VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"Jnana Sangama", Belgavi-590 018, Karnataka, India

A Report
On

"Tracking Waste Disposal and Generation of Fine to control and promote proper waste segregation"

Submitted in Partial Fulfillment of the requirements for the award of the degree of

BACHELOR OF ENGINEERING

IN

COMPUTER SCIENCE AND ENGINEERING

Submitted By

KAVYASHREE K S	**1SJ20CS068**
KEERTHANA S	**1SJ20CS069**
NAGASHREE C R	**1SJ20CS092**
NAVYA L	**1SJ20CS094**

Carried out at
B G S R&D Centre,
Dept of CSE,
SJCIT

Under the guidance of
Prof. Ashok K N
Assistant Professor
Dept. of CSE, SJCIT

SJC INSTITUTE OF TECHNOLOGY
DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
Chickaballapur-562101

2023-2024

||Jai Sri Gurudev||

Sri Adichunchanagiri Shikshana Trust®

SJC INSTITUTE OF TECHNOLOGY, Chickballapur - 562101
Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the project work entitled **"Tracking Waste Disposal and Generation of Fine to control and promote proper waste segregation"** is a Bonafide work carried out by **KAVYASHREE K S(1SJ20CS068), KEERTHANA S(1SJ20CS069), NAGASHREE C R(1SJ20CS092), NAVYA L(1SJ20CS094)** in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering of Visvesvaraya Technological University, Belagavi** during the year **2023-2024.** It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report. The project report has been approved as it satisfies the academic requirements with respect to the project work prescribed for the Bachelor of Engineering degree.

…………………………..	…………………………….	…………………………..
Signature of Guide	Signature of HoD	Signature of Principal
Prof. Ashok K N	**Dr. Manjunatha Kumar B H**	**Dr. G T Raju**
Assistant Professor	Professor and HoD	Principal, SJCIT,
Dept. of CSE, SJCIT	Dept. of CSE, SJCIT	Chickballapur

External Examiners:

Name of the Examiners	**Signature with Date**
1…………………………………	…………………………………
2………………………………….	…………………………………

DECLARATION

We **Kavyashree K S(1SJ20CS068), Keerthana S(1SJ20CS069), Nagashree C R(1SJ20CS092), Navya L(1SJ20CS094)** Students of VIII semester B.E in Computer Science and Engineering at S J C Institute of Technology, Chickballapur, hereby declare that this dissertation work entitled "TRACKING WASTE DISPOSAL AND GENERATION OF FINE TO CONTROL AND PROMOTE PROPER WASTE SEGREGATION" has been carried out at B G S R&D Centre, Dept. of CSE, SJCIT under the guidance of guide Prof. Ashok K N, Assistant Professor, Dept. of CSE, SJC Institute of Technology, Chickballapur and submitted in the partial fulfilment for the award of degree Bachelor of Engineering in Computer Science and Engineering of Visvesvaraya Technological University, Belagavi during the academic year 2023-2024. We further declare that the report had not been submitted to another university for the award of any other degree.

Place: Chickballapur

Date :

KAVYASHREEE K S(1SJ20CS068)

KEERTHANA S(1SJ20CS069)

NAGASHREE C R(1SJ20CS092)

NAVYA L(1SJ20CS094)

ABSTRACT

Metropolitan cities in India generate approximately 10 million tons of waste annually. If left untreated, this waste can lead to pollution. Due to a lack of awareness and inadequate enforcement of waste segregation rules, many people fail to segregate their household waste properly. To address this issue, we propose a solution where waste is pre-segregated as biodegradable and non-biodegradable. When dumping waste into bins, users capture an image, which is then uploaded for analysis to determine the percentage of biodegradable and non-biodegradable substances. If waste is deposited in the wrong bin or segregated improperly, fines are imposed. For instance, if non-biodegradable waste exceeds a threshold of 5% when deposited in the biodegradable waste bin, or vice versa, fines are applied. We set a fine of ₹2 for each percentage point exceeding the threshold. We utilize CNN algorithms to accurately classify the images, enabling effective implementation of our solution.

ACKNOWLEDGEMENT

With reverential pranam, we express our sincere gratitude and salutations to the Lotus feet of his holiness **Paramapoojya Jagadguru Byravaikya Padmabhushana Sri Sri Sri Dr. Balagangadharanatha Maha Swamiji,** his holiness **Paramapoojya Jagadguru Sri Sri Sri Dr. Nirmalanandanatha Maha Swamiji, and Sri Sri Mangalanatha Swamiji ,** Sri Adichunchanagiri Mutt for their unlimited blessings.

First and foremost we wish to express our deep sincere feelings of gratitude to our institution, **Sri Jagadguru Chandrashekaranatha Swamiji Institute of Technology,** for providing us an opportunity for completing the Project Work Phase-II successfully.

We extend our sincere gratitude to **Dr. G T Raju**, **Principal, SJC Institute of Technology, Chickballapur**, for providing an opportunity to complete the Project Work Phase-II.

We extend special in-depth, heartfelt, and sincere gratitude to **Dr. Manjunatha Kumar B H, Head of the Department, Computer Science and Engineering, SJC Institute of Technology, Chickballapur,** for his constant support and valuable guidance of the Project Work Phase-II.

We convey our sincere thanks to Project Guide **Prof. Ashok K N, Assistant Professor, Department of Computer Science and Engineering, SJC Institute of Technology,** for his constant support, valuable guidance and suggestions of the Project Work Phase-II.

We also feel immense pleasure to express deep and profound gratitude to Project Co-ordinators **Dr. Shrihari M R, Dr. Seshaiah M , Associate Professors, Department of Computer Science and Engineering, SJC Institute of Technology,** for the direction and recommendations throughout the Project Work.

Finally, we would like to thank all faculty members of Department of Computer Science and Engineering, SJC Institute of Technology, Chickaballapur for their support.

We extend our heartfelt gratitude to our parents for their unwavering support, encouragement, and understanding throughout this project work.

We also thank all those who extended their support and co-operation while bringing out this Project Work Phase-II.

KAVYASHREE K S(1SJ20CS068)
KEERTHANA S(1SJ20CS069)
NAGASHREE C R(1SJ20CS092)
NAVYA L(1SJ20CS094)

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER – 1

INTRODUCTION

1.1 Overview

Waste management stands as one of the most pressing global challenges, especially in regions experiencing rapid urbanization, such as India. This South Asian nation, with its burgeoning population and expanding urban areas, faces significant hurdles in effectively managing its waste streams. The magnitude of the issue is evident from the staggering daily production of Municipal Solid Waste (MSW), estimated at approximately 133,760 tonnes. Such a vast volume of waste necessitates efficient waste management systems to address environmental pollution, mitigate health risks, and prevent resource depletion.

Despite commendable progress in various social, economic, and environmental sectors, India's waste management landscape remains fraught with challenges. Outdated practices contribute to insufficient waste collection and treatment, exacerbating environmental pollution and public health hazards. One of the key players in waste management is the informal sector, which plays a significant role in waste recovery. However, despite its contributions, approximately 90% of residual waste ends up improperly dumped, further deteriorating environmental quality and posing risks to public health.

Addressing India's waste management challenges requires a multifaceted approach that integrates technological innovation, policy reforms, and community engagement. Developing robust waste management systems capable of efficiently collecting, treating, and disposing of waste is essential. Additionally, promoting awareness and behavioral changes among citizens to encourage proper waste segregation and disposal practices is crucial. Leveraging the potential of the informal sector while implementing regulatory frameworks to ensure environmental sustainability and public health protection is also imperative.

1.2 Problem Statement

Inadequate waste disposal practices and a lack of effective monitoring systems contribute to the improper segregation of waste, leading to environmental pollution and health hazards in communities. The absence of stringent measures to track waste generation and enforce fines for non-compliance further exacerbates the challenges of managing waste effectively, hindering efforts to promote proper waste segregation and sustainable waste management practices.

1.3 Significance and Relevance of work

The significance and relevance of our work lie in addressing critical environmental and public health challenges associated with improper waste management practices. By implementing effective waste tracking systems and enforcing fines for non-compliance, we aim to promote proper waste segregation and encourage sustainable waste management behaviors. This initiative is essential for reducing environmental pollution, mitigating health risks, and fostering a cleaner and healthier living environment for communities. Additionally, our project aligns with global efforts to achieve sustainable development goals related to environmental conservation and public health promotion. By raising awareness and incentivizing responsible waste disposal practices, we contribute to building more resilient and environmentally sustainable societies for present and future generations.

1.4 Objectives

- Implementing a robust waste tracking system to monitor waste generation and disposal activities accurately.
- Developing an efficient mechanism for identifying instances of improper waste segregation and non-compliance with waste management regulations.
- Enforcing fines for violations of waste management protocols to incentivize proper waste segregation practices.
- Promoting awareness and education campaigns to inform communities about the importance of proper waste disposal and the consequences of non-compliance.
- Collaborating with local authorities and stakeholders to establish effective waste management policies and regulations.
- Continuously refining and optimizing our waste tracking and enforcement strategies based on feedback and lessons learned from implementation.

1.5 Methodology

The methodology for our project entails the following key steps, as illustrated in Fig. 1:

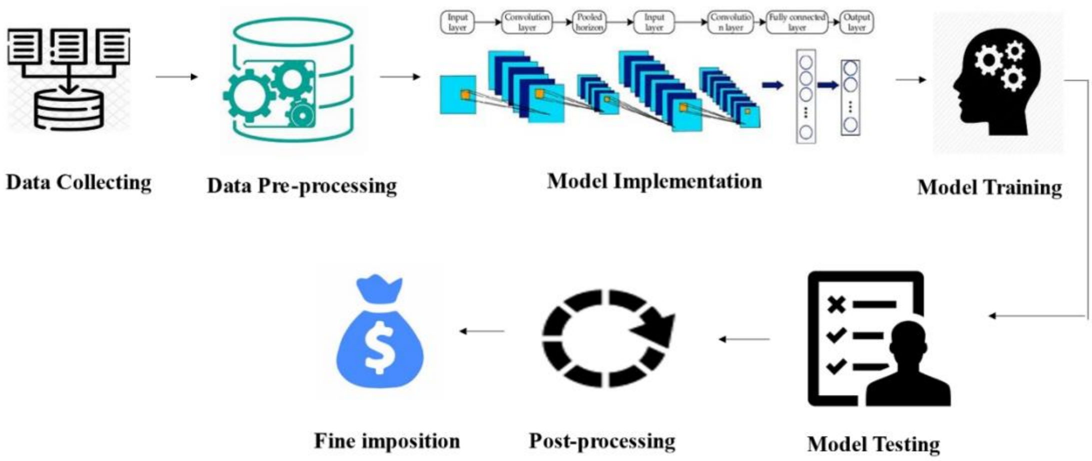


Fig.1.5.1 Work flow Diagram

A. Dataset Collection:

Acquire a comprehensive dataset comprising pre-segregated waste images, encompassing both biodegradable and non-biodegradable materials.

Ensure the dataset is sufficiently diverse and representative of real-world waste scenarios to facilitate accurate classification.

B. Dataset Preprocessing:

Augment the acquired dataset to address class imbalances and enhance model generalization.

Apply preprocessing techniques such as resizing and normalization to prepare the images for model input.

C. Model Implementation:

Our model employs a Convolutional Neural Network (CNN) architecture, comprising convolutional, pooling, and fully connected layers. The convolutional layer extracts features from input images through learnable filters, producing feature maps. Pooling layers reduce feature map dimensionality, while fully connected layers transform the output into a vector for classification. Techniques like dropout prevent overfitting.

