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Do-It-Yourself-Recommender System

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Abstract- Rapid urbanization with population growth leads to a sharp increase in waste generation, which causes significant environmental damage. Despite the daunting nature of this challenge, it can be effectively managed by promoting waste recovery. In our research, we propose a new approach that uses machine learning and blockchain technologies to solve this problem. Our system uses a Deep Neural Network (DNN) based on the Efficientnetb0 architecture, which is trained on about 11,700 images and achieves a training accuracy of 94% in identifying garbage objects. We have developed a complete solution where DNN detects garbage objects and makes suggestions. several do-it-yourself (DIY) ideas to reuse or recycle them. To ensure transparency and make decision- making more efficient, all transactions are recorded in a blockchain ledger that allows verification and validation of DIY ideas proposed by network participants. The integration of smart contracts with the Ethereum blockchain platform further improves the reliability and security of our system. Our template is accessible through a user-friendly web platform built with Streamlit, which includes a web-capture script written in Python that effectively sources DIY ideas. . Scraping the web typically takes about a second on a desktop computer running Ubuntu 18.04 64-bit with an Intel Core i7 processor, 16GB of RAM, and Python 3.6.In addition, we perform a blockchain performance evaluation. based on smart contracts that evaluate latency and performance using Ethereum benchmarking tools. To our knowledge, our research is a pioneering effort to integrate blockchain technology and deep learning to develop a DIY recommendation system to address waste management challenges.

Index Terms- Machine learning, Deep neyral network (DNN), Efficientnetb0 architecture, waste object recognition, Do- it-yourself (DIY) ideas

I. INTRODUCTION

The increasing complexity of human activity and the depletion of natural resources and the deterioration of the environment emphasize the urgency of sustainable development efforts. The excessive generation of municipal solid waste combined with a lack of recycling practices presents a significant waste management challenge.

Urbanization exacerbates this problem and emphasizes the need for local solutions to promote sustainable waste management. This study proposes an original waste recommendation system that combines deep learning and blockchain technology to facilitate personalized recycling strategies. The aim is to provide specific do-it-yourself (DIY) recommendations tailored to identified waste products so that consumers can explore creative recycling options before disposing of the products.

A deep neural network classifier based on the EfficientNetb0 architecture works as an image recognition module (IRM) trained on a dataset of 11,700 product waste images in 12 categories. Cross-validation confirms the more than 90% object recognition accuracy of the model, which lays the foundation for context-based recommendations.

These visual ratings are fed into a web scraping module that uses Python scripts to extract relevant DIY recycling recommendations from online sources.

Most importantly, the system integrates the Ethereum blockchain to securely store recommendations with smart contracts that manage key actions such as adding, revising, or canceling reuse recommendations based on expert validation. This symbiotic fusion of deep learning and blockchain provides an end-to-end reliable pipeline from waste detection to tailored recycling ideas to decentralized storage and curation of recommendations.

Combinations of artificial intelligence and blockchains applied at a regional scale can have a positive impact on sustainable waste management by promoting grassroots change. This approach is an example of how technological innovation combined with community participation can meet the societal need for environmental protection.

II. LITERATURE SURVEY

"Do-It-Yourself Recommender System" is a project that aims to integrate deep learning and blockchain technology to promote waste recovery and recycling. By offering DIY ideas adapted to waste, it aims to promote sustainable management practices. Waste management faces major challenges, and the World Bank expects to increase annual solid waste production to 3.40 billion tons by 2050. The low percentage of recycling and composting (13 .5% and 5.5%) highlight the shortcomings of current waste management strategies. In addition, the mismanagement of 33-40% of global waste represents a major environmental threat. Current approaches have explored transfer learning models for waste image recognition, such as ResNet and VGG16. Data such as TrashNet and capsule networks have been used to sort plastic waste. While blockchain technology holds promise for waste management, specific recycling recommendations have not yet been fully developed. Deep learning plays a vital role in object recognition, and convolutional neural networks (CNN) enable automatic recognition. Transfer learning techniques improve the efficiency of model training, while alerting mechanisms improve CNN's focus on critical image details. Web capture enabled by the DuckDuckGon API ensures privacy-focused data extraction while respecting privacy and website user terms. In addition to blockchain technology, specifically Ethereum smart contracts enable users to modify self- executing contracts, increasing transparency and collaboration. The anti-counterfeit ledger provided by the blockchain facilitates the recording and control of DIY recommendations. Integration with existing communication platforms offers the opportunity to increase accessibility and usability.

