

Intelligent Robotics Using Microelectronics Exploring the Future of Smart Machines

Mrudula Kandalkar^{1,*}, Arya Deshpande², Sakshi Kulkarni³

Abstract

In the past few years, robotics technology has made remarkable progress. To assist humans in their work, robots that can recognize and track people are required; as a result, tools like the “Human Following Load carrier” that can converse and live with people must be created. Localizing the robot and its surroundings is one of the primary obstacles to enabling the robot to do different jobs in the real world. A robot needs to have sophisticated navigational abilities to track a person through traffic, in busy regions, and in both indoor and outdoor environments. The following robot, which can carry objects in addition to humans, is what the project aims to build. It can be used in farms, shopping malls, building sites, and airports. Ultrasonic sensors detect the human target's presence and distance, with the Raspberry Pi Pico processing this data to determine the target's position. An algorithm adjusts the robot's speed and direction through pulse-width modulation signals to the DC motors. The integration of the Raspberry Pi Pico with the sensors and motors is optimized for precise control and reliable performance. Testing in various indoor scenarios demonstrates the robot's ability to consistently follow a human target and navigate around obstacles effectively. Future enhancements will focus on system robustness, advanced sensor fusion techniques, and outdoor functionality. A microcontroller, or microprocessor, is the device that runs the entire system.

Keywords: Human following, trolley, Raspberry Pi Pico, sensors, obstacles avoidance

INTRODUCTION

These days, robotics and automation are widely used terms. We can picture a world run by machines in the future. We require an automated device everywhere we go. such as voice or smartphone-controllable automatic doors, automatic fire protection, and automatic appliances. A robot can readily perform a task where there is a significant risk to a human's life. While a living thing's energy and adaptability are limited, a robot never runs out of power. We find it to be quite efficient, and we also save a lot of time. The robot is a frequent and interesting object in our minds. Assistance or help is now required. An alternative solution to this issue could be a human-following robot.

The enormous potential of human-following robots to do routine chores like weight carrying and target individual monitoring through interaction and collaboration is the subject of active research. By using the sensors for human detection, human movement estimate, collision avoidance, and obstacle avoidance, more user-friendly robots that are prepared to live with people have been made possible by recent developments in vision and sensor technologies. Feynman's vision of tiny machines, which dates back several decades, has sparked a great deal of materials science, robotics, and computer science research. The area of miniaturized robotics has grown quickly in recent years, and various research groups have contributed to the

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many difficulties that this field entails. Because they have allowed for the development of smaller robots with unique functions and new features, smart materials have been especially significant. Nevertheless, despite all the attempts, a completely autonomous system-engineered miniaturized robot (SEMR) of any practical significance has not yet been built, despite the abundance of readily available soft materials and cutting-edge technologies.

A cutting-edge area of study that has drawn a lot of attention lately is humanoid robots. The field of robotics research will remain crucial to many electronics applications well into the twenty-first century. Robots that can interact and coexist with humans, like "A Human Following Robot," are necessary in this fast-paced society. It can assist us and carry out our commands. Additionally, it aids in a variety of vocations, including industry, subterranean work, construction, space exploration, and medical and military uses.

LITERATURE SURVEY

Using IoT, the Gujar et al. initiative allowed to develop several low-cost innovations that will benefit greatly. their smartphone and their robot may be readily connected with the help of Arduino and a Bluetooth module. It gets easier to use with the aid of the established connection. The project implemented the source code in the Arduino microcontroller using the Arduino IDE. They can interface their smartphone with their robot by using the HC-05 Bluetooth Module. The Arduino will then transmit commands to the L298N Motor Driver IC, which will interface with the motors and facilitate even easier movement [1].

To create a single, better estimate of position and orientation, several different sensor readings are combined in a unique wireless two-dimensional position and orientation estimation and tracking technique published by Akbar et al. This technique exemplifies the idea of sensor fusion. A 5.8 GHz RFID system with three readers and a customized tag containing a three-axis accelerometer, three-axis gyroscope, and three-axis magnetometer is used to accomplish the technique. Backscattered data packets offer measurements of the tag's linear accelerations, angular velocities, and orientations. Received signal intensities and packet-to-packet phase changes at the reader are utilized to determine radial tag positions and radial tag velocities [2]. A novel approach called MRLIHT Mobile RFID (M-RFID)-based Localization for Indoor Human Tracking was presented by Qian et al. Real-time indoor location tracking is implemented successfully and affordably by MRLIHT, based on the M-RFID model, in which RFID tags are fixed and disseminated throughout the monitoring area and RFID readers are mounted on moving objects (humans). MRLIHT first creates the response areas of tags for the reader based on the readings of numerous tags identified by an RFID reader concurrently. The reader's possible geographic zone is then identified using MRLIHT, and two algorithms are developed there. Ultimately, MRLIHT determines the reader's location by segmenting the reader's possible location region into more precise grids [3].

