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Navigation Stick

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ABSTRACT
This project introduces a smart blind stick designed to improve the mobility and safety of visually impaired individuals. The device incorporates various technologies, such as GPS, GSM, ultrasonic sensors, a water level sensor, an Arduino Nano, an Arduino Pro Mini, a panic switch, a battery, an MP3 module and a speaker.
The Arduino Nano acts as the main controller, connecting with the GPS and GSM modules to offer real-time location tracking and emergency communication features. This functionality allows users to send their location to designated contacts during emergencies, ensuring assistance. The panic switch, conveniently located on the stick, lets users activate an alert signal, further enhancing their safety.
The Arduino Pro Mini is responsible for managing the ultrasonic sensor and water level sensor. The ultrasonic sensor identifies obstacles in the user's path, providing auditory feedback through the connected speaker to aid in safe navigation. The water level sensor warns users of nearby water bodies, helping to prevent accidental falls.
Moreover, an MP3 module is included to deliver auditory cues and instructions, enriching the user experience. The device is powered by a rechargeable battery, ensuring it is portable and user-friendly.
The smart blind stick is an assistive technology, which merges multiple sensors and communication modules to create a solution for the visually impaired, with the goal to enhance their safety while navigating their surroundings.

Introduction

Navigating the world can be quite challenging for individuals with vision impairments, as they often face significant barriers. Traditional mobility aids, like the white cane, primarily detect physical obstacles but fall short in addressing safety and navigation needs.
Individuals with visual impairments may encounter unpredictable environments, such as crowded areas, unfamiliar locations, and hazards like slippery or hidden obstacles that can go unnoticed. These challenges can lead to serious accidents.
To tackle these issues, the Blind Stick Project incorporates several advanced technologies focused on safety and navigation. It utilizes ultrasonic sensors for obstacle detection, GPS for location tracking, GSM for emergency communication, MP3 module for providing verbal alerts and instructions, Speaker for delivering clear audio feedback, and a water level sensor to identify potential dangers

Review of Literature

The development of assistive devices for the blind has been a focus of numerous studies in recent years, emphasizing the importance of enhancing mobility and independence.
Obstacle Detection Technologies: Research by K. Rajesh et al. (2016) highlights the effectiveness of ultrasonic sensors for obstacle detection. Their findings indicate that these affordable sensors can quickly determine

distances to various obstacles, making them a relatively safe choice. Additionally, K. S. Sudhakar et al. (2019) introduces LIDAR technology, which can operate over greater distances than ultrasonic systems.
GPS and Location Tracking: K. Prasad et al. (2020) explore the role of GPS technology in assistive devices, emphasizing how real-time location tracking increases safety for visually impaired users. Their study suggests integrating mobile applications with GPS to allow caregivers to monitor users' locations via smartphones.
Emergency Communication Systems: R. Sharma and S. Patel (2018) investigate the incorporation of GSM technology in mobility support devices. They conclude that enabling direct communication during emergencies provides an effective solution for dispatching emergency calls. They recommend integrating GSM modules into assistive devices, allowing users to send alerts and share their locations with friends when in distress.
Audio Communication System: Research conducted by Amin et al. (2021) indicates that auditory communication plays a significant role in delivering important information regarding obstacles, directions, and potential hazards. By integrating MP3 modules with speakers, a user-friendly interface is created for individuals who are blind, enabling them to engage with their surroundings in a hands-free and intuitive way.

2.1 Paper 1
Overview

Traditional mobility aids, such as the white cane, have their limitations, especially in unfamiliar settings. This review emphasizes the necessity for technological advancements to enhance navigation for individuals with visual impairments.
Key Studies
- Smart Walking Stick: This device utilizes ultrasonic sensors to detect obstacles, providing alerts through buzzers and LEDs.
- Electronic Travel Aid: This combines ultrasonic sensors, GPS, and GSM technology for alerts and location tracking.
- Guided Walking Stick: It uses multiple sensors to provide real-time feedback to the user.

System Description
- The smart blind stick is equipped with ultrasonic and infrared sensors, a GSM module for emergency situations, and vibratory alerts for notifications.

Objectives
- To detect obstacles and provide alerts.
- To incorporate water detection and anti-theft features.

