Anti-Theft System for Bicycles

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I. Tools Used

Description	Tool
Programming Language	Python
IDE	PyCharm
Testing	Unit Test
Emulated Data	Physics Toolbox-'Accelerometer Data'

II. Use Case-Diagram

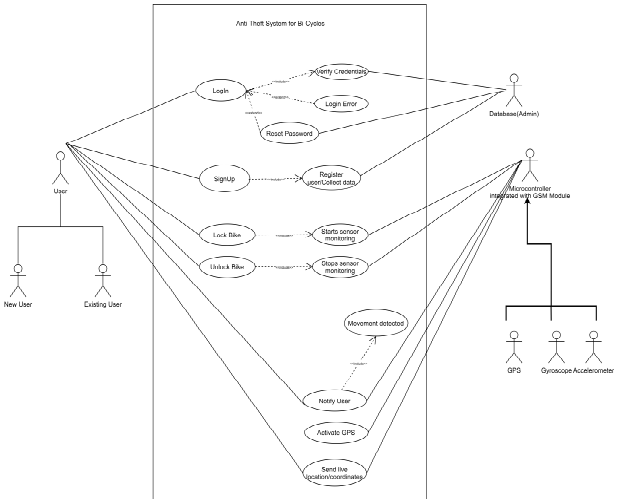

Fig 1. Use-Case Diagram

III. User Stories

Log In

Use case - Log in
User Story – He / She is a returning user who wants to lock the bicycle. The user logs into the system by providing the user credentials such as "Mobile number, Password" and once after he clicks on "Login", the user is logged in.
Requirement Specifications – "Login page" shall have Mobile Number and Password fields to be filled in by the user. Upon user input the Anti-theft System verifies the entered credentials with the database and allow user to login or display login error in the event of wrong password entered.

Sign Up

Use case - Sign Up
User Story – He/ She is the new user and needs to setup the application and create an account, the "Sign Up" page displays the fields to collect the details of the user. The user provides all the details such as, "First Name, Last Name, E-Mail, Password, Confirm Password, Security Questions, Mobile Number" and once he clicks "Submit", the account is created and the user is landed on the application main page.
Requirement Specification – In registration page, the Anti-Theft Application shall collect the user info which are listed below: First Name, Last Name, User Mail ID, Password, Confirm Password, Mobile Number, Discipline. Also, Anti-theft System should verify provided Mobile Number is unique.

Reset the password

Use case – Reset the password
User Story – On account of forgetting the password, there will be a field "Forgot the password?", upon selection the user is directed to reset the password where the user will be asked for security questions and upon successful authentication of the questions, the user is allowed to reset the password.
Requirement Specification – The Anti-theft System shall collect the required fields: username, answers for security questions**,** upon successful authentication, can reset the password**.**

Lock the bike

Use case – Lock the bike
User Story – The user will lock the bike when parked and once locked the hardware is activated and the sensors are tracking for any suspicious movements
Requirement Specification – The Anti-theft System shall lock the bike and it activates the hardware for sensor monitoring.

Unlock the bike

Use case – Unlock the bike
User Story – The user will unlock the bike that is parked and once unlocked the hardware is deactivated and the sensors stop recording the movements.
Requirement Specification – The Anti-theft System shall lock the bike and it deactivates the hardware for sensor monitoring.

Movement Detection

Use case - Movement Detection
User Story – Once the user locks the bike, the microcontroller which is integrated activates the

Accelerometer and Gyroscopic sensors for detecting the movement.
Requirement Specification – The Anti-theft System shall look for any signals from the microcontroller in the event of any movement detected.

Notify User

Use case - Notify User
User Story - The user will be notified by push notifications send by the application in view of any movement detected when the bike is locked by the user.
Requirement Specification – The Anti-theft System shall collect the data from the microcontroller in the event of any movement detected and sends the notification to the user.

Track the Location

Use case – Track the location.
User Story – On account of theft, if the user intervention is not possible, the GPS is activated and the live location is updated to the user via the application.
Requirement Specification - If there is any movement detected and if the user is not able to intervene, the GPS activates and tracks the location. So, that the user is able to locate his vehicle

IV. Activity Diagram

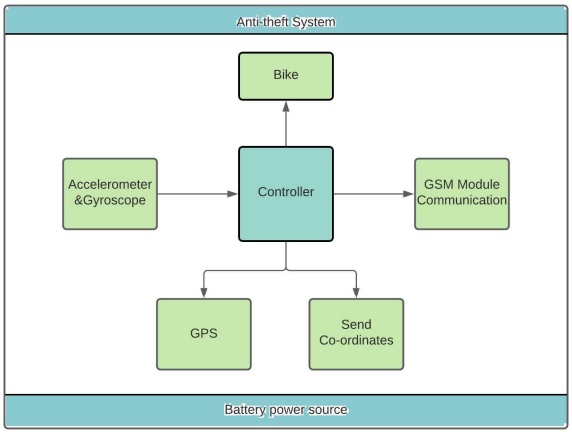

Fig 2. Hardware Architecture Diagram

The Anti-theft System is a hardware that helps track the vehicle in the event of theft. The software that controls the system is the embedded system that senses for any movement in the vehicle and notifies the user.

