type	User Story Number	User Story / Task	Acceptance criteria
Customer (Mobile user)	USN-1	As a homeowner, I want to have a user-friendly mobile app that allows me to take pictures of garbage items and receive real-time classification results, helping me make informed decisions about recycling and waste disposal.	The mobile app should be available for both iOS and Android platforms.
	USN-2	As a waste collection truck driver, I want a user-friendly interface on the truck's onboard system that provides real-time guidance on which bins to place collected garbage items, optimizing my collection route and reducing sorting errors.	The onboard system should have a clear and intuitive interface, easily accessible to the truck driver during garbage collection rounds.
Customer (Web user)		As a customer web user, I want to have a seamless experience on the website for accessing information about the garbage classification system and submitting feedback or inquiries.	The website should have a user-friendly interface with clear navigation and intuitive design.
Customer Care Executive		As a customer care executive, I want a customer management system that allows me to efficiently handle customer inquiries, track feedback, and provide timely responses.	The customer management system should have a user-friendly interface for customer care executives to log in and access customer inquiries and feedback.
Administrator		As a system administrator, I want to receive automatic alerts and notifications whenever the system experiences downtime or encounters critical errors, so I can quickly address the issues and minimize service disruptions.	The system should send email or push notifications to the system administrator when system downtime exceeds 5 minutes.

5. CODING & SOLUTIONING

5.1 Feature 1

```
from tensorflow.keras.preprocessing.image import ImageDataGenerator
```

- ImageDataGenerator: The ImageDataGenerator is a class in the tensorflow.keras.preprocessing.image module that generates batches of augmented image data in real-time during model training.
- Keras: Keras is a high-level neural network API written in Python that allows for fast experimentation and prototyping of deep learning models.
- image: from tensorflow.keras.preprocessing import image imports the image module from Keras' tensorflow.keras.preprocessing package. This module provides a number of image preprocessing utilities, such

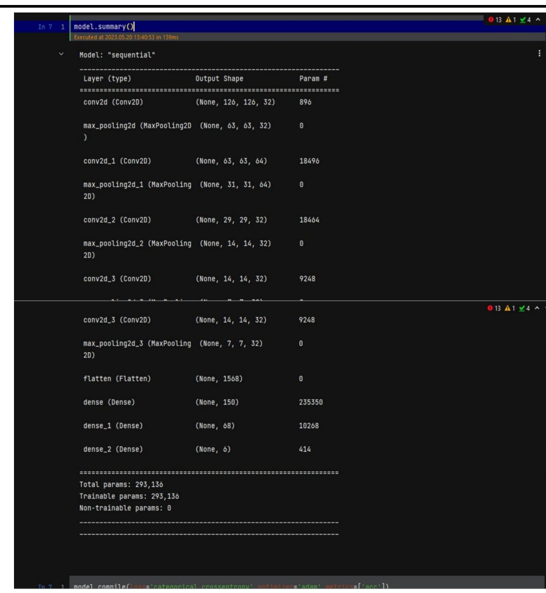
as loading images, converting images to arrays, and applying various image transformations.

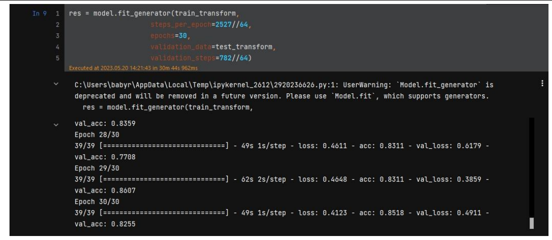
5.2 Feature 2

Predicts the type of garbage and shows its type.

6. RESULTS

6.1 Performance Metrics

S.No.	Parameter	Values	Screenshot
1.	Model Summary	-	

2.	Accuracy	Training Accuracy - 0.8518 Validation Accuracy - 0.8255	

7. ADVANTAGES & DISADVANTAGES

Advantages:

Improved accuracy: Deep learning algorithms can effectively analyze and classify garbage items based on their visual features, leading to higher accuracy compared to traditional methods. This can result in better waste management and recycling processes.

