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Convolutional Neural Network for Solid Waste Segregation and Management

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Abstract

Garbage, a solid material that is dumped in billions of tons a very year. About a lakh of one metric of wastes is dumped every day in some countries like India. This is due to the increase in the productivity of goods and all object matters that concern day to day use. We, as a consumer will collect the necessary materials and throw away the wastes into open lands or in some water bodies, sometimes even on the roadsides. Since the segregation of waste materials which are useful and useless items seems to be a tedious task for humans at home. They simply throw away the waste materials into the garbage can or land areas, and in turn, all these wasteland areas are filling rapidly. This is all due to the production of materials for meeting the demands of the exponentially growing world's population. Though the production of these plastic/packing materials can be avoided to some sought of the amount. The real matter tells about the segregation and recycling of these materials. The solid waste materials which are left untreated or uncollected will definitely cause degradation to the land areas, water bodies and much more pollution to the environment. Even though we are collecting all the waste materials regularly, it is really a tuff job to segregate waste materials. With the help of manpower, we can able to segregate these materials, but how quick and efficient it can be done when comparing with the automatic detection of waste materials and segregation propose. This automatic segregation of waste will also help in reducing the cost of labor wage, in terms of business productivity. More the segregation of waste from trivial waste will helpful for the recycling process. The process of recycling can able to reduce the production of new solid substances. Overall proposed work is done successfully, for the efficient classification of solid waste matters and had achieved good accuracy.

IndexTerms *– Biodegradable, Non-Biodegradable, Internet of things, Convolutional Neural Network, Deep learning, Flap, Ultrasonic Sensor, Controller, Servo motor, Raspberry Pi*

1. INTRODUCTION

Deep Learning has its own application under the Computer Vision model. Since the growth of the computing power of the hardware components is increased and also the availability of the high-end systems, made the job easy for the applications comes under the child root of Deep Learning. Convolutional Neural Network (CNN), is the algorithm that is similar in nature to the Neural Networks. Neural Networks are capable of performing the operation which is done by the biological neurons. CNN, in the same way, will have basically three layers namely, input layer, hidden layer, and output layer, represented by Fig. 1.

2. RELATED WORK

In the work [1], the author has classified the materials based upon their properties. He used a Bayesian framework for the classification. The classes of objects are paper, metal, Etc. They have used an augmented Latent Dirichlet Allocation [aLDA] model for each object's feature extraction. So that the model can able to differentiate the objects.

In the work [2], they have proved that the convolutional neural network has very good accuracy in pattern recognition. In early of CNN, every feature pattern is given separately to the machine to make them learn, which was a very complex task. But after the introduction of CNN, image recognition has become much easier. This is because CNN will automatically extract all

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the features present in the image. There is no need for a separate feature extraction stage. And to increase the accuracy of any CNN model, the most efficient thing is the dataset. A larger number of samples will result in the model to produce very good accuracy [3].

In the work [2], the author had used two learning algorithms for the automatic separation of waste materials. The algorithms are namely a CNN and Support Vector Machine (SVM). Each algorithm tries to classify the waste materials into three categories as plastic, paper, and metal. They had used an input image of resolution 256 X 256 colored images. Based on the accuracy produced by both the classifiers, the best one is implemented on the Raspberry Pi kit. The use of the Pi kit is used for the separation of the classified waste into the corresponding trash bin. Overall in his work, the accuracy produced by the SVM classifier is 94.8%, and accuracy for the CNN algorithm is 83%. The drawback of this work is that the model is exposed to the over fitting problem, this is because the author has used only a very small set of images for the training purpose. In the work done by [4], an Auto Trash for automatic detection of trash and separating it into two categories like recyclable and compost is done. In this, they had used the Tensor flow for the use of image classification and camera connected along with the Raspberry Pi, for the movement of the trash into the respective containers. The setup involves a rotating top fitted with the camera, once the object is placed it is detected it is moved to either one of the classes[10-15]. A smartphone-based application is proposed in the work of [5], in which the application tracks the location of the Pile of garbage, which is located in the nearby location of the user. This work uses a CNN architecture for the detection of garbage image within the image. The dataset used for training this model is a GINI (Garbage in Image) and produces an accuracy of 87%.

