SAFETY DEVICE FOR FALL DETECTION

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Device summary

WHAT IS THE DEVICE?

The device detects the fall of a person from a large height such as a tall building during construction or a chimney in a factory and sends a signal to the base station so that immediate medical help can be provided.

MOTIVATION..

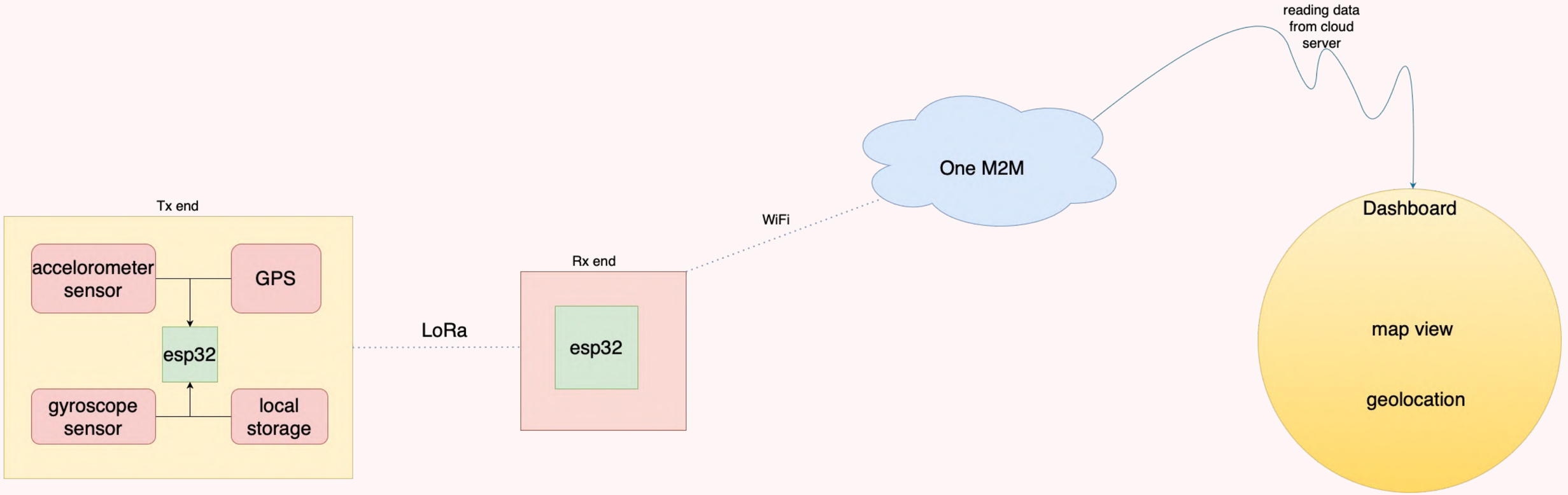
Construction and Chimney workers in factories are at high risk of falling from great heights.
A lot of the times these construction sites are remote and news of the falling does not reach necessary authorities till it is too late.
The main motivation is to help these people and prevent such casualties to make a safer working environment.

