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Smart Solid Waste Management Using Machine Learning and IOT

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ABSTRACT: The emerging rise in the population and urbanization alarms the nation for its environment safety. The incorrect handling and waste disposal will cause immense threat to the growing cities. Therefore, it has raised the need for proper waste collection and classification of wastes with proper disposal. The current waste disposal system in India consists of unclassified and unorganized wastes collected and then segregated at different stations. This classification done by manual labor forces can bring health related issues to the waste sorters and also being less efficient, time consuming and not completely feasible due to their large amount. Our project proposes a solution that can identify and classify the waste and updates amount of waste in the dashboard (recyclable, organic and harmful wastes) without any human hand. The system uses deep learning algorithms to identify and classify the wastes into particular category; the categorized wastes are updates in dashboard, using raspberry pi, camera and sensors and firebase. This project will help the environment in making more valuable and ecologically safe and help us to make rich green ecosystem and a promising better future.

KEYWORDS: Machine Learning, Image Preprocessing, Waste Prediction and Real-time Waste Monitoring.

I. INTRODUCTION

In this growing world, waste management has become a major issue. Approximately 68.8 million tonnes of mixed waste (recycled, organic and hazardous) is generated domestically. According to the report, the world population will increase by 20% by 2025. The population is at its peak. This population growth will increase demand and consumption of utilities, generating more waste at the same rate. There are three types of waste generated: recyclable waste, organic waste and hazardous waste. Improper handling and collection of this waste is highly detrimental to all forms of life and can cause air, water and soil pollution and life-threatening disease. Properly disposing of this waste can help turn it into a resource.

The number of ways has been proposed to overcome these challenges, but the importance to classify and update the waste at its initial stage is important to organize the amount waste into different category. The human hand in classifying and updating amount of waste is less efficient. To overcome this challenge, we use deep learning algorithm for waste classification for better and efficient results. The waste is identified with the algorithm trained to a machine and it identifies the type of waste and categorizes the amount of waste into a dashboard.

II. RELATED WORK

Nowaskowski and Pamula, 2020[1], “Application of Deep Learning Object Classifier to Improve E-waste Collection Planning” this model presents the waste classification method using a pre-trained CNN model identically known as ResNet-50 and Support Vector Machine (SVM). The accuracy of the model was 87%, which was tested on a public dataset.

Bobulski and Kurbanek, 2019 [2], “Waste Classification System Using Image Processing and Convolutional Neural Network (CNN)”. In this work, they had only focused on the detection of polyethylene. The authors had also performed several numbers of experiments to detect terephthalate, polyethylene, high-density polyethylene, polypropylene, and polystyrene.

Huiyu and O, O. G., & Kim, S. H., 2019[4], “Automatic Classifications and Recognition for Recycled Garbage by Utilizing Deep Learning Technology” proposed that unique classification model to identify the types of waste using deep learning mechanisms. The system was also applied to recycle garbage.

Ruiz et al., 2019 [5], “Automatic Image-Based Waste Classification” proposed that several CNN architectures for the automatic classification of waste: VGG-16, VGG-19, ResNet, Inception and Inception-ResNet. The experiments were performed on the TrashNet dataset, where the best classification results achieved using a ResNet architecture with 88.66% of average accuracy.

Misera et al., 2018[6], “An IOT-Based Waste Management System Monitored by Cloud” proposed that novel system of identification and classification of electronics waste, known as e-waste. The model utilized a CNN model to classify and an RCNN model to identify several types of e-waste. The model tracked out the accuracy of detection and classification ranged from 90 to 97%.

Chu et al, 2018[7], “Multilayer Hybrid Deep-Learning Method for Waste Classification and Recycling” suggest a multilayer hybrid deep-learning system (MHS) to automatically sort waste disposed of by individuals in the urban public area. This system deploys a high resolution camera to capture waste image and sensors to detect other useful information. The MHS uses a CNN based algorithm to extract image features and a multilayer perceptions (MLP) method to consolidate image attributes and other characteristics information to classify wastes as recyclable or not. The MHS is trained and validated against the manually labeled items, achieving overall classification accuracy higher than 90%. In this study the researchers analyzes a total of two classes recyclable and others.

Bai et al., 2018[8], “Deep Learning Based Robot for Automatically Picking Up Garbage on The Grass” proposed that implementation of an IoT based smart garbage system to reduce the amount of food waste. This model uses mesh technology to bring all the components under control. The proposed model was integrated with a router and a server to collect and analyze the information for food poisoning. After successfully tested on several experiments, the amount of food waste was reduced by 33%.

