

Waste Sorting Mobile Application for Interactive AI Based Waste Management System

Rishabh Kansal, Lavanya Yadav, Aju D



Abstract: A lot of us are misinformed about trash and how it can be managed. We don't know what kind of trash can be repurposed or be turned into usable items such as manure. We tend to throw everything out together without segregating at the source of generation. Through our app, they can simply point towards objects and understand what to do with that trash. The goal is to sensitize people not only to segregate trash but also reduce their waste regeneration through practices like composting and reusing. We should first try to understand the plight of waste management in India and how it can be made better. In this project, we will create a mobile app, Python Server with Flask, and Watson Visual Recognition. This mobile app sends pictures of waste and garbage to be analyzed by a server app, using Watson Visual Recognition. The server application will use pictures of common trash to train Watson Visual Recognition to identify various categories of waste, e.g. recycle, compost, or landfill. The resultant smart dustbin is very effective as people have an urge of curiosity and after learning more about their waste, they always tend to make the right decisions. We aim to make a difference in the society through our app and help in making a cleaner and better tomorrow.

Keywords: Waste Management, CNN, IBM Watson, iOS Mobile Application, AI.

I. INTRODUCTION

We are hugely motivated by our prime minister's mission to create a clean and better India. Swachh Bharat mission was called up by the now prime minister Narendra Modi. It aims to keep the country clean, free from open defecation, rivers free from pollutants, clean beaches, proper garbage disposal system in every remote part of the country and much more. To achieve these goals government is providing funds under different programs. With many organizations involved in plentiful activities, a lot of difference has been seen. Central government is also awarding the rankings to the city and villages.

Manuscript received on May 25, 2020.

Revised Manuscript received on June 29, 2020.

Manuscript published on July 30, 2020.

* Correspondence Author

Rishabh Kansal, Student, Department of Computer Science and Engineering, VIT University, Vellore, Tamil Nadu, India.

Lavanya Yadav, Student, Department of Computer Science and Engineering, VIT University, Vellore, Tamil Nadu, India.

Dr Aju D, Associate Professor, Department of Computer Science and Engineering, VIT University, Vellore, Tamil Nadu, India.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an [open access](https://creativecommons.org/licenses/by-nc-nd/4.0/) article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

India has the second biggest populace among all the nations and without a doubt will produce a generous measure of waste, it creates near 62 million tons of metropolitan strong waste (blended waste containing both recyclable and non-recyclable waste) each year, with a normal yearly development pace of 4% (PIB 2016). The produced waste can be isolated into three significant classifications: Natural (a wide range of biodegradable waste), dry (or recyclable waste), and biomedical (or clean and perilous waste). Despite the fact that Squander The executives in India has taken walks throughout the years, a couple of issues should be explained.

Assortment of waste is finished by the sweepers utilized in road clearing and essential waste assortment in every city. Residential strong waste is normally tossed in the city in plastic sacks or in the area dumpster from where sweepers gather it. The waste is then shipped legitimately by tractor to the out-skirt of the urban areas. Where the waste will at that point be isolated into the accompanying classes biodegradable wet waste or inorganic dry waste. After which the various kinds of waste are dealt with and afterward discarded in the most ideal way like landfills, composting, incineration, and so on.

It has been seen that activities for assortment of waste from house-to-house and waste isolation have been embraced in just seven urban areas, which carried us to the issue of at-home waste isolation. On the off chance that the waste is isolated proficiently at home and gathered independently it won't just increment the productivity of strong waste administration yet in addition removal of waste. The Atmosphere Emergency which is one of the fundamental worries of the considerable number of nations overall is legitimately connected to squander creation and removal, which is the reason we have to address it. Isolation is the most significant advance in squander treatment. Assorted waste materials require various methods for treatment; blended waste can't be dealt with. As waste is isolated as biodegradable wet waste and inorganic dry waste, two distinct classes of waste can be dealt with in like manner. Biodegradable waste can be kept in empty land for fertilizing the soil or can be sent to dumping ground. Non-biodegradable waste can be additionally reused or can be dealt with independently. These issues we are defying today have motivated us to change our profound attached approach to manage waste collection and disengagement. The Smart-Dustbin will change the way where garbage is disposed of in each home by guaranteeing that people hurl waste into the grouping it falls under.



