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A Empirical Analysis of Intelligent Waste and Junk Segregation Based on Machine Learning Model

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ABSTRACT

Waste management is a widespread concern in today's society, and the problem is getting worse all the time as the world's population continues to grow. Waste management plays an important role in maintaining a healthy ecological environment. It is critical to properly dispose of garbage at dumping sites in order to facilitate sorting at the base level. For the traditional method of sorting garbage, additional time and personnel are required. Waste may be separated into several categories using a variety of procedures and tools. Image processing may be used to analyses and categories rubbish, which can be a very productive technique to deal with waste items in general. The purpose of this study is to examine existing research papers that have been presented throughout the world. This will allow us to identify the issues, the algorithm that was utilised, and the methodology of the papers that were mentioned. It may also be used to determine whether or not a particular algorithm should be employed in a future investigation. These papers discuss the many approaches and planned systems that were used to separate waste throughout the waste segregation process. These also discuss the disadvantages of the already-existing systems and algorithms that were employed in their research. This document provides a plethora of chances for the generation of new knowledge in the process of developing a new system.

Keywords - Convolution Neural Networks, Deep Learning, Image Processing, Segregation, Support Vector Machine, Waste Classification.

I. INTRODUCTION

Trash is one of the world's most serious problems, affecting everyone and everything that lives. In the investigation, it was shown that 74 percent of plastic outflows into the Philippine waters were due to rubbish disposal. The Philippines creates around 35,000 tonnes of rubbish per day [21], with plastic, paper, and culinary waste being the most prevalent types of garbage discarded [4]. Furthermore, 81

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percent of plastic debris was dumped into the ocean from terrestrial sources [10]. According to the findings of this study, there are two reasons for the leaking of collected garbage: one is unlawful dumping by various firms, and the other is through dump sites that are located near waterways.

Additionally, Manila, the capital of the Philippines, was confronted with the challenge of what to deal with the more than 8,600 tonnes of rubbish generated each day by its 1.5 million citizens [27]. Manila City was not alone in this regard. Plastic bags accounted for 679,957 pieces of debris in the water, followed by paper bags, which accounted for 253,013 pieces, and food wrappers, which accounted for 103,226 pieces. There were also 38,394 pieces of clothes and shoes found, as well as 55,814 tobacco-related materials such as cigarette butts (34,154), lighters, and wrappers, and 11,077 diapers, among other things. These can cause poison and toxic waste to accumulate in the ocean, and you may be able to see these trashes in some bodies of water, such as the Manila Bay.

Furthermore, the Philippines continues to suffer from a waste problem, despite the fact that it has a significant environmental activist movement [26]. They emphasised on their report that out of the total 178 local government units (LGUs) in the Metro Manila area, there are still 39.89 percent that do not comply with the 10-year solid waste management plan, 27.53 percent that do not comply with regulations for segregation at source, 23.03 percent that do not comply with regulations on segregated collection, 44.38 percent that do not have a functional materials recovery facility, and 10.11 percent that do not have an apex landfill.

Local governments were having a difficult time implementing the Ecological Solid Waste Management Act of 2000 [26], according to the data. In order to promote reuse and recycling, the Philippine government has undertaken a slew of initiatives and projects, none of which have proven to be very effective. Even though some local government units have implemented the "No Segregation, No Collection Policy" and the "No Burn Pilipinas" campaign, there are still municipalities and towns that do not adhere to the policy [28] and have failed to execute Republic Act 9003.

Waste management has become a very common phrase in today's society, and it is used to describe a series of activities ranging from waste generation to waste disposal that can assist in sorting out the plethora of problems caused by improper waste disposal, which include adverse effects on human health and the environment [17].

The enormous industrialization and urbanization that has occurred in recent years has resulted in an incredible growth in the generation of undesired trash. It has been a source of contention in the community on how to properly divide garbage. However, a variety of programmers are being undertaken in order to distinguish between trash and recyclable materials. People have been separating garbage for almost 20 years, and many waste sorting centers now have their own automated assembly lines, as well. However, this process cycle is not without flaws: There are several manual procedures involved in the present quality control phase in the garbage sorting process [23].