In the work done by [3], they had used a dataset of images which are manually collected. The number of image samples for the classes is about 400 plus. The number of classes used in this work is six like metal, glass, paper, Etc. Two algorithms are deployed for this work, SVM with the Scale Invariant Feature Transform (SIFT) and the CNN algorithm. CNN is built by using the torch 7 framework. The final result shows that SVM outperforms the CNN algorithms with an accuracy of 63%.In the work proposed by [6], automatic segregation of the waste is done, by having a stepper motor that turns the flap with the desired angle, so that the identified material is moved into the respective container. This is achieved by using the camera, which senses the type of object places under it. On successful identification of the image, the object is moved[7-9].

3. CONVOLUTIONAL NEURAL NETWORK ALGORITHM

In the early days, it has been a very tuff task for all the researches to produce better accuracy for the segregation of waste materials. This is due to the lack of superpower computing components and the availability of datasets.

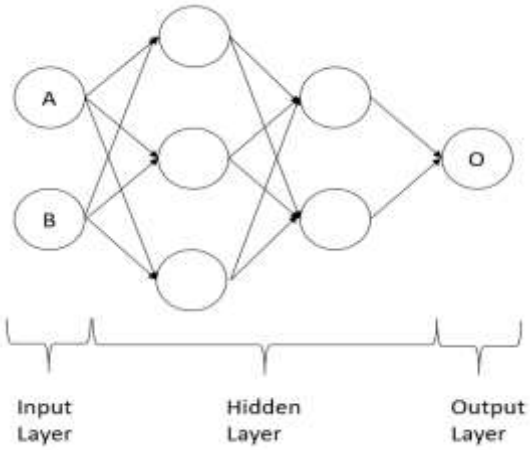

Figure 1 . CNN Layers

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There are two steps in the management of waste materials. First, we have to identify the type of waste and segregate it into the corresponding category. There are many ways for the segregation process. It can be done by passing an X-Ray over it and based upon the density of the material it can be classified and also in other ways like weighing the materials for the classification of lightweight solid objects, Etc. The identification of waste materials can be done by using machine learning algorithms and image processing techniques. Convolutional Neural Network is an algorithm, which is an efficient algorithm for the classification of images.

But in present, with the availability of all superpower computing components and dataset for the waste materials made the job easy for the researches to do their research towards the waste management task.

A. Convolutional Layer

DOT operation is performed between the input image Pixel and the given filter.

B. ReLU Activation Function

ReLU simply skips the positive values and change all the negative values which are presented in the feature map.

C. Pooling Layer

The output feature map which is produced is half the size of it when it is introduced in this.

D. Fully Connected Layer

Set of nodes, which all have edges between the set of nodes in the previous and next layer.

4. PROPOSED METHODOLOGY

A. Software Module

The proposed work was divided into two modules**,** namely Hardware and Software. The software module was implemented with the help of TensorFlow using keras, a high-level python-based code, which can be run on top of the TensorFlow. We had developed this model from scratch, thus our model has seen only the images of waste materials. The images here are cropped to a certain factor, by hiding all background details present in the images are hidden. The CNN algorithm is used for the building of the architecture.

Details and Params of our model

- Conv. Layer1 (Filter = 2, Stride=1, Kernel_Size=2)
- Conv. Layer2 (Filter = 2, Stride=1, Kernel_Size=2)
- MaxPooling (size=2)
- Dropout= 0.7
- Conv. Layer3 (Filter = 2, Stride=1, Kernel_Size=2)
- Conv. Layer4 (Filter = 2, Stride=1, Kernel_Size=2)
- MaxPooling (size=2)
- Dropout= 0.8
- Conv. Layer5 (Filter = 2, Stride=1, Kernel_Size=2)
- MaxPooling (size=2)
- Conv. Layer6 (Filter = 2, Stride=1, Kernel_Size=2)
- MaxPooling (size=2)
- Dropout= 0.4
- Dense Layer = 60 units
- Dense Layer = 30 units
- SoftMax (7)

