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Design and Implementation of Campus Tour Guiding Robots with Navigation Techniques

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Abstract - The work presents the design of a compact robot intended to help students and visitors locate facilities across a campus. A Raspberry Pi coordinates voice-based destination requests, motor commands, route data, obstacle sensing, and user feedback through a display and speaker. For the initial prototype, routes are registered by manually driving the robot from a known start point and recording directional commands with their durations and motor-speed settings. When a destination is requested, the controller replays the corresponding sequence. An ultrasonic sensor acts as a safety layer: if an object enters the configured stopping range, movement is halted and a buzzer/display warning is issued. This approach avoids the cost and computational demands of a full LiDAR-based mapping stack, making it suitable for controlled indoor corridors where the route and start position remain consistent. The design combines embedded control, human–robot interaction, and reactive obstacle stopping. Prototype trials and measured performance are still required to quantify navigation accuracy and reliability.

Keywords - campus guide robot, Raspberry Pi, voice interaction, route recording, ultrasonic sensing, embedded systems

I. INTRODUCTION

Finding a particular office, laboratory, library, or department can be difficult for first-time campus visitors. Traditional signboards and staff assistance remain useful, but they may not always provide continuous, personalized directions. A mobile guide robot offers another way to present directions and campus information while moving between selected locations.

The proposed platform is a four-wheel indoor robot controlled by a Raspberry Pi. Its main functions include accepting a destination through voice input, retrieving the associated route, controlling the motors, checking for obstacles, and communicating status through a display, speaker, and buzzer. The software also supports route administration through a dashboard.

Rather than building a LiDAR-SLAM map, the prototype uses a time-based route-registration method. During setup, an administrator drives the robot along a route and saves a sequence of forward, reverse, turning, and stop commands with their durations and speed settings. Each sequence is associated with a destination such as the ECE Department, library, or Principal's Office. On a later request, the robot runs the saved sequence from the designated starting point. Obstacle sensing provides a basic protective response during playback. When the ultrasonic sensor detects an object within a configured threshold, the controller interrupts motor output, activates a buzzer, and displays a warning. Movement may resume after the path is clear. Because the route is replayed open-loop, performance can vary with wheel slip, battery level, motor differences, floor surface, and starting position; therefore, the initial design is intended for repeatable, controlled routes.

I. LITERATURE REVIEW

Socially aware navigation evaluation [1]. Research on social robot navigation argues that performance should be assessed not only by collision avoidance but also by human comfort, legibility, politeness, and context. It also points to the value of common benchmarks and evaluation measures so that different navigation methods can be compared consistently.

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Neural distance-field navigation [2]. A recent approach combines robot-body and scene signed-distance representations with RGB-D sensing to generate collision-free trajectories in changing indoor scenes. Its reported evaluation highlights the potential of learned geometry representations for handling objects that move or appear along a route.

Navigation assistance for visually impaired users [3]. The described assistive robot combines object recognition, depth information, shared control, and spoken feedback. The study emphasises spatial awareness and collision prevention while allowing the user to retain directional input.

AI-enabled virtual tours [4]. IntelliTour combines language processing and adaptive content with pathfinding for virtual visits. Its focus is on tailoring the tour experience and improving engagement rather than controlling a physical campus robot.

Visual navigation for laboratory tours [5]. The reported laboratory guide uses visual perception and path-planning methods, including SLAM-related localisation and A* search, to navigate without relying exclusively on stored timed movements. The study also notes that processing demand and lighting can affect operation.

Network-supported museum guidance [6]. A 5G-enabled museum robot offloads some perception and speech tasks to remote computing resources. The work reports interactive visitor engagement while identifying network variability, battery capacity, and noisy speech environments as practical challenges.

Robot–wearable interaction [7]. This work explores transferring a navigation conversation between a humanoid robot and a wearable device. It highlights continuity of interaction, clear route instructions, and timely responses as important elements in campus assistance.

Socially cognizant campus guide [8]. The described campus robot combines perception, human tracking, speech recognition, and route planning. The comparison of planning approaches illustrates the trade-off between movement speed and reliability in crowded spaces.

Augmented-reality campus navigation [9]. An AR-based application overlays directional cues and waypoints on a smartphone camera view. This provides an alternative to physical guide robots and demonstrates how visual prompts can make campus navigation easier to follow.

AIoT campus exploration [10]. The CampuScout system integrates object recognition, QR-code interaction, connectivity, speech output, and remote viewing. Its reported user evaluation suggests that interactive information can make campus exploration more engaging.

