Chapter 1

EnviroWatch: A Comprehensive Environmental Monitoring Web Frame and Cleanup Coordination System using CNN

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Abstract EnviroWatch” is an innovative web framework designed to address the global challenge of increasing unprocessed waste, with 14 million tons produced annually. The framework utilizes a comprehensive approach to track environmental health, collaborating with governmental and non-governmental entities. Leveraging Data Analytics and real-time monitoring, EnviroWatch facilitates efficient cleanup planning and engagement with communities. Residents can contribute garbage images through an easy-to-use mobile application, which expedites communication with NGOs and the government. The experiment uses a Convolutional Neural Network (CNN) architecture called the Vision Transformer (ViT) model for image recognition. It divides images into patches in order to identify and classify garbage. Government bodies and NGOs can access the platform to gather crucial data and coordinate cleanup initiatives, fostering a collaborative effort towards environmental well-being.

Keywords: Convolutional Neural Network (CNN), Vision Transformer (ViT), Machine Learning, Image Detection, Data Analysis.

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1.1 Introduction

The introduction of new technology has brought about a number of advancements in our world. A development with so many positives but come with various negatives as well. Even while progress has advanced quickly, nature has been impacted. And trash is one of the main problems. The common method of waste disposal is by unplanned and uncontrolled dumping at landfill areas.[7] Our lives are negatively impacted by trash in a variety of ways. Burning trash pollutes the air, leaving it outside generates foul odors, reduces biodiversity, causes health problems, and can spread various diseases that stray animals who rummage through the trash for food may contract. When this garbage is thrown into lakes, rivers, the sea, or other bodies of water, the water becomes contaminated. The Center for Science and Environment contends that creative recycling and disposal techniques should be used in place of landfills. [7] The problem of clogged waterways is also caused by trash that is dumped into bodies of water.

There is a ton of trash next to the road as we walk beside it. The pile continues to expand throughout the days, contaminating the surrounding area. Priority should be given to good waste management, which involves separating garbage into dry and moist categories and further classifying waste into categories such as e-waste, recyclable waste, biodegradable waste, etc. It is essential to control garbage if civilization is to be healthy. A report found that 1.5 lakh metric tons of rubbish are created daily, with about 65 percent of that material going untreated and into the open air.[6] The amount of rubbish generated has risen along with the population. This waste management has three factors which are collection, segregation and management. We have proposed a solution to address first factor i.e., Collection

To address this pressing issue, we developed" EnviroWatch," a modern online platform designed to track environmental health and coordinate cleaning efforts. This platform facilitates communication between citizens, other organizations, and government representatives regarding garbage-related complaints, complete with a dynamic dashboard that aids in real-time monitoring for organizations.

1.1.1 Motivation

The Main purpose of developing EnviroWatch is to bridge the gap between the governmental bodies, NGOs and common people. To build a platform for betterment of the environment and to solve the global crisis of garbage. EnviroWatch has been developed as a comprehensive web platform. To enhance environmental monitoring and streamlining cleanup coordination efforts. Additionally, to facilitate seamless interaction between end-users, government bodies, and non-governmental organizations (NGOs), EnviroWatch offers a user-friendly mobile application. This integrated approach empowers individuals and organizations to collaboratively com-bat the escalating garbage crisis, thus fostering a cleaner and healthier environmentfor all.

1.2 Literature Review

In paper [1], Geethamani R, Rakshana P, Raveena P, Ragavi R, titled “Garbage Management System” published in year 2021, proposed a waste management system where it states the information about the waste is generated in large amount from decades and piled up in different parts of the country. The Management system has proposed a technology-based solution with 5 kinds of users (admin, user, people, buyer, distributor). They have stated role of each user in the waste management system. The administrator has overall control of activities. The admin assigns the workfor distributors. The Drivers 2 are the garbage collectors, they can post and view thestatus of their work through the driver dashboard. They have also introduced people dashboard for people to raise complaints and submit feedback. The buyers are people who need the garbage waste. They collect the garbage according to its segregation like e-waste, recyclable waste, biodegradable waste, etc. System proposed a cost-effective, web-based garbage waste management system. Here, they have created a Webpage and web application that aims to connect people to their workforce.

In paper[2], R.S.Sandhya Devi, Vijaykumar VR, M.Muthumeena, titled ”Waste Segregation using Deep Learning Algorithm” published in year 2018 have proposed a system for waste segregation using deep learning.. They have proposed this system by considering the problem for manual segregation of garbage which is less efficient, time consuming, and not feasible. They have used CNN for classification of objects into biodegradable and non-biodegradable. They have also implemented python libraries like Theano, TensorFlow, NumPy, Matplotlib, Pillow, OpenCV, etc.for training their model. By using Big Data and CNN they have created a real timefully automated waste segregation model without involving manual work. We havesuggested a method that uses images to identify trash and separate it based on our analysis of their reference.

