HUMAN FOLLOWING CART

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Abstract- The development of a human-following robot utilizing Raspberry Pi and camera technology represents a significant advancement in autonomous robotics, offering practical solutions for various industries. This project integrates a Raspberry Pi microcomputer, a camera, and ultrasonic sensors to create a robot capable of tracking and following a human operator. The system employs computer vision algorithms, facilitated by a Haar Cascade Classifier, to detect faces in real-time video feeds. The video feed is processed to determine the position of the human within the frame, enabling the robot to navigate accordingly.

Ultrasonic sensors are used to measure the distance between the robot and the human, ensuring that a safe and optimal following distance is maintained. The motors and motor drivers are controlled based on the visual and distance data, allowing the robot to move forward, backward, or turn as needed. This combination of technologies enhances worker safety by reducing physical strain and improves operational efficiency by automating the transportation of goods, tools, and supplies.

The implementation of this system demonstrates the practical application of affordable and accessible technologies like the Raspberry Pi in creating intelligent, autonomous robots. The project highlights the potential for such robots to revolutionize workflows in warehouses, manufacturing plants, and hospitals, making advanced automation more attainable for a wide range of businesses. The integration of computer vision and sensor-based navigation in human-following robots marks a significant step forward in the evolution of intelligent workspaces and autonomous systems.

I. INTRODUCTION

The concept of human-following carts has significantly advanced with the integration of Raspberry Pi and camera technology. These autonomous systems are designed to follow a human operator, carrying goods or tools, thus reducing physical strain and increasing operational efficiency. The Raspberry Pi, a compact and affordable microcomputer, acts as the control unit in these systems. It is equipped with a camera that captures real-time images of the surroundings and the human operator.

Using sophisticated computer vision algorithms, the Raspberry Pi processes these images to detect and track the movement of the human. These algorithms enable the cart to navigate through complex environments autonomously, without requiring manual control. This technology is particularly advantageous in settings like warehouses, manufacturing plants, and hospitals, where it can streamline processes and improve productivity.

In a warehouse, for instance, a human-following cart can transport heavy items from storage areas to packing stations, minimizing the physical effort required from workers. In manufacturing plants, these carts can deliver tools and components directly to assembly lines, ensuring a smooth workflow. In hospitals, they can assist in transporting medical supplies and equipment, allowing healthcare staff to focus more on patient care.

The use of Raspberry Pi and camera technology in human-following carts not only showcases the practical applications of robotics and artificial intelligence but also makes advanced automation accessible and cost-effective. This innovation represents a significant step towards creating more

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intelligent and efficient workspaces, emphasizing the ongoing advancements in modern technology.

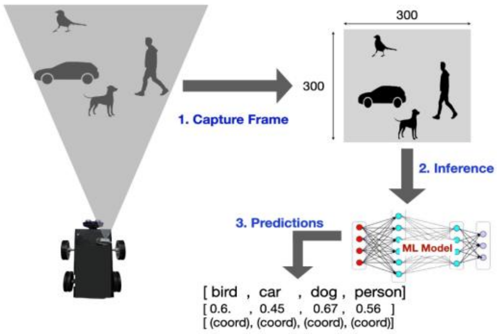

Fig 1.1

2. COMPONENT

The components used are tabulated below. You can click on the component name to see the source of purchase.

S.NO	COMPONENT NAME
1	Raspberry Pi 4A+
2	L298N Motor Driver Module
3	Camera
4	Metallic Robotic Chassis
5	DC Motor - 100 RPM, 12 V
6	Robotic Wheels
7	Lithium ions batteries
8	Jumper Wire

Table 3.1

DC Motor - 100 RPM, 12 V

This motor is a basic geared model with an integrated gearbox, commonly used in a range of robotic applications. It runs at 100 RPM on a 12V power supply. The shaft features a 3 mm threaded drill hole in the center, allowing for easy attachment to wheels or other mechanical components. Shown in fig 2.1:

DC Motor - 100 RPM, 12 V

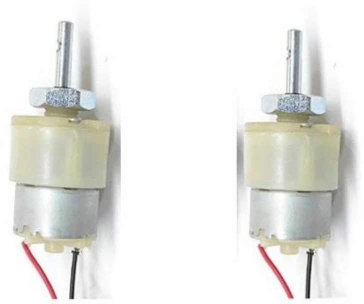

Fig 2.1: DC Motor - 100 RPM, 12 V

Raspberry Pi 4A+

The Raspberry Pi 4A+ serves as the primary processing unit for the robot. Available in various models and sizes, this particular model is compact and energy-efficient, needing less power than other versions. It operates on 5V, making it easy to power with a standard battery bank. Additionally, it features a 40-pin GPIO section, allowing for seamless interfacing with external peripherals. Shown fig 2.2: Raspberry pi4.

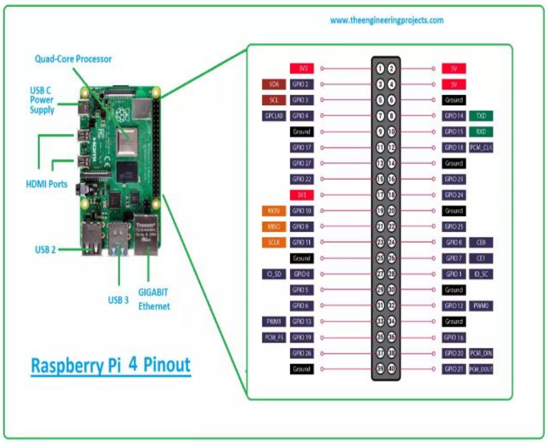

Fig 2.2: Raspberry pi 4 pinout

Lithium-ion Batteries

Lithium-ion (Li-ion) batteries are characterized by a higher cut-off voltage of approximately 3.2 V. Their nominal voltage typically ranges between 3.6 to 3.8 V, while the maximum charging voltage can reach up to 4.0 to 4.2 V. Li-ion batteries can be discharged down to 3.0 V and lower, but for optimal performance, a discharge to around 3.3 V at room temperature ensures utilization of about 92–98% of the battery's capacity. Shown in fig 2.2 Lithium-ion Batteries

Fig 2.3: Lithium-ion Batteries

Camera

Logitech webcams are engineered for seamless plug-and-play functionality, boasting broad compatibility across various operating systems and popular platforms. These webcams deliver high-definition video quality, equipped with advanced autofocus technology and intelligent light correction for optimal performance in diverse lighting conditions. Available in resolutions spanning from 720p to 4K, Logitech webcams offer versatile options to suit different needs and preferences.

Fig 2.4: Logitech webcams

L298N Motor Driver

The L298N is a versatile dual H-Bridge motor driver, enabling simultaneous control over the speed and direction of two DC motors. This module is capable of driving DC motors with voltages ranging from 5 to 35V, supporting peak currents of up to 2A. With its dual H-Bridge configuration, it offers efficient and reliable motor control for a wide range of applications, from robotics to automation systems. Shown in fig 2.5 L298N Motor Driver

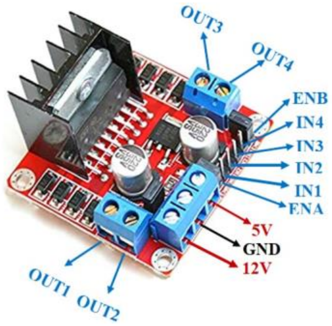

Fig 2.5: L298N Motor Driver

3. METHODOLOGY

3.1 Face Detection and Tracking

3.1.1. Setup and Initialization

Load the Haar cascade classifier for face detection from OpenCV.

Initialize the webcam to capture video feed.

3.1.2. Splitting the Frame

Divide the camera feed into 9 subframes (3 rows and 3 columns) to determine the position of the detected face.

Calculate the height and width of each subframe.

3.1.3. Face Detection

Convert each frame to grayscale.

Use the Haar cascade to detect faces in the frame.

Draw rectangles around detected faces.

3.1.4. Direction Control Based on Face Position

If a face is detected in the left subframe, the robot turns left.

