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Autonomous Library Assistant

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Abstract: This project presents the design and development of an Autonomous Library Assistant Robot designed to help disabled people locate book sections inside a library. In large libraries, physically searching for books is difficult for people with disabilities and can take a long time without assistance. The proposed system uses an ESP32 microcontroller with WiFi communication to receive commands from a web-based interface developed using HTML. The robot moves using two 12V planetary gear motors controlled by BTS7960 motor drivers and follows predefined paths using a 5-channel IR sensor array. The user selects the required subject from the web application running on Raspberry Pi, and the robot moves forward to guide the user to the desired section. This system reduces manual effort, improves accessibility, and demonstrates the use of robotics in assistive and smart library automation.
Keywords: Robot, Assistive Robot, ESP32, Library Automation, Line Following, WiFi Control, Disabled Assistance.

I. INTRODUCTION

In large libraries contain many book racks arranged in different sections, which makes it difficult for users to locate the required books quickly. This problem becomes more serious for disabled people, elderly users, or individuals with limited mobility who may find it difficult to move freely inside the library without assistance. Although modern libraries provide digital catalog systems to search for books, these systems only display the rack number or section name and do not help the user physically reach the required location. This increases the dependency on library staff and makes the process time-consuming.

With the advancement of robotics and embedded systems, autonomous mobile robots can be used to improve accessibility and automation in indoor environments. Robots are widely used in industries, hospitals, and warehouses for navigation and transportation purposes. However, such systems are usually costly and complex, making them unsuitable for small institutions. Therefore, a simple and low-cost assistive robotic system is required to help users, especially disabled people, to navigate safely and easily inside a library.

In this project, an Autonomous Library Assistant Robot is proposed to guide users automatically to different book sections. The robot is controlled using an ESP32 microcontroller which provides both processing capability and WiFi communication. A web-based interface developed using HTML,runs on a Raspberry Pi and allows the user to select the required subject or book category. The selected command is sent wirelessly to the robot through the local network.

The robot moves along a predefined path using a line-following technique with the help of a 5-channel IR sensor array. Two 12V planetary gear DC motors controlled by BTS7960 motor drivers are used for smooth and stable movement. The system is designed to be low cost, reliable, and suitable for indoor environments such as libraries, hospitals, and smart campus buildings. The proposed robot reduces manual effort, improves accessibility for disabled users, and demonstrates the practical application of robotics in assistive and smart library automation.

II. SYSTEM METHODOLOGY

The Autonomous Library Assistant Robot works based on wireless command control and line-following navigation.

1) User Interface and WiFi Communication: A web-based interface is created using HTML, CSS, and JavaScript and runs on Raspberry Pi. The user selects the required subject using the interface. The command is sent to ESP32 through WiFi using the IP address.
2) Motor Control System: The robot uses two 12V planetary gear DC motors for movement. BTS7960 motor drivers are used to control the motors because they support high current. The ESP32 sends control signals to the motor driver to move the robot forward, stop, or turn.
3) Line Following Navigation: A 5-channel IR sensor array is used for line-following navigation. A black line is drawn on the floor to represent the path to different book sections. The IR sensors detect the line and send signals to the ESP32.

4) Safety and Obstacle Handling: While moving, the robot checks for obstacles in front of it. If an obstacle is detected, the robot stops automatically and waits until the path is clear. This prevents collision and ensures safe operation inside the library.
5) Working Procedure