Samann, 2017[9], “The Design and Implementation of Smart Trash Bin” proposed that introduces a significant way of the automated, robust waste management process. This design depicted a smart trash bin designated by the ultrasonic sensor and several numbers of gas sensors. They also proposed a real-time view of waste using cloud server and android application. Again, no machine learning approaches had been utilized.

Malapur, and Pattanshetti, 2017[10], “IOT Based Waste Management” presented a cost-effective and intelligent trash bin to ensure waste management. Due to bringing the system under the operation of IoT, this model adds a set of devices like Arduino nano, ultrasonic sensor, and a GSM module. When the waste level crossed a minimum threshold level, the system would send an SMS to the User's mobile number using the GSM module. The system was enriched with a PIR motion sensor and a memory card that was responsible for assigning an audio message to the users. This model had also claimed that the performance of the proposed system was satisfactory.

Thung, and Yang, 2016 [11], “Classification of Trash for Recyclability Status”, designed two models, one that supports vector machines (SVM) with scale-invariant feature transform (SIFT) features and a convolutional neural network (CNN). The accuracy rate for SVM is 63% and 23% for CNN. The target is to take images of a single piece of recycling or garbage and classify it into six classes consisting of glass, paper, metal, plastic, cardboard, and trash.

Mittal G, Yagnik K B, Garg M, Krishnan N.C., 2016[12], “SpotGarbage: Smartphone app to detect garbage using deep learning”, who deployed a project to detect whether an image contains garbage or not. This project employs the pretrained AlexNet model and achieves a mean accuracy of 87.69%. However, this project aims at segmenting garbage in an image without providing functions of waste classification.

An automated system proposed by. Costa et al., 2016[13], “Artificial Intelligence in Automated Sorting in Trash Recycling”, based on deep learning approach and traditional techniques by aiming the correct separation of waste in

four different recycling categories: Glass, metal, paper and, plastic. The researchers concluded that CNN approaches tends to be more Future Internet 2020, 12, 141 4 of 13 computational expensive than the traditional techniques but requiring better computational resources and the experimental results using VGG-16 methods reached 93% of accuracy in its best scenario which is lower than our algorithm. Moreover, the classification is made in four classes: Glass, paper, metal and plastic.

Hong et al., 2014[14], “IOT Based Smart Garbage System for Efficient Food Waste Management”, proposed by introducing a smart trash can using the mechanism of IoT and Raspberry.

Sreelakshmi et al., 2019[3], “Capsule Networks and Visualization for Segregation of Plastic and Non-Plastic Wastes”, this model used Capsule Neural Network (Capsule-Net) for solid waste management, which was capable of detecting plastic and non-plastic materials. The authors had worked on two public data sets and found the accuracy of 96.3% and 95.7%. The complete integration was developed and tested on several hardware devices. The authors had worked on two public data sets and found the accuracy of 96.3% and 95.7%. The complete integration was developed and tested on several hardware devices.

III. METHODOLOGY

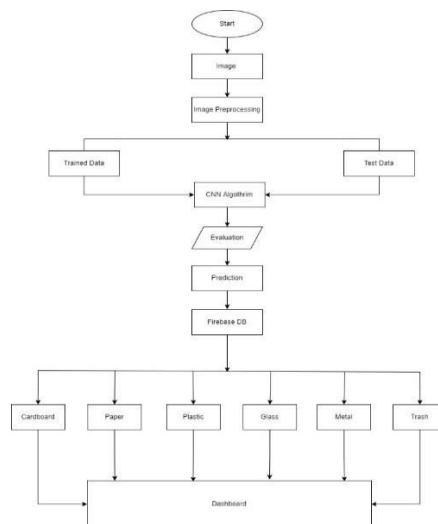


Fig 3.1: Block Diagram of Methodology

Creating a solid waste classification model using CNN (Convolution Neural Network), which would then be utilized to update the amount of solid trash utilizing IoT. Paper, plastic, and metal are the three sorts of solid waste that our model will be trained to recognize. The image is captured by picamera and used as an input for our trained model, which is then predicted by the deep learning model. The data is sent as an input IoT model, which determines the category of waste and amount of waste generated for each category which keeps dynamically changing in the dashboard.

HARWARE IMPLEMENTATION

Raspberry Pi 3B

A small device the size of a credit card that connects to a TV or computer monitor and uses a regular keyboard and mouse. It is a small portable computer that people of all ages can learn to program and write in languages like Python and Scratch. You can do everything a desktop computer can do, including surfing the Internet, watching high-definition videos, word processing and spreadsheet writing, and you can even play sports. For example, the device has the ability to communicate with the external environment and has been used in a wide range of communications development projects, from jukeboxes to infrared cameras to twitter birdhouses and weather stations.