Waste Sorting Mobile Application for Interactive AI Based Waste Management System

A considerable number individuals in the current day age regardless of everything need more care about hurling refuse fittingly, in spite of the way that diverse concealing dustbins are kept people don't generally follow this.

Another reason behind the poor waste organization in India is the nonappearance of care. Waste generators don't understand what they can do to reduce their carbon impression.

Notwithstanding the way that preparing the dirt is a huge bit of the Swachh Bharat Abhiyan campaign, the nonappearance of data makes it incapable. The guideline change that is required is a modification in the standpoint of the people concerning waste evacuation and that will happen bit by bit, anyway this gadget will help people to do all things considered.

II. THEORETICAL BACKGROUND

A lot of us are misinformed about trash and how it can be managed. We don't know what kind of trash can be repurposed or be turned into usable items such as manure. We tend to throw everything out together without segregating at the source of generation. Through our app, they can simply point towards objects and understand what to do with that trash. The goal is to sensitize people not only to segregate trash but also reduce their waste regeneration through practices like composting and reusing. We should first try to understand the plight of waste management in India and how it can be made better.

According to a new report by ASSOCHAM-PwC [1]; The multiplication of airless open dumps of trash prompts discharges of methane, which ingests the sun's warmth, warms the air and adds to an unnatural weather change. Methane is more than multiple times more powerful as a warmth catching gas than carbon dioxide. Simultaneously, leachate, a dark fluid overflowing out from the loss as it gradually decays over a time of 25 to 30 years, debases soil and ground water, the last being utilized by numerous individuals in the urban zones as an essential hotspot for drinking. Foul scent from the waste decaying in airless stores, and smoke from the flames that routinely emit in them, are different outcomes of dumping waste in the open. The trash slopes are presently surrounding the urban communities as the urban areas extend. The city inhabitants have been going from column to post, from courts to the National Green Tribunal, in the expectation of some restorative activity. The GoI had advised the Metropolitan Strong Waste (The executives and Taking care of) Rules in 2000, in this way making it compulsory for all urban neighborhood bodies in the nation to participate in assortment, isolation, optional capacity in secured receptacles, transportation in secured vehicles, handling through treating the soil or waste-to-vitality advances and removal of rejects in designed/clean landfills. Entryway to entryway assortment inclusion is meager, best case scenario, and isolation at family unit level is an irregularity. Assortment even from network canisters isn't standard. Assortment effectiveness is low. Handling is restricted to little bit of the waste. Dumping is done in land-fills with no respect for condition and without following logical techniques for removal. Such insufficient removal practice lead to issues that will hinder human and creature wellbeing and result in financial, natural and organic misfortunes.

Ill-advised waste administration causes general wellbeing and ecological dangers like environmental change, air and water contamination, soil tainting, spreads scents and infection, and breeds vermin including flies, mosquitoes, rodents, canines and monkeys.

Vanishing of urban water bodies and wetlands in urban regions can be ascribed to unlawful dumping of Construction squander. Much of the time, land engineers purposely do this to recover eco-touchy zones for land. In Mumbai, manufacturers dump C&D squander in the beach front mangroves and springs.

There are numerous classifications of Municipal Solid Waste (MSW, for example, food squander, refuse, business squander, institutional waste, road clearing waste, modern waste, development and destruction waste, and sanitation squander. [2] After assortment of civil waste from family units, there are three different ways of removal—fertilizing the soil units, bio-methanation to deliver bio-gas, and recuperating heat vitality in the structure dry fills from flammable portions. Waste To vitality (cremation, pelletisation, biomethanation)- in 2013-14 Budget, the FM proposed to help districts for squander to-vitality extends in PPP mode, proper motivators and administrative system would be given.

