Enhancing Waste Management Efficiency : Smart Trash Can with Object Detection and Lid Automation

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Abstract

With the use of IR sensors, an Arduino Uno R3, a DC motor, and a dual motor driver, this project aims to create a smart trash can. The objective was to develop an intelligent waste management system that opens the dustbin lid when it detects objects nearby, stays open for a predetermined amount of time, and then shuts. To show real-time feedback, the system also had an LCD display. The project saw success as a result of thorough testing, which included evaluating the functioning of the code and testing each individual component. Successful object detection, lid opening and closing, and LCD display of pertinent messages were all achieved by the trash can. The system showed stability and continued to function for a considerable amount of time. Overall, this initiative offers a practical and easy-to-use approach to efficient trash management.

1 Introduction

Problem statement

The issue at hand is the inefficiency and inconvenience brought on by conventional waste management techniques, primarily when it comes to opening and closing the dustbin lid and evaluating its state. Lack of an automated system often requires manual intervention, which puts users in an undesirable and unsanitary situation. Additionally, it becomes difficult to manage waste effectively and arrange for timely disposal without a clear indication of the dustbin's full or empty status.

1.1 Domain

The domains our solution focuses on are:

- Waste management- this project of ours focuses on management of waste in a smart and effective way.

- Smart city infrastructure - The use of technology in our project and addition of elements that makes the everyday use and the disposal of waste more efficient .
- Health facilities - this smart trash can also provides health benefits as distance is maintained from the trashcan and not touching any part of it prevents spreading any disease,and maintains hygiene and cleanliness

1.2 Why the world cares about the problem that is being addressed

Smart trashcan project addresses the growing concern of waste management and environmental sustainability.By utilising advanced technologies like IR sensors, DC motors, and Arduino, an automated solution that efficiently opens and closes the dustbin lid based on the presence of an object and keeps the user updated about the level of the trash within is created . This innovation contributes to waste reduction, improves hygiene, and enhances the overall cleanliness of public spaces. With increasing global attention towards smart and sustainable solutions, our project showcases the potential for technology to revolutionise waste management practices and create a cleaner and greener future.

1.3 Our Approach

The approach of the project is to design and develop a smart dustbin system that addresses challenges generally faced by everyone on a daily basis .we therefore have built a system that will utilise an IR sensor to detect the presence of individuals near the dustbin and automatically open the lid, allowing for touch-less and convenient waste disposal. The sensor-based technology will enhance hygiene, reduce the risk of cross-contamination, and promote a clean environment, we also have installed IR inside the dustbin to notify whenever the dustbin is full that way it'll avoid the case of overflowing and spilling of waste, this smart dustbin having a touch-less operation makes it easier for the physically challenged people to operate this system conveniently.

1.4 Our Contribution

- Hygiene: Our solution contributes to the upkeep of a tidy and sanitary atmosphere by automatically opening and closing the dustbin lid. Because users don't have to touch the lid anymore, there is less chance of contamination and the spread of germs.
- Efficient trash Management: The technology encourages efficient trash management by detecting the dustbin's full or empty status and displaying it to users. By making it simple for users to decide when the dustbin needs to be emptied, overflow may be avoided and garbage collection schedules can be improved.
- Sustainability: Our project helps with sustainability initiatives by improving waste management procedures. It contributes to a cleaner and more environmentally friendly environment by lowering the likelihood of littering and incorrect trash disposal.

- Helpful for the physically handicapped : Our product will be helpful for the physically handicapped due to it's automated opening and closing .

2 Background and Related work

The project aims to use different components to bring out the desirable result

2.1 Components used

- Arduino uno R3 compatible development board.
- HW-201 Infrared Obstacle Avoidance IR Sensor Module.
- L298N 2A Dual Motor Driver Module with PWM Control.
- 16*2 LCD with Green Backlight.
- 12V 1A Power Supply(SMPS) Adaptor.
- 10 RPM DC Motor.