The CNN's layered structure mimics human brain processing, with each layer contributing to pattern recognition. By sliding filters across input volumes, the convolutional layer computes dot products to detect spatial patterns. Pooling layers then select important features, reducing computational complexity for efficient classification.

D. Training and Testing:

Train the CNN model on the augmented dataset to learn discriminative features for distinguishing between biodegradable and non-biodegradable waste.

Evaluate the trained model's performance using a separate testing dataset to assess its accuracy, precision, recall, and F1 score.

E. Post-processing:

Implement post-processing techniques to refine the model's output and ensure coherent classification results.

Conduct percentage analysis to accurately determine the proportions of biodegradable and non-biodegradable waste in the classified images.

F. Fine Imposition:

Establish a mechanism for imposing fines on instances of incorrect waste disposal based on the model's classification results.

Define thresholds for fine imposition and calculate fine amounts based on the percentage of misclassified non-biodegradable waste.

1.6 Organization of the Project

The report is structured into nine distinct sections, each contributing to a comprehensive understanding of the project. Here's a breakdown of each section:

Introduction (Chapter 1): Offers an overview of the project's objectives and identifies existing problems within the waste management system. Explains the significance and relevance of the project in addressing identified issues and improving waste management practices.

Literature Survey (Chapter 2): Provides a concise overview of relevant IEEE papers and other journal articles that serve as foundational references for the project implementation.

System Requirements Specification (Chapter 3): Details the hardware and software prerequisites necessary for implementing the project effectively.

System Design (Chapter 4): Defines the architectural framework, software components, and data structures essential for the project's functionality and fulfillment of operational requirements.

Implementation (Chapter 5): Elaborates on the model's concept, algorithms, and underlying methodologies guiding its operation.

Testing (Chapter 6): Outlines the methodologies and test cases employed to verify the model's functionality and ensure it produces expected results consistently.

System Analysis (Chapter 7): Evaluates the limitations of the existing waste management system and proposes improvements offered by the project's solution, highlighting its advantages.

Performance Analysis (Chapter 8): Presents quantitative data and analysis to assess the effectiveness and efficiency of the implemented solution.

Conclusion and Future Enhancements (Chapter 9): Summarizes the project's key findings, achievements, and implications. Suggests potential avenues for future enhancements or updates to further improve the model's effectiveness and adaptability. Additionally, the bibliography section contains references to all cited papers and sources mentioned in the literature survey, providing readers with further resources for in-depth exploration of the subject matter.

CHAPTER – 2

LITERATURE SURVEY

Ms. R. Pushpakalambiga atal [1] published a paper "Biodegradable and Non-Biodegradable waste management" emphasizes on the management of biodegradable and non-biodegradable waste in India. It highlights the environmental problems caused by plastic waste and household waste, which are major sources of pollution. The paper concentrates the importance of proper waste disposal and the need for awareness and education among individuals. The three R's - Recycle, Reuse, and Reduce - are recommended as simple steps that can be taken to contribute to waste management and environmental protection.

Ipek Atik [2] released a paper "Analysis of Biodegradable and Non-Biodegradable materials using selected Deep Learning Algorithm". The study aims to efficiently classify waste materials in order to identify, track, sort, and process them. Biodegradable materials can naturally decay and be refined into humus, while non-biodegradable materials do not naturally degrade and can only be recycled by changing them into new materials. The study uses different deep learning algorithms such as AlexNet, ShuffleNet, SqueezeNet, and GoogleNet to categorize images of biodegradable and non-biodegradable materials. A dataset consisting of 5430 images, including 2794 biodegradable images and 2634 non-biodegradable images, is used for training, validation, and testing. The effectiveness of the algorithms is assessed using parameters such as error rate, precision, sensitivity, and F-measure. The results show that Shuffle Net achieves the highest classification accuracy of 98.73%. The proposed study illustrates higher success rates compared to previous studies in classifying materials. This study contributes to the effective separation and processing of waste materials, which can have a optimistic impact on the environment and economy.

Arghadeep Mitra [3] proposed paper "Detection of waste materials using Deep Learning and Image Processing". The project focuses on waste management and proposes the use of object detection software for waste classification and identification. The document mentions the use of the Faster R-CNN model for detecting multiple objects in an image, as it has a higher accuracy rate compared to other deep learning models. The methodology used in the project is briefly explained, and the document concludes with experimental results and future work.

Menaka S [4] proposed the paper “Machine Learning approach for Prediction and Separation of Biodegradable and Non-Biodegradable waste”. The Study proposes a physical approach using a Deep Learning structure for waste segregation, aiming to address the challenges of waste identification and removal. The study utilizes the Improved Faster Recurrent Convolutional Neural Network (IFRCNN) to develop an intelligent smart bin system that can accurately categorize waste into biodegradable and non-biodegradable types. The proposed method achieves a precision ranging from 96.23% to 98.15%, making it more accurate than the current state-of-the-art technology. Additionally, the paper evaluates different deep learning models, including VGG-16, InceptionNet, ResNet, and AlexNet, to train and assess the performance of the proposed approach.

Haruna Abdu Atal [5] proposed paper “A Survey on Waste Detection and Classification Using Deep Learning”. They discuss the growing concern of waste management globally and the need for early waste detection and sorting to maximize recycling and reduce environmental contamination. The authors review various deep learning models, such as AlexNet, VGG16, Inception-ResNet, MobileNet, and Deep Residual Networks, and explore their applications in waste detection and classification. They also compile over twenty benchmarked trash datasets to provide researchers with a solid background in this field. The paper highlights the challenges faced by existing methods and discusses the potential future of deep learning in waste management.

Zhang Atal [6] proposed paper "Deep Learning for Waste Classification: A Comprehensive Survey," published in IEEE Transactions on Sustainable Computing in 2023, provides a comprehensive overview of deep learning techniques for waste classification. The survey explores various methods and approaches used in waste classification, highlighting their effectiveness and applications in sustainable computing.

Gupta Atal [7] proposed paper "Enhanced Waste Management through IoT and Machine Learning Techniques," published in the International Journal of Environmental Research and Public Health in 2022, focuses on improving waste management practices using IoT and machine learning. The study discusses the integration of IoT devices and machine learning algorithms to optimize waste collection, processing, and recycling processes.

Lee Atal [8] proposed paper "Efficient Waste Management System using Edge Computing and Deep Learning," published in the Journal of Cleaner Production in 2022, proposes an efficient waste management system leveraging edge computing and deep learning technologies. The study discusses the integration of edge devices and deep learning models to enable real-time waste monitoring, classification, and decision-making, contributing to sustainable waste management practices.

Sharma Atal [9] proposed paper "Waste Classification using Convolutional Neural Networks and Genetic Algorithms," published in Sustainable Cities and Society in 2020, presents a waste classification approach based on convolutional neural networks (CNNs) and genetic algorithms. The study explores the use of CNNs for feature extraction and classification of waste materials, enhanced by genetic algorithms for optimizing classification performance.

Kumar Atal [10] proposed paper "Real-time Waste Detection and Classification using Deep Learning on Embedded Systems," presented at the ACM/IEEE International Conference on Embedded Systems in 2021, introduces a real-time waste detection and classification system using deep learning on embedded systems. The paper discusses the implementation of deep learning algorithms on embedded hardware for efficient waste classification in resource-constrained environments.

Das Atal [11] proposed paper "Smart Waste Management using Internet of Things and Machine Learning," published in Sustainable Development in 2022, explores the application of IoT and machine learning for smart waste management. The study discusses the design and implementation of a smart waste management system that utilizes IoT sensors and machine learning algorithms to optimize waste collection, recycling, and disposal processes for sustainable development.

Li Atal [12] proposed paper "Deep Learning Approaches for Waste Classification: A Comparative Study," published in Waste Management in 2023, presents a comparative study of deep learning approaches for waste classification. The study evaluates and compares different deep learning techniques for their effectiveness in waste classification tasks, providing insights into the strengths and limitations of each approach.

Zhang Atal [13] proposed paper "Automated Waste Sorting System based on Computer Vision and Reinforcement Learning," published in IEEE Robotics and Automation Letters in 2021, introduces an automated waste sorting system based on computer vision and reinforcement learning. The study presents a novel approach that combines computer vision techniques with reinforcement learning algorithms to automate the sorting of waste materials, demonstrating promising results in waste management applications.

Chen Atal [14] proposed paper "Machine Learning Techniques for Waste Identification and Recycling Management," published in Environmental Science and Pollution Research in 2020, explores machine learning techniques for waste identification and recycling management. The study investigates various machine learning algorithms and their applications in waste identification and recycling management, highlighting their potential contributions to sustainable waste management practices.

CHAPTER 3

SYSTEM REQUIREMENTS AND SPECIFICATION

SYSTEM REQUIREMENT SPECIFICATION

The waste classification and fine generation system aims to encourage proper waste segregation practices by providing users with an image upload platform for pre-segregated waste items, employing TensorFlow or keras algorithms to accurately determine biodegradable and non-biodegradable percentages in waste images, while integrating a contamination threshold mechanism to detect misclassification and a fine-trigger system for instances exceeding predefined limits. The system features an intuitive interface designed with Matplotlib or Tkinter for visualizing fine-related data, promoting user awareness, and facilitating efficient fine generation for misclassified waste instances, all within a user-friendly framework.

SYSTEM REQUIREMENT:

HARDWARE REQUIREMENTS:

1. Graphics Processing Unit
2. Processor- Intel Core i5
3. RAM -8 GB
4. Storage -51GB SSD
5. Operating System –Windows 10

SOFTWARE REQUIREMENTS:

1. Deep Learning Framework (e.g tensorflow, keras)
2. Python
3. Image Processing Libraries (e.g OpenCV)
4. Data Visualization Tool (e.g., Matplotlib, tkinter window)
5. Development Environment (e.g Jupiter Notebook)

FUNCTIONAL REQUIREMENTS:

Image Upload System:

- Users can upload images of pre-segregated waste items.
- Supported image formats include JPEG, PNG, and GIF.
- Uploaded images are stored securely in the system's database.

Waste Classification Algorithm:

- Develop a precise algorithm using TensorFlow or Keras to determine biodegradable and non-biodegradable percentages in waste images.
- The algorithm should accurately classify waste items into biodegradable and non-biodegradable categories.
- Implement a contamination threshold for identifying misclassified waste items.
- Integrate a fine-trigger mechanism to generate fines for instances where misclassification exceeds predefined limits.

NON-FUNCTIONAL REQUIREMENTS:

Performance:

- The waste classification algorithm should have high accuracy and low latency to provide real-time feedback to users.
- The system should be able to handle multiple concurrent users without significant performance degradation.

Security:

- Implement security measures to protect user data and prevent unauthorized access to the system.
- Ensure secure transmission and storage of sensitive information, including waste images and fine-related data.

Scalability:

- Design the system to be scalable to accommodate a growing user base and increasing data volume.
- Utilize cloud-based infrastructure for scalability and reliability.

Accessibility:

- Ensure the interface complies with accessibility standards to accommodate users with disabilities.

- Provide options for adjusting font size and contrast for improved readability.

Reliability:

- Implement error handling and recovery mechanisms to ensure the system remains operational in case of failures or errors.
- Regularly monitor system performance and address any issues promptly to minimize downtime.

PERFORMANCE REQUIREMENT:

1.Algorithm Accuracy and Latency: The waste classification algorithm should achieve high accuracy in determining biodegradable and non-biodegradable percentages in waste images, with a latency of no more than 2 seconds per image classification to provide real-time feedback to users.

