IU International University of Applied Science

BERLIN

A PROJECT REPORT

on

“WOMAP – Women’s Safety Route Companion”

Submitted by

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In partial fulfillment of the requirements for the I semester

Master’s

in

Computer Science

Under the Guidance of

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at

IU

International University of Applied Science

BERLIN

2025 - 26

Abstract

Women's safety during travel continues to be a major concern, especially in unfamiliar or poorly lit areas. Many people feel anxious when walking alone or using public transport at night because there are limited tools that focus on personal safety. Existing navigation apps mainly show the shortest or fastest routes but do not consider how safe those routes are. The Women's Safe Route Companion project aims to solve this problem by creating a smart and easy to use platform that helps women choose safer routes when travelling. The system provides route suggestions based on the factors like past safety incidents, lighting conditions and nearby public spaces. It also allows users to share their live location with trusted contacts, send emergency alerts and report unsafe situations to help others stay informed. The main goal of this project is to build a supportive and reliable companion that increase women's confidence while travelling. By raising awareness and encouraging community participation, the project hopes to make daily travel safer and more comfortable for women everywhere.

Acknowledgement

It is with great satisfaction and euphoria that we are submitting the Project Report on **"WOMAP – Women's Safety Route Companion "**. I have completed it as a part of the curriculum of IU International University of Applied Science, Berlin in partial fulfillment of the requirements for the I semester of Master's in Computer Science .

I am profoundly indebted to our guide, **Holger Klus**, Professor, IU International University of Applied Science for innumerable acts of timely advice, encouragement and I sincerely express our gratitude.

Finally, yet importantly, I express my heartfelt thanks to our family & friends for their wishes and encouragement throughout the work.

Suneeth Kokala (4252195)

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Chapter 1

Introduction

Women's safety remains a major concern in many urban regions, where unpredictable environments, inadequate public surveillance and limited access to timely safety information can heighten the risk of harassment and crime. Although modern navigation tools efficiently identify the fastest or shortest routes, they often fail to incorporate real world safety indicators that are essential for vulnerable groups, particularly women traveling alone. The Women's Safety Route Companion project aims to bridge this critical gap by delivering a smart, data driven safety routing system that prioritizes personal security over distance or travel time.

The platform integrates multiple data sources including historical crime records, user submitted incident reports and contextual environmental factors to compute a dynamic safety score for different routes. By visualizing these insights on an interactive map, the system empowers users to make informed travel decisions based on both safety and convenience. Additionally, real time alerts notify users when they enter high risk areas, while live location sharing adds a layer of reassurance for trusted contacts.

The solution leverages modern technologies such as FastAPI for high performance backend services, React for an intuitive user interface, PostgreSQL for structured data management and external APIs like Google Maps and Twilio WhatsApp for route visualization and emergency communication. Beyond its technical capabilities, the project contributes to societal safety by encouraging community participation through incident reporting and crowdsourced safety updates. Ultimately, the Women's Safety Enroute Companion aims to enhance mobility confidence, reduce risk exposure and foster safer urban navigation for women across diverse settings.

Target Group

The primary target group for this project is women who travel alone, particularly in urban environments where safety concerns are more prominent. This includes female students, working professionals, commuters and travelers who require reliable route guidance and real time safety alerts. The system also supports parents, guardians and trusted contacts who wish to monitor the safety of their family members during travel. Additionally, law enforcement agencies and community safety organizations may utilize the incident data and safety insights generated by the system to identify high risk areas and improve public safety initiatives.

Risks

- **Technical risks:** Integration with real time mapping APIs may be complex.
- **Data risks:** Limited or incomplete safety or crime datasets could reduce the accuracy of route recommendations.
- **Adoption risks:** Users may hesitate to rely on the application if trust, usability, and accuracy are not well established.

Functional Requirements

- **Route Planning & Safety Guidance:** Enter start/destination, receive multiple route options, highlight the safest route and view it on an interactive map.
- **Safety Data Integration:** Use crime/safety databases, allow incident reporting and display past reports for specific routes or locations.
- **Real-time Alerts & Notifications:** Notify users in unsafe areas and update routes if safer paths are detected.
- **Admin Features:** Approve, edit or delete incident reports and manage safety datasets.

Non-Functional Requirements

- **Performance:** Fast route suggestions (3 seconds) and support for 100+ simultaneous users.
- **Security:** Encrypt all user data, enforce HTTPS communication and restrict system access to authorized users only.
- **Usability:** Provide an intuitive, mobile friendly interface where main functions are accessible within three clicks.
- **Availability & Reliability:** Ensure 99% uptime with quick recovery from failures i.e If a failure occurs such as a server issue, network outage or system crash the application should recover quickly, restoring normal service with minimal delay..
- **Maintainability & Scalability:** Use modular, well documented code that supports easy feature updates and scalability for increased users and data volume.

Chapter 2

Literature Survey

The literature survey gives a brief overview of the various Features and methods implemented for finding the safe route. This helps in identifying the gaps in the already existing systems and helps in identifying the particular features of safety which will help bridge the gaps.

Patel and Sharma (2021) et al. [1] proposed a smart route recommendation system for women's safety using geographic information systems (GIS) and IoT enabled data collection. Their model integrates crime statistics, environmental factors and user reported incidents to compute a weighted safety score for each possