Importance of Waste Segregation using Waste Segregating Robot

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***Abstract*—The generation of waste is increasing day by day with the increasing population and changing lifestyle in developing countries. Dumping of mix waste into landfills affects the environment, the living organisms, and their health. Waste segregation is the most important step in the process of disposing waste properly, can be done either manually or automatedly method. Segregating waste at dump yards manually is not only a tedious, time consuming but also risky for the health of rag pickers. Automated segregation using trending technologies prove to be simple and easy to use methods for segregating waste as its less time-consuming. The paper explains how Waste segregating robots based on Deep learning is used to segregate waste as dry waste, hazardous waste, wet waste, and plastic waste.**

***Index Terms*—Waste segregation, waste management, Source of waste, IoT, dustbins, robot, image processing, Deep learning, AI, YOLOV3, Raspberry pi, Linux, Python, Coco dataset**

I. INTRODUCTION

Any substance which is discarded, useless, defective or worthless is termed as waste. Around 62 MT of municipal solid waste is generated per-annum out of which only 43 MT of waste is collected,11.9 MT is treated and 31 MT is dumped in landfills sites. If this mixed waste is not segregated properly then it may lead to various environmental and health issues so it is necessary to segregate these waste properly either manually or by using automated devices. Sorting of mixed waste as per their common characteristics or types is known as segregation. Any biodegradable waste consisting of cooked, uncooked food, fruits, vegetable peels, flowers, and other organic decomposition material is considered as wet waste. Any non-degradable material which is not wet/soiled including both recycled as well as non-recycling materials are termed as dry waste. The dry waste consists of paper, toilet towels, plastic bottles, etc. Any reactive, corrosive objects are considered as hazardous waste, it may include medical waste, toxic substances- cleaning agents, metals- corrosive cosmetics, e-waste (electronic waste)-earphones, monitor, battery, non-working remotes, etc.

A. SOURCES OF WASTE

Source	*Typical waste generators*	*Types of solid wastes*
Residential	Single and multifamily dwellings.	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (*e.g.*, bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes.).
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants.	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes.
Commercial	Stores, hotels, restaurants, markets, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes.
Institutional	Schools, hospitals, prisons, government centers.	Same as commercial.
Construction and demolition	New construction sites, road repair, renovation sites, demolition of buildings.	Wood, steel, concrete, dirt, etc.
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants.	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas; sludge.
Process (manufacturing, etc.)	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing.	Industrial process wastes, scrap materials, off-specification products, slay, tailings.
Agriculture	Crops, orchards, vineyards, dairies, feedlots, farms.	Spoiled food wastes, agricultural wastes, hazardous wastes (*e.g.*, pesticides).

Fig. 1. Source Of Waste

B. COMPOSITION OF MSW in India

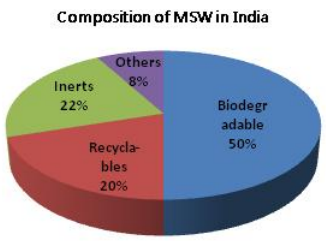

Fig. 2. Composition Of Waste

The above pie diagram interprets that the highest amount i.e 50 percent of waste generated in India is Biodegradable. Recyclable waste found is 20 percent, inert waste is 22 percent while another waste is 8 percent.

II. OBJECTIVE

This paper considers the main issue of waste management and the importance of waste segregation. Different methods for waste segregation available and stating reasons for recommending an automated device for segregating waste rather than the manual method.

Other points like sources of generation of waste, the composition of waste found are also mentioned in this paper. Various health issues, environmental issues due to improper waste segregation and issues that rag pickers face daily are discussed.

III. PROBLEMS

A. ENVIRONMENTAL ISSUES

1) Burning of garbage: Many residential areas burn garbage containing polythene bags, leaves of trees, paper, rubber to reduce the volume and uncover metals. Thus a thick smoke is created which consists of carbon monoxide, soot and nitrogen oxides which degrade air quality and affect human health.

