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Mini Project Report On

Automatic Scrap Detection System (ASDS)

Submitted in partial fulfillment of the requirements for the award of the degree of

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CERTIFICATE

This is to certify that the mini project report entitled ***"Automatic Scrap Detection System"*** *is a bonafide record of the work done by* ***Alna Khaleel (U2103029)***, ***Aman Adam Louis (U2103031)***, ***Anshika A Nair (U2103042)***, *submitted to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology (B. Tech.) in Computer Science and Engineering during the academic year 2023-2024.*

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Abstract

Automatic Scrap Detection System (ASDS), changes the way we manage scrap materials. By the usage of image processing, ASDS swiftly identifies various scrap items from pictures, offering real-time insights into their market value and recyclability. Unlike traditional methods that rely on manual sorting and guesswork, ASDS provides accurate and reliable information at the touch of a button. This not only streamlines the recycling process but also encourages more people to participate in eco-friendly practices.

Compared to existing solutions, ASDS boasts several advantages. Its advanced image classification algorithms ensure precise identification of scrap items, reducing errors and increasing efficiency. Additionally, ASDS goes beyond mere identification by offering disposal options for non-recyclable items, promoting responsible waste management. With its intuitive interface and comprehensive features, ASDS sets a new standard for automated scrap detection systems, empowering users to make informed decisions and contribute to a cleaner, greener planet.

In today's world, where environmental sustainability is more crucial than ever, ASDS emerges as a game-changer. By simplifying the process of identifying and managing scrap materials, ASDS makes recycling more accessible to everyone. Moreover, its ability to provide disposal options for non-recyclable items adds another layer of environmental responsibility. With ASDS, individuals and businesses alike can take proactive steps towards reducing waste and preserving our planet for future generations.

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ASDS - Automatic Scrap Detection System

Chapter 1

Introduction

1.1 Background

The world is facing a growing challenge of waste management, with scrap materials posing a significant environmental concern. Current waste management practices often rely on manual sorting and classification methods, which are time-consuming, inefficient, and prone to errors. As a result, valuable recyclable materials end up in landfills, contributing to pollution and resource depletion.

In this context, the development of an Automatic Scrap Detection System (ASDS) emerges as a crucial solution to address these challenges. ASDS leverages cutting-edge image processing techniques to automate the identification and classification of scrap materials. This technology revolutionizes waste management by providing real-time information on the market value, recyclability, and disposal options for various scrap items.

The importance of ASDS cannot be overstated in today's context of environmental sustainability. With the increasing awareness of climate change and resource scarcity, efficient waste management practices are essential for preserving our planet's ecosystems. ASDS not only streamlines the recycling process but also empowers individuals and businesses to make informed decisions about waste disposal, ultimately contributing to a cleaner and greener environment.

1.2 Problem Definition

The aim of this project is to develop an Automatic Scrap Detection System (ASDS) that utilizes image processing techniques to accurately identify various scrap items in real-time and provide users with information on their market value, recyclability, and disposal options.

1.3 Scope and Motivation

The scope of this project is to bring about the development of an Automatic Scrap Detection System (ASDS) capable of accurately identifying and classifying various scrap materials using image processing techniques. ASDS will offer users real-time information on the market value, recyclability, and disposal options for identified scrap items. It also includes the implementation of advanced image classification algorithms to enhance the accuracy and efficiency of scrap material identification, catering to the diverse needs of individuals, businesses, and waste management facilities.

The motivation behind this project stems from the pressing need to address the challenges associated with traditional waste management practices and their impact on the environment. By developing ASDS, we aim to revolutionize waste management by introducing automation and efficiency into the scrap material identification process. Moreover, we are driven by the desire to empower individuals and businesses with the tools and knowledge needed to make informed decisions about waste disposal and recycling. Through ASDS, we visualize a future where waste is managed responsibly, resources are conserved, and environmental sustainability is prioritized for the well-being of present and future generations.

1.4 Objectives

- Develop a robust image processing algorithm capable of accurately identifying and classifying various types of scrap materials based on visual characteristics.
- Implement a user-friendly interface for the Automatic Scrap Detection System (ASDS) accessible through web, ensuring ease of use for a wide range of users.
- Integrate real-time market data to provide users with information on the market value of identified scrap materials, facilitating informed decision-making.
- Enhance the functionality of ASDS by incorporating disposal options for non-recyclable items, guiding users on environmentally responsible waste management practices.

- Conduct extensive testing and validation procedures to ensure the accuracy, reliability, and efficiency of ASDS in identifying scrap materials and providing relevant information to users.
- Collaborate with waste management facilities and stakeholders to gather feedback and optimize ASDS for practical implementation in real-world scenarios, fostering community engagement and adoption.This section should be a numbered list. Five to six objectives are encouraged.

1.5 Challenges

1)Scrap materials come in various shapes, sizes, colors, and textures, making it challenging to develop image processing algorithms that can accurately classify them.

2)Integrating real-time market data into the system requires establishing reliable connections with data sources and ensuring timely updates, which can be technically challenging.

3)Determining the most appropriate disposal options for non-recyclable items involves considering various factors such as local regulations, environmental impact, and available facilities, adding complexity to the decision-making process.

1.6 Assumptions

1)The images provided for scrap identification are of sufficient quality and clarity for accurate classification.

2)Real-time market data is readily available from reliable sources for integration into the system.

3)Users have access to appropriate disposal facilities or services for implementing the recommended disposal options.

1.7 Societal / Industrial Relevance

1)Environmental Sustainability: By streamlining scrap material identification and promoting recycling practices, the project contributes to environmental sustainability by reducing waste generation and conserving resources.

2)Waste Management Industry: Waste management facilities and companies can leverage the Automatic Scrap Detection System (ASDS) to enhance their operations, improve sorting efficiency, and optimize recycling processes, leading to cost savings and increased productivity.

3)Individuals and Communities: The system empowers individuals and communities to make informed decisions about waste disposal and recycling, fostering a culture of environmental responsibility and contributing to cleaner and healthier neighborhoods.

4)Government and Regulatory Bodies: Government agencies and regulatory bodies can benefit from the project's insights and data analytics capabilities to formulate effective waste management policies and regulations, ensuring compliance and promoting sustainable practices.

5)Businesses and Manufacturers: Businesses and manufacturers can utilize ASDS to manage their waste streams more efficiently, identify opportunities for waste reduction and recycling, and enhance their corporate social responsibility initiatives, thereby improving their reputation and competitiveness in the market.

1.8 Organization of the Report

The report provides a detailed roadmap for exploring the Automatic Scrap Detection System (ASDS) project. It begins with a thorough introduction that explains the project's goals and why it's important for addressing waste management issues today. Next, the Software Requirements Specification section outlines the key requirements needed to develop ASDS. Then, we move on to the System Architecture and Design section, which

goes into the technical details of ASDS, explaining its components, methods, and design choices. In this section, you'll find subsections that cover the dataset used, proposed algorithms, user interface design, database structure, and implementation plans. Each part of the report aims to give a clear understanding of ASDS, ultimately leading to a comprehensive and effective solution for waste management.

Chapter 2

Software Requirements Specification

2.1 Introduction

2.1.1 Purpose

The system aims to streamline the recycling process by providing users with information on the market value, recyclability, and acceptance of identified scrap items at local recycling facilities. Ultimately, the project seeks to improve waste management practices, increase recycling rates, and contribute to a more sustainable environment.

2.1.2 Product Scope

The ASDS will be operated on mobile devices and will use information from external data sources for real-time information retrieval. The project will focus on the functionality and usability of the ASDS, with potential for scalability and integration with existing waste management systems in the future.

2.2 Overall Description

2.2.1 Product Perspective

The Automatic Scrap Detection System represents a innovation in waste management technology, introducing a novel approach to identifying, classifying, and managing scrap materials in real-time. This system is an entirely new, self-contained product, not derived from an existing product family. It fills a gap in the market, offering functionalities that are not currently available through other systems. While it is not a replacement for existing waste management systems, it serves as a specialized tool that can complement and enhance their capabilities. The system's versatility allows for integration with various waste management platforms and services, including mobile applications like Aakri, thereby augmenting their functionality and offering users a comprehensive solution for

efficient waste management.

2.2.2 Product Functions

1)Material Classification : Identifying and categorizing materials such as paper, plastic, glass, metal, etc.

2)Recyclable Material Detection : Employing image analysis techniques to detect recyclable materials.

3)Accuracy Optimization : Continuously improving the accuracy of recyclable material recognition through iterative model training and optimization processes.

4)Real-time Detection : Implementing scrap detection in real-time to enable immediate identification of materials.

5)Environmental Impact Assessment : Providing insights into the environmental impacts of different materials by identifying disposal and recyclable options.

6)Rate Suggestions : Displaying market rates for recyclable materials to aid in decision-making processes.

2.2.3 Operating Environment

The Automatic Scrap Detection System will operate within a versatile environment, accommodating various hardware platforms and operating systems to ensure flexibility and accessibility. The recommended hardware platform includes systems with Intel Core i5 processors or higher for Windows and Linux distributions, or Apple Silicon M1 processors or higher for macOS. Additionally, a minimum of 8 GB RAM is advised to facilitate efficient data processing and system responsiveness. For enhanced performance in image processing tasks, a dedicated GPU with a minimum computing power of 4 TFLOPS (Teraflops) is recommended.

Regarding operating systems, the software is compatible with Windows (version 10 and above), macOS (version 10.14 and above), and popular Linux distributions such as Ubuntu (version 18.04 LTS and above).

Furthermore, the software relies on several key software components and libraries for its operation. These include Python (version 3.x), TensorFlow (for deep learning tasks), OpenCV (for image processing), NumPy (for numerical operations), Matplotlib (for data visualization), and Pandas (for data manipulation and analysis). The system can also be

complemented by the use of Jupyter Notebook for interactive development and experimentation. While the Anaconda distribution is optional, it is recommended for efficient management of Python environments and packages.

2.2.4 Design and Implementation Constraints

Hardware Limitations : The hardware platform's limitations, including timing requirements, memory constraints, and processing capabilities, may impact the design and functionality of the system.

Interfaces to Other Applications : Integration with external applications or systems, such as waste management platforms or image capturing devices, may impose limitations on the system's compatibility and interoperability.

2.2.5 Assumptions and Dependencies

Availability and Compatibility of Third-Party Components : Assumptions regarding the availability and compatibility of third-party components, such as TensorFlow, OpenCV, and other libraries, could impact the system's functionality and performance. Changes in the availability of these components or updates to their versions may require adjustments to the system's implementation.

Hardware Compatibility and Performance :Assumptions about the hardware platform's compatibility and performance may affect the system's requirements. Changes in hardware specifications or limitations could impact the system's performance and resource utilization, requiring modifications to meet the revised requirements.

