AUTONOMOUS CAMPUS NAVIGATION ROBOT USING RASPBERRY-PI

Ms. Arya C
Department of Electronics and Communication Engineering
St. Thomas College of Engineering And Technology, Mattanur
Kannur, India
aryac@stthomas.kannur.ac.in

Abhinrag K
Department of Electronics and Communication Engineering
St. Thomas College of Engineering And Technology, Mattanur
Kannur, India
abhinragkabhi@gmail.com

Amshiga Ranjith
Department of Electronics and Communication Engineering
St. Thomas College of Engineering And Technology, Mattanur
Kannur, India
amshigaranjith04@gmail.com

Hridik N
Department of Electronics and Communication Engineering
St. Thomas College of Engineering And Technology, Mattanur
Kannur, India
hridikhridik25@gmail.com

Rashna Ratheesh M
Department of Electronics and Communication Engineering
St. Thomas College of Engineering And Technology, Mattanur
Kannur, India
rashnarashna58@gmail.com

Abstract— **Navigating large and complex college campuses can be difficult for newcomers, visitors, and visually impaired individuals. To address this challenge, an Autonomous Campus Navigation Robot is proposed to provide intelligent and interactive guidance within campus environments. The system is designed to assist users in reaching their desired destinations efficiently while reducing confusion in unfamiliar surroundings. The robot uses intelligent path planning techniques to determine the shortest and most efficient route between different campus locations. By processing a digital representation of the campus layout, the system can guide users through optimal paths while adapting to real-time environmental conditions. A camera module is also integrated into the system to capture visual information from the surroundings, enabling monitoring and improving situational awareness during navigation. Users can interact with the system through a simple interface, allowing them to select destinations and receive guidance. The system also provides audio-based instructions to assist users during navigation, making it particularly useful for visually impaired individuals. Overall, the proposed system combines autonomous navigation, visual monitoring, and interactive user guidance to create a smart and accessible solution for campus navigation. The project demonstrates how intelligent robotic systems can enhance mobility, accessibility, and user experience in modern educational environments.**

I. INTRODUCTION

Large university and college campuses consist of multiple buildings, departments, laboratories, libraries, and administrative offices connected through complex pathways. New students, visitors, and especially visually impaired individuals often face difficulties in locating their destinations within such environments. Traditional navigation aids such as static maps, signboards, or verbal directions are often limited because they do not provide interactive or real-time guidance.

With advancements in robotics and intelligent systems, autonomous robots can be used to assist users in navigating complex environments efficiently. These systems combine sensors, processing units, and intelligent algorithms to guide users automatically from one location to another.

In this project, an Autonomous Campus Navigation Robot is developed to guide users to various locations within a campus. The system uses the A* (A-Star) path planning algorithm to determine the shortest and most efficient route between the robot's current position and the selected destination. The algorithm analyses different possible paths on a digital campus map and selects the optimal route for navigation. A mobile application is used as the user interface through which the user can select the desired destination. The robot receives this information and begins navigation accordingly. For safe movement, an ultrasonic sensor is used to detect obstacles in real time and prevent collisions. A Pi Camera is integrated into the system to capture visual information from the surroundings, enabling environmental monitoring and improved navigation awareness. The robot moves using DC motors controlled through a motor driver, allowing it to move forward, turn, and stop according to the calculated path. Audio guidance and visual indicators provide navigation feedback to the user during operation.

By integrating intelligent path planning, obstacle detection, visual monitoring, and user interaction, the proposed system provides a smart and accessible navigation solution for modern campus environments.

II. LITERATURE REVIEW

Traditional campus navigation systems such as static maps, signboards, and mobile-based applications often fail to provide efficient and real-time guidance within large and complex environments like universities and institutions. These methods require prior familiarity with the campus layout and do not offer interactive or physical assistance to users. With the rapid expansion of campus infrastructure and increased visitor movement, there is a growing need for an intelligent and automated navigation solution.

To address these limitations, the proposed project Autonomous Campus Navigation Robot using Raspberry Pi introduces a smart robotic system capable of guiding users efficiently within campus environments. The system integrates advanced technologies such as ultrasonic sensors, camera modules, and intelligent path planning algorithms like A* to enable autonomous navigation. The Raspberry Pi acts as the central controller, processing user input received through a mobile application and determining the optimal path to the selected destination.