Pure Pursuit path tracking [11]. Pure Pursuit is presented as a comparatively lightweight method for tracking a target path on a wheeled robot. The work compares it with other tracking strategies and discusses the balance between tracking stability, deviation, and implementation cost.

Hermes tour guide robot [12]. The Hermes project combines indoor movement, QR-code detection, speech, and expressive interaction. Its reported limitations on cornering and path tracking illustrate that physical alignment and sensing reliability remain important.

Hospital visitor guidance [13]. The hospital guide uses onboard sensing, a controller, and a touchscreen to help visitors reach destinations. The study describes practical benefits while noting that floor irregularities and sensor precision can influence arrival accuracy.

Review of campus and tour robots [14]. The review surveys systems that use combinations of SLAM, ROS, sensor fusion, cameras, IMUs, and other sensors. It also discusses how speech and expressive behaviour can support more natural human–robot interaction.

Humanoid tour guidance [15]. The described tour-guide robot combines localisation, semantic mapping, RFID, motion control, and speech synchronisation. Its design illustrates how navigation and interaction functions can be integrated for guided indoor visits.

Taken together, the reviewed work covers advanced mapping and perception, assistive navigation, virtual and augmented tours, and socially aware interaction. The present prototype adopts a narrower, lower-cost scope: replaying administrator-recorded routes with ultrasonic stop-on-obstacle protection. This makes the system simpler to implement, but it does not provide the localisation or dynamic replanning capabilities of full SLAM-based systems.

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II. PROPOSED METHODOLOGY

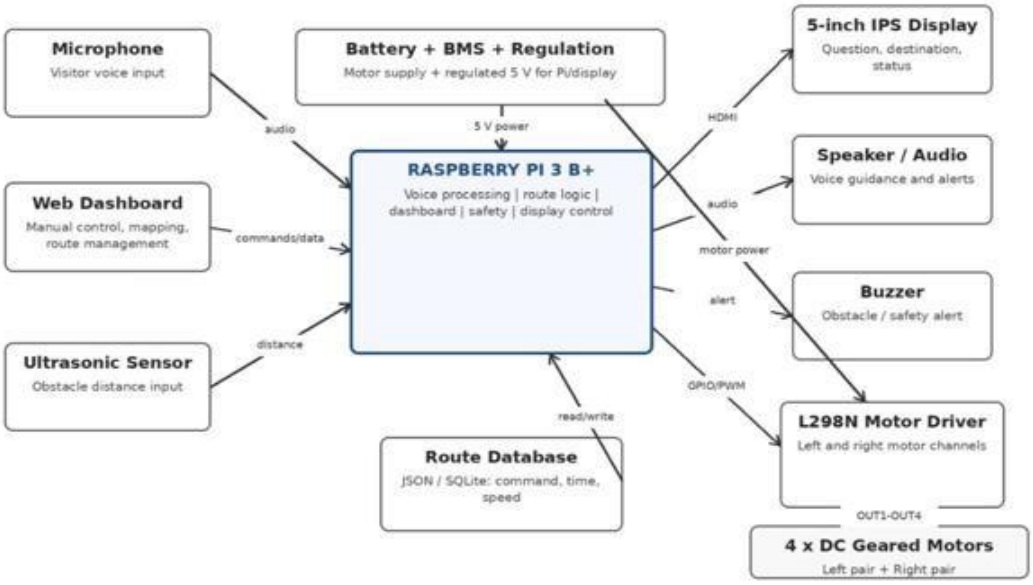


Figure 1. Block diagram of the campus tour guiding robot.

The system is organised into control, interaction, navigation-and-safety, and power functions. A Raspberry Pi runs the software and coordinates the connected modules. A user states a supported destination through the voice interface; the software identifies the request and loads the matching route record. The motor driver then executes the stored movement commands while the ultrasonic sensor is checked throughout travel.

A. Central Controller Layer

The Raspberry Pi acts as the main integration unit. It receives recognised voice commands and dashboard inputs, reads obstacle measurements, stores or retrieves route records, sends control signals to the L298N motor driver, and updates the display, speaker, and buzzer. Route files associate destination names with timed motion commands and speed settings.

B. Human–Robot Interaction Layer

The microphone provides voice input, while the speaker and display return spoken and visual feedback. The interface should confirm the recognised destination and indicate whether the robot is moving, paused for an obstacle, or waiting for an administrator action. This feedback helps users understand the robot's current state.

C. Navigation and Safety Layer

Routes are created during a registration session: an administrator manually drives the robot from a repeatable starting point, and the software records the direction, duration, and motor-speed values. During a guidance session, these commands are played back in sequence. The ultrasonic sensor has priority over route playback. If the measured distance crosses the configured threshold, the controller stops the motors and activates the warning outputs. The saved route can continue when the path is clear, subject to safe implementation and testing. This is timed open-loop navigation, not map-based localization; consequently, route accuracy depends on consistent starting conditions and mechanical behaviour.