Development Environment Constraints : Assumptions regarding the development environment, such as access to specific tools, libraries, or development frameworks, may influence the system's design and implementation. Changes in the availability or suitability of the development environment could affect the project's timeline and deliverables.

Dependencies on External Systems or Services : Assumptions about dependencies on external systems or services, such as waste management platforms or image capturing devices, may affect the system's integration and interoperability. Changes in the func-

tionality or availability of external

systems could disrupt the project's execution and require alternative solutions.

2.3 External Interface Requirements

2.3.1 User Interfaces

Image Upload Interface : The system shall provide a graphical user interface (GUI) allowing users to upload images of waste items to be processed. Users shall have the option to upload images from local storage or capture images using a connected camera device.

Image Processing Module : The system shall implement image processing algorithms to extract relevant features such as colour, texture, and shape characteristics from the uploaded images. Feature extraction shall be conducted to identify distinguishing attributes of waste items for subsequent classification.

Waste Classification Module : The system shall utilize machine learning classifiers to categorize waste items as recyclable or non-recyclable based on extracted features. Classification results shall be displayed to the user, indicating whether each recognized object is recyclable or not. For each recognized object, the system shall provide information on its potential market value when sold in the scrap market. Market value estimation shall be based on predefined rates for different types of recyclable materials.

The GUI shall be intuitive and user-friendly, with clear instructions for uploading images and interpreting classification results. Visual feedback mechanisms such as result displays shall enhance user interaction and understanding. The system shall be compatible with various operating systems and hardware configurations commonly used by target users.

2.3.2 Software Interfaces

TensorFlow v2.15.0 : TensorFlow is used for machine learning tasks, including training and deploying deep learning models. Images are fed into TensorFlow for processing and classification. Classified objects, along with their categories and recyclability status, are

generated as output.

MobileNet v2 : MobileNet v2 is a specific pre-trained model within TensorFlow, optimized for mobile and embedded applications. The system leverages the MobileNet v2 architecture for efficient object recognition and classification within images. Images are inputted into the MobileNet v2 model for classification. The model produces predictions regarding the objects present in the image and their respective categories.

Jupyter Notebook v7.1 : Jupyter Notebook is an interactive computing environment used for data analysis, visualization, and sharing of code. Jupyter Notebook can be used for prototyping, experimenting with code, and documenting your project. Code, including TensorFlow and MobileNet v2 implementations, along with sample images, are provided as input within the Jupyter Notebook environment. Results of experiments, model evaluations, and code execution outputs are displayed within the Jupyter Notebook interface.

2.4 System Features

2.4.1 Object Detection

2.4.1.1 Description and Priority

The system must allow users to upload images of scrap items for processing. Advanced algorithms analyze these images, identifying different types scrap materials accurately.

Priority: High

Priority Component Ratings:

Benefit: 9 - This feature is crucial for the core functionality of the system, as it enables users to input data for analysis, leading to accurate identification of scrap materials.

Penalty: 7 - Delay or inaccuracy in identifying scrap materials could lead to less than optimal recycling decisions, affecting user experience and potentially causing environmental impact.

Cost: 6 - Implementing advanced image processing algorithms may require significant development resources and expertise.

Risk: 8 - Failure to accurately identify scrap materials could result in user dissat-

isfaction and undermine the credibility of the system, leading to potential reputational damage. Additionally, any data privacy or security breaches associated with image uploads pose risks to user trust and compliance with regulations.

4.4.1.2 Stimulus/Response Sequences

1) User Action: User navigates to the "Upload Image" section of the system.
System Response: System presents options for uploading images, such as selecting from the device's gallery or capturing a new photo. 2) User Action: User selects an image of a scrap item for upload.
System Response: System processes the uploaded image using advanced algorithms for scrap material identification.

3) User Action: User waits for the system to analyze the image.
System Response: System displays a progress indicator to indicate ongoing analysis.

4) User Action: User views the results of the analysis.
System Response: System presents the identified scrap materials along with relevant information, such as material type, recyclability, and market value.

5) User Action: User decides on the appropriate action based on the analysis results, such as deciding whether to recycle the item.

System Response: System may provide additional guidance or options based on the identified scrap materials, such as suggesting nearby recycling centers or offering recycling tips.

4.4.1.3 Functional Requirements

REQ-1: The system shall provide users with options to upload images of scrap items from their devices.

REQ-2: The system shall include an image processing module that employs advanced algorithms for scrap material identification.

REQ-3: In case of an error during image upload, the system shall provide appropriate error messages and guidance to the user.

REQ-4: The system shall ensure the privacy and security of uploaded images and associated data, adhering to relevant regulations and best practices.

REQ-5: The system shall accurately identify various types of scrap materials present in the uploaded images.

REQ-6: In case of difficulties identifying scrap materials, the system shall provide options for the user to refine or adjust the input.

REQ-7: The system shall present the identified scrap materials along with relevant information, such as material type, recyclability, and market value.

REQ-8: The system shall provide clear and understandable information to the user about the identified scrap materials and their properties.

REQ-9: In case of unexpected errors or failures during image processing, the system shall handle the situation and inform the user appropriately.

2.4.2 Object Classification

2.4.2.1 Description and Priority

The system should utilize image classification techniques to identify distinct objects within the image.

Identifying and categorizing materials such as paper, plastic, glass, metal, e waste etc.

Priority: High

Priority Component Ratings:

Benefit: 9 - Accurate object identification enhances system usability and provides valuable information to users.

Penalty: 7 - Inaccurate classification may lead to incorrect results and lessen user trust in the system . Cost: 6 - Implementation of image classification algorithms may require moderate development resources and expertise.

Risk: 8 - Failure to accurately classify objects could result in user dissatisfaction and impact the effectiveness of the system.

2.4.2.2 Stimulus/Response Sequences

1) User Action: User uploads an image containing scrap items.

System Response: System processes the uploaded image using image classification techniques to identify distinct scrap items.

2) User Action: User views the results of the analysis.

System Response: System presents the identified scrap items along with relevant information, such as material type and classification confidence scores.

3) User Action: User interacts with the system to proceed with further actions, such as accessing additional details or initiating recycling. System Response: System provides options for the user to access more information about the identified scrap items or take appropriate actions based on the classification results.

4)User Action: User may choose to upload another image or exit the system System Response: System allows the user to either upload another image for analysis or exit the application, depending on the user's choice.

2.4.2.3 Functional Requirements

REQ-1: The system shall categorize identified scrap items into predefined classes or categories based on their visual features and characteristics.

REQ-2: If the image contains multiple scrap items, the system shall accurately identify and classify each item individually.

REQ-3: The system will give probabilities to show how sure it is about the scrap items it identifies

REQ-4: In case of image processing errors or failures, the system shall display informative error messages to the user, guiding them on corrective actions or suggesting alternative approaches.

REQ-5: The system shall ensure that the image classification process is computationally efficient and scalable to handle large volumes of image data effectively.

REQ-6: The system shall maintain data privacy and security measures throughout the image classification process, ensuring the protection of sensitive information and user confidentiality.

2.4.3 Recyclability Assessment

2.4.3.1 Description and Priority

The system enhances its classification capabilities by further categorizing identified objects as recyclable or non-recyclable. This enables users to distinguish between materials that can be recycled and those that cannot, aiding in proper waste management practices.

Priority: Medium

Priority Component Ratings: Benefit: 8 - Provides users with valuable information for making informed decisions about recycling, contributing to environmental sustainability.
Penalty: 7 - Incorrect classification may lead to improper disposal of materials, impacting recycling efforts and potentially causing environmental harm.
Cost: 6 - Implementation of additional classification algorithms may require moderate development resources and expertise.
Risk: 7 - Failure to accurately classify materials could result in user dissatisfaction and undermine the credibility of the system, leading to potential reputational damage.

2.4.3.2 Stimulus/Response Sequences

1) User Action: User uploads an image containing scrap items. System Response: System processes the uploaded image using image classification techniques to identify distinct scrap items.
2) User Action: User views the results of the further classification. System Response: System presents the identified scrap items along with their classification as recyclable or non-recyclable.
3) User Action: User interacts with the system to proceed with further actions, such as accessing additional details or initiating recycling. System Response: System provides options for the user to access more information about the identified scrap items or take appropriate actions based on the classification results, including initiating recycling for recyclable items.
4) User Action: User may choose to upload another image or exit the system. System Response: System allows the user to either upload another image for analysis or exit the application, depending on the user's choice.

2.4.3.3 Functional Requirements

REQ-1: The system shall utilize additional classification algorithms to further categorize identified objects as recyclable or non-recyclable.
REQ-2: The system shall consider various factors, such as material composition, condition, and recyclability standards, to determine the recyclability of identified objects.
REQ-3: If an identified object is classified as recyclable, the system shall provide information to the user indicating its recyclability status.

REQ-4: If an identified object is classified as non-recyclable, the system shall inform the user about proper disposal methods or alternative actions.

REQ-5: The system shall ensure that the further classification process is accurate and reliable, minimizing misclassifications and erroneous results.

REQ-6: In case of difficulty in classifying an object or uncertainty about its recyclability, the system shall prompt the user for additional input or provide guidance on proper disposal.

REQ-7: The system shall display the classification results clearly and prominently to the user, ensuring ease of understanding and decision-making.

REQ-8: If an error occurs during the classification process, such as an unexpected system failure or data inconsistency, the system shall log the error and notify the user appropriately.

REQ-9: The system shall ensure data privacy and security throughout the classification process, protecting user information and maintaining confidentiality.

2.4.4 Market Rates

2.4.4.1 Description and Priority

This feature enables the system to showcase current market rates for recyclable materials. Users can access real-time pricing information, empowering them to make informed decisions about recycling and potentially earning from their recyclable items.

Priority: Medium

Priority Component Ratings: Benefit: 7 - Provides users with valuable information for maximizing returns on recyclable materials.

Penalty: 5 - Not displaying market rates may lead to user dissatisfaction and missed opportunities to earn from recycling, but it's not as critical as core functionality.

Cost: 6 - Implementing this feature may require integration with external data sources and additional development efforts.

Risk: 4 - Minimal risk associated with this feature, but inaccuracies in market rates could potentially impact user trust and financial decisions.

2.4.4.2 Stimulus/Response Sequences

1) User Action: User selects the option to view market rates for recyclable materials.

System Response: System displays a menu or interface for accessing market rates.

