Digital Innovations & Contemporary Research in SCIENCE, ENGINEERING & TECHNOLOGY
Vol. 12. No. 4, 2024 Series

Article Citation Format
Abiola O.A., Adeleke O. & Ajayi, J.O. (2024): Development Of An Artificial Intelligence Body Gesture Detection Dustbin With An Autonomous System. Journal of Digital Innovations & Contemporary Research in Science, Engineering & Technology. Vol. 12, No. 4. Pp 1-8. www.isteams.net/digitaljournal. dx.doi.org/10.22624/AIMS/DIGITAL/V12N4P1

Article Progress Time Stamps
Article Type: Research Article
Manuscript Received: 22nd August, 2024
Review Type: Blind Peer
Final Acceptance:22nd September, 2024

Development Of An Artificial Intelligence Body Gesture Detection Dustbin With An Autonomous System

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ABSTRACT

Effective waste collection is essential in homes and offices to maintain a healthy society, particularly for the elderly and individuals with disabilities. Smart technologies offer an innovative approach to addressing real-world challenges and fostering sustainable development. This system uses a microcontroller, ultrasonic sensors (HC-SR04) to detect the distance or movement of objects, an Arduino Uno as software frame work, a servo motor to open the lid, and a battery for continous power. Automatic activation is triggered by body gestures, making the system both user-friendly and efficient in waste disposal. The ultrasonic sensor detects a user's presence and sends signal to the Arduino Uno board which in turn activates the servo motor to open the dustbin lid. This operation minimizes the risk of contamination, as waste can be disposed without direct contact with the bin. The dustbin is mounted on an autonomous system that moves towards the user and returns to its designated position using features like line-following, path-finding, and Bluetooth-based (HC-05) wireless control for intelligent navigation.

Keywords: Ultrasonic sensor, Autonomous system, smart bin, AI, Navigation, Gesture, Body.

1. INTRODUCTION

Recently, garbage disposal has emerged as a significant global concern. The large volume of waste produced are often disposed into environment without considering its negative impact. The main problem with traditional dustbins is that garbage frequently overflows and waste often discarded around the bin instead of inside it, leading to dirty and unhygienic surroundings. (Arthur et. al., 2024). With the rapid rise in population, effective waste management has become crucial. Overflowing bins contribute to numerous deaths each year from environmental diseases such as Cholera, Diarrhea, Malaria, and Typhoid. Solid waste management is increasingly becoming a global challenge, driven by population growth, inefficient city governance, low public awareness, and insufficient funding for waste management programs. (Prabhakaran et. al., 2023).

According to the World Bank report, by 2025, around 2.2 billion of waste are expected will be generated. Then, approximately 1.3 billion tons of municipal waste are generated per year (Patil et. al., 2017). To address this, we propose an automatic, self-controlled dustbin system to make waste management smarter and more convenient. Dustbins play crucial role in our daily lives and require proper maintenance. If not properly maintained, they can create an unhealthy environment and contribute to pollution, which negatively impacts our health. *(*Vasu et. al., 2024). Dustbins are essential for collecting garbage, including recyclable, non-recyclable, and decomposable materials, commonly used in homes, offices, and public spaces. This project introduces an automatic dustbin powered by an Arduino Uno, utilizing an ultrasonic sensor to detect when an item is near, triggering the lid to open via a servo motor. This IoT-based solution represents a modern, automated approach to cleanliness, particularly useful in households where children may inadvertently contribute to messiness with toys, electronics, and other items. The automatic dustbin is engaging for children and encourages cleanliness in a fun way. The system opens when an object is within its range, waits for a set period for waste disposal, and closes automatically after disposal to prevent odour coming from the bin. The lid remains closed when not in use, ensuring efficient and hygienic waste disposal.

2. RELATED WORKS

Chitale et al. (2023) introduced a system that integrates smart garbage tracking, segregation, and collection processes. This system is equipped with ultrasonic sensors, rainfall/moisture sensors, inductive proximity sensors, and servo motors, all controlled by an Arduino unit. The Arduino platform serves as the software framework to operate the model and achieve the desired outcomes. The design and implementation of a smart dustbin system using Internet of Things (IoT) technology was proposed by Sontakke et al., (2024).