Fig 3.2: Raspberry Pi 3B

Picamera

The Pi camera module is a small, light camera that works with the Raspberry Pi. The MIPI camera serial interface protocol is used to communicate with the Pi. It's commonly utilised in image processing, machine learning, and surveillance applications. Because the payload of the camera is so small, it's widely utilised in surveillance drones. Aside from these modules, Pi can use regular USB webcams that are connected to a PC.

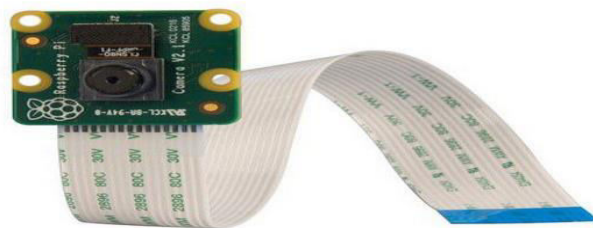


Fig 3.3: Picamera

SOFTWARE IMPLEMENTATION

Firestore

Backend-as-a-Service (BaaS) provider Firestore began as a YC11 startup. It has changed from being Google Cloud Platform to a platform for developing applications of the future. A list of items can be stored in the form of a tree using the real-time database Firestore (a NoSQL JSON database). Data may be synchronised among many devices. Developers may build apps for Android, iOS, and the web using Google Firestore, a platform for Google-enabled app development. For reporting and resolving application faults, gathering data, and creating marketing and product trials, Firestore offers a number of capabilities. The three core services offered by Firestore are hosting, user authentication, and real-time databases. Without writing any server-side code, you may create apps utilizing these services and the Firestore iOS SDK.

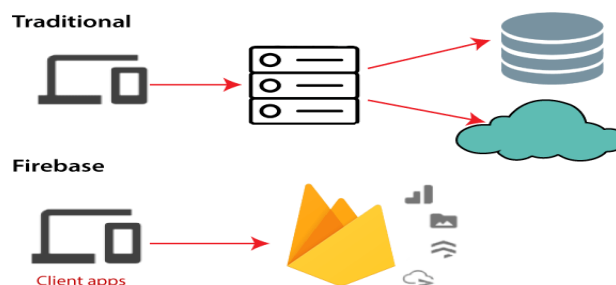


Fig 3.4: Firestore



Thonny Python IDE

By combining essential tools (such as a code editor, compiler, and debugger) into a single software package, an integrated development environment (IDE) assists computer programmers. The environment is already provided by an IDE, thus users do not need to install the language's compiler or interpreter on their computers. Thonny is a free, special Python IDE created with novices in mind.

Data Collection

Dataset Acquisition is the process of collecting required data for the proposed project, to gather the input data, a camera connected to raspberry pi camera module will scan the waste materials. After successfully finishing the waste scanning and image capturing process, a pre-processing component for the captured images taken by the camera in real-time is performed. There are many publicly available datasets from Kaggle, UCI, Dataworld.

Data Pre - Processing

Data preprocessing can be done on a local control system. Incoming waste includes several types of waste such as plastic, glass, metal, cardboard, paper waste, and more. The incoming stream contains real-time images with some noise, such as blurry areas in the image, unwanted objects, etc. The RGB image is converted to a grayscale model with alpha transparency so that the background of the image is transparent. The main difference between regular grayscale and alpha grayscale is the normalization of images with transparent backgrounds. To reduce blur, I used a sharpening kernel with a 2D filter. To apply normalization, you need to pass an image array to the filter. Before feeding the input image to the classifier, we need to resize the image to match the classifier's input layer.

Convolutional Neural Network

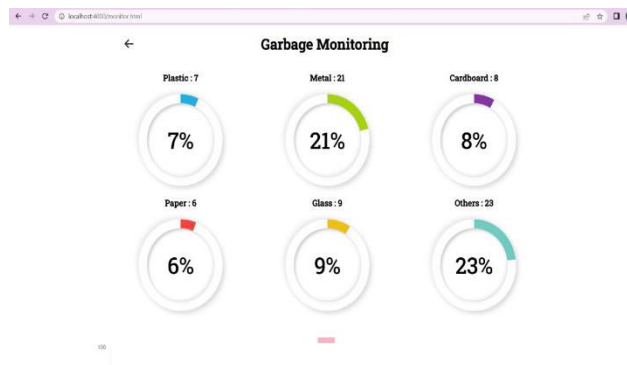
A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning system that can take an input picture, give relevant weights and biases to different characteristics and objects in the image, and then discriminate between them. A ConvNet requires substantially less pre-processing compared to other classification techniques. ConvNets can learn these filters/characteristics with adequate training, whereas basic techniques need hand-engineering of filters. A Convolutional Neural Network has three layers in general. Input, convolution, pooling locally and connected.