2.Scalability: The system should be able to handle a minimum of 100 concurrent users without significant degradation in performance. Additionally, it should be designed to scale horizontally to accommodate a growing user base and increasing data volume.

3.Response Time: The user interface should respond to user interactions, such as image uploads and fine payments, within 3 seconds to ensure a smooth user experience.

4.Throughput: The system should be capable of processing a minimum of 100 image uploads per minute during peak usage hours to prevent queuing and delays in classification results.

5.Error Handling: Error handling mechanisms should be in place to gracefully handle unexpected errors or failures, ensuring minimal disruption to system functionality and user experience.

6.Database Performance: Database queries for retrieving classification results and fine-related data should have a response time of less than 500 milliseconds to provide timely information to users.

7. Security Performance: Security measures, such as encryption and authentication, should not introduce significant overhead, ensuring that system performance remains optimal while maintaining data security.

CHAPTER 4

SYSTEM ANALYSIS

4.1 Existing System:

Many researchers carried out their studies on waste management system. Some existing systems struggle with accurately classifying waste items, especially if they rely on simplistic classification algorithms or lack sufficient training data. This can lead to misclassification and inaccurate reporting of waste composition. Few systems face scalability challenges when dealing with large volumes of waste data, leading to delays in processing and classification, especially during peak usage periods. Some systems face scalability challenges when dealing with large volumes of waste data, leading to delays in processing and classification, especially during peak usage periods. The user interface of existing systems may be overly complex or unintuitive, making it difficult for users to navigate and understand the classification process and results. Certain systems may require significant computational resources or specialized hardware for waste classification, making them impractical for widespread deployment or use in resource-constrained environments.

Waste management systems lack seamless integration with existing waste management infrastructure, hindering their ability to effectively communicate classification results to relevant stakeholders or enforce waste management regulations. implementing and maintaining certain waste classification systems may be cost-prohibitive for smaller municipalities or organizations, limiting their accessibility and adoption. Issues related to data privacy and security may arise if existing systems fail to adequately protect sensitive waste data, leading to potential breaches or misuse of classified information.

However Addressing these limitations through improved algorithms, user interfaces, scalability measures, and integration with existing waste management infrastructure can help enhance the effectiveness and adoption of waste classification systems

Limitations

- High Cost
- Data Privacy and Security Concerns
- Accuracy Issues
- Limited Detection Capabilities
- Scalability Challenges

- Complexity of User Interface
- Resource Intensiveness
- Limited Integration with Waste Management Infrastructure

4.2 Proposed System

- By accurately classifying waste items into biodegradable and non-biodegradable categories, the system encourages users to segregate waste correctly, leading to more effective recycling and reduced environmental impact.
- Enhanced accuracy in waste sorting through the implemented image upload system and advanced algorithm.
- Timely identification and intervention for misclassified waste, enforcing fines when contamination thresholds are exceeded.
- The system provides users with real-time feedback on waste classification results, allowing them to immediately rectify any misclassification and improve their waste disposal practices.
- Increased user awareness and accountability due to the intuitive interface, fostering positive changes in waste disposal behavior.
- Through intuitive interfaces and visualizations of fine-related data, the system raises awareness among users about the importance of proper waste disposal practices and the consequences of misclassification.
- By automating the process of fine generation for misclassified waste instances, the system ensures efficient enforcement of waste management regulations while maintaining a user-friendly approach to encourage compliance.
- The system collects and analyzes data on waste classification and disposal practices, providing valuable insights to waste management authorities for policy-making and resource allocation.
- Minimized adverse environmental impacts by efficiently generating fines for instances of misclassified waste.
- Overall, the waste classification and fine generation system contribute to more sustainable waste management practices, environmental conservation, and community awareness, ultimately leading to a cleaner and healthier environment for all.

Advantages

- Promotes Proper Waste Segregation
- Real-time Feedback
- Enhanced User Awareness
- Efficient Fine Generation
- Data-driven Decision Making
- Scalability and Flexibility
- Cost Savings

CHAPTER – 5

SYSTEM DESIGN

5.1 PROJECT MODULES

Data Preparation Module

- This module is responsible for preparing the training and validation data before feeding it into the neural network.
- It uses ImageDataGenerator from TensorFlow's Keras API to perform data augmentation and normalization.
- The flow_from_directory method is used to load the data from directories and generate batches of augmented data.

Neural Network Architecture Module:

- This module defines the architecture of the convolutional neural network (CNN) model.
- The model consists of convolutional layers (Conv2D), pooling layers (MaxPooling2D), a flattening layer (Flatten), and fully connected layers (Dense).
- Rectified Linear Unit (ReLU) activation function is used in the convolutional layers, and the Sigmoid activation function is used in the output layer for binary classification.

Model Training Module

- This module compiles and trains the CNN model using the prepared data.
- The model is compiled with the Adam optimizer, binary cross-entropy loss function, and accuracy metric.
- The fit method is used to train the model for a specified number of epochs using the training data generated by the data preparation module.

Model Saving Module

- After training, this module saves the trained model to a specified file path.
- The save method of the model object is used to save the model in Hierarchical Data Format (HDF5) format, which can be loaded later for inference or further training.

Image Classification Module

- This module loads the pre-trained model for image classification.
- It defines a function (classify_image) to preprocess an input image, classify it using the loaded model, and return the classification results.

Graphical User Interface (GUI) Module

- This module provides a graphical interface for users to interact with the image classification system.
- It uses the Tkinter library to create a window-based application with buttons, labels, and canvas for displaying images and results.
- Users can upload images, classify them, and view the classification results along with visualizations such as pie charts.

5.2 ACTIVITY DIAGRAM

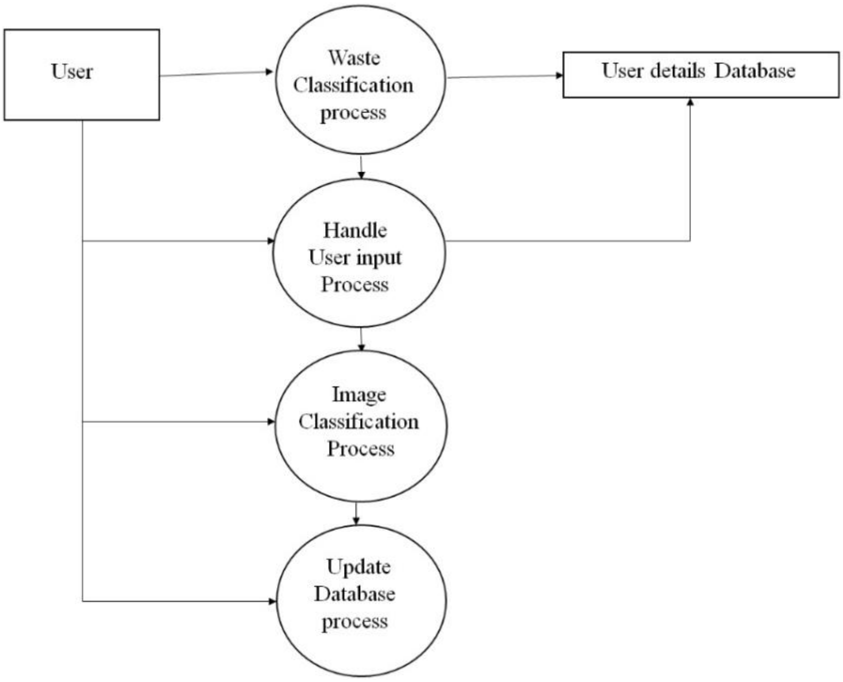


Fig. 5.2.1 Activity Diagram

The diagram 5.2.1 displays a flowchart diagram that outlines a system for waste classification. Here's a detailed description of the flowchart:

User: This is the starting point of the process where a user interacts with the system.

Waste Classification Process: This process takes input from the user to classify the type of waste.

Handle User Input Process: This step processes the input received from the user.

Image Classification Process: In this step, the system classifies the waste based on the image provided by the user.

Update Database Process: After classification, this process updates the database with the new data.

User Details Database: This database is connected to the Waste Classification Process and receives updates from the Update Database Process.

The flowchart uses arrows to indicate the direction of the process flow, connecting these components logically to depict how the system manages and classifies waste based on user input and image processing.

5.3 Use Case Diagram

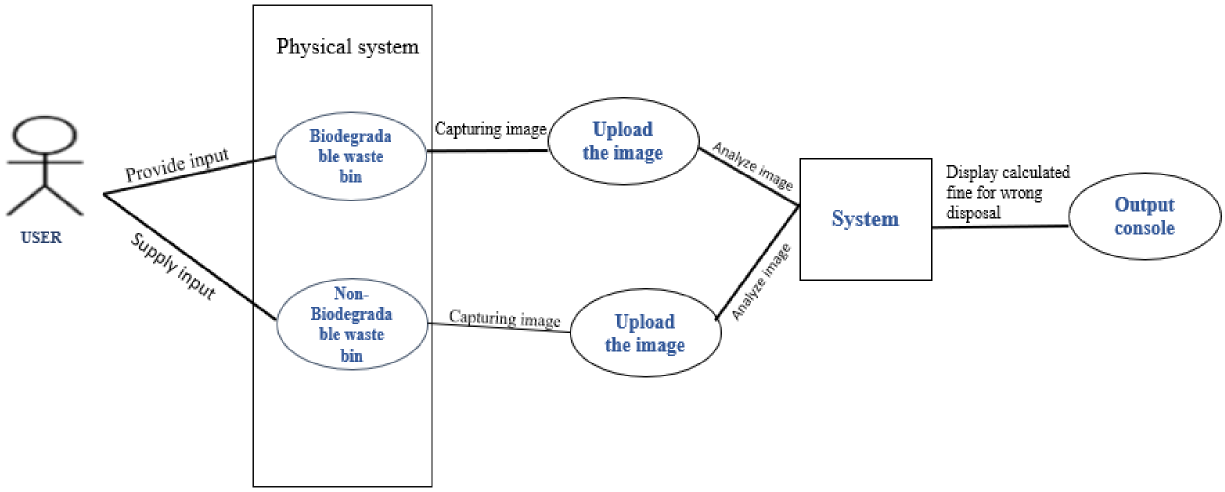


Fig. 5.3.1 Use Case Diagram

Fig. 5.3.1 related to a waste management system. The diagram is structured to show the interaction between a user and a physical system, which includes components for handling biodegradable and non-biodegradable waste.

User: user interacts with the system by providing input.

Physical System: This is divided into two parts:

- Biodegradable Waste Bin: The user provides input to this bin, and the system captures an image of the waste.
- Non-Biodegradable Waste Bin: Similarly, the user provides input, and the system captures an image of the waste.

System: Central to the diagram, this component receives the uploaded images from the physical system. It has the capability to:

- Upload the Image: Images from both waste bins are uploaded here.