2.2 Components Explained

2.2.1 Arduino Uno R3

This is the central component of the project and serves the microcontroller that controls and coordinates all the parts of the project. It provides the necessary processing power, input/output pin, etc. In the code, it is responsible for reading sensor values, controlling the motor driver and displaying on the LCD display.

2.2.2 HW-201 Infrared Obstacle Avoidance IR Sensor Module

It is used the detect motion and the presence of objects in the dustbin. It emits infrared signals and measures the reflected signals to detect the presence of obstacles. In this project, the sensor is used to trigger the lid-opening mechanism and indicate when the bin is full. When an obstacle/motion is detected, a signal is sent to the Arduino to either open the bin or to display full/empty on the LCD display. The sensor is connected to digital input pins on the Arduino, and its state is read in the code using the "digitalRead()" function.

2.2.3 L298N 2A Dual Motor Driver Module with PWM Module

The motor driver module is used to control the DC motor that is responsible for opening and closing the dustbin. It provides H-Bridge functionality, allowing control over the speed and direction of rotation of the motor. The motor driver is connected to the digital output pins of the Arduino. You can control the rotation direction and speed by setting the appropriate pin states. The code uses the "digitalWrite()" function to control the motor driver pins and initiate the desired actions.

2.2.4 LiquidCrystal I2C library and 16X2 LCD Display

The LCD display module provides visual feedback to the user. The library allows an interface between the 16*2 Display and the Arduino Uno using I2C communication. In the code, the LCD is used to show messages such as “SMART DUST BIN”, “OPEN”, “CLOSING”, “FULL” and “EMPTY”. The code initializes the display, clears it, sets the cursor position and uses “lcd.print()” to display the desired messages.

2.2.5 12V 1A Power Supply (SMPS) Adaptor

The power supply provides a stable power source to the Arduino Uno, motor driver, motor, etc. In this project, it supplies 12V with a current capacity of 1A. A stable power supply is crucial for the proper functioning of components and the prevention of damage to components.

2.3 Concepts used

2.3.1 I/O

t refers to the capability of Arduino Uno to interact with digital signals. Digital input pins can detect and read the state of a signal, while the output can set the state of a signal to control external devices.

2.3.2 H-Bridge

t is an electronic circuit configuration commonly used to control the direction and speed of DC motors. It consists of 4 switches arranged in an “H” shape. By toggling the switches in different sequences, we can control the motor’s rotation direction and speed.

2.3.3 Pulse Width Modulation (PWM)

It is a technique used to control the power and intensity of a signal by varying the duty cycle within a fixed period. In this project, the PWM module of the motor driver allows controlling the DC motor’s speed by adjusting the PWM signal’s duty cycle.

2.3.4 Inter-Integrated Circuit (I2C)

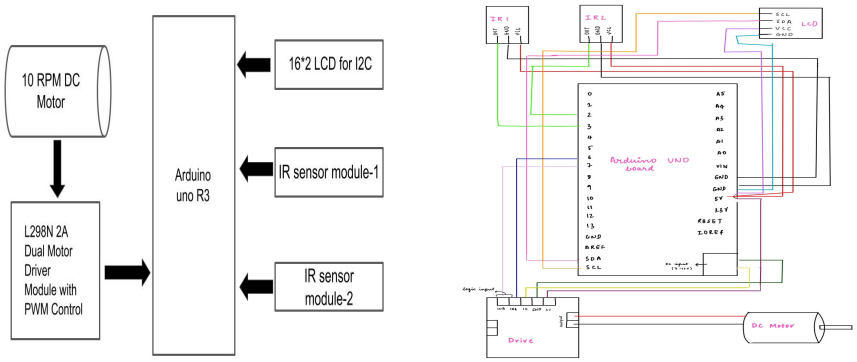
It is a serial communication protocol that allows multiple devices to communicate with each other using only 2 wires. It is used to connect Arduino and the LCD. It enables efficient and easy communication between the devices.

3 Project Details

3.1 System Architecture

System architecture involves the block diagram and circuit diagram of our product . The main component being Arduino Uno R3 all the other components are connect to it as shown in Figure 1

for example.



