

IoT Project: Log Data from Your Bike Rides

Real-Time Remote Bike Ride Monitoring Using a Sustainable IoT System and Integrated Android App

Giuseppe Pasquini

University of Trento

November 19, 2024

Outline

- 1 Project Overview
- 2 System Architecture
- 3 Data Collection
- 4 Smartphone Application
- 5 Raspberry Pi Configuration
- 6 Bike Setup and App Testing
- 7 Data Visualization and Storage
- 8 Error Handling and Configuration
- 9 Future Work
- 10 Conclusion

Project Overview

- This project presents a sustainable IoT system for real-time bike ride monitoring, optimizing energy consumption and simplifying design.
- **Key Changes:**
 - **Energy Efficiency:** Removed GPS module to reduce power consumption.
 - **Energy Harvesting:** Uses only Thermoelectric Generators (TEGs), eliminating solar panels.
- A custom Android app collects data via Bluetooth Low Energy (BLE) and integrates it with smartphone GPS.
- Collected data is transmitted to an MQTT server, stored in InfluxDB, and visualized using Grafana for real-time monitoring.

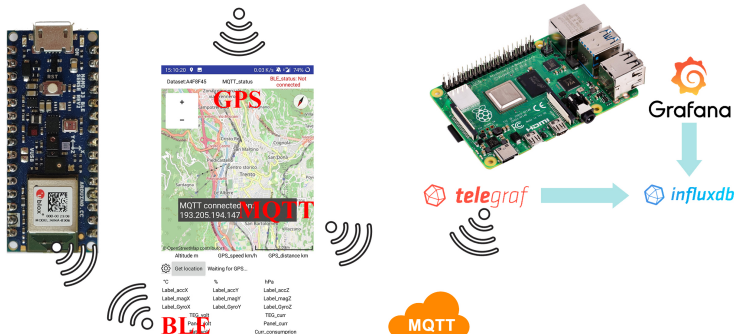
System Architecture

- **Components:**

- Arduino Nano 33 BLE Sense Rev2
- Raspberry Pi 4 for data storage (InfluxDB, Grafana)
- Android smartphone with RideSyncloT app

- **Communication:**

- Bluetooth Low Energy (BLE) for data transmission
- MQTT for data upload to the cloud



- **Sensors and Data Types:**

- **IMU (BMI270 and BMM150):** Tracks acceleration, angular velocity, and magnetic heading for real-time motion and orientation.
- **Temperature and Humidity (HS3003):** Measures environmental conditions, crucial for evaluating energy harvesting efficiency.
- **Barometric Pressure (LPS22HB):** Monitors altitude changes, valuable for hilly terrain.

- **Data Transmission and Simulation:**

- BLE services and characteristics created using `ArduinoBLE.h` for efficient, reliable data transmission.
- Simulated power consumption/harvesting data to mimic energy management system (future TEG integration).

- **Data Transmission Intervals:** Optimized for power savings:

- IMU data: every 2 seconds.
- Environmental data: every 20 seconds.
- Simulated power data: every 1 second.

RideSyncloT App

- **Key Functions:**

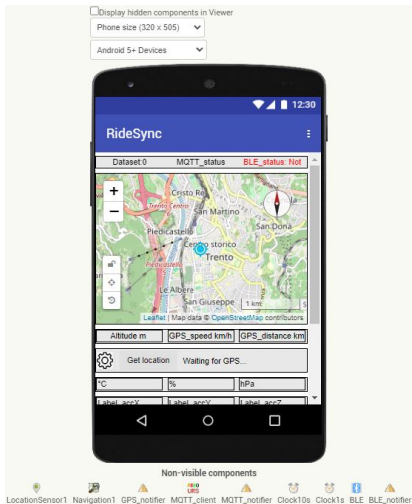
- **Bluetooth Connection:**

Maintains a seamless BLE connection to receive data from the Arduino.

- **GPS Data Collection:** Uses the smartphone's GPS to log real-time location data.

- **MQTT Publishing:** Sends both sensor and GPS data via MQTT.

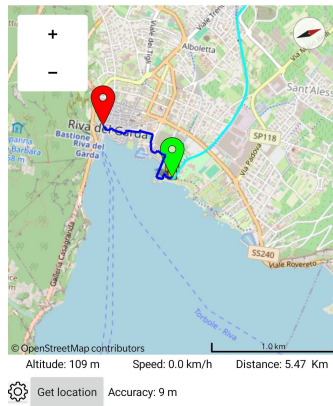
- **User Interface:** An interactive map displays real-time GPS and sensor data, ensuring a user-friendly experience while processes run in the background.



