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A Comprehensive Analysis of Automated Waste Segregation System Using Convolutional Neural Networks

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ABSTRACT: The current Indian government has begun various tasks for propelling sanitation and neatness. Megacities in India, for instance, Ahmedabad, Hyderabad, Bangalore, Chennai and more importantly Mumbai have a dynamic monetary development and high wastage per capita. Some issues and difficulties like the absence of gathering and isolation at source, shortage of land, dumping of e-waste, and so on. The present waste collection framework collects a wide range of waste in an unsorted way by utilizing physical work. The separation of this waste is an extraordinarily redundant, repetitive, and inefficient endeavor, which is numerous a period perilous to the sufficiency of the authorities. In this manner, there is a requirement for a framework, which robotizes the strategy of waste separation, with the objective that the waste transfer can be executed viably and profitably. The proposed model utilizes machine learning strategies such as CNN to accurately characterize the objects into different categories. The grouped waste can be isolated into different classifications using rotating bins. The automated order along these lines helps during the time spent on sanitation. The ordered waste can be additionally arranged and handled by the businesses for recycling. This impacts the computerized transfer framework to work rapidly and productively. This model can be scaled up to a cutting-edge level with the objective that it can be utilized as a part of semi urban and urban domains.

I. INTRODUCTION

1. Background

One of the global problems that affect everyone and all living things is garbage. The most common garbage thrown are plastic, paper and kitchen waste. The leakage of collected garbage is due to the illegal dumping by different companies and another one is through dump sites and located near waterways. Many programs and projects are done by the Philippine government in the implementation of Reuse and recycle but none of them are successful. Waste management is a very common term and is used to describe the series of activities from waste generation to disposal that can help sort the innumerable problems due to improper waste disposal that includes adverse effects on human health and the environment. Due to rapid industrialization and urbanization causes an extraordinary increase in the origination of unwanted waste. The current quality control step in waste sorting process requires a lot of manual operations. The framework relies upon the Machine learning domain and it is to make a whole self-administering seclusion framework in semi-urban and urban areas. The field of Machine learning is stressed over the subject of how to create computer programs that consequently improve with inclusion. Lately, numerous effective machine-learning applications have been created, going from information mining programs that figure out how to recognize beguiling charge card exchanges, to data separating frameworks that take in customers' examining tendencies, to automatic vehicles that figure out how to drive on open Inter-states. Waste arranging can happen physically at the family and assembled through some gathering plans, or consequently separated by mechanical natural treatment frameworks. Waste segregating is the procedure by which waste is separated into various components. Dry waste incorporates paper, plastic, glass, metal, cloth, and wood. Wet waste, commonly implies natural waste for the most part produced by eating foundations and is overwhelming in weight because of sogginess. Waste can similarly be isolated on premise of biodegradable or non-biodegradable waste. Waste is accumulated at its source in each zone and segregated. Populace blast, combined with an enhanced lifestyle of people, brings about expanded age of strong squanders in urban and furthermore rural locales of the country. In India like each and every other division, there is a stepped capability

between solid waste from urban and nation zones. In CNN innovation is utilized to order the protest from the identified articles gathered from the movement identifier. As it is very difficult to build and train a new CNN model with less data, we can use the method of transfer learning where we select a neural network which is already trained on the similar dataset and train it on our dataset so that the previously learned features by the neural network will be transferred to the new model which results in higher accuracy even for small datasets.

2. *Motivation*

In the industrial level, the sorted mixed waste is done through the following techniques, manual sorting of large items, other materials are sorted through its size with the help of large rotating drums. It has smaller in size, the diameter has holes in which particles will be dropped and large items will hang in the drum. Currently, there exist various types of machinery which attempt to sort one material from another with differing degrees of success. In the Philippines, no modern technology has been used to segregate waste. Only the manual process of segregating was then used.