Reusing of things, for example, plastic, paper, glass, elastic, ferrous and non-ferrous metals. Cloth pickers assume a key job anyway the procedure of manual reusing can't be scaled-up and simultaneously dealing with squander legitimately presents wellbeing and ecological dangers. Further, all the work is done in casual part. There is a lot of research in India over waste management and how this crucial daily life issue can be solved. One such paper "Solid Waste Management in India An Assessment of Resource Recovery and Environmental Impact" [3] by Isher Judge Ahluwalia, Utkarsh Patel extensively discusses the ecological and budgetary manageability of strong waste administration in Indian urban communities. It presents an evaluation of the quickly rising volume of city strong waste, its evolving creation, the proceeding with training of blending biodegradable (wet) squander with dry waste at the wellspring of age, and the developing volume of plastic in the waste. The current framework is centered around assortment and transportation of generally blended unsegregated waste.

This examination additionally presents the wellsprings of ozone harming substance outflows from the strong waste part. Other than introducing some alleviation decisions to react to the developing test, it likewise proposes instruments for guaranteeing that the framework is monetarily reasonable.

Another research titled "Challenges and opportunities associated with waste management in India" by Sunil Kumar, Stephen R. Smith, Geoff Fowler, Costas Velis, S. Jyoti Kumar, Shashi Arya, Rena, Rakesh Kumar and Christopher Cheeseman states [2] - India faces major environmental challenges related with waste age and insufficient waste arrangement, transport, treatment and expulsion. Current structures in India can't adjust to the volumes of waste made by a growing urban masses, and this impacts on the world and general prosperity. The challenges and deterrents are imperative, in any case so are the probabilities.

This paper explores an overall class on 'Legitimate solid waste organization for urban networks: openings in South Asian Association for Regional Cooperation (SAARC) countries' sifted through by the Council of Scientific and Industrial Research-National Environmental Engineering Research Institute and in this way the Royal Society.

The appropriate response is clear in the wake of breaking down all the examination papers.

The best system for overseeing waste needs to begin with isolation of strong waste at the wellspring of age and the treatment of various parts of the loss in properly various manners, in this way lessening the remaining waste that maybe would otherwise go to landfills. While the standards of strong waste administration are by and large better comprehended and more examined in open space, no Indian city has accomplished an all encompassing answer for the difficulties of strong waste administration. The consideration with respect to city authorities to assortment of isolated waste and its transportation, treatment/handling, reusing and safe removal is still in a beginning stage. Customer personal conduct standards in Indian urban communities have additionally not adjusted to encourage the procedure of the board of this loss by isolating natural or biodegradable waste from other waste at the wellspring of age.

III. PROJECT DESCRIPTION

The premise of the project is to create an image classification system that can analyze live images of waste material and classify them. The intention is to mount such a smart device at smart dustbins which will also behave as public sensitization dustbins. Here, people will bring their waste and learn about its properties. They will be made to understand what category of waste they are disposing. This learning about classification will not only lead to waste minimization but also increase in the waste that is re-used.

The Data Flow is as follows:

- i. User interacts with the mobile app and captures an image.
- ii. The image on the mobile phone is passed to the server application running in the cloud.
- iii. The server sends the image to Watson Visual Recognition Service for analysis and sends back the classification result to the mobile app.
- iv. Visual Recognition service classifies the image and returns the information to the server.

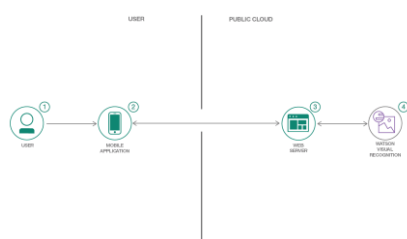


Figure 1: Data Flow of the project

- Included components

Watson Visual Recognition: Visual Recognition understands the contents of images - visual concepts tag the image, find human faces, approximate age and gender, and find similar images in a collection.

