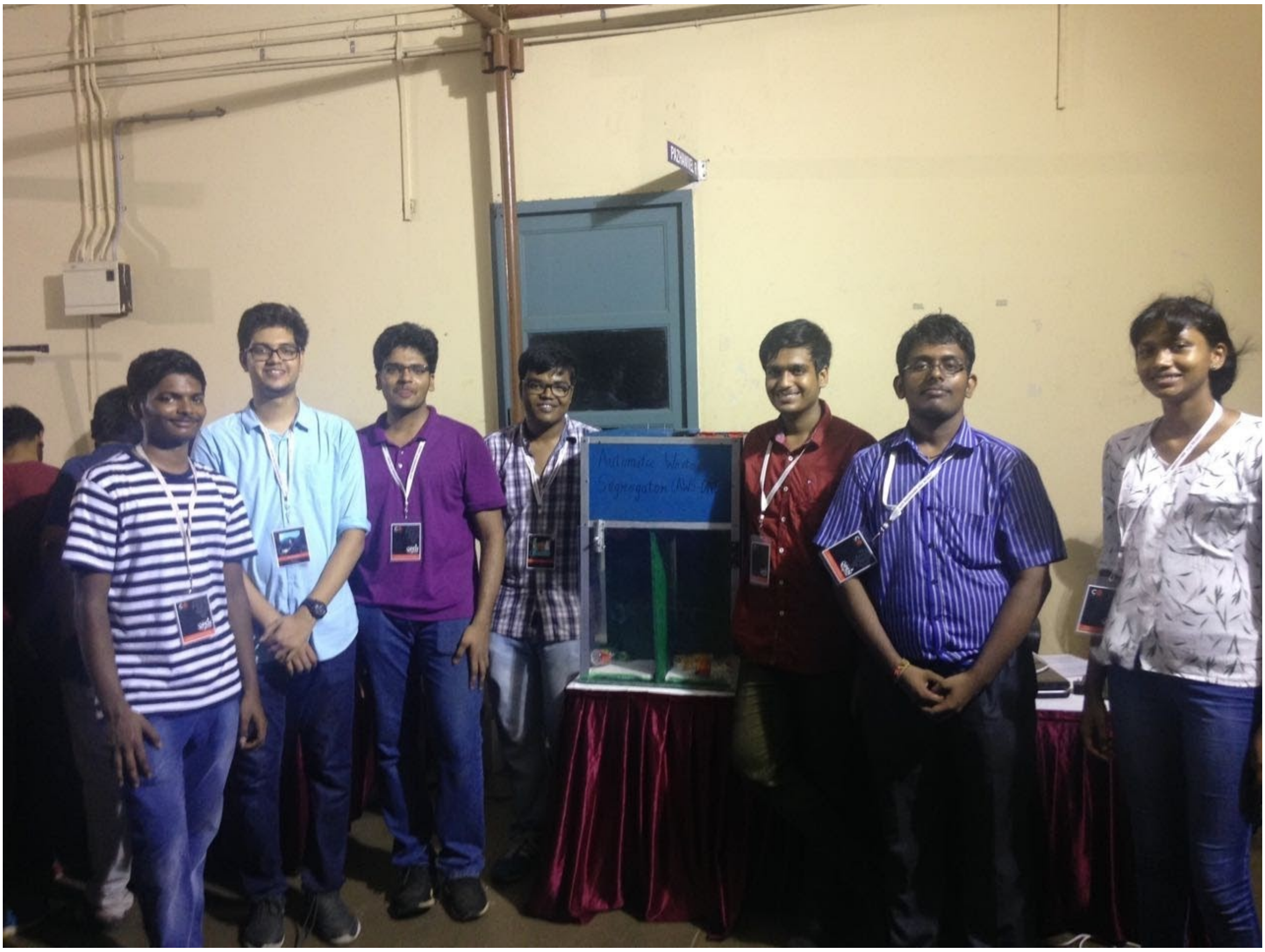
TEAM SAHAAY AND TEAM CVG

AWS-ONE

AUTOMATIC WASTE SEGREGATING BIN

Team Pictures



Team Members

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1. Abstract:

India produces an average of 0.5 kilograms of waste [1], per person, every day. With a population of over 1.2 billion, this translates to an overwhelming amount of Muncipal Solid Waste (MSW) being produced. However, there is virtually no segregation at source in India [2], hence most waste is dumped directly into landfills. This leads to huge piles of waste and poor living standards for ragpickers and those in the vicinity. It also leads to groundwater pollution, the effects of which can percolate to hundreds of kilo meters. If the issue of waste segregation in India is not solved in the near future, there will be a point after which landfills cannot accommodate anymore waste, leading to overflowing of landfills, and accumulation of waste in urban areas, which will lead to serious health and sanitary problems, making cities almost uninhabitable.

Hence, the development of technology for segregation at source is necessary. In the present study, we explore one possibility, in the form of self segregating dustbins, which uses deep learning on features based on vision,inductance and capacitance, coupled with a mechanical sorting system, to identify and classify waste into distinct categories, and segregate it at source.

In the future, we hope to expand our categories to include recyclable and non-recyclable plastic, and to meet EU segregation standards.Our current prototype has two major drawbacks, that it cannot handle more than one piece of waste thrown into it at a time, and that it has a slightly large detection time, of a few seconds. We are confident of addressing this problem suitably in future iterations.

2. Introduction

We have created a highly accurate, robust and low-cost self segregating dustbin to address the issue of waste segregation in India.

The dustbin consists of four compartments, one for each category of waste, viz. Metal, Glass, Plastic and Organic Waste. Using techniques of Computer Vision, Deep Learning and composite features of capacitance and inductance, the bin is able to categorize waste into one of these four categories. The waste is then dumped into the correct compartment using mechanical techniques.

The Automatic Waste Segregation (AWS) system is capable of self-enhancement of databases, allowing for auto-learning, which means it can adapt itself to identify new kinds of waste. It can adapt to new standards of waste management (such as the banning of sub-50 micron plastic bags in 2005), and classify new materials effectively.

The advantages of our solution are listed below:

1. **Low Cost:** A normal dustbin costs around Rs. 600. Through a minimalistic design, and by stripping our electronics to their bare essentials, this smart, self segregating bins can be mass produced at a cost of Rs. 1200. Also, if waste is segregated at the grassroots level, it leads to savings elsewhere, as large landfills and massive segregation plants which cost crores of rupees and consume a lot of energy, are not required. Thus, our innovation eliminates the need for secondary and tertiary waste segregation, often an expensive and complex process. As metal, glass, plastic and organic waste are

sorted on the spot, they can be recycled, to reduce wastage. The organic waste can be composted, to generate biofuel. Infact, a report by IIT Kanpur (2006) found the potential of recovering at least 15 per cent or 15,000 MT of waste generated every day in the country. Energy-from-waste is a crucial element of SWM because it reduces the volume of waste from disposal also helps in converting the waste into renewable energy and organic manure.

2. **Landfills:** Presently, due to the lack of grassroots segregation, all waste is dumped into landfills. This results in a terrible stench, makes the surrounding areas uninhabitable, and pollutes the groundwater, the effects of which can be felt up to hundreds of kilometers away. Hundreds of ragpickers also develop severe illness after working in landfills for extended periods of time. Thus, the strain on landfills will be reduced, by ensuring that only non-recyclable non biodegradable waste makes its way to landfills.

3. **Setting up of an integrated waste management system:** the smart bin is fully IoT enabled as a receptor and is programmable for receiving external communication over LAN, WAN and proximity protocols. This has multiple benefits. Automated notifications for waste collection, efficient waste collection routes for garbage trucks and robustness towards changing waste standards (we can monitor where and when banned material like sub 50 micron plastic is used) are a few.

