SCHOOL OF COMPUTER SCIENCE ENGINEERING AND INFORMATION SYSTEMS

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SWE4005 – INTERNET OF THINGS

J COMPONENT

SMART WALKING STICK FOR VISUALLY IMPAIRED PERSON

REVIEW – 3

SLOT – C1

TEAM MEMBERS

21MIS0182 – Swapna Sri

21MIS0192 - Manisha T.

21MIS0375 - Sanskriti Lal

21MIS0253 - Sparsh Rajvanshi

ABSTRACT

This project presents the development of a smart assistance stick designed to aid visually impaired individuals in navigating their surroundings safely. The system integrates several components, including an Arduino Uno, ESP8266, ultrasonic sensor, water sensor, NEO-6M GPS module, and a buzzer, assembled on a breadboard with connecting wires. The ultrasonic sensor detects nearby obstacles, triggering the buzzer to alert the user. Additionally, the water sensor signals the presence of water on the ground, while the GPS module provides real-time location data. The ESP8266 facilitates communication, potentially transmitting location data to a smartphone application for enhanced user tracking. This compact, cost-effective solution enhances environmental awareness, improving safety and independence for visually impaired individuals.

PROBLEM STATEMENT

Visually impaired individuals face significant challenges in navigating their surroundings safely and independently. Traditional walking sticks offer limited support, as they primarily provide tactile feedback for obstacles directly in front of the user. However, these solutions do not address other hazards, such as uneven surfaces, water puddles, or obstacles beyond the stick's reach. Additionally, visually impaired individuals may face difficulty conveying their location to family or caregivers in real time, which can be crucial in case of emergencies. Therefore, a more comprehensive solution is needed to enhance mobility, situational awareness, and safety for visually impaired individuals.

INTRODUCTION

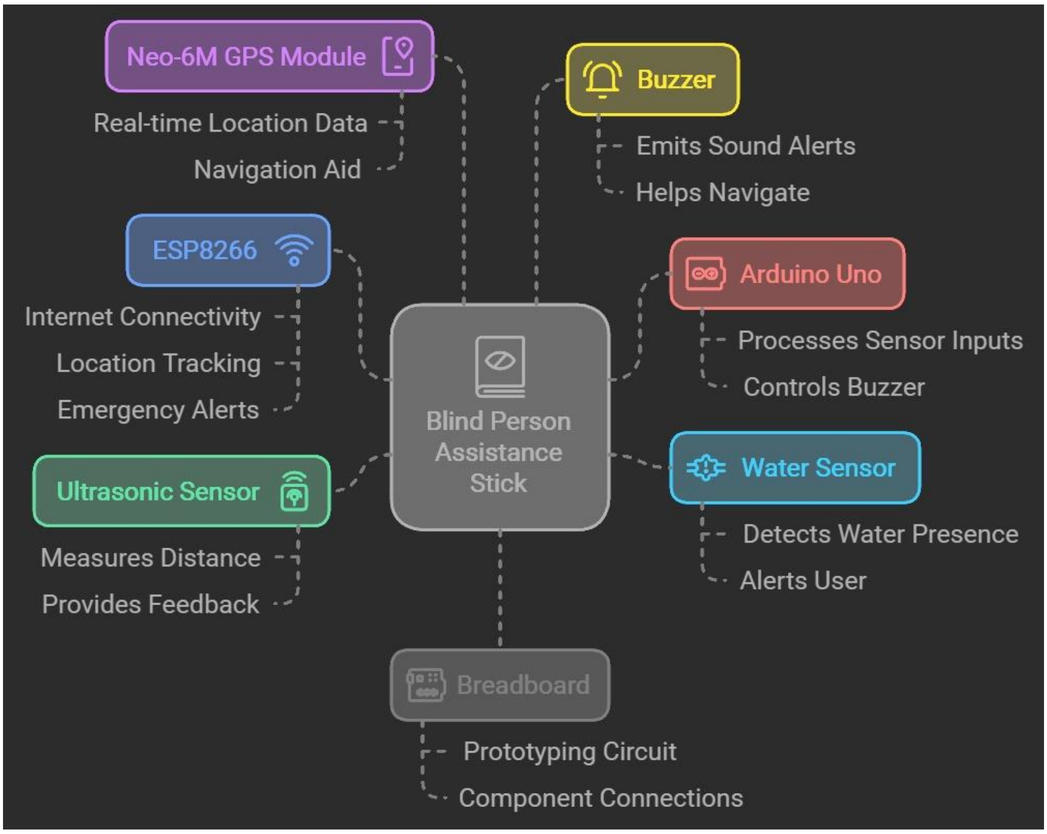
This project introduces a "Smart Assistance Stick" designed to enhance mobility and safety for visually impaired users. The device integrates multiple sensors and modules, including an ultrasonic sensor, water sensor, NEO-6M GPS module, and ESP8266, all powered and controlled by an Arduino Uno microcontroller. The ultrasonic sensor detects obstacles in the user's path, while the water sensor alerts the user to wet surfaces, reducing the risk of slips or falls. The GPS module continuously monitors the user's location, which can be shared via the ESP8266, enabling family members or caregivers to access real-time location data if needed. The stick is also equipped with a buzzer that provides immediate auditory feedback upon detecting hazards, enhancing the user's spatial awareness and independence. This low-cost, easy-to-use solution aims to improve the quality of life for visually impaired individuals, providing them with a greater sense of confidence and security in their daily movements.

OBJECTIVE

The primary objective of this project is to design and develop an IoT-enabled Smart Walking Stick for Visually Impaired Persons that enhances their mobility, safety, and independence. Specifically, this smart walking stick aims to:

1. **Detect Obstacles in Real-Time**: Utilize ultrasonic sensors to identify obstacles in the user's path and provide immediate feedback through audio and haptic alerts, enabling safe navigation.
2. **Enhance User Experience through Cloud-Based Analytics**: Leverage a cloud platform to collect user data for continuous performance monitoring and improvement based on user feedback and usage patterns.
3. **Promote Greater Independence and Quality of Life**: Create a reliable, easy-to-use mobility tool that empowers VIPs with increased autonomy, confidence, and safety in their daily activities.

ARCHITECTURE DIAGRAM



CONTROLLER REQUIRED

1. Hardware required

- Arduino Uno
- Esp8266
- Water sensor
- Connecting wires
- Ultrasonic sensor
- Neo -6M GPS Module
- Buzzer
- Breadboard

1. Hardware Components:

- **Arduino Uno**: Serves as the primary microcontroller, handling sensor data processing, managing inputs and outputs, and controlling the walking stick's various components.
- **ESP8266**: A Wi-Fi module that enables the stick to connect to the internet, facilitating real-time data transmission to the cloud. It can send alerts or data logs to a connected device, like a smartphone, which could notify caregivers or track the user's location.
- **Water Sensor**: Detects the presence of water or slippery surfaces. This sensor can alert the user to avoid potential hazards like puddles, ensuring safer navigation.
- **Ultrasonic Sensor**: Used for obstacle detection. It measures the distance between the stick and any nearby objects, warning the user through an audio alert or vibration when an object is too close.
- **Neo-6M GPS Module**: Provides location tracking. It can send the user's coordinates to a caregiver via the cloud, which is useful in case of emergencies or if the user becomes disoriented.
- **Buzzer**: Generates audio feedback when obstacles are detected or to alert the user to other hazards.

- **Breadboard and Connecting Wires**: These are essential for prototyping, allowing for the secure and flexible arrangement of components without soldering.

2. Software required

 Arduino IDE: To program and upload code to the Arduino Uno for controlling sensors, the GPS module, and the buzzer.
 Blynk App (optional, for smartphone integration): To create a user-friendly interface for monitoring location data if connected with the ESP8266, allowing caregivers to track the user's position.
 Serial Monitor or Serial Plotter (within Arduino IDE): For debugging and testing sensor readings and ensuring accurate GPS and ultrasonic sensor data.
 ESP8266 Libraries: For handling Wi-Fi communication with the ESP8266 module, especially if connecting to Blynk or another IoT platform for real-time data transmission.
 GPS Library (TinyGPS or TinyGPS++ for Arduino): To parse and process data from the NEO-6M GPS module, making it easier to extract location coordinates.
 Blynk Library (if using Blynk): Required for communication between the ESP8266 and the Blynk app, allowing remote data visualization and alerts.

DESIGN METHODOLOGY

1. Purpose & Requirements Specification

• **Purpose**: The primary purpose of the Smart Walking Stick project is to assist visually impaired individuals in navigating their surroundings safely and independently. This smart assistive device offers real-time detection of obstacles and alerts the user, enabling them to make quick decisions and avoid potential hazards in their path. The device aims to bridge the gap between traditional walking aids and modern assistive technologies by offering enhanced functionality in a portable, user-friendly format.