The system is designed to optimize waste management by automating the lid-opening process based on proximity detection and monitoring the bin's fill level. It incorporates sensors, an Arduino UNO R3 microcontroller, a servo motor, and a 16x2 character display for real-time data collection and display, facilitating efficient waste disposal. By encouraging proper segregation and timely disposal, the system promotes environmental sustainability and convenience. The primary goal of the project was to create an intelligent trash can that simplifies waste management, enabling the disposal of various materials such as plastic and paper. The system uses sensors, including an Arduino UNO microcontroller with 16 input/output pins, an ultrasonic sensor to detect the distance or movement of objects, and a servo motor to control the lid's motion. When someone approaches within 60 cm, the lid opens automatically. Additionally, once the bin is full, the system sends signals to a device, indicating the fill level for timely disposal.

Sharma et. al., (2020) developed a system named the "Automatic Waste Segregating and Self-Sanitizing Dustbin," which operates based on sensor technology. The primary goal of the project is to promote a clean, hygienic, and disease-free environment by focusing on waste segregation and sanitization without human involvement. Furthermore, it aims to reduce the release of harmful gases from decomposing waste. The system is also capable of detecting waste and automatically sending notifications when the bin reaches its full capacity. An intelligent garbage monitoring system utilizing sensors with RFID technology integrated over the Internet of Things was developed by Dhana et. al., (2017). The system employed a photoelectric sensor and a weight sensor to measure the weight and volume of the garbage bags, displaying this information to the relevant authorities. The officials are alerted when the dustbin nears its capacity, enabling timely emptying before it overflows.

Smart dustbin uses an Arduino microcontroller, ultrasonic sensor, servo motor, and jumper wires. Once the hardware and software connections are complete, the smart dustbin program activates from the design of Vasu et. al., (2024) and when a person approaches, the lid automatically opens and closes after a short interval when the person is no longer within range. Hania et. al., (2019) proposed an Automatic Waste Segregator and Monitoring System, designed to automatically sort wet waste, paper, plastic, and aluminum into separate bins. This system is built on a microcontroller-based platform using the Arduino Mega 2560 board, interfaced with the ESP8266 12E LoLin NodeMCU V3 module. It incorporates various sensors, including an inductive proximity sensor, laser module, light-dependent resistor (LDR), liquid sensor module, and ultrasonic sensor, to facilitate the waste segregation process.

Saad et. al., (2023) developed a prototype for a smart dustbin condition monitoring tool capable of providing detailed information and notifying waste collectors with the IoT-based dustbin's location. The system uses ultrasonic sensors to detect objects and measure the waste height, a load cell sensor to measure the waste's weight, and GPS to track the bin's location. The NodeMCU ESP8266 processes sensor data and sends it to users. Test results showed that the object detection hardware could automatically open and close the dustbin when an object was within a distance of ≤50 cm. The waste height and weight detectors were measured with errors of 0.4% and 0.15%, respectively. Software testing confirmed the system successfully sent WhatsApp notifications when the waste height was within 3 cm of the sensor or when the waste weight reached 4000 grams. The notification message of 69 bytes was sent with a throughput of 327.95 kbps, taking 2.61 seconds to deliver.

Smart Dustbin System (SDS) by Arthur et. al., (2024) was designed for densely populated urban areas to promote hygiene. The study analyzed advancements in IoT technology applied to smart bins and explored the various sensors placed in and around the bins. These sensors are crucial in segregating waste into categories such as degradable, non-degradable, wet, and dry.

Smart trash bin using IoT to prevent overflow by sending alerts when it needs to be emptied was designed by Prabhakaran et. al., (2023). Built on a microcontroller, the system uses ultrasonic sensors on each of the two trash bins to display the current fill status on both an LCD screen and a smartphone. It employs infrared (IR) and ultrasonic sensors to detect the trash level and automatically open and close the bin. The implementation of Dijkstra's algorithm in simulations helps identify the shortest route for collecting filled bins, making the garbage collection process more efficient, and time-saving, and reducing fuel consumption for truck drivers. Tahir et. al., (2024) developed a smart dustbin equipped with various sensors to automatically segregate waste and monitor the fill level. The system uses specific sensors to differentiate between dry and wet waste, with the waste levels being tracked and recorded simultaneously. This innovation promotes cleanliness in society and helps reduce the spread of diseases caused by waste accumulation.