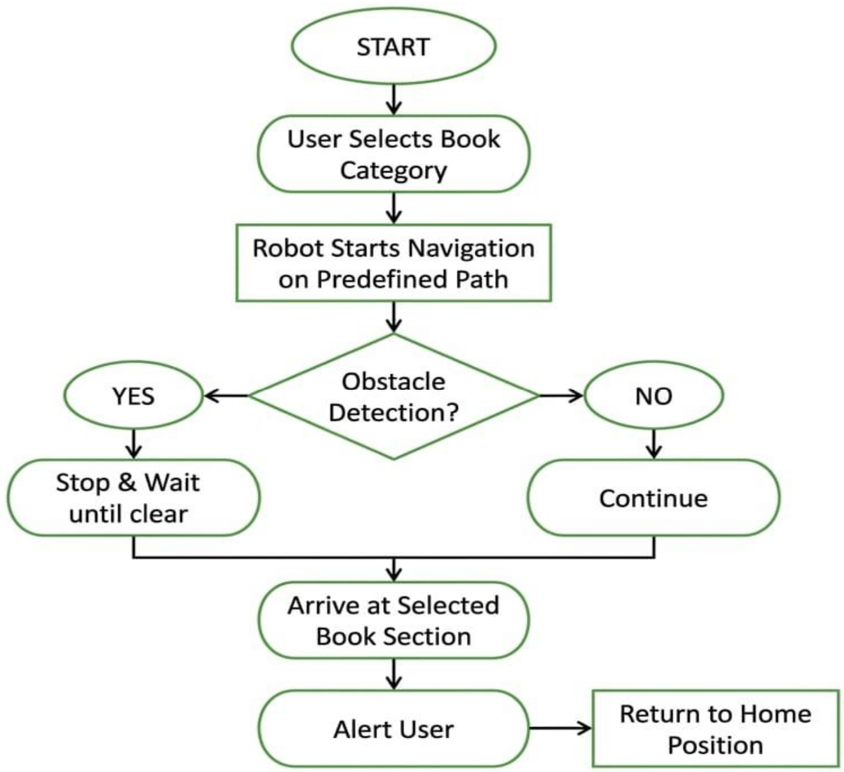

Fig.1 Block Diagram of the System Methodology

III.HARDWARE AND SOFTWARE IMPLEMENTATION

1) User Interface: A web-based interface is created using HTML, CSS, and JavaScript to allow the user to select the required book category. The interface runs on Raspberry Pi and sends commands to the robot through WiFi.
2) WiFi Communication: ESP32 connects to the local network and works as a web server. It receives commands from the user interface using the IP address and processes the request to control the robot.
3) Microcontroller Unit: An ESP32 microcontroller is used as the main control unit. It receives signals from the sensors and controls the motor driver to move the robot in the required direction.
4) Motor Driver: BTS7960 motor drivers are used to control the DC motors. The driver receives PWM control signals from ESP32 and provides high current to run the motors smoothly.
5) DC Gear Motors: Two 12V planetary gear DC motors are used for robot movement. These motors provide high torque which is required for smooth navigation of the robot.
6) Line Following Sensor: A 5-channel IR sensor array is used for navigation. The sensors detect the black line on the floor and send signals to the ESP32 to keep the robot on the correct path.
7) Robot Chassis: The robot body is made using an acrylic sheet with two driving wheels and one caster wheel to provide stability and smooth movement.
8) Power Supply: A 12V rechargeable battery is used to power the motors and motor drivers. A buck converter is used to provide 5V supply for ESP32, sensors, and Raspberry Pi.
9) Control Software: The control program is written in Arduino IDE for ESP32. The program reads sensor values, receives WiFi commands, and controls the motors accordingly.
10) System Operation: When the user selects a subject from the web page, the command is sent to ESP32, the robot starts moving along the line, and it stops when *the destination is reached.*

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IV. RESULT & DISCUSSION

The proposed Autonomous Library Assistant Robot was designed and tested in an indoor environment using a predefined line path representing different book sections inside a library. The robot was powered using a 12V battery and controlled using an ESP32 microcontroller with WiFi communication. The web-based interface running on Raspberry Pi successfully sent commands to the robot through the local network. When the user selected a subject from the interface, the command was received by the ESP32, and the robot started moving along the predefined path without any delay. This confirmed that the wireless communication between the user interface and the robot was working correctly. The movement of the robot was controlled using two 12V planetary gear DC motors connected to BTS7960 motor drivers. The motor driver provided stable control even when the robot was carrying load. The two-wheel drive mechanism with one caster wheel provided good balance and smooth turning. During testing, the robot was able to move forward, stop, and change direction based on the control signals without vibration or power loss. The use of high torque motors improved the stability of the robot during continuous operation. For navigation, a 5-channel IR sensor array was used for line-following. A black line was drawn on the floor to represent the path to different book sections. The IR sensors detected the line accurately, and the ESP32 adjusted the motor speed to keep the robot on the correct path. The robot was able to follow straight paths and curves without losing the track. The line-following method proved to be reliable and suitable for indoor environments such as libraries and laboratories where the path can be fixed. The WiFi-based control system was tested using a web interface developed with HTML, CSS, and JavaScript. The interface allowed the user to select different book categories easily. When a button was pressed, the command was sent using the IP address of the ESP32. The response time of the system was very small, and the robot started moving immediately after receiving the command. This shows that the system can be used in real-time applications without delay. The robot was designed mainly to assist disabled people in locating book sections inside the library. During testing, the system was able to guide the user along the predefined path without the need for manual help. This reduces the effort required to search for books and improves accessibility for disabled and elderly users. The system also reduces the workload of library staff because the robot can guide users automatically. The overall performance of the robot was stable, and all hardware components worked properly together. The power supply system using a 12V battery and buck converter provided sufficient voltage for motors, controller, and sensors. The robot was able to operate continuously for a long time without overheating or power failure. The results show that the proposed system is low cost, reliable, and suitable for smart library automation.

The developed system can also be extended for other indoor applications such as hospitals, shopping malls, warehouses, and smart campus navigation systems. By adding more sensors and advanced control algorithms, the robot can be improved to perform fully autonomous navigation. The results confirm that the proposed Autonomous Library Assistant Robot is an effective assistive robotic system for guiding disabled users safely and efficiently.

Fig.2 Complete Hardware Setup

V. CONCLUSIONS

The Autonomous Library Assistant Robot was successfully designed and developed to help disabled people locate book sections inside a library environment. The system uses ESP32 microcontroller with WiFi communication to receive commands from a web-based interface running on Raspberry Pi. The robot moves along a predefined path using a line-following method with the help of a 5-channel IR sensor array. Two 12V planetary gear DC motors controlled by BTS7960 motor drivers provide smooth and stable movement of the robot. The system was tested in an indoor setup, and the robot was able to move correctly based on the selected subject from the user interface.

The main objective of the project was to reduce the difficulty faced by disabled users while searching for books in large libraries. The developed robot can guide users automatically without the need for manual assistance. The wireless control system allows easy operation, and the line-following navigation provides accurate movement. The use of low-cost components makes the system affordable and suitable for educational institutions. The results show that the proposed system is reliable, simple to operate, and useful for smart library automation.

This project demonstrates the practical application of robotics, embedded systems, and wireless communication in assistive technology. The system can be further improved by adding obstacle detection, encoder-based distance control, voice command input, and database integration to make the robot fully autonomous. In the future, the same concept can be used in hospitals, shopping malls, warehouses, and smart campus environments to guide people safely to their destination. The proposed Autonomous Library Assistant Robot provides an effective solution for improving accessibility and automation in modern libraries.

VI. ACKNOWLEDGMENT

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