• **Requirements:** In our requirements gathering, we identified several key functionalities for the Smart Walking Stick

- Obstacle Detection: The device should detect obstacles within a (1-20cm) meter range using an ultrasonic sensor to ensure sufficient reaction time for the user. The Arduino Uno processes this information to provide real-time feedback.

- Real-Time Feedback: Audio alerts serve as the primary form of feedback, informing users of obstacles' proximity with different tones or intervals. Future enhancements may include vibration feedback to cater to varied preferences.

- Environmental Awareness: Equipped with a water sensor, the stick detects wet surfaces and notifies the user of potentially hazardous terrain, such as puddles or slick areas, allowing for safer movement in varied environments.

- Lightweight and Ergonomic Design: The stick is designed to be lightweight and easy to handle for prolonged use, balancing portability with functionality. Its modular structure makes it customisable for different user needs and scalable for additional features.

- Scalability for Advanced Features (Future implementations): The modular design allows for future upgrades, such as a camera for object detection, GPS connectivity for outdoor navigation, and a potential emergency alert system to enhance the user's safety further.

2. Process Model Specification

We identified key use cases and processes to ensure the Smart Walking Stick effectively meets the needs of visually impaired users:

- Obstacle Detection: The stick uses an ultrasonic sensor to detect obstacles within a set range, providing timely alerts to prevent collisions. The Arduino processes the data and triggers alerts when an object is detected nearby.

- Haptic and Audio Alerts: To communicate obstacle proximity and severity, the stick delivers feedback through audio alerts.

- Environmental Detection: Equipped with a water sensor, the stick can detect and alert the user to environmental hazards, such as wet surfaces, puddles, or slippery areas. Future enhancements may also include stair or slope detection to further improve safety.

- Navigation Assistance (Future implementations) : While not yet implemented, a GPS feature is planned to help users navigate to predefined locations, providing turn-by turn assistance for more extended outdoor use.1

3. Domain Model Specification

Physical Entities:

The Smart Walking Stick integrates several physical components to ensure reliable functionality:

- Ultrasonic Sensor: Detects obstacles in the user's path by measuring the distance to objects within a specified range, allowing for timely alerts.

- Water Sensor: Detects wet or slippery surfaces, alerting the user to potential hazards in their path.

- **Microcontroller (Arduino Uno)** : Acts as the central processor, collecting and processing data from sensors and managing output responses for real-time feedback.

- Sound Transmitter: Provides audio alerts to communicate obstacles and environmental conditions.

- Power Source: A rechargeable battery powers the device, ensuring it is lightweight and portable for everyday use.

Virtual Entities:

The system is designed to model and process various types of data that facilitate real-time feedback for the user:

- Obstacle Proximity: Data on the distance of detected obstacles, which triggers the appropriate audio alerts.

- Environmental Conditions: Information gathered from the water sensor to indicate hazardous surfaces, such as puddles or wet areas.

- Alert Status: Maintains the current alert level to provide feedback based on the obstacle's proximity and environmental factors.

4. Information Model Specification

Data Structures:

The Smart Walking Stick processes several categories of data to support real-time alerts and feedback for users:

- Sensor Data:

- Obstacle Proximity: Data from the ultrasonic sensor, measuring the distance of obstacles to categorise them as "safe," "caution," or "danger."

- Environmental Data: Information from the water sensor to alert the user about wet or slippery surfaces.

- Alert Levels:

- Defined thresholds categorise proximity alerts into levels, such as "safe," "caution," and "danger," allowing the user to understand the urgency based on alert type.

- Device Status:

- Information about the device's battery level and overall operational status to ensure users are informed about battery life and any necessary recharges.

5. Service Specifications

- Obstacle Detection Service: Continuously monitors for obstacles using the ultrasonic sensor data. When an obstacle is detected within a specified range, the service triggers immediate audio feedback to alert the user.

- Feedback Service: Provides real-time audio alerts to indicate obstacle proximity. The intensity or frequency of alerts can be adjusted based on the distance, allowing users to gauge the urgency. Future implementations may include vibrational feedback as an additional alert mode.

- Environmental Awareness Service: Detects environmental hazards such as wet or slippery surfaces using a water sensor and alerts the user to potential risks. This service improves the user's safety in various settings by notifying them of surface conditions.