(a) (b)

Figure 1: SYSTEM ARCHITECTURE (a) This is the block diagram. (b) This is the circuit diagram.

3.2 Implementation details

1.Gather the necessary components:

- Arduino Uno R3
- IR sensors 2
- DC motor
- Dual motor driver module (L298N)
- Jumper wires and wires
- Power supply (battery or adapter)
- Metal strip
- Trash can
- 16 X 2 LCD

2.Connect the above components as shown in the block diagram above

- Solder the Driver, IR Sensors to the arduino uno R3 board.
- Connect the LCD to the board
- Connect the output of the IR sensor to the pin 2 and 3 of the board respectively
- Connect output A of driver to the DC motor

- Attach a metal strip to the dc motor such that it lifts the lid of the bin when the motor rotates in a single direction
- Connect the IN1 and IN2 to the pin 6 and 7 of the arduino board

3. Writing the Arduino code.

- write the Arduino Code involving all the components and in accordance to the connection that is made.

4. Upload the code to the Arduino

- Connect the Arduino to your computer via USB cable.
- Open the Arduino IDE .
- Write the code into a new sketch.
- Select the appropriate board and port from the Tools menu.
- Click on the "Upload" button to upload the code to the Arduino.

5. Testing the smart trash can.

3.3 Test plan and results

3.3.1 Test plan

Test plan includes testing the individual components for their functionality and then making sure they perform the tasks required for the project and then check them altogether

- Testing the Arduino uno R3 :This was done by running a basic blink program on the board to make sure the board is in a working condition .
- Testing if the IR sensors are working properly:Test whether the IR sensor is correctly detecting objects (e.g., hand movement) , a LED is connected to the board and is checked if it lights up on detecting objects after uploading a basic code that does that.
- Testing Motor Control:Make sure the motor turns in a clockwise and anti-clockwise direction using the dual driver . This helps in checking both the DC motor and Dual motor driver module (L298N).
- Testing if LCD is working properly
- Once we make sure all the components are working individually, we proceed to make the required connections and run the program written.
- Testing Dustbin Status Detection:
  - Ensure the motor behavior aligns with the detected dustbin status.

  - Simulate various scenarios by placing objects in the dustbin to change its status.
  - Verify that the system correctly detects when the dustbin is full or empty based on the IR sensor readings and display the required message on the LCD.
  - Make sure the lid opens and closes to the required degree and also closes when after some time

- Testing stability and robustness
  - Conduct a long-duration test to verify that the system operates consistently without any issues.
  - Test the system under different lighting conditions and ensure the IR sensor readings are accurate.
  - Check for any abnormal behavior, such as motor stalling or erratic movements or if the motor runs on a continuous loop.

- Testing if the trash can is user friendly and user experience .

3.3.2 Test Result

- The above test provided positive results when the components were tested individually
- The code ran with negligible errors and gave desirable results.
- A bit of compilation was faced when it came to rotation duration of the motor which was overcome by trial and error.
- The trash can's lid opened when an object was detected and closed after a specified duration .
- The LCD read "OPENING" and "CLOSING" when the lid was opening and closing and also "FULL" "EMPTY" when the trash can was full and empty respectively .
- The trash can's condition was stable over a long period of time.

3.4 Analysis of the results

The components performed well individually and also when put together , the code functionality aligned with the desired behavior, and the system exhibited stability and long-term performance. The minor challenges encountered during the testing process were overcome through trial and error, showcasing the project's adaptability and resilience.Overall, the analysis of the test results indicates that the smart trash can project has been successful.

4 Future work

- Waste Separation(Biodegradable and Non-Biodegradable Waste Detection):Future smart trash cans' ability to separate trash into biodegradable and non-biodegradable categories will be a key feature. Advanced sensors or image recognition technology will be used to do this. Dustbins with sensors placed will analyse the garbage and distinguish between organic (biodegradable) and inorganic (non-biodegradable) waste. As an alternative, waste will be identified and classified using image recognition technology, where cameras or scanners will take pictures of the waste and an AI-powered system will do so based on visual criteria.