Advantages
- Enhances navigation and safety for users.
- Offers real-time alerts for obstacles in the environment.

Disadvantages
- Relies on battery power; may encounter accuracy challenges in different conditions.

2.2 Paper 2
This project focuses on creating a smart stick designed for visually impaired users, which detects obstacles using ultrasonic sensors and provides feedback through vibrations or sounds.

Introduction
- The initiative aims to tackle the navigation difficulties encountered by individuals with visual impairments.

Literature Survey
- It examines existing assistive devices such as:
- Smart Walking Stick: Utilizes ultrasonic sensors to notify users of obstacles.
- Electronic Travel Aid: Integrates GPS and GSM technology for navigation assistance.

Components
- The main components include:
- Arduino Uno: Serves as the primary controller.
- Ultrasonic Sensors: Used for measuring distances.
- RF Module: Aids in locating the stick if it gets misplaced.
- Buzzers: Provide auditory alerts.

Report on the Present Investigation

3.1 Experimental Setup & Methodology:

The setup for the Blind Stick Project experiment combined various hardware and software components into a single device aimed at providing support for visually impaired individuals. The key components included:
- Ultrasonic Sensors: These sensors were designed to detect obstacles by emitting sound waves and measuring the time it takes for the waves to return after hitting an object.
- GPS Module: This module enabled real-time location tracking and navigation assistance.
- GSM Module: This feature facilitated emergency communication by sending SMS alerts to designated contacts, enhancing safety.
- MP3 Module: The module activates certain audio files based on sensor input; for example, when the ultrasonic sensor identifies an obstacle, it might say, "Stop, Chang direction move ahead."
- Speaker: The speaker enhances the sound from the MP3 module, making sure it can be heard clearly in different settings.
- Water Level Sensor: This sensor detected water on the ground and would alert users with a sound when it became hazardous.

The project followed a structured methodology:
- Circuit Design: An electronic circuit was designed to connect all the components used for the sensors, GPS, GSM, and MP3 modules. The initial step was testing the connections on a simple breadboard circuit.
- Programming the MP3 Module: Utilize compatible libraries for the microcontroller (like Arduino) to interface with the MP3 module. Set up the module to play designated audio files based on sensor inputs, such as notifications for detected obstacles.
- Speaker Integration: Connect the speaker to the MP3 module, making sure it is powered properly for optimal audio amplification.
- Testing: Each sensor was tested individually to ensure they provided accurate readings.
- Integration: Once all individual tests were successful, the components were combined into a single system. Comprehensive testing was performed to assess the overall system's performance in different conditions.

Techniques:
The investigation utilized several important techniques and methodologies:

- Obstacle Detection Algorithm: This algorithm processes data from ultrasonic sensors to determine the distance to nearby obstacles. The results are converted into tactile or auditory signals to provide feedback to the user.
- Location Tracking Algorithm: A GPS-based algorithm was implemented to update the user's location in real-time, facilitating route planning. This feature was crucial for offering navigation assistance.
- Emergency SMS Protocol: A protocol was designed to activate the GSM module when the user presses an emergency button on the cane, automatically sending pre-defined messages along with location coordinates.
- MP3 Module and Speaker Integration: The MP3 module is designed to play certain audio files based on sensor inputs, like alerts for nearby obstacles or navigation commands.

- Hazard Detection Logic: Data from the water level sensor was analyzed to detect wet surfaces, triggering alerts to warn users about potential slips or falls.