PROGRESS

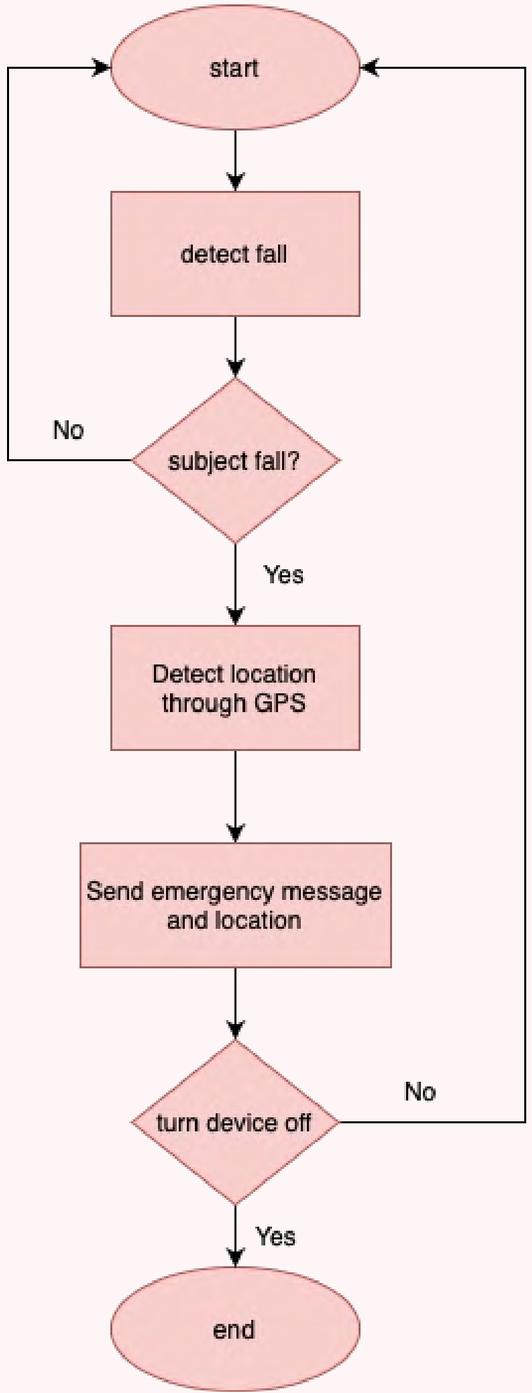
- Integration of LoRaWAN with the MPU6050 accelerometer and gyroscope module and the GPS module.
- Coming up with the algorithm for fall detection and implementing the algorithm.
- Checking the range of LoRaWAN communication as well as performing the Bit Error Rate vs Location experiment to determine the optimum distance between base station and location of the worker.
- Finishing the PCB implementation of the circuit.
- Using the GPS module to accurately determine the location where the fall has occurred to provide timely help.
- Sending correct data to OM2M and Thingspeak and retrieving this data to display on dashboard for user convenience.

tinkerCAD

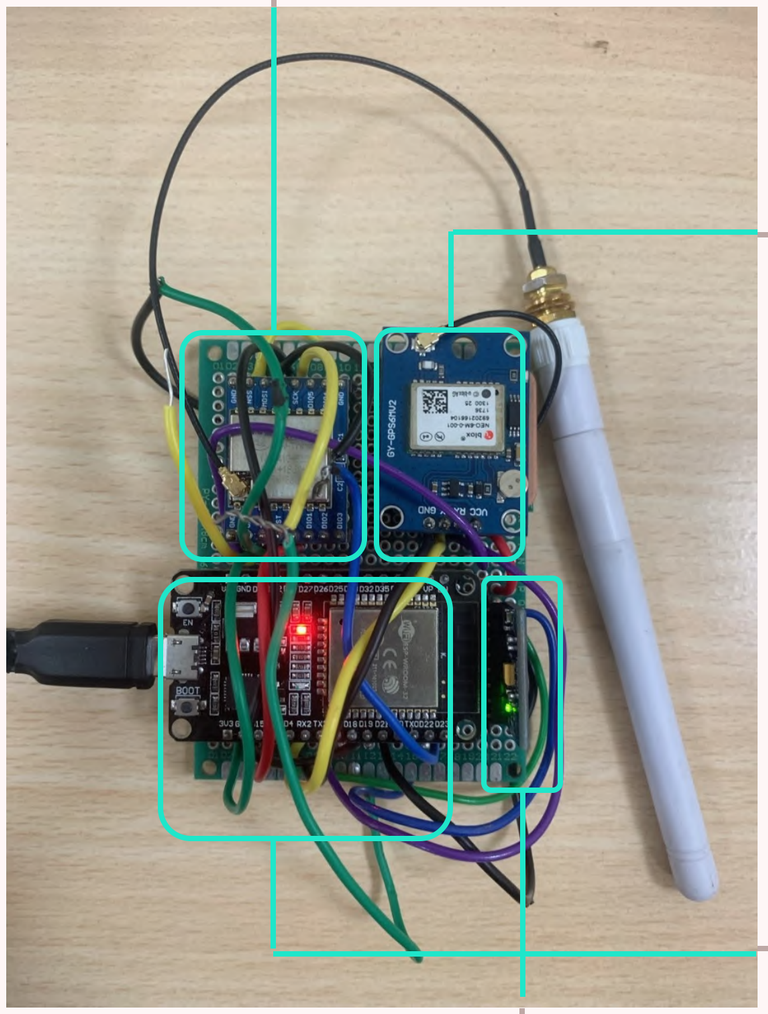
IMPLEMENTATION..



Process flow..



