REPORT

TRASH SORTING ROBOT

GROUP MEMBERS

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MODULE: ROBOTICS

Abstract

The trash sorting robot uses a TensorFlow deep learning framework called SSD MobileNet V2 to identify and sort three types of trash, which are paper, metal, and plastic. The system uses a Raspberry Pi, Arduino UNO, CNC shield, Nema 17 stepper motor, and a servo motor to obtain this capability. The robot is designed to be user-friendly and efficient, with the capacity to sort trash quickly and correctly.

The Trash Sorting Robot uses a progressive and sensible solution to the hassle of waste control. The deep learning-based computer vision algorithm is highly accurate and perceives the kind of trash with a high accuracy. The machine is also incredibly customizable, with the potential to feature new types of trash to the machine as wished.

Acknowledgement

We would like to express our thanks to the National Institute of Business Management – Kandy Innovation Centre for giving us this opportunity to work on a project like this through the robotics module. We also extend our special thanks to Mr. Thisara Ganegoda (BTech Eng (Hons) Mechatronics, AMIE(SL) for your guidance and support throughout the development of the Trash Sorting Robot.

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Introduction

In the current climate of rapid urbanization and growing environmental issues, the effective management of waste has become necessary for sustainable living. Traditional waste disposal methods are proving to be inadequate, mainly due to an increase in pollutants and ecological imbalances. The Trash Sorting Robot challenge emerges as a response to this assignment, leveraging modern-day technology to revolutionize waste sorting tactics.

The increasing quantity of waste, coupled with the need for recycling, brings the need for progressive solutions that go past manual sorting. Automation, mainly through the mixing of robotics and computer vision, offers a promising avenue for addressing those problems. Our mission focuses on creating a wise gadget able to recognize and segregate waste, thereby streamlining the recycling procedure.

The objective of the Trash Sorting Robot is mainly two: first, to identify and sort trash effectively, and second, to make a contribution to environmental sustainability by means of promoting effective recycling practices.

As we go through the innovative design, we aim to showcase the capacity impact of integrating robotics and computer vision in addressing actual-international demanding situations. The Trash Sorting Robot showcases a technological leap forward in waste management but also embodies a constant effort to mitigate the environmental footprint related to improper waste disposal. Through this assignment, we undertake to encourage a shift towards smart, automatic waste sorting structures that can be adapted globally for a cleaner and extra sustainable destiny.

Methodology

The methodology hired inside the development of the Trash Sorting Robot consists of an integration of hardware components, software program algorithms, and deep learning, transfer learning algorithms. The layout and implementation of the system are key to reaching efficient trash sorting. The following sections provide an in-depth breakdown of the methodology:

Hardware Configuration:

The basis of the Trash Sorting Robot lies in a carefully decided combination of hardware. The center setup consists of a Raspberry Pi serving because the brain of the machine, an Arduino UNO managing motor control thru a CNC shield, a Nema 17 stepper motor for bin rotation, and a servo motor for controlled trash disposal. The additives are interconnected to shape a cohesive system, and the bodily layout is optimized for practicality and simplicity of renovation.

1. Raspberry Pi 3B+

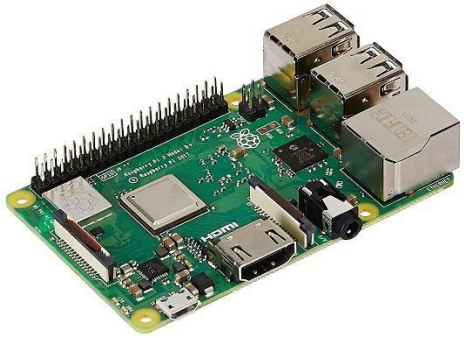


Figure 1: Rasberry Pi 3B+

Raspberry Pi acts as the main controller or the host device for the complete. This runs the machine learning model and a webcam is connected to the device which will give the input for the raspberry pi. From the input images raspberry pi will predict which type is the trash and transmit the output to the Arduino.

2. Nema17 Stepper Motor

Figure 2: NEMA17 Stepper Motor

The Nema 17 stepper motor is a electromechanical tool utilized in robotics and automation. Standard dimensions (1.7 inches or 43.2 mm square). This stepper motor operates with the aid of dividing a complete rotation into a series of steps, taking into consideration specific management of angular position. In the Trash Sorting Robot, the Nema 17 motor is used for rotating the trash bin to align the proper compartment to get the right waste.