- Emergency Alert Service (Planned): Although not implemented in the current version, a future feature includes a panic button that could send an alert to pre-saved emergency contacts. This functionality would improve user safety by providing a quick way to seek help when necessary.

6. IoT Level Specification

Level 1 (Basic):

Currently, the Smart Walking Stick functions as a standalone device, providing local alerts through audio feedback based on obstacle detection and environmental conditions. The basic configuration requires no external connectivity, keeping it simple and power efficient.

Level 2 (Connected):

In future upgrades, the device can be connected to a smartphone via Bluetooth. This connectivity would enable advanced features, such as real-time status monitoring and emergency alerts through a dedicated app. The app could also manage settings for the device, such as adjusting feedback types and adding emergency contacts.

7. Functional View Specification

The device's functions are categorized as:

• **Sensing:** Continuous collection of data on obstacles and environmental conditions. The ultrasonic sensor detects objects in the user's path, while the water sensor provides information on surface conditions, enhancing situational awareness.

• **Feedback:** Real-time audio alerts inform the user about obstacle proximity and terrain conditions, helping them navigate safely. Audio signals are used as the primary alert mode, with potential for vibration feedback in future versions.

• **Emergency Alerts (Planned):** A planned feature includes a panic button that would notify emergency contacts. This feature aims to increase user safety by providing a direct line of communication for assistance if needed.

8. Operational View Specification

• Communication Method: Although Bluetooth connectivity is a planned feature, the current prototype functions as a standalone device, providing obstacle detection and environmental alerts directly to the user. Bluetooth integration would allow for future enhancements, including connecting the stick to a smartphone for additional features such as location tracking and emergency alert management.

• Service Hosting: For power efficiency, key alert and navigation functions are currently processed directly on the device using the microcontroller. In a future connected model, the smartphone app would handle more power-intensive tasks, like emergency alerts, reducing the demand on the stick's battery and processing resources.

9. Device & Component Integration

Integrate sensors, feedback mechanisms, and power management:

- **Component Integration**:

The Smart Walking Stick integrates essential components for obstacle detection and feedback:

- Hardware Setup: The ultrasonic sensor and water sensor are connected to the Arduino Uno microcontroller to detect obstacles and surface conditions. Audio feedback is provided through a speaker, enabling quick alerts for real-time navigation.

- Compact Design: All components are integrated into a lightweight, compact form factor suitable for prolonged use and easy handling by visually impaired users.

- **Software Integration:** The microcontroller is programmed to process sensor data and trigger audio alerts when obstacles or hazards are detected. The firmware is designed to facilitate seamless data processing and response. In future versions, software will manage Bluetooth communication with a smartphone app.

- **Testing:** Rigorous testing is performed to ensure reliable component functionality and integration. For example, the obstacle detection feature is tested to verify accurate audio feedback upon sensor activation, confirming that alerts are triggered precisely within the specified detection range.

10. Application Development

Develop the accompanying smartphone application:

- **Emergency Alerts:** Users can configure emergency contacts within the app. Upon pressing a designated alert button on the stick, the app would notify these contacts and share the user's location, enhancing safety and response.

- **Object Detection Support:** If a camera sensor is added, the app could provide users with descriptions or notifications of detected objects, helping them better understand their surroundings.

- **Customisation Options:** The app would allow users to adjust feedback settings, such as audio intensity, and define detection ranges for obstacles, enabling personalised control over alert thresholds and responses.

- **Battery Monitoring:** The app could display the battery level of the device, notifying users when it is low to ensure uninterrupted operation.

CODE

Code for Arduino uno, water sensor, ultrasonic sensor and buzzer

```
// Water sensor

const int waterSensorPin = A0;

const float waterDetectionThreshold = 1.0; // cm


// Ultrasonic sensor

const int triggerPin = 9;

const int echoPin = 10;

const float distanceThreshold = 10.0; // cm

long duration;

float distance;


// Buzzer

const int buzzerPin = 8;

const int waterDetectedFrequency = 1500;
```

```
const int objectDetectedFrequency = 2000;

void setup() {
  Serial.begin(9600);
  pinMode(waterSensorPin, INPUT);
  pinMode(triggerPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(buzzerPin, OUTPUT);
}

void loop() {
  // Check water sensor
  float waterLevel = getWaterLevel();
  if (waterLevel > waterDetectionThreshold) {
    Serial.println("Water detected!");
    tone(buzzerPin, waterDetectedFrequency, 500);
  } else {
    noTone(buzzerPin);
  }

  // Check ultrasonic sensor
  float objectDistance = getDistance();
  if (objectDistance < distanceThreshold) {
    Serial.println("Object detected!");
    tone(buzzerPin, objectDetectedFrequency, 500);
  } else {
    noTone(buzzerPin);
  }
```

