

**PROVISIONAL PATENT APPLICATION OF
Jaidev Shah**

FOR

**Project LandfillRobo: Smart Recyclable Waste Management and Landfill Fire
Detection Solution**

CROSS-REFERENCES TO RELATED APPLICATIONS

Not Applicable

**STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR
DEVELOPMENT**

Not Applicable

MICROFICHE APPENDIX

Not Applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates to the field of Smart Waste Management and Landfill Management. More specifically, the invention is directed towards using robotics for efficient collection of recyclable waste and early detection of landfill fires using specific sensors.

With both housing and industrial waste production rising exponentially, underdeveloped waste management infrastructure in many countries and cities around the world is not able to effectively collect recyclable materials after being disposed inside the landfill.

This project aims to solve three major problems with the Waste Management System in such landfills around the globe.

A) Health and Occupational Hazards faced by landfill workers

Landfill workers have to face extremely dangerous and hazardous conditions inside the landfill. Landfill workers contract the following diseases from working in these hazardous conditions: Skin Diseases, Respiratory Diseases, Lung Cancer, Bladder Cancer, Malaria, Congenital deformations, Metal poisoning (Lead, Mercury, Arsenic, etc)

B) Inefficient Collection of Recyclable Materials

Recycling waste materials namely Plastics, Metals and E-Waste is one of the largest challenges faced by developing countries. Landfills can be converted to

assets for India by increased collection of recyclable materials from them, thus saving Natural Resources and Energy.

The need to increase the amount of products we recycle has never been so highlighted.

Landfill	Location	Size	TPD(Tonnes Per Day)
Deonar	Mumbai	326 Acres	9600
Pirana	Ahmedabad	40 Acres	3600
Ghazipur Yard	Delhi	70 Acres	9000
Perungudi	Chennai	228 Acres	9500

Table 1 : Case Study: Landfills of Urban India have reached their capacity for years now

C) Spontaneous Fires in Landfill

Inside the landfill, biological decomposition creates substantial heat, releases combustible gases and can cause material in the landfills to spontaneously combust. Such landfill fires lead to widespread air pollution[Smog] and health hazards for workers and residents of the city.

2. Description of the Related Art:

Although there are no such robotics solutions deployable in landfills that are aimed at autonomously collecting recyclable waste, Sweden's AASS Research Centre at Orebro University had built a robot prototype that moves itself around in its environment searching for methane leaks in the landfill. My invention focuses on a number of factors other than Methane(CO₂, H₂S, Temperature, other gases) to give a definite prediction of a landfill fire nearby.

SUMMARY

This invention aims to use multiple semiautonomous robots to identify and collect specific recyclable waste. Thus, this invention can be applied not only inside landfills but also at smaller Waste Collection Outlets inside the city, such that collection does not have to be done by humans in hazardous conditions. With supplemental charging through a Solar Power, and equipped with gas and temperature sensors along with robust detection parameters, this invention would notify concerned authorities about the landfill fire and its location, before the fire spread and caused layers of dangerously toxic smog.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG 1. LandfillRobo Prototype Perspective View
FIG 2. LandfillRobo Circuitry and Inner Components View
FIG 3. LandfillRobo Sensor Readings
FIG 4. Sensor Readings Screenshot
FIG 5. Haar Based Cascade Classifier Training Process for Image Recognition of Plastic Waste Materials (eg. Bottles)
FIG 6. Sensor Characteristics of the Gas Sensors, Used to obtain ppm readings of specific gases
FIG 7. My Calibration of the gas sensor to give ppm readings from Voltage Outputs

DETAILED DESCRIPTION

FIG. 1 shows the prototype of the invention in a completely functioning state. This prototype is wirelessly linked to a mobile application where Sensor Readings are displayed. The actual solution would have a central database where data from each robot, having an unique identification number, would be stored with exact (x,y,z) coordinates of the location in the landfill where the readings were generated. The actual invention would include low cost Location Sensors and a higher resolution camera for image recognition using Haar Based Cascade Classifiers (An OpenCV Machine Learning Approach). The Intel Galileo Microcontroller runs an image recognition program using this cascade classifier and directs the robot to move to that specific coordinate and collect the recyclable waste.

CONCEPT

i. Teams of IOT LandfillRobos [For Plastic, Metals and E-Waste]

Each category of recyclable waste (Plastics, Metals and Electronic Waste) would have a team of robots to collect the waste and store it.

Each track wheeled robot would be equipped with a scooper mechanism, enabling it to lift recyclable waste and store it in the attached bin. This waste would, at the end of the day, be collected at the recycling base, where the materials are actually recycled.

Every robot has a wireless module, enabling it to communicate via M2M technology and relay data with other members of its team. This increases productivity as it allows for the robots to maximize collection through collaboration.