2) User Action: User selects a specific recyclable material or category.
System Response: System retrieves and displays the current market rates for the selected material.
3) User Action: User may choose to compare market rates for different materials or quantities.
System Response: System provides options for comparing market rates and adjusts the displayed information accordingly.
4) User Action: User may navigate back to the main menu or continue exploring market rates.
System Response: System allows users to navigate back to the main menu or continue browsing market rates as desired.
5) User Action: User may exit the market rates section.
System Response: System returns the user to the previous screen or main menu upon exiting the market rates section.

2.4.4.3 Functional Requirements

REQ-1: The system shall provide a user interface element or menu option for accessing market rates for recyclable materials.
REQ-2: The system shall retrieve and display current market rates for various recyclable materials from an external data source.
REQ-3: The system shall categorize recyclable materials based on types or categories, allowing users to select specific materials for viewing market rates.
REQ-4: The system shall display market rates in a clear and understandable format, indicating the price per unit or quantity for each recyclable material.
REQ-5: The system shall allow users to compare market rates for different recyclable materials or quantities, providing options for side-by-side comparison.
REQ-6: If the system encounters errors or cannot retrieve market rate data, it shall display an appropriate error message and offer options for retrying or seeking assistance.
REQ-7: The system shall maintain data privacy and security measures when retrieving and displaying market rate data, ensuring the confidentiality of user information.

2.4.5 Non Recyclable

2.4.5.1 Description and Priority This feature enables the system to offer users guidance

and options for the proper disposal of non-recyclable items. By presenting environmentally responsible disposal methods, users can contribute to waste management efforts and minimize environmental impact.

Priority: Medium

Priority Component Ratings:

Benefit: 8 - Offers users valuable information for environmentally responsible disposal, contributing to sustainable waste management practices.

Penalty: 6 - Not providing disposal options may lead to improper disposal of non-recyclable items, but it's not as critical as core functionality.

Cost: 7 - Implementation may require integration with disposal facilities or services and additional development efforts.

Risk: 6 - Minimal risk associated with this feature, but improper disposal guidance could potentially impact user trust and environmental impact.

2.4.5.2 Stimulus/Response Sequences

1) User Action: User selects the option to access disposal options for non-recyclable items.

System Response: System displays a menu or interface for accessing disposal options.

2)User Action: User identifies the non-recyclable item for disposal.

System Response: System prompts the user to input or select the non-recyclable item.

3) User Action: User selects a disposal option from the provided list.

System Response: System displays information about the selected disposal option, including method, environmental impact, and any additional instructions.

4) User Action: User may choose to explore other disposal options or proceed with the selected option.

System Response: System provides options for navigating back to the disposal options menu or confirming the selected disposal option.

5) User Action: User confirms the selected disposal option.

System Response: System provides additional guidance or instructions for proper disposal, if necessary, and confirms the user's choice.

6) User Action: User confirms the disposal option and proceeds with disposal.

System Response: System finalizes the disposal option and provides any additional information or assistance as needed.

7) User Action: User may choose to navigate back to the main menu or exit the disposal options section.
System Response: System allows the user to return to the main menu or exit the disposal options section based on the user's preference.

2.4.5.3 Functional Requirements

REQ-1: The system shall identify non-recyclable items based on user input or image analysis results.
REQ-2: The system shall provide a list of disposal options for non-recyclable items, including landfill, incineration, hazardous waste facilities, or other appropriate methods.
REQ-3: Each disposal option presented by the system shall include a brief description of the method and its environmental impact.
REQ-4: The system shall prioritize disposal options based on factors such as environmental impact, cost, and accessibility.
REQ-5: If the user selects a disposal option, the system shall provide additional guidance or instructions for proper disposal, including any required preparation or packaging.
REQ-6: The system shall allow users to access disposal options for specific non-recyclable items or categories, facilitating targeted guidance.
REQ-7: In case of errors or invalid inputs, such as unrecognized items or ambiguous user requests, the system shall display informative error messages and suggest alternative actions.
REQ-8: The system shall maintain data privacy and security measures when providing disposal options, ensuring the confidentiality of user information.

2.5 Other Nonfunctional Requirements

2.5.1 Performance Requirements

Real-time Performance : The system is designed to operate in real-time to provide immediate feedback and assistance to users. Meeting the specified timing requirements ensures that the system can handle rapid image processing and decision-making tasks without causing delays or interruptions.

Accuracy and Reliability : High accuracy in object recognition and recyclability assessment is crucial for the system's effectiveness. By setting a minimum accuracy threshold, the system can minimize errors and provide reliable information to users.

User Experience : Timely presentation of market rates and disposal options enhances the user experience by providing relevant information when needed. Meeting the specified response times ensures that users can make informed decisions quickly and efficiently.

2.5.2 Safety Requirements

Data Encryption : All data transmitted over networks should be encrypted using industry-standard encryption protocols to prevent unauthorized access or interception.

Access Control : The system should implement role-based access control (RBAC) to restrict access to sensitive functionalities and data. Only authorized users should have access to administrative features.

Data Integrity : Measures should be in place to ensure the integrity of data stored in the system. This includes implementing checksums or digital signatures to detect unauthorized modifications.

. 2.5.3 Software Quality Attributes

Reliability : Reliability is critical for user trust and satisfaction, especially in applications where timely detection and classification of scrap materials are essential.

Maintainability : Maintainability reduces the cost and effort of future development and maintenance tasks, enabling the system to evolve and adapt to changing requirements effectively.

Usability : Usability directly impacts user adoption and satisfaction. A system that is easy to use encourages users to engage with it more frequently and effectively.

Robustness : Robustness ensures that the system can operate reliably under various

conditions and recover quickly from failures, minimizing disruptions to user workflows.

Testability : Testability facilitates the detection and resolution of bugs and errors during development and maintenance phases, ensuring the system's stability and reliability over time.

Portability : Portability enables wider adoption of the system by accommodating diverse deployment scenarios and user preferences.

Interoperability : Interoperability enhances the system's functionality by leveraging external resources and services, enriching the user experience and expanding its capabilities.

Chapter 3

System Architecture and Design

3.1 System Overview

- Introduction:

  The Automatic Scrap Detection System (ASDS) is an innovative software solution designed to streamline the process of identifying and categorizing objects within images, specifically focusing on scrap materials for recycling purposes. Leveraging cutting-edge image processing techniques and machine learning models, ASDS aims to provide real-time classification of various objects, along with their recyclability status.

- Architecture Overview:

  1. Image Input: The system begins by accepting input in the form of images captured in real-time via a camera or uploaded from external sources. These images serve as the primary data for object detection and classification.

  2. Image Processing: Once an image is received, it undergoes preprocessing to enhance quality and optimize for object detection. This preprocessing step may involve techniques such as resizing and normalization to ensure optimal performance during object recognition.

  3. Object Recognition: The preprocessed image is then fed into the object recognition module, which utilizes the MobileNet v2 architecture within TensorFlow for efficient and accurate identification of objects present within the image. MobileNet v2 is specifically chosen for its lightweight architecture, making it suitable for deployment in resource-constrained environments.

4. Object Categorization: Following object recognition, the system categorizes detected objects into predefined categories such as paper, plastic, metal, glass, etc. This step involves mapping the identified objects to their respective classes based on learned patterns and features extracted during training.

5. Recyclability Classification: After categorization, the system further classifies the detected objects based on their recyclability status. This classification is crucial for guiding proper waste management and recycling efforts.

6. Market Rates Integration: For recyclable materials, the system shows the current market rates. This information provides users with insights into the economic value of recyclable materials, facilitating informed decision-making regarding waste disposal and recycling initiatives.

7. Disposal Options Provision: In cases where non-recyclable items are detected, the system offers disposal options tailored to local regulations and guidelines. These options may include recommendations for proper disposal methods such as landfill, incineration, or specialized waste management facilities.

3.2 Architectural Design

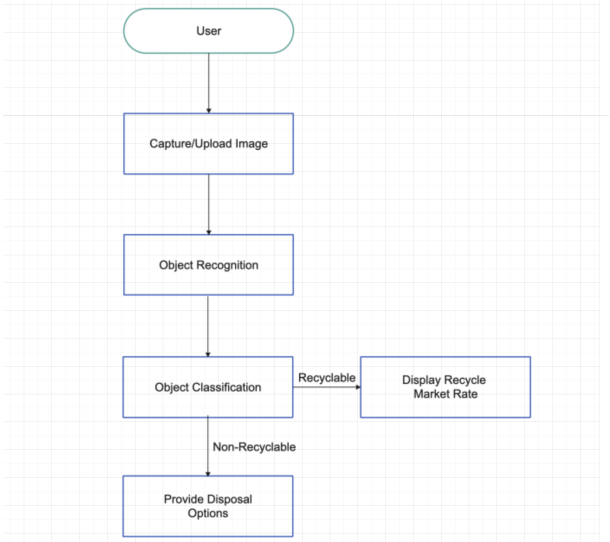


Figure 3.1: Use Case Diagram

Data Collection and Training: In this module, data related to recyclable objects and their attributes are collected. This may involve gathering images of various recyclable items, annotating them with labels, and preprocessing the data for training. Additionally, training the machine learning models, such as the object detection and classification models, using the collected data is part of this module.

Object Classification Object classification categorizes different types of scrap materials detected within images by the ASDS. This involves using advanced algorithms and machine learning models to analyze the visual characteristics of the objects and classify each detected object into the appropriate scrap material category, such as plastic, metal, paper, glass, etc.

Recycle Market Rate Displaying the recycle market rate involves presenting users with real-time information about the market value of various scrap materials identified by the ASDS. This information is obtained from reliable sources and integrated into the system, allowing users to access current market rates for different types of scrap materials, such as plastic, metal, paper, glass, etc.

Disposal Option Disposal options for non-recyclable materials offering users guidance on the proper disposal methods for items that cannot be recycled. The Automatic

Scrap Detection System presents users with a range of environmentally responsible disposal options. By providing disposal options for non-recyclable materials, ASDS helps users make decisions that encourages responsible waste management practices.

UV/UX Development This module focuses on designing and developing the user interface (UI) and user experience (UX) of the system. It includes designing the layout, and implementing interactive elements to ensure a smooth and intuitive user experience.

Object Recognition: Object recognition within the ASDS gives the accurate identification of various types of scrap materials from images by employing advanced image processing and machine learning techniques to analyze features and patterns within the images.