2) Pollution:: If mix waste is left for a long time then chemical reactions take place to form hazardous gases which later leaches into the ground and contaminates ground and surface water

3) Floods:: The uncollected waste blocks the drainage system this results in floods where a huge amount of loss takes place of both life and economy.

4) Water pollution:: People often throw wet waste as well as dry waste in water bodies which contaminates the water. As a result aquatic life gets endangered.

B. HEALTH ISSUES

Flooding of water results in the breeding of mosquitoes or the contamination of water bodies and increases the water-borne diseases, malaria, dengue. Residential solid waste containing excreta and other refuse from the household can cause serious health hazards and spread infectious diseases. Untreated waste attracts flies, rats, other creatures which in turn increases health issues and creates an unhygienic environment.

As per UN-Habitat health data, children living in households where solid waste is dumped or burned in the yard faces a high rate of diarrhea and acute respiratory infections. [9].

IV. METHODS

A. MANUAL METHOD

The waste segregation method adopted at the household level is to segregate waste as wet and dry before waste getting collected by municipal waste collectors in different bins. Depending on the characteristics of different types of waste and their disposal method different colors of bins are designed to thrown waste. Dry waste often placed in blue color bin, wet waste in the green bin, biomedical waste in red bins, hazardous waste in the yellow bin. Due to insufficient awareness among citizens, it is found that this method of manually segregating waste is not working properly as mix waste is dumped in the dumping yard.

Type of waste	Colour of dustbin
Dry waste	yellow
Wet Waste	Green
Hazardous waste	blue
Plastic waste	Red

TABLE I
MAPPING OF TYPE OF WASTE WITH DISPOSAL DUSTBIN COLOUR

Rag pickers face health issues while segregating waste in dumping areas. They are exposed to various cuts, infections, respiratory diseases, tuberculosis, harassment, humiliation, sexual abuse on the streets as well and work without any job security, salary or dignity.

B. AUTOMATED METHOD

To avoid health issues while segregating waste it's better to use the automated device to segregate waste at dump yards before dumping waste into landfills. Automated devices will not only segregate waste properly but also avoid human errors in classifying waste. Automated devices like a robotic arm, IoT based smart waste segregating dustbin, waste segregating machine or robot, etc.

1) Eco- friendly IOT Based Waste Segregation and management: Waste collection and segregation at a domestic level based on their nature of composition i.e. metal, plastic and biodegradable, the waste is stored accordingly in their respective segments of the dustbin. [1]

2) An automatic classification method for environment: It is an automated recognition system using a deep learning algorithm in Artificial Intelligence to classify objects as biodegradable and non-biodegradable. The training was done using the initial data set, now the system can identify objects real-time and classify them almost accurately. It is an eco-friendly method as biodegradable waste is further utilized for power generation. [2]

3) Smart garbage segregator using image processing: While randomly moving a smart robot will sense any object, capture its image, process it, performs segmentation and separates as degradable and non-degradable waste. [4]

V. PROPOSED SYSTEM

Waste segregating robot is based on Deep learning. The proposed system is trained using YOLOV3 on the custom dataset to identify the waste. The model is trained on wet waste, dry waste, hazardous waste, and plastic waste. The proposed system will segregate waste as wet waste, dry waste, hazardous waste, and plastic waste. It applies YOLOV3 deep learning algorithm on the captured image of a waste object. The detected waste is then dumped in the yellow, red, green and blue color dustbin. Table 1 shows, the type of waste that robot dumps in a different color dustbin.