The robot navigates autonomously by analyzing a digital map of the campus and continuously monitoring its surroundings to detect and avoid obstacles in real time. Additionally, the system provides user-friendly interaction through a touch-based or mobile interface along with audio guidance, making it highly accessible, especially for new visitors and visually impaired individuals. By combining robotics, embedded systems, and intelligent navigation techniques, the proposed system offers an efficient, low-cost, and user-friendly solution for modern campus navigation challenges. For this review, we analyzed three key research papers: [1] Campus Navigation and Augmented Reality Guided Mobile Application, [2] I Am Old Too!: Understanding the Impact of Empathy and Voice Characteristics on Older Adults' Perception of Voice Assistants, and [3] Development of a Socially Cognizant Robotic Campus Guide. These studies provide valuable insights into navigation technologies, human–robot interaction, and intelligent guidance systems. The findings highlight the importance of interactive navigation, user-friendly interfaces, and autonomous robotic systems in improving campus navigation and accessibility.

A. *Campus Navigation and Augmented Reality Guided Mobile Application*

This study presents a mobile application designed to assist users in navigating large and complex environments such as university campuses, hospitals, and corporate buildings using augmented reality technology. The system overlays navigation directions onto the real-world environment through a smartphone interface, helping users easily locate buildings and facilities. The application improves accessibility and user experience by providing visual guidance and interactive navigation features. However, the system mainly depends on a mobile interface and does not provide a physical robotic assistant to guide users in real time within the campus environment.

B. *I Am Old Too! Understanding the Impact of Empathy and Voice Characteristics on Older Adults' Perception of Voice Assistants*

This research examines how voice characteristics and empathetic responses influence the perception of voice assistants among older adults. The study found that voice assistants with human-like interaction and empathetic responses improve user trust, engagement, and communication. Such systems create a sense of companionship and make technology easier to interact with. However, the acceptance of these systems may vary depending on cultural factors. The research mainly focuses on home-based voice assistants and highlights that limited work has been conducted on integrating voice interaction with campus navigation robots.

C. *Development of a Socially Cognizant Robotic Campus Guide*

This study introduces a robotic campus guide designed to assist visitors in navigating campus environments. The system focuses on improving human–robot interaction by incorporating socially interactive behaviors and user-friendly interfaces. The robot uses sensors and navigation modules to guide users to specific locations within the campus. Although the system improves user engagement, it relies on costly hardware components and touchscreen interfaces that may not be accessible to all users. The study also highlights the need for improved object detection and navigation accuracy for efficient autonomous operation.

III. PROPOSED SYSTEM

The proposed system is an Autonomous Campus Navigation Robot using Raspberry Pi, designed to provide intelligent and real-time navigation assistance within large and complex campus environments. The system enables autonomous movement by guiding users to their selected destinations using an efficient path planning mechanism, making it suitable for both indoor and semi-structured campus areas.

In this system, the Raspberry Pi acts as the central controller that processes user inputs, executes navigation algorithms, and controls the robot's movement. Instead of SLAM-based mapping, the system uses the A* (A-Star) path planning algorithm to determine the shortest and most efficient path between the robot's current position and the selected destination. The campus environment is represented as a predefined digital map, allowing accurate and reliable navigation.

An ultrasonic sensor is used to continuously monitor the surroundings and detect obstacles in real time. When an obstacle is detected, the robot either stops or changes its direction to avoid collisions, ensuring safe navigation. The robot's movement is achieved using DC motors, which are controlled through an L293D motor driver IC to provide proper speed and directional control.

For user interaction, the system incorporates a mobile or touchscreen-based interface through which users can easily select their desired destination. The system also provides navigation assistance through a speaker, delivering audio-based instructions that improve accessibility, especially for visually impaired users. LED indicators are used to provide visual feedback about the robot's operational status.

During operation, the robot receives the destination from the user, calculates the optimal path using the A* algorithm, and begins navigation accordingly. It continuously monitors its environment, updates its movement in response to obstacles, and follows the planned path until the destination is reached.

By integrating intelligent path planning, real-time obstacle detection, autonomous motion control, and user-friendly interaction, the proposed system offers a smart, cost-effective, and reliable solution for campus navigation. It enhances accessibility, reduces confusion for new users, and contributes to the development of modern smart campus infrastructure.

