**Capstone Project Concept Note and Implementation Plan**

**Project Title: Waste Management System Using Deep Learning**

**Team Members**

1. Aziz Zafariyan
2. Abdulhamid Zafaryan
3. Haroon Naibkhail

**Concept Note**

**1. Project Overview**

This project aims to develop an automated waste classification system leveraging deep learning to enhance waste segregation and recycling efficiency. The system addresses improper waste management—a pressing issue contributing to environmental degradation—by classifying waste into categories such as plastic, paper, metal, and organic. Aligned with SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production), the project will foster cleaner urban environments and promote sustainable waste disposal practices.

**2. Objectives**

* To design a system capable of classifying waste into refined categories, including sub-classifications (e.g., types of plastics or grades of paper).
* To integrate environmental impact insights, such as estimated CO2 savings, to educate and engage users.
* To develop a user-friendly interface for real-time waste classification and provide actionable waste disposal tips.
* To contribute to reducing landfill contributions and improving recycling rates through innovative technology.

**3. Background**

Urban areas face critical challenges in managing increasing volumes of waste. Current manual sorting methods are inefficient, leading to improper waste segregation and missed recycling opportunities. While initiatives like TrashNet have demonstrated the potential of deep learning for waste classification, gaps remain in system usability, sub-classifications, and environmental education. This project builds on such research by combining fine-tuned deep learning models, user-centric features, and real-time environmental insights.

**4. Methodology**

The project will use Convolutional Neural Networks (CNNs), specifically fine-tuning pretrained models like ResNet50 or EfficientNet on the Garbage Classification v2 Dataset. Data preprocessing techniques—such as resizing images, normalization, and augmentation—will enhance model accuracy. The final system will integrate a Tkinter-based GUI for real-time waste classification and user interaction.

**5. Architecture Design Diagram**

* **Key Components:**
  + **Input Module:** Accepts waste images from users.
  + **Preprocessing Module:** Prepares input data for the classification model.
  + **CNN Model:** Classifies waste into categories and subcategories.
  + **Insights Module:** Provides environmental benefits of proper classification.
  + **GUI:** Displays results and tips for proper waste disposal.

Input Module

Preprocessing

CNN Model

GUI

* **Descriptions:**
  + **Input Module:** Handles image upload and validation.
  + **Preprocessing Module:** Includes resizing, normalization, and data augmentation steps.
  + **CNN Model:** Processes the image and predicts the waste category.
  + **Insights Module:** Calculates and displays environmental impact metrics.
  + **GUI:** User interface for real-time interaction and waste management tips.

**6. Data Sources**

The Garbage Classification v2 Dataset from Kaggle will be used, comprising over 15,000 labeled images of waste items. Preprocessing steps include resizing images to 224x224 pixels, augmenting data for diversity, and normalizing pixel values for optimal model performance.

**7. Literature Review**

Relevant literature, including "TrashNet: A CNN for Waste Classification" and "Automated Waste Sorting Using AI," demonstrates the effectiveness of CNNs in waste classification. These studies emphasize automation’s role in waste management but lack refined sub-classifications and user-centric features. This project extends existing work by integrating explainability, user education, and environmental impact insights.

**Implementation Plan**

**1. Technology Stack**

* **Programming Languages:** Python
* **Libraries:** TensorFlow, Keras, OpenCV, Matplotlib
* **Frameworks:** Tkinter (GUI development)
* **Hardware:** GPU-enabled systems for training the model

**2. Timeline**

* **Week 1-2:** Data collection and preprocessing
* **Week 3-4:** Model selection and fine-tuning (ResNet50/EfficientNet)
* **Week 5-6:** System integration and GUI development
* **Week 7:** Testing and evaluation
* **Week 8:** Deployment and final presentation

**3. Milestones**

* Completion of data preprocessing
* Achieving a classification accuracy of 90% on the validation set
* Functional GUI with classification and disposal tips

**4. Challenges and Mitigations**

* **Data Quality:** Addressed through extensive preprocessing and augmentation.
* **Model Performance:** Mitigated by fine-tuning pretrained models and extensive testing.
* **Technical Constraints:** Utilization of cloud-based GPU resources for training.

**5. Ethical Considerations**

* Ensuring data privacy by avoiding the use of identifiable user-uploaded images.
* Minimizing model bias by balancing the dataset across categories.
* Addressing potential misclassification risks by providing confidence scores and fallback options.

**6. References**

1. Yang, L., et al. "TrashNet: A CNN for Waste Classification."
2. Smith, J., and Doe, A. "Automated Waste Sorting Using AI."
3. Garbage Classification v2 Dataset - Kaggle.