III. RELATED WORKS

This paper delves into Waste Object Recognition using Deep Learning, expanding on previous research efforts. While prior works [2-5] explored various deep learning models such as DenseNet, ResNet, and MobileNet for classifying waste, typically into a limited number of categories ranging from 6 to 8 classes, this paper extends the classification to 12 classes. This extension enables the generation of more specific reuse recommendations tailored to each waste category.

Moreover, the paper introduces a novel aspect in Recycling and Reuse Recommendation Systems. Previous studies [15, 21-23] primarily focused on optimizing waste collection and transportation systems or modeling uncertainties in demand, but they lacked tailored recommendations for reusing or recycling recognized waste objects. In contrast, this paper bridges that gap by providing personalized recommendations for reuse and recycling, leveraging the object recognition capabilities of deep learning models.

In the realm of Blockchain Integration for Waste Management, while blockchain technology has been applied to various aspects such as solid waste management [24], smart contract interaction [25], and e-waste metal recovery [27], this paper uniquely employs blockchain for verifying the DIY reuse recommendations. By integrating blockchain, the paper ensures the transparency and credibility of the recommendations generated through machine learning and web scraping techniques.

Lastly, this paper emphasizes a User-centric Waste Reduction approach. Unlike previous works that indirectly influence public participation in waste management processes [21,22], this paper takes a direct approach by engaging users through personalized reuse recommendations. By involving users in the reuse and recycling process and employing blockchain for transparency, the paper promotes a more sustainable and user-driven approach to waste reduction.

IV. PROPOSED WORK

Our system entails the development of a waste recommendation system that integrates deep learning and blockchain technology to promote reuse and recycling. The system aims to automatically identify waste objects using a deep neural network and provide "Do-It-Yourself" (DIY) recommendations for reusing or recycling waste materials. It also incorporates blockchain technology to validate recommended DIY ideas through the deployment of smart contracts on the Ethereum blockchain platform, ensuring transaction verifiability and supporting better decision-making. The system's objective is to address waste management challenges and promote environmental sustainability by providing tailored reuse recommendations and decentralized recommendation storage and curation.

V. PROPOSED METHODOLOGY

The proposed methodology outlines the development of a DIY Recommendation System integrating deep learning (DL) and blockchain technologies for effective waste management. It begins with collecting and preprocessing a dataset of approximately 11,700 waste object images to train the Image Recognition Module (IRM) based on the EfficientNetB0 architecture. Using Python and Tensor Flow, the IRM is trained to achieve high accuracy (94%) in identifying and classifying waste items. Simultaneously, a Web Scraping Module (WSM) is developed using Python libraries to extract DIY ideas from online sources based on identified waste objects, ensuring relevant recommendations for waste repurposing and recycling.

To validate and secure DIY recommendations, blockchain technology is integrated through smart contracts written in

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Solidity for execution on the Ethereum platform. These contracts ensure the integrity and transparency of recommendations, enhancing user trust in the system. Implementation occurs on a desktop computer with an Intel Core-i7 processor, 16 GB RAM, Ubuntu 18.04 OS, using Python 3.6 and OpenCV for real-time object detection and evaluation.

System performance is evaluated through real-time experiments, targeting a training accuracy of 94.17% and validation accuracy of 86.18% to validate the IRM's reliability in waste object detection. Performance testing assesses scalability, privacy, and flexibility, measuring transaction delays and efficiency of blockchain-based smart contracts for optimal system performance and user experience.

In summary, this methodology leverages ML and blockchain technologies to create an innovative DIY Recommendation System for waste management, providing users with actionable recommendations for sustainable waste reuse and recycling. The system aims to promote environmental conservation and waste reduction practices through advanced technology-driven solutions.

Overview of the proposed methodology:

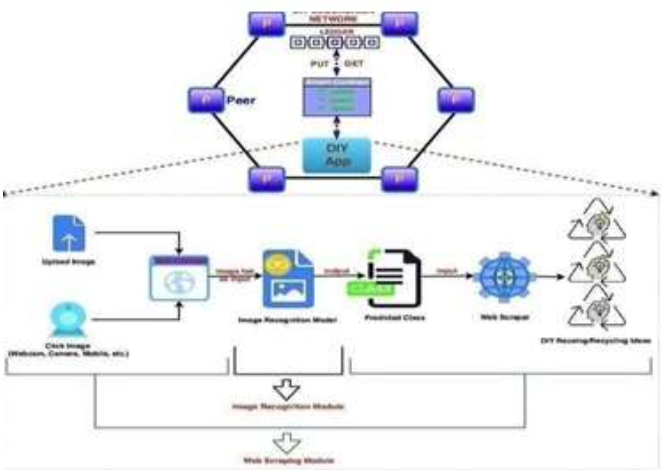

Figure.1: Deep Learning and Blockchain-oriented

Framework for the object recognition and idea recommendation

1. Image Recognition Module (IRM)
The core of the system is the implementation of the EfficientNetB0 architecture for waste object detection. Using Python and TensorFlow, the DNN model is trained on the preprocessed dataset to achieve high accuracy (targeting 94%) in identifying and classifying waste items. The model's performance is extensively evaluated using training and validation datasets to validate accuracy metrics.

2. Web Scraping Module (WSM)
Simultaneously, a web scraping module is developed using Python libraries to gather DIY ideas and recommendations based on the identified waste objects. The WSM is designed to extract relevant information from online sources and is tightly integrated with the IRM to provide contextual recycling and repurposing suggestions. The Web Scraping Module is designed for programmatically extracting information from websites using DuckDuckGo's search engine. This module employs DuckDuckGo's privacy-focused search API, enabling developers to retrieve search results and parse relevant data from the HTML of corresponding web pages. This approach ensures privacy-centric data extraction, adhering to website terms of service and respecting user privacy. The process involves sending HTTP requests, receiving search results, and parsing HTML content, providing an efficient means to obtain information from the web without compromising user privacy.

3. EfficientNetB0
EfficientNetB0 is a carefully engineered convolutional neural network architecture tailored for image classification tasks. It introduces an innovative approach to optimizing both the accuracy and computational efficiency of the model. Unlike traditional scaling methods that focus on individual dimensions, EfficientNetB0 employs a novel combined scaling technique that uniformly scales three key aspects: depth (number of layers), width (number of channels), and resolution (input image size). This holistic scaling strategy is governed by fixed scaling factors, allowing for a harmonious balance between model complexity and performance gains. By striking this delicate equilibrium, EfficientNetB0 achieves superior performance compared to previous architectures while maintaining a high level of computational efficiency. This unique characteristic makes EfficientNetB0 an attractive choice for a wide range of image classification tasks, particularly in resource- constrained environments such as mobile devices or edge computing platforms, where balancing accuracy and efficiency is of paramount importance. The architectural design of EfficientNetB0 offers a compelling trade-off between model size and accuracy, enabling its deployment in scenarios where computational resources are limited without sacrificing considerable performance. This versatility has contributed to its growing popularity and adoption across various domains and applications.

4. DuckDuckGo
DuckDuckGo stands out as a privacy- centric platform that places user privacy and data protection at the forefront of its mission. Introduced as an alternative to mainstream search giants, DuckDuckGo challenges the status quo by rejecting the practice of tracking user activity and personalizing search results based on individual browsing histories. This approach ensures that users can navigate the web without the looming threat of targeted advertisements or the risk of their online

behavior being monitored and cataloged. DuckDuckGo's search results are generated solely based on the user's query, without factoring in personal data or browsing habits. This commitment to anonymity and neutrality effectively reduces the potential for online profiling and the creation of user-specific digital footprints. By abstaining from storing personal information or employing user tracking technologies, DuckDuckGo offers a refreshingly transparent and secure search experience for individuals who prioritize their online privacy.

5. Ethereum

Ethereum's decentralized nature and the ability to create and run DApps have opened up a world of possibilities across various industries, ranging from finance and supply chain management to gaming and decentralized governance. By leveraging the transparency, immutability, and security inherent in blockchain technology, Ethereum aspires to revolutionize the way we conceptualize and implement digital agreements, transactions, and applications.