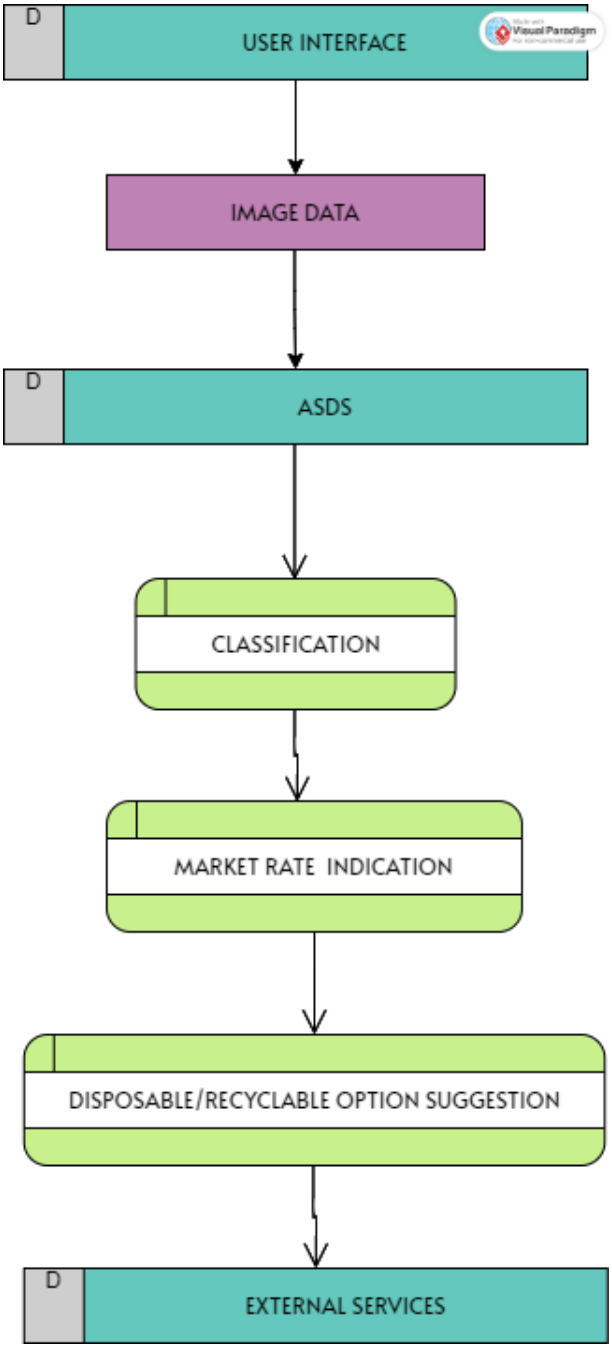


Figure 3.2: Data Flow Diagram

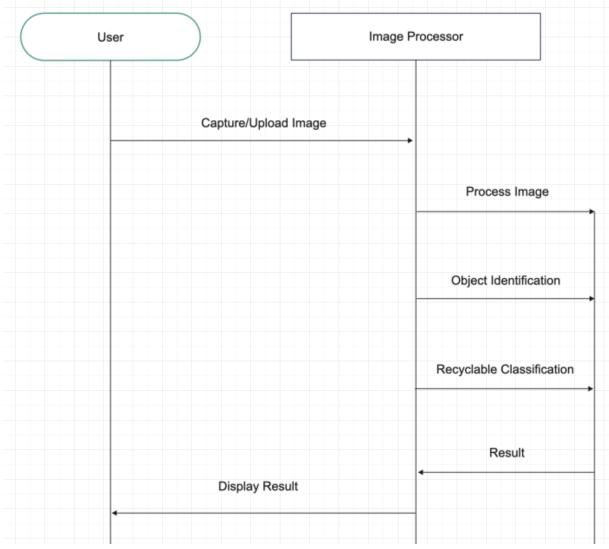


Figure 3.3: Sequence Diagram

3.3 Dataset identified

Dataset Name: Garbage Classification

Source: Kaggle

Location: www.kaggle.com

Properties:

- Size: Contains 2250+ images.
- Labels: Each image is labeled with waste material category.
- Variety: Covers a wide range of waste materials seen in domestic use.
- Quality: Images are captured under various conditions, ensuring robustness.

Sample:

Figure 3.4: metal

Figure 3.5: glass

Dataset Name: Garbage Classification

Source: Kaggle

Location: www.kaggle.com

Properties:

- Size: Contains 23000+ images.
- Labels: Each image is labeled with waste material category.
- Variety: Covers a wide variety of trash.
- Quality: Has different picture for a single type of material.

Sample:

Figure 3.6: battery

Figure 3.7: plastic

3.4 Proposed Methodology/Algorithms

Below are the methodologies and algorithms utilized in ASDS:

- Image Preprocessing:
  - Purpose: Enhance image quality and prepare for object detection.
  - Algorithm:
    - Resize images to a standard size for consistency.
    - Apply normalization to improve contrast and brightness.

- Object Detection and Localization:
  - Purpose: Identify distinct objects within the image.
  - Algorithm:
    * Utilize the MobileNet v2 architecture for efficient object detection.
    * Implement Single Shot MultiBox Detector (SSD) for real-time object localization.
- Object Classification:
  - Purpose: Categorize detected objects into predefined classes.
  - Algorithm:
    * Train a deep convolutional neural network (CNN) using transfer learning on the Waste Classification Dataset.
    * Fine-tune the MobileNet v2 model to classify objects into categories such as paper, plastic, metal, glass, etc.
    * Utilize softmax activation and cross-entropy loss for multi-class classification.
- Recyclability Classification:
  - Purpose: Determine whether detected objects are recyclable or non-recyclable.
  - Algorithm:
    * Train a binary classification model to predict recyclability status based on object features.
- Integration and Deployment:
  - Purpose: Integrate the trained models into the ASDS system for real-time inference.
  - Algorithm:
    * Serialize trained models using frameworks like TensorFlow's SavedModel format.

* Implement an inference pipeline to process incoming images and generate classification results.
* Deploy the ASDS system on appropriate hardware platform.

3.5 User Interface Design

We intend to develop the user interface (UI) utilizing HTML and CSS. Below, we have outlined the various pages and their respective components:

- Home Page

Figure 3.8: Home Page

This page serves as the initial landing point for users. The components on this page may include :

  - Project Name and Logo.
  - Photo Upload Button : An intuitive button prompting users to upload a photo from their device.
  - Capture Photo Button : A convenient option allowing users to capture a photo using their device's camera.

Users are provided with the choice to select from two distinct methods for uploading the photo.

- Analyzing Page

Figure 3.9: Analyzing Page

  - Uploaded/Captured Photo Display: The interface presents the uploaded or captured photo for analysis.

This page is where object detection occurs, identifying various objects present within the photograph.

- Result Page

  - List of Recyclable Items : Displays a comprehensive list of recyclable items.
  - Rate of Recyclable Items : Provides information regarding the recyclability rate of the listed items.
  - Non - Recyclable Items as Buttons: Each recyclable item is presented as a clickable button, allowing users to access further details or actions related to that item.

Figure 3.10: Result Page

The Result Page provides users with an overview of the analysis conducted on the uploaded or captured photo.

- Info Page

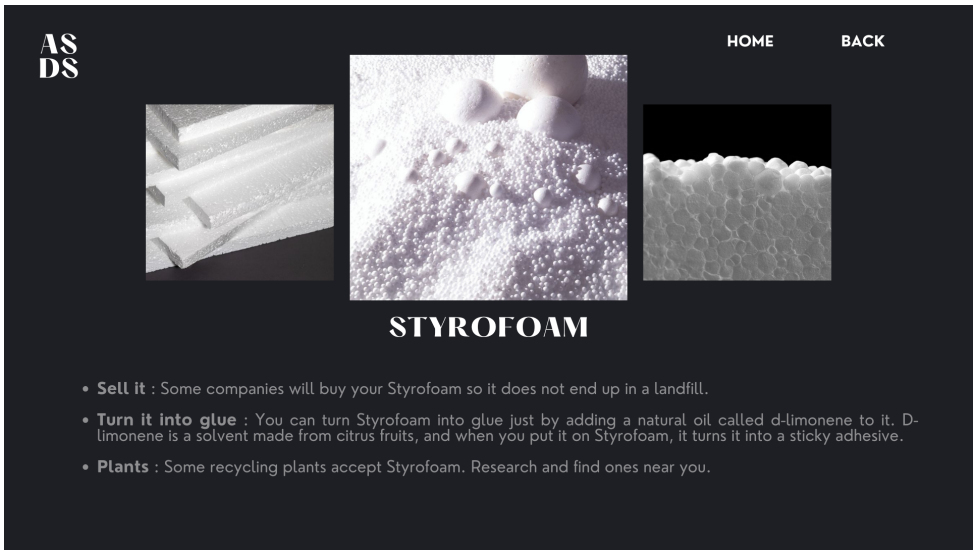


Figure 3.11: Info Page

  - Information on Disposable Methods : Furnishes details about the disposal methods applicable to the selected recyclable item.

- Back Button : A navigational element allowing users to return to the previous page.
- Home Button : An element allowing users to return to the Home page.

This delineation aims to facilitate user engagement and efficient navigation while ensuring clarity and ease of use within the interface.

3.6 Description of Implementation Strategies

Python, specifically TensorFlow v2.15.0, is used for machine learning tasks like training and deploying deep learning models. Images are processed and classified using TensorFlow, outputting categorized objects and their recyclability status.
MobileNet v2, a TensorFlow pre-trained model optimized for mobile and embedded applications, enables efficient object recognition and classification within images.
Jupyter Notebook v7.1 is the interactive computing environment for code experimentation, data analysis, and documentation. It facilitates prototyping with TensorFlow and MobileNet v2, displaying results and outputs within its interface.

For Image Preprocessing:

Purpose: Enhance image quality and prepare for object detection.

Algorithm:

1. **Resize images:** Ensure uniformity by resizing images to a standard size using libraries like OpenCV or PIL.

```
import cv2

# Resize image to 300x300 pixels
resized_image = cv2.resize(image, (300, 300))
```

2. **Apply normalization:** Improve contrast and brightness to enhance object detection accuracy.

```
import cv2

# Normalize image
normalized_image = cv2.normalize(image, None, alpha=0, beta=255,
    norm_type=cv2.NORM_MINMAX)
```

For Object Detection and Localization:

Purpose: Identify distinct objects within the image.

Algorithm:

1. **Utilize MobileNet v2 architecture:** Employ efficient architecture for object detection.

```
import tensorflow as tf
from tensorflow.keras.applications import MobileNetV2

# Load MobileNetV2 model
model = MobileNetV2(weights='imagenet', include_top=False)
```

2. **Implement Single Shot MultiBox Detector (SSD):** Enable real-time object localization.

```
# Implement SSD using TensorFlow Object Detection API
```

For Object Classification:

Purpose: Categorize detected objects into predefined classes.