3. METHODOLOGY

Arduino-based Autonomous car with automatic dustbin is an IOT-based project that provides an efficient waste management system in which the garbage bin have an ultrasonic sensor to sense a body movement and automatically open the lid for disposal of waste. We employed an Arduino for code execution, and an ultrasonic sensor for detecting an object, which inturn automatically opens the lid. The use of this technology, bring significant changes in terms of cleanliness and reduces the stress of moving around to use a dustbin.

The sensor-based dustbin frame work in Figure 1. gives a vivid operation of the system mounted on an autonomous car with android based Bluetooth for easy operation for people of all ages.

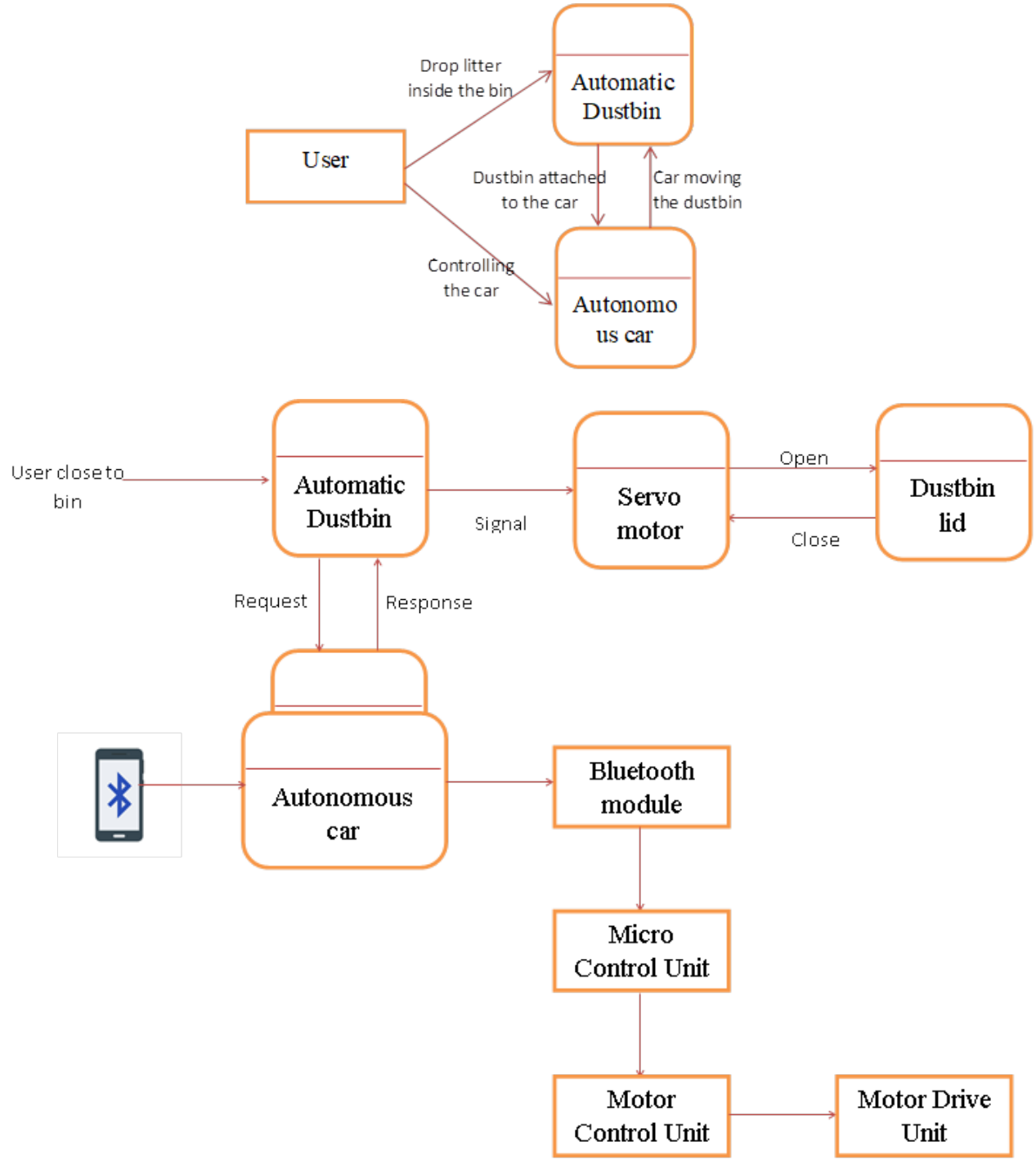

Figure 1.: Frame work for smart bin with bluetooth enabled autonomous system

3.1 Arduino/Microcontroller

The Arduino Uno is a microcontroller board that is dependent on the ATmega328 (datasheet). The microcontroller in Arduino from Figure 2(a) is Microchip ATmega328P and the Operating Voltage is 12 volts. The Input Voltage ranges from 7 to 20 Volts and the Digital I/O Pins are 14 of which 6 provide PWM output. The analog Input Pins are 6, and the DC Current per I/O Pin is 20 mA. Direct Current for 3.3V Pin is 50 mA. The main part is the flash Memory contains 32 KB of which 0.5 KB is used by bootloader SRAM for this Arduino has 2 KB and EEPROM of 1 KB with a Clock Speed of 16 MHz.The Length of the Arduino is 68.6 mm With a Width of 53.4 mm weighing 25 g.

(a) (b) (c)

Figure 2. (a,b,c): Arduino Uno, Ultrasonic Sensor and Servo motor

The ultrasonic sensor is a non-contact type of sensor used to measure an object's distance and velocity from Figure 2(b). This sensor operates on sound wave property to measure the velocity and distance of the object. In this project, the sensing distance is preset in the Arduino uno code and its adjustable for prompt sensing and lid opening.

3.2 Servo Motor

A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control in Figure 2 (c) is a signal (either analog or digital) representing the position commanded for the output shaft to open the lid in this operation.

