

Design and Development of Smart Reverse Vending System for Pet Bottles collections and Recycling using Design Thinking

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ABSTRACT

Nowadays with the increasing amount of waste generated and limited landfill space for waste disposal, recycling is one of the important approaches to manage the waste effectively. The current manual recycling practice in which the user need to bring the waste in bulk to the recycling center might be hassle and hence become a discouraging factor for them to recycle. To overcome such an issue, in this project an automated recycle bin with a reward feature is proposed that is derived from an IoT based vending machine concept. The system is implemented with microcontroller and collection of sensors. The reward is given to the user based on the weight of the bottle detected by the sensor. All the process will be controlled by a microcontroller. The grinded plastic scraps consume less energy, when it undergoes recycling process. Design thinking approach is applied by conducting a wide-scale survey among the general public, the study was able to identify the underlining reasons for low recycling rate, the awareness and willingness of the public to engage with Vending machine, and incentives that would motivate them. The machine attracts the users with rewards. Finally, this research provides a straightforward idea to implement the IoT based vending machine with ease to make the environment clean and green.

Keywords: Smart Reverse Vending system - Design thinking – IoT sensors – recycling of plastics – underground storage unit.

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I. INTRODUCTION

India has the second largest population in the world and contributes to large amount of plastic waste. Plastic wastes are harmful for the environment. People dump plastic wastes in public places instead of throwing it in the dustbin. Plastic waste in public places causes bad odour, spoils mood and spreads disease. Recycling is one of the important approaches taken for managing waste effectively. This IoT based vending machine, which are accessible to every person and can be used to make the surplus plastic bottles ready for recycling, not only store the products, but also grind them into small scraps and make them more suitable for recycling. IoT based vending machine is an innovative concept which has been introduced to help collect recycling materials effectively and hence boost up recycling activities and consequently improve the waste management.

II. LITERATURE REVIEW

Maofic Farhan [2] suggested the design of a Smart Bottle Recycle Machine (SBRM) which is designed on a Field Programmable Gate Array using an ultrasonic range sensor. The detector was used to calculate the number of bottles and distinguish between them. Since hardware based implementation on a FPGA is usually much faster than the software based implementation on a microcontroller PGA was chosen. Machine learning algorithm developed on python platform was used to classify and collect the used bottles in the paper by Dhulekar [3]. The system consist raspberry-PI connected with camera and out of audio-visual interactive system. Reward is given through printed coupon generated using thermal receipt printer. The machine is designed in a way to accept plastic bottles and credits these as points, which then can be used to buy products. The proposed design of BRM provides identification of bottle and efficient recycling in low cost.

Dumpayan [4] proposed the operation of the machine which run on either commercial power or solar power showed great accuracy in recognizing RFID accounts, differentiating between plastic and non- plastic bottles, storage or updating of points of each account, and distributing products. Along with providing a renewable source of energy, the addition of the solar panel and battery also serves as back-up power in the event of commercial power outage. In the paper by Kokoulin [5], the authors describe their results in IoT and Convolutional Neural Networks application in reverse vending machine. This machine is implemented with IoT controllers and tiny single-board computers which have greater memory and computational restrictions. These controllers could recognize the different types of waste using cameras and provide sorting and preprocessing. This paper shows CNN implementation on IoT for reverse vending machine.

Aditya gaur [6] suggested a Reverse Vending Machine that supports only plastic items as an input, coins as an output. The Reverse Vending machine (RVM) is implemented using Xilinx in Verilog. This paper explains the duplication of Reverse Vending Machine for detecting fraud using Strain Gauge Weight Sensor, Capacitive Proximity Sensors and Infrared Photoelectric Sensor to detect. Edgar Scavino [7] proposed an experimental machine vision apparatus was used to identify and extract recyclable plastic bottles conveyor belt. Color images of the bottles were taken with a Web camera, and the identification was performed by our homemade software, based on the shape and dimensions of object images.

Even though, there many systems and practices introduced by Government and Non-Government organizations in India, still the objective is not met, because of poor understanding of customer in nature. Design thinking, an innovative problem solving approach facilitates the solution provider to understand the customer/people problem in the ground level and more relevant information collected from people at their footstep provides clear way of proceeding towards ground-breaking solutions. This human-centered, non-linear, iterative process makes the teams to understand users, challenge assumptions, redefine problems and create innovative solutions to prototype and test.