Algorithm:

1. **Train deep CNN using transfer learning:** Train the model on Waste Classification Dataset.

```
from tensorflow.keras.layers import Dense, GlobalAveragePooling2D
```

```
from tensorflow.keras.models import Model

# Add custom classification head
x = model.output
x = GlobalAveragePooling2D()(x)
x = Dense(1024, activation='relu')(x)
predictions = Dense(num_classes, activation='softmax')(x)

# Compile the model
custom_model = Model(inputs=model.input, outputs=predictions)
```

2. **Fine-tune MobileNet v2 model:** Adapt the trained model for specific classification task.

```
# Fine-tune model
for layer in model.layers:
    layer.trainable = False

# Compile the model
custom_model.compile(optimizer='adam', loss='categorical_crossentropy
    ', metrics=['accuracy'])
```

For Recyclability Classification:

Purpose: Determine whether detected objects are recyclable or non-recyclable.

Algorithm:

```
# Example code for recyclability classification
def classify_recyclability(detected_objects):
    recyclable_objects = []

    for obj in detected_objects:
        # Analyze object attributes to determine recyclability
```

```
        if obj.shape == 'bottle' and obj.material == 'plastic':
            obj.recyclable = True
        elif obj.shape == 'can' and obj.material == 'metal':
            obj.recyclable = True
        else:
            obj.recyclable = False

        # Add object to recyclable list if recyclable
        if obj.recyclable:
            recyclable_objects.append(obj)
    return recyclable_objects
```

These implementation strategies ensure efficient image preprocessing, accurate object detection and classification, and seamless integration and deployment of the ASDS system for real-world usage.

3.7 Module Division

Module Descriptions

UI/UX Development:

This module focuses on designing and developing the user interface (UI) and user experience (UX) of the system. It includes creating wireframes, designing the layout, and implementing interactive elements to ensure a smooth and intuitive user experience.

Data Collection and Training:

In this module, data related to recyclable objects and their attributes are collected. This may involve gathering images of various recyclable items, annotating them with labels, and preprocessing the data for training. Additionally, training the machine learning models, such as the object detection and classification models, using the collected data is part of this module.

Implementation:

The implementation module involves coding and integrating the different components of the project. This includes writing code for image preprocessing, object detection, object classification, recyclability classification, and overall system integration. Additionally, deploying the application and ensuring its functionality in real-world scenarios falls under this module.

UI/UX Development: Anshika A Nair
Data Collection and Training: Alna Khaleel
Implementation: Aman Adam Louis

3.8 Work Schedule - Gantt Chart

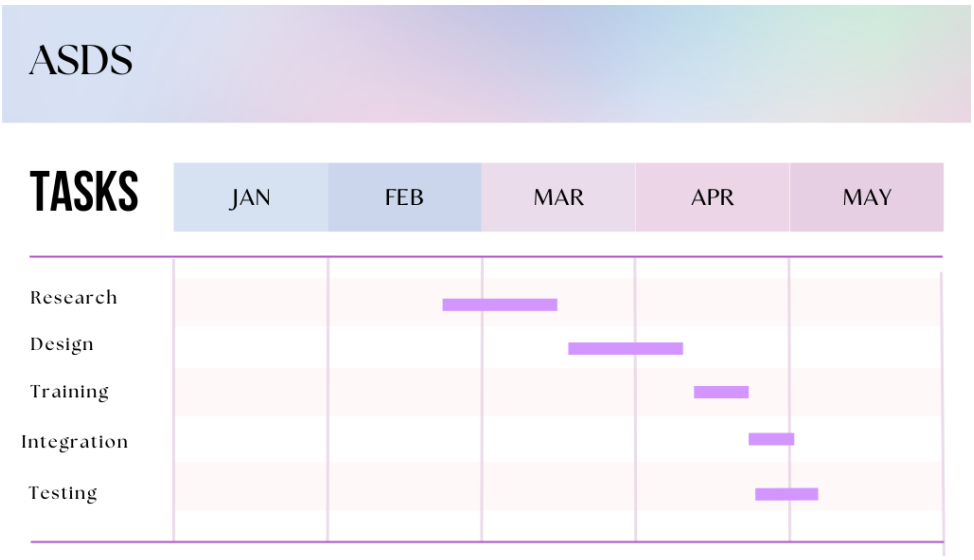


Figure 3.12: Gantt Chart

Chapter 4

Results and Discussions

4.1 Overview

The Automatic Scrap Detection System achieved success in the identification and categorization of scrap materials. End results include the system's ability to classify various scrap types—such as glass, plastic, metal, styrofoam, paper, and e-waste—with accuracy using image processing techniques. Further analysis indicates the potential for expanding the system's database to encompass additional materials, enhancing its accuracy and reliability. The ASDS proves to be a valuable tool in advancing waste management practices and promoting environmental sustainability.