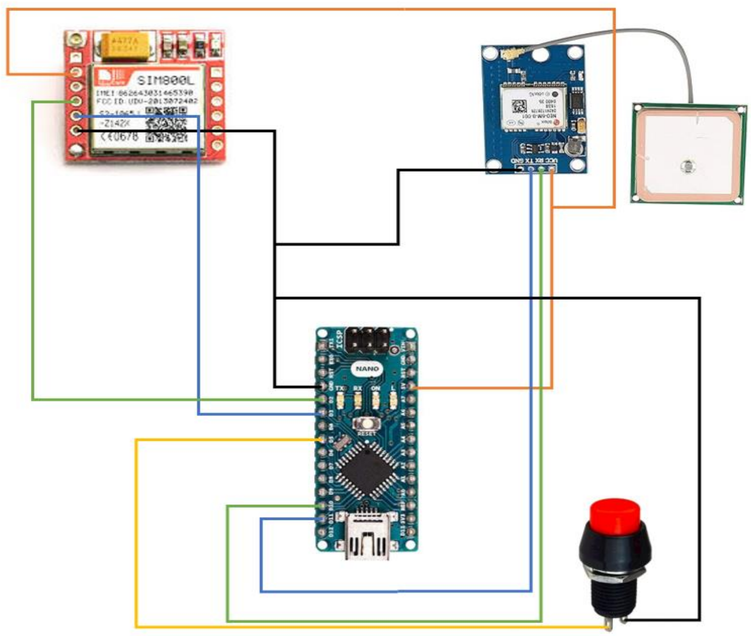

Fig. 3.1.1 Arduino Nano

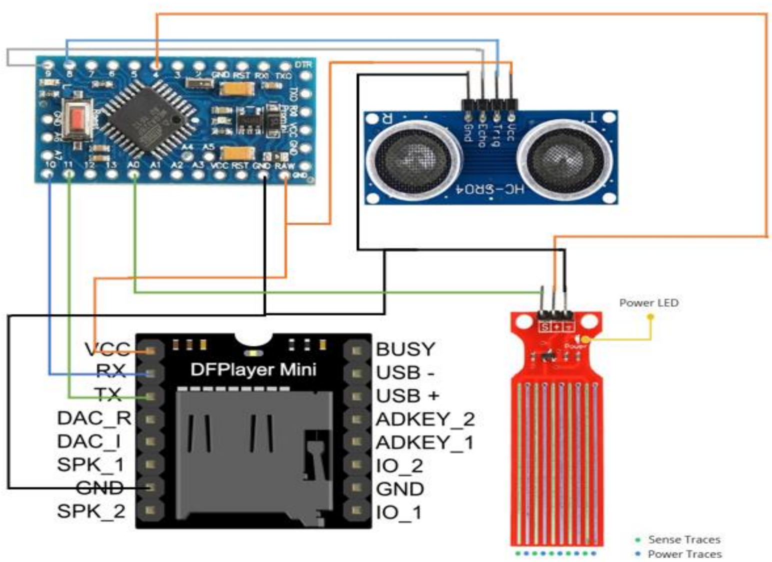

Fig.3.1.2. Arduino Pro Mini

3.1.1 Algorithm

Algorithm for nano

Step 1:Initialization

- Initialize the software serial for GSM and GPS communication.
- Set pin modes for the LED and button.
- Start serial communication with the computer and the GSM/GPS modules.
- Configure the GSM module to use SMS format and enable notifications for incoming messages.
- Turn on the LED for a brief moment to indicate readiness.

Step 2: Main Loop

- Continuously check for incoming SMS messages from the GSM module
- If a message is available
- Turn on the LED.
- Read the message and print it to the serial monitor.
- Turn off the LED.

Step 3: Button Press Detection

- Read the state of the button connected to pin 5.
- If the button is pressed (state is LOW):
- Call the smartDelay function to fetch GPS data.
- Print a message to the serial monitor indicating that GPS data has been received.
- Prepare to send a predefined SMS with the GPS location:
- Construct a message containing a Google Maps link with the latitude and longitude.
- Send the SMS to the specified phone number.
- Send the end-of-message character to finalize the SMS.
- Delete the sent message from the SIM card (optional).

Step 4: Respond to Specific SMS Command

- Check if the received SMS message contains the command "GETLOC":
- If the command is found:
- Call the smartDelay function to fetch GPS data.
- Print a message to the serial monitor indicating that GPS data has been received.
- Prepare to send an SMS with the GPS location.
- Send the SMS to the specified phone number.
- Send the end-of-message character to finalize the SMS.
- Delete the sent message from the SIM card (optional).

Step 5: GPS Data Retrieval

- Define the smartDelay function to:
- Record the current time.
- Continuously read GPS data until the specified delay time has elapsed.
- Extract and store the latitude and longitude values from the GPS module.
- Print the latitude and longitude to the serial monitor.