CIRCUIT

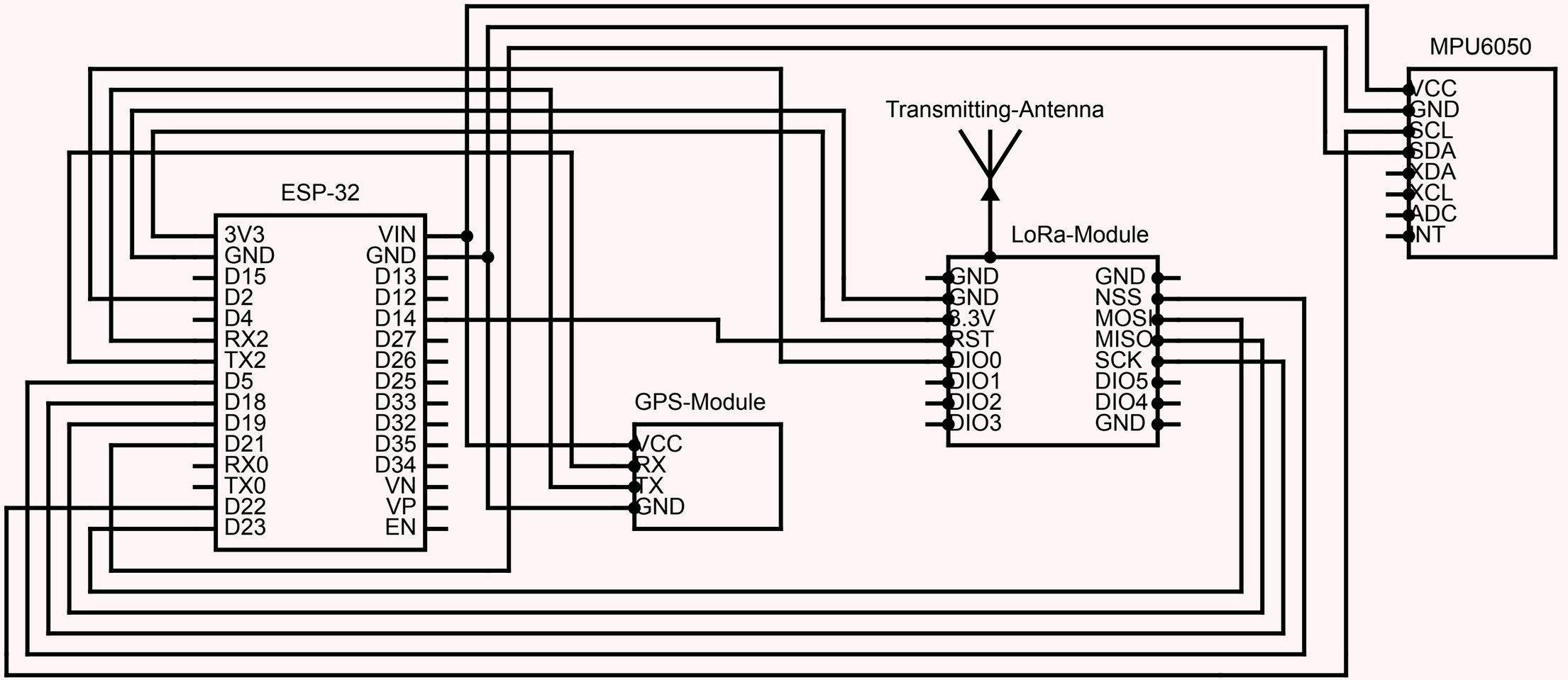


Transmitter end:

1) LoRa Module
2) MPU6050 - accelerometer+gyroscope
3) gps module
4) esp32

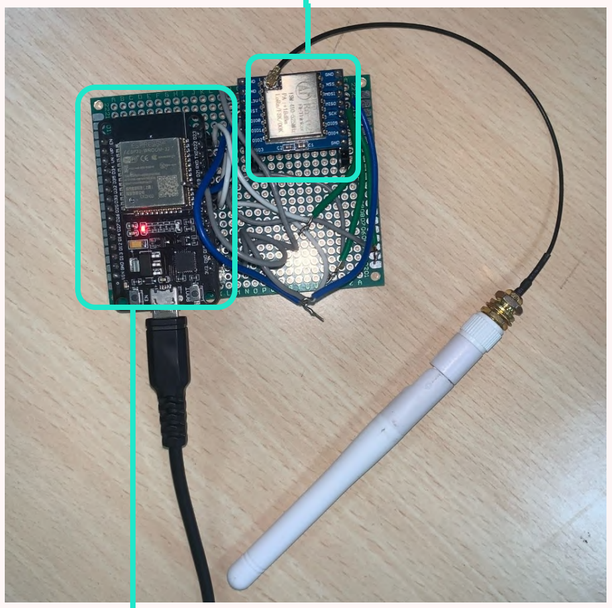
CIRCUIT-DIAGRAM

Transmitter end:



CIRCUIT

Receiver end:

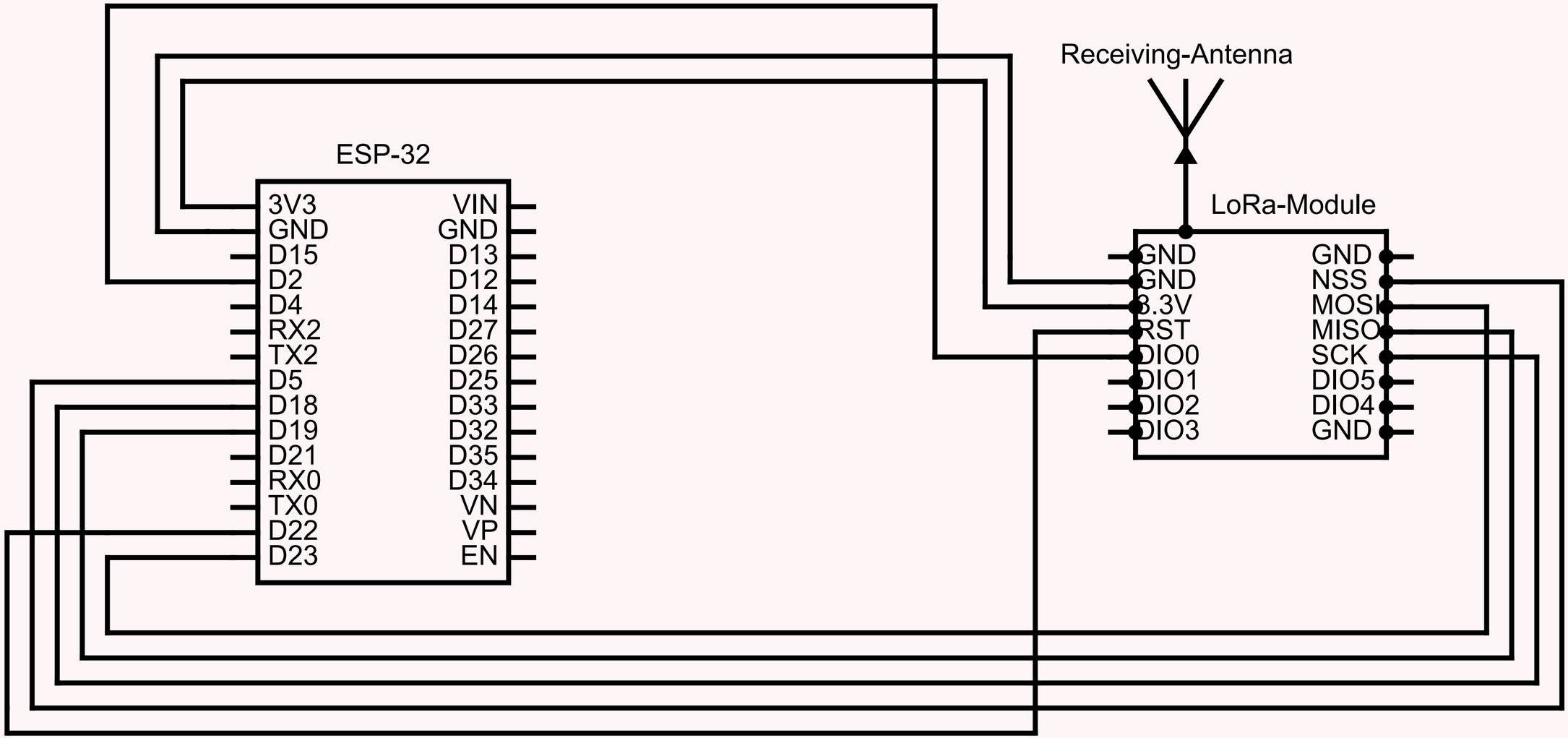


1) LoRa Module

2) esp32

CIRCUIT-DIAGRAM

Receiver end:



THE ALGORITHM

1. The main idea behind the algorithm is that a person falling from a large height undergoes free fall.
2. Thus, the MPU6050 is used to measure the acceleration of the person during operation.
3. A sudden steep change in the root mean square acceleration, i.e. sqrt(Ax^2 + Ay^2 + Az^2) (where Ax, Ay, Az is the acceleration of the person in x-, y- and z-direction respectively) indicates that a fall might have occurred.
4. To check whether a fall has occurred, we compare the root mean square acceleration recorded with a lower threshold and an upper threshold and the angleChange after the person has fallen.
5. If all three of these conditions are satisfied simultaneously, we say a fall has occurred.
6. Next, we check consciousness of the person using accelerometer values. A stable acceleration indicates the person is currently unconscious.
7. The location of the person obtained using the GPS module is then sent to the base station so that immediate medical help can be sent.