4. **Biomedical Applications:** The separation of hazardous waste in hospitals is of essence. Our model can be extended to differentiate between hazardous and non-hazardous waste.

5. **Elimination of human error:** Currently, the error in human segregation is around 60%. With this prototype, we hope to bring down this percentage to around 5%, a significant increase.

6. **Encouraging increased usage of dustbins in public places:** Due to the aesthetic nature of the dustbin, human psychology suggest that more people will use dustbins (citation here). A reward system can also be setup for people who use dustbins frequently and correctly.

7. In places where grassroots segregation is not possible, **the technology we use is scalable**, that is, the deep learning methodology can be use to segment, identify and segregate waste from among large dumps.

Hence, we believe, that our innovation has the potential to transform waste management in India.

3. Research

The current solutions to tackle the issue of waste segregation, and why they fail in the Indian context are listed below:

1. Manual Segregation: Although large schemes in India are dedicated towards ensuring that people segregate their own waste by using several, separate bins, people do not tend to follow these guidelines. Thus, the issue can only be solved by technology. The employment of ragpickers to segregate waste leads to serious health issues for the them.
2. Incineration: This creates a large amount of carbon dioxide and other hazardous items, which increases global warming. Also, the presence of potentially combustible items in the waste, can lead to safety issues.
3. Large Recycling Plants: In foreign countries, large recycling plants which extend to hundreds of meters in size, are used to segregate waste. These plants cost millions of dollars. If it can be ensured that the waste is segregated at the source, then this money can be saved.
4. Previous attempts at self segregating bins: have not been largely successful primarily because most of them rely on naïve impedance measurements in a series manner, leading to pooling of misclassification. Our approach is rather new to the field, considering that Deep Learning on RISC nodal architectures took off only since 2015.

http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7899202: Used series impedance which lead propogation of misclassification, leading to high degree of error

http://www.ejournal.aessangli.in/ASEEJournals/EC286.pdf: Uses only capacitive sensors to differentiate between wet and dry waste, which results in low accuracies.

4. Task Overview

1. Electrical Module: This primarily deals with the control and sensory information of the various parts of the prototype. To enable composite feature extraction, a miniature camera, an inductive coil, and capacitive plates are used. Components include an L298N Motor Controller and a LM339 quad comparator based Schmitt trigger. The challenging aspects of power management and low capacitance measurement are suitably handled here.

2. Deep Learning and Processing Section

A RISC based low consumption micro-processor is used for both nodal linkage to the Deep Learning distribution, and electronic control, which includes generating Pulse Width Modulation signals for motor control, [3] protocol based communication with graph node (server) and deployment of Tensorflow graphs.

3. Mechanical

This module is concerned with ensuring that the waste is directed into the correct compartment. It consists of two parts, a 3-4th disc and a brush rotated by stepper motors. Once the waste falls on the disc, it rotates so that the empty portion is aligned over the correct waste compartment (category). The brush then rotates, sweeping the waste into the compartment.

4. Results

The module (Fig. 2) built was successfully able to handle organic, plastic, glass and metallic waste. Overall visual network accuracy (Fig. 1) was tested on a dataset drawn from OpenImage [5] and COCO [6] datasets, reporting an accuracy of 90.6%. The graph deployment was also visualised and tested on a 3,000 odd real dataset collected by hand, giving an accuracy of 87%.

5. Project Timeline

March 2017: Idea conceived

July 2017: Idea proposed, discussions on feasibility take place

August 2017: Report submitted. Members recruited.