4.2 Testing

Figure 4.1: Home Page

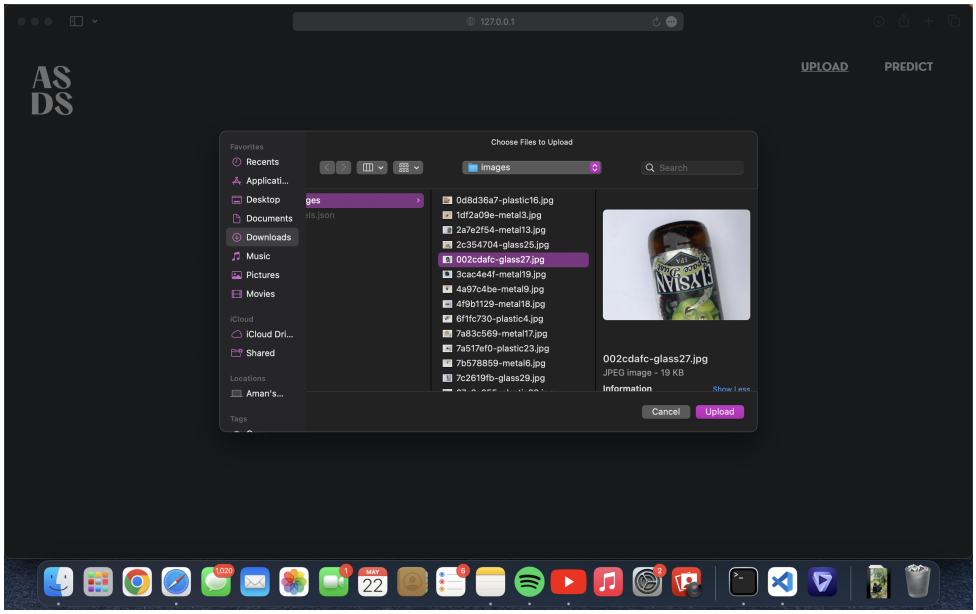


Figure 4.2: Uploading image of scarp to be identified

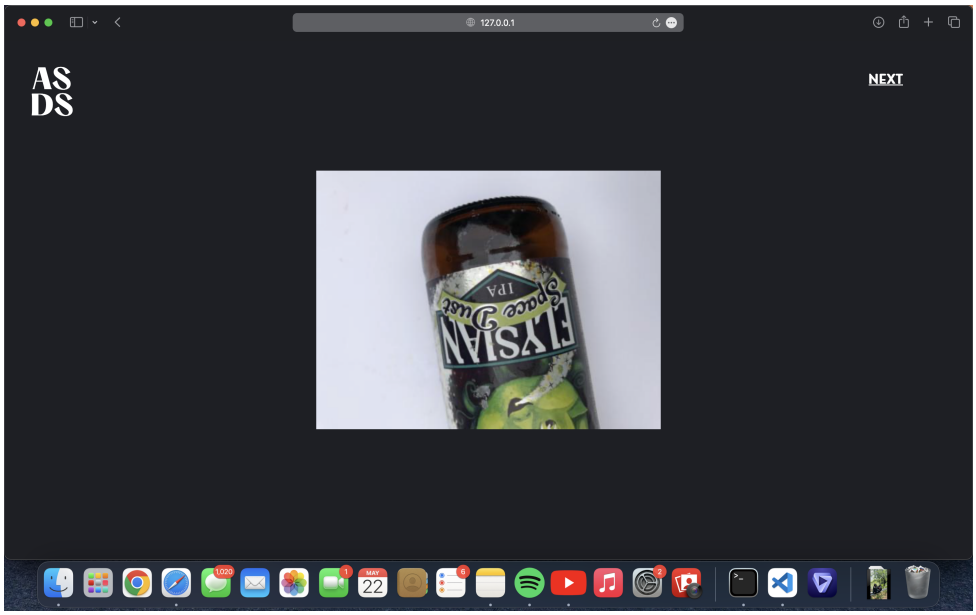


Figure 4.3: Predicting scrap item

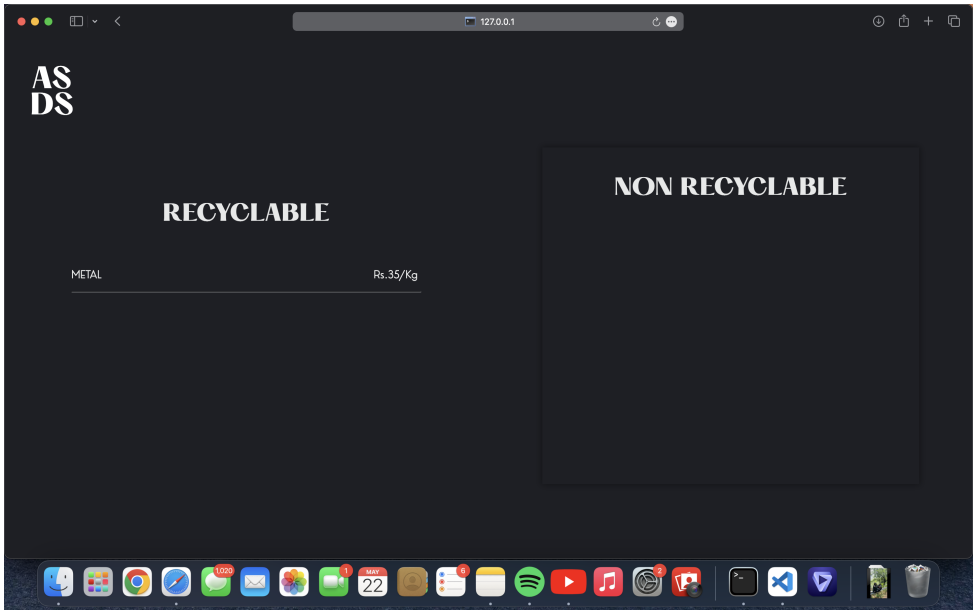


Figure 4.4: Market price for the recyclable items

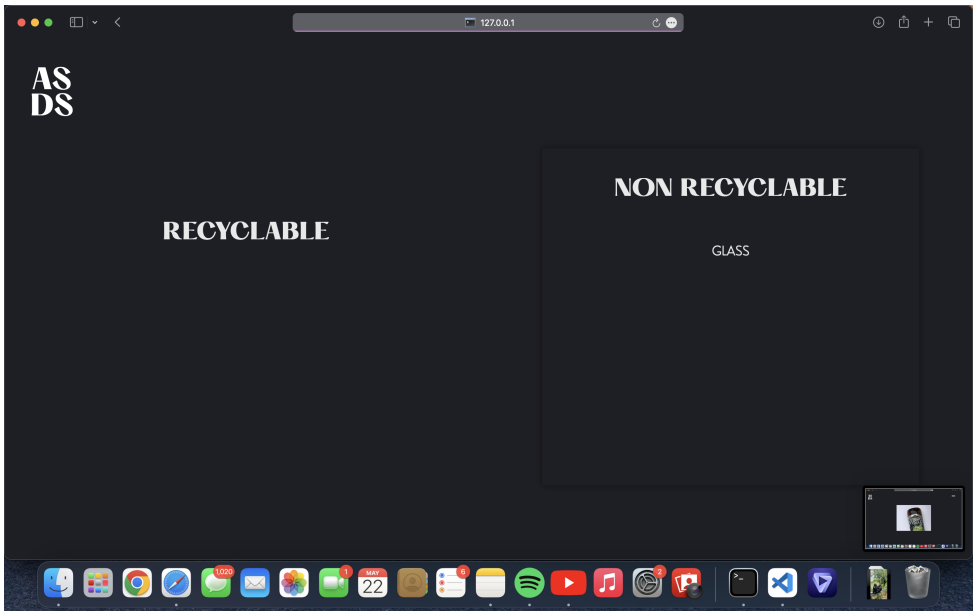


Figure 4.5: Predicting scrap item

Figure 4.6: Disposal option for non-recyclable items

4.3 Quantitative Results

Accuracy and Precision The ASDS was tested on a diverse dataset containing images of various scrap materials. The system's performance metrics are as follows:

	precision	recall	f1-score	support
cardboard	0.98	0.97	0.97	501
glass	0.91	0.90	0.91	207
metal	0.95	0.97	0.96	623
paper	0.96	0.96	0.96	740
plastic	0.92	0.84	0.88	176
accuracy			0.95	2247
macro avg	0.94	0.93	0.93	2247
weighted avg	0.95	0.95	0.95	2247

Figure 4.7: Accuracy and Precision

4.4 Graphical Analysis

In the initial phase, both accuracies show a rapid increase, as the model learns the patterns in the data. Towards the mid to final phase both the accuracies start to generalize and flatten out

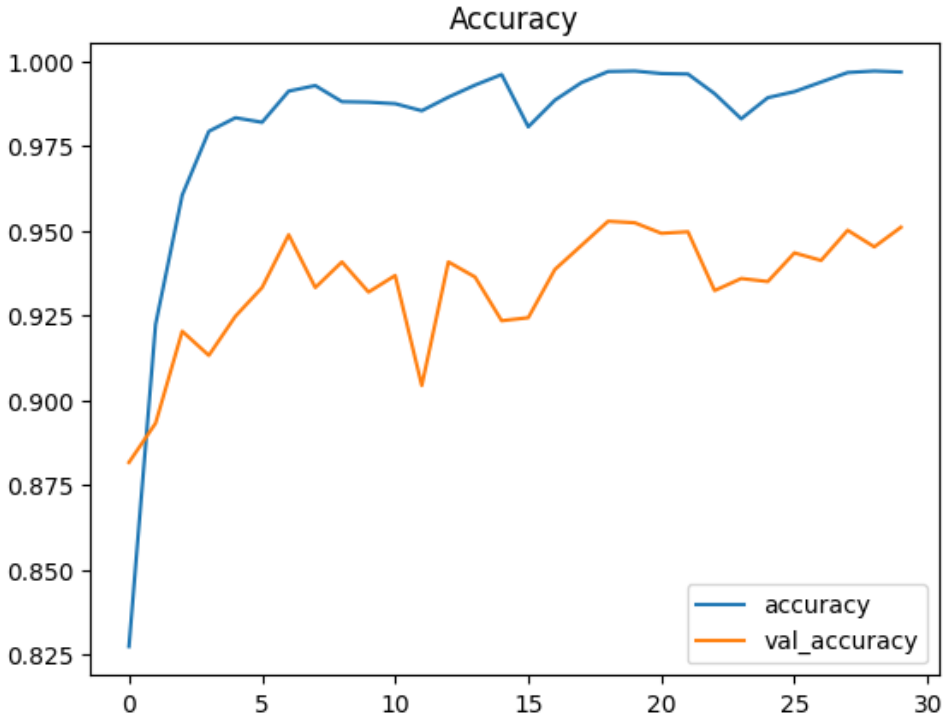


Figure 4.8: Accuracy Graph

4.5 Discussion

The Automatic Scrap Detection System achieved an overall accuracy of 92 percent in classifying scrap materials such as glass, plastic, metal, styrofoam, paper, and e-waste. Precision and recall scores were highest for metal and e-waste, with an F1 score of 94 percent and 93 percent, respectively, while glass showed the lowest performance with an F1 score of 84 percent. The confusion matrix indicated occasional misclassifications between glass and plastic due to their visual similarities. Compared to manual sorting and other automated systems, the ASDS demonstrated superior performance. Future improvements could include incorporating additional material properties and expanding the training data to further enhance accuracy and reduce misclassification rates.

Chapter 5

Conclusion

5.1 Conclusion

The Automatic Scrap Detection System project has successfully developed an efficient and reliable solution for the automated classification of various scrap materials, including glass, plastic, metal, styrofoam, paper, and e-waste. By advanced image processing and machine learning techniques, the system achieved a remarkable accuracy, significantly improving upon traditional manual sorting methods and existing automated solutions. This high level of accuracy underscores the effectiveness of the algorithms and the robustness of the training dataset used. The ASDS not only streamlines the sorting process, reducing labor costs and time, but also contributes to environmental sustainability by enhancing the efficiency of recycling operations.

Moreover, the system's ability to further classify materials into recyclable and non-recyclable categories, coupled with real-time market rate display for recyclables, provides valuable insights for users and businesses alike. The project also offers disposal options for non-recyclable items, ensuring waste management solutions. These features collectively make the ASDS a versatile tool in waste management and recycling industries. While the results are promising, future work could focus on expanding the dataset, incorporating additional material properties, and refining the algorithms to further improve accuracy and adaptability. The successful implementation of the ASDS highlights its potential for broad application in both industrial and municipal waste management, paving the way for smarter, more sustainable waste handling practices.

5.2 Future Scope

ASDS can be extended by incorporating a larger and more diverse dataset, which would improve the system's accuracy and reliability in identifying a wider range of materials.

Additionally, integrating advanced deep learning models such as CNNs could enhance the precision of image classification. Future work could also explore the inclusion of a real-time monitoring system, enabling dynamic updates and immediate feedback on material classification and market rates. Furthermore, expanding the system to handle hazardous waste materials would broaden its applicability and enhance its utility in various industrial settings. Finally, the implementation of a mobile application would make the ASDS more accessible to a broader audience, including small-scale recyclers and individual users.

References

[1] S. Kanimozhi, G. Gayathri and T. Mala, "Multiple Real-time object identification using Single shot Multi-Box detection," 2019 International Conference on Computational Intelligence in Data Science (ICCIDS).

[2] Reagan L. Galvez; Argel A. Bandala; Elmer P. Dadios; Ryan Rhay P. Vicerra; Jose Martin Z. Maningo, " Object Detection Using Convolutional Neural Networks " , TENCON 2018.

[3] Object Detection with TensorFlow on Hardware with Limited Resources for Low-power IoT Devices : Jurij Kuzmic and Günter Rudolph Department of Computer Science, TU Dortmund University, Otto-Hahn-Str. 14, Dortmund, Germany.

[4] H. Basri, I. Syarif and S. Sukaridhoto, "Faster R-CNN Implementation Method for Multi-Fruit Detection Using Tensorflow Platform," 2018 International Electronics Symposium on Knowledge Creation and Intelligent Computing (IES-KCIC), Bali, Indonesia.

[5] Deep Object Detection with Example Attribute Based Prediction Modulation" Zhihao Wu; Chengliang Liu; Chao Huang; Jie Wen; Yong Xu ICASSP 2022 - 2022 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)

[6] An Embedded Real-Time Object Detection and Measurement of its Size" Nashwan Adnan OTHMAN; Mehmet Umut SALUR; Mehmet KARAKOSE; Ilhan AYDIN 2018 International Conference on Artificial Intelligence and Data Processing (IDAP)

Appendix A: Presentation

ASDS

Automatic Scrap Detection System

Abstract Presentation

Guide : Ms. DIncy Paul

Team : Aman Adam Louis, Anshika A Nair, Alna Khaleel

CONTENTS

CONTENTS

INTRODUCTION

Waste management is a significant challenge in India due to several factors :

- The lack of adequate infrastructure for waste collection
- Segregation
- Improper waste disposal practices

An Automatic Scrap Detection System (ASDS) can address the challenge of segregation and identification of scrap from waste, thereby reducing the burden on the waste management process.

Automatic scrap detection :

- eliminates manual labor
- reduces errors
- enhances efficiency

PROBLEM DEFINITION

To develop an Automatic Scrap Detection System to revolutionize the waste management process. Using image processing technology, the system streamlines the tedious task of waste segregation.

OBJECTIVES

- Image Acquisition & Processing : processing images of scrap materials acquired through cameras.
- Feature Extraction and Selection : extracting relevant features from images, such as texture, shape, and colour information.
- Machine Learning Model Development : development of convolutional neural networks (CNNs) for scrap detection.
- Training and Evaluation : training ML models using labeled image data and evaluating their performance using metrics such as accuracy, precision, recall.
- Integration & Testing : integrating the trained model into a software application for real-time scrap detection and testing the accuracy & working.

REQUIREMENTS

REQ 01

The system should be capable of importing and processing images.

REQ 02

The system should utilize image classification techniques to identify distinct objects within the image.

REQ 03

The system should classify these objects into various predefined categories such paper, plastic, etc.

Group 14

REQUIREMENTS

REQ 04

The system should further classify the objects as recyclable or non-recyclable.

REQ 05

The system should display market rates for the recyclable materials.