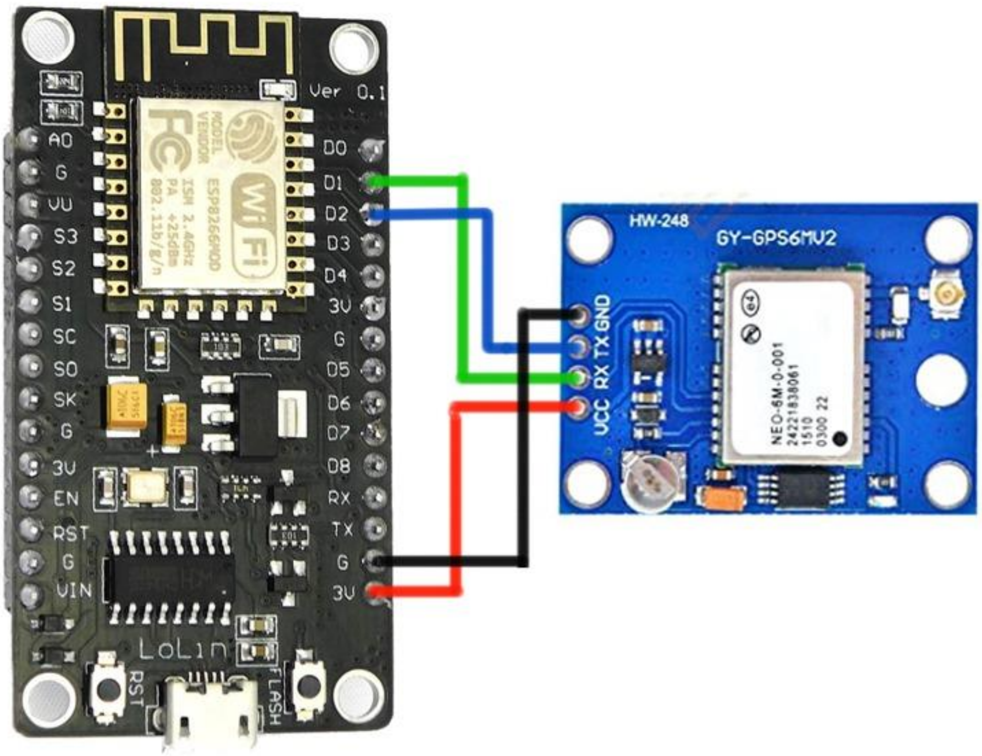
```
  delay(100);
}

float getWaterLevel() {
  int sensorValue = analogRead(waterSensorPin);
  float voltage = sensorValue * (5.0 / 1023.0);
  return voltage;
}

float getDistance() {
  digitalWrite(triggerPin, LOW);
  delayMicroseconds(2);
  digitalWrite(triggerPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(triggerPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  return (duration * 0.0343) / 2;
}
```

NEO 6M GPS CODE WTH ESP 8266 using blynk application - to find longitude and latitude