THE ALGORITHM

```
if (Amp <= 2 && impact_flag == false)
{
    free_fall_flag = true;
    Serial.println("TRIGGER 1 ACTIVATED");
}

if (free_fall_flag == true)
{
    free_fall_flag_count++;
    if (Amp >= 12 && free_fall_flag_count > 4)
    {
        impact_flag = true;
        Serial.println("TRIGGER 2 ACTIVATED");
        free_fall_flag = false;
        free_fall_flag_count = 0;
    }
}
```

- Amp = root mean square acceleration.
- Amp <= 2 indicates the person is in free fall. In general, the relative acceleration drops to 0 but due to air resistance and other physical parameters, Amp can go uptill 2. Hence, 2 is set as the lower threshold.
- Amp >= 12 indicates the person has fallen and thus an impact has occurred. Likewise, the relative acceleration goes to 10 but while experimenting, Amp goes uptill 2. Hence, 12 is set as the upper threshold.

THE ALGORITHM

```
if (impact_flag == true)
{
    impact_flag_count++;
    angle_change = pow(pow(gx, 2) + pow(gy, 2) + pow(gz, 2), 0.5);
    Serial.print("angle change: ");
    Serial.println(angle_change);
    if (angle_change >= 30 && angle_change <= 400)
    {
        angle_change = true;
        impact_flag = false;
        impact_flag_count = 0;
        Serial.print("angle change: ");
        Serial.println(angle_change);
        Serial.println("TRIGGER 3 ACTIVATED");
    }
}
```

- Once impact has occurred, we now check the change in angle of the person to determine whether the fall has occurred or not.
- An unconscious person does not show any movement and thus no or slight change in angle is observed. This would require immediate medical attention.
- The lower threshold for angle is 30 degrees and upper threshold is 400 degrees which was determined experimentally.

THE ALGORITHM

```
if (angle_change == true)
{
    fall = true;
    angle_change = false;
    angle_change_count = 0;
    Serial.print("angle change: ");
    Serial.println(angle_change);
}
if (fall == true)
{
    Serial.println("FALL DETECTED");
    LoRa.beginPacket();
    LoRa.print("1/"+String(lat0,6)+"/"+String(lng0,6)
    Serial.println("1/"+String(lat0,6)+"/"+String(lng0
    LoRa.endPacket();
    fall = false;
}
```

- Once impact has occurred, we now check the change in angle of the person to determine whether the fall has occurred or not, we check the magnitude of the change in angle and set angleChange flag.
- After this, we check if the subject is stationary by reading the angleChange for 10times(i.e., 1 sec), if it does happen we set the fall flag to true.
- **Fall is detected.**

THE ALGORITHM

freely falling
lower amplitude is observed(~0) since there is no force acting on the body
free fall flag is set.

impact
higher amplitude is observed due to deceleration caused by the ground
impact flag is set.

angleChange
sudden increase in the change of angle during the impact and becomes zero after the impact
angleChange flag is set.

