**Train location monitoring and collision avoidance system using GPS and RFID**

**Team ID: 15**

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**Introduction**

Train collisions and derailments are one of the most serious challenges faced by Indian railways. These accidents often result in significant loss of life, property damage, and operational delays. Though, the organisation is trying to enhance safety by implementing a new system named Kavach, an Automatic Train Protection (ATP) system designed to prevent collisions and derailments, Kavach requires extensive retrofitting of railways infrastructure and rolling stock, making implementation resource-intensive and time-consuming.

Our project aims to provide a complementary and more resource-efficient alternative by minimizing retrofitting requirements, so that the system can be deployed fast. We propose a smart, IoT-based Train Collision Avoidance System using ESP32 microcontrollers, GPS modules, and RFID technology. This system aims to detect and prevent collision risks and derailment risks by leveraging GPS for real-time location tracking and RFID for precise identification of the train's running line. The idea is to provide an interim safety solution, bridging the gap until the full implementation of the Kavach system happens.

**Scope**

Instead of deploying physical train models or tracks, this project will simulate the movement of trains through a handheld setup carried around IIIT campus. GPS modules will provide real-time geolocation data as the user moves, while RFID will identify specific "tracks" via pre-placed RFID tags at designated campus locations. The system aims to replicate scenarios of multiple trains running on multiple lines including parallel lines and detecting collision risks without extensive physical infrastructure.

This project will be a proof-of-concept for a simple collision avoidance system. Our proposal does not encompass every aspect of a fully functional railway-grade solution, for example the network we will use will be cellular, but it will establish the practical viability of quickly deploying a simpler collision-avoidance system leveraging IoT. Some parts of the system can be used as they are, while others can be improved to create a complete, fully functional deployable solution.

**The project**

The project involves developing a handheld IoT-based system to simulate train operations. This setup will be carried manually around campus to simulate train traffic movement. The system integrates GPS and RFID technology to gather real-time data, including location tracking and track identification. A microcontroller processes this data and transmits it to a cloud platform for further analysis. For now, we will utilize a cellular network for communication. However, to enhance the system into a real-world deployable solution, we would require a more robust and reliable network, such as LoRa WAN or satellite communication, to ensure consistent performance under varying conditions. The communication system will be two-way, so that the system can be extended in future to control actuators for automatic actions such as stopping trains.

**Project’s Objectives**

* Demonstrate real-time train location tracking using GPS modules.
* Simulate track identification with RFID technology.
* Develop collision avoidance and derailment avoidance features using these data.
* Present a cost-effective, scalable alternative that minimizes retrofitting requirements compared to existing solutions like the Kavach system.

**Deliverables**

* A functional handheld prototype simulating train GPS tracking and RFID-based track identification.
* Real-time alerts and data visualization on a cloud platform (e.g., OM2M or Thing Speak).
* A collision avoidance mechanism that detects proximity risks between simulated trains and triggers alerts for timely intervention
* A functionality to detect and warn when trains deviate or lose their designated tracks, enhancing safety by identifying unexpected movements or misalignments.
* Configurations to simulate this system on varying size of rail traffic involving varying numbers of parallel tracks, showcasing conflict identification in a multi-line system.

**Hardware Requirements**

* **ESP32 Microcontroller (Quantity- 2)**

Serves as the central processing unit for each train unit, responsible for data acquisition, processing, and transmission.

* **GPS Modules (e.g., NEO-6M) (Quantity- 2)**

Provides real-time geolocation data to track train positions.

Store links:

<https://robu.in/product/neo-6m-gps-module-with-eprom-normal-quality/?gad_source=1&gclid=Cj0KCQiA8q--BhDiARIsAP9tKI1yC3UA3Dr8RQV_HdqlNsAXWeOhFqfwvTERQn8VdwHWeiVADU31S3YaAoAmEALw_wcB>

<https://www.amazon.in/dp/B084YZ15G3?ref=cm_sw_r_ud_dp_NV6WGRNEG2KQE0H0NGGF&ref_=cm_sw_r_ud_dp_NV6WGRNEG2KQE0H0NGGF&social_share=cm_sw_r_ud_dp_NV6WGRNEG2KQE0H0NGGF>

* **RF Tags**: **(Quantity- 10)**

These tags will be strategically placed at various points in our simulation to represent specific tracks or positions.

Store links:

<https://robu.in/product/rfid-13-56mhz-card/>

* **RFID Readers/Writers**:

Quantity - 2 These modules will be used to write and read the tags and facilitate communication with the microcontroller to identify the track location.

Store links:

<https://robu.in/product/mifare-rfid-readerwriter-13-56mhz-rc522-spi-s50-fudan-card-and-keychain/?gQT=1>

<https://www.flipkart.com/geeta-enterprises-pack-4-mfrc-522-rc522-card-read-antenna-rfid-reader-ic-proximity-module-key-chain-arduino-fm-transmitter-electronic-hobby-kit/p/itm3a4d951bd52bf?pid=EHKG3YZR7XABXPEC&cmpid=product.share.pp&_refId=PP.a8dc1957-6f60-4611-a13c-995f16fb6a68.EHKG3YZR7XABXPEC&_appId=WA>

* **Batteries (Quantity- 2)**

Portable power source for independent operation of the train units.

Store links:

<https://electronicspices.com/product/1800mah-3-7v-18650-li-ion-lithium-rechargeable-cell-battery-pack-of-1pcs?srsltid=AfmBOorGfNka78rEmzlWxvpyOXLQCrLR5ov28aj5tUGILSTL2rANbnfTZ2Y&gQT=1>

<https://robu.in/product/dmegc-inr18650-26e-3-7v-2600mah-li-ion-battery/>

<https://robu.in/product/panasonic-cr2016-3v-lithium-coin-battery/>

**Data Collection Plan**

During campus simulations, GPS will track geolocation, and RFID will identify the "track" represented by pre-placed tags. Wi-Fi modules will enable communication between setups to share proximity data and generate collision alerts. All data will be processed by ESP32 and uploaded to a cloud platform for visualization and analysis.

Proximity scenarios between multiple setups will help evaluate communication reliability and accuracy.

Expected Outcomes:

* We will assess what constitutes as "conflict" scenario, distinguishing between potential and actual collision risks.
* We will analyse proximity thresholds and the data's context, such as direction, speed, and track assignment.
* The accuracy of GPS will also be evaluated.
* Based on the limitations of system (e.g., margin of error in dense environments), strategies such as error correction, redundant checks with RFID will be explored
* Successfully validate GPS-based location tracking and RFID-based track identification for handheld simulations.

**Conclusion**

This project aims to deliver a Train Collision Avoidance System that minimizes retrofitting requirements and complements existing solutions like Kavach. By combining GPS and RFID for real-time location and track identification, our handheld prototype simulates essential functionalities while providing a resource-efficient proof of concept. Initial testing using cellular networks will establish the foundation for future upgrades to more reliable communication frameworks, ensuring scalability and adaptability in real-world applications.

**References**

[**https://en.wikipedia.org/wiki/Kavach\_(train\_protection\_system)**](https://en.wikipedia.org/wiki/Kavach_(train_protection_system))

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