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Trash Classification: Classifying garbage using Deep Learning

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Abstract—Officials in developing countries like India usually acknowledge the need for better management. However, little efforts are done to improve the situation, and changes take a long period of time. As we know, India's population is equivalent to 17.7% of the total population. With the rise of development of smart cities across India, a Smart Garbage Management system is very necessary. Since the amount of waste is multiplying day by day. It is essential to bring the best approach to manage this problem because the generated waste exceeds 2 billion tones. The existing gms in India practices collection of domestic and industrial waste and dumping into big dumping yards. Solid waste separation is done by laborers which is not so systematic, consumes a lot of time and it is not even completely feasible due to large amounts of garbage. The purpose of this research is to build a real time application which recognizes the type of waste and categorize it into defined categories. By implementing this Trashnet classification system, we want to reduce the physical efforts and effectively segregate the waste into different categories. The model used for this study is Convolution Neural Network (CNN), a Machine Learning algorithm which is used on a dataset containing images of garbage. This system ensures a best way for waste management and will also speed up the segregation process with higher accuracy. This study lasts with remarkable results and is successful to classify various images of waste in correct classes.

Keywords—Deep Learning, Convolution neural network, Trash net, Classification

1. INTRODUCTION

The increasing urbanization of India poses so many threats as with increase in population land consumption increases, utilities increases, consumption of food increases, use of resources increases and more than these the quantity of waste

generated by 1.37 billion people increases. Waste management system is a large challenge for urban areas among most parts of countries all over the world. A huge quantity of garbage is increased each and every day in India. It is sad to know that 5% of this huge amount of garbage is recycled. The only solution to this problem is to identify and classify the garbage at the initial stage by itself. The proper separation process of waste is managed so as to get less amount of risks on our health and ecosystem. Presently there is no best and profitable system for classification of wastes. Our point is to reduce the physical efforts and effectively segregate the waste. Our goal is to achieve an increase in efficiency of garbage processing solution and to classify non-recyclable garbage because it is very difficult to get a waste separation process which classifies garbage with 100% accuracy and 0% loss. We need to get proposed methods which not only provide environmental benefits but also benefit for saving manpower and time.

2. PROBLEM STATEMENT

World bank's calculation that India's waste will reach 3.77 lakh tons by 2025, which makes waste management one of the vital issues in our country. It has been predicted that since the growth of population reaches 9.6 billion people by 2050. It is very difficult to deal with the lot of waste. To further add to this problem, the world sees India, a country which generates 1.43 lakh tones of solid waste per day. This review gives out various problems related to Waste management in smart and automated cities, where the waste collection system is not developed[16]. Presently in India, there is no automatic waste segregation system at domestic level and so the need of the hour is developing a tamper, cheap cost, eco-friendly and feasible classification model for urban households[2]

3. RELATED WORK

Over the most recent couple of decades, specialists and researchers have been dealing with precisely grouping the pictures into their separate classes. By custom, because of the need for computational force and restricted picture datasets, picture arrangement was difficult. However, today, because of regularly expanding handling intensity of the GPUs and the accessibility of enormous datasets, it has become attainable to utilize PC vision procedures effectively. In the field of grouping of pictures, notable and profoundly skilled CNN design is Alex Net [1], and ImageNet Large Scale Visual Recognition Challenge (ILSVRC) was won by it in 2012. The engineering is nearly straightforward and not very profound, and is, obviously, known to perform well. Alex Net was compelling on the grounds that it began a pattern of CNN approaches being exceptionally famous in the ImageNet go up against and turning into the best in class in picture arrangement.

The isolation of waste incorporates two fundamental advances – ID and partition. The standard waste isolation procedures incorporate weight based isolation, Trommel separators which relies upon the molecule size, Eddy current separators which is utilized for metal isolation, X-Ray innovation can be utilized to separate waste material dependent on their densities. Recognizable proof of the waste is a significant advance before detachment and it very well may be done effectively with the assistance of various AI and picture preparing calculations. Convolutional neural systems (CNNs) are most picked for grouping of pictures. The CNNs permits to remove interesting characteristics from the picture and afterward order it into foreordained classes. Some of the researches that have been done and related to our review are listed below:-

In paper[1], The tests were carried out on proven CNN models in this study. The results obtained from this research, Adam received better accuracies in the test than Adadelata. In addition , the data augmentation procedure was implemented to improve classification accuracy due to small Trashnet dataset samples. The best results were obtained from DenseNet121 with 95% fine-tuning. The success rate of InceptionResNetV2 model was 94% for test accuracy using fine-tuning. It was found that deep learning models were incorporated in the classification of recyclable waste. They have carried out some experiments on known deep

learning models for this purpose; the performance rate in real-time systems was poor because of the lack of sufficient data and the images having white color background.