Table 1: List of Components and their properties

Serial No.	Name	Model	Function	Operating Voltage
1	Arduino Uno	R3: ATmega328P	Reads sensor data and control actuator, Communicate with other components	5V (USB) 7-12V(external power)
2	Ultrasonic Sensor	HC-SR04	Measure distance, detects lid opening and closing, sends distance data to Arduino Uno	4.5 - 5.5V
3	Servo Motor	SG90	Control dustbin lids, receives control signal from Arduino Uno.	4.8 - 6V
4	Driver Board	L298N	Amplifies Arduino's ouput signals, control wheel drive.	5 - 35V
4	Bluetooth Module	HC-05	Establish wireless communication, send and receives to and from smartphone.	5V

Serial No.	Name	Model	Function	Operating Voltage
5	Dc Motor And Wheel	BLDC	Converts electrical energy into mechanical energy to rotate the wheel.	6 - 24V
6	Dc Converter	LM2576-5.0	Converts input DC voltage to output DC voltage	+12V to -5V
7	Lithium-Ion Battery	Li-ion 18650	Powers the entire system and support rechargeable operations	3.7V

3.2 Arduino Uno interraction with Ultrasonic Sensor

The positive VCC pin of the ultrasonic sensor is connected to the 5V pin on the Arduino.
The GND pin of the ultrasonic sensor is connected to the GND pin on the Arduino.
The TRIG pin of the ultrasonic sensor is connected to pin 9 on the Arduino.
The ECHO pin of the ultrasonic sensor is connected to pin 10 on the Arduino.

3.3 Arduino Uno interraction with Servo Motor

The positive VCC pin of the servo motor is connected to the 5V pin on the Arduino.
The GND pin of the servo motor is connected to the GND pin on the Arduino.
The signal pin of the servo motor is connected to pin 9 on the Arduino.

3.4 Arduino Uno interraction with Bluetooth Module

The VCC pin of the Bluetooth module is connected to the 5V pin on the Arduino.
The GND pin of the Bluetooth module is connected to the GND pin on the Arduino.
The TX pin of the Bluetooth module is connected to pin 10 on the Arduino.
The RX pin of the Bluetooth module is connected to pin 11 on the Arduino.