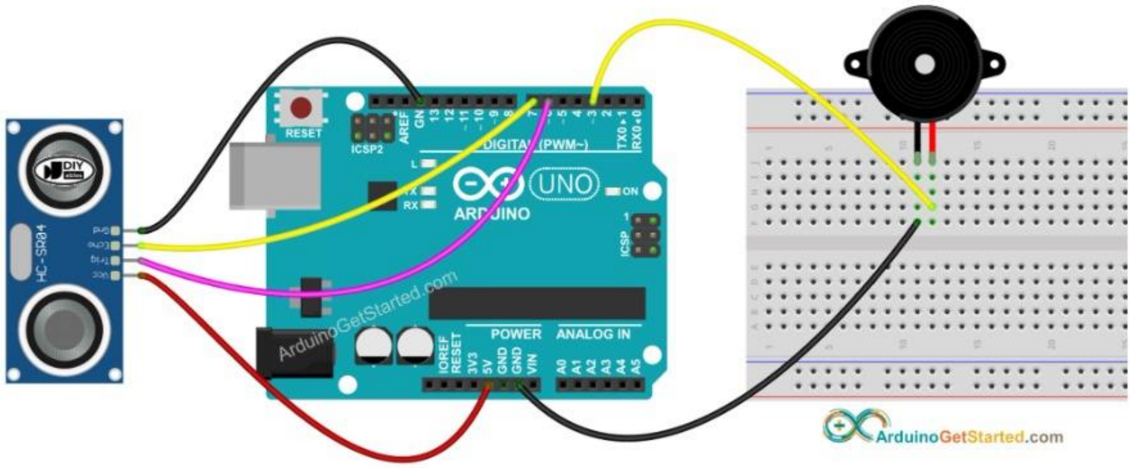
```
#define BLYNK_TEMPLATE_ID "TMPL3kEKOSCNI"
#define BLYNK_TEMPLATE_NAME "gprs module "
#define BLYNK_AUTH_TOKEN "utLE4s2Mgm9pOvBc6wJ6r1K8fVRnUE8e"

#include <BlynkSimpleEsp8266.h>
#include <SoftwareSerial.h>
#include <TinyGPS++.h>
```

```
#include <ESP8266WiFi.h>

// GPS module connections
#define gpsRxPin 5    // GPIO 5 (D1)
#define gpsTxPin 4    // GPIO 4 (D2)

TinyGPSPlus gps;                  // Create GPS object
SoftwareSerial neo6m(gpsRxPin, gpsTxPin);  // Initialize SoftwareSerial for GPS
BlynkTimer timer;                  // Create a timer for sending data

// WiFi and Blynk credentials
const char *ssid = "Galaxy S23 bhau";
const char *password = "bhau1234";
char auth[] = BLYNK_AUTH_TOKEN;

void setup() {
  Serial.begin(115200);              // Start Serial for debugging
  neo6m.begin(9600);                 // Start SoftwareSerial for GPS module
  Blynk.begin(auth, ssid, password);   // Connect to Blynk

  timer.setInterval(2000L, sendGpsData);  // Set timer to send data every 2 seconds
}

void sendGpsData() {
  // Read data from GPS
  while (neo6m.available() > 0) {
    gps.encode(neo6m.read());
  }
```

```
  // If valid location data is obtained, send to Blynk
  if (gps.location.isValid()) {
    double latitude = gps.location.lat();    // Use double instead of float
    double longitude = gps.location.lng();   // Use double instead of float

    // Send latitude and longitude to Blynk virtual pins as double values
    Blynk.virtualWrite(V1, latitude);    // Latitude (double)
    Blynk.virtualWrite(V2, longitude);   // Longitude (double)

    // Print GPS data to Serial Monitor
    Serial.print("Latitude: ");
    Serial.print(latitude, 6);
    Serial.print(" | Longitude: ");
    Serial.println(longitude, 6);
  } else {
    Serial.println("Waiting for GPS signal...");
  }
}

void loop() {
  // Blynk and timer processing
  Blynk.run();
  timer.run();
}
```