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Dropout is used to avoid overfitting issues in the model. This is done randomly by the code, in which certain edges between the nodes in the FC layers are disconnected at every epoch/iteration. Image augmentation is done to our model, so that our model does not see the image twice. [7,8]

Fig. 4 represents the overall architecture diagram of our model (TrashSep). The input is feed to the architecture with the range of (100 x 100 x 3) and it is passed into the all respective layer cited above. Finally, the output is obtained at the out layer of the model. This model produces only two outputs and hence sigmoidal activation function is used here.

B. Hardware Module

The hardware module consists of a microcontroller, required sensors via ultra-sensor and a camera. The trash bin comes with a Raspberry Pi and a camera is attached. The Raspberry Pi controls the complete working of this work. The step by step working of this module is as follows

- The camera is triggered to capture the image only when waste falls into the bin.
- The image is sent to the classifier model
- Servo motors are controlled to sort the waste such that the waste falls into its respective side of the bin.

This module captures the image only when the presence of an object and it is done by using the ultrasonic sensor. It detects whether an object is placed on the bin or not and it sends a signal to the Raspberry Pi. The ultrasonic sensor is controlled using GPIO Pin in the Raspberry Pi.

The camera is only triggered when an object/waste Is kept in the cap of the bin. As the Raspberry Pi lacks the computational power to run a CNN model, the classifier model has been connected to the Raspberry Pi using a cloud service. Thus communication between Raspberry Pi and the classifier model occurs through Dropbox.

Thus the captured image is sent to the classifier model and based on the result, Raspberry Pi controls the servo motors connected with the flaps, using GPIO Pin [9]. All the working history of the system is stored in the database separately for future use. The main components of the segregator/smart Bin mechanism are Fig. 3 shows the smart bin has the main flap attached with servo motors that turn the flap into two directions.

Figure . 2. Overall model view of our model

An ultrasonic sensor is placed in a system such a way it can detect a presence of object accurately. A camera comes attached with a bin thus it captures the image of the work when triggered by the output of the ultrasonic sensor. The system is power by a solar panel and has a battery backup that can last for more hours.

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Fig. 2 shows the separation bin connected with the software module. It consists of two separations namely, Bio and Non-Bio as seen in the front view of the trash bin.