It distinguishes itself by offering a Turing- completescripting language, enabling developers to create a wide range of applications beyond simpletransactions. Ethereum's blockchain technology supports a global network of nodes, ensuringtransparency, security, and immutability. Its versatility has led to widespread adoption in various industries, including finance, supply chain, and decentralized finance (DeFi).

6. Smart Contracts

Smart contracts on Ethereum are self-executed agreements written in code, enforcing predefined rules when conditions are met. Utilizing Ethereum's scripting language, typically Solidity, these contracts operate on a decentralized network, ensuring transparency and security. They enable trustless transactions without intermediaries, finding applications in decentralized finance (DeFi) and beyond. Once deployed, smart contracts on Ethereum are immutable, providing a tamper-resistant foundation for various decentralized applications and blockchain solutions. Their versatility has led to widespread adoption in diverse industries.

7. Yt_dlp Module

yt_dlp is a powerful Python module that extends the functionality of youtube-dl, offering enhanced features for downloading and managing online videos from various platforms. It provides robust support for video extraction, format selection, metadata retrieval, and customization of download options. yt_dlp is actively maintained and frequently updated to ensure compatibility with evolving video streaming services, making it a versatile tool for developers and users seeking advanced video downloading capabilities beyond what standard youtube-dl offers.

8. Geocoder Module

The geocoder module in Python facilitates geocoding and reverse geocoding tasks, enabling developers to convert addresses into geographic coordinates (latitude and longitude) and vice versa. It supports integration with multiple geocoding providers, allowing flexible configuration based on user preferences and project requirements. The geocoder module simplifies location- based services by abstracting complex geospatial operations into a user-friendly interface, making it suitable for applications that require geolocation data processing and mapping functionalities.

9. Nominatim Module

Nominatim is a geocoding service and Python module provided by OpenStreetMap (OSM), offering powerful tools for address lookup, geocoding, and reverse geocoding operations. It leverages OSM's extensive map data to accurately resolve addresses to geographic coordinates and retrieve detailed location information. Nominatim is widely used in web mapping applications, spatial analysis tools, and location-based services for geospatial data handling. It supports batch geocoding, language localization, and customizable search parameters, making it a versatile choice for integrating address-based functionalities into Python applications.

Training and Algorithm used: Training Data

The training dataset comprises approximately 11,700 images sourced from multiple repositories, including ImageNet, TrashNet, and a Kaggle dataset, meticulously categorized into 12 distinct classes('battery', 'biological', 'brown-glass', 'cardboard', 'clothes', 'green-glass', 'metal', 'paper','plastic', 'shoes', 'trash', 'white-glass'). This diverse dataset facilitates a comprehensive classification framework, allowing precise identification and recommendation based on specific waste objects. By leveraging images from ImageNet, TrashNet (a specialized dataset for trash classification), and additional Kaggle sources, the dataset encompasses a wide variety of waste

	Precision	Recall	F1-score	Support
Bottle	0.79	0.67	0.72	201
Cans	0.65	0.63	0.64	179
Cardboard	0.67	0.59	0.63	177
Cups	0.69	0.66	0.68	208
Cutlery	0.87	0.41	0.56	196
Jars	0.7	0.8	0.75	91
Laptop Acc.	0.61	0.84	0.7	195
Organic Waste	0.75	0.86	0.8	195
Paper	0.8	0.7	0.74	150
Plastic Bag	0.92	0.85	0.88	206
Stationery	0.47	0.82	0.59	204
Utensils	0.57	0.37	0.45	203
Accuracy			0.68	2205
Macro Avg	0.71	0.68	0.68	2205
Weighted Avg	0.71	0.68	0.68	2205

Figure 2: Quantitative results of IRM

items commonly encountered in real-world scenarios. Each image in the dataset is associated with one of the 12 predefined classes, enabling the Image Recognition Module (IRM) to learn and differentiate between different types of waste objects with high accuracy. This structured approach to dataset collection and categorization enhances the training process, empowering the machine learning model to effectively identify and classify waste items during inference. The utilization of multiple datasets ensures robustness and versatility in waste object detection, contributing to the system's overall accuracy and performance in generating precise DIY recommendations for sustainable waste management practices.