- Featured Technologies

Mobile: Systems of engagement are increasingly using mobile technology as the platform for delivery.

Flask: A micro web development framework for Python.

Our goal is simple, we want users to interact with the dustbin and learn about their waste. We want them to segregate waste and understand the importance of re-usability. This small device can be a big low cost contribution to the goal of waste reduction & becoming more eco-friendly.

IV. TECHNICAL SPECIFICATIONS

i. Convolutional Neural Network

To understand the framework, we must first understand neural networks and how they work and are implemented in the field of image classification - Modeled in accordance with the human brain, a Neural Network was built to mimic the functionality of a person's brain. The human brain may be a neural network made from multiple neurons, similarly, a man-made Neural Network (ANN) is formed from multiple perceptrons.

Though it must not be mistaken that CNN are only limited to the field of image recognition. They are widely used in many industries including the Wall Street for decision making and other data driver algorithms.

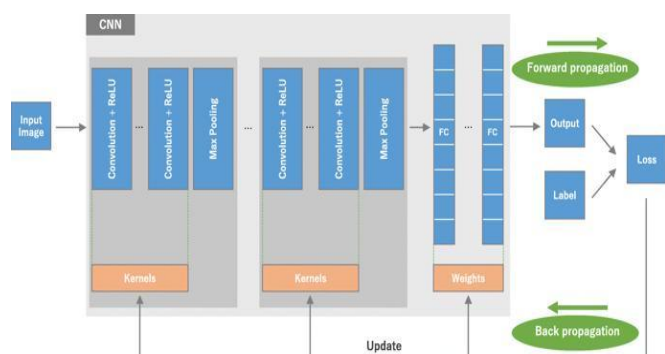


Figure 2: Overview of CNN Architecture

A run of the mill neural system has anything from a few dozen to hundreds, thousands, or maybe an enormous number of faux neurons called units organized during a progression of layers, all of which associates with the layers on either side. a number of them, referred to as information units, are intended to urge differing types of knowledge from the surface world that the system will endeavor to seek out out about, perceive, or in any case procedure.

ii. Image Recognition

Image recognition is a computer vision task that attempts to recognize and order different components of images and additionally recordings. Image recognition models are prepared to accept an image as information and yield at least one marks portraying the image. The arrangement of conceivable yield names are alluded to as target classes. Alongside an anticipated class, image recognition models may likewise yield a certainty score identified with how certain the model is that an image has a place with a class.

For example, on the off chance that you needed to construct an image recognition model that consequently decided if a canine was in a given image, the pipeline would, extensively, resemble this:

- Image recognition model prepared on images that have been marked as "dog" or "not dog"
- Model input: Image or video outline

Waste Sorting Mobile Application for Interactive AI Based Waste Management System

- Model yield: Class name (for example dog) with a certainty score that shows the probability of that image containing that class of item.

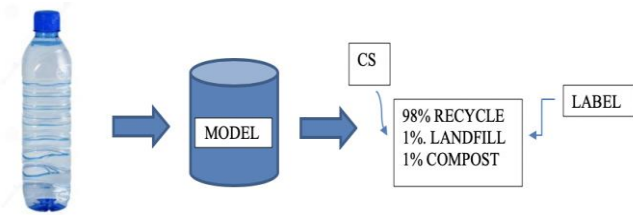


Figure 3: Representation of Image Recognition Model

Image recognition is a wide and wide-going computer vision task that is identified with the more broad issue of example recognition. All things considered, there are various key qualifications that should be made while thinking about what arrangement is best for the difficult you're confronting.