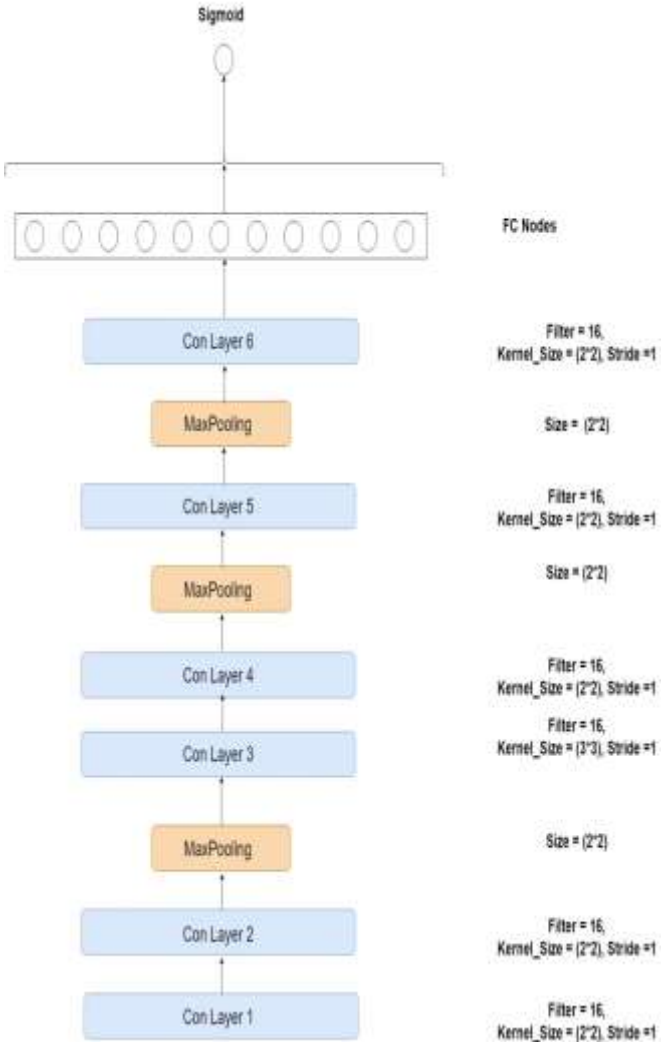

Figure . 4. The architecture of our model

Figure . 3. Top view of our trash bin

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5. EXPERIMENTS AND EVALUATIONS

A. Dataset

The data for our work is collected from Kaggle (An open-source dataset – Trashnet Image). The secondary method is done manually; in which we had added some images which are not part of the dataset classes. Based on the type of the trash we had grouped the set of images into Biodegradable and Non-Biodegradable. The set of images present inside the classes like cardboard, paper, leather, and rubber is considered to be a bio-degradable item. The other set of images belonging to the classes like E-waste, glass, metal, and plastic is considered non-biodegradable. Fig. 5 and Fig. 6 represent the images present in our dataset (I-Paper, II – Cardboard, I – Bottle, II – Metal, III – Plastic), respectively. Table I shows the list of classes present in the dataset.

Figure . 5. Biodegradable images

Figure. 6. Non-Biodegradable images

Table 1 : NUMBER OF CLASSES USED IN OUR MODEL

Class No.	Class Name
[0]	Cardboard
[1]	E-Waste
[2]	Glass
[3]	Leather
[4]	Metals
[5]	Paper
[6]	Plastic

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B. Evaluation metrics

The evaluation we used in our work is the confusion matrix. Depending upon the images used for testing, this metric will help to differentiate them into four categories as follows Positive - Positive, Negative - Negative, Positive -Negative, Negative - Positive.

Samples (3000)	**Correct No**	**Correct Yes**	**Value**
No Predicted	1258	194	0.8663
Yes Predicted	124	1424	0.9198
Value	0.9102	0.8800	0.8940

Figure . 7. Overall Confusion Matrix for all Ten (10) Class

6. RESULTS AND DISCUSSION

Thus our model has trained and tested under the dataset of seven classes, in which the classes belong to two categories. The first category consists of classes like paper, cardboard, leather and the second category consist of classes like metal, plastic, Etc. Finally, with the detection of objects by the camera the flap attached to the kit is turned with respect to the bio or non- bio side present in the trash bin.

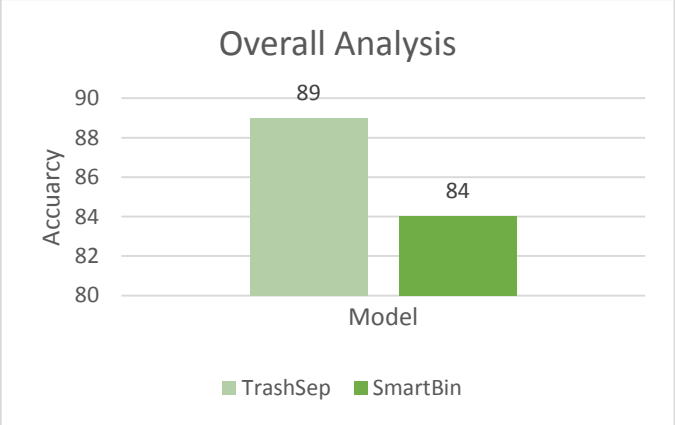

Figure . 8 Comparison of SmartBin and our Model

Fig.8 shows the comparison of the SmartBin model [6] and the TrashSep model. Fig.7 displays the confusion matrix for our work which has an accuracy of 89%.