3. Servo Motor

Figure 3: Servo Motor

A servo motor is a rotary actuator that provides unique control over angular function. It consists of a motor, a potentiometer for function remarks, and a manipulated circuit. In the Trash Sorting Robot, the servo motor is used to push the trash into the right compartment of the bin.

4. CNC Shield

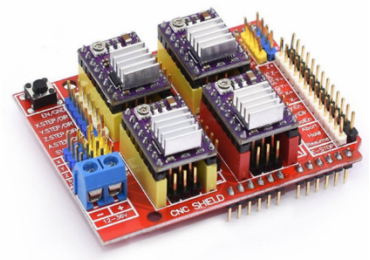


Figure 4:CNC Shield

The CNC (Computer Numerical Control) protect is an interface board that permits an Arduino microcontroller to govern stepper motors.Here,the CNC shield, coupled with the Arduino UNO, serves as

the bridge among the control algorithms and the Nema 17 stepper motor, facilitating the suitable rotation of the trash bin.

5. Web Cam

Figure 5:Web Cam

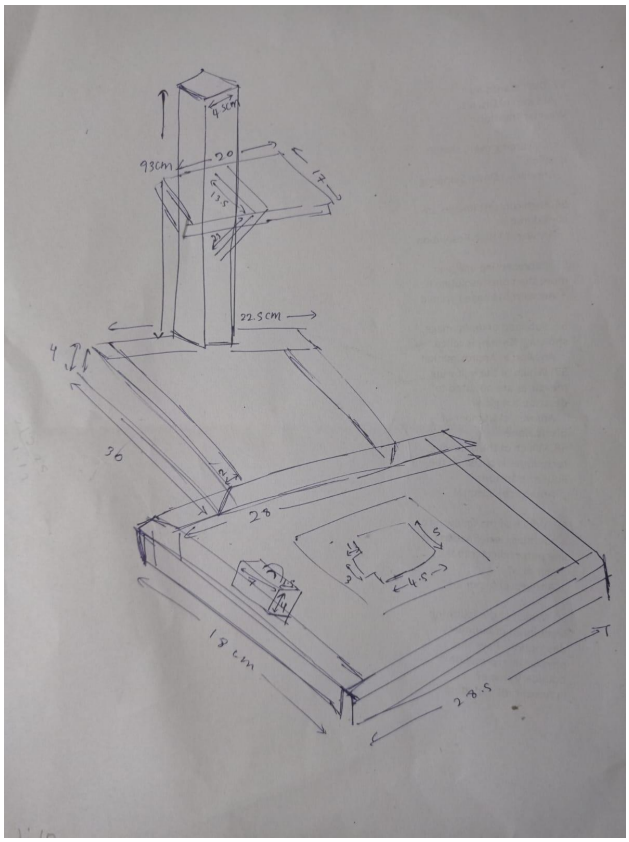
Digital camera connected to the Raspberry Pi that captures video. In the Robot, the webcam performs a critical position in shooting real-time photos of incoming trash gadgets. These images are then processed by means of the computer vision to perceive the sort of trash, beginning the sorting manner. The webcam acts as the eye of the machine, deciding what trash it is.

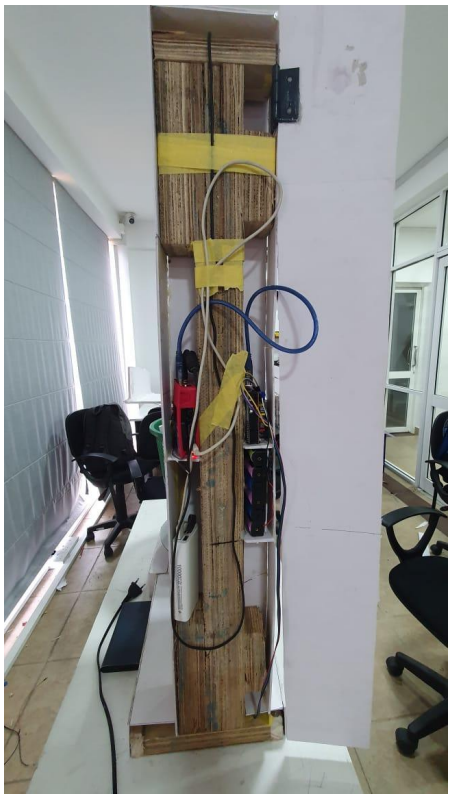
6. Arduino Uno

Figure 6:Arduino UNO

In the trash Sorting Robot, the Arduino UNO executes programmed commands to manage additives such as motors and sensors.