Wiring Diagram



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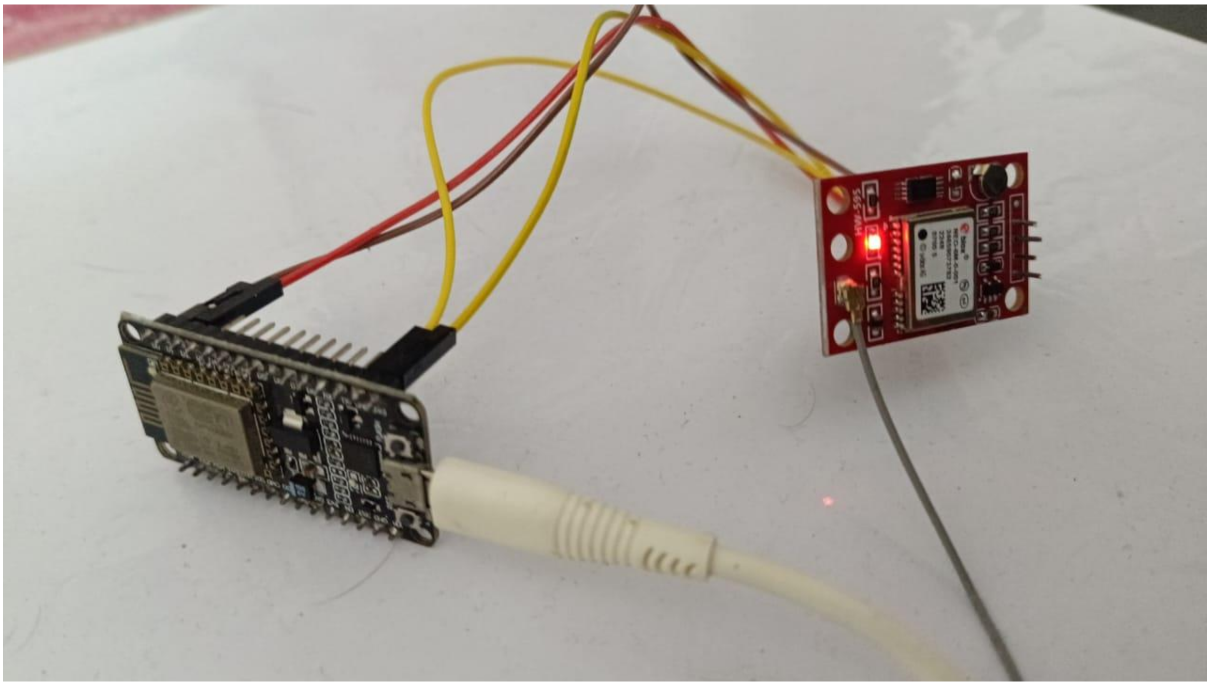
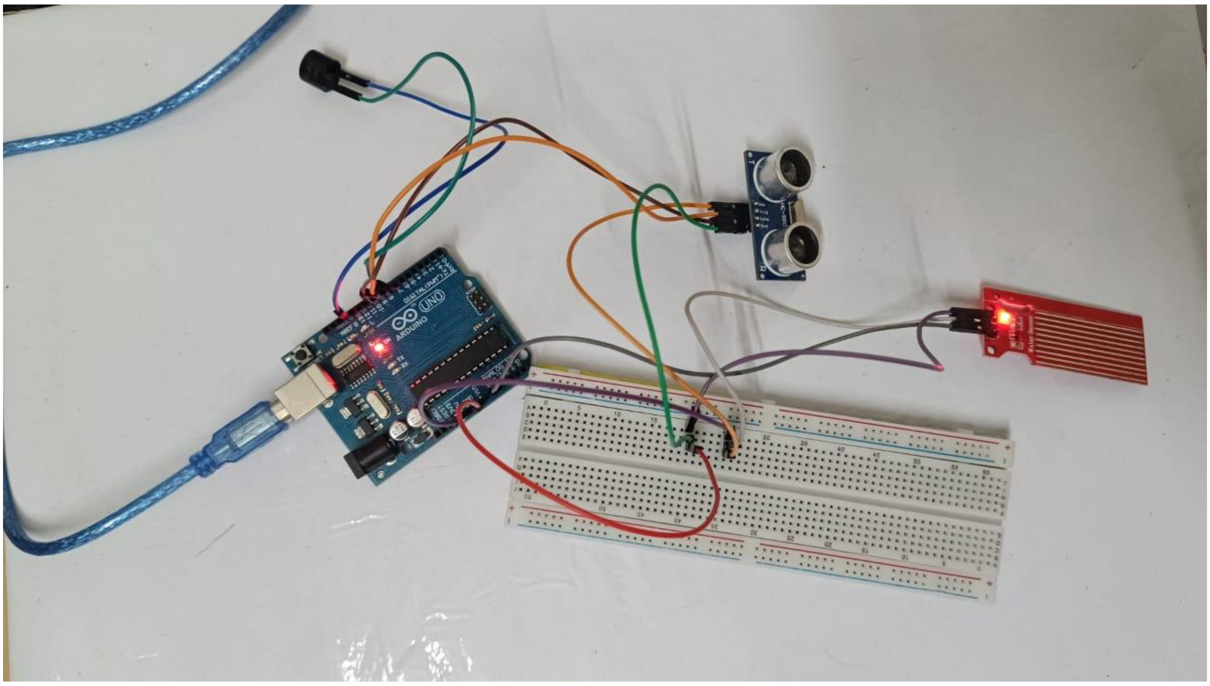
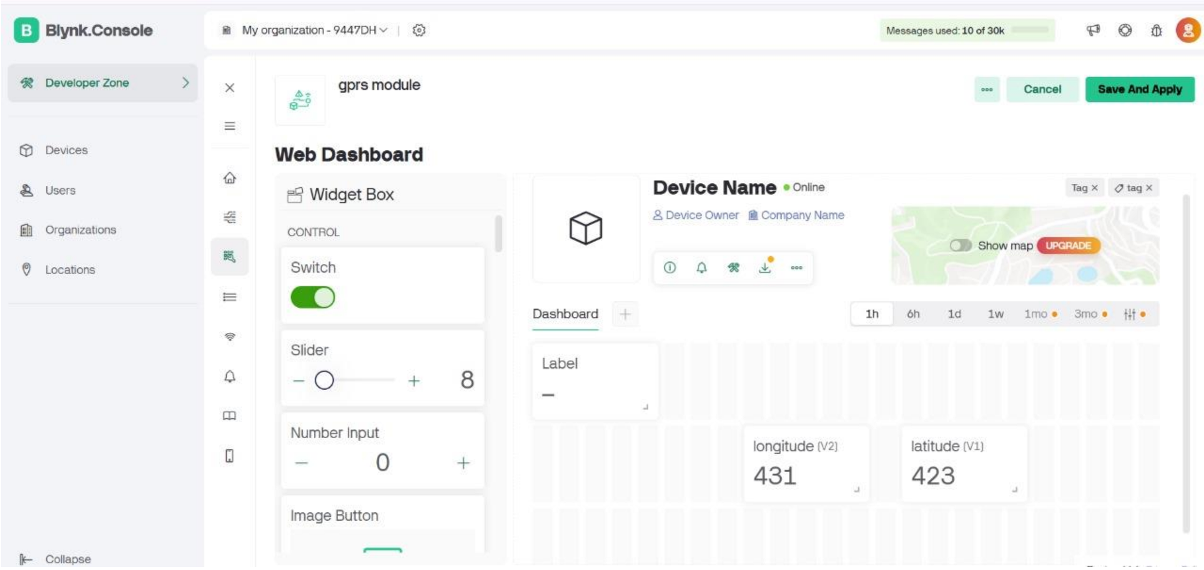