D. Power Layer

The motor supply and Raspberry Pi supply must be regulated according to their respective requirements. A battery-management system can protect the battery, and a suitable buck converter can provide a stable 5 V rail for the controller and compatible peripherals. Motor current should be routed through the motor driver rather than drawn from the Raspberry Pi's logic supply.

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III. RESULTS

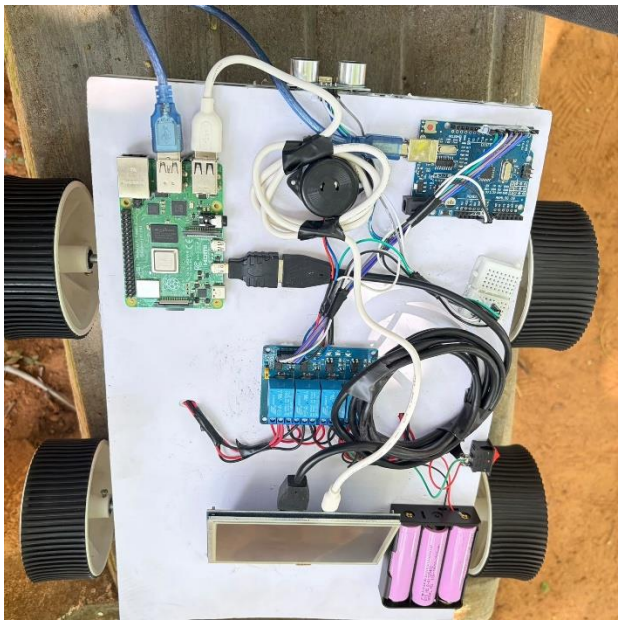


Figure 2. Finial Result of campus navigation.

The design is intended to accept supported destination requests, load the matching stored route, and move the robot by issuing timed motor commands. The display and speaker provide confirmation and guidance information. During movement, the ultrasonic sensor checks for nearby objects; a detection within the selected threshold should stop the robot and trigger a buzzer. When the route ahead is clear, playback can continue.

The route-management dashboard is intended to let an administrator register and maintain destination routes and use manual control when required. Since the supplied document describes expected behaviour rather than presenting measured prototype trials, numerical claims about success rate, arrival error, response time, or obstacle-detection accuracy should not be reported until they have been measured. Evaluation should record route completion, stopping distance, repeatability across runs, voice-command recognition, and behaviour under different battery and floor conditions.

IV. DISCUSSION

The main advantage of the proposed approach is its relatively straightforward hardware and software structure. It can demonstrate campus guidance without the additional cost and integration work of a full LiDAR-SLAM platform. Timed route playback is suitable for corridors and other spaces where the robot starts from a known location and the environment remains similar to the route-registration conditions.

The same simplicity introduces limitations. The robot does not estimate its precise position along the route, and timed motor commands can accumulate error if the wheels slip or the floor, load, or battery condition changes. A single forward-facing ultrasonic sensor also provides only limited information about the surrounding space and does not itself identify a safe detour. Accordingly, the current design should be described as a predefined-route guide with reactive obstacle stopping, not as a robot that independently computes the globally shortest path in an arbitrary environment.

Future testing should establish a safe stopping threshold and verify repeatability over multiple runs. Additional encoders, improved localization, multiple sensors, or camera-based perception could be considered if later versions require more reliable movement or dynamic rerouting.

V. CONCLUSION

This paper describes a low-cost campus and tour-guiding robot built around a Raspberry Pi, a four-wheel platform, voice interaction, a display and speaker, a motor driver, and ultrasonic obstacle sensing. An administrator records each route as a timed sequence of movement commands, which the robot can replay when the corresponding destination is requested. The safety layer interrupts motion when an obstacle is detected and alerts nearby users. The method is appropriate as an initial demonstration for controlled indoor routes, but its accuracy depends on repeatable starting positions, motor behaviour, and floor conditions. Prototype measurements

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are needed before claims about navigation performance can be confirmed.

VI. FUTURE SCOPE

Further development could add wheel encoders and improved localisation to reduce accumulated route error, along with a camera or additional ranging sensors for broader obstacle awareness. A more advanced planner could select an alternate route when a corridor is blocked. Multilingual speech interaction and a mobile application could make destination selection more accessible, while systematic trials could assess reliability across different routes and operating conditions. These extensions may also support adaptation to hospitals, museums, offices, and tourist facilities, provided each environment is validated for safety.

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