3.5 Driver Board interraction with Servo Motor

The power input of the driver board is connected to an external power source (e.g., a battery). The output of the driver board is connected to the servo motor. The sensor detects objects within a certain range and sends a signal to the Arduino uno that processes the signal as seen in Figure , which shows all the connections to the mainboard. Which processes the signal from the ultrasonic sensor and sends commands to the servo motor to open or close the dustbinlid. The servo motor moves the dustbin lid based on the commands received from the Arduino microcontroller.

Bluetooth Module: Allows for wireless communication between the Arduino and a smart phone or another device, enabling remote control or monitoring of the dustbin.

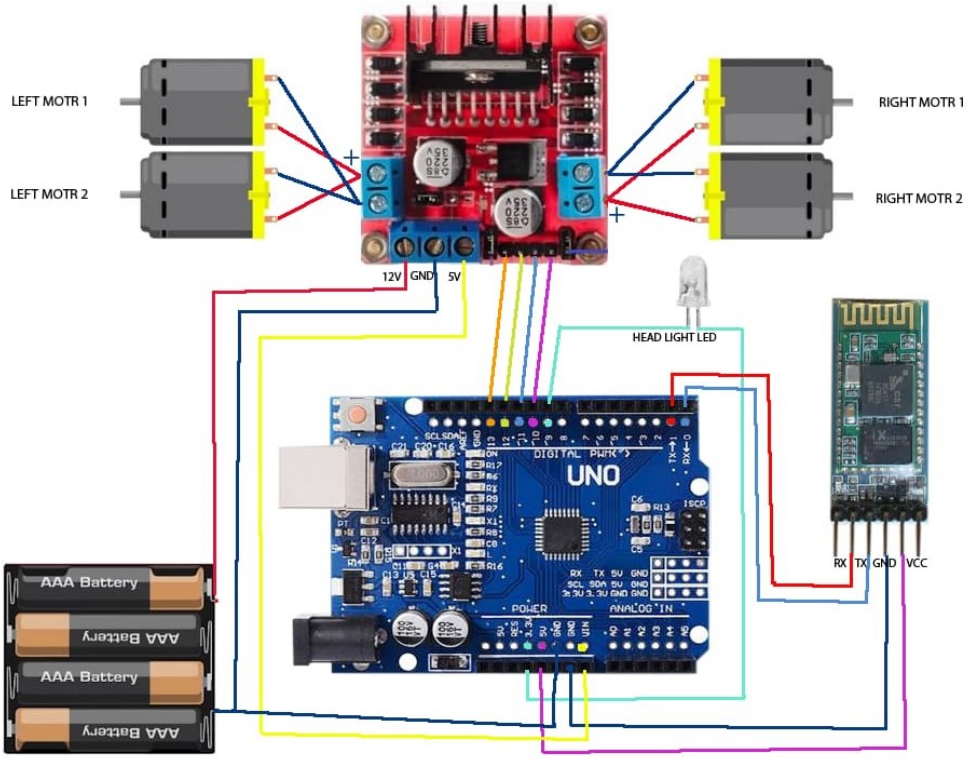

Figure 3: Connection from Arduino to other components

4. RESULT AND DISCUSSION

Autonomous car and automatic Dustbin works on the principle of object detection using an ultrasonic sensor under the control using Bluetooth module. The ultrasonic sensor transmits sound waves. These waves get reflected whenever an object comes into the vicinity of the sensor. This generates an electrical signal which is used to open the dustbin lid. The Bluetooth module is connected to the smartphone app which is then connected to move the dustbin to where it will be used and return it to its position.

(a) (b) (c)

Figure 4.(a,b,c): Smartbin with ultrasonic sensor, Smartbin with bluetooth enabled autonomous system and smartbin with component case.

5. CONCLUSION

The autonomous car with Automatic Dustbin with Arduino project is a simple yet innovative solution to improve waste management. It offers many advantages over traditional dustbins and can help maintain a clean and hygienic environment which is also easy to access with the help of autonomous cars. The project can be easily implemented with basic knowledge of electronics and programming.

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