7. CONCLUSION

In this proposed work, we had acquired an accuracy of about 89%, but this accuracy can be increased by making some changes to the architecture with respect to the more number of samples for the dataset so that we can train our model with many more images. Thus training our model with a large amount of dataset, will result in a high prediction percentage. In our future work, we will add some amount of images to the classes as well as adding some new classes which are not present in the dataset. IoT model can also be modified for supporting many arms (Flaps) for the segregation of trashes into the respective classes.

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References

[1] C. Liu, L. Sharan, E. H. Adelson, and R. Rosenholtz, "Exploring features in a bayesian framework for material recognition," in Computer Vision and Pattern Recognition (CVPR), 2010 IEEE Conference on. IEEE, 2010, pp. 239–246.

[2] Comparing Deep Learning And Support Vector Machines for Autonomous Waste Sorting by George E. Sakr, Maria Mokbel, Ahmad Darwich, Mia Nasr Khneisser, Ali Hadi – 2016 IEEE International Multidisciplinary Conference on Engineering Technology (IMCET).

[3] Gary Thung and Mindy Yang, "Classification of Trash for Recyclability Status," CS 229, Stanford University, 2016. Available: https://github.com/garythung/trashnet.

[4] J. Donovan, "Auto-trash sorts garbage automatically at the TechCrunch Disrupt hackathon." Available: https://techcrunch.com/2016/09/13/auto-trash-sortsgarbage-automatically-at-the-techcrunch-disrupt-hackathon/

[5] G. Mittal, K. B. Yagnik, M. Garg, and N. C. Krishnan, "Spotgarbage: Smartphone app to detect garbage using deep learning," in Proceedings of the ACM International Joint Conference on Pervasive and Ubiquitous Computing, pp. 940–945. (2016), Available: http://doi.acm.org/10.1145/2971648.2971731.

[6] Sachin Hulyalkar, Rajas Deshpande, Karan Makode, Siddhant Kajale, Implementation of SmartBin Using Convolutional Neural Networks, International Research Journal of Engineering and Technology (IRJET), Volume: 05 Issue: 04 | Apr-2018.

[7] Alex Krizhevsky, Ilya Sutskever, and Geoffrey E. Hinton, ImageNet Classification with Deep Convolutional Neural Networks, Communication of ACM, 60 (6), 84-90 (2012), doi:10.1145/3065386.

[8] Francois Chollet, "Building powerful image classification models using very little data", Available: https://blog.keras.io/building-powerful-image-classification-models-using-very-little-data.html.

[9] Huafeng Shi, Saurabh Bondarde and Vishakh B V, "AutoRecycle", Columbia University, 2016. Available:http://icsl.ee.columbia.edu/iot-class/2016fall/group8/#results.

[10] N.Deepa, P.Pandiaraja, "Hybrid context aware recommendation system for e-health care by Merkle Hash tree from cloud using evolutionary algorithm", Journal of soft Computing springer ,Vol 24,Issue 10,pp 7149-7161.

[11] K Sumathi, P Pandiaraja,"Dynamic alternate buffer switching and congestion control in wireless multimedia sensor networks",Journal of Peer-to-Peer Networking and Applications,Springer US,PP 1-10.

[12] P.RajeshKanna, P.Pandiaraja "An Efficient Sentiment Analysis Approach for Product Review using Turney Algorithm", Journal of Procedia Computer Science Elsevier ,Volume 165 ,Issue 2019 ,PP 356-362.

[13] P. Santhi, S.Thilagamani," A Survey on Audit Free Cloud Storage via Deniable Attribute Based Encryption", IRA-International Journal of Technology &Engineering,Vol.5,No.1,PP.1-5,2016.

[14] P.Pandiaraja,P.Viajayakumar,V.Vijayakumar,R.Seshadhri,"Computation efficiency Attribute based broadcast group key management for secure document access in public cloud" ,Journal of information Science a Engineering,Vol.33,No3,PP 695-712.

[15] P.Pandiaraj, P.Vijayakumar, "Efficient Multikeyword search over Encrypted data in untrusted cloud environment",Second International conference on Recent trends and challenges in Computational Model -ICRTCCM -17,PP 251-25