The three flags are set and fall is detected

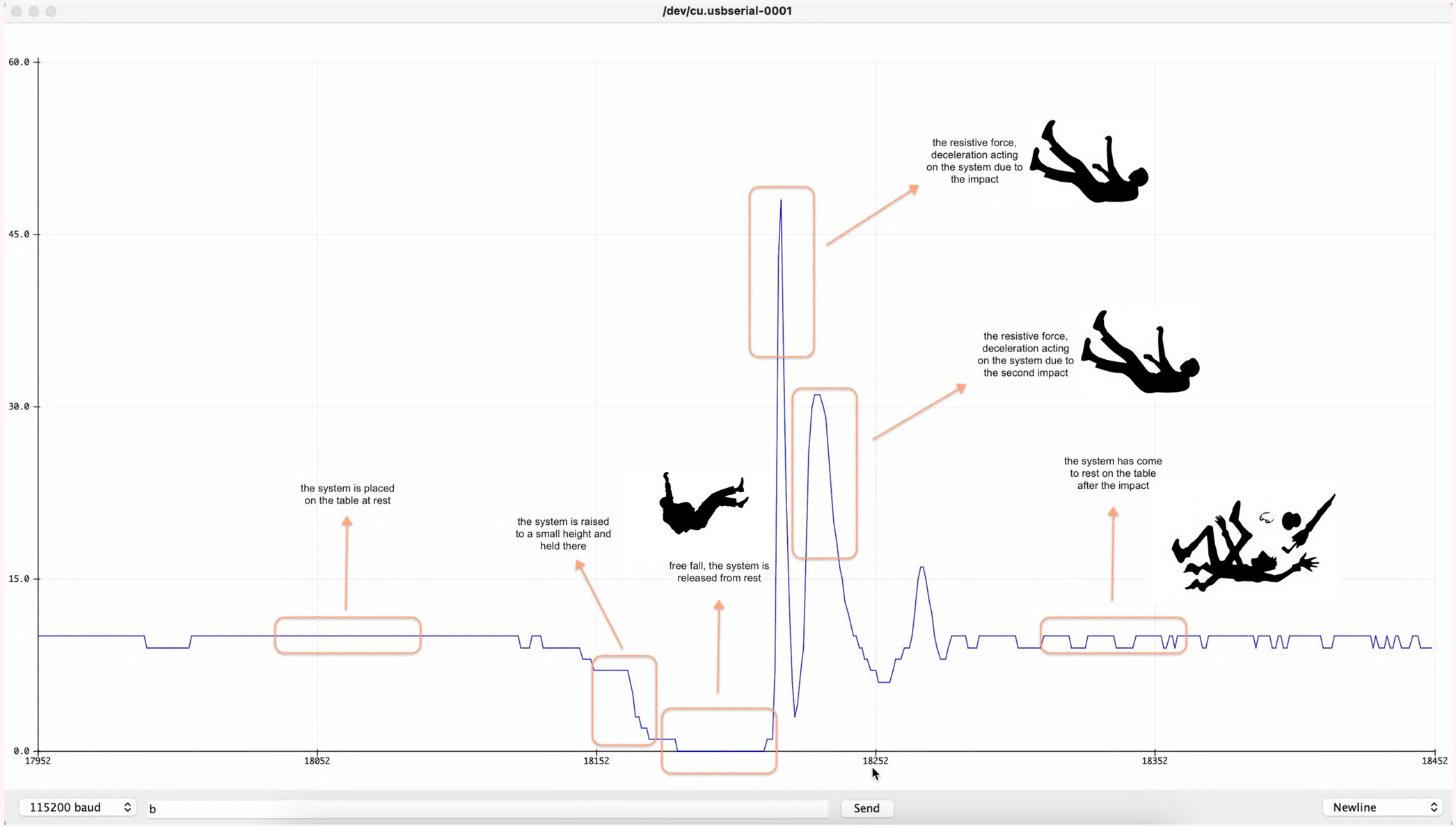
THE ALGORITHM

```
13:42:41.962 -> 0
13:42:42.061 -> 1
13:42:42.061 -> TRIGGER 1 ACTIVATED
13:42:42.171 -> 34
13:42:42.171 -> TRIGGER 2 ACTIVATED
13:42:42.171 -> angle change: 142
13:42:42.171 -> angle change: 1
13:42:42.171 -> TRIGGER 3 ACTIVATED
13:42:42.280 -> 11
13:42:42.386 -> 10
13:42:42.496 -> 10
13:42:42.610 -> 10
13:42:42.686 -> 10
13:42:42.792 -> 10
13:42:42.897 -> 10
13:42:43.002 -> 10
13:42:43.112 -> 10
13:42:43.112 -> 5
13:42:43.112 -> angle change: 0
13:42:43.112 -> FALL DETECTED
13:42:43.323 -> 10
```