The following approaches [24] are used to sort mixed garbage at the industrial level: manual sorting of big objects, sorting of other materials according to their size with the use of huge rotating drums, and sorting of other materials according to their composition. It is smaller in size, and the diameter of the drum features holes through which particles will be dropped and huge things will be suspended inside it.

The current state of the art includes a variety of forms of machines that seek to separate one type of material from another with varying degrees of success [19]. In the Philippines, there has been no usage of contemporary technologies to separate waste streams.

The manual procedure of segregation was the only one available at the time [28].

The primary goal of this study is to examine previous research papers that have been presented across the world. This will allow us to identify the issues, the algorithm that was utilised, and the methodology of the papers that were mentioned. It may also be used to choose the most appropriate algorithm to be employed in a future investigation.

The next part will address some of the research that has been presented, as well as new technologies that have been developed to separate trash and innovations. This will also discuss several research that have been undertaken to remove waste concerns, as well as their pros and disadvantages.

II. EXISTING STUDIES

Fact that there are various studies utilised the different methodology and studies where it applies to further explain the complex research given. It also contains strengths and drawbacks that may be utilised to decide which algorithm is best. Many systems exist to sort garbage into distinct groups. These are:

- Intelligent Waste Separator (IWS) [9]- may replace conventional waste management; The prototype uses a multimedia integrated CPU, picture processing especially utilising the image recognition method, and machine learning to choose and sort trash. The prototype is a multimedia shared garbage can with extra basins [8].

- Spot Garbage is a smartphone app. It detects a mound of trash and locates it using smartphone location services. Convolutional neural networks are used to identify trash in photos.

Smart Waste Collection using Infrared Sensors [16]- This automatic waste sorter employs Convolutional Neural Networks to separate waste into several categories. This technology improves recycling and reuse operations, resulting in improved waste management. The project aims to design and construct a system that can successfully separate garbage utilising Artificial Neural Networks and Image Analysis, especially the image recognition method.

Induction technique is used to understand sensor data streams and create an efficient description of object features that specify material separation strategies.

- Waste Sorting System The research uses Artificial Neural Networks [18] to design and construct a waste segregation system. The suggested system can correctly classify garbage by using recognition and classification ideas in Artificial Neural Networks.

- Automatic Garbage Segregator and Monitoring System [2] divides waste into three categories: metal, plastic, and moist (organic). Other wastes are classified as wet waste, which includes leftovers and vegetable peels [5].

Most of the research employed microcontrollers and were prototypes. Waste variations are unknown. Some studies are done for specific reasons. Other wastes and new wastes could not be identified. Moreover, buying and maintaining such research in the microcontroller is quite pricey. Sorting and classifying garbage is beneficial in many domains, including industry, household, business, and education. There was no current research on automating and sorting garbage in schools. Using today's technology to sift waste and determine what may be recycled can be quite effective.

III. ALGORITHM USED AND THEIR ANALYSIS

The following table shows the systematic review of the literature, an algorithm used by the studies presented, their strength and weaknesses and their findings.

TABLE I. STUDIES PRESENTED AND ALGORITHM (a)

Studies Presented	Algorithm Used	Strength	Weaknesses	Segregated Wastes	Findings
Intelligent Waste Separator (IWS)	Machine Learning	Due to IWS bursting anatomy waste separation do not dependon people. Consequently, avoiding mixing waste in bins has a fewer ratio of error.	The capacities of waste separator do not allow in obtaining information and response is slow.	aluminum cans, plastic cutlery, and plastic bottles	The result shows that it has the possibility toa positioned independent object in classification algorithm that was based withonly two of the seven HIMs in differentiating and classifying wastes.
Spot Garbage	Deep learning	A model that can describe the garbage from others. It is 11 times faster than naïve windowsliding and can perform prediction. It also uses an Android App	Garbage detection fails in an insufficiently available image. When there is a similar to garbage, it can misclassify the garbage orsometimes lose the distinct attributes when afar.	Plastic Bottles, tin cans, paper, metals some decayed objects	There are outperforms approach with the useof deep learning method, image trusting on image processing increased by 7% for accuracy and specificity was 11%