EfficientNetB0 Algorithm

The choice of the EfficientNetB0 architecture for the deep neural network (DNN) in the DIY Recommendation System is driven by its balance of efficiency and performance in object detection tasks. EfficientNet models are known for their ability to achieve impressive accuracy while maintaining computational efficiency, making them suitable for resource-constrained environments like desktop computers. The EfficientNetB0 architecture optimizes model parameters to efficiently capture relevant features from images, enabling the system to accurately identify and classify waste objects from the extensive dataset of 11,700 images. This efficiency is crucial for real-time processing and inference, enhancing the system's responsiveness and usability. Additionally, leveraging EfficientNetB0 contributes to the overall success of the system in achieving a high accuracy rate of 94% in waste object detection, enabling precise recommendations for sustainable waste management practices.

Tensor flow.keras

TensorFlow.keras is an API within TensorFlow that simplifies the process of building, training, and deploying deep learning models. It provides a user-friendly interface for defining neural network architectures using high-level building blocks such as layers, optimizers, and loss functions. TensorFlow.keras integrates seamlessly with TensorFlow, allowing developers to leverage TensorFlow's computational graph capabilities while benefiting from an intuitive and flexible model development workflow.

Tensorflow Framework

-TensorFlow is an open-source machine learning framework developed by Google that facilitates building and training deep learning models. It provides a comprehensive ecosystem of tools and libraries for implementing various neural network architectures, including convolutional neural networks (CNNs) used for image classification tasks. TensorFlow enables efficient computation and optimization of complex models on CPUs and GPUs, making it a popular choice for developing advanced machine learning applications.

Training Process

Data Preprocessing

Data collection and pre- processing using TrashNet and EfficientNetb0 involves several tailored steps. Firstly, for TrashNet, the dataset, specifically designed for garbage classification, needs to be obtained from the TrashNet repository or a relevant platform. It's crucial to identify and comprehend the various trash categories within the dataset, such as paper, glass, plastic, etc. Image samples should be reviewed for quality assurance, ensuring diversity and quantity for effective model training. During pre-processing, standardizing image dimensions, normalizing pixel values, applying augmentation techniques, and implementing a train-test split are essential steps. Once the data is prepared, integration with EfficientNetb0, a powerful deep learning architecture, is initiated. EfficientNetb0 is chosen for its effective feature learning capabilities. Transfer learning is employed by leveraging pre-trained weights from EfficientNetb0onalargedatasetlike ImageNet to capitalize on learned features.

Model Initialization

The EfficientNetB0 model is initialized with pretrained weights on a image classification dataset . Transfer learning is employed to fine-tune the model's parameters specifically for the task of object detection on the trashnet dataset consisting of 12 classes of waste.

Loss Function

Categorical Crossentropy is a popular loss function used for multi-class classification tasks. It measures the dissimilarity between predicted class probabilities and true class labels encoded as one-hot vectors. Categorical Crossentropy penalizes incorrect predictions by computing the logarithm of the predicted probabilities for the true class. This loss function is well-suited for training neural networks with softmax activation at the output layer, effectively optimizing model parameters to minimize classification errors across multiple classes.

Optimization

Adam is an efficient optimization algorithm commonly used for training deep neural networks. It combines the advantages of both AdaGrad and RMSProp by maintaining adaptive learning rates for each parameter and incorporating momentum.

Adam dynamically adjusts learning rates based on the estimated first and second moments of gradients, enabling faster convergence and improved performance on non-stationary problems. Its adaptive nature makes it robust to variations in gradient magnitudes and sparse gradients, making it a popular choice for optimizing neural network parameters during training.