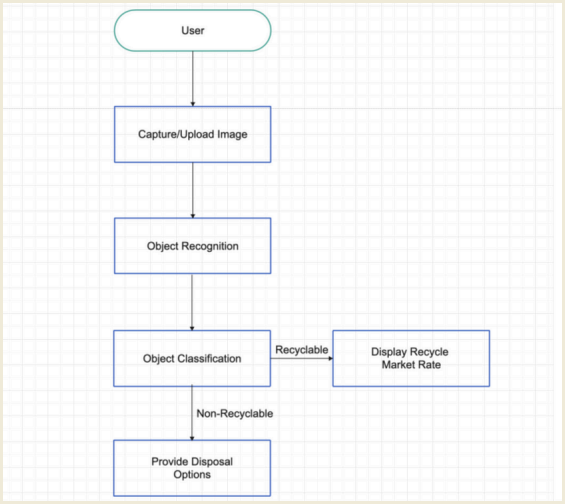
REQ 06

The system should provide disposal options for non-recyclable items.

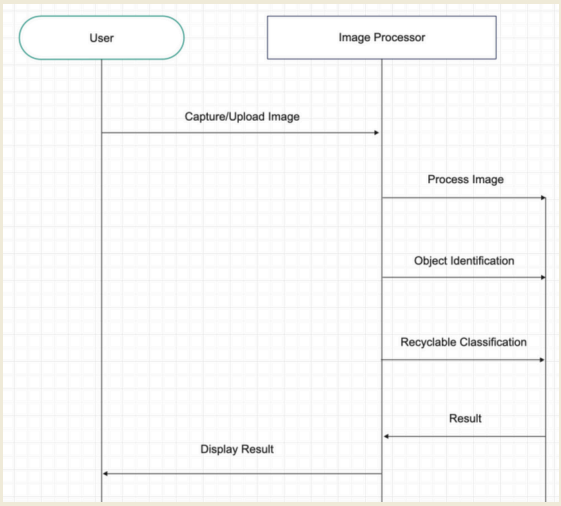
SYSTEM DESIGN

The Automatic Scrap Detection System (ASDS) is an innovative software solution designed to streamline the process of identifying and categorizing objects within images, specifically focusing on scrap materials for recycling purposes. Leveraging cutting-edge image processing techniques and machine learning models, ASDS aims to provide real-time classification of various objects, along with their recyclability status.

- Image Input: The system receives real-time camera or uploaded images for object detection.
- Object Recognition: Utilizes MobileNet v2 for efficient and accurate object identification.
- Object Categorization: Identifies objects and categorizes them into predefined classes.
- Recyclability Classification: Classifies objects based on recyclability status.
- Market Rates Integration: Provides current market rates for recyclable materials.
- Disposal Options: Offers disposal options for non-recyclable items based on local regulations.



Architectural Diagram



Sequence Diagram

MODULES

DATA COLLECTION AND TRAINING:

In this module, data related to recyclable objects and their attributes are collected. This may involve gathering images of various recyclable items, annotating them with labels, and preprocessing the data for training. Additionally, training the machine learning models, such as the object detection and classification models, using the collected data is part of this module.

OBJECT RECOGNITION:

Object recognition within the ASDS gives the accurate identification of various types of scrap materials from images by employing advanced image processing and machine learning techniques to analyze features and patterns within the images.

OBJECT CLASSIFICATION:

Object classification categorizes different types of scrap materials detected within images by the ASDS. This involves using advanced algorithms and machine learning models to analyze the visual characteristics of the objects and classify each detected object into the appropriate scrap material category, such as plastic, metal, paper, glass, etc.

RECYCLE MARKET RATE:

Displaying the recycle market rate involves presenting users with real-time information about the market value of various scrap materials identified by the ASDS. This information is obtained from reliable sources and integrated into the system, allowing users to access current market rates for different types of scrap materials, such as plastic, metal, paper, glass, etc.

DISPOSAL OPTION:

Disposal options for non-recyclable materials offering users guidance on the proper disposal methods for items that cannot be recycled. The Automatic Scrap Detection System presents users with a range of environmentally responsible disposal options. By providing disposal options for non-recyclable materials, ASDS helps users make decisions that encourages responsible waste management practices.

UI/UX DEVELOPMENT:

This module focuses on designing and developing the user interface (UI) and user experience (UX) of the system. It includes designing the layout, and implementing interactive elements to ensure a smooth and intuitive user experience.

For Object Detection and Localization:

Purpose: Identify distinct objects within the image.

Algorithm:

1. Utilize MobileNet v2 architecture: efficient architecture for object detection. Load the MobileNetV2 model.
2. Implement Single Shot MultiBox Detector (SSD): Implement SSD for real-time object localization.

For Object Classification:

Purpose: Categorize detected objects into predefined classes.

Algorithm:

- Train deep CNN using transfer learning: Train the model on the Waste Classification Dataset. Add a custom classification head to the model.
- Fine-tune MobileNet v2 model: Fine-tune the trained model for the specific classification task.

For Recyclability Classification:

Purpose: Determine whether detected objects are recyclable or non-recyclable.

Algorithm:

- Define a function classify_recyclability(detected_objects) that iterates through detected objects and determines their recyclability based on predefined parameters.

Sample Dataset and Source

Dataset Name: Garbage Classification

- Source: Kaggle
- Location: https://www.kaggle.com/datasets/asdasdasasdas/garbage-classification?resource=download

plastic60.jpg

Properties:

- Size: Contains 2250+ images.
- Labels: Each image is labeled with waste material category.
- Variety: Covers a wide range of waste materials seen in domestic use.
- Quality: Images are captured under various conditions, ensuring robustness.

metal5.jpg

Sample Dataset and Source

Dataset Name: Garbage Dataset

- Source: Kaggle
- Location: https://www.kaggle.com/datasets/sumn2u/garbage-classification-v2

glass9.jpg

Properties:

- Size: Contains 23000+ images.
- Labels: Each image is labeled with waste material category.
- Variety: Covers a wide variety of trash.
- Quality: Has different picture for a single type of material.

battery105.jpg

AS
DS

UPLOAD CAPTURE

Sample Screenshots of UI (at last)

ASDS

Automatic Scrap Detection System

AS
DS

AS
DS

RECYCLABLE

PLASTIC	Rs. 10 / Kg
METAL	
PAPER	

NON RECYCLABLE

STYROFOAM

SANITARY NAPKINS

FOOTWEAR

AS
DS

RECYCLABLE

PLASTIC

METAL

PAPER

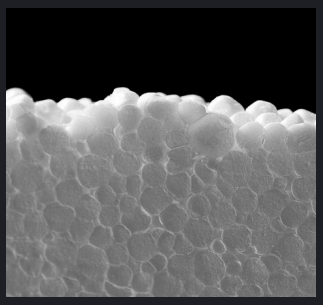
NON RECYCLABLE

STYROFOAM

SANITARY NAPKINS

FOOTWEAR

AS
DS

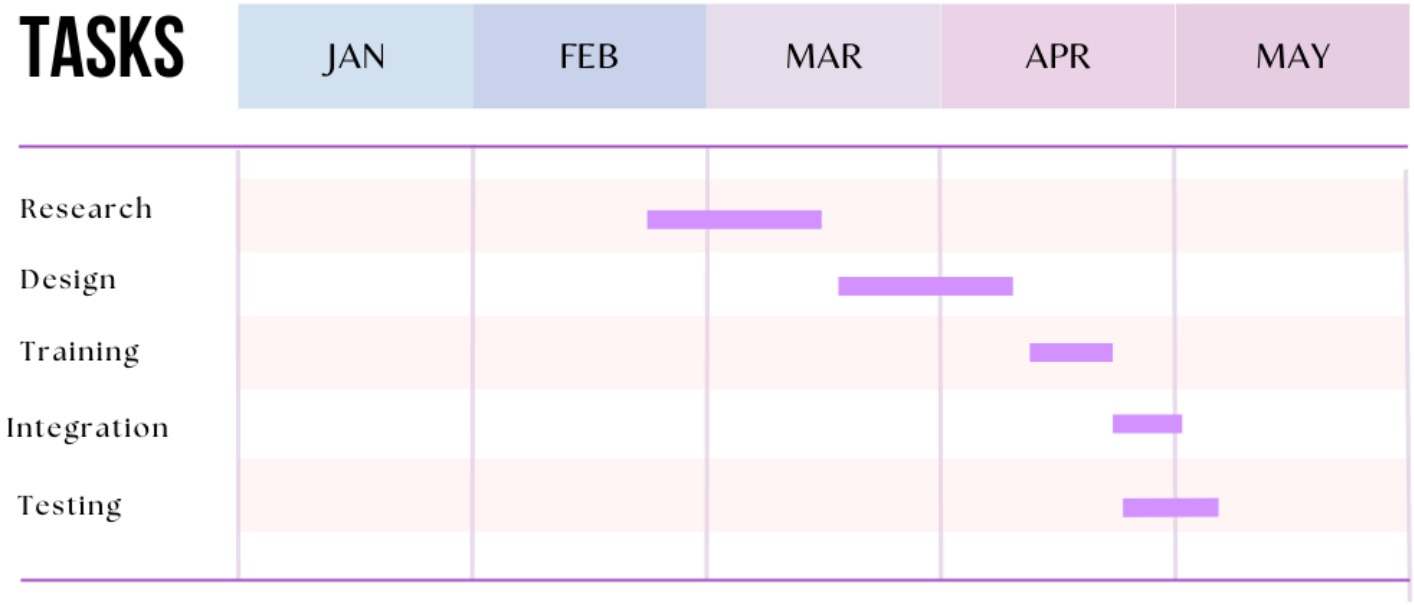


STYROFOAM

- **Sell it** : Some companies will buy your Styrofoam so it does not end up in a landfill.
- **Turn it into glue** : You can turn Styrofoam into glue just by adding a natural oil called d-limonene to it. D-limonene is a solvent made from citrus fruits, and when you put it on Styrofoam, it turns it into a sticky adhesive.
- **Plants** : Some recycling plants accept Styrofoam. Research and find ones near you.

ASDS

WORK DIVISION



SOFTWARE/HARDWARE REQUIREMENTS

software

- Operating System: Compatible with Windows, macOS, or Linux distributions.
- Python: Version 3.x (recommended).
- Jupyter Notebook
- TensorFlow

hardware

- Processor : Intel core i5 or higher/ Apple silicon M1 or higher
- Ram: 8Gb or higher
- GPU: 4 TFLOPS or higher

CONCLUSION

In conclusion, our scrap detection project aims to revolutionize waste management practices by leveraging image processing techniques to recognize recyclable and non-recyclable materials efficiently. By harnessing the power of machine learning models and advanced image analysis algorithms, we can accurately classify various types of materials, including paper, plastic, glass, metal, and other common items found in waste streams.