3. *Objective*

Waste management is a pervasive problem in today's world and is rising continuously with a rise in urbanization. Waste management has a vibrant part to have an ecological environment. Proper waste disposal at the dumping sites has an essential part in sorting at the base level. Increases in time and more manpower is needed in order to sort waste using the traditional process. Sorting waste can be done in various methods and forms. Analyzing and classifying the garbage using image processing can be a very productive way to process waste materials. This paper aims to analyze existing research presented studies around the globe. This will enable to determine the problems, an algorithm used and method of those cited studies. It can also assess the correct algorithm to be used in a future study. These paper talk about the different methods and proposed systems in which waste segregation took place. These also talk about the drawbacks faced by the already existing systems and algorithms they used. With it, this paper gives a lot of opportunities to produce new knowledge in creating a new system.

4. *Scope of the Project*

Various methods has been used in order to analyze and present the studies and researches presented. Considerations were made in searching years it cover, databases to be used for searching, keywords to search and relatedness to the focus of paper. Researcher searched for an updated study ranges from year 2014 up to 2018. To be able to present some innovations, keywords such as Machine Learning, image processing, artificial intelligence and a combination of waste segregation was used in searching in the database from two large databases: Scopus and Web of Science. They were selected because they are the most comprehensive source of scholarly paper and articles

II. RELATED WORK

The different systematic review of the literature and some studies that prove the strength, weaknesses, and findings of the different studies found. It was also indicated the application to where it was applied and the conclusion in which it further discussed the output of the study. It was noted as well some of the disadvantages of the different studies which help the proponent to identify as to what algorithm and application should she used and why this kind of application be used. In addition to the study presented, there are studies such as Sakr [22] that used NVIDIA DIGITS for preparing the Convolutional Neural Network, while Support Vector Machine (SVM) was trained through Matlab 2016. The drawback in Sakr's [22] study was the lesser quantity of descriptions and images in the preparation and training set. The training images were scaled down from the original 256 x 256 size to 32 x 32 size. This decreasing interjected to extra other relevant issues. The final implemented model produced in this research had a small average implementation period (0.1s) on a raspberry pi 3. Yang [23] researched on classifying garbage into six different classes like metal, paper, cardboard etc. The dataset used was hand collected which consisted of 400 plus images for each of the categories considered. Support Vector Machines with a scale of irregular feature transform (SIFT) features and Convolutional Neural Network were the models that were used to classify the images into various categories. Eleven layer CNN architecture was implemented in this, which is very similar to Alex Net. The experiments show that the SVM performs more efficiently than CNN.



III. PROPOSED METHOD

Various methods has been used in order to analyze and present the studies and researches pre- sented. Considerations were made in searching years it cover, databases to be used for searching, keywords to search and relatedness to the focus of paper. Researcher searched for an updated study ranges from year 2014 up to 2018. To be able to present some innovations, keywords such as Machine Learning, image processing, artificial intelligence and a combination of waste segregation was used in searching in the database from two large databases: Scopus and Web of Science. They were selected because they are the most comprehensive source of scholarly paper and articles. Upon searching, there are 100 results found. But since some of the study is outdated it was not considered. In addition, some researches were not related in the study, some of them focused on energy waste such as battery and other electronic wastes, aluminum and others. Since this paper focuses on recyclable materials such as paper, bottles, cartoons, and plastics other wastes was not then ruminated. It is the reason why there are only 6 studies that were just included. As it was the major problem raised in the segregation process in the Philippines.