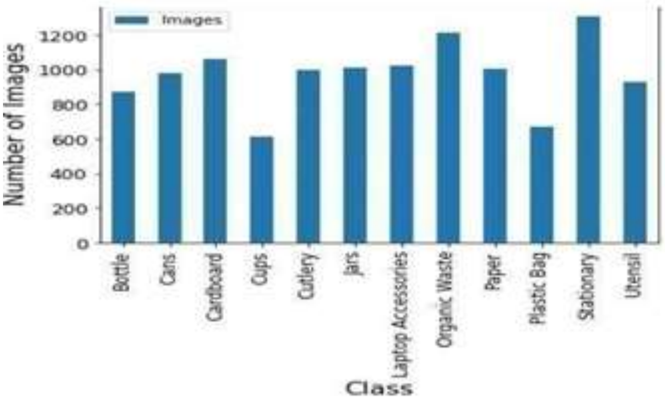

Figure 3: Number of Images with Target Labels

Training Pipeline

The training pipeline for the DIY Recommendation System begins with data collection and preprocessing of approximately 11,700 waste object images. These images are categorized into 12 distinct classes. The EfficientNetB0 deep neural network (DNN) architecture is then employed for training on this dataset to achieve high accuracy (94%) in identifying and classifying waste objects.

The training process involves leveraging TensorFlow and Keras to implement the model, using categorical cross-entropy as the loss function and the Adam optimizer for efficient parameter updates. The trained model is rigorously evaluated using validation data to assess performance metrics such as accuracy and loss. Finally, the best-performing model is saved for deployment in the system's Image Recognition Module (IRM) to identify waste items accurately for DIY recommendations.

VI. RESULTS

Testing the Algorithm: The testing phase of the algorithm encompassed a comprehensive evaluation of its performance across various key parameters. Firstly, the trained Deep Neural Network (DNN) utilizing the EfficientNetb0 architecture demonstrated commendable accuracy rates, with a training accuracy of 94.17% and a validation accuracy of 86.18% for object recognition tasks. Real-time assessment further validated the system's efficacy, as it seamlessly identified a range of waste items through webcam evaluation, redirecting users to pertinent

"Do-It-Yourself" (DIY) reuse ideas based on these identifications. The robustness of the classification framework, built upon a dataset of approximately 11,700 images categorized into 12 distinct classes sourced from ImageNet, TrashNet, and a Kaggle dataset, enabled precise recommendations tailored to specific waste objects. Moreover, the performance of the Image Recognition Module (IRM) mirrored that of the DNN, reinforcing the model's efficiency in waste object recognition and recommendation generation. Benchmarking of deployed smart contracts using the Ethereum platform showcased optimal latencies and throughputs, ensuring swift transaction processing. The recommendation process, involving web scraping for fetching DIY ideas, demonstrated remarkable efficiency with an average processing time of approximately 1 second.

Additionally, the model's accuracy graph depicted a consistent increase in accuracy with each epoch, indicating effective learning with minimal overfitting. Finally, comparative analysis with existing approaches affirmed the algorithm's superiority in waste classification and recommendation. Overall, the testing phase underscored the algorithm's robustness and its potential to revolutionize waste management practices in the pursuit of environmental sustainability.

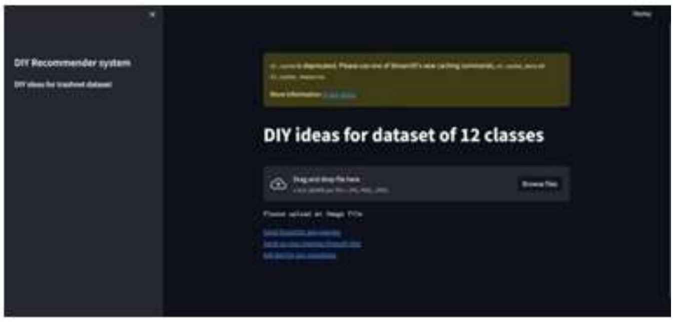

Figure 4: User Interface for input the waste object image

Figure 5: Recognized image's Target class

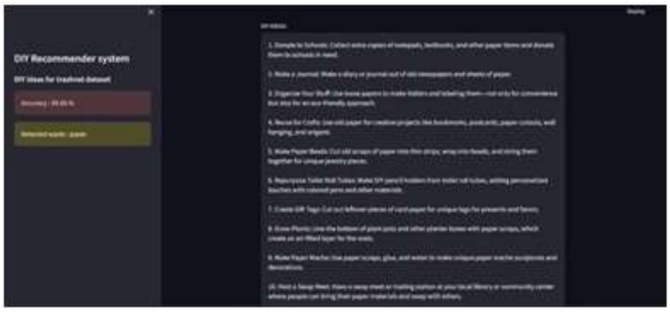

Figure 6: Web Scraping Ideas

Figure 7: Web Scraping video from YouTube of respective DIY idea using YTDLP module