Automation: Deep learning models can automate the garbage classification process, reducing the need for manual sorting. This can save time, effort, and costs associated with human labor.

Scalability: Deep learning models can handle large volumes of data and scale well, making them suitable for processing a high number of garbage items quickly. This scalability is crucial in urban areas with dense populations and large amounts of waste.

Adaptability: Deep learning models can adapt and learn from new data, allowing them to improve their classification accuracy over time. This adaptability makes them capable of handling variations in garbage items and evolving waste streams.

Disadvantages:

Data requirements: Deep learning models rely on large amounts of labeled training data to achieve high accuracy. Collecting and annotating such data can be time-consuming and expensive, especially for niche or specialized garbage items.

Model complexity: Deep learning models, particularly deep neural networks, can be complex and computationally intensive. Training and deploying these models may require significant computational resources and expertise, which can pose challenges for some organizations or regions with limited resources.

Lack of interpretability: Deep learning models often operate as black boxes, making it difficult to understand the exact reasons behind their classification decisions. This lack of interpretability can hinder trust and acceptance, especially in critical applications such as waste management.

Environmental impact: Deep learning models typically require powerful hardware infrastructure, which consumes significant amounts of energy. This energy consumption contributes to the carbon footprint and environmental impact associated with deep learning systems.

Limited context awareness: Deep learning models primarily rely on visual features for garbage classification. They may struggle to account for contextual information, such as the composition, weight, or chemical properties of garbage items. This limitation can affect the accuracy and effectiveness of classification, particularly when dealing with complex waste materials.

8. CONCLUSION

In conclusion, intelligent garbage classification using deep learning offers several advantages and disadvantages. The application of deep learning algorithms in waste management can improve accuracy, automate the classification process, and scale to handle large volumes of data. These benefits contribute to efficient waste sorting and recycling practices. However, challenges such as data requirements, model complexity, lack of interpretability, environmental impact, and limited context awareness should be considered. Despite these challenges, ongoing advancements in deep learning techniques aim to overcome these limitations and improve the effectiveness of intelligent garbage classification systems. As further research and development take place, the potential for deep learning to revolutionize waste management and contribute to a more sustainable future remains promising.

9. FUTURE SCOPE

The future scope for intelligent garbage classification using deep learning is vast and holds significant potential.

- Enhanced accuracy: Continued research and development in deep learning algorithms can lead to even higher accuracy in garbage classification. Techniques such as transfer learning, ensemble methods, and advanced neural network architectures can be explored to improve classification performance.

- Real-time monitoring: Integrating intelligent garbage classification systems with IoT (Internet of Things) sensors and devices can enable real-time monitoring of waste streams. This can provide valuable data on waste generation patterns, optimize collection routes, and facilitate proactive waste management strategies.

- Mobile applications: Developing mobile applications that utilize deep learning models for garbage classification can empower individuals to make informed recycling decisions. Users can simply capture an image of an item and receive instant feedback on how to properly dispose of it, promoting widespread participation in recycling efforts.

- Waste composition analysis: Deep learning models can be employed to analyze the composition of waste, including identifying hazardous materials or contaminants. This information can guide recycling processes and help optimize resource recovery from different waste streams.

- Robotics and automation: Integrating deep learning with robotic systems can enable automated sorting of garbage items in recycling facilities. Robots equipped with vision systems can efficiently identify and separate various types of waste, leading to increased processing speed and accuracy.
- Continuous learning and adaptation: Deep learning models can be designed to continually learn and adapt to new waste materials, variations in packaging, and evolving recycling guidelines. This adaptability can ensure that the classification system remains up to date and effective in handling changing waste compositions.

10. APPENDIX

Source Code

https://drive.google.com/drive/folders/1b5I-DFWSM_e2NZCXW6Lwy-r0iG2NYxL4?usp=sharing

GitHub & Project Video Demo Link

https://github.com/naanmudhalvan-SI/PBL-NT-GP--2703-1680616747

https://drive.google.com/drive/folders/1qlXGlX-yKkX_FdrEhKHWAq92tjkAqpfp?usp=sharing