Design





Deep Learning Model Training

The heart of the trash identification procedure is a deep learning model implemented using TensorFlow's object detection framework. A comprehensive dataset containing pictures of plastic, metal, and paper were collected and trained. The model trained to appropriately understand and classify these objects in real-time. Iterative training and validation techniques have been carried out to enhance the model's accuracy and make certain dependable trash identification. We have used Azure cloud platform to do all the computationally demanding tasks.

To make the system faster we converted the TensorFlow model into a TensorFlow Lite model which uses far less resources than the original model.

Integration of Hardware and Software

The Raspberry Pi serves as the host device, responsible for coordinating the whole machine. It gets input from the camera module, identifies the trash from the video feed. Commands are then dispatched to the Arduino UNO, which controls the Nema 17 stepper motor via the CNC Shield to rotate the bin to the suitable compartment and turns on the servo motor to push the trash. The raspberry pi is connected with Arduino through a USB serial port so both devices can communicate and work with a minimum delay time.

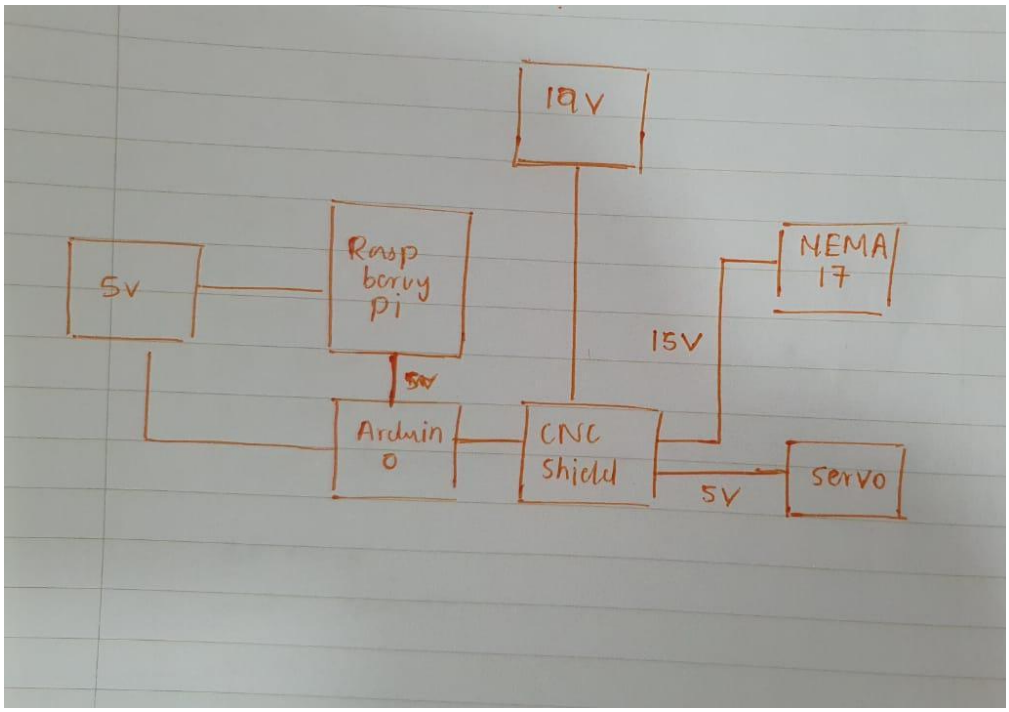
Trash Sorting Process

Upon the deposition of an object into the Trash Sorting Robot, the camera captures pics in real-time. The deep learning model uses those pictures, identifies the kind of trash, and relays commands to the Arduino UNO. The Nema 17 stepper motor rotates the bin, aligning the ideal compartment with the enter slot. Simultaneously, the servo motor opens the corresponding compartment, allowing the trash to be gently driven into its designated area.

Testing and Calibration

Rigorous trying out and calibration have been conducted to make certain the reliability and accuracy of the gadget. This includes tuning the motor control parameters, optimizing the deep learning model, and addressing any hardware-software integration troubles. The gadget underwent complete checking out with various types of trash items to validate its performance beneath various conditions.

