Fabrication of Reverse Vending Machine

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Abstract - The Reverse Vending Machine (RVM) now becomes an automated plastic waste collection system with the user being rewarded for returning plastics bottles. This paper is focused on the design and implementation of an affordable miniaturized semi-automated Reverse Vending Machine (RVM) which detects bottle existence using ultrasonic sensor, verify the bottle weight with using load-cell setup and stores valid bottles in an in-house collection bin. When a good accept is given, a candy will thrown as the reward. This prototype is driven by an Arduino microcontroller, which collects information from the sensor, controls the dosing unit and all functions including the three LEDs and the buzzer.The prototype is a response to the growing threat of plastic pollution, and aims to fuel a culture of recycling in schools, colleges and public spaces.

Key Words: Reverse Vending Machine, Ultrasonic Sensor, Load Cell, Arduino Uno, Candy Dispenser, Recycling.

1. INTRODUCTION

The waste plastic is certainly one of the most polluting problems that has faced contemporary society. Improper disposal of plastic bottles also causes blockages in drainage systems, soil pollution, and potential environmental hazards. Traditional waste collection bins are rendered useless by misuse, non-segregation and the lack of incentive to throw waste properly.

A Reverse Vending Machine is one option out of many that is trying to solve this problem in an automated way and which incentivize the users by giving them some rewards for recycling. Upon insertion of a plastic bottle, the machine registers the presence of the bottle, verifies if the bottle meets the minimum weight requirements, and then stores the bottle in a secure bin if it is valid. As a prize, the machine releases a candy.

In this work, we present an approach on the design of RVM utilizing low cost components that will enable the deployment in university campus, malls, bus stand and small public place. The design employs an ultrasonic sensor for detecting a bottle, load cell for verifying the weight and a basic delivery mechanism to dispense a will be able to prove effective mechanical movement, autonomous navigation, and automated book retrieval, reward to the user. The objective is to demonstrate the viability of cost-effective recycling stations.

2. LITERATURE SURVEY

Sharma et al. [1], have designed a cost-effective reverse vending machine for acceptance of plastic bottles and identification using Arduino and IR sensors. Their prototype demonstrated good performance in a controlled indoor environment and successfully showed the core function of automatic bottle detection and storage. However, it did not have features to engage users, such as rewards, feedback, and security functions, so it was not as suitable for deployment in large public areas.

Khan et al. [2], introduced an RVM which employs image processing technique to recognize plastic bottles with the detection rate exceeding above 90%. Their machine vision technique achieved a dramatic reduction of false accept non-valid objects. In contrast, the proposed system didn't achieve good results when the illumination was too weak or the back- ground was complicated, so further study is needed on environmental calibration and robustness improvement.

Li et al. [3], developed an RVM based on IoT and a mobile application, which allows users to earn rewards for each bottle they return. The system tied bottle returns to a digital points and rewards program that greatly boosted participation and helped keep them recycling. The model encouraged users to participate more in recycling by allowing them to see how much each individual recycled using a mobile application, unlike the static-bin model. While these prerequisites are perfect for the city, they would be next to useless in a rural area or the third world. Additional complexity arises from app ecosystem maintenance and data privacy concerns.

Fernandes et al. [4], proposed an RVM with an internal bottle-crusher to compact waste material for volume reduction. Their design uses gear driven rollers to crush the bottles, an effective way to optimize the storage. The mechanism, however, had higher power requirement and necessitated use of strong´ material which could sustain ever-rolling mechanical stress, thus increasing system costs and consumption of energy.

Kumar et al. [5], presented a solar based RVM on different plane for application in remote and rural area. The system performed well in good sunlight and are compatible with the concept of using sustainable energy. However, its performance was poor in cloudy days, and a larger energy-storage system or a hybrid power system should be considered for ensuring continuous operation.

Banu et al. [6], developed an RVM with GSM module and LCD for real-time communication and monitoring. This bin was auto notified to maintenance team via SMS alert when it is full thereby enhancing operational efficiency. However, the use of GSM technology raised the overall price and a mobile network coverage was necessary. ciently calculates optimal routes within the library, ensuring quick and accurate book return operations. The study confirms that the A-Star algorithm yields reliable and accurate results, making it a suitable method for autonomous navigation in library environments.

Chauhan et al. [7], studied the cost-effecticiency to mount RVMs at metro stations and presented a revenue model related to the digital advertisements that are published on the machine. The model was found to be workable in the underground bustle, but was very reliant on the regular patronage of a corporate sponsor advertising.

3. TECHNOLOGY AND HARDWARE IN PROJECT

The RVM Arduino Uno is the mind of the RVM is illustrated in Fig.1. It takes input from all sensors (u.s. sensor, load cells) and controls the actuators (candy dispenser servo, internal bottle flap mechanism). Arduino manages the whole process, from sensing the bottle to weighing it, accepting it and dispensing the reward. It runs all the modules in real-time to coordinate, and therefore the Arduino based system attains high precision bottle validation system and stable RVM operation.