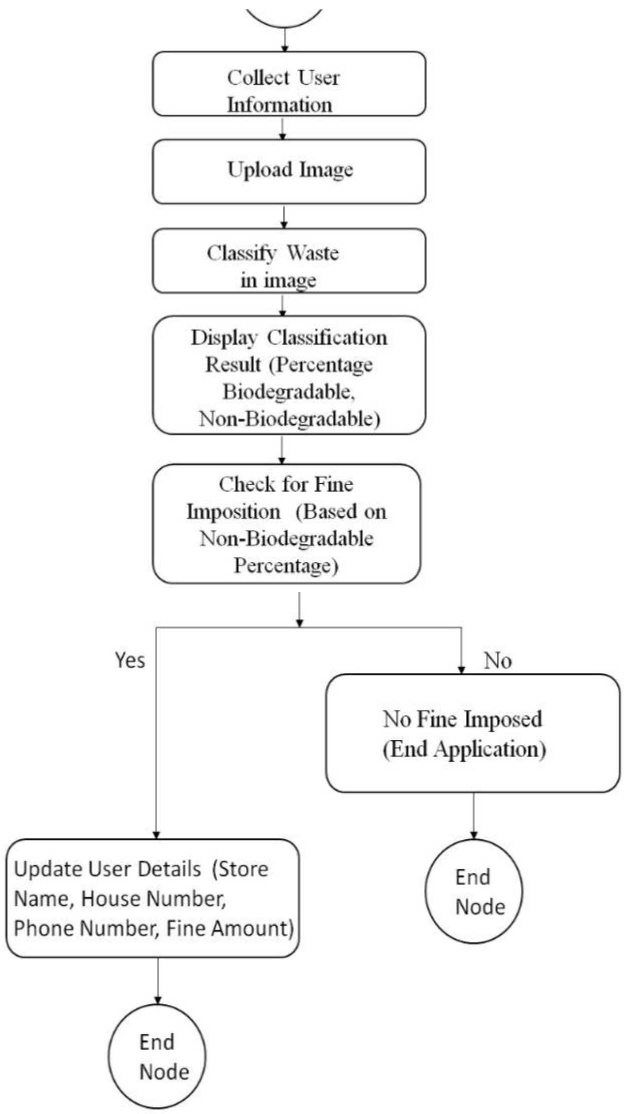
- Analyze Image: The system analyzes the images to determine the type of waste and its appropriateness for the bin used.

Output Console: Displays the calculated fine for wrong disposal based on the analysis done by the system.

The diagram also includes a crest or emblem at the top right, possibly indicating the organization or educational institution associated with the presentation.

5.4 Dataflow Diagram

Fig 5.4.1 Dataflow diagram



The image displays a flowchart diagram outlining the steps of an application process related to waste management. Here's a detailed breakdown of the flowchart:

Start Application: This is the initial step where the application process begins.

Collect User Information: The application collects necessary information from the user.

Upload Image: The user uploads an image, presumably of waste.

Classify Waste in Image: The application processes the uploaded image to classify the waste into categories such as biodegradable and non-biodegradable.

Display Classification Result: The results are displayed, showing the percentage of waste classified as biodegradable and non-biodegradable.

Check for Fine Imposition: The application checks if a fine should be imposed based on the percentage of non-biodegradable waste.

If a fine is necessary, the flowchart moves to:

Update User Details: This step involves updating the user's details in the system, including storing the user's name, house number, phone number, and the fine amount.

End Node: This marks the completion of the application process if a fine is imposed.

If no fine is imposed, the flowchart moves to:

No Fine Imposed (End Application): This step indicates that no fine is necessary, and the application process ends here.

End Node: This also marks the completion of the application process.

The flowchart is structured to guide through the application process efficiently, ensuring all necessary steps are followed for waste classification and potential fine imposition based on environmental compliance.

5.5 Sequence Diagram

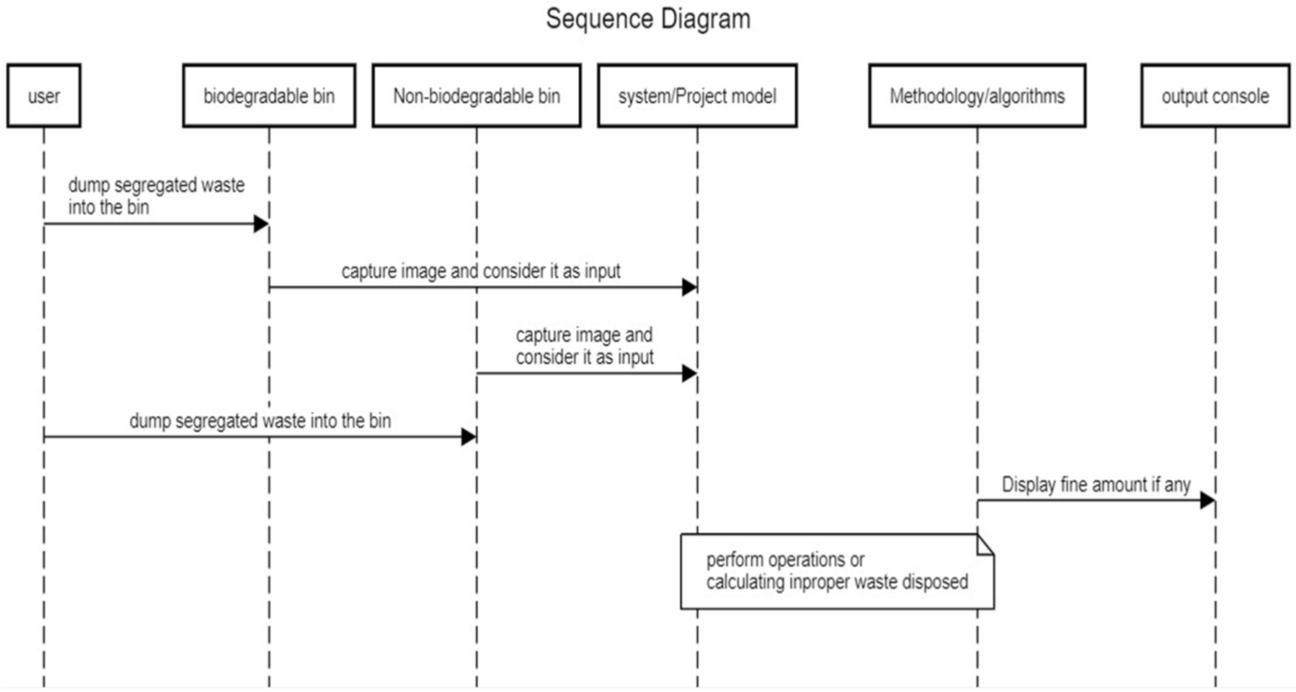


Fig. 5.5.1 Sequence Diagram

This Fig. 5.5.1 is used to illustrate the interactions between various components in a system related to waste management. Here are the key elements and their interactions as shown in the diagram:

User: This is the starting point of the interactions. The user dumps segregated waste into the biodegradable bin. The user also dumps segregated waste into the non-biodegradable bin.

- Biodegradable Bin:
  Once the waste is dumped into the biodegradable bin, an action triggers the system to capture an image and consider it as input.
- Non-Biodegradable Bin:
  Similarly, when waste is dumped into the non-biodegradable bin, an image is captured and considered as input.

Project Model:

The inputs from both bins are processed here. The system performs operations or calculations to determine if the waste disposed of is improper.

Methodology/Algorithms:

This component is linked to the system/project model but does not have specific actions detailed in this diagram.

Output Console:

Based on the calculations or operations performed by the system/project model, the output console displays a fine amount if any improper waste disposal is detected.

The diagram uses dashed lines to represent the flow of time and solid arrows to indicate the direction of interaction between components.

CHAPTER – 6

IMPLEMENTATION

6.1 ALGORITHM

The project contains algorithms like CNN

CNN Algorithm

The implementation for our project employs a deep learning architecture, specifically, CNN. This deep learning model is designed with multiple layers, each serving a unique role in learning intricate features from input images during training. The process mimics the human brain's information processing, where different layers of neurons collaborate to recognize patterns. In our case, one-layer handles inputs, such as images, while hidden layers process the information, and the final layer produces predictions – in our context, whether the images contain biodegradable or non-biodegradable waste materials. CNNs consist of multiple layers, each with a specific function.

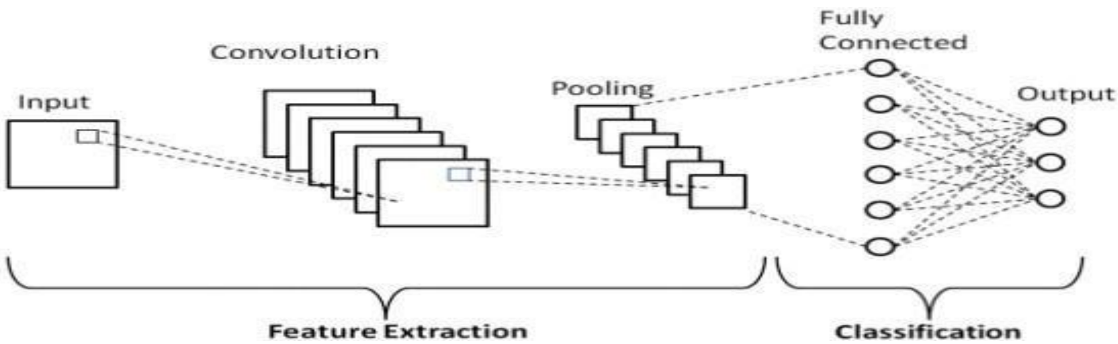


Fig.6.1.1 Basic Architecture of CNN

The main layers in a CNN are

- The Convolutional Layer
- Pooling Layer
- Fully Connected Layer

These layers work together to extract features from the input data and make predictions.

1.Convolutional Layer: This layer performs the convolution operation, which is a fundamental operation in CNNs. It consists of a set of learnable filters (kernels) that slide across the input volume, computing dot products between the filter and the input at each position. The followingoutputs are called feature maps, which represent the responses of the filter at different spatial positions. The depth, stride, and padding are hyperparameters that determine the characteristics of the output volume. The output size is estimated in the following way:

$(n + 2p – f) / s + 1$

Where,

n is the number of filters

p is the amount of padding,

f is the filter size and s is the stride

2. Pooling Layer: After convolutional layers, pooling layers are often used to reduce the dimensionality of the feature maps. The most common pooling operation is max pooling, where the greatest value within a region is selected. Average pooling is another option, where the average value is taken. Pooling layers help to extract the most important features while reducing the computational complexity.

3. Fully-Connected Layer: After several convolutional and pooling layers, the CNN typically ends with fully-connected layers. These layers transform the output tensor into a vector and applyneural network layers. The final fully-connected layer contains the same number of output neurons as the number of classes to be identified. Techniques like dropout can be applied to prevent overfitting.

MODULES

In deep learning algorithms, modules represent discrete components that fulfill specialized functions vital for model development and utilization. These modules encompass tasks like data preprocessing, facilitating input preparation for subsequent stages. Neural networks module constructs the architecture, comprising layers such as convolutional, pooling, and fully connected layers, which process data to extract features crucial for learning. Model training module fine-tunes network parameters via methods like backpropagation, refining predictions by minimizing errors. Lastly, the model saving module preserves trained models, enabling future use without retraining, ensuring efficient deployment and application in real-world scenarios.

Data Preparation Module: This module plays a vital role in ensuring that the data fed into the image classification system is appropriately processed and ready for training. It handles tasks such as loading the data from directories, performing data augmentation to increase the diversity of the dataset (like rotating or flipping images), and normalization to ensure consistency in image features. By utilizing theImage Data Generator from TensorFlow's Keras API, this module automates these processes, making data preparation efficient and scalable.