TABLE II. STUDIES PRESENTED AND ALGORITHM (b)

Studies Presented	Algorithm Used	Strength	Weaknesses	Segregated Wastes	Findings
IoT based Waste Collection System using Infrared Sensors	Azure Machine Learning System	The proposed IoT-based methodologycan easily provide information. It helps the company to efficiently routeand effectively scheduled collection of garbage.	It lies in real time generateddata and collection of waste.	No specified waste segregated	It uses IR sensors to notified the server if the bin is full andschedule for collection.
Adaptive and Interactive Modelling System (AIMS)	Artificial Intelligence and Induction Algorithm	Using a set of Pareto optimal models for classification is that they provide greater flexibility and ideal behavior under a variety of circumstances.	The error of randomly guessing the class would be50% and the error of a simple model classifies everything as clear is 40%.	glass, metal, and plastic	They use machine learning techniques that can be effectively applied to containersorting

TABLE III. STUDIES PRESENTED AND ALGORITHM (c)

Studies Presented	Algorithm Used	Strength	Weaknesses	Segregated Wastes	Findings
Waste Segregation System Using Artificial Neural Networks	Classification using Convolutional Neural Networks	Using one of the Machine Learning tools, Convolution Neural Networks was designed and executed. It is devised to achieve segregation of waste thereby reducing human intervention in the handling of waste items.	No physical mechanical device to categorize wastesinto different bins. Accuracy rate should be added to train the data set.	Bottles, cans, milk covers, paper bags, andboxes. Spoons, papers,straws, and plastic bags	Using CNN's, the categorization of the waste objects is achieved with the current accuracy rate of 70%. The expansion in the waste categories' database helps in increasing the accuracy rate when training the network for the classification purpose
Automatic Waste Segregator and Monitoring System	An algorithm was not specified except it used ultrasonic sensor and induction sorting	Sorting of waste at the primary stage will make waste management more effective andfruitful.	It is very costly, Waste separation is time-consuming. Size of waste must be less than or equal to the dimension of a funnel	Metallic wastes (paperclip, battery, safety pin), organic waste (leftover foods) and dry waste (paper, small bottle, cartons, tetra pack)	The proposed be able to monitor the solid waste collection process and management of the overall collection process.

It shows the systematic review of literature and certain studies that show the strength, flaws, and conclusions of the many studies identified. It also stated the applicability and conclusion of the study. It was also stated some of the drawbacks of the many studies that assist the proponent determine what algorithm and application to utilise and why.

Sakr [22] utilised NVIDIA DIGITS to prepare the Convolutional Neural Network, while Support Vector Machine (SVM) was trained using Matlab 2016. The lack of explanations and photos in Sakr's [22] study was a flaw. The training pictures were reduced from 256 × 256 to 32 x 32. In addition, it raised more pertinent problems. The final model constructed in this study took under 0.1s on a Raspberry Pi 3.

Yang [23] classified rubbish into six categories: metal, paper, cardboard, etc. The dataset utilised was hand-collected and consists of over 400 photos for each category. Support Vector Machines with SIFT features and Convolutional Neural Networks were utilised to categorise the photos. This uses an 11-layer CNN architecture, similar to AlexNet. The experiments suggest that SVM outperforms CNN.

Table IV illustrates the Garbage Classification models employed and their accuracies. [1]

TABLE IV. GARBAGE CLASSIFICATION MODELS

Model	Algorithm Used	Accuracy
Sakr (2016) study	SVM and CNN	94% and 83 %
Spot Garbage	Convolutional Network	87 %
Yang (2016) Research	SVM	63%

IV. METHODOLOGY USED

The studies and researches offered have been analysed and presented in various ways. Years covered, databases searched, keywords searched, and relevance to paper's emphasis were all considered. Researchers sought an updated analysis from 2014 to 2018. These keywords were used to search Scopus and Web of Science databases to highlight some advancements. They were chosen as the most extensive source of scientific papers.