A. REQUIREMENTS

1) Software Requirements:

1) Geanny IDE
2) Python 2.7 or above

2) Hardware Requirements:

1) Raspberry pi 3B+
2) Motor MG995
3) Motor MG905
4) Pi camera

B. DESIGN

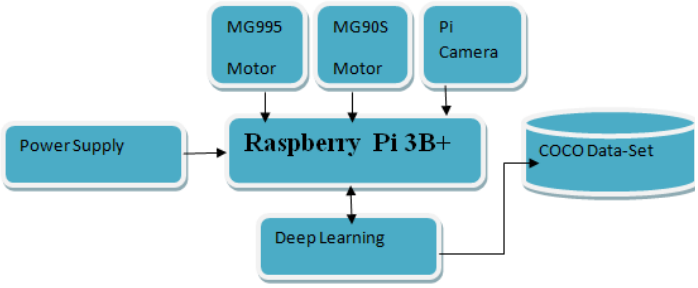

Fig. 3. Block diagram of Smart Garbage Segregating Robot

Fig 3 represents the block diagram of the waste segregating robot. The proposed model uses a pi camera to capture images, motor MG905 and MG995 are used for hand movements of the robot. Raspberry pi model 3B+ is used to provide a Linux operating system.

VI. IMPLEMENTATION

1) Pi camera captures the image of the waste object.
2) The captured image undergoes the YOLOV3 deep learning algorithm where the algorithm compares it with its CoCo dataset to identify the type of waste.
3) The identified waste gets labeled as either dry waste, wet waste, hazardous waste or plastic waste.
4) Once the waste is identified robot picks up the waste object from a heap of waste.
5) Places the object in color dustbin assigned to that particular type of waste.

VII. RESULT & DISCUSSION

Object detection performed by YOLOV3 not only identifies the waste but also displays the accuracy of that waste object. Fig 4 is the result of real-time waste detection done on sample waste objects. Fig 4 shows that the book is identified as dry waste with an accuracy of 0.939251, an apple is identified as wet waste with an accuracy of 0.958695, vase as hazardous waste with an accuracy of 0.997976 and plastic bottle as plastic waste with an accuracy of 0.999392 respectively. Fig 5 shows how the robot throws paper in the yellow dustbin, orange peels in the green dustbin, expired tablet packet in blue dustbin and plastic bottle in red dustbin respectively.

In table II the results obtained after considering 5 waste objects as test cases each of dry waste, wet waste, hazardous waste, and plastic waste. It is found that the total average accuracy obtained is 86.78%.

Fig. 4. YOLOV3 waste detection results on sample objects

Fig. 5. Result of placing waste correctly in colourful dustbin by robot

Sr.No	Object	Waste type	Count	Accuracy
1	Paper	Dry waste	10	88
2	Cardboard	Dry waste	10	86.67
3	Book	Dry waste	10	93.8
4	Clothes	Dry waste	10	86
5	Paper plates	Dry waste	10	80
6	Fruits	Wet Waste	10	87
7	Peels of fruits	Wet Waste	10	90.51
8	Packaged food	Wet Waste	10	88
9	Flowers	Wet Waste	10	86
10	Leaves	Wet Waste	10	80
11	Glass	Hazardous waste	10	85
12	Vase	Hazardous waste	10	89.81
13	Expired medicines	Hazardous waste	10	88.78
14	Sanitary pads	Hazardous waste	10	88.65
15	Diapers	Hazardous waste	10	85.21
16	Plastic threads	Plastic waste	10	80
17	Plastic bags	Plastic waste	10	90.35
18	Plastic bottles	Plastic waste	10	91.21
19	Pens	Plastic waste	10	86.21
20	Clay	Plastic waste	10	84.51
Total average accuracy obatined			86.78%	

TABLE II
TEST CASES

VIII. CONCLUSION

The automated method not only reduces the time for performing any task but also reduces human errors as compared to manual work. The waste segregating robot is a self-learning model as it identifies the new object and classifies it as wet waste, dry waste, hazardous waste, and plastic waste respectively. This is an eco-friendly method that is cheap and easy to build. This system can be used at a small scale i.e in educational institutes, hospitals, restaurants, etc as well as on large scale like in landfills. This system can be extended by defining more types of waste and training it as per them. This system will reduce the task of rag pickers and the risks associated with their health and lives. A moving robot can be implemented further who will collect waste if found on roads and will segregate it and place it in a correct dustbin. It will also inform the number of heaps of waste segregated and segregated waste containing dustbins are full.

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