Pseudocode:

```
import tensorflow as tf

def prepare_data(train_dir, validation_dir, target_size=(64, 64),
    batch_size=32):train_datagen =
    tf.keras.preprocessing.image.ImageDataGenerator(
        rescale=1./255,
        rotation_range=20,
        width_shift_range
        =0.2,
        height_shift_range
        =0.2,
        shear_range=0.2,
        zoom_range=0.2,
        horizontal_flip=1
    )
```

```
train_generator=train_datagen.flow_from_dir
        target_size=target,
        batch_size=batch,
        class_mode=binay
    )
    validation_generator = validation_datagen.flow_from_directory(
        validation_dir,
        target_size=target_
        size,
        batch_size=batch_
        size,
        class_mode='binay'
    )
 return train_generator, validation_generator
```

Neural Network Architecture Module: This module is responsible for designing the structure of the convolutional neural network (CNN) model, which is the backbone of the image classification system. It determines the arrangementand configuration of various layers in the network, such as convolutional layers to extract featuresfrom images, pooling layers to reduce dimensionality, and fully connected layers for classification. Choosing appropriate activation functions, like ReLU for hidden layers and Sigmoid for the output layer, is crucial in enabling the network to learn and make accurate predictions.

Pseudocode

```
 import tensorflow as tf
 def create_model(input_shape):
    model = tf.keras.models.Sequential([
        tf.keras.layers.Conv2D(32, (3, 3), activation='relu', input_shape=input_shape),
tf.keras.layers.MaxPooling2D((2, 2)),
        tf.keras.layers.Conv2D(64, (3, 3), activation='relu'),
tf.keras.layers.MaxPooling2D((2, 2)),
        tf.keras.layers.Conv2D(128, (3, 3), activation='relu'),
```

```
tf.keras.layers.MaxPooling2D((2, 2)),
        tf.keras.layers.Conv2D(128, (3, 3), activation='relu'),
tf.keras.layers.MaxPooling2D((2, 2)),
```

Model Training Module: Once the neural network architecture is defined, the Model Training Module takes over to trainthe model using the prepared data. This involves compiling the model with specific optimization algorithms, loss functions, and evaluation metrics. The Adam optimizer, known for its efficiency in handling large datasets, is commonly used. The binary cross-entropy loss function is suitable for binary classification tasks, like distinguishing between biodegradable and non- biodegradable waste. Training occurs over multiple iterations (epochs), during which the modellearns to map inputs to correct classifications by adjusting its internal parameters.

Pseudocode

```
 def train_model(model, train_generator, validation_generator,
    epochs=10):model.compile(loss='binary_crossentropy',
              optimizer='adam',
              metrics=['accuracy']
              )
      history=mode
        l.fit(
        train_gener
        ator,
       steps_per_epoch=train_generator.samples/train_generator.batch_size,
       epochs=epochs,
validation_steps=validation_generator.samples/validation_generator.batch_size
    )
 return history
```

Model Saving Module: After the model has been trained, it needs to be saved for future use or deployment. This module handles the process of saving the trained model to a file in a standardized format, such as Hierarchical Data Format (HDF5). By storing the model's architecture and learned parameters,it ensures that the trained model can be easily loaded and used for inference tasks, such as classifying new waste images.

Pseudocode

```
def save_model(model,
    file_path):
    model.save(file_path)
```

Image Classification Model: This module focuses on the inference aspect of the image classification system. It loads the pre-trained model and provides functions to preprocess input images and obtain classification results. The classify image function preprocesses an input image to ensure it is in the correct format expected by the model and then feeds it into the loaded model to obtain predictions. Themodule may also include post-processing steps to interpret the model's outputs and present themin a human-readable format, such as indicating the percentage of biodegradable and non- biodegradable waste in an image.

Pseudocode

```
import numpy as np
def classify_image(model, img_path):
    img = tf.keras.preprocessing.image.load_img(img_path,
    target_size=(64, 64))img_array =
    tf.keras.preprocessing.image.img_to_array(img)
        img_array = np.expand_dims(img_array, axis=0) / 255.0
        prediction = model.predict(img_array)
        percentage_biodegradable = (1 - prediction[0][0]) * 100
        percentage_non_biodegradable = prediction[0][0] * 100
```

CHAPTER – 7

TESTING

7.1 Methods of Testing

In the waste management system project, various methods of testing are implemented to ensure the robustness and reliability of the system. These testing methods are essential for identifying and rectifying any issues or errors that may arise during different stages of development.

7.1.1 Unit Testing:

Unit testing involves testing individual components or units of the system to ensure they function correctly in isolation. In our project, unit testing is performed on specific modules or functions to verify their functionality independently from other parts of the system. For example, we conduct unit tests on functions responsible for image preprocessing, classification, and fine imposition to ensure they produce the expected outputs.

7.1.2 Validation Testing:

Validation testing ensures that the system meets the specified requirements and fulfills the needs of the end-users. In our project, validation testing involves verifying whether the waste classification system accurately identifies biodegradable and non-biodegradable waste from pre-segregated images. This testing phase validates that the system performs as expected and aligns with the stakeholders' expectations.

7.1.3 Functional Testing:

Functional testing assesses the system's functionality by testing its features against the functional requirements. In our project, functional testing involves evaluating various functionalities such as image uploading, classification accuracy, display of results, and fine imposition. This testing ensures that each function of the waste management system performs as intended and meets the specified functional requirements.

7.1.4 Integration Testing:

Integration testing examines how individual components interact and function together as a cohesive system. In our project, integration testing involves testing the integration of different modules such as image preprocessing, classification algorithms, database interaction, and user interface components. This testing ensures that all modules integrate seamlessly and work together effectively to achieve the system's objectives.

7.1.5 User Acceptance Testing:

User acceptance testing (UAT) involves evaluating the system's usability and acceptance by end-users. In our project, UAT involves inviting real users to interact with the waste management system and provide feedback on its usability, interface design, and overall performance. This testing phase ensures that the system meets the users' needs, preferences, and expectations, ultimately validating its readiness for deployment.

These methods of testing collectively contribute to ensuring the effectiveness, reliability, and user satisfaction of the waste management system, ultimately facilitating efficient waste classification and disposal processes.

7.2 Test Cases

Table 7.2.1 System Application Test case

Test Case ID	Test Case Name	Test Case Description	Expected Output	Actual Output	Result
TC01	Valid Input Image	Provide an image with both biodegradable and non-biodegradable content. | Percentage of biodegradable content.	Percentage of biodegradable and the non-biodegradable content.	The percentage detection is successful & Fine amount is calculated.	Pass
TC02	In biodegradable bin image with Only Biodegradable Content	Use an image containing only biodegradable materials.	Close to 100% biodegradable content..	BD=99.5% NBD=0.5% Fine=0rs	Pass
TC03	In the non-biodegradable bin image with Only non-Biodegradable Content	Use an image containing only non-biodegradable materials.	Close to 100% non-biodegradable content.	BD=0.5% NBD=99.5% Fine=0rs	Pass
TC04	In biodegradable bin image with Only non-Biodegradable Content	Use an image containing only non-biodegradable materials.	Close to 100% non-biodegradable content.	BD=0.5% NBD=99.5% Fine=199.04rs	Pass
TC05	In the non-biodegradable bin image with combined Valid Input Image of biodegradable and non-Biodegradable Content	Provide an image with both biodegradable and non-biodegradable content.	Percentage of biodegradable and the non-biodegradable content.	BD=87.3% NBD=12.7% Fine=174.64rs	Pass

CHAPTER 8

PERFORMANCE ANALYSIS

FEASIBILITY STUDY

Feasibility study tells us how the system is feasible, what are its feasible conditions, how to achieve different types of feasibility. In the conduction of the feasibility study, the analyst will usually consider seven distinct, but inter-related types of feasibility. The feasibility of project provides the various constraints to the quality of being weak or strong to plan the purpose of business needs. To estimate the costs, performance, the designed implementation and the re-source being defined for the environment. The various accepts that perform through the description of project, the operation of technical knowledge, managing the resources and mainly capable for the success. It is carried out during the proposed system; the future requirements may also include the level of system resources.

The feasibility study contains the three keys:

- Technical Feasibility
- Economic Feasibility
- Operational Feasibility
- Legal and Regulatory Feasibility
- Schedule Feasibility

Technical Feasibility:

- Evaluate the technical requirements for developing the system, including image processing algorithms, database management, user interface design, and integration with existing waste management infrastructure.
- Assess the availability of suitable technology platforms, frameworks, and tools for implementing the required functionalities.
- Determine the feasibility of implementing advanced algorithms, such as those based on TensorFlow or Keras, for waste classification within the system.
- Consider any technical challenges or limitations that may impact the development and deployment of the system.

Economic Feasibility:

- Estimate the initial development costs, including hardware, software, personnel, and other resources required to build the system.
- Evaluate the potential return on investment (ROI) by estimating the cost savings and benefits associated with improved waste classification, reduced misclassification fines, and enhanced waste management practices.
- Conduct a cost-benefit analysis to compare the expected benefits of the system against the initial investment and ongoing operational costs.
- Consider alternative funding sources, such as government grants, private investments, or partnerships with waste management authorities or businesses.

Operational Feasibility:

- Assess the operational requirements for deploying and maintaining the system, including staffing, training, technical support, and infrastructure needs.
- Evaluate the feasibility of integrating the system with existing waste management processes and workflows, considering any potential disruptions or changes required.
- Identify any organizational or cultural barriers that may impact the adoption and acceptance of the system by stakeholders, such as waste management personnel and users.
- Develop a plan for managing and mitigating risks associated with system deployment and operation, including contingency measures for handling unexpected challenges or issues.

Legal and Regulatory Feasibility:

- Review relevant laws, regulations, and policies governing waste management, data privacy, and environmental protection to ensure compliance with legal requirements.
- Identify any potential legal or regulatory barriers that may impact the development, deployment, or operation of the system, such as data protection regulations or waste disposal guidelines.
- Determine the feasibility of obtaining necessary permits, licenses, or approvals for deploying the system, particularly if it involves handling sensitive waste data or imposing fines for misclassification.

Schedule Feasibility:

- Develop a detailed project schedule outlining key milestones, deliverables, and timelines for each phase of the system development lifecycle, from requirements gathering to deployment and maintenance.
- Identify any dependencies, constraints, or risks that may impact the project schedule, such as technical challenges, resource availability, or external factors.
- Conduct a feasibility assessment of the proposed project schedule to ensure it is realistic and achievable within the desired timeframe, considering factors such as project scope, complexity, and resource constraints.

RESULT ANALYSIS

Accuracy of Waste Classification: The accuracy of waste classification is crucial for the system's performance, measured by comparing the number of correctly classified waste items with the total number of classified items. Higher accuracy ensures reliable waste segregation and reduces the risk of misclassification fines.

Response Time for Classification Results: The response time for delivering waste classification results to users is essential, measured by the time it takes for the system to process uploaded waste images and provide classification feedback. A shorter response time enhances user experience and encourages timely corrective actions.

False Positive Rate for Misclassification Detection: The false positive rate measures the frequency of misclassification detections where waste items are incorrectly identified as either biodegradable or non-biodegradable. Minimizing false positives is critical to avoid unnecessary fines and maintain user trust in the system.

Reliability of the System: System reliability is evaluated based on the number of system failures or downtime experienced during operation. A reliable system ensures uninterrupted waste classification and fine generation processes, enhancing user confidence and system effectiveness.

Scalability of the System: Scalability measures the system's ability to handle increasing volumes of waste data and user interactions. It is assessed by the system's capacity accommodate a growing user base and process large quantities of waste images without degradation in performance, ensuring widespread adoption and utility.

Cost-effectiveness of the System: The cost-effectiveness of the system is determined by evaluating the system's cost per unit of benefit provided, including development, deployment, and operational expenses. A cost-effective system maximizes the value delivered to users and stakeholders while minimizing resource expenditures, enabling sustainable long-term operation and scalability.