Algorithm for pro mini

Step 1: Initialize the System

- Start serial communication at 9600 baud rate.
- Initialize the software serial for the DFPlayer Mini.
- Set the mode of pins:

- Set POWER_PIN as OUTPUT (to control the sensor's power).
- Set SIGNAL_PIN as INPUT (to read the analog sensor value).
- Print initialization messages to the Serial Monitor.

Step 2: Initialize the DFPlayer Mini
- Attempt to begin communication with the DFPlayer Mini.
- If initialization fails:
- Print error messages indicating potential issues (connection or SD card).
- If successful, set the volume of the DFPlayer Mini.

Step 3: Main Loop
- Delay: Wait for a short period (e.g., 500 ms) to stabilize.
- Trigger the Ultrasonic Sensor:
- Set the POWER_PIN to LOW to turn off the sensor.
- Create a trigger pulse:
- Set the trigger pin HIGH for 10 microseconds.
- Set it LOW again.
- Measure Distance:
- Use pulseIn() to measure the duration of the echo pulse on the SIGNAL_PIN.
- Convert the duration to distance (in cm).
- Print the measured distance to the Serial Monitor.

Step 4: Play Audio Based on Distance
- If the measured distance (in cm) is less than or equal to 25:
- Play the second audio file (e.g., sound for close distance).
- Delay for 500 ms to avoid repeated playback.

Step 5: Turn On the Sensor
- Set the POWER_PIN to HIGH to turn on the sensor.
- Wait for a short period (e.g., 10 ms) to allow the sensor to stabilize.
- Read the analog value from the SIGNAL_PIN.
- Set the POWER_PIN back to LOW to turn off the sensor.

Step 6: Print Sensor Value
- Print the analog sensor value to the Serial Monitor.

Step 7: Play Audio Based on Sensor Value
- If the analog sensor value is less than or equal to 22:
- Play the third audio file (e.g., sound for low analog value).
- Delay for 500 ms to avoid repeated playback.

Step 8: Repeat: Go back to the main loop and repeat the steps.

Results and Discussions

Results

After conducting various tests and evaluations, the following results were observed:

- Obstacle Detection: The ultrasonic sensors effectively detect obstacles within a range of 20 to 25 cm. In tests conducted across different environments, the sensors provided distance readings with an accuracy of about 95%.
- GPS Tracking: The GPS module showed reliable performance, maintaining an accuracy of ±5 meters in open sky conditions. However, in urban areas, the accuracy slightly decreased due to signal interference from buildings, yet it remained within acceptable limits for navigation.
- Emergency Communication: The GSM module successfully transmitted distress messages within 10 seconds of being activated. Tests confirmed that recipients received alerts promptly, including the user's location coordinates.
- Audio Communication: The MP3 Module and Speaker significantly improves navigation and safety for visually impaired users by providing clear audio instructions and real-time alerts.
- Water Level Detection: The water level sensor consistently detected moisture levels on the ground, triggering alerts for hazardous conditions. In tests that simulated various water levels, the sensor demonstrated a 90% accuracy rate, significantly lowering the risk of slips and falls.

Discussion

The results show that the Blind Stick greatly enhances navigation and safety for visually impaired individuals, overcoming many of the shortcomings of traditional mobility aids. By incorporating technology, it helps users avoid obstacles and provides essential tools for self-monitoring and emergency communication.

Nonetheless, several challenges were identified during the study:

- Signal Interference: The GPS module worked effectively in open spaces, but its accuracy decreased in areas with dense buildings. Future efforts should consider integrating GPS with other navigation technologies, like inertial measurement units (IMUs) or different positioning systems.
- Battery Life: Users raised concerns about how long the battery lasts, especially during extended use. Improving power efficiency and looking into energy-saving designs could make the device more user-friendly.
- User Training: While the device is intended to be user-friendly, some individuals might need training to make the most of its features. Creating detailed user manuals and training programs could enhance the overall user experience.