The main objective of Hasan et al.'s work was to develop and build a robot that could track a target while simultaneously moving in its direction. A special handcrafted tag was put on the person the robot needs to follow in order to simplify things. The primary challenge with this type of work is that target detection is an extremely delicate process. For the robot to identify the object and accomplish the task, it must be distinct. This uniqueness issue is resolved by the simple tag, which also makes the process reasonably simple. The video is captured by a tiny camera, and the processor then analyzes it to extract the relevant data [4].

According to Subramanian et al.'s work, the variation in the moving object's axis level facilitates the acquisition of a control signal via Lab VIEW image processing code that is transmitted wirelessly to the Arduino board. The LabVIEW-VDM program is used to process the object's snapshot photos. The robot receives the appropriate commands (coordinate details) to follow the moving color item based on the movement in its position. The goal of this project was to create a tiny, mobile robot that could track an object in motion. Here, we take pictures of the colored moving item using a mobile device's camera or webcam [5].

A human-following robot system that made use of an ultrasonic sensor was presented by Tai et al. For a human following robot, an ultrasonic sensor is favored over a laser range finder (LRF) or camera because of its large detecting area, less reliance on light, capacity to detect glass and shiny walls, compact size, light weight, low memory usage, and lower power consumption. But because it's a specular sensor rather than tightly focused, it can lead to inaccurate human estimation and recognition, particularly at the legs. As a result, the corresponding algorithms required to address this problem should be created. This mobile robot platform has three pieces of 40 kHz ultrasonic sensors installed on it [6]. Myungsik et al. created a standalone RFID reader with direction-finding capabilities for mobile robot applications that use dual-directional antennas. With the current state of RFID technology and search and localization capabilities added, robots will be able to locate and dock to a static target in an actual area without the need for a map or landmarks. Additionally, we showcase RFID-enabled monitoring and following of an unpredictable-moving target using a mobile robot. The dual-directional antenna on the robot faces the target transponder, and it is the RFID reader that informs it of the direction of arrival (DOA) of the signal of interest [7]. Theja et al. solely work with a human-following robot that uses an RFID and a metal to identify its owner and follow them. various settings like clinics, schools, and retail centers. For most of us, having a robot helper sounds like a pipe dream. A robot that can assist us with carrying things, go shopping with us, or run with us in the park. A robot that can assist hospital nurses or carry medical supplies to wounded soldiers in times of conflict. Such robots have so many benefits that they will probably become popular in the future [8].

Huang et al. provided a thorough overview of the cutting-edge technologies utilized to infuse micromachines with intelligence. They also shed light on how to build next-generation intelligent micromachines that can adapt to a variety of situations and are intended for application in new sectors [9].

A thorough literature overview of the topic of reconfigurable and intelligent machines was published by Molina et al. The presentation of pertinent research concerns pertains to the creation and introduction of tools for reconfigurable machines [10]. The foundation of SEMRs is covered in the review by Bandari et al. [11], along with the identification of six key areas (structure, motion, sensing, actuation, energy, and intelligence) that call for extra work to advance SEMRs. Miniaturized robotics research over the last ten years has mostly centered on fabrication and design simplicity. A detailed analysis of the physical, mechanical, and electrically constructed SEMRs on the market today reveals a number of shortcomings with regard to self-sufficiency, full-scale integration, and miniaturization. This review has highlighted a few of these problems. Unavoidably, some remain unexplored, paving the way for the development of the upcoming generation of intelligent, self-operating SEMRs.

PROPOSED WORK

The block diagram illustrated in Figure 1 shows the architecture of a human-following robot. It includes three ultrasonic sensors connected to a Raspberry Pi Pico microcontroller. These sensors detect the presence and measure the distance to a human target, providing essential input data to the microcontroller. The Raspberry Pi Pico processes this data to determine the appropriate movement and direction for the robot. It then sends control signals to a motor driver, which adjusts the power supplied to the DC motors. The DC motors, in turn, drive the robot's wheels, enabling it to follow the human target and navigate around obstacles effectively.