IV. METHODOLOGY

In CNN innovation is utilized to order the protest from the identified articles gathered from the movement identifier. As it is very difficult to build and train a new CNN model with less data, we can use the method of transfer learning where we select a neural network which is already trained on the similar dataset and train it on our dataset so that the previously learned features by the neural network will be transferred to the new model which results in higher accuracy even for small datasets This paper portrays vision and example acknowledgment method using the descriptor and the correlation with the picture acknowledgment by utilizing profound learning. "Automatic Garbage Collector Robot Model" this investigation paper intends to layout and makes AGATOR (Automatic Garbage Collector), a rotor robot displays as programmed city worker to counter aggregation of junk in the stream which has no stream reasonably and proficiently. Two well-known learning algorithms are utilized namely deep learning using CNN and Support Vector Machines (SVM). Convolution Neural Networks has had a great impact on pattern recognition. The proposed idea is to make an autonomous system that segregates the waste. The system segregates the waste utilizing CNN algorithm in machine learning. The algorithm detects and classifies the waste as indicated by the dataset provided to CNN. The algorithm accordingly classifies the waste as different categories of waste. As mentioned the given system utilizes microcontrollers and sensors to segregate the waste directly whereas we look forward to first classify the waste and reduce the use of bigger hardware components. The result is then processed to the hardware components of the system where Renesas microcontroller is being used to dump the waste in the bins. Government Bodies at all levels (central, state and municipal) are taking proactive steps to improve the municipal solid waste scene in India. The Government of India issued new rules that regulate the MSWM at the local level. The mandatory requirements of the rule are Source segregation and storage at source Door to door collection Abolition of open storage Daily sweeping of the street .Transportation of waste in covered vehicles Waste processing by composting or energy recovery Disposal of inerts by sanitary landfilling A Convolutional Neural Organization is a Profound Learning calculation which can take in info picture, relegate significance to different articles in the picture and ready to separate between pictures. CNNs are utilized for picture characterization and acknowledgment on account of its high precision. The CNN follows a various leveled model which chips away at building an organization, similar to a pipe, lastly gives out a completely associated layer where every one of the neurons are associated with one another and the result is handled. A convolutional neural organization is a sort of fake neural organization utilized in picture acknowledgment and handling that is explicitly intended to deal with pixel information. A neural organization is an arrangement of equipment as well as programming designed after the activity of neurons in the human mind. VGG16 could be a convolution neural net architecture which was wont to win ILSVR competition in 2014. It's considered to be one in every of the superb vision model architecture till date. Most unusual thing about VGG16 is that rather than having an oversized number of hyper-parameters they focused on having convolution layers of 3x3 filter with a stride 1 and always used same padding and maxpool layer of 2x2 filter of stride 2. Within the end its 2 FC followed by a SoftMax for Output. The 16 in VGG16 refers thereto has 16 layers that have weights. This network may be a pretty large network and it's about 138 million parameters

1. *Materials Collection*

Research papers ranges from the year 2014 to 2018 were included in this review. The process were as follows

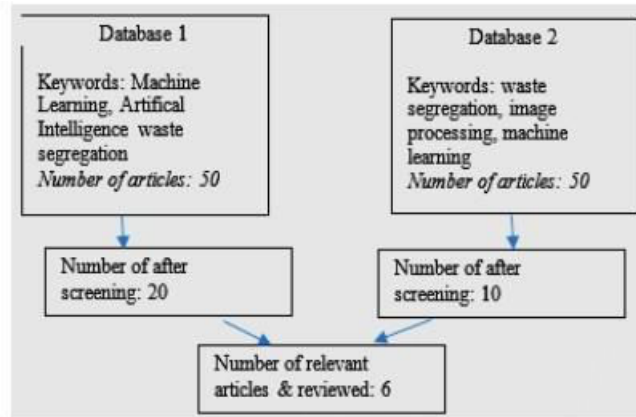


Fig. 1. Selection of Articles

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

Fig. 2. Categorization of Study

2. *System*

Not only the studies presented was considered but as well the system they have presented. The system which encompasses the technical aspects used by the research to execute and implement the studies. It shows the different systems that was made in the study, their techniques and the focus. Authors was able to indicate and the year it was published. This will help the study to indicate the proper and validate the method used by the researcher in evaluating the paper presented. Moreover, it is useful because the studies presented above are more likely related and relevant to the future work of the researcher.

3. *Image Processing*

The study of Garcia [6], which is called the Automated Waste Segregation System started with converting the image on RGB, followed by using grayscale and binarizing it. At this point, it removes the unwanted features of the image using an ordinary Webcam. They also used the Image Variant Movements in which it patterns to Hu [7] on the object representation and the application of image analysis in the irregular movement. For the purpose of classification, the method used was helpful in selecting a set of numerical attribute extracted from wastes. With the formula they used, they also concluded with the system training and waste classification in which Euclidean distance was used. K-NN Classifier was also utilized in order to classify a new item by searching for its k nearest training items.