Sensors on the LandfillRobo prototype transmit real time gas concentration data with coordinate to the Mobile App and the Central Computer. This helps in landfill fire prevention and early detection. Furthermore, this data can be used to identify regions generating high amounts of useful biogas from decomposing organic matter in landfills.

Metal Detectors on the Metal and E-Waste Robots enable greater efficiency for collection in highly hazardous regions.

The LandfillRobos recognize waste objects to be collected by using an image processing algorithm, which is optimized to recognize common plastics, metals and e-waste objects.

ii. The Mobile App to receive live landfill data from the sensors on the robot.

My android application performs the following functions:

It sends commands to the LandfillRobo connected to it wirelessly to reach a particular (x,y,z) coordinate[Region of high concentration recycling waste] and pick up the waste autonomously.

Whenever the CO₂ levels cross a threshold value of 75 ppm above median value and surrounding temperature jumps to 4 degrees, the Microcontroller, using data from the MQ135 and DHT 11, sends a wireless alert to the mobile app/central computer notifying of a landfill fire at an exact location inside the landfill.

iii. The Central Computer

Mapping the landfill as an (x,y,z) coordinate system, the computer receives real time coordinates of all LandfillRobos. The central computer makes sure that the same region is not revisited and that the entire landfill is covered efficiently by sending specific coordinates to individual robots. This process drastically enhances efficiency of recyclable waste collection.

Further applications of this invention and technology could be to create autonomous river robots with pH sensors, low cost dissolved oxygen sensors, mercury testing sensors for use in polluted rivers and water bodies to not only collect floating plastic waste for recycling but also give important data of water quality/contamination at different locations along the water body.

Other than fire monitoring and waste collection, future applications can include using Location Tagged Sensor Data to identify regions in the landfill producing a high amount of landfill gas as a potential energy source [Waste to Energy (WTE) Market].

HAAR BASED IMAGE RECOGNITION ON LANDFILLROBO FOR IDENTIFYING TO COLLECT RECYCLABLE MATERIALS

Haar Based Cascade Classifier Training is a machine learning based approach where a cascade function is trained from positive and negative images. It is then used to detect objects in other images. Initially, the algorithm needs a lot of positive images and negative images (images without plastic bottles) to “train” the classifier. Then Haar features are extracted from each image.

OpenCV uses machine learning algorithms to search for specific objects within a picture. There are thousands of small patterns/features that must be matched. The algorithms break the task of detecting the waste type into thousands of smaller, bite-sized tasks called classifiers.

For something like a plastic waste object like a bottle, there are about 1000 classifiers, all of which must match for it to be detected (within error limits). To boost efficiency of detection and decrease latency, this technique called Image Recognition using Haar Based Cascade Classifiers uses cascades. A cascade literally means: A series of waterfalls or stages.

Thus, the cascade breaks the process of detecting the object into multiple levels. For each level, it does a quick test. If it is successful, it does a slightly more detailed test, and so on. The algorithm may have 30-50 of these stages or cascades, and it will only detect a face if all stages pass. The efficiency advantage is that most pictures will return negative during the first couple stages, meaning the program doesn't have to spend time checking all 1000 classifiers. Hereby, realtime detection of specific recyclable waste objects is very much possible and can be implemented on LandfillRobo.

B)Materials Used in creating working model:

I would like to acknowledge the support of FABLABS-CEPT and the facilities it offered as well as my two school friends who have helped me create this working model.

- 1) Intel Galileo Gen 2 Microcontroller
- 2) Arduino Uno
- 3) Adafruit Motor Shield
- 4) MQ2, MQ135, MQ136 Gas Sensors
- 5) DHT11 Temperature and Humidity Sensor
- 6) HC05 Bluetooth Module
- 7) V Solar Panel
- 8) 2 MegaPixel USB Camera for Image Recognition

C)Sensor Description

MQ2: Methane, Butane and Isopropane

MQ135: CO₂

MQ136: H₂S and CO (Hydrogen Sulphide and Carbon Monoxide)

Note: H₂S is a gas commonly released on burning of plastic wastes and CO is produced on incomplete combustion of a number of wastes in the landfill.

The actual LandfillRobo which will be deployed in landfills would differ in size. Nevertheless, the technology and functionality behind its working and its objectives remain the same.

ABSTRACT

This invention demonstrates using technology and data analytics to make the process of collection of waste much more efficient. Deployed in a landfill, multiple LandfillRobo's could work collaboratively 20+ hours a day till returning to base for a recharge, collecting almost four times the recyclable waste collected by a human worker. Through M2M Communication between the robots and each robot periodically sharing its location with the others, the area covered in the landfill is maximized and collection would be optimized. Preventing often widespread Landfill fires, and thus combating pollution and improving the

standards of living of thousands of workers and residents living in and around the landfill, this invention has occupied a niche in the field of Smart Waste Management.