Hardware Specifications

Raspberry Pi Pico

The central microcontroller that processes the input data from the ultrasonic sensors. It interprets the distance measurements and determines the required movement and direction for the robot to follow the human target. The Raspberry Pi Pico sends control signals to the motor driver as shown in Figure 2.

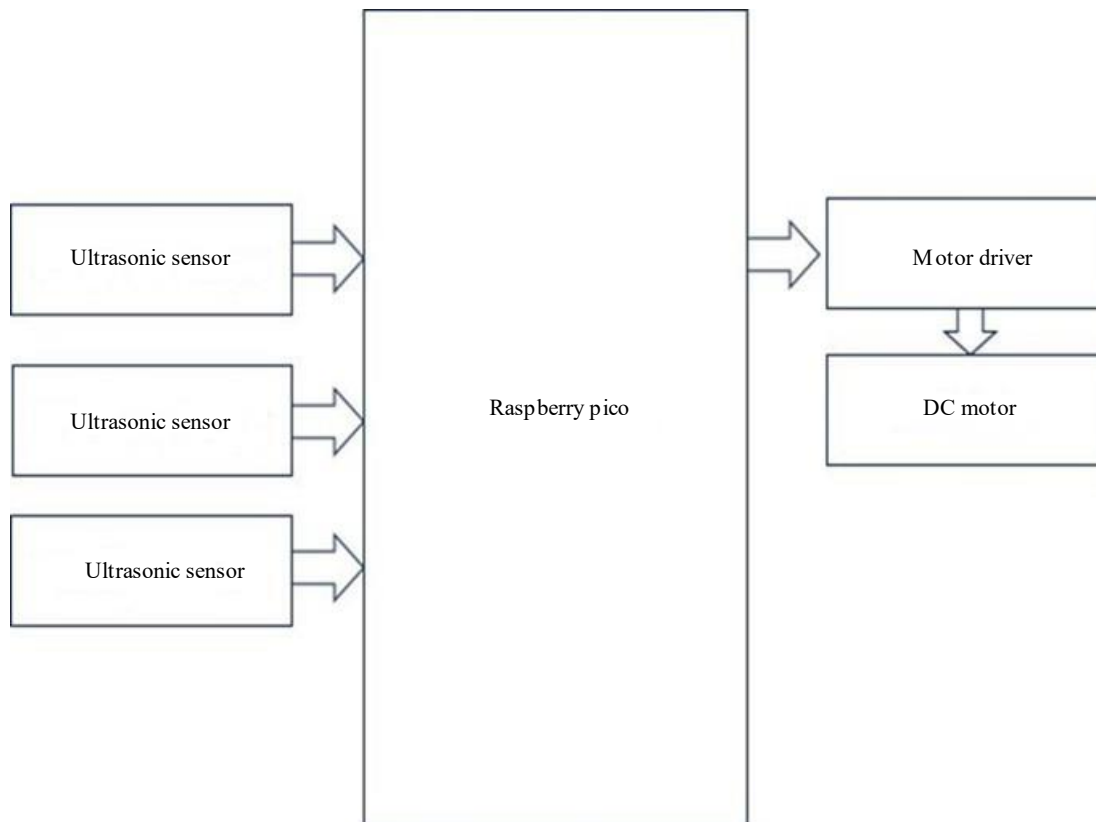


Figure 1. Block diagram of proposed system.



Figure 2. Raspberry Pi Pico.

Ultrasonic Sensor

The excellent non-contact range detection with high precision and steady results provided by the HC-SR04 ultrasonic range sensor is based on the premise of using sonar to estimate the distance to an item. The microcontroller and sensor are connected. Because an ultrasonic sensor emits sound waves as shown in Figure 3 rather than light waves like an infrared (IR) sensor does, it is deemed suitable for outdoor applications despite sunlight intensity.

Motor Driver

The vehicle is driven by an L293D dual H-bridge motor driver, as shown in Figure 4, which regulates its direction and speed. The module can operate a DC motor with an output voltage between 5 and 35 volts and a maximum energy of up to 2 amps. The microcontroller and DC motor (wheels) are connected by a motor driver. It regulates wheel motion in accordance with the microcontroller's instructions.