Navigation with OpenRouteService

- **Navigation and Route Guidance:**

- Set a destination by long-pressing on a Point of Interest (POI) within the map.
- The app calculates and displays the optimal route using the OpenRouteService (ORS) API.
- Provides turn-by-turn directions, estimated distance, and alternative routes.



Raspberry Pi Configuration

- **Data Storage and Management:**

- InfluxDB: Time-series database for efficient IoT data storage.
- Telegraf: Collects MQTT data and forwards it to InfluxDB.

- **Data Flow:**

- MQTT messages from RideSyncIoT are ingested by Telegraf.
- Data is stored in InfluxDB on the Raspberry Pi 4.
- Real-time analysis and monitoring are done using Grafana.



Bike Setup and App Testing

- **Setup:**

- Smartphone mounted on bike using a holder.
- Arduino Nano 33 BLE Sense Rev2 on the handlebar.
- Powered by a portable power bank.

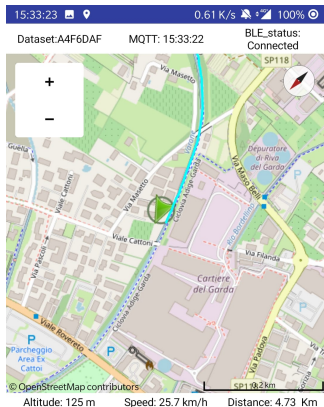
- **Testing Focus:**

- Stability of IoT system.
- Reliability of BLE and MQTT connections.

- **Testing Criteria:**

- Data visualization accuracy.
- GPS data accuracy.
- Configuration functionality.
- Navigation directions using OpenRouteService.
- Connection stability and error handling.

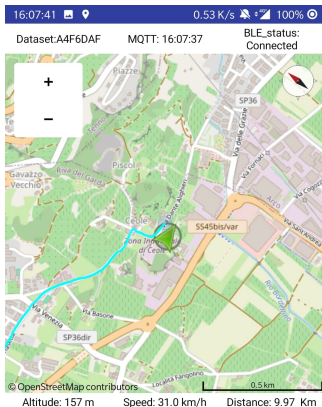
RideSyncloT App



Get location

Accuracy: 3 m

Temp: 18.2 °C	Hum: 85.6 %	Press: 1020.5 hPa
Acc X: 0.3 g	Acc Y: 0.0 g	Acc Z: 1.0 g
Mag X: 19.7 μ T	Mag Y: -31.3 μ T	Mag Z: 20.0 μ T
Gyro X: 1.8 °/s	Gyro Y: -0.1 °/s	Gyro Z: -1.7 °/s
TEG_volt: 3.1 V	TEG_curr: 27 mA	
Solar_volt: 0.4 V	Solar_curr: 64 mA	
Battery_volt: 0.5 V	Curr_consumption: 81 mA	



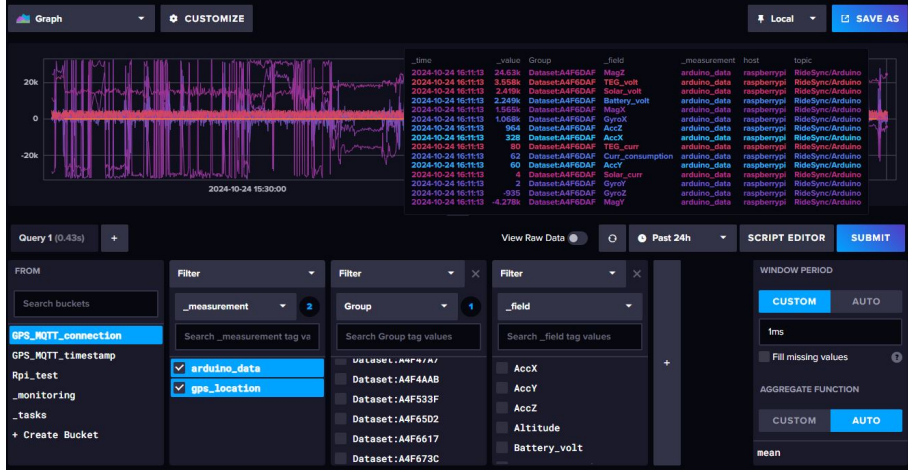
Get location

Accuracy: 30 m

Temp: 18.6 °C	Hum: 82.7 %	Press: 1016.5 hPa
Acc X: 0.3 g	Acc Y: 0.0 g	Acc Z: 1.0 g
Mag X: 24.6 μ T	Mag Y: 5.4 μ T	Mag Z: 24.1 μ T
Gyro X: 1.5 °/s	Gyro Y: 0.5 °/s	Gyro Z: -0.6 °/s
TEG_volt: 4.0 V	TEG_curr: 57 mA	
Solar_volt: 3.0 V	Solar_curr: 82 mA	
Battery_volt: 1.9 V	Curr_consumption: 6 mA	