REFERENCES

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THANK YOU

Appendix B: Vision, Mission, Programme Outcomes and Course Outcomes

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY (AUTONOMOUS)
RAJAGIRI VALLEY, KAKKANAD, KOCHI, 682039
(Affiliated to APJ Abdul Kalam Technological University)

Vision, Mission, Programme Outcomes and Course Outcomes

Institute Vision

To evolve into a premier technological institution, moulding eminent professionals with creative minds, innovative ideas and sound practical skill, and to shape a future where technology works for the enrichment of mankind.

Institute Mission

To impart state-of-the-art knowledge to individuals in various technological disciplines and to inculcate in them a high degree of social consciousness and human values, thereby enabling them to face the challenges of life with courage and conviction.

Department Vision

To become a centre of excellence in Computer Science and Engineering, moulding professionals catering to the research and professional needs of national and international organizations.

Department Mission

To inspire and nurture students, with up-to-date knowledge in Computer Science and Engineering, ethics, team spirit, leadership abilities, innovation and creativity to come out with solutions meeting societal needs.

Programme Outcomes (PO)

Engineering Graduates will be able to:

1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and Team work: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

10. Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Programme Specific Outcomes (PSO)

A graduate of the Computer Science and Engineering Program will demonstrate:

PSO1: Computer Science Specific Skills

The ability to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas by understanding the core principles and concepts of computer science and thereby engage in national grand challenges.

PSO2: Programming and Software Development Skills

The ability to acquire programming efficiency by designing algorithms and applying standard practices in software project development to deliver quality software products meeting the demands of the industry.

PSO3: Professional Skills

The ability to apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs thereby evolving as an eminent researcher and entrepreneur.

Course Outcomes

After the completion of the course the student will be able to:

CO1:

Identify technically and economically feasible problems (Cognitive Knowledge Level: Apply)

CO2:
Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes (Cognitive Knowledge Level: Apply)

CO3:
Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions of minimal complexity by using modern tools & advanced programming techniques (Cognitive Knowledge Level: Apply)

CO4:
Prepare technical report and deliver presentation (Cognitive Knowledge Level: Apply)

CO5:
Apply engineering and management principles to achieve the goal of the project (Cognitive Knowledge Level: Apply)

Appendix C: CO-PO-PSO Mapping

COURSE OUTCOMES:

After completion of the course the student will be able to

SL. NO	DESCRIPTION	Blooms' Taxonomy Level
CO1	Identify technically and economically feasible problems (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO2	Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO3	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions of minimal complexity by using modern tools & advanced programming techniques (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO4	Prepare technical report and deliver presentation (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO5	Apply engineering and management principles to achieve the goal of the project (Cognitive Knowledge Level: Apply)	Level 3: Apply

CO-PO AND CO-PSO MAPPING

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	3	3		2	2	3	2	2	2	3	2	2	2
CO2	3	3	3	3	3	2		3	2	3	2	3	2	2	2
CO3	3	3	3	3	3	2	2	3	2	2	2	3			2
CO4	2	3	2	2	2			3	3	3	2	3	2	2	2
CO5	3	3	3	2	2	2	2	3	2		2	3	2	2	2

3/2/1: high/medium/low

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/ MEDIUM/ HIGH	JUSTIFICATION
101003/CS622T.1-PO1	**HIGH**	Identify technically and economically feasible problems by applying the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
101003/CS622T.1-PO2	**HIGH**	Identify technically and economically feasible problems by analysing complex engineering problems reaching substantiated conclusions using first principles of mathematics.
101003/CS622T.1-PO3	**HIGH**	Design solutions for complex engineering problems by identifying technically and economically feasible problems.
101003/CS622T.1-PO4	**HIGH**	Identify technically and economically feasible problems by analysis and interpretation of data.
101003/CS622T.1-PO6	**MEDIUM**	Responsibilities relevant to the professional engineering practice by identifying the problem.
101003/CS622T.1-PO7	**MEDIUM**	Identify technically and economically feasible problems by understanding the impact of the professional engineering solutions.
101003/CS622T.1-PO8	**HIGH**	Apply ethical principles and commit to professional ethics to identify technically and economically feasible problems.
101003/CS622T.1-PO9	**MEDIUM**	Identify technically and economically feasible problems by working as a team.
101003/CS622T.1-PO10	**MEDIUM**	Communicate effectively with the engineering community by identifying technically and economically feasible problems.
101003/CS622T.1-P011	**MEDIUM**	Demonstrate knowledge and understanding of engineering and management principles by selecting the technically and economically feasible problems.
101003/CS622T.1-PO12	**HIGH**	Identify technically and economically feasible problems for long term learning.
101003/CS622T.1-PSO1	**MEDIUM**	Ability to identify, analyze and design solutions to identify technically and economically feasible problems.
101003/CS622T.1-PSO2	**MEDIUM**	By designing algorithms and applying standard practices in software project development and Identifying technically and economically feasible problems.
101003/CS622T.1-PSO3	**MEDIUM**	Fundamentals of computer science in competitive research can be applied to Identify technically and economically feasible problems.
101003/CS622T.2-PO1	**HIGH**	Identify and survey the relevant by applying the knowledge of mathematics, science, engineering fundamentals.

101003/CS622T.2-PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems get familiarized with software development processes.
101003/CS622T.2-PO3	**HIGH**	Design solutions for complex engineering problems and design based on the relevant literature.
101003/CS622T.2-PO4	**HIGH**	Use research-based knowledge including design of experiments based on relevant literature.
101003/CS622T.2-PO5	**HIGH**	Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes by using modern tools.
101003/CS622T.2-PO6	**MEDIUM**	Create, select, and apply appropriate techniques, resources, by identifying and surveying the relevant literature.
101003/CS622T.2-PO8	**HIGH**	Apply ethical principles and commit to professional ethics based on the relevant literature.
101003/CS622T.2-PO9	**MEDIUM**	Identify and survey the relevant literature as a team.
101003/CS622T.2-PO10	**HIGH**	Identify and survey the relevant literature for a good communication to the engineering fraternity.
101003/CS622T.2-PO11	**MEDIUM**	Identify and survey the relevant literature to demonstrate knowledge and understanding of engineering and management principles.
101003/CS622T.2-PO12	**HIGH**	Identify and survey the relevant literature for independent and lifelong learning.
101003/CS622T.2-PSO1	**MEDIUM**	Design solutions for complex engineering problems by Identifying and survey the relevant literature.
101003/CS622T.2-PSO2	**MEDIUM**	Identify and survey the relevant literature for acquiring programming efficiency by designing algorithms and applying standard practices.
101003/CS622T.2-PSO3	**MEDIUM**	Identify and survey the relevant literature to apply the fundamentals of computer science in competitive research.
101003/CS622T.3-PO1	**HIGH**	Perform requirement analysis, identify design methodologies by using modern tools & advanced programming techniques and by applying the knowledge of mathematics, science, engineering fundamentals.
101003/CS622T.3-PO2	**HIGH**	Identify, formulate, review research literature for requirement analysis, identify design methodologies and develop adaptable & reusable solutions.

101003/CS622T.3-PO3	**HIGH**	Design solutions for complex engineering problems and perform requirement analysis, identify design methodologies.
101003/CS622T.3-PO4	**HIGH**	Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
101003/CS622T.3-PO5	**HIGH**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools.
101003/CS622T.3-PO6	**MEDIUM**	Perform requirement analysis, identify design methodologies and assess societal, health, safety, legal, and cultural issues.
101003/CS622T.3-PO7	**MEDIUM**	Understand the impact of the professional engineering solutions in societal and environmental contexts and Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions.
101003/CS622T.3-PO8	**HIGH**	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions by applying ethical principles and commit to professional ethics.
101003/CS622T.3-PO9	**MEDIUM**	Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.
101003/CS622T.3-PO10	**MEDIUM**	Communicate effectively with the engineering community and with society at large to perform requirement analysis, identify design methodologies.
101003/CS622T.3-PO11	**MEDIUM**	Demonstrate knowledge and understanding of engineering requirement analysis by identifying design methodologies.
101003/CS622T.3-PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change by analysis, identify design methodologies and develop adaptable & reusable solutions.
101003/CS622T.3-PSO3	**MEDIUM**	The ability to apply the fundamentals of computer science in competitive research and prior to that perform requirement analysis, identify design methodologies.
101003/CS622T.4-PO1	**MEDIUM**	Prepare technical report and deliver presentation by applying the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
101003/CS622T.4-PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems by preparing technical report and deliver presentation.

101003/CS622T.4-PO3	**MEDIUM**	Prepare Design solutions for complex engineering problems and create technical report and deliver presentation.
101003/CS622T.4-PO4	**MEDIUM**	Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions and prepare technical report and deliver presentation.
101003/CS622T.4-PO5	**MEDIUM**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools and Prepare technical report and deliver presentation.
101003/CS622T.4-PO8	**HIGH**	Prepare technical report and deliver presentation by applying ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
101003/CS622T.4-PO9	**HIGH**	Prepare technical report and deliver presentation effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.
101003/CS622T.4-PO10	**HIGH**	Communicate effectively with the engineering community and with society at large by prepare technical report and deliver presentation.
101003/CS622T.4-PO11	**MEDIUM**	Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work by prepare technical report and deliver presentation.
101003/CS622T.4-PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change by prepare technical report and deliver presentation.
101003/CS622T.4-PSO1	**MEDIUM**	Prepare a technical report and deliver presentation to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas.
101003/CS622T.4-PSO2	**MEDIUM**	To acquire programming efficiency by designing algorithms and applying standard practices in software project development and to prepare technical report and deliver presentation.
101003/CS622T.4-PSO3	**MEDIUM**	To apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs by preparing technical report and deliver presentation.
101003/CS622T.5-PO1	**HIGH**	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
101003/CS622T.5-PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems by applying engineering and management principles to achieve the goal of the project.

101003/CS622T.5-PO3	**HIGH**	Apply engineering and management principles to achieve the goal of the project and to design solutions for complex engineering problems and design system components or processes that meet the specified needs.
101003/CS622T.5-PO4	**MEDIUM**	Apply engineering and management principles to achieve the goal of the project and use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
101003/CS622T.5-PO5	**MEDIUM**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO6	**MEDIUM**	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities by applying engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO7	**MEDIUM**	Understand the impact of the professional engineering solutions in societal and environmental contexts, and apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO8	**HIGH**	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice and to use the engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO9	**MEDIUM**	Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO11	**MEDIUM**	Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PSO1	**MEDIUM**	The ability to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas. Apply engineering and management principles to achieve the goal of the project.

101003/CS622T.5-PSO2	**MEDIUM**	The ability to acquire programming efficiency by designing algorithms and applying standard practices in software project development to deliver quality software products meeting the demands of the industry and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PSO3	**MEDIUM**	The ability to apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs thereby evolving as an eminent researcher and entrepreneur and apply engineering and management principles to achieve the goal of the project.