DC Motor

Typically, a gear box is linked to a DC motor to facilitate wheel spinning. The wheel is assisted in rotating gently to cover the grass to be chopped by a DC motor running at 30 rpm. For the four wheels, we used two DC gear motors. The 5 mm DC motor shaft has a 3 mm drilled hole in it, as shown in Figure 5. It is then put into the holes in the chassis and secured with threads. We made shafts strong enough to support the chassis' weight.



Figure 3. Ultrasonic sensor.

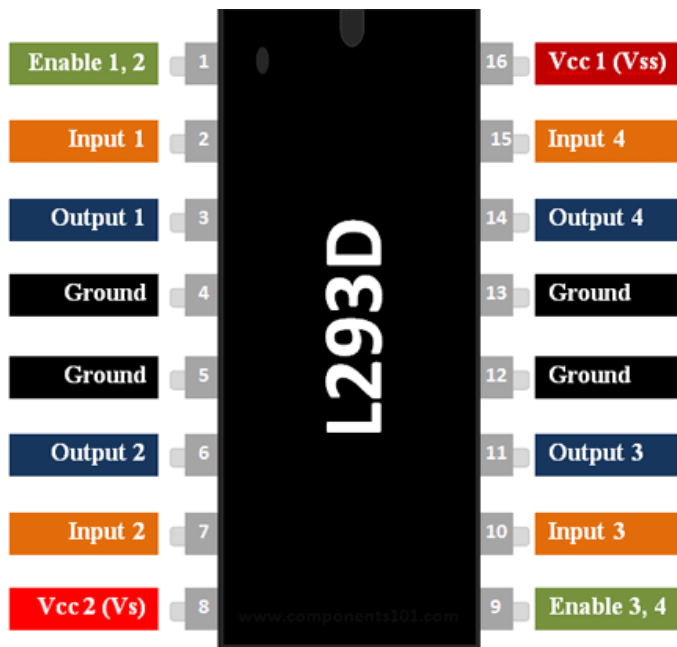


Figure 4. L293D motor driver IC.



Figure 5. DC motor.

RESULT DISCUSSION

A revolutionary period in technology is being ushered in with the development of smarter, more powerful machines thanks to the merging of intelligent robotics and microelectronics. These developments could have a big impact on a lot of different industries, such as manufacturing, healthcare, home applications, and autonomous systems. This paper explores the use of microelectronics in intelligent robotics, emphasizing recent advancements, difficulties, and potential applications. The simulation result is presented in Figure 6.

Microelectronics' Place in Robotics

Intelligent robots are largely dependent on microelectronics, which is the creation and use of incredibly small electronic components. Microprocessors, sensors, actuators, and communication modules are examples of important parts. These components are necessary for modern robots to be able to perceive, process, and act.

Microprocessors

Managing intricate calculations, data processing, and control algorithms, microprocessors act as the brains of intelligent robots. Robotic systems can operate more efficiently and with more computing power thanks to developments in microprocessor technology, such as multi-core and neuromorphic circuits.

Sensors

Sensors provide robots the ability to sense their surroundings, gather information, and decide what to do. Compact, high-precision sensors for vision, touch, motion, and environmental monitoring have been developed as a result of microelectronic developments. These sensors are essential for jobs demanding a high degree of autonomy and interaction.

Actuators

Accurate control of robotic movements and actions is made possible by microelectromechanical systems and other microelectronic actuators. These actuators are essential for a wide range of applications, from industrial automation to delicate surgical robotics.

Communication Modules

Real-time data sharing between robots and other systems is made possible by wireless communication technologies that are driven by microelectronics. Swarm intelligence, collaborative robotics, and Internet of Things (IoT) integration all depend on this interconnectedness.

The integration of microelectronics is driving several innovative developments that will shape intelligent robotics in the future. These include the following:

- *Advances in sensitive automation:* The integration of microelectronics is driving several innovative developments that will shape intelligent robotics in the future. These include the following:
- *Autonomous systems:* Thanks to developments in microelectronics, autonomous vehicles, unmanned aerial vehicles, and robotic delivery systems are becoming more dependable and effective. Decision-making, obstacle avoidance, and real-time navigation are made possible by high-performance sensors and CPUs.
- *Interaction between humans and robots:* Advances in microelectronics allow robots to comprehend and react to human emotions, gestures, and commands. Applications in customer service, education, and healthcare depend on this advancement.
- *Wearable robots:* Microelectronic-powered exoskeletons and other wearable robotic devices help people with mobility problems and enhance human capabilities in industrial contexts.
- *Swarm robotics:* Drawing inspiration from the natural world, swarm robotics combines the cooperation of numerous robots to accomplish intricate tasks.