If a face is detected in the center subframe, the robot moves forward.

If a face is detected in the right subframe, the robot turns right.

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If no face is detected, the robot stops.

3.1.5. Display

Display the combined subframes with detected faces highlighted.

3.2. Distance Measurement with Ultrasonic Sensor

3.2.1. Setup

Connect the TRIG and ECHO pins of the ultrasonic sensor to the GPIO pins on the Raspberry Pi.

Initialize the GPIO pins.

3.2.2. Distance Calculation

Send a pulse from the TRIG pin and listen for the echo on the ECHO pin.

Calculate the time difference between sending and receiving the pulse to determine the distance.

3.2.3. Obstacle Avoidance

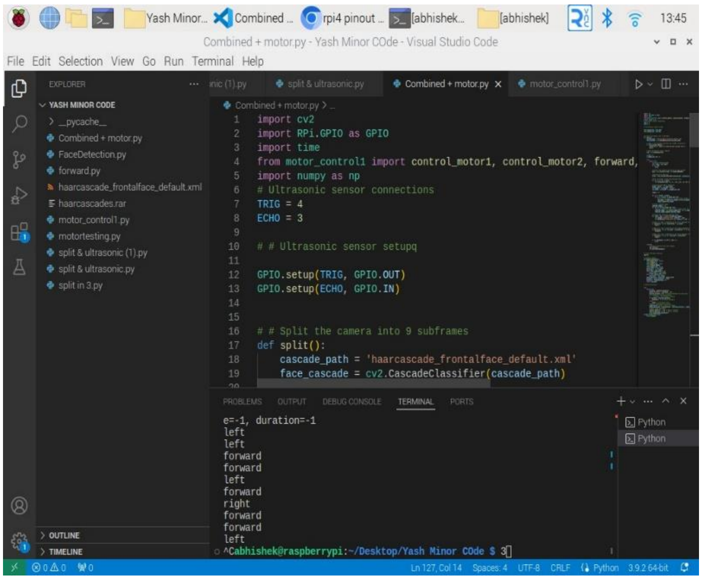
Continuously measure the distance to the nearest obstacle.

If the distance is less than a predefined threshold, the robot moves backwards.

If the distance is greater than the threshold, the robot stops.