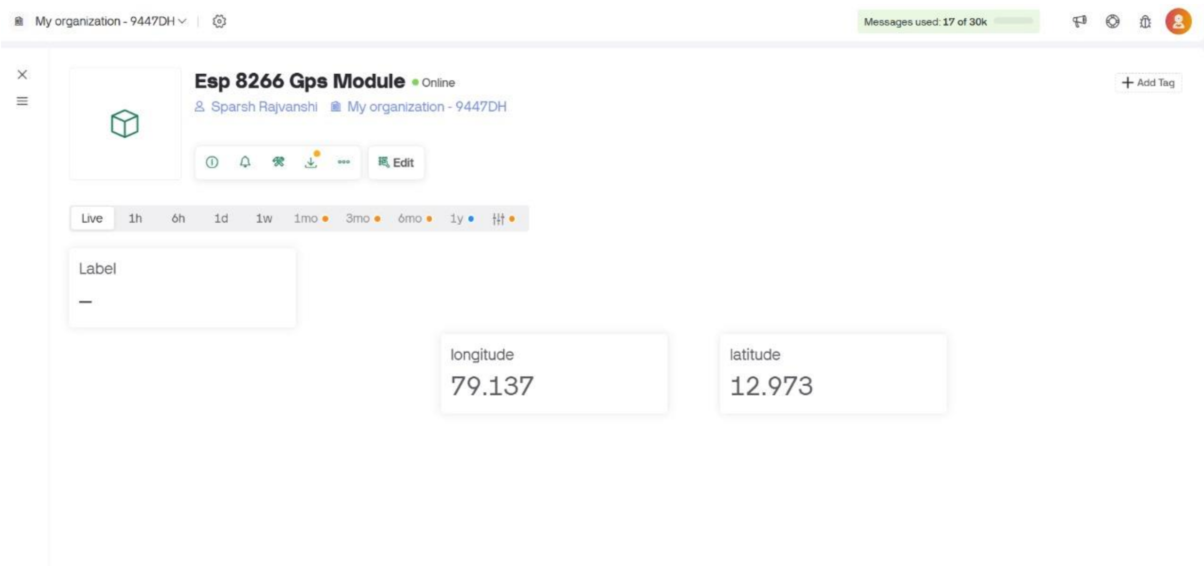
Arduino uno, ultrasonic sensor ,buzzer ,brad board





RESULTS AND CONCLUSION





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