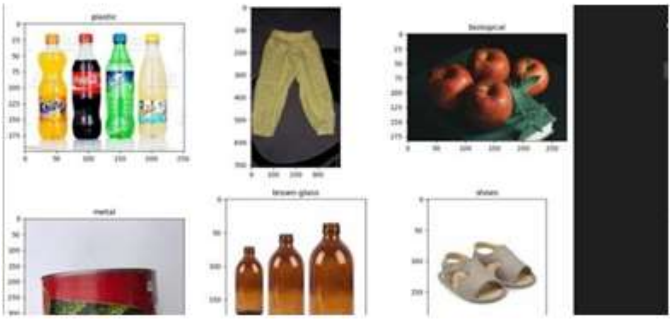

Figure 8: Trained images number of 12 classes

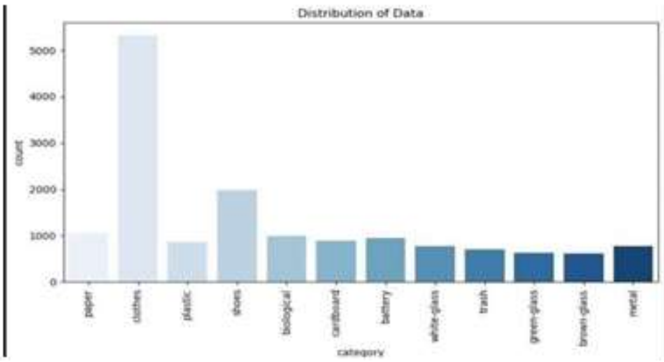

Figure 9: Distribution of Data

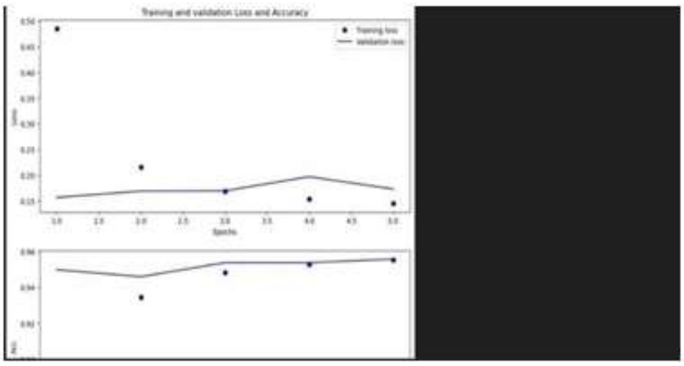

Figure 10: Training and validation Loss and Accuracy

Figure 11: Confusion Matrix

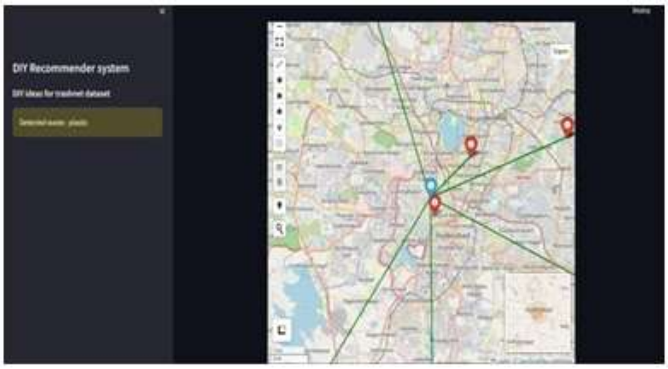

Figure 12: Integration of maps to show nearby waste management amenities using open street maps.

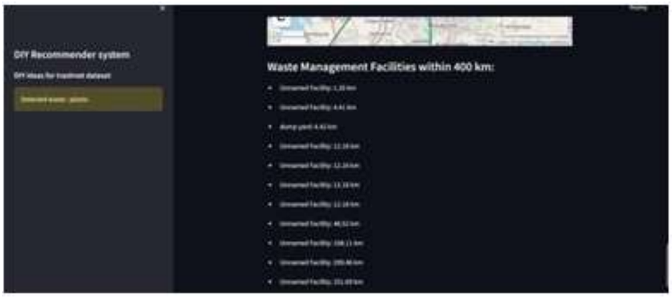

Figure.13:.Near by waste management amenities from current location of user.