Extensively, we can break image recognition into two separate issues: single and multiclass recognition. In single class image recognition, models anticipate just one mark for every image. In case you're preparing a dog or feline recognition model, an image with a dog and a feline will in any case just be allocated a solitary mark. In situations where just two classes are included (dog; no dog), we allude to these models as twofold classifiers.

Multiclass recognition models can allocate a few marks to an image. An image with a feline and a dog can have one mark for each. Multiclass models ordinarily yield a certainty score for every conceivable class, portraying the likelihood that the image has a place with that class.

While there are various conventional factual ways to deal with image recognition (straight classifiers, Bayesian order, bolster vector machines, choice trees, and so on.), this guide will concentrate on image recognition procedures that utilize neural systems, as those have become the best in class ways to deal with image recognition.

iii. IBM Watson Visual Recognition System

The IBM Watson Visual Recognition administration is an incredible AI instrument that distinguishes picture content. The administration accompanies the accompanying pretrained models; yet can likewise be modified to perceive custom classes.

- General: A prepared model that lets you utilize a functioning and huge informational collection to pick up bits of knowledge from your own photos.
- Food: Similar to the general model, yet this model uses a particular food informational collection. You can utilize the model to discover any kind of food, and one of the primary applications is in the providing food and eatery industry, particularly on the off chance that you need to make a particular menu.
- Explicit: Allows you to investigate whether a picture contains improper substance.
- Text: Allows you to separate content from an image and have a literary metadata. This choice is as of now in private beta, however you can pursue it.
- Custom: Lets you make a custom model with your own photos and train it to show signs of improvement results.

A typical method to utilize Visual Recognition is by getting

to the Visual Recognition APIs from your application. The Watson group discharges SDKs that help many programming dialects with the goal that you can utilize Visual Recognition effectively in a web or versatile application.

Given the information being chipped away at, one of the most widely recognized methods of utilizing Watson Visual Recognition is with a portable app. The following are is the engineering for an iOS app that utilizes Core ML. On the off chance that making a non-iOS app, the reason is the equivalent, just evacuate the Core ML segment.

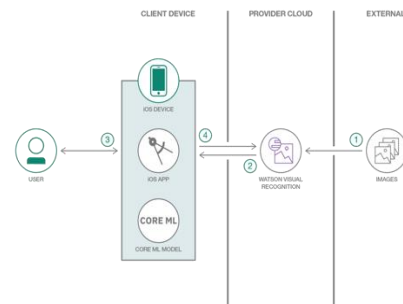


Figure 4: Working of IBM Visual Classifier in context to an iOS - Mobile application

V. DESIGN APPROACH

Our complete setup transfers the ML heavy lifting to the cloud which means that the processing cost on spot is very low. We can implement it on low cost hardware with a basic camera and install these devices on public dustbins. This would result in more efficient waste segregation at the most basic production level.

Following is how we deployed the visual recognition system Step 1: Deploy the Server Application to IBM Cloud First we need to create a root folder where we will be working from which will contain our server side code as well as classifier database

Then, we need to login to the Cloud Foundry CLI.

```
cf login -a https://api.ng.bluemix.net
```

Next, provision a Lite tier Visual Recognition Service and name it wws-visual-recognition. You can provision it using the above link or the command below.

```
cf create-service watson_vision_combined lite wws-visual-recognition
```

Step 2: Deploy the server application

Now we go to the server sub folder, push our server

application to Cloud Foundry

```
cd server
```

```
cf push
```

Once the deployment succeeds, our backend server will create the custom model and be able to classify the different kinds of waste once the model finishes training.

VI. CONSTRAINTS AND ALTERNATIVES

The largest constraint to the project is the fact that we still need to press a button to activate the visual classifier. And transmitting a live video feed to the cloud for constantly analysing every frame and determining what object is in the frame will be too heavy a task increasing both the cloud computing costs as well as the mobile data costs.