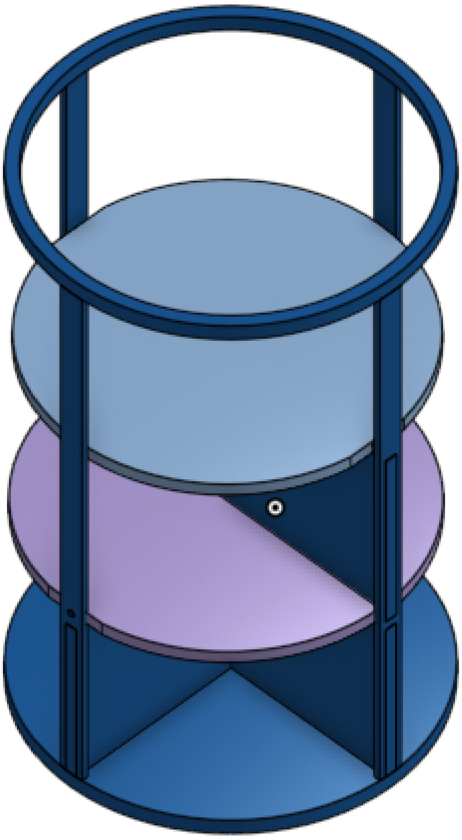
September 2017: Design completed, using OnShape. Materials bought, and prototyping begins

October 2017: Prototype completed, testing begins.

December 2017: Work on Prototype 2 begins

6. Design History and overview

Design 1:



Rejected because only 20% of the dustbin was being used for storage

Design 2:

Uses about 75% of space for storage, however cannot handle more than one piece of waste at a time

7. Marketing Opportunities

1. Can be installed in every household to promote segregation at source
2. Can be installed in public places such as eateries and parks
3. Can be used to segregate large piles of waste in conjunction with a mechanical arm
4. Possible application in hospitals for dealing with biomedical waste

Unique Features:

1. Our innovation is extremely low cost (Rs. 1200), which ensures that every citizen of India, and every public place can afford to use this dustbin, which can result in widespread usage, without incurring large costs
2. We are using techniques of Deep Learning, Computer Vision and composite features of capacitance and inductance to obtain accuracies of 95%, which is extremely high

8. Gallery: https://www.youtube.com/watch?v=UCOkQKzeg3Q

9. Acknowledgements

To Tanay Garg, Sahaay head for imploring us to take up the project, providing us with funds and for assisting us with every form of technical know-how

To Chandrahaas and Pranjal, the *stud* seniors who shared their own experiences and lessons from venturing into this challenging field

To the DoSt, for inspiring us to take up this problem

Appendix A – Budget and Cost Analysis

Mechanical

a) PP Sheets: Rs. 1500
b) Aluminium T-Slot Extrusions: Rs. 6500
c) Clamps, locks and other hardware: Rs. 410
d) Stepper Motors Rs. 1200 X 2
e) Acrylic Sheets: Rs. 2000

Electrical

a) R-Pi: Rs. 2500
b) Arduino Rs. 400
c) L298 Rs. 280
d) IC 7414 Rs. 19
e) Camera: Rs. 400
f) Jumper Wires, Breadboard

Appendix B – Bibliography

[1] Khanjan Ajaybhai Kalyani, Krishan K. Pandey, Waste to energy status in India: A short review, Renewable and Sustainable Energy Reviews, Volume 31, 2014, Pages 113-120.

[2] Kaushal, Rajendra Kumar et. al, Municipal Solid Waste Management in India-Current Statecand Future Challenges: A Review, International Journal of Engineering Science and Technology (IJEST), Volume 4.4, 2012, Pages 1473-1489.

[3] Christian Szegedy, Sergey Ioffe and Vincent Vanhoucke, Inception-v4, Inception-ResNet and the Impact of Residual Connections on Learning ,AAAI, 2017, Pages 4278-4284.

[4] Krasin, I., et al, Openimages: A public dataset for large-scale multi-label and multi-class image classification, Dataset available from https://github. com/openimages 3, 2017

[5] Lin, Tsung-Yi, et al., Microsoft Coco: Common objects in context, European conference on computer vision, Springer, Cham, 2014, Pages 740-755