Figure 14: Creation of Smart Contracts

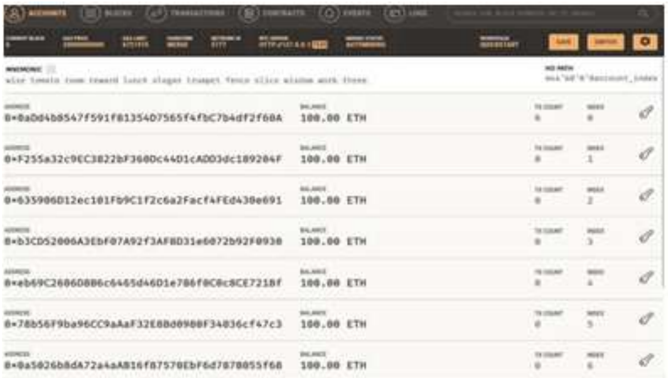

Figure 15: Creation of Transactions

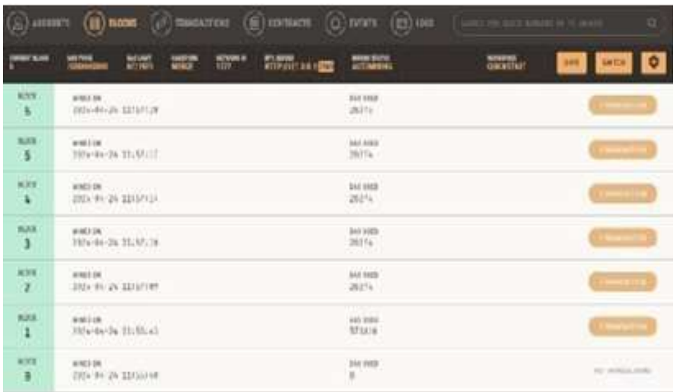

Figure 15: Creation of Blocks through ganache and ethereum

VII. CONCLUSION

1. Conclusion

In summary, this paper advocates for the timeless principle of "reduce, reuse, recycle" as a cornerstone of sustainable waste management. By providing customized DIY recommendations for repurposing everyday household items, it not only encourages resourcefulness but also fosters a culture of creative recycling. This approach empowers individuals to reimagine the potential of seemingly disposable objects, thereby diverting them from landfills and extending their lifespan.

Moreover, the decentralization of recommendation verification through blockchain technology enhances trust and transparency within the waste management ecosystem. By leveraging the immutable nature of blockchain records and smart contracts, the system ensures that recommended reuse ideas are authentic and verifiable, instilling confidence in users and stakeholders alike.

The widespread adoption of this waste management model holds promise for significantly reducing the volume of waste destined for landfills, thereby mitigating pollution and its adverse environmental impacts. Furthermore, by promoting community-driven, localized efforts, this approach fosters a sense of collective responsibility for environmental stewardship. Through small-scale initiatives spearheaded by communities, the model can inspire broader systemic change toward a cleaner, healthier environment for current and future generations.

2. Future Works

Future works in the field of waste management and recycling could focus on several key areas. Firstly, there is a need for further research and development in the integration of advanced technologies such as machine learning, blockchain, and real-time image recognition to enhance waste classification and recommendation systems. This could involve exploring more sophisticated deep learning models and techniques for object recognition, as well as optimizing the performance of blockchain-based smart contracts for validating DIY recommendations. Additionally, future works could delve into the development of more comprehensive and userfriendly recommendation systems for reusing and recycling waste materials. This could involve creating innovative solutions that leverage blockchain technology to provide trusted and transparent recommendations, as well as enhancing the user experience through seamless integration with web platforms and mobile applications. Furthermore, there is potential for future research to explore the application of blockchain technology in waste management beyond recommendation systems. This could include investigating the use of blockchain for supply chain management, product traceability, and waste segregation at the household level, with a focus on promoting resource reuse and reducing environmental impact. Overall, future working this domain should aim to advance the integration of cutting-edge technologies to address waste management challenges, promote sustainable practices, and contribute to environmental conservation.

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