- Keeping the bin's lid locked to prevent overflow:Future smart dustbins will be equipped with a mechanism that will automatically lock the lid as soon as the bin fills to capacity in order to prevent overflow. Highly sensitive sensors that measure the amount of trash in the bin will be used to do this. The system will activate a mechanism to lock the lid when the waste reaches a certain level, making sure that no more garbage can be added until it is emptied.

- Waste Compression Within the Bin,by the usage of Solar energy :Future solar-powered smart trash cans will permit the compression of trash inside the can. The compression mechanism on these cutting-edge trash cans will be powered by solar energy thanks to their highly effective solar panels. As the trash builds up, the system will trigger the compression mechanism, which will apply pressure to lower the amount of trash and so free up more space inside the bin. This will enable greater capacity and greatly lessen the frequency of waste collection. Rotating the PVC in accordance with the Sun's Position to maximise the functionality of Future smart trash cans, they will be built with rotating Photovoltaic Cell (PVC) panels that will autonomously shift their position dependent on the movement of the sun in order to maximise solar energy generation. This will guarantee that the solar panels are always pointed in the direction that will receive the most sunlight during the day, resulting in effective energy conversion and powering the dustbin's numerous features.

- Text Alerts to Government Agencies for Waste Collection:Future smart trash cans will be smoothly coupled with a communication system to deliver SMS messages or alerts to the relevant government agencies in charge of waste management. The trashcan will automatically send a message to the appropriate authorities with its location when it is full or needs to be emptied. This will enable prompt garbage collection and prevent overflow, ensuring the area's cleanliness and hygienic conditions.

- Using wireless technology, remote control and monitoring:In the future, remote monitoring and management of the smart trash cans will be possible due to the implementation of wireless communication, such as cutting-edge Wi-Fi or Bluetooth technologies. Through a smartphone application or online interface, this connectivity will make it possible to receive notifications, status updates, and remote control of the trash can in real time. Users can schedule trash pickups, track the compression process, and, if necessary, remotely unlock the bin in addition to receiving updates on the bin's fill level and monitoring the compression process. For future

waste management plans that are more effective, this link will make it easier to collect and analyze data.

5 Conclusion

In conclusion, the smart dustbin project has been successful in realising its main goal of developing an automated and practical trash disposal system. Key functionalities to improve the user experience have been implemented in the project by adding the L298N dual motor driver module and other components.

The use of IR sensors for infrared obstacle avoidance is one of the smart trashcan's noteworthy features. With the help of these sensors, users can dispose of waste without having to make physical contact. As soon as a user approaches the dustbin, the lid will automatically open, promoting convenience and hygiene. The lid-opening mechanism is activated in response to the presence of a user or an object being detected by the IR sensors.

The Arduino Uno R3 microcontroller, which offers the required control and processing capabilities, is the system's brains. To control the movement of the lid, it interacts with the L298N dual motor driver module and receives input from the IR sensors. In order to provide accurate and controlled lid operation, the microcontroller processes the sensor data and delivers the necessary signals to the motor driver module.

The 10RPM DC motor, which is powered by the L298N module, moves the lid. The motor driver module enables the motor to rotate smoothly and in a controlled manner, ensuring that the lid opens and closes without a hitch. This enables effective waste removal and avoids any jerks or unexpected motions that can be inconvenient or harmful.

The project can be expanded in the future to include more features and advancements. As was described previously, the smart dustbin system can incorporate concepts like waste segregation detection, lid locking to avoid overflow, waste compression using solar power, text alerts for waste pickup, and wireless connectivity for remote monitoring and control. These improvements would enable improved dustbin monitoring and control while also promoting sustainability and waste management efficiency.

We may develop a more complete and cutting-edge trash disposal system that satisfies the requirements of contemporary society by continuously enhancing and increasing the capabilities of the smart dustbin.