In paper[2], This paper makes use of Faster R-CNN to get proposals for regions and identify objects. Some of the areas where they were lacking where training of the model was not done from scratch and instead of that use of the pre-trained model was done. They have only used ZF Net that has 5 convolutional layers and 3 fully-connected layers because of which the architecture was not good. Test was done on the given dataset but on the real Images.

In paper[3] , This narrative literature review evaluated global issues due to different fractions of waste showing how several pollution sources affect the environment, population health and sustainable development. The findings and case studies presented that serve as a guide for scholars and stakeholders to measure comprehensive impacts and to plan integrated solid waste collection and treatment systems to enhance global sustainability.

In paper[4], The proposed framework has been determined for successful programmed isolation of waste at the source itself, along these lines diminishing the physical endeavors. The framework depends on ideas of Machine Learning, Image preparation. The goal of this undertaking is to catch pictures of a solitary waste material and successfully recognize and isolate it into four classes viz. Metal, glass, paper and plastic. The model utilized for this task is Convolutional Neural Network (CNN), a Machine Learning calculation. This framework will guarantee compelling robotized squander the board and will accelerate the procedure of isolation with no human intervention[7].

A novel application was proposed in this paper[5] for measuring the cleanliness of a place, with the use of a deep learning framework. The application helps in localizing and classifying waste from three meters of height in RGB images taken by a camera facing ground. Due to the unavailability of a waste dataset they used their proposed acquisition to get photos. We have also developed an annotation method to mark items for 25 different forms of waste in our dataset.. In order to increase the accuracy of the existing system we can attach more images other than the butt of cigarette leaflet to their dataset.

In this paper[6], the specialists took the pictures of a solitary bit of reusing or trash and grouped it into six classes consisting of glass, paper, metal, plastic, cardboard, and rubbish. The models which are utilized help vector machines (SVM) with scale-invariant element change (SIFT) highlights and a convolutional neural system (CNN). Their tests indicated that the SVM performed better than the CNN; be that as it may, the CNN was not prepared to its full capacity because of difficulty finding ideal hyper parameters. So one has to continue working on the CNN to figure out why it did not train well and to train it to achieve a good accuracy. It is expected that it should have performed significantly better than the SVM classifier.

This Paper[7]. AI. Convolutional neural systems have greatly affected example acknowledgment. Sooner than the presentation of CNNs, highlights were physically picked and structured and afterward followed by a classifier. The CNN has given an additional preferred position which permits it to consequently take in the highlights from the preparation information. The engineering of CNN makes it particularly strong for picture acknowledgment. The investigation recommends that enormous marked informational indexes have opened up for preparing and approval. In addition, CNN learning calculations have been actualized on the enormously equal designs preparing units (GPUs) which quicken learning and derivation and hence it gets great for picture acknowledgment [6].

This Paper[8] recommends that CNNs can be creatively utilized for order of waste substances. The review additionally expresses that on tuning hyper parameters suitably, the exactness of the CNNs can be expanded essentially. In addition, the dataset likewise assumes a basic job for deciding the exactness of the model. Hence, the exactness can be expanded considerably by addition of new pictures in current datasets [7].

This Paper[9], proposes a Multilayer Hybrid profound learning System to naturally sort squander which is arranged by a people in the urban open region. CNN-based calculation is utilized by Multilayer Hybrid System to take out the picture highlights and a multilayer perceptron (MLP) strategy to join pictures and other element data to group squanders as recyclable. This examination breaks down an aggregate of 50 diverse waste things that are normally found in the

researched territory. Among which, 40 are recyclable and 10 are the others[12]. The MHS is skilled and approved against the physically marked things, accomplishing in general order exactness higher than 90% under two divergent testing situations, which broadly beats a circumstance CNN-put together technique depending with respect to picture just data sources. The proposed MHS is both financially and earthly.