Increasing these costs would alleviate all the advantages this project brings with its simplicity and low cost nature. The only solution to this problem is the construction of either a voice activated feature or the addition of a basic foot pedal installed near the bins that the users are more comfortable to press and trigger the application.

VII. RESULTS

The output of the mobile application is as follows:

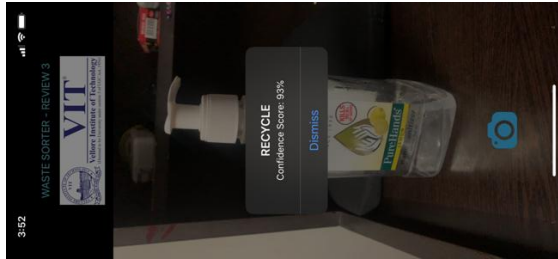


Figure 5: Plastic bottle: Output: Recycle

Plastic Bottle: CS = 9.3/10

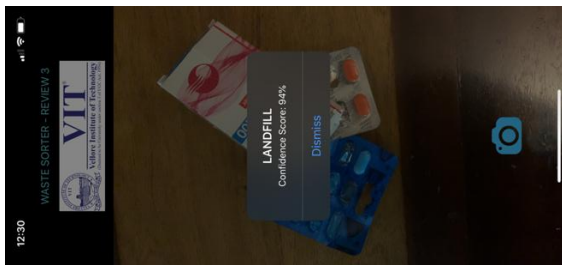


Figure 6: Medicine: Output: Landfill

Medicine waste etc.: CS = 9.4/10

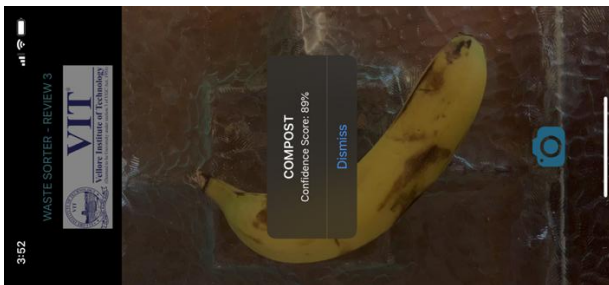


Figure 7: Banana Waste: Output: Compost

Banana Waste: CS = 8.9/10

Our initial database is user generated of about 100 images containing 100 labelled items across 3 categories. Since we are using CNN architecture the system keeps making itself smarter through re-enforced learning. So, as the system is used more and more, it will identify more objects.

We also noticed that the confidence score increased on multiple scans of the same object from different angles. We conducted. 50 tests scanning 40 different items. The following were all the confident scores that we recorded:
8.7,9.1,9.9,7.9,7.1,9.5,7.3,7.0,7.5,8.7,6.3,7.9,7.4,8.1,9.6,7.7,7.1,9.6,7.4,9.6,6.9,6.9,8.1,7.8,7.8,9.3,7.1,8.8,9.7,8.6,8.2,8.5,8.4,6.9,7.7,7.4,7.7,1.8,5.8,4.8,2.6,8.7,0.9,3.9,3.6,4.6,3.8,0.8,0.6,5 – Mean = 8.0058

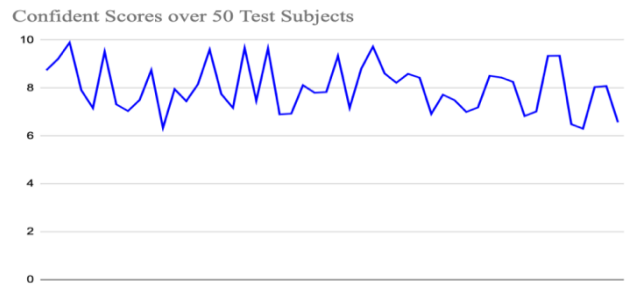


Figure 8: Line graph of confident scores over 50 test subjects

Average confident score is approx. 8.01/10 – a decent score pointing towards a successful system that would work well in the real world.