In paper[3], Rahul Chauhan, Kamal Kumar Ghanshala, R.C. Joshi, titled “Convolutional Neural Network (CNN) for Image Detection and Recognition” The use of deep learning algorithms—more especially, Convolutional Neural Networks (CNNs)—is covered in this paper. These methods are based on deep neural networks that have many hidden layers. Because of this, they can process massive datasets with millions of parameters, which are usually displayed as two-dimensional graphics. CNNs convolve input images and generate desired outputs by using filters. For image detection and recognition applications, the study largely focuses on CNN model construction and performance evaluation. The CNN method is used to the MNIST and CIFAR-10 datasets in this work. The CNN model attains a 99.6 percent accuracy rate on the handwritten digits dataset known as MNIST. Real-time augmenting of data for CIFAR-10 is used to assess the CNN model’s performance. This data likely includes images of objects in various classes.

In paper[4], Bo-Kai Ruan, Hong-Han Shuai, Wen-Huang Cheng, titled “Vision Transformers: State of the Art and Research Challenge” The study report demonstrates the effective use of vision transformers—which were first created for natural language processing—in a range of computer vision applications. Researchers have expanded the application of transformers to image identification, object detection, picture segmentation, posture estimation, and 3D reconstruction by utilizing the strong self-attention mechanism that these devices possess. The main goal of the study is to provide a comprehensive review of the literature that has already been written about various architecture designs and training approaches, such as self-supervised learning, that are unique to vision transformers. The ultimate goal is to provide a comprehensive assessment that not only describes the state of the field as it stands today but also points up areas for future study where computer vision and transformers converge.

In paper[5], Galiveedu Shoaib, Somesh Nandi, titled “Power Bi Dashboard for Data Analysis”, With an emphasis on SAP Cockpit, an online platform for tracking global accounts and sub-accounts, the research study explores the use of SAP, a well-known business 3 process management software. The report highlights the necessity of monitoring relevant data and monthly consumption and tackles issues with unauthorized service configurations under certain sub-accounts. In order to conduct the research, a contract sheet must be obtained from the internal team and used with the secure data export and import platforms, SAP Cockpit and SharePoint Online. Access is limited to examine the exported data in order to protect confidentiality. Making a SAP dashboard using Power BI is the main fix suggested in the paper. This dashboard is designed to find and track individuals who have illegally set up services within the sub-accounts. In general, the research focuses on how to utilize technology—specifically, SAP and Power BI—to improve data monitoring, identify unapproved activity, and enforce budgetary control in an organizational setting.

1.3 Methodology

1.3.1 Problem Statement

The expanding trash problem is a crisis that is only going to get worse. It is creating pollution, water obstructions, harm to public health, and environmental threats that are everywhere. Action must be taken right now to address this growing issue that disturbs ecosystems and our everyday life. A platform that connects regular people with cleanup groups, governmental institutions, and other entities is desperately needed to address this problem.

1.3.2 System Architecture

The suggested system is a platform that runs on the cloud and is intended to effectively handle environmental cleaning drives. Real-time object detection in photos is achieved by combining Vision Transformer technology with Convolutional Neural Network (CNN) models. Through a smartphone app, users may post waste photographs, and the easily navigable web interface lets them view statistical data, take part in activities, and communicate with a chatbot. Administrators can examine user-uploaded photographs and take immediate action from a dashboard to which they have privileged access. Additionally, they can schedule cleanup tasks according on web interface insights, customizing them to meet certain environmental requirements for optimal efficiency. Using this strategy guarantees that cleanup efforts are environmentally conscious and optimized. By giving users a direct way to report environmental issues and assisting with real-time data collecting, the system increases user involvement. It permits prompt responses to environmental problems, enabling administrators to take immediate action on particular situations. All things considered, the system is a useful instrument for organizing and maximizing cleanup operations, guaranteeing a proactive and successful strategy for environmental preservation.