This Paper[10], is planned to expand a profound learning application which recognizes kinds of trash into refuse so as to offer recyclability with a vision framework. Preparing and testing will be performed with picture information comprising various classes on divergent trash types. The informational collection utilized during preparing and testing will be created from one of a kind casings taken from trash pictures. Additionally,

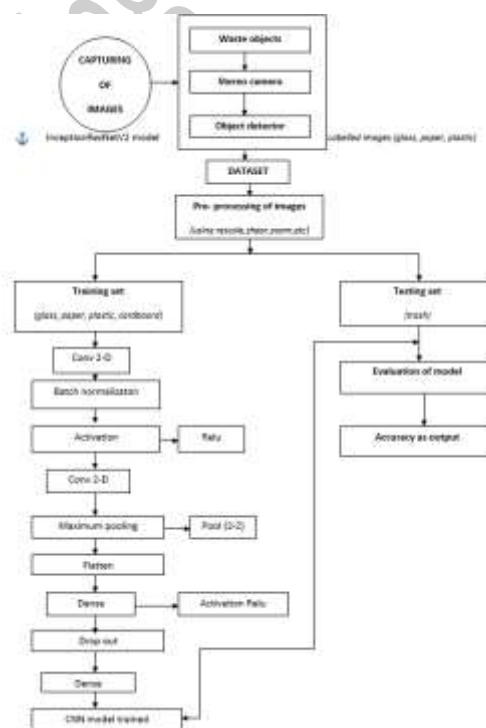


Fig.1 System Design for Trashnet

move learning was utilized to get shorter preparing and test measures with higher precision. As adjusted models, Alexnet, VGG16, Googlenet and Resnet structures were yielded In request to execution trial of classifiers, two unique classifiers are utilized as Softmax and Support Vector Machines. 6 distinctive kinds of waste pictures

were accurately arranged with the most elevated precision with GoogleNet+SVM as 97.86%[9].

This Paper[11], This paper proposes an answer that can recognize and characterize the waste and sort it into the specific waste receptacle (recyclable, natural and destructive squanders) with no human hand. The framework utilizes profound learning calculations to recognize and arrange the losses into specific classification; the ordered reused and natural squanders can be utilized for future better purposes. This procedure will help the earth in making progressively significant and environmentally protected and help us to make a rich green biological system and a promising better future[10].

4. PROPOSED METHOD

The garbage collection in India still depends on unorganized collection of waste. The segregation process is still handled by mankind which has many health issues, time consuming, costly and less effective. In the existing system, all the garbage collected from households and industries was dumped on the outskirts of towns and cities. Due to uncontrolled dumping of waste, it gave rise to the problems like overflowing landfills but also contributed a huge amount in terms of ground waste pollution and Global warming [11].

A new concept uses deep learning algorithms to segregate the waste at initial level thus making waste management more powerful. The designed method sorts the waste into different categories with higher accuracy. This study reviews the best and effective approach to segregate the garbage into different types.

The proposed method mainly focuses on identification and segregation of waste by using deep learning algorithms like convolution neural networks(CNN). Usually, all the toxic wastes are dumped with recyclable waste which causes huge damage to land. This project proposes an idea where to segregate the toxic waste with higher accuracy.

This method work in different phrases which are as follows:

1. Capturing of images
2. Collection of datasets
3. Pre- processing of images
4. Training data
5. Testing data
6. Evaluation of model

3.1 PHRASES OF SYSTEM DESIGN

The phrases of system design are as follows:

a) Capturing of images:

- *Waste objects :-* In this step, we are considering different local areas or bins for collection of waste images.
- *Stereo camera :-* Stereo camera provides a Large-scale High-resolution Outdoor Stereo Dataset. So, In order to get clean and proper images for the dataset. We used a stereo camera to capture images of different types of wastes.
- *Object Detector :-* Object detector is a technology which relates to computer types of application and image processing that detects and defines various objects such as humans, buildings and cars from images. The technology has power to identify once or various types of objects within a d image at one. So, we used this technology to classify images into different categories like glass, paper, plastic, metal, cardboard.

b) Collection of Dataset:-

After capturing images, it is classified into different types such as glass, paper, plastic, metal, cardboard. It is important to train the model to get best accuracy. Initially, it is labeled and sequential of images have taken place. Further, it is divided into two categories: training and testing dataset.

c) Pre – processing of images :-

Various functions on images at cheapest rate of abstraction whose goal is to improve the images dataset that conquer undesired deformation or increase some image information important for next processing is known as Imagepre-processing. Pre-processing plays an essential role to get the best result. Under this, we can perform various operations which are as follows: batch-size, rescale, labels, image-size, shear-range, zoom-range, etc.

d) Training Data :-

In machine learning, a common goal is to study and develop algorithms that learn from previous achievements and make various predictions on a dataset. The model is started from

fitting of a training dataset that is an example used to fit the parameters of the model.