The Figure 2 shows the hardware components and organization of the Anti-theft system. The system is powered by a battery source. The integral role of the system is to monitor the vehicle for any movement.

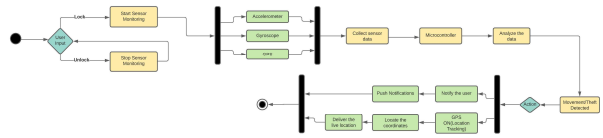

Fig 3. Activity Diagram

The Figure 3 shows the how the software transforms an input to a sequence of commands in a system. The architecture is presented in a micro-level. It mainly emphasizes the usage of different sensors for detecting the movement, locating the bicycle and its control via a microcontroller. The sensors include Accelerometer and the Gyroscope Sensor and GPS. The Accelerometer senses the vibration or a change in the motion with the help of a piezoelectric material that produces an electric charge that is proportional to the force. The Gyroscope sensor on the other hand is used for measuring the angular velocity. The hardware designed consist of all these sensors to detect the movement of the vehicle and also sending alert.

Once the user locks the bike, the hardware is activated and the sensors start monitoring. If there is any vibration or movement felt, these sensors send a signal to the microcontroller which then alerts the user by push notifications sent to the user mobile. Simultaneously, the GPS module integrated with these sensors, after receiving the signal starts locating the bike making it easy for the user to track the bike. The system also sends the geographical coordinates of the current location and updates it in regular intervals.

V. Task Cards

Tasks:
1.Start Sensor Monitoring.
2.Accelerometer sensing.
3.Gyroscope sensing.
4.Movement Detection.
5.GPS activation.

Task_1: Start Sensor Monitoring

The sensor starts to monitor for any movement once the user locks the bike. It is based on the status of the lock/unlock condition of the bike.

The microcontroller integrated with the lock system of the bike send signals to the sensors when an input is detected.

Task_2: Acceleration Sensing

The Accelerometer sensor is the one that detects the movement in the event of any vibration felt.

Using the piezoelectric material, if the motion is detected, it then compares with the threshold value and communicates to the microcontroller.

Check the recorded value with the predefined value. The microcontroller then analyzes the data received from the sensor and upon validation sends a notification to the user.

Task_3: Gyroscopic Sensing

The Gyroscope sensor senses the angular velocity of the vehicle. Similar to the function of the accelerometer, it senses the velocity and compares with the predefined threshold value and if it exceeds the value, sends signal to the microcontroller.

Task_4: Movement Detection:

Movement detection is an integral part to check whether the vehicle is in pursuit or idle.

Upon collecting the data from the sensors, the microcontroller analyzes it. Check the analyzed data against the predefined threshold value. If exceeds, issue a signal to notify the user that the vehicle is in motion.

Task_5: GPS Activation

The GPS Activation is done to locate the vehicle in the event of any theft.

On receiving signal from the microcontroller, the GPS is activated. The GPS updates the location to the user making it easy for the user to track down the bicycle.

VI. Development of the Prototype

Task taken for development: Acceleration Sensing and notifying the user.

Objective: The main objective of this prototype is to sense the acceleration and notify the user in the event of theft.

Functionalities:

1. Collecting the emulated accelerometer data and analyzing it.
2. Comparing the analyzed data with the predefined value of acceleration.
3. If the acceleration exceeds the predefined value (say >5 m/s^2), the user is notified.
4. The user is notified by sending push notifications

Development:

The acceleration sensing and notifying the user in the event of movement detection, is developed as a single standalone prototype along with unit testing. The emulator used in building this prototype – "Physics Toolbox", analyzes the data from the emulator. This emulator uses our smartphone's accelerometer sensor to record the data we require.

The prototype is built in Python. The libraries that were used include pandas, matplotlib and tkinter. The pandas library is mainly used for reading the data file, matplotlib is used for data visualization and tkinter library is used to send push notifications to the user.

The prototype compares the acceleration of the bike with the data collected. If the acceleration exceeds the predefined value (say >5 m/s^2), a push notification is sent to the user.

VII. References

[1]. Ian Sommerville - Software Engineering (2015, Pearson)

[2]. Mishra, Amit & Joseph, Elijah & Yahaya Maipan-uku, Jamilu & Awal, Aisha. (2019). An Android Based Intelligent Anti-theft and Tracking System for Automobiles.