Power Management:



Time Management

	14-16 NOV	16-20 NOV	20-24 NOV	24-30 NOV	01-04 DEC	04-08 DEC	08-11 DEC
1. Proposal Submission							
2. Initial Planning							
3. Finalizing Design and Methodology							
4. Creating the exterior design							
5. Collecting Images							
6. Training the deep learning model							
7. Testing hardware components							
8. Integrating and connecting the components							
9. Software Implementation							
10. Testing							
11. Fixing the errors							
12. Completing the whole design and project							

Budget

The budget for the hardware components has been quite high for this Trash sorting robot. The main costs were for the electronics that we had to purchase or borrow. Along with which the material and decorations had its cost as well.

Raspberry Pi V3 - Rs. 23,000

Arduino Uno - Rs. 3500

CNC Shield - Rs.2800

Stepper Motor - Rs. 2,900

Stepper Motor Driver - Rs. 600

Servo Motor - Rs.560

Wood - Rs. 4500

Form Board - Rs.6000

Bearings - Rs. 480

Webcam - Rs. 5200

Battery pack 19v Rechargeable - Rs. 1300 * 6

wiring - Rs. 350

Other costs - Rs. 5760

Total Cost - Rs. 63,450

Discussion

The discussion section delves into the performance, challenges, and broader implications of the Trash Sorting Robot venture. Here, we analyze the key components of the gadget, providing insights into its effectiveness and regions for ability improvement.

1. Deep Learning Model Accuracy

The heart of the Trash Sorting Robot lies in its capability to identify and classify the kind of trash. The deep learning model uses TensorFlow's object detection, established good accuracy. However, it is vital to know the continuous evolution of the version to accommodate a broader range of trash items and environmental conditions. Fine-tuning and increasing the dataset can further enhance the version's accuracy, making sure dependable sorting throughout diverse eventualities.

2. Hardware Responsiveness

The integration of the Nema 17 stepper motor and servo motor showcased strong responsiveness throughout the sorting method. The particular rotation of the trash bin and managed operation of the servo motor contributed to the gadget's normal performance. However, calibration demanding situations have been encountered to begin with, emphasizing the significance of meticulous parameter adjustment. Future iterations may want to discover superior motor control algorithms to optimize overall performance similarly.

3. Environmental Impact and Sustainability

The Trash Sorting Robot addresses the pressing issue of sustainable waste management. By automating the sorting process, the system contributes to green recycling practices. However, it is critical to bear in mind the broader environmental effect, inclusive of the lifestyles cycle of additives, energy intake, and recyclability. Future iterations should discover green materials and energy-green additives to align with sustainability goals.

4. Scalability and Integration

The scalability of the Trash Sorting Robot for broader waste control applications became a focus of dialogue. While the prototype correctly handles plastic, metallic, and paper objects, scalability considerations must discover accommodating additional waste categories. Moreover, integrating the Trash Sorting Robot with present waste management structures or deploying it in public areas calls for cautious consideration of logistical and regulatory demanding situations.

Future Implementations

The success of the Trash Sorting Robot venture lays the muse for future enhancements and expansions. Here, we discover ability avenues for development and further capabilities that might in addition elevate the competencies and impact of the system:

1. Advanced Deep Learning Model

Continuous refinement and expansion of the algorithm and getting to know versions are important for accommodating a broader range of trash gadgets. Future implementations need to be aware of increasing the dataset length and variety to extend the version's accuracy and generalization. Additionally, exploring superior algorithms, architectures and techniques, which includes switch mastering, can make a contribution to a much better and adaptable trash identification machine.

2. Incorporation of Sensor Fusion

To increase the Trash Sorting Robot's abilities, integrating additional sensors for environmental monitoring may be taken into consideration. Incorporating technology like infrared sensors or weight sensors can provide supplementary information for greater accurate trash identity. Sensor fusion can decorate the device's reliability and adaptability in one-of-a-kind running conditions.

3. Cloud Integration for Data Analytics

Implementing cloud-based statistics analytics can offer valuable insights into waste composition and sorting styles. By importing records from more than one Trash Sorting Robot to a centralized cloud platform, municipalities and waste control authorities can benefit from a complete understanding of waste developments, permitting statistics-pushed choice-making and optimization of waste collection routes.

4. Mobile Application for User Interaction

Enhancing user interaction may be carried out by way of growing a dedicated mobile application. This utility could provide customers with real-time updates, or even gamify the recycling process to encourage participation of people. A consumer-friendly app could make a contribution to increased recognition and engagement with the waste sorting initiative.

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