Fig.1 Arduino Uno

Fig.2 shows the ultrasonic sensor which is used to detect whether a bottle is inserted or not at the inlet slot. The sensor is continuously measuring the distance by sending ultrasonic pulses and receiving echoes. When a bottle is detected within a predefined distance, the Arduino initiates the next step of the process. This sensor ensures the system is operating only when a real object is placed inside, thereby preventing false readings and wastage of work.

Fig.2 Ultrasonic sensor

The IR sensor is used as an auxiliary sensor unit within RVM as shown in Fig.3. The IR sensor works by sending out an infrared light on an object and measuring the intensity of that light which is reflected. An IR based bottle filling monitoring system When the bottle is placed in the inlet, the IR sensor detects the break of the beam and a signal is transmitted to Arduino for processing.

Fig.3 IR sensor

The servo motor is an important element in the Reverse Vending Machine (RVM) as it controls the candy dispenser system with accuracy in angular motion. It works by getting control signals from the Arduino and is opened up to a predefined angle, so it opens the dispensing flap and releases one candy for each valid bottle throw. Fig.4 shows the servo motor which is fixed at the reward outlet and moves back to its initial position after the discharge so that the candies cannot be discharged twice. Its precision, small size and robust nature allows the application of this servo for controlled motion ensuring a fluid, uniform, and intuitive reward system contained within the RVM. placement of books at various levels without vibration or misalignment.

Fig.4 Servo Motor

4. RESULTS & DISCUSSIONS

The testing of reverse vending machine The result of testing the subsystems of RVM was very reliable when they were tested separately. The ultrasonic sensor did detect bottles within its range and what was more it make the validation procedure more aspected without any false readings. After the correct calibration, a load cell can distinguish between a valid plastic bottle and lighter, or invalid, objects and therefore can be used to accept the wrong recyclable material or to refuse it. The servo-based candy dispensing mechanism ran seamlessly and it was engineered to dispense exactly one candy after a successful bottle deposit, a sweet surprise that rewards our "reuse and recycle" design ethos.

So, to make full use of each module, I had to combine all of them into one Arduino program. The unified code is quite large and complicated which causes surprising delays in sensor readings, and timing conflicts between detecting the bottle, measuring its weight, and dispensing candy. At times, the load cell values jittered as multiple processes were running concurrently and the servo was slightly delayed when performing multiple tasks at the same time. These difficulties were mainly the result of blocking delays, un-modular code design, and multiple competing functions operating on the resource constricted micro-controller.

So the only major limitations were related to software interfacing versus hardware capabilities. The mechanical parts, the sensor holders and the internal structure were ok, but the software structure need a changes to getting more stable by the use. Use of non-blocking timing functions (e.g., millis()), code modularization, and optimization of read cycles of sensors can significantly enhance the real time performance and system coherence.

The results indicate that the RVM hardware design is suitable for performing bottle detection, weight checking, and reward delivery in a reliable manner. With improvements in software efficiency, the system will be able to achieve even better coherence between detection validation and dispensing. This shows to the idealist that they can make a Reverse vending machine that is cheap and easy to use with simple electronics, Also further enhancements in code design will enhance the work stability and make the user happier.

5. DESIGN OF CAD MODEL

The Fig.5 CAD model of the RVM is made up of the following components, the Base Structure, the B ote Inlet Slot Ultrasonic Sensor Mount, IR Sensor Holder, Load Cell Platform, Collection Bin, Servo-Based Candy Dispenser Unit, Arduino Controller Housing and the External Enclosure Frame.

Fig. 5 CAD Model

6. ASSEMBLY OF THE PHYSICAL PROTOTYPE

The Fig.6 assembly of the RVM consists of the following components:

Base: The base serves as a platform for major RVM functional blocks such as sensor, load cell unit, collection bin, Arduino board, and candy dispensing mechanism. This provides mechanical stiffness and maintains the alignment of the process in placing and weighing the bottle.

Ultrasonic Sensor: An ultrasonic sensor is located at the bottle inlet to detect a bottle entering. It's place to measure distance has to be suitable to be precise, and we want to be sure the ball is properly detected.

IR Sensor: Along the route of the bottle inlet, you can find an IR sensor that detects the object and stabilizes the bottle before weighing. It adds additional verification and prevents false actuations when inserting the bottle.

Servo-Based Candy Dispenser: Near the output chute with the candy dispensing flap the servo motor is attached. Once a valid bottle is detected and accepted, the servo rotates to dispense a single candy and then returns to its original position to stop further dispensing.

Arduino Controller Board: The Arduino Uno is attached to an aluminum plate for insulation inside the cabinet and serves as the main controller of the system. It receives the input signals from the sensors, and controls the load cell, servo and indicator according to the programmed logic.

Wiring and Power Supply: Proper insulated wire is used to tie all sensors, actuators and modules together. The wiring design is implemented such that it eliminates the possibility of confusion, and guarantees proper sequential signals and good power throughout the RVM.

Fig. 6. Assembly of Project

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