VIII. CONCLUSION

The resultant smart dustbin is very effective as people have an urge of curiosity and after learning more about their waste, they always tend to make the right decisions. Our system is based on a CNN which constantly better itself by reinforced learning. The system is also very low cost as the machine learning computation is done on the cloud (IBM Watson). This means that the cost of the actual device on-point is very low. All we need is a basic smartphone, a monthly mobile plan and the common dust-bins to complete the prototype. This small investment might seem like a simple system but actually yields very profitable results as informed people segregate the waste on their own – reducing the costs of the municipal department, saving tax money and creating a better, cleaner world.



Figure 9: Cost Analysis Diagram of Prototype

REFERENCES

1. Hazardous wastes mounting at the rate of 2-5 % per year-ASSOCHAM-PwC. (n.d.). Retrieved from <https://www.assocham.org/newsdetail.php?id=6296>
2. Kumar, S., Smith, S. R., Fowler, G., Velis, C., Kumar, J., Arya, S., ... Cheeseman, C. (n.d.). Challenges and opportunities associated with waste management in India. Retrieved from <https://royalsocietypublishing.org/doi/full/10.1098/rsos.160764>
3. Ahluwalia, I. J., & Patel, U. (n.d.). Solid Waste Management in India An Assessment of Resource Recovery and Environmental Impact. Retrieved from https://icrier.org/pdf/Working_Paper_356.pdf
4. O'Shea, Keiron & Nash, Ryan. (2015). An Introduction to Convolutional Neural Networks. ArXiv e-prints.
5. Chauhan, Rahul & Ghanshala, Kamal & Joshi, R.. (2018). Convolutional Neural Network (CNN) for Image Detection and Recognition. 278-282. 10.1109/ICSCCC.2018.8703316.

Waste Sorting Mobile Application for Interactive AI Based Waste Management System

6. Sultana, Farhana & Sufian, A. & Dutta, Paramartha. (2018). Image Classification using CNN.
7. Aivaliotis, Panagiotis & Zampetis, A. & Michalos, George & Makris, S.. (2017). A Machine Learning Approach for Visual Recognition of Complex Parts in Robotic Manipulation. *Procedia Manufacturing*. 11. 423-430. 10.1016/j.promfg.2017.07.130.
8. Amasuomo, Ebikapade & Baird, Jim. (2016). The Concept of Waste and Waste Management. *Journal of Management and Sustainability*. 6. 88. 10.5539/jms.v6n4p88

AUTHORS PROFILE



Rishabh Kansal is a final year student pursuing a B. Tech in Computer Science and Engineering from VIT University, Vellore. He is an avid programmer who specializes in iOS Development, Machine Learning and Business Analytics. He has worked for startups, been part of both technical and entrepreneurial clubs. He wants to make this world a better place through machine learning and AI.



Lavanya Yadav is a final year student pursuing a B. Tech in Computer Science and Engineering from VIT University, Vellore. She is an avid learner and researcher who is interested in Machine learning and Image processing, she has done many advanced courses for the same. She has always been interested in management and administration and was a part of few Clubs in these positions. She is currently working for a technical startup and will be pursuing a job in the Consultancy Field.



Dr Aju D received his PhD. in Computer Science and Engineering from VIT University, Vellore, India. He received his M.Tech. degree in Computer Science and IT from Manonmaniam Sundaranar University, Tirunelveli. He received his M.C.A degree from Madras University, India. Presently, he is working as Associate Professor at VIT University in the department of Computer Science and Engineering. He has published 30 research articles in different reputed international peer-reviewed journals. And, he has served as reviewer for few international peer-reviewed journals. He is having more than 15 years of teaching and research experience. Consecutively, he has received research awards from 2014 to 2019 for his outstanding contribution towards research and publication at VIT University. His research area of interest includes Digital Image Processing, Medical Imaging, Computer Graphics, Multimedia Systems and Digital Forensics.