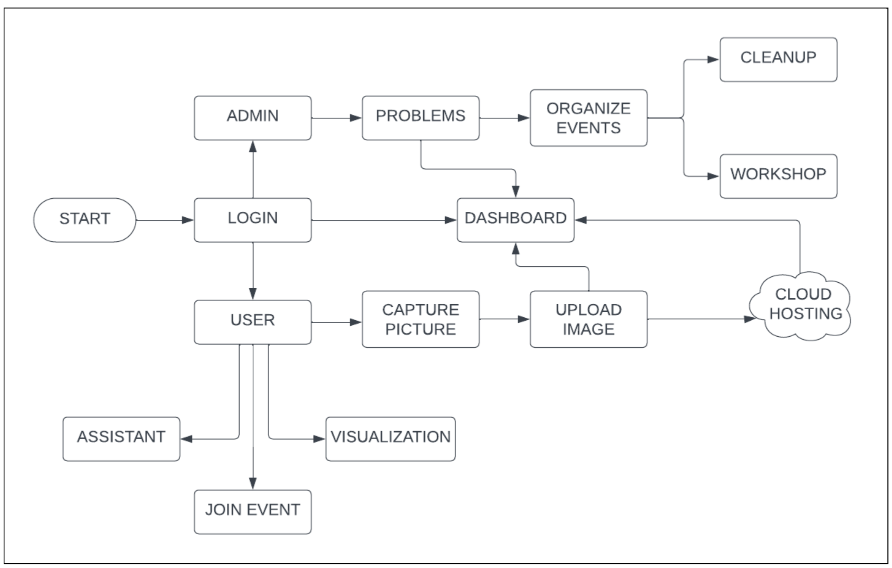

Fig. 1.1 System Architecture

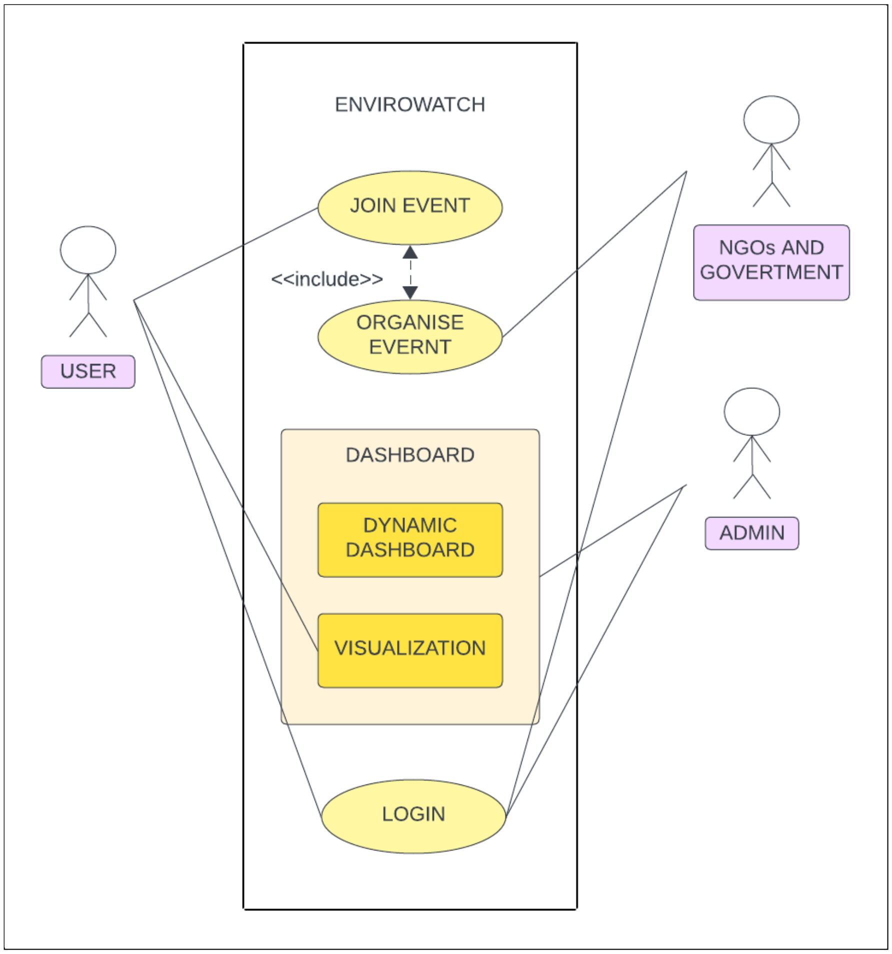

Fig. 1.2 Use Case Diagram

1.3.3 *Working*

In our environmental monitoring project, Convolutional Neural Networks (CNNs) are essential as they greatly improve the accuracy and efficiency of waste identification. CNNs are first used in image preprocessing, where they perform operations including augmentation, normalization, and scaling to increase the model's ability to generalize. Convolutional Neural Network (CNN) architectures like Faster R-CNN or YOLO (You Only Look Once) are employed to detect and identify objects in images accurately. CNNs excel in learning hierarchical features from photos and extracting visual features to understand artifacts.