InfluxDB Data Explorer

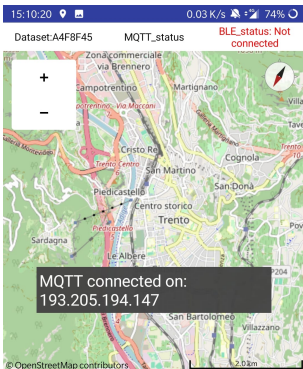
Data Explorer



Grafana Dashboard



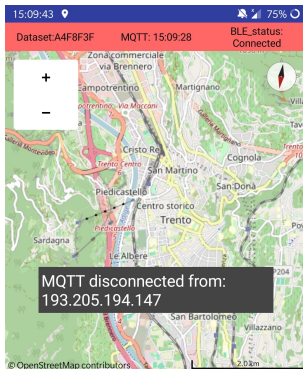
Error Handling Capabilities



Altitude m GPS_speed km/h GPS_distance km

Get location Waiting for GPS...

*C	%	hPa
Label_accX	Label_accY	Label_accZ
Label_magX	Label_magY	Label_magZ
Label_GyroX	Label_GyroY	Label_GyroZ
TEG_volt	TEG_curr	
Panel_volt	Panel_curr	
Batt_volt	Curr_consumption	



Altitude m GPS_speed km/h GPS_distance km

Get location Waiting for GPS...

Temp: 24.7 °C	Hum: 0.0 %	Press: 1014.0 hPa
Acc X: 0.0 g	Acc Y: 0.1 g	Acc Z: 1.0 g
Mag X: 5.9 µT	Mag Y: 9.9 µT	Mag Z: 13.5 µT
Gyro X: 0.1 °/s	Gyro Y: -0.0 °/s	Gyro Z: -0.1 °/s
TEG_volt: 1.1 V	TEG_curr: 62 mA	
Solar_volt: 3.5 V	Solar_curr: 73 mA	
Battery_volt: 1.9 V	Curr_consumption: 50 mA	



Altitude m GPS_speed km/h GPS_distance km

Get location Waiting for GPS...

Temp: 24.7 °C	Hum: 0.0 %	Press: 1014.0 hPa
Acc X: 0.0 g	Acc Y: 0.1 g	Acc Z: 1.0 g
Mag X: 5.6 µT	Mag Y: 10.1 µT	Mag Z: 12.6 µT
Gyro X: 0.1 °/s	Gyro Y: -0.1 °/s	Gyro Z: -0.1 °/s
TEG_volt: 3.7 V	TEG_curr: 40 mA	
Solar_volt: 1.1 V	Solar_curr: 79 mA	
Battery_volt: 4.1 V	Curr_consumption: 44 mA	

RideSyncloT Configuration Screen

15.06.24 4G LTE 73%

Dataset name: Dataset:A505B0D

Broker: 193.205.194.147

Port: 10883

Protocol: TCP

Broker Username: RideSync

Broker Password: RideSync

MQTT Connect

BluetoothLE scanning...

On android <= 11 BLE requires GPS permission and GPS to be enabled in order to function properly.

BLE scanning BLE connect

7E:C9:73:39:97:8B Nano33BLErev2
-70
63:23:03:80:28:89 null -97

- **MQTT Broker Parameters:**

- Specify IP address, port, and protocol settings.

- **Bluetooth Device Selection:**

- Scan and connect to available Bluetooth devices.

- **Dataset Configuration:**

- Create and manage unique dataset identifiers for InfluxDB.

- Focus on advancements in energy harvesting:
 - Optimization of thermoelectric generator module.
 - In-depth evaluation of energy consumption metrics.
- Continuous monitoring of energy harvesting efficiency to enhance autonomous performance.
- Explore further applications in sports monitoring and rider localization to improve performance tracking.

Conclusion

- The RideSyncloT system effectively collects, transfers, stores, and visualizes bike ride data.
- Significant energy reduction: 80% compared to previous models by integrating smartphone GPS.
- Potential applications in:
 - Sports analytics: Real-time performance data.
 - Downhill and urban contexts: IoT connectivity for improved safety and monitoring.
- Successful testing confirmed stability and accuracy in data visualization and error handling.