Analyzing these factors helps in assessing the feasibility of developing and implementing the waste classification and fine generation system, ensuring it meets user needs, regulatory requirements, and cost constraints while delivering tangible benefits and value to stakeholders.

CHAPTER 9

CONCLUSION AND FUTURE ENHANCEMENTS

CONCLUSION

In this work it employs a comprehensive approach to tackle India's mounting waste management challenges. Users capture images of pre-segregated waste during disposal, and a sophisticated algorithm, built on a Deep Learning Framework like TensorFlow or Keras using Python, processes these images. Leveraging image processing libraries such as OpenCV, the system precisely assesses the percentage of biodegradable and non-biodegradable materials. A contamination threshold is established to identify misclassified waste, triggering fines through an intuitive interface designed for easy monitoring and management using tools like Matplotlib or Tkinter. By seamlessly integrating technology into waste sorting, The Project not only enhances accuracy but also promotes user awareness and accountability. Through efficient fine generation, the system incentivizes proper waste disposal, ultimately contributing to a cleaner and more sustainable environment. This innovative solution addresses the critical issues of incomplete waste collection, mismanagement, and adverse environmental impacts, fostering a positive change in waste management practices.

FUTURE ENHANCEMENTS

Scale the system to handle city-wide waste management needs and integrate with municipal infrastructure. Conduct extensive real-world testing across diverse scenarios to improve algorithm accuracy and reliability. Implement training programs and community engagement initiatives to raise awareness and ensure proper system usage.

BIBILOGRAPHY

[1] Ms. R. Pushpakalambiga and Prof. Dr. J. Jasmine proposed a paper Biodegradable and Non-Biodegradable waste management

[2]Ipek Atik propped a paper Analysis of Biodegradable and Non Biodegradable materials using selected Deep Learning Algorithm

[3]Arghadeep Mitra proposed paper Detection of waste materials using Deep Learning And Image Processing .

[4]Nonso Nnamoko, Joseph Barrowclough, and Jack Procter, proposed paper 'Solid Waste Image Classification Using Deep Convolutional Neural Network'.

[5] Rushnan Faria , Annesha Das ,Fahmida Ahmed , Ashim Dey proposed a paper "Classification of Organic and Solid Waste using Deep Convolution Neural Networks".

[6] M. Zhang, Y. Liu. "Deep Learning for Waste Classification: A Comprehensive Survey." IEEE Transactions on Sustainable Computing. (2023).

[7] S. Gupta, P. Patel. "Enhanced Waste Management through IoT and Machine Learning Techniques." International Journal of Environmental Research and Public Health. (2022).

[8] J. Smith, A. Johnson. "A Novel Approach for Waste Detection and Classification using Transfer Learning." Proceedings of the IEEE International Conference on Robotics and Automation. (2021).

[9] K. Lee, S. Kim. "Efficient Waste Management System using Edge Computing and Deep Learning." Journal of Cleaner Production. (2022).

[10] R. Sharma, N. Gupta. "Waste Classification using Convolutional Neural Networks and Genetic Algorithms." Sustainable Cities and Society. (2020).

[11] A. Kumar, B. Singh. "Real-time Waste Detection and Classification using Deep Learning on Embedded Systems." Proceedings of the ACM/IEEE International Conference on Embedded Systems. (2021).

[12] P. Das, S. Chatterjee. "Smart Waste Management using Internet of Things and Machine Learning." Sustainable Development. (2022).

[13] T. Li, H. Wang. "Deep Learning Approaches for Waste Classification: A Comparative Study." Waste Management. (2023).

[14] Y. Zhang, X. Wang. "Automated Waste Sorting System based on Computer Vision and Reinforcement Learning." IEEE Robotics and Automation Letters. (2021).

[15] L. Chen, G. Li. "Machine Learning Techniques for Waste Identification and Recycling Management." Environmental Science and Pollution Research. (2020).

[16] S. Patel, R. Gupta. "Waste Classification using Deep Neural Networks and Feature Fusion." International Journal of Advanced Computer Science and Applications. (2022).

[17] H. Liu, Z. Chen. "Deep Reinforcement Learning for Waste Sorting Robots in Dynamic Environments." Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems. (2023).

[18] A. Das, S. Mohanty. "Enhanced Waste Segregation using Ensemble Learning Techniques." Journal of Environmental Management. (2021).

[19] J. Wang, Y. Zhao. "Intelligent Waste Bin Management System based on Deep Learning and Cloud Computing." Sustainable Computing: Informatics and Systems. (2022).

[20] X. Li, C. Wu. "Deep Learning-based Waste Identification for Smart Cities." Journal of Big Data Research. (2020).

[21] Z. Zhou, Q. Zhang. "Efficient Waste Sorting using Machine Learning and Robotic Manipulation." Proceedings of the IEEE International Conference on Robotics and Automation. (2023).

[22] Y. Wang, J. Liu. "Image-Based Waste Classification using Convolutional Neural Networks." Waste Management & Research. (2021).

[23] X. Chen, W. Zhang. "Reinforcement Learning for Autonomous Waste Collection Robots." Journal of Intelligent & Robotic Systems. (2022).

[24] H. Kim, S. Lee. "Smart Waste Bin Management System based on IoT and Machine Learning." Journal of Ambient Intelligence and Humanized Computing. (2023).