In addition, we further improve the accuracy of garbage identification by combining the outputs of CNN and Vision Transformer (ViT) through data fusion to obtain more thorough knowledge of visual content. Architecture and design decisions take into account performance, addressable waste categories, dataset specifics, and other application requirements. The performance of the models is optimized and fine-tuned according to the specific use case.

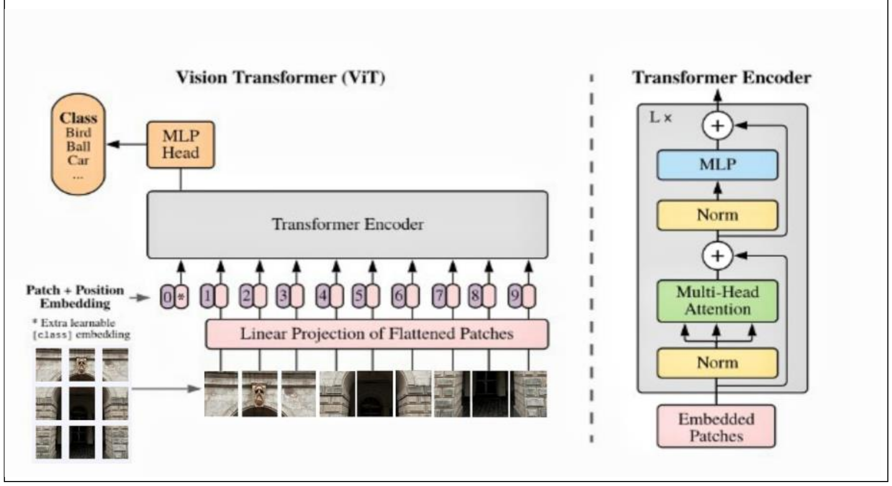

Fig. 1.3 Vision Transformer ViT Architecture

The Vision Transformer (ViT) has demonstrated its efficacy as a dependable model for image classification in computer vision tasks. Initially introduced in the paper "An Image is Worth 16x16 Words: Transformers for Image Recognition" by Alexey Dosovitskiy and his team, ViT has been recognized for its efficiency and effectiveness.

Here is a simplified approach to integrating ViT into our project:

1. Data preparation: Build a labeled dataset containing images of various waste items such as cardboard, plastic, paper, etc. Divide the dataset into training, validation and testing subsets to facilitate modeling and evaluation.
2. Preprocessing: Normalize pixel values to a standard range and resize photos to a consistent size appropriate for input to the ViT model.
3. ViT Model Architecture: The transformer architecture that makes up the ViT model was initially created for natural language processing. The transformer is modified to handle image data by linearly embedding the picture’s fixed-size patches. The transformer layers then get the embeddings to learn hierarchical representations.
4. Fine-tuning: Train your ViT model from scratch or use a pre-trained model (from the torchvision library, for example) and refine it using your waste cate-

gorization dataset. This entails changing the model's weights to reflect features unique to your task.

5. Training: Utilizing the training dataset, train the ViT model. If you began with a model that was already trained, make use of methods like transfer learning. Evaluate how well the model performed on the set of validations to avoid over-fitting.
6. Evaluation: Using the testing dataset, evaluate the model's recall, precision, accuracy, and other relevant metrics.
7. EnviroWatch Integration: After the ViT model has been trained and is operating effectively, include it into your EnviroWatch system. Sort the many types of waste that users upload through the mobile application using the ViT model.
8. User Feedback and Ongoing Improvement: Gather input from users to enhance both the EnviroWatch platform as a whole and the model's functionality. Using fresh data, update the ViT model on a regular basis to accommodate evolving waste types and patterns.
9. Chatbot Integration: Utilize the chatbot to offer support, direction, or more details on environmental issues and trash classification.