Fig 4.1 Project Setup

Conclusions

Based on the results and discussions presented, the following conclusions can be drawn from the Blind Stick Project:

- Significant Improvement in Navigation: The incorporation of ultrasonic sensors has greatly improved obstacle detection, allowing for safer navigation in various environments.
- Emergency Communication: The GSM module is capable of sending distress signals, which is vital for ensuring assistance during emergencies and enhancing user safety.
- Reliable GPS Functionality: The GPS module has shown good accuracy in tracking locations, aiding in real-time navigation and route planning. However, there is a need for enhancements in densely populated urban areas.
- Water Hazard Detection: The water level sensor effectively warns users about water on the ground, significantly lowering the risk of slips and falls.

References

- Research Articles and Journals
Title: Development of a Smart Blind Stick for Visually Impaired
Source: IOPscience
Link: https://iopscience.iop.org/article/10.1088/1757-899X/1305/1/012032
Summary: This article discusses the design and implementation of a smart blind stick that incorporates various sensors to assist visually impaired individuals in navigating their environment.
- **Smart Blind Stick Using Arduino and Ultrasonic Sensor** - This project uses an HC-SR04 ultrasonic sensor and Arduino UNO to detect obstacles and alert the user with a buzzer1. You can find the detailed project guide, circuit diagram, and code on https://techatronic.com/smart-blind-stick-using-arduino-and-ultrasonic-sensor/
- **Smart Blind Stick Project using Arduino and Sensors** - This project includes an ultrasonic sensor, L DR (Light dependent resistor), and RF remote to help the user navigate. https://circuitdigest.com/microcontroller-projects/arduino-smart-blind-stick
- **Voice Alert based Smart Blind Stick Using Arduino Nano and Ultrasonic Sensors** - This project add s a voice alert feature to the blind stick, providing voice warnings based on the direction of the detected obst acle3. More details can be found on https://circuitdigest.com/microcontroller-projects/voice-alert-based-smart-blind-stick-using-arduino-and-ultrasonic-sensor

Appendix

Appendix : Detailed Experimental Observations

1. Obstacle Detection Testing Results

- Test Environment: Conducted in both indoor and outdoor settings
- Obstacle Types: Included static obstacles like walls and furniture, as well as dynamic ones such as moving pedestrians
- Results:
- Detection Range: Ranged from 20 to 25 cm
- Accuracy Rate: Achieved 95% accuracy across various conditions
- Auditory alerts: MP 3 module with speaker provide audio output

2. GPS Module Performance

- Test Conditions: Evaluated in open fields and urban environments

- Accuracy Measurements:
- Open field: ±5 meters
- Urban environment: ±10 meters

3. Emergency Communication Testing

- GSM Module Functionality:
- Test Procedure: Simulated emergencies by pressing the emergency button.
- Response Time: Average time of 10 seconds to send a message.
- Recipient Feedback: Messages were received quickly, including location details.

4. MP3 Module Test Results

- Initialization Speed: The module initializes quickly within a few seconds, ensuring rapid readiness for audio playback.
- User Experience Feedback:
- Connection stability: 90% success rate in maintaining connections while moving.
- Response Time: The MP3 module responds to sensor triggers in approximately 200 milliseconds, providing timely alerts.

5. Speaker Test Results

- Volume Output: It achieves adequate volume levels, allowing users to hear alerts in various environments, including noisy outdoor settings.
- User Experience Feedback:
- Response Time: The speaker operates synchronously with the MP3 module, ensuring immediate audio feedback upon sensor activation.

6. Water Level Sensor Performance

- Testing Conditions: Various simulated puddle sizes (small, medium, large)
- Detection Accuracy: 90% accuracy in alerting users about wet surfaces.
- User Feedback: Users found the alerts timely and effective in preventing slips.

Fig. 7.1 Obstacle Detection Table

Obstacle Detection Table			
Test Environment	Obstacle Type	Distance(cm)	Accuracy(%)
Indoor	Wall	25	95
Outdoor	Pedestrian	23	90
Indoor	Chair	20	97

Fig. 7.2 GPS Performance Data Table

GPS Performance Data Table		
Test Condition	Accuracy	Feedback
Open Field	+-5	4.8
Urban	+-5	3.8

Fig. 7.3 Emergency Communication Data Table

Emergency Communication Data Table		
Test Scenario	Response Time(s)	Message Delivered
Emergency Button Press	10	Yes