Training Set is passed through different layers of the Convolutional Neural Network. Workings of following layers are as follows:

- Layer 1 called as Conv2d layer convolves the images using 32 filters each size of 3*3.
- Layer 2 again Conv2D layer also used as convolve the images and using 64 filters each size of 3*3.
- Layer 3 is MaxPooling2D layer picks the max value in a matrix of size of 3*3.
- Layer 4 is Dropout at a rate of 0.5.
- Layer 5 is flattening the output from layer 4 and this flatten passed to layer6.
- Layer 6 is a hidden layer of the network containing 250 neurons.
- Layer 7 is an output layer consisting of 10 neurons of 10 types of output using soft max function.

e) Testing Data :-

Test data is the data that is used in the test of a software system. Specifically identified data is known as test data. Test data can be generated by automation tools and we can also generate test data by testers. Mainly in regression testing data test is used as the same data can be used again and again.

f) Evaluation of Model :-

The evaluation of a model is an integral part of any model development process. It helps us to find the best suitable model to represent our data and

get the best chosen model for future work. There are two ways in data science to check the performance of a model: cross-validation and hold-out. It is necessary to avoid overfitting so we use a test set to evaluate the performance of the model.

4. IMPLEMENTATION

The implementation of this project starts with recognition of an image and then classifying that image.

4.1 Convolution Neural Network

CNN is a type of Deep Learning algorithm which accepts input in the form of images, and it will assign importance to various aspects in the dataset and be able to metamorphose one from another. The comparison to various classification algorithms for pre-processing required in CNN is much less. In primitive methods with limited training, ConvNets have the ability to learn these training methods. The system designed by ConvNet is defined as a corresponding connection pattern of Neurons in the Human Brain and inspired by the organization of the Visual Cortex. A collection of such fields is used to overlap to cover the entire visual area.

4.2 Dataset Used

A good dataset provides a model to train in an efficient way. In this project, we used a different dataset to train our model with configuration. Datasets used in this study are mentioned in Table 1 :

Table I Description of various datasets used

Dataset	Resolution of image	Size of train data	Size of test data	No. of classes	Name of classes
1.Garythung Yang	512 *384	2390	137	5	Glass, paper, plastic, cardboard, metal
2.Waste classifier master	64*64	940	459	2	Cardboard and metal
3.Trash net	60*30	22564	2481	2	Organic and recyclable
4.Real images	512*384	940	11	2	Cardboard and metal

In the below graphs, we are trying to show the training accuracy against validation accuracy. As shown in graph, corresponding decrease of losses in training and validation dataset with the increase in accuracies.

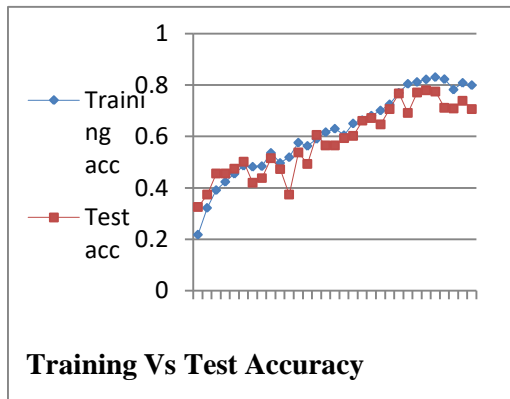


Fig. 2 A graph which shows variation between Training acc and test acc of dataset 1