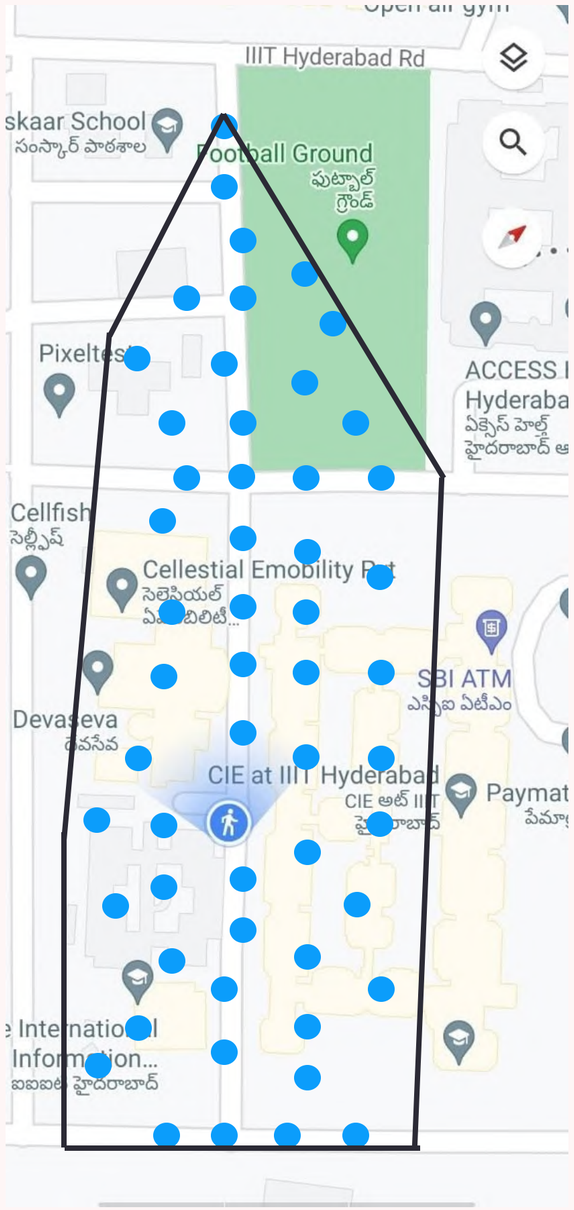
The three flags are set and fall is detected

GRAPH -The accelerations along the axes and the Amp is plotted on the Serial Plotter