IV. PROPOSED SYSTEM DESIGN

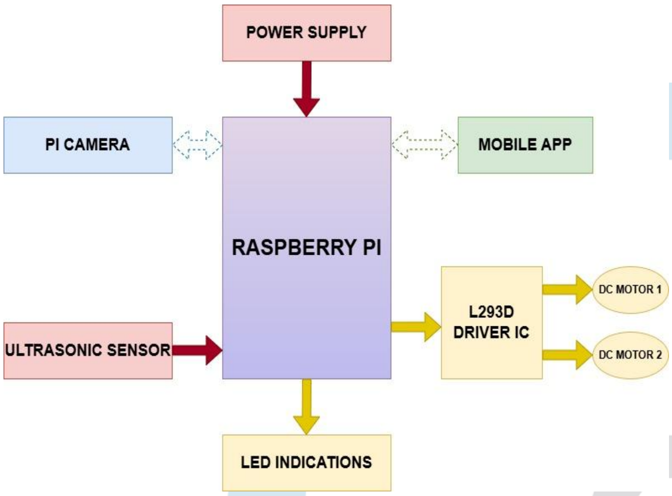

Fig.1. Block Diagram

The block diagram represents the overall architecture of the Autonomous Campus Navigation Robot using Raspberry Pi. The system consists of different modules that work together to enable autonomous navigation within a campus environment. Sensors such as the ultrasonic sensor and Pi Camera are used to collect information from the surroundings. The ultrasonic sensor detects obstacles by measuring distance, while the camera provides visual monitoring of the environment. This sensor data is continuously sent to the Raspberry Pi for processing. The Raspberry Pi acts as the main controller of the system. It receives input from the user interface, processes sensor data, and executes the A* (A-Star) path planning algorithm to determine the shortest and most efficient path to the selected destination. Based on this computed path, the Raspberry Pi generates control signals for navigation. The motor driver (L293D) receives these control signals and drives the DC motors accordingly. This enables the robot to move forward, backward, turn left, or turn right as required. A user interface (mobile application or touchscreen) allows users to select their destination easily. Additionally, a speaker provides audio guidance, and LED indicators give visual feedback about the system status. The power supply unit provides the required electrical energy to all components of the system, ensuring smooth operation. By integrating sensor data, intelligent path planning, user input, and motor control, the system enables the robot to navigate autonomously and efficiently within a campus environment while avoiding obstacles in real time.

V. **CONCLUSION**

This project presented the design and implementation of an Autonomous Campus Navigation Robot using Raspberry Pi and the A* path planning algorithm. The system integrates sensors such as an ultrasonic sensor for obstacle detection and a Pi Camera for visual monitoring to enable the robot to navigate safely within a campus environment. The Raspberry Pi acts as the central controller, processing sensor inputs and executing the A* algorithm to determine the shortest and most efficient path to the selected destination. Based on this, control signals are sent to the motor driver (L293D), which drives the motors to move the robot accordingly. The system is capable of avoiding obstacles in real time and navigating effectively without the use of complex SLAM-based mapping. The proposed system offers a cost-effective, simple, and intelligent solution for assisting visitors in large campuses, improving accessibility and reducing dependence on manual guidance. In the future, the system can be enhanced by integrating advanced computer vision techniques for improved object detection and recognition. Features such as voice-based interaction, mobile application integration, and real-time path updates can further improve user experience. Additionally, the system can be extended for use in environments like hospitals, airports, and shopping malls, making it more versatile and scalable.

REFERENCES

[1] P. Hart, N. Nilsson, and B. Raphael, "A Formal Basis for the Heuristic Determination of Minimum Cost Paths," *IEEE Transactions on Systems Science and Cybernetics*, vol. 4, no. 2, pp. 100–107, 1968.

[2] S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 3rd ed. New Jersey, USA: Prentice Hall, 2010.

[3] A. Koubaa, *Robot Operating System (ROS): The Complete Reference*, Springer, 2016.

[4] J. Borenstein and Y. Koren, "Obstacle Avoidance with Ultrasonic Sensors," *IEEE Journal of Robotics and Automation*, vol. 4, no. 2, pp. 213–218, 1988.

[5] Simon Monk, *Programming the Raspberry Pi: Getting Started with Python*, McGraw-Hill, 2016.

[6] D. W. Patterson and J. A. Hennessy, *Computer Organization and Design*, Morgan Kaufmann, 2013.

[7] M. Margolis, *Arduino Cookbook*, O'Reilly Media, 2011.

[8] R. Szeliski, *Computer Vision: Algorithms and Applications*, Springer, 2010.