A search yields 100 results. However, some of the research is obsolete. Also, certain investigations were not linked to the study, such as battery and other electronic wastes, aluminium, and others. We didn't ruminate on other wastes because this article concentrates on recyclable goods like paper and bottles. That is why just six studies were included. It was the main issue raised in the Philippines during segregation.

TABLE V. CATEGORIZATION OF STUDY

Study	Research Area	Focus/Process	Study Type	Area
1	Machine Learning	Waste separation	Prototype	Household
2	Deep Learning	Waste description	Model	Community
3	Azure Machine Learning	Infrared waste segregation	IR Sensor	Industry
4	Artificial and Induction	Waste classification	Model sensor	Industry
5	Convolutional Neural Network	Waste segregation	Prototype / sensor	Community
6	Induction	Waste sorter	prototype	Household

Table V describes the category of the study. The research presented was categorized according to their research area, type focus and where it was applied.

V. RESULTS AND DISCUSSION

As the related literature and studies were carefully analyzed and reviewed the following are the results of this study.

TABLE VII. TABLE OF REVIEWED ALGORITHM AND ACCURATENESS

Algorithm	Accuracy	Author
Deep Learning	On Image Processing Increased By 7% For Accuracy And Specificity Was 91%	Google developers
Azure Machine Learning System	91%	Dille, 2019
Artificial Intelligence and Induction Algorithm	91%	Shavlik, Mooney, & Towell, 1991
Classification Using Convolutional Neural Networks	Current Accuracy Rate of 99.68%	Xin And Wang, 2019

SVM and CNN	94% And 83 %	Sakr 2016
SVM	Current Accuracy Rate 89.41%	Yang, 2016

Table VII lists the study's algorithms. The researcher only chose the most widely used algorithm in the experiments. A study by the researcher found that among the six most regularly used algorithms, classification utilising a Convolutional Neural Network had the best accuracy level. Even though they are all categorised as machine learning algorithms, one stands out. It was also noted that most of the algorithms utilised were over 90% accurate. This indicates that the algorithms used to classify and sort garbage are the most trustworthy.

However, using only a convolutional neural network in one project can provide the most accurate picture classification. As seen in the table, combining the efforts of an algorithm renders it incapable of doing its function.

VI. CONCLUSION AND FUTURE WORKS

Many academics and research enthusiasts have previously investigated many stages and ways of effective waste management and disposal. Many gadgets have been devised to facilitate this procedure. Various techniques and hardware components like Raspberry Pi were employed to achieve the aim. The technology scans images of items to categorise them. However, these devices only function with maximum accuracy on photos comprising single items to be detected and categorised. Convolutional Neural Networks are thought to represent a key stride in the development of object identification and classification algorithms. They can only be employed on materials that can be claimed to stay in a fixed shape or size, which appears impossible when it comes to trash and scraps. Earlier, approaches to categorise pictures based on physical reflectance qualities of diverse objects and material categorization were proposed. Previous studies focused on single item detection and classification, and employed many algorithms on the same datasets to compute and assess the algorithms' precision and accuracy. The main flaws of previous systems are that they only classify a single item in a picture. In reality, separating individual things from a waste pile and then classifying them is tough and time consuming due to the massive volume of garbage there. So several things in a single picture must be recognised and separated. The current models also classify wastes into a small number of categories. Wastes are frequently recycled or composted. Paper, plastic, metal, and other recyclable materials are all recycled individually.

Sorting recyclables from wastes and rubbish into categories would improve and simplify recycling. The tremendous expansion in computer and technology has increased the use of electronic gadgets dramatically during the last decade. A smartphone, for example, has a 2-year average life. Electronic garbage generation will skyrocket in the next decades. It will be tough to recycle these parts because each one is constructed of various materials that must be recycled differently. So we need an effective way to recycle electronics and their parts. Hence, a fresh waste segregation study is required. Garbage categorization in bulk should also be considered, as well as determining and categorising waste produced in school. To detect and sort recyclable items, image processing power is required.

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