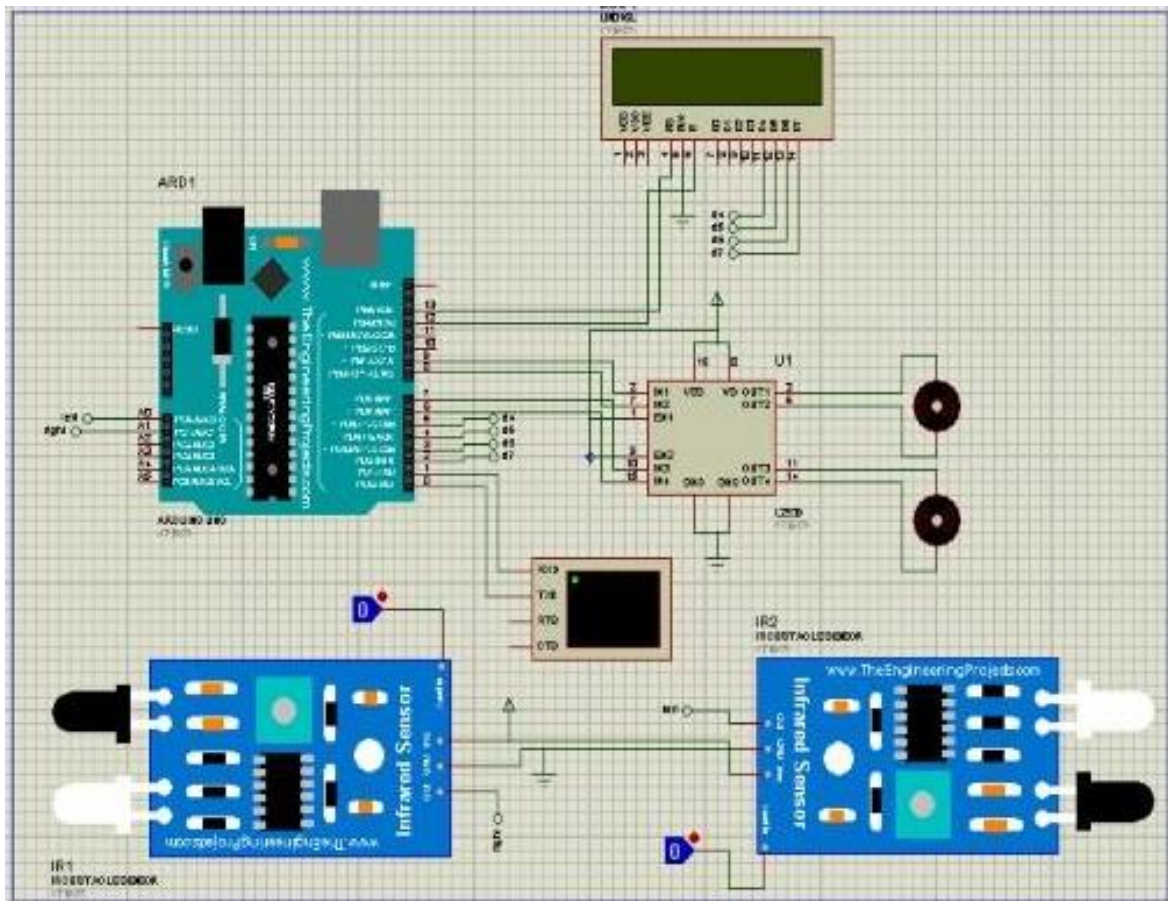


Figure 6. Circuit diagram.

CONCLUSION

This innovative system seamlessly combines advanced sensing technology with precise motor control to create a versatile and practical solution. Through the integration of the ultrasonic sensor, the robot is able to accurately detect and track the movement of a human target, fostering seamless interaction and enhanced usability. The Raspberry Pi Pico serves as the central processing unit, orchestrating the functionalities of the system with efficiency and reliability. Moreover, the utilization of DC motors enables smooth and responsive movement, ensuring optimal performance in varied environments. Overall, this project not only showcases the potential of low-cost microcontrollers in robotics but also paves the way for the development of more sophisticated autonomous systems capable of navigating dynamic surroundings with agility and precision.

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