Training and Testing

To better support the model, datasets from ongoing review were separated for configuration and testing using the SciKit library. It contains the Imputer class to help handle the missing information. Various ranges such as 80:20, 70:30 and 60:40 aspect ratios were created and used for review. An 80:20 ratio means that 80% of the information is considered preparation information and the remaining 20% information is considered test information. Currently, the entailed step is to split the data set into two plan sets and a test set. A basic rule of thumb is to allocate 80% of the data set to the production set, and thus an additional 20% to the test set.

IV. EXPERIMENTAL RESULTS

Picamera is connected to the Raspberry Pi 3B model, which serves as the source for image capture. After an image has been acquired, it is processed by the CNN model, which predicts the types of waste, including paper, plastic, metal, glass, and trash. The Firebase real-time database receives the result. When firebase DB is updated, the latest results are uploaded to our website, which shows analytics about the categorized garbage.



V. CONCLUSION

Using the deep learning paradigm and the Internet of Things, we have created a project that is a real-time trash monitoring system. Then, in order to assure real-time data monitoring through the internet, we developed a dashboard in the webserver. We were able to understand the limitations of the current technology with the help of the literature research. The problem was defined once the holes were found. By creating a suitable model utilizing a variety of tools and methodologies, we were able to establish a framework for real-time trash categorization and monitoring that produced satisfying results and met objectives.

REFERENCES

- [1] P. Nowakowski, T. Parmula, "Application of Deep Learning Object Classifier to Improve e-waste Collection Planning," Waste Management. Silesian University of Technology Katowice Poland, 2020.
- [2] Bobulski j., & Kubanek M., "Waste Classification System Using Image Preprocessing and Convolution Neural Networks," *In international work conference on artificial neural network*, 2019.
- [3] K Sreelakshmi, S Akarsh, R Vinayakumar, K P Soman, "Capsule Networks and Visualization for Segregation of Plastic and Non-Plastic Wastes," *2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS)*, Coimbatore, India, March, 2019.
- [4] L. Huiyu, O O.G., & Kim, S H, "Automatic Classifications and Recognition for Recycled Garbage by Utilizing Deep Learning Technology," *7th International Conference on Information Technology: IoT and Smart City*, Shanghai, China, December, 2019.
- [5] Ruiz, V Sánchez, Á Vélez, J.F Raducanu, B., "Automatic Image-Based Waste Classification," *In From Bioinspired Systems and Biomedical Applications to Machine Learning*; Ferrández Vicente, J.M., Álvarez-Sánchez, J.R., de la Paz López, F., Toledo Moreo, J., Adeli, H., Eds.; Springer International Publishing: Cham, Switzerland, 2019
- [6] D Misra, G Das, T Chakraborty, D Das, "An IOT-Based Waste Management System Monitored by Cloud", *Journal of Material Cycles and Waste Management*, July, 2018 [Online]. Available:<https://doi.org/10.1007/s10163-018-0720-y/>.
- [7] Chu, Y Huang, C Xie, X Tan, B Kamal, S Xiong, X. Multilayer Hybrid Deep-Learning Method for Waste Classification and Recycling. *Comput. Intell. Neurosci*, 2018.
- [8] J Bai, S Lian, Z Liu, K Wang, D Liu, "Deep Learning Based Robot for Automatically Picking Up Garbage on The Grass," presented IEEE Transactions on Consumer Electronics, China, Volume 64, Issue 3, August 2018, Article number 8419288, Pages 382-389.
- [9] F E Samann, "The Design and Implementation of Smart Trash Bin," *Academic Journal of Nawroz University*, 2017.
- [10] Malapur B S, and Pattanshetti V R, "IOT Based Waste Management". An application to smart city, *International Conference on Energy, Communication. Data Analytics and Soft Computing (ICECDS)*, August, 2017.
- [11] Thung M, and Yang G, "Classification of Trash for Recyclability Status," [Online]. Available:<http://cs229.stanford.edu/proj2016/report/ThungYangClassificationOfTrashForRecyclabilityStatus-report.pdf>, 24 August, 2020.
- [12] Mittal, G Yagnik, K B Garg, M Krishnan, N C, "SpotGarbage: Smartphone app to detect garbage using deep



- learning,” *In Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, Heidelberg, Germany, September, 2016.
- [13] Costa, B Bernardes, A Pereira, J Zampa, V Pereira, V Matos, G Soares, E Soares, C Silva, A, “Artificial Intelligence in Automated Sorting in Trash Recycling,” 2018.
- [14] Hong, Park, Lee, Jeong, Park, “IOT Based Smart Garbage System for Efficient Food Waste Management,” *The Scientific World Journal*, 2014.



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