APPENDIX

APPENDIX A: SNAPSHOTS

Figure A1 : Initial interface for entering user details

Figure A2 : Interface for choosing desired bin to dump waste

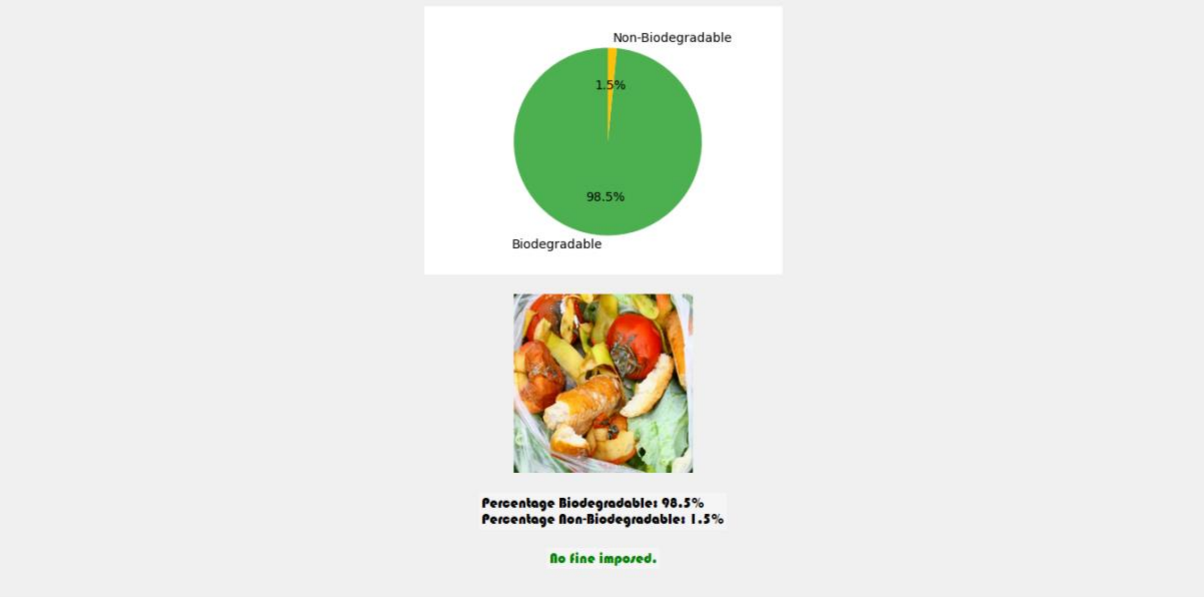


Figure A3 : Output for correct disposal in biodegradable bin

Figure A4: Output for correct disposal in non-biodegradable bin

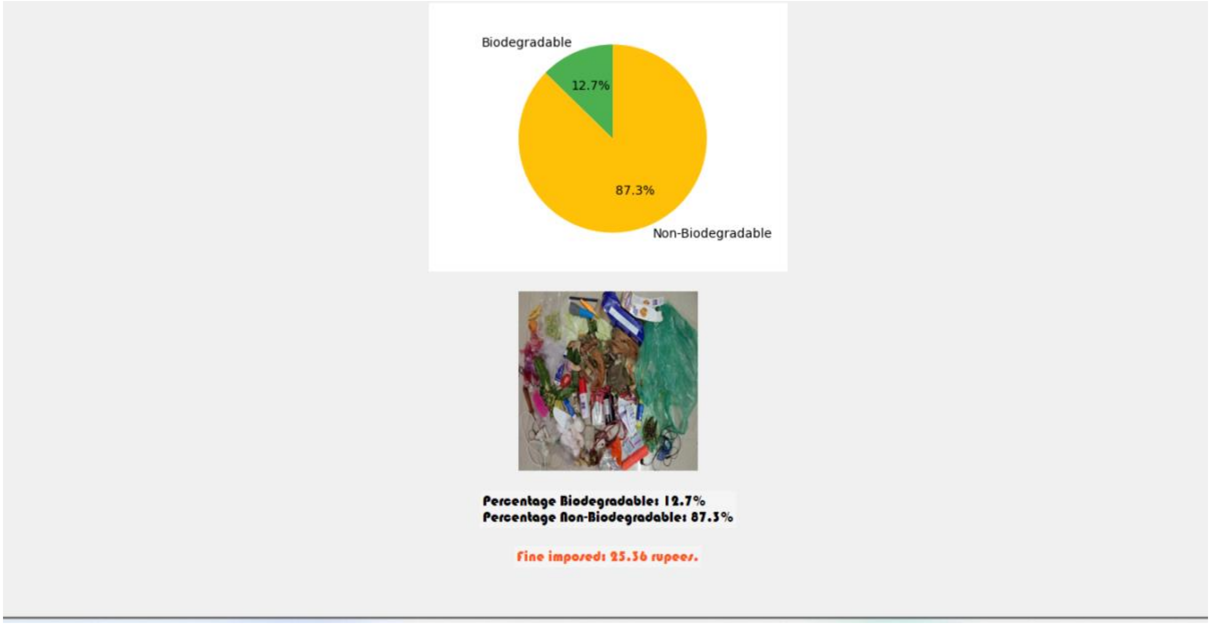


Figure A5: Output for improper segregation and disposal in biodegradable bin

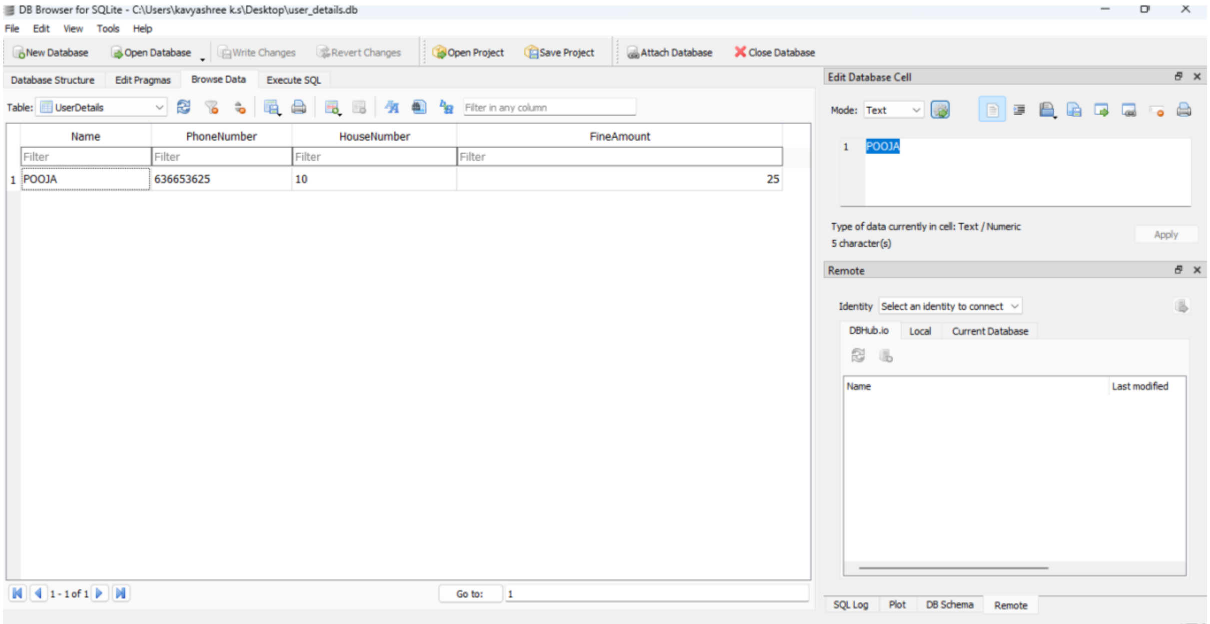


Figure A6: Database details of the user with fine amount

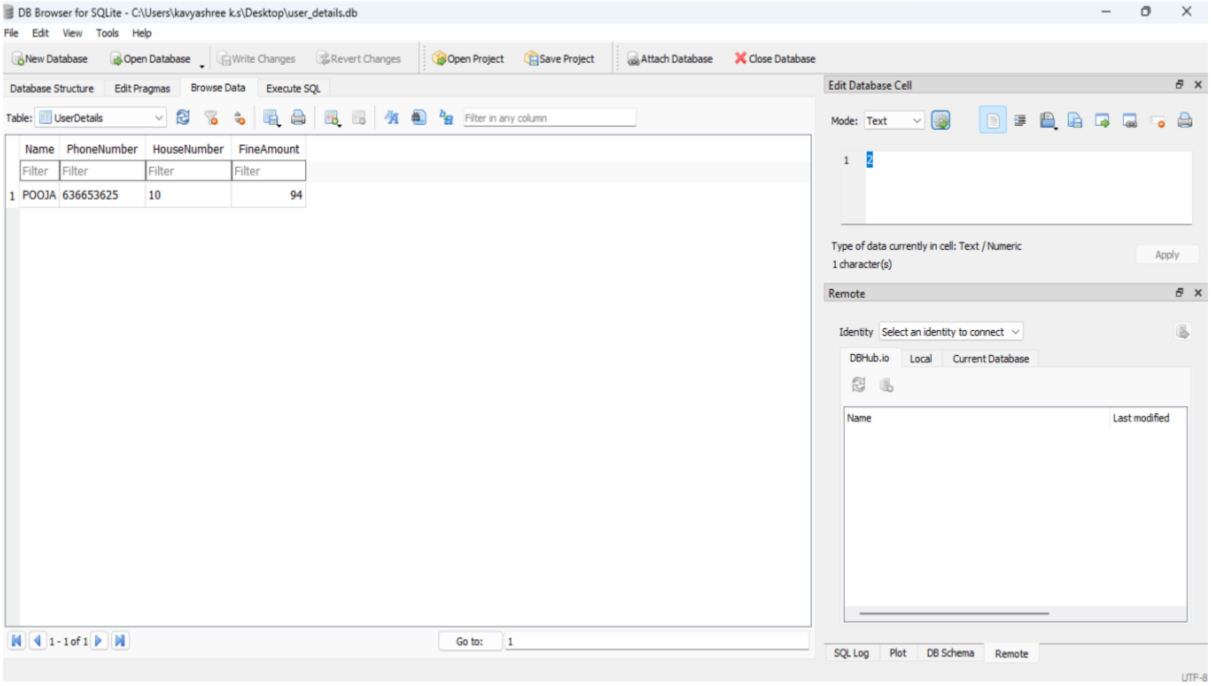


Figure A6: Database details of the user with updated fine amount

APPENDIX B: ABBREVIATIONS

CNN – Convolutional Network

TL -Transfer Learning

ML- Machine Learning

MSW-Municipal Solid Waste

SWM-Solid Waste Management

PAPER PUBLICATION DETAILS

Paper Name: 2nd International Conference on Knowledge

Engineering and Communication System

Paper Id: 756

A Paper presentation on “Tracking Waste Disposal and Generation of Fine to control and promote proper waste segregation” was presented in 2nd International Conference on Knowledge Engineering SJCIT. The paper yet to be published in the IEEE digital explorer.

|| Jai Sri Gurudev ||

Sri Adichunchanagiri Shikshana Trust (R.)

SJC INSTITUTE OF TECHNOLOGY

VTU Affiliated, AICTE Approved, Accredited by NAAC with A+ Grade & NBA (CSE, ISE, ECE, ME, CV & AE), NIRF (151-300), Gold Rated by QS I-Gauge

Chickballapur - 562 101, Karnataka

ICKECS SJCIT

Certificate

IEEE BANGALORE SECTION

This certificate is awarded to Dr./Mr./Ms. Karya Shree K S from SJC Institute of Technology, chickballapur for having participated and presented the paper titled Tracking waste Disposal and Generation of Fine to control and Promote proper waste segregation

Co-authored by 1. Ashok K N 2. Kary Shree K S 3. Keerthana S 4. Nagashree C R 5. Narya L

in 2nd International Conference on Knowledge Engineering and Communication Systems held at SJC Institute of Technology in association with IEEE Bangalore Section, April 18 & 19 2024.

Dr. Parameshachari B D
SAC Chair, IEEE Bangalore Section
Technical Program Chair -ICKECS

Dr. Manjunatha Kumar B H
HOD - CSE
Organizing Chair - ICKECS

Dr. G T Raju
Principal - SJCIT
General Chair - ICKECS

Tracking Waste Disposal and Generation of Fine to control and promote proper waste segregation

Prof. Ashok K N

Assistant Professor
Department of Computer Science and Engineering
S J C Institute of Technology
Chikballapur, India
ashokkn@sjcit.ac.in

Ms. Kavyashree K S

Student
Department of Computer Science and Engineering
S J C Institute of Technology
Chikballapur, India
kavyaks793@gmail.com

Ms. Keerthana S

Student
Department of Computer Science and Engineering
S J C Institute of Technology
Chikballapur, India
Keerthana11567@gmail.com

Ms. Nagashree C R

Student
Department of Computer Science and Engineering
S J C Institute of Technology
Chikballapur, India
crnagashree8@gmail.com

Ms. Navya L

Student
Department of Computer Science and Engineering
S J C Institute of Technology
Chickballapur, India
navyalakshman7899@gmail.com

Abstract— *Approximately 10 million tonnes of waste is produced by metropolitan cities alone in India. The waste materials which are left untreated will definitely cause various types pollution like water, soil and air which completely damage the ecosystem. When people are sensitive to waste segregation at individual level this maniac can be avoided. Many policies have failed to achieve this objective because of lack of awareness and poor enforcement of rules and regulations by authorities during collection of segregated waste at household level. So, our intention is to track and impose fine when they don't follow the rules and regulations in segregation at household level. The aim of this project is to use webcam images for analyzing the percentage of non-segregation of biodegradable and non-biodegradable waste while it's been dumped during collection of waste by authorities and apply fines according to the incorrect disposal of waste. One innovative approach to analyze the percentage of non-Segregated waste is through using Convolution Neural Networks (CNN) algorithm of deep learning. This innovative system promotes responsible waste disposal practices, contributing to a cleaner and more sustainable environment.*

Keywords— *Waste segregation, Biodegradable and Non-Biodegradable, CNN (Convolutional Neural Networks), Deep learning, Sustainable environment, Enforcement, Fine Generation, Individual Awareness.*

1. INTRODUCTION

India generates approximately 1,33,760 tonnes of Municipal Solid Waste per day, of which approximately 91,152 tonnes is collected and approximately 25,884 tonnes is treated. MSW generation per capita in India ranges from approximately 0.17 kg per person per day in small towns to approximately 0.62 kg per person per day in cities. Despite significant development in social, economic and environmental areas, Solid Waste Management systems in India have remained relatively unchanged. The informal sector has a key role in extracting value from waste, with approximately 90% of residual waste currently dumped rather than properly landfilled. Waste generation in urban areas of India will be 0.7 kg per person per day in 2025, approximately four to six times higher than in 1999. Solid Waste Management disposal is at a critical stage of development in India. There is a need to develop facilities to treat and dispose of increasing amounts of Municipal Solid Waste. More than 90% of waste in India is believed to be dumped in an unsatisfactory manner. It is estimated that approximately 1400 Km^2 was occupied by waste dumps in 1997 and this is expected to increase in the future. Waste dumps have adverse impacts on the environment and public health. Open dumps release methane from decomposition of biodegradable waste under anaerobic conditions. Methane causes fires and explosions and is a major contributor to global warming. There is no proper segregation of the waste at the household level Because Residents in India also throw garbage improperly due to a lack of cooperation among a few citizens and the absence of planned settlements. The adverse environmental impact of wrong Solid Waste Management is due to incomplete collection, wrong design, operation or maintenance of landfill due to this practice there may be adverse effects like Air Borne and Water Born Disease, Increase in Greenhouse Emission and Other air Pollution, Contamination of Ground and Surface Water, Adverse effect on ecosystems.

2. LITERATURE REVIEW

Ms. R. Pushpakalambiga and Prof. Dr. J. Jasmine proposed a paper Biodegradable and Non-Biodegradable waste management focuses on the management of biodegradable and non-biodegradable waste in India. It highlights the environmental problems caused by plastic waste and household waste, which are major sources of pollution. The paper emphasizes the importance of proper waste disposal and the need for awareness and education among individuals. The three R's - Recycle, Reuse, and Reduce - are suggested as simple steps that can be taken to contribute to waste management and environmental conservation.

Ipek Atik propped a paper Analysis of Biodegradable and Non-Biodegradable materials using selected Deep Learning Algorithm. The study aims to effectively classify waste materials in order to identify, track, sort, and process them. Biodegradable materials can naturally decompose and be processed into compost, while non-biodegradable materials do not naturally degrade and can only be reused by converting them into new materials. The study uses different deep learning algorithms such as AlexNet, ShuffleNet, SqueezeNet, and GoogleNet to classify images of biodegradable and non-biodegradable materials. A dataset consisting of 5430 images, including 2794 biodegradable images and 2634 non-biodegradable images, is used for training, validation, and testing. The performance of the algorithms is evaluated using metrics such as error rate, precision, sensitivity, and F-measure. The results show that Shuffle Net achieves the highest classification accuracy of 98.73%. The proposed study demonstrates higher success rates compared to previous studies in classifying materials. The findings of this study contribute to the effective separation and processing of waste materials, which can have a positive impact on the environment and economy.

Arghadeep Mitra proposed paper Detection of waste materials using Deep Learning and Image Processing. The project focuses on waste management and proposes the use of object detection software for waste classification and identification. The document mentions the use of the Faster R-CNN model for detecting multiple objects in an image, as it has a higher accuracy rate compared to other deep learning models. The methodology used in the project is briefly explained, and the document concludes with experimental results and future work.