4. *Detection of Individual Objects*

As stated in the study of Mittal [11], they have used 2 ways in perceiving an image and segregating them. One deals with the detection of individual objects in which they extract patches and combine predictions of an object. They have used patch generation, wherein images from the Garbage in Images (GINI) dataset are processed in order to generate stable size. They also Created GarbNet Model in which it permits the loads and heaviness of the images were modified by means of the pre-trained prototype. After the pre-trained model was done, they are optimizing the GarbNet Model. As they optimize the model, fewer neurons were used with a fully associated level resulting to radical change reducing of 87.9convolutional neural network (CNN) as they compute the redundant with the intersecting amenable fields. In addition, the assistance of Image Processing helps the extracted image from patches were used as a baseline.

5. *Infrared Obstacle Line Sensor*

The system features an Infrared Obstacle Line Sensor that is fitted on the dustbin. The sensor system is connected to Raspberry Pi 2 board, in which it was fitted with a Wi-Fi or GSM Module that connects to the internet. As the dustbin has filled-up, a notification was sent to the server using the Python (Django Framework) to schedule the collect predicted times this will improves the scheduling process [16]

6. *AI Sorting Techniques*

The specific area of interest in this project is machine learning in which little or no a priori knowledge is assumed available for the construction of knowledge bases. Such learning-based algorithms are more robust than their counterparts, which rely on hardwiring physical features into a control circuit. The machine learning induction algorithm is able to adapt to changing situations through integrating new conditions and findings with those it has already seen. The study conducted used a prototype system in which AIMS is the model used for the recursive splitting into the sorting mechanism. There is a conveying system that enables the container to transmit, radiate and convey. Acoustic hardware was integrated for the sensor interrogator and database assimilator to be able to define and segregate waste [19].

7. *Acquisition of the Images of Waste Materials*

This study defines the waste first. To be able to do that, the researcher used to categorize the waste into six (6) parts. After considering the waste category, the also determine the database wherein about 500 images of an item was collected [18]. The code to train the CNN trims the number of images in each category. Thus, they train the CNN that is the machine learning tool that consists of several layers in a network which was the Deep Networks (Alex). Determining the label of the new input image was conducted by AlexNet a trained CNN with 25 layers. They transfer the learning which involves the modification of a pre-trained network the accuracy rate of the network can be further increased by training a Linear SVM Classifier [5]. By training the SVM Classifier [5] using the extracted features from the re-trained network, a multiclass classifier of high accuracy can be achieved.

8. *Controlled by Arduino Uno board/Ultrasonic Sensor*

This study was made possible through the use of parts like ultrasonic sensors, inductive proximity sensor, DC motors, blower, and electromagnet are interfaced to the Arduino board [2]. There is an ultrasonic sensor that is fixed in the inlet to detect the falling of waste. The echo received from the waste is received by the microcontroller to calculate the delay [4]. This will be placed on every outlet in order to check whether the bin is filled or not. A notification is being sent to the server whenever the bins are filled through the help of GSM Module.

9. *Data Augmentation and Preprocessing*

Picture characterization research datasets are normally exceptionally huge. Regularly, arbitrary trimming of rescaled pictures alongside irregular level flipping and irregular RGB tone and brilliance shifts are utilized. Various plans exist for rescaling and trimming the photos Multi-crop assessment during test time is moreover frequently utilized, albeit computationally costlier and With restricted execution improvement. Point of the irregular rescaling and trimming is to discover the significant highlights of each article at various scales and positions. Keras doesn't carry out those information increase strategies out of the crate, however they will effectively execute through the pre-handling capacity

of the ImageDataGenerator modules. Different capacities on pictures at least expensive pace of reflection whose objective is to help the photos dataset that overcome undesired distortion or increment some picture data significant for next handling is thought as Imagepre-handling. Prehandling's important job is to initiate the least complex out- come. Under this, we can perform different activities which are as per the following: group size, rescale, marks, picture size, shear-range, zoomrange, and so forth.

10. Dataset

Dataset carries with it different classes, it's classified into differing kinds like Glass, Paper, Metal, Plastic, Cardboard. It's important to coach the model to urge best accuracy. Initially, it's labeled and sequential of images have taken place. Further, it's divided into three categories: training, testing and validation of dataset.

11. Training Data

In ML, a regular objective is to check and foster calculations that gain from past accomplishments and make different forecasts on a dataset. The model is begun from fitting of a preparation dataset that is a model acclimated fit the boundaries of the model. Preparing Set is gone through various layers of the Convolutional Neural Organization.