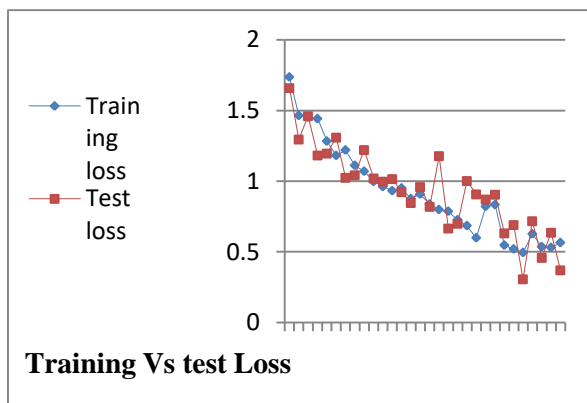


Fig. 3 A graph which shows variation between Training and test loss of dataset 1

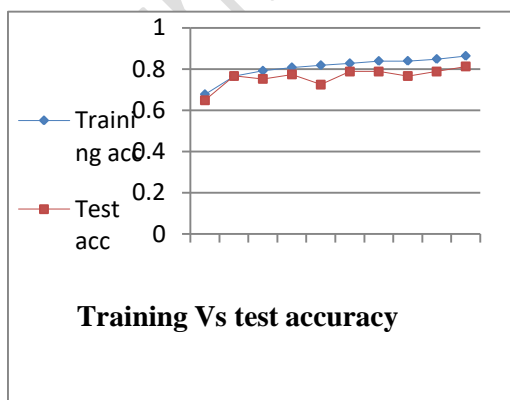


Fig. 4 A graph which shows variation between Training acc and test acc of dataset 2

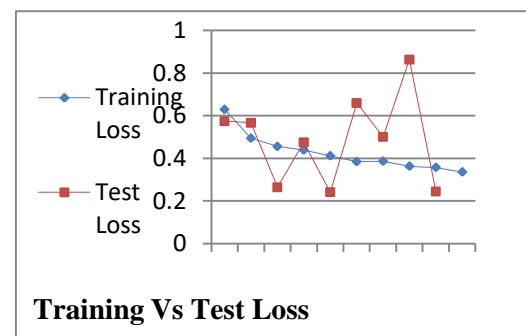


Fig. 5 A graph which shows variation between Training and test loss of dataset 2

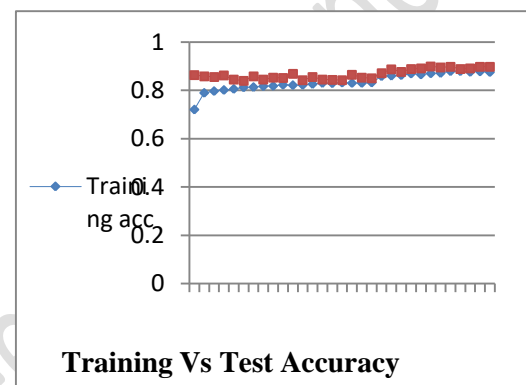


Fig. 6 A graph which shows variation between Training acc and test acc of dataset 3

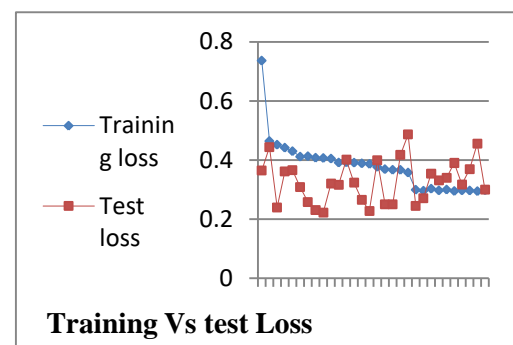


Fig. 7 A graph which shows variation between Training and test loss of dataset 3

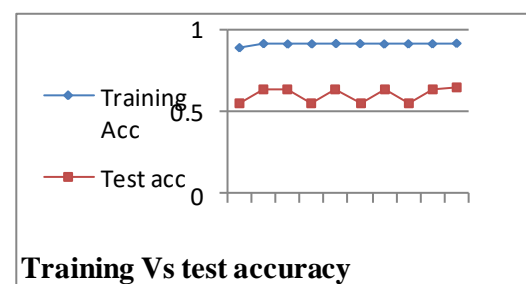


Fig. 8 A graph which shows variation between Training acc and test acc of dataset 4

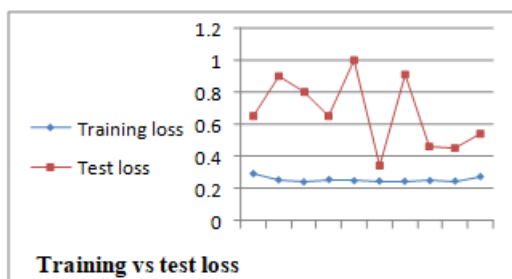


Fig. 9 A graph which shows variation between Training acc and test loss of dataset 4

5. RESULT

We have resized the pictures size to decrease complexity, reducing the size of the batch to more appropriate for dataset size. After applying the deep learning technique CNN to classify the wastes in different categories. The proposed method is trained and validated against the labeled pictures to achieve classification accuracy under testing scenarios, which performs a CNN-based model relying on image inputs. In this project, the implementation part is done by using tensorflow which is a deep learning software. Here, we used three dataset which gives following accuracy:

Table II Result accuracy

DATASET	TRAIN ACCURACY (%)	TEST ACCURACY (%)
Dataset 1	80	78
Dataset 2	90	84
Dataset 3	87	89
Dataset 4	91	81

6. FUTURE SCOPE

- This project indeed has a very vast scope not only in India but Globally too because the project is very effective in segregating the waste this segregation will finally lead to protecting our environment and people's health which is major problem in today's world
- Project can be further improved in many ways
 - A: It is obvious that after a certain period of time the bin will get full. Using modules such as wifi and proximity

sensors etc. the data that bin is filled completely can be sent to the concerned authority who can then be alerted to see and empty the bin.

