**#Major – Project - Readme –File**

**Title of this Project:** Geo Waste Classification Using Deep Neural Networks.

**Project Idea:**

Currently, waste management practices often rely on traditional methods like manual sorting and basic automated systems, which are inefficient and prone to errors. These methods have several disadvantages, including high labour costs, slow processing times, and limited accuracy in waste classification. Human involvement in waste management is not only labour-intensive but also poses health risks due to exposure to hazardous materials. Additionally, manual sorting is inconsistent and cannot keep up with the increasing volumes of waste. Implementing geo waste classification using deep neural networks, with capabilities for multiple object detection, can revolutionize waste management by providing accurate, real-time classification of different types of waste. This system can significantly reduce the need for human intervention, thereby minimizing health risks and operational costs. By leveraging advanced image recognition and geolocation data, the project aims to enhance the efficiency and effectiveness of waste sorting, leading to more precise recycling processes and better resource allocation for waste collection and treatment. This innovative approach can ultimately contribute to more sustainable waste management practices and a cleaner environment.

**System Design:**

The proposed system, named "Geo Waste Classification Using Neural Networks," integrates various algorithms and models for detecting waste and identifies the most efficient model for this task, providing recycling methods for the detected components. Mask R-CNN (Mask Region-based Convolutional Neural Network) is a sophisticated deep learning model designed for instance segmentation. Building upon the Faster R-CNN framework, Mask R-CNN introduces an additional branch dedicated to predicting segmentation masks alongside the existing components for object detection and bounding box regression. This allows the model not only to accurately identify and locate objects within an image but also to provide pixel-level segmentation, outlining the precise boundaries of each detected object. Mask R-CNN’s capability for detailed instance segmentation makes it a powerful tool in applications of computer vision, such as image segmentation, object recognition, and scene understanding, offering high accuracy in delineating and understanding complex visual scenes. This precision is particularly beneficial in waste management, as it enables the system to distinguish and classify various waste materials accurately, facilitating effective recycling and waste treatment processes.

**Software and Hardware Requirements:**

**Hardware:**

Operating System: Windows

Processor: Intel Core i5

Memory (RAM): 8 GB

**Software:**

Python

Colab

**Methodology:**

**Object Detection:**

Object Detection includes detecting of waste objects present in input image provided. For this detection it utilizes bounding boxes concept that detects waste objects which gives a clear visual to user to identify those objects**.**

**Object Classification:**

Object Classification is used for classifying waste objects detected in object objection into various classes of waste. This classes includes plastic, cloth, cardboard, glass, metal etc. It provides the object classification result to user.

**Recommending Recycle Method:**

Once the waste object detection and classification are done the next step is to recommend appropriate recycling method. For this major waste object is identified and for that particular class recycling method is recommended.

**Technologies used:**

**Deep Learning**

Deep learning, part of machine learning, focuses on learning data representations through architectures like deep neural networks, and has been applied to fields such as computer vision and natural language processing, often achieving results superior to human experts.

**TensorFlow**

TensorFlow is an open-source machine learning platform with a comprehensive ecosystem for building and deploying ML applications. Developed by Google Brain, it supports a wide range of ML and deep learning research and applications.

**Pandas**

Pandas is a Python library for data manipulation and analysis, providing efficient data structures like Data Frame and Series. It facilitates tasks such as data cleaning, transformation, and statistical analysis, and is essential for handling large datasets.

**Keras**

Keras is a high-level neural network API in Python, designed for ease of use and fast experimentation. It supports building and training models on frameworks like TensorFlow, Theano, and CNTK, and offers extensive tools for data preprocessing and model deployment.

**NumPy**

NumPy is a core Python library for scientific computing, supporting large, multi-dimensional arrays and matrices. It offers efficient array operations and is widely used in numerical simulations, data analysis, and machine learning.

**Matplotlib**

Matplotlib is a Python library for creating static, animated, and interactive visualizations, excelling in 2D plotting. It provides extensive customization for generating publication-quality figures and integrates well with libraries like NumPy and Pandas.

**Algorithms used:**

**SVM (Support Vector Machine)**

SVM is a supervised machine learning algorithm used for classification and regression tasks, known for its effectiveness in high-dimensional spaces and its use of a hyperplane to separate different classes.

**CNN (Convolutional Neural Network)**

CNN is a deep learning architecture designed for processing structured grid data like images, utilizing convolutional layers to automatically and adaptively learn spatial hierarchies of features.

**YOLO (You Only Look Once)**

YOLO is a real-time object detection system that predicts bounding boxes and class probabilities for objects in an image in a single evaluation, making it highly efficient and fast.

**MobileNet**

MobileNet is a family of efficient deep learning models designed for mobile and embedded vision applications, using depth wise separable convolutions to reduce model size and computational cost**.**

**Mask R-CNN (Mask Region-based Convolutional Neural Network)**

Mask R-CNN is an advanced deep learning model for instance segmentation, extending Faster R-CNN by adding a branch for predicting segmentation masks, allowing for precise pixel-level object detection.

**Conclusion and Future Scope:**

In conclusion, this project represents a comprehensive exploration of advanced waste detection algorithms, incorporating a diverse range of technologies such as Convolutional Neural Networks (CNN), Support Vector Machines (SVM), Mask Region-based Convolutional Neural Network (MRCNN), YOLO, and MobileNetV2. Notably, the utilization of MRCNN emerges as a particularly promising choice, demonstrating superior effectiveness in capturing detailed information and spatial relationship within images. This capability allows MRCNN to efficiently detect waste objects, classify them accurately, and recommend appropriate recycling methods. The integration of deep neural networks in geo waste classification has proven to significantly enhance both the accuracy and speed of waste detection and categorization. This innovative approach not only addresses current waste management challenges but also lays the groundwork for substantial future advancements.

Looking ahead, the potential combination of this technology with Internet of Things (IoT) devices stands to revolutionize the waste management field. IoT integration can automate the recycling process, drastically reducing the necessity for direct human involvement. This reduction in manual handling not only enhances operational efficiency but also minimizes human exposure to potentially hazardous materials, thereby improving safety standards. Overall, this project contributes valuable insights into the advancement of accurate waste detection technologies, with MRCNN establishing itself as a noteworthy and promising algorithm. The comprehensive approach adopted in this project promises to enhance the efficiency, safety, and overall effectiveness of waste management and recycling operations. By paving the way for more sustainable and technologically advanced environmental practices, this project holds the potential to significantly impact the future of waste management, making it more efficient, safe, and environmentally friendly.