12. Testing Data

Test information is that the information that is used in the trial of a product. Explicitly recog- nized information is perceived as test information. Test information are regularly produced via Computerization apparatuses and that we might create test information by analyzers. Principally in relapse testing information test is utilized in light of the fact that similar information might be utilized over and over.

V. RESULTS AND DISCUSSIONS

As the related literature and studies were carefully analyzed and reviewed the following are the results of this study. It shows the different algorithms presented in the study. The researcher only choose the most commonly used algorithm in the different studies presented. As the researcher analyzed, it was discovered that among the six (6) most commonly used algorithm classification using the Convolutional Neural Network has the highest accuracy level in terms of classifying an objects. Although, all of them are classified as the machine learning algorithm there are still an algorithm that will stand out amongst them. It was noticed as well that most of the algorithm used were above 90waste are most reliable one. On the other hand, having the convolutional neural network alone as being used in one project can have the most accurate level of classifying an image. From the table as well, it can be noted that using the combined effort of an algorithm makes it an algorithm cannot perform its duty.

It shows the system reviewed and findings of the researcher. Since there are also system re- viewed included in the study, it was noted that most of them were used devices and hardware to have an even image processing and classification such as camera then process the image. The system presented used different kinds of algorithm but most of them were from the machine learning it shows the system reviewed and findings of the researcher. Since there are also system reviewed included in the study, it was noted that most of them were such as convolutional neural network that makes the classification and segregation much easier.

It was clearly noted that having used of neural networks makes it easier for a certain system to make a classification and sorting. It is notable as well that three (3) of the presented system used convolutional neural network (CNN) which makes CNN as the most algorithm being used in classifying and segregating waste. To enable a segregation, they used machines and hardware.

VI. CONCLUSION AND FUTURE SCOPE

Various steps and methods of efficient waste management and disposal have already been re- searched and carried out by many researchers and research enthusiasts. Many devices have also been designed in order to carry on this process efficiently. Hardware components such as rasp- berry pi have been used along with various algorithms to achieve the goal. Images of objects are scanned using the device in order to classify them accordingly.

But a major shortcoming of such devices is that all these devices work with maximum accu- racy only on images containing single objects to be recognized and classified. Convolution Neural Networks is considered to play a very important role in the process of object recognition and classification and can be said to be the major step towards the

development of such methods. Methods and steps that consider the shape and size of objects for their recognition and classification have also been developed, but they can be used only on objects that can be said to stay in a specific shape or size, which seems to be a bit difficult when it comes to wastes and scraps. Physical reflectance properties of various objects and also a classification of objects based on their materials have also been used earlier to propose methods to classify images accordingly. Previous researches have been more about single object recognition and classification, and moreover, different algorithms were implemented on the same datasets in order to calculate and evaluate the precision and accuracy of the algorithms used to demonstrate the importance and application of the specified algorithm with respect to the kind of datasets used.

The major drawbacks of these already existing systems are that they aim to classify an only single object in an image. In a real-world scenario, it is very difficult to separate individual objects from a garbage pile and then classify them as the amount of garbage present will be in the magnitude of millions of tons and it will be very time consuming. Hence there is a need to recognize and segregate multiple objects in a single image. Also in the current models, the number of categories in which wastes are classified is very less. Wastes are usually classified as recyclable and compost. Recyclable materials consist of paper, plastic, metal etc. and each of it is recycled separately in a different way. Hence to classify the recyclable materials from garbage and wastes into different categories would make the recycling process better and easier. From the past decade, there is a huge increase in the use of electronic gadgets, which can be attributed to the explosive growth in computer and technology. The average life of an electronic gadget like a smartphone is around 2 years. In the next few decades, the number of electronic wastes generated will increase drastically. It will be very difficult to recycle these components as each part are made of made of different materials and each of these materials has to be recycled in different ways.

Therefore an efficient method to recycle electronic gadgets and their spare parts is needed. With this, a study to conduct new wastes segregation is a must. Research opportunities can be worth considering in which the time it response in determining the waste being thrown must be quick, waste classification in bulk should also be in consideration and determining and sorting waste produce in school should be focus on. Image processing capability must be high in order to determine and segregate recyclable materials.

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