GRAPH -The rms acceleration is plotted on the Serial Plotter



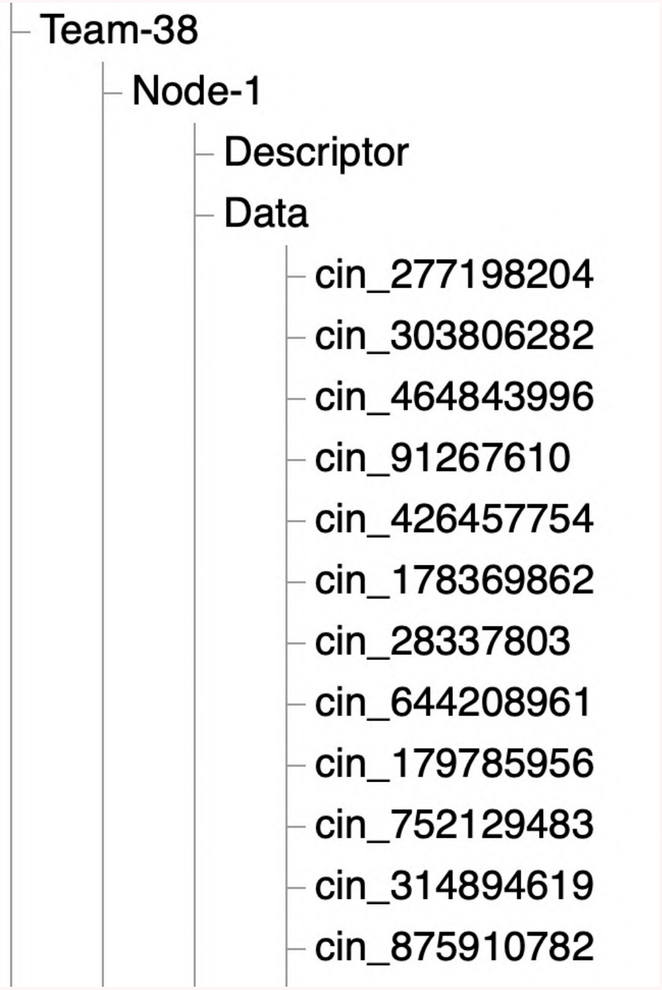
Range of LoRaWAN communication



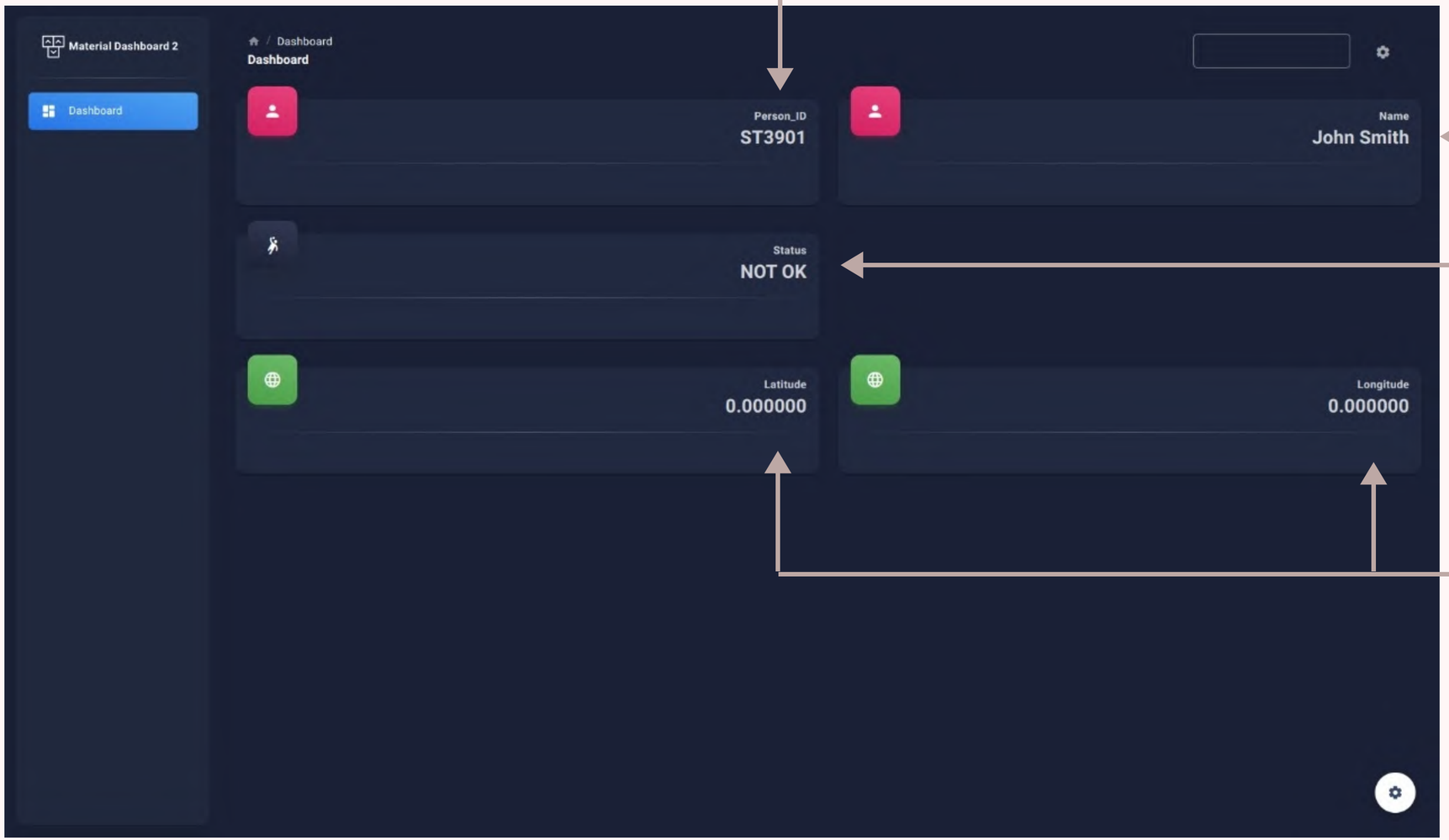
- The range is determined by keeping the transmitter's position fixed on the Himalaya Bridge. This is indicated by the symbol of a person in the adjacent figure.
- The dotted lines indicate the range of LoRaWAN communication i.e. the area surrounding the transmitter in which the reciever can receive data.
- The experimentally determined range is less than the actual range. It doesn't reach till kadamba due to dense trees. There is good communication near football ground because it is an open space. T-Hub is one of the main obstacles that blocks the communication between transmitter and receiver.

ONE M2M

Attribute	Value
rn	cin_2609812
ty	4
ri	/in-cse/cin-2609812
pi	/in-cse/cnt-398688186
ct	20221127T172047
lt	20221127T172047
lbl	• V1.0.0
st	0
cnf	text
cs	23
con	[1, 0.000000, 0.000000]



DASHBOARD



Worker ID

Worker Name

Fall Status

Latitude and Longitude

CHALLENGES FACED

1. The soldering and protecting the hardware of the circuit while testing was a big challenge. Fear of damage to the circuit was one of our main concerns.
2. The GPS module kept giving zero values on keeping a delay in the code and the delay had to be adjusted or removed in order to get proper latitude and longitude values.
3. The trees and buildings in the campus hindered LoRa communication and the bit values were sometimes hindered.

Q&A

THANK YOU!!