Project Proposal – Team 13

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Project/Team Title: Next-Gen Bike

The idea for the project is to make a multi-sensor bike that is capable of detecting cyclist skill using his balance and amount of crashes, to determine road conditions and potentially suggest optimal routes based on terrain roughness.

Introduction / Problem Statement:

With the increasing popularity of bike-friendly cities, bikes are becoming a more and more important means of transport. In spite of that, modern bikes are still typically not equipped with any safety or skill monitoring.
Mapping Solutions like Google Maps offer another big challenge to bikers: They don't consider the road conditions, which can lead to a lot of surprises for bike riders. By tracking the road condition and the skill of the cyclist, we can help bike cyclists choose paths that are suitable for their skill.

Proposed IoT Solution:

Our bike will be equipped with several sensors, allowing us to create a personal cyclist profile depending on the fitness level, balance, crashes and driving behaviour on rough terrain of the cyclist.
Simultaneously we collect important data about the road quality, underground and difficulty of certain routes that we can use to update our model, for example by using vibration, leaning angle and acceleration of the bike.
Depending on that driving score and the collected road data the application should then be able to propose a suitable route to the next destination on their smartphone.
Especially for people with balancing problems (e.g. elderly people or people with physical restraints) the application will automatically adapt to their needs.

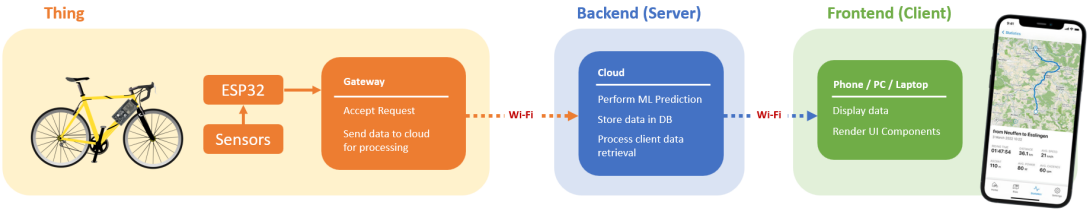
Sensors /Actuators/Hardware Used:

The sensors that will be integrated are a set of vibration sensor, acceleration sensor, Inertial Measurement Unit and a GPS sensor [1].
Actuators would not be necessary for the current iteration of the project.
Using the Inertial Measurement Unit and tilt sensor, we can measure the speed, position, and leaning angle of the bike to help determine the balance of the bike. We can use the vibration sensor to measure the roughness of the terrain the bike is on. The crashes can be detected using the acceleration of the bike with support from the vibration sensor.

Machine Learning Models:

We will be collecting vibration/balancing data from the ESP32 sensors. As we want to determine the rider's skill level based on the data from his balance, we will require a classification model. We will be using a SVM as it is easier and requires less resources to train than a Neural Network. Similarly, the roughness of the terrain requires a classification model, hence SVM will be appropriate as well. However, if we feel that the features are a lot more complicated, we may use Neural Network to classify instead.

System Architecture:
Data will be collected through the sensors and ESP32, which will then be sent to the Cloud for processing. The following diagram illustrates a high-level design of our system.



Details on which cloud providers (e.g. AWS / Google Cloud Platform) to use will be polished at a later time. Our team will also proceed with a monolithic structure as an initial base, as microservices are not appropriate given the small scale of this MVP.

Other Cool Features:
Displaying data on the client side would be done through a progressive web app (PWA), such that users are able to view the data through different mobile phones and desktop/laptops. We also plan to experiment with using a cloud-based ML pipeline, and a geolocation tracker. For the ones taking cycling more seriously we plan that one can even change preferences between classes like mountain biking, road biking, touring, triathlon etc.

Progress so far:
For the GPS module we preliminary decided on the “GPS Module 6M” as it is the well known standard, has good hardware specifications and documentation.

Possible Limitations or Challenges:
In order to successfully route cyclists to the correct path, enough data needs to be collected beforehand. In a real world scenario, a lot of data and users would be needed for this to be useful.
The sensor data has a lot of noise and outliers, which can lead to accuracy problems both for the round roughness as for the cyclist balance. We hope to compensate this accurately with machine learning. The location tracking for mapping routes and routing cyclists pose a big challenge because of their high complexity.

Timeline:
02.10.2023 - Finish Project Proposal (All)
08.10.2023 - Finalise planning of sensors, the wiring and the system architecture (All)
09.10.2023 - Start backend architecture (Max, Florian)
Start hardware wiring on ESP32 (Jason, Wei Chang)
12.10.2023 - Collect data and exploratory data analysis, start building ML models (Max, Florian)
18.10.2023 - Cloud deployment for backend (Max, Florian)
Start frontend implementation (Jason, Wei Chang)
22.10.2023 - First working prototype (ready to test, deliver and process data)
23.10.2023 - Polish frontend implementation, further testing (All)
10.11.2023 - Project should be done and only small corrections to be done
17.11.2023 - Submission

References:
[1] https://kuriosity.sg/products/gps-module-neo-6m