B: Work can also be extended in introducing a robot in the bin which automatically dumps the bin when it finds it to be full.

7. CONCLUSION

The proposed thought predominantly centers on the recognizable proof and order of the waste that is very nearly dumping in squander canister. Generally, landfill is used to dump the unsegregated waste and made to rot which takes several years in the case of non-biodegradable waste and the blending of poisonous hurtful squanders will debase the land assets and water resources [14]. This task proposes a thought where the machine all alone can distinguish the loss without human intercession dependent on the arrangement of datasets, independent of its shape and size, effectively and order them [8]. Our proposed framework can learn without anyone else and hence can constantly refresh itself if there should arise an occurrence of new materials. The points of interest to the proposed framework would incorporate simple disintegration, lesser wellbeing risks and quicker procedure that requires just an underlying venture and is programmed. Tweaked CNN structures were utilized in the proposed technique.

REFERENCES

- [1.] Bogdan Alexe, Thomas Deselaers, and Vittorio Ferrari, "What is an object?", *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, 2010.
- [2.] Bogdan Alexe, Thomas Deselaers, and Vittorio Ferrari. "Measuring the objectness of image windows", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 34(11), 2189-2202, 2012.
- [3.] Sean Bell, Paul Upchurch, Noah Snavely, and Kavita Bala, "Material recognition in the wild with the materials in context database." *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, 3479-3487, 2015.

- [4.] caffe-android-lib,” at
<https://github.com/sh1r0/caffe-android-lib>.
- [5.] Design of a Convolutional Neural Network Based Smart Waste Disposal System.
- [6.] Thung, Gary and M. Yang. “Classification of Trash for Recyclability Status.” (2016).
- [7.] Gary Thung and Mindy Yang, “Classification of Trash for Recyclability Status,” CS 229, Stanford University, 2016. Available:
<https://github.com/garythung/trashnet>.
- [8.] 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.
- [9.] George E Sakr, Maria Mokbel, Ahmad Darwich, Mia Nasr Khneisser and Ali Hadi, “Comparing Deep Learning And Support Vector Machines for
Autonomous Waste Sorting” in Multidisciplinary Conference on Engineering Technology (IMCET), IEEE International, November 2 - 4, 2016.
- [10.] Rahmi Arda Aral , Şeref Recep Keskin , Mahmut Kaya , Murat Hacıömeroğlu ,”Classification of TrashNet Dataset Based on Deep Learning Models”
in Computer Engineering Gazi University Ankara, Turkey.
- [11.] Fine-Tuning Models Comparisons on Garbage Classification for Recyclability Umut Özkaya^{1*} and Levent Seyfi ² ¹Department of Electrical and
Electronics Engineering/Konya Technical University, Konya, Turkey.
- [12.] Smart Waste Management Using Deep Learning with IoT Jobin Joseph ¹ , Aswin R² , Allen James³ , Alwin Johnny⁴ and Prince V Jose⁵ ¹ St.
Joseph’s College of Engineering and Technology.
- [13.] S. Dugdhe, P. Shelar, S. Jire, and A. Apte, Efficient waste collection system, in 2016 Int. Conf. Internet Things Appl. IOTA 2016, 2016, pp.
143147. <https://doi.org/10.1109/IOTA.2016.7562711>
- [14.] J. Donovan, “Auto-trash sorts garbage automatically at the techcrunch disrupt hackathon.”
- [15.] G. Mittal, K. B. Yagnik, M. Garg, and N. C. Krishnan, “Spotgarbage: Smartphone app to detect garbage using deep learning,” in Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing, ser. UbiComp ’16. New York, NY, USA: ACM, 2016, pp. 940–
945.
- [16.] S. Zhang and E. Forssberg, “Intelligent liberation and classification of electronic scrap,” Powder technology, vol. 105, no. 1, pp. 295–301, 1999.