We also take into the account of few common challenges in front of us before we get into the solution approach.

- Usual garbage cans. People throw all the possible trash on the ground, even though bins are kept nearby. Most of them are ignorant of the damaging effects caused by littering. Public waste bins are filling up faster than ever and inevitably many of the bins end up overflowing before collected, causing not only cluttered streets and bad odors but also negative health and environmental impacts.
- Door to Door waste collection. This might be a good idea but the transportation fee and the overall expense will result in a huge loss from our side. Also it requires a lot of man power and time to collect waste plastic bottles from each and every home within a city. The storage space is also a problem when it comes to collecting waste manually.
- Burning Plastics in industrial area. Incineration of plastic waste in open fields is a major source of air pollution. Burning plastic smells awful. The burning of plastics releases toxic gases like dioxins, furans, mercury and polychlorinated biphenyls (better known as BCPs) into the atmosphere, and poses a threat to vegetation, and human and animal health. Dioxins settle on crops and in our waterways where they eventually enter our food and hence our bodies. These dioxins are potentially lethal persistent organic pollutants that can cause cancer and disrupt thyroid and respiratory systems.

During the empathy phase, we have interacted with people in the different places and understand the public places like Bus stand in the junction places are more vulnerable for dumping bet bottles by passengers. After having detailed discussion with the team by considering the challenges, it is concluded that Placing Vending Machine at public places and people can be attracted towards this system by giving rewards for the waste pet bottles collection.

In the definition phase, our team derived the problem statement with the following objectives

- Reducing plastic waste bottle
- Clean and green technology
- Help to collect recycling materials effectively and boost up recycling activities and consequently improve the waste management
- A person can be rewarded by disposing their waste plastic bottles

MICROCONTROLLER

1. NodeMCU

NodeMCU is an open source IoT platform. The level of machine is monitored using NodeMCU, as the machine reaches the limit the trash collectors are informed and the exact location of machine is sent by the help of global positioning system.

2. ARDUINO MICROCONTROLLER

The Arduino microcontroller performs all the automated functions. The automated function instructs the user on how to use the vending machine through LCD. Also it automatically detects the plastic bottle with the help of Sensor. The detected plastic bottles automatically falls into the Grinding machine and the blades in the machine, grinds the plastic bottle into scraps. The scraps are stored in the underground storage area and the intimation to collect the scraps is shared automatically to the trash collector by nodeMCU using GPS.

WEIGHING MACHINE

After the detection, the plastic bottles are weighed by the weighing machine. The weighing machine calculates the weight in grams. The user can collect the reward as per the weight of the plastic bottles. Then the weighed plastic bottle falls directly into the Grinding machine. The user can collect the reward as per the weight of the bottles.

GRINDING MACHINE

Recycling and reusing these plastics can be one of the best ways to stop the pollution. The plastic grinder makes it easier and safer process. A plastic grinder is used to reduce the larger and more plastic waste by grinding them. Here, in this machine the plastic bottles falls directly into the grinding machine after detection where the neck of the bottle is separated and the remaining piece of the bottle is grinded and stored. Recycling the plastic will be bull's eye only if they are prepared for the process before. The preparation procedures can vary. Only a grinding process will help best in recycling the plastic. The process involves:

- The feeding of raw material i.e., the waste plastic in the input area.
- They are then sent to the main grinding unit where they are crushed and grinded.
- The neck of the bottle is slashed and stored separately
- They can be crushed to the desirable size with the adjustment knob in the machine.

- They are then sent out to the storage unit where the crushed product is received.
- This will save a lot of space in the storage area.

Display Unit

Display Unit is a type of flat panel display, designed to project on-screen information of a microcomputer onto a larger screen with the aid of a standard overhead projector, so that large audiences may view instructions on how to use the machine without getting confused. The Specific reward for the user is also displayed on the LCD screen

STORAGE

The storage unit for this machine is placed underground for extra storage space. The capacity of the storage area is 50 kilograms. The weight is constantly calculated by the Force sensor and when the weight reaches 48 kilograms, an intimation to collect the scraps will be send by the NodeMCU to the trash collector.