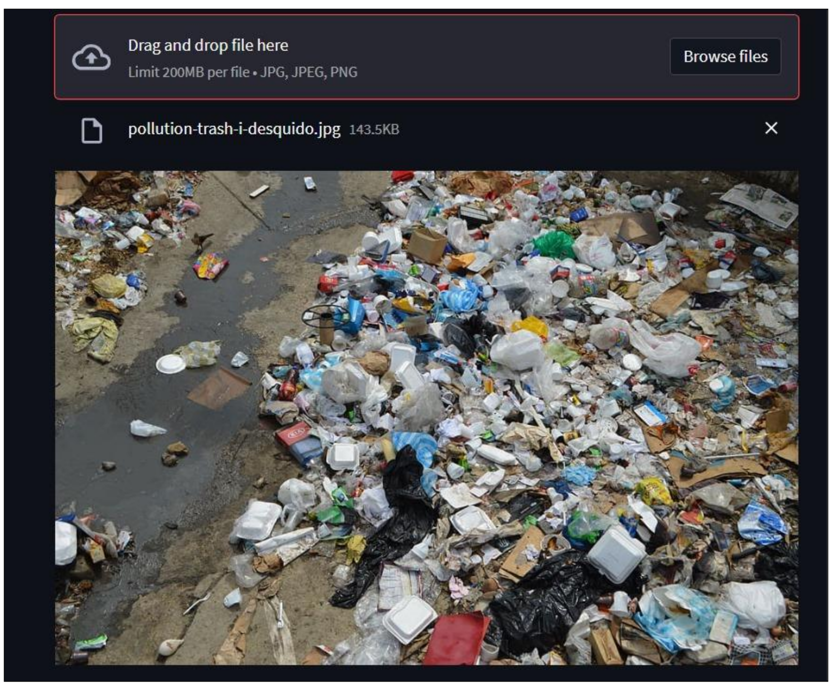

Fig. 1.4 Upload Image

In the context of our research project, Figure 3 serves as a pivotal visual representation point, where an image containing diverse waste materials is inputted for analysis. For our waste identification system, which seeks to determine the percentage composition of different sorts of garbage within it, this image serves as an essential dataset. Follow-up examination has resulted in perceptive findings, which have been compiled into the comprehensive table depicted in Figure 4. This graph provides a visual representation showcasing the distribution of various trash categories present in the uploaded image. The identified categories of garbage include general waste, cardboard, metal materials, paper goods, and plastic. These diverse types of waste collectively paint a complex and intricate picture of the waste landscape captured in the image. Consequently, the graph serves as a valuable tool for comprehending and quantifying the different components comprising the relevant waste stream.

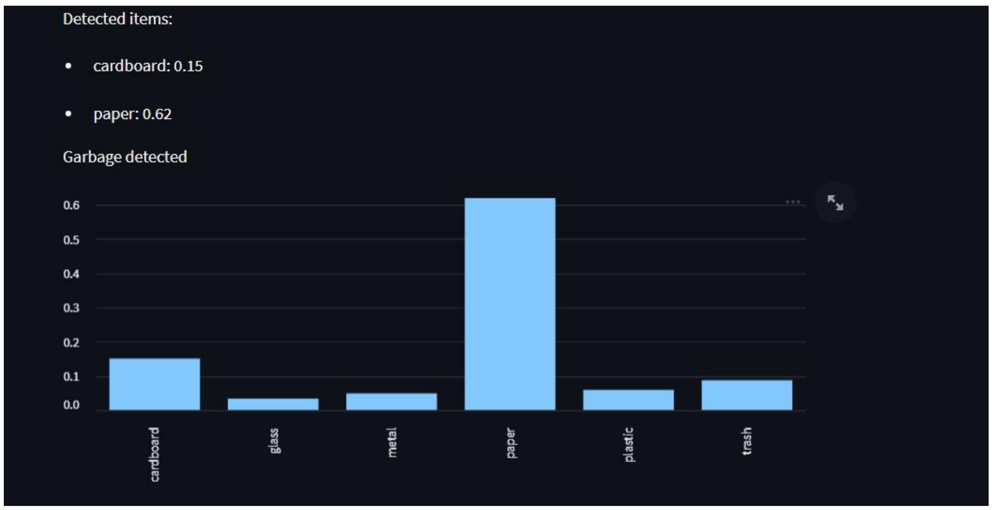

Fig. 1.5 Accuracy Graph

1.4 Conclusion and Future Scope

In conclusion, EnviroWatch offers an innovative solution to the growing problem of unprocessed waste, an integral part of technology for efficient environmental management. The platform encourages a collaborative approach to waste management and data collection by facilitating seamless communication between communities, NGOs, and government agencies through advanced image recognition using user-friendly mobile applications and the Vision Transformer model. By streamlining environmental health tracking through data analytics and real-time monitoring, EnviroWatch encourages a proactive and cooperative approach to trash management. This platform holds promise as a highly effective tool in combating waste pollution, biodiversity loss, and related health issues.

EnviroWatch plans to use GPS tracking devices for heat maps and land clearance with the goal to boost production and make planning and monitoring easier. Working alongside government representatives expedites the approval process and builds assurance. While social networking inclusion in mobile apps promotes more active participation, advanced data analytics provide deeper insights.

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