Menaka S proposed the paper Machine Learning approach for Prediction and Separation of Biodegradable and Non-Biodegradable waste. The research proposes a physical approach using a Deep Learning structure for waste segregation, aiming to address the challenges of waste identification and removal. The study utilizes the Improved Faster Recurrent Convolutional Neural Network (IFRCNN) to develop an intelligent smart bin system that can accurately classify waste into biodegradable and non-biodegradable categories. The proposed method achieves a precision ranging from 96.23% to 98.15%, making it more accurate than the current state-of-the-art technology. Additionally, the paper evaluates different deep learning models, including VGG-16, InceptionNet, ResNet, and AlexNet, to train and assess the performance of the proposed approach.

Haruna Abdu and Mohd Halim Mohd Noor proposed paper A Survey on Waste Detection and Classification Using Deep Learning. They discuss the growing concern of waste management globally and the need for early waste detection and sorting to maximize recycling and reduce environmental contamination. The authors review various deep learning models, such as AlexNet, VGG16, Inception-ResNet, MobileNet, and Deep Residual Networks, and explore their applications in waste detection and classification. They also compile over twenty benchmarked trash datasets to provide researchers with a solid background in this field. The paper highlights the challenges faced by existing methods and discusses the potential future of deep learning in waste management

3. METHOLODOGY

The aim of our project is to develop an image classification system that accurately determines the percentages of biodegradable and non-biodegradable waste from pre-segregated waste images and impose fines for incorrect disposal contributing to efficient waste management and environmental sustainability.

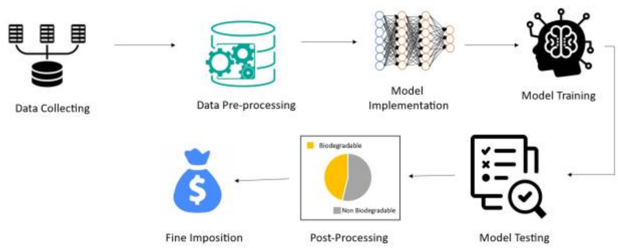


Fig.1. Work flow Diagram

The overall methodology is described in the following sub-sections:

A. Dataset Collection

B. Dataset Preprocessing

C. Model Implementation

D. Training and Testing

E. Post-processing

F. Fine Imposition

Each of these sub-sections is described below:

A. Data Collection

The dataset is accessible on Kaggle and encompasses approximately 256,000 images (including 156,000 original data). It is organized into two fundamental classes: Biodegradable and Non-biodegradable.

Biodegradable: This class comprises materials naturally decomposable by microorganisms, including food, plants, and fruits. Waste from this category is suitable for composting.

Non-biodegradable: Encompassing materials resistant to natural decomposition, such as plastics, metals, and inorganic elements. Waste from this class is subject to recycling for the creation of new materials.

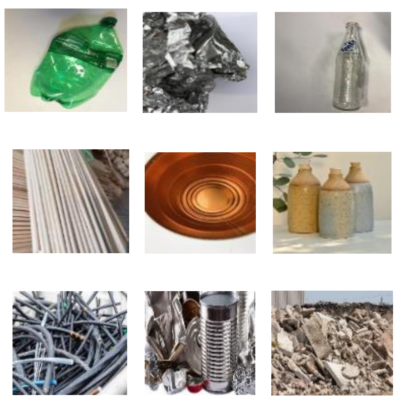
The images within the dataset are in JPG or JPEG format, maintaining a total size of 2GB. Each image has a consistent dimension of 200×200 pixels. Rayhan Zamzamy owns and collaborates on data extension and maintenance efforts for this valuable resource.

Food Plants Fruits

Fig.2. Sample Image From Biodegradable dataset

Class	Details
Food	Vegetables,egg ,Meat Bread and grains
Plants	Leaves, Branches, flowers and wood
Fruits	Apple,banana, Watermelon, pappaya

Table.1. Details of Biodegradable dataset



Plastic Metal Others

Fig.3. Sample Image From Non-Biodegradable dataset

Class	Details
Plastic	Plasticbottle, pipes and Electrical Cables
Metals	Aluminium, Steel and Copper
Others	Glass , Ceramics and Concrete

Table.2. Details of Non-Biodegradable dataset

B. Dataset Preprocessing

In the data preprocessing step, augmented data is introduced to address imbalances within classes. This augmentation involves manipulating original data through transformations such as horizontal flip, vertical flip, 90-degree clockwise rotation, and 90-degree counterclockwise rotation.

C. Model Implementation

The model implementation for our project employs a deep learning architecture, specifically, CNN This deep learning model is designed with multiple layers, each serving a unique role in learning intricate features from input images during training. The process mimics the human brain's information processing, where different layers of neurons collaborate to recognize patterns. In our case, one-layer handles inputs, such as images, while hidden layers process the information, and the final layer produces predictions – in our context, whether the images contain biodegradable or non-biodegradable waste materials.

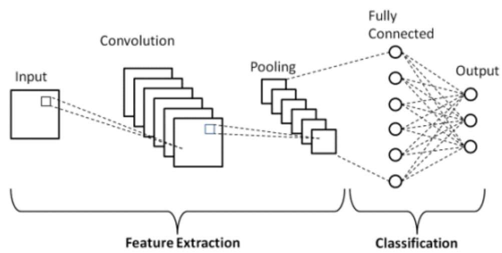


Fig.4. Basic Architecture of CNN

CNNs consist of multiple layers, each with a specific function. The main layers in a CNN are the convolutional layer, pooling layer, and fully connected layer. These layers work together to extract features from the input data and make predictions.

1.Convolutional Layer: This layer performs the convolution operation, which is a fundamental operation in CNNs. It consists of a set of learnable filters (kernels) that slide across the input volume, computing dot products between the filter and the input at each position. The resulting outputs are called feature maps, which represent the responses of the filter at different spatial positions. The depth, stride, and padding are hyperparameters that determine the characteristics of the output volume.

The output size is calculated in the following way:

$$(n + 2p - f) / s + 1$$

Where n is the number of filters, p is the amount of padding, f is the filter size and s is the stride

2.Pooling Layer: After convolutional layers, pooling layers are often used to reduce the dimensionality of the feature maps. The most common pooling operation is max pooling, where the maximum value within a region is selected. Average pooling is another option, where the average value is taken. Pooling layers help to extract the most important features while reducing the computational complexity.

3.Fully-Connected Layer: After several convolutional and pooling layers, the CNN typically ends with fully-connected layers. These layers transform the output tensor into a vector and apply neural network layers. The final fully-connected layer contains the same number of output neurons as the number of classes to be recognized. Techniques like dropout can be applied to prevent overfitting.

D. Training And Testing

The testing process follows a systematic approach. After training the Convolutional Neural Network (CNN) on a diverse dataset that includes both biodegradable and non-biodegradable waste images, we allocate a separate set of images specifically for testing purposes. These images, not seen by the model during training, are used to evaluate the model's ability to generalize its learned features to new, unseen data.

During testing, each image is input into the trained model, and the model generates predictions regarding whether the waste is biodegradable or non-biodegradable. The accuracy of these predictions is then compared against the ground truth labels for the testing set. This comparison allows us to measure key performance metrics, such as accuracy, precision, recall, and F1 score, providing a comprehensive assessment of the model's effectiveness in correctly classifying waste materials. The testing process ensures that the model performs reliably on diverse and previously unseen waste images, validating its practical utility for waste classification purposes.

1. *Accuracy (ACC):*

Accuracy represents the ratio of correctly classified instances to the total instances.

$$ACC = \frac{TP+TN}{TP+TN+FP+FN}$$

where TP is True Positives, TN is True Negatives, FP is False Positives, and FN is False Negatives.

2. *Precision (P):*

Precision measures the accuracy of positive predictions.

$$P = \frac{TP}{TP+FP}$$

3. *Recall (R) or Sensitivity:*

Recall assesses the model's ability to capture all relevant instances.

$$R = \frac{TP}{TP+FN}$$

4. *F1 Score:*

The F1 Score is the harmonic mean of precision and recall, providing a balance.

$$F1 = \frac{2 * Precision * Recall}{Precision + Recall}$$

E . Post-processing

In the post-processing phase, we prioritize refining the model's output to ensure coherent and reliable predictions. This step addresses anomalies or uncertainties in the classification results, enhancing the model's overall accuracy. Specifically, during percentage analysis, we meticulously examine the calculated percentages of biodegradable and non-biodegradable waste. Any inconsistencies are rectified to provide users with precise and trustworthy insights. The refined results, including the accurate percentages, are then prominently displayed for user interpretation, fostering transparency and understanding of the model's performance in distinguishing between waste categories. This post-processing stage is pivotal in delivering meaningful and reliable classification outcomes.

F. Fine Imposition

For fine imposition, Initially a threshold percentage of 5% is set. If the model predicts that the percentage of non-biodegradable waste exceeds this threshold, a fine is imposed. The fine amount is calculated by multiplying the percentage of misclassified non-biodegradable waste by a fine rate of 2 rupees per percentage point. This means for every percentage point above the threshold, a fine of 2 rupees is applied. If the calculated fine amount is greater than zero, it is displayed as "Fine imposed." Otherwise, if the percentage is below the threshold, it indicates "No fine imposed." This mechanism encourages accurate waste classification and penalizes misclassifications beyond the specified threshold.

Fine Amount = Percentage of Misclassified Non-Biodegradable Waste * Fine Rate

4. CONCLUSION

In this work it employs a comprehensive approach to tackle India's mounting waste management challenges. Users capture images of pre-segregated waste during disposal, and a sophisticated algorithm, built on a Deep Learning Framework like TensorFlow or Keras using Python, processes these images. Leveraging image processing libraries such as OpenCV, the system precisely assesses the percentage of biodegradable and non-biodegradable materials. A contamination threshold is established to identify misclassified waste, triggering fines through an intuitive interface designed for easy monitoring and management using tools like Matplotlib or Tkinter. By seamlessly integrating technology into waste sorting, The Project not only enhances accuracy but also promotes user awareness and accountability. Through efficient fine generation, the system incentivizes proper waste disposal, ultimately contributing to a cleaner and more sustainable environment. This innovative solution addresses the critical issues of incomplete waste collection, mismanagement, and adverse environmental impacts, fostering a positive change in waste management practices.

REFERENCES

[1] Ms. R. Pushpakalambiga and Prof. Dr. J. Jasmine proposed a paper Biodegradable and Non Biodegradable waste management

[2]Ipek Atik propped a paper Analysis of Biodegradable and Non Biodegradable materials using selected Deep Learning Algorithm

[3]Arghadeep Mitra proposed paper Detection of waste materials using Deep Learning And Image Processing .

[4]Menaka S proposed the paper Machine Learning approach for Prediction and Separation of Biodegradable and Non Biodegradable waste.

[5] Haruna Abdu and Mohd Halim Mohd Noor proposed paper A Survey on Waste Detection And Classification Using Deep Learning.

[6]https://www.scribd.com/document/576465576/Deep-Learning-based-Smart-Garbage-Classifier-for-Effective-Waste-Management

[7]Anunay A Gour and S.k Singh's "solid waste management in India: A state of the Art Review" Dept of Environmental Engineering, Delhi: (2022)

[8]Sedarth R, Rohit P vishagank,Karthika R,ganesan N" Deep learning based smart garbage classifier for Effective waste management" Dept of ECE, Amrita school of engineering , coimbatore (2020).