Operating Procedure

The working of the machine starts with inserting the plastic bottle. The operations of the vending machine is relatively straightforward in that when the recycler brings the used plastic bottle to the machine, a "receiving opening" is designed precisely to accept the bottles. The opening ensures that the device can take only one container at a time. The user can place the empty plastic bottle inside the opening area. IDEC sensor is placed above the opening area and when the bottle is inserted the sensor automatically detects the plastic bottle. The process of IDEC sensor is, it surveys that the inserted bottle is plastic or not. After detection of plastic bottle the vacuum pump starts to sucks the inserted plastic bottle.

TYPE OF INPUT	RESULT
Coco-cola bottle	Accepted
Miranda bottle	Accepted
Bisleri water bottle	Accepted
Glass bottle	Rejected
Stainless steel bottle	Rejected
Aluminium bottle	Rejected
Copper bottle	Rejected

The plastic bottle falls directly into the grinding machine after detection. Here, the neck of the bottle is slashed and stored separately. The plastic bottle is then grinded into small scraps by the blades in the grinding machine. The scraps are stored in the underground storage area. When the storage reaches the limit, intimation is sent to the garbage collector to collect the scraps.[1]

Rewards

The user needs to insert an empty plastic bottle inside the opening area. The instructions can be followed by the user during the process. The reward for the user is generated based on the weight of the plastic bottle which is weighed by the weighing machine. The reward options are enabled based on the weight of the scraps. The user can collect their reward.

The Rewards are,

Range (.in gms)	Rewards
0-20	Reward1
20-50	Reward 2
Above 50	Reward 3

IV. IMPLEMENTATION

The design and implementation of proposed reverse vending machine is constructed by the fulfillment of certain criteria:

- **Reliability**

The machine must be able to work with minimum supervision. It must be able to work within 24 hours without any fail. All the components used in the design of machines should work properly according to the designated task.

- **Accuracy**

The machine must be able to differentiate plastic bottles from other types of bottles and reject the non-plastic bottles. IDEC sensor is used for this detection. The weight of plastic bottles must also be accurate.

- **Response Time**

The machine must be able to complete operation fast. Transaction time should be minimum for the user. The machine should show fast collection of data and execution of commands.

- **Efficiency**

The machine must accept all types of plastic bottles irrespective of its size, shape and color. The machine should also reject all bottles that are not plastic.

- **Functionality**

The machine must be able to function and complete process of operation without fail starting with the detection of plastic bottle up to range of the weight for reward.

The machine accepts only bottles that are plastics and all other materials are rejected by the machine. The bottle is then grinded by the sharp blades in the grinding machine that turns the plastic bottle into small scraps which are then stored in the storage area. This is where we have implemented the idea of underground storage area. The underground storage area not only saves space but also provides extra storage area. Storage units that are placed above ground level usually consume lot of space thus affecting the size of the machine. In this storage area, there will be separate storage space for both the neck of the bottle and the grinded scraps.

The grinded scraps are stored in the underground storage area. The storage area gets filled with grinded scraps whenever the user inserts an empty plastic bottle. The capacity for the storage area is 50kgs. When the weight of the scraps reaches 48kgs, intimation is sent to the garbage collector to collect the scraps for recycling. The reason for setting the intimation limit to 48kgs is to alert the garbage collector to collect the scraps before the capacity of the storage space reaches the limit and overflows. This will allow the garbage collector to collect the scraps within the stipulated time. The scraps can be collected using a vacuum from underground.

V. CONCLUSION

Nowadays, the world is at risk by plastic pollutions which is one of the world’s biggest environmental threats. Dustbins are overflowed due to used bottles and mostly it goes to landfill to be buried. Plastic is non-bio degradable and takes time to decompose. In this paper, the IoT based vending machine for recycling Plastic bottles has been proposed, which employed the combination of two concepts; RVM and grinding machine. Indirectly, it can motivate the public to recycle a small quantity of plastic bottle at the nearest and reachable area while gaining the rewards. At the same time, by having the grinding mechanism, this proposed project has reduced one necessary process sin the recycling centre. It is highly recommended to

implement and maintain this system by private vendor.

VI. FUTURE WORK

There is large scope of research and improvement for this Reverse Vending Machine. However in developing countries, Reverse Vending Machine (RVM) are not very common because of their high implementation and maintenance cost. They are not affordable and hence are not implemented in most of the developing countries. This project should work as a proof for a low cost vending machine for recycling plastic bottles in such cases. The remaining problems and scopes of this work are:

- Improved detection accuracy
- Simpler user identification method
- Can accept glass bottles
- Solar energy can be used for power supply
- Can be used by large number of people.

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