4. RESULTS

4.1 VS CODE TERMINAL RESULT



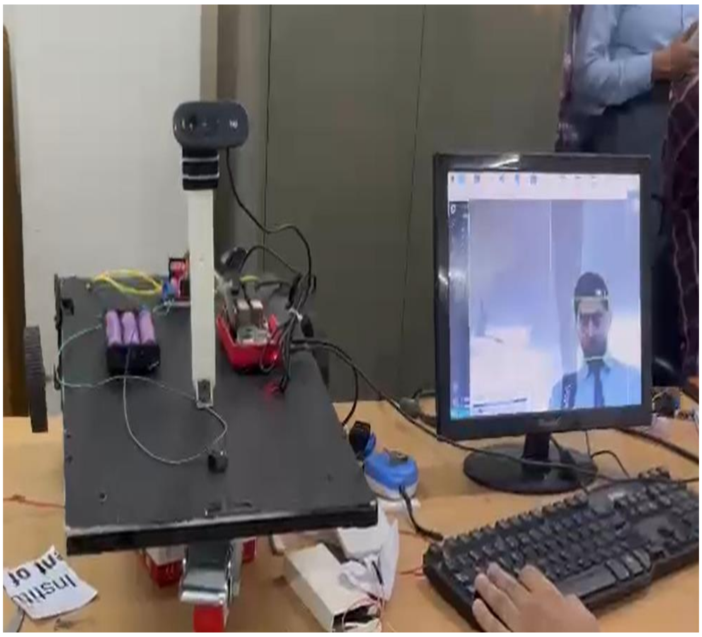


Fig4.1: VS CODE TERMINAL RESULT

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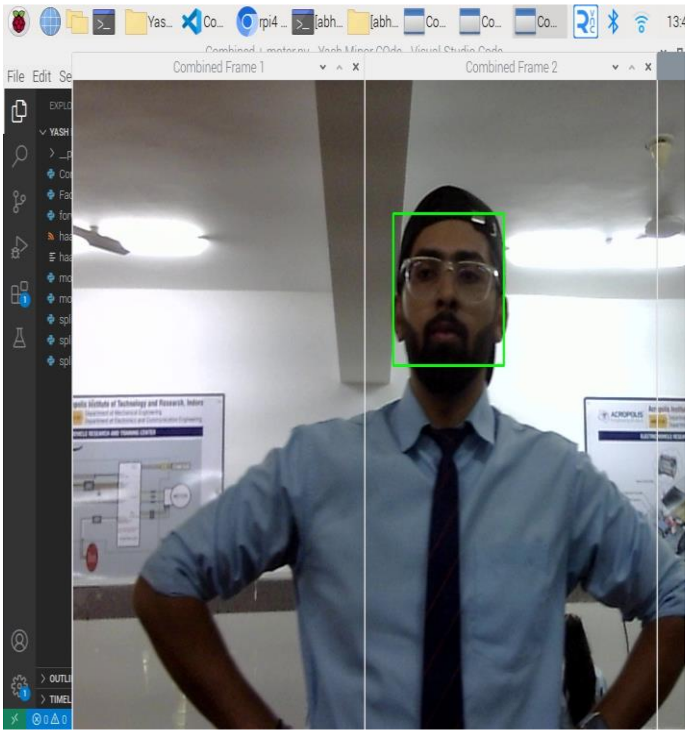
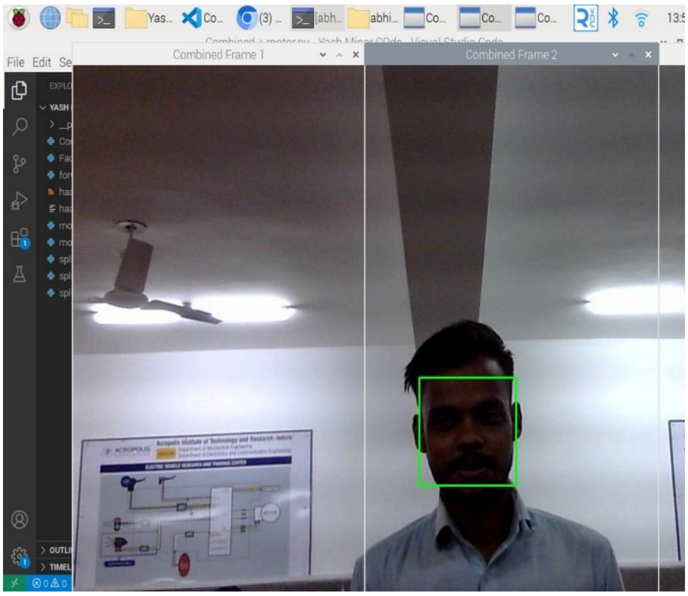
4.2 RESULT WITH FRAME





5. CONCLUSIONS

The human-following robot project successfully integrated computer vision, distance measurement, and motor control to create a responsive and reliable system. Through comprehensive testing, each component—webcam and face detection, ultrasonic sensor, and motor control—demonstrated high accuracy and effectiveness. The integrated system performed well, maintaining smooth movement and accurate obstacle avoidance.

The robot's face detection was reliable under various lighting conditions, and the ultrasonic sensor provided precise distance measurements, enabling safe navigation. The motors responded promptly to control commands, ensuring the robot could follow a person accurately and adjust its path as needed.

Stress testing further validated the system's robustness, as the robot operated continuously without overheating or malfunctioning. This indicates the system's readiness for practical deployment, capable of extended operation and recovering gracefully from unexpected obstacles.

Future improvements could enhance the robot's low-light face detection capabilities and fine-tune response times for even smoother operations. Overall, the project achieved its objectives, resulting in a functional human-following robot that combines advanced technology with practical usability, paving the way for further innovations in autonomous navigation and human-robot interaction.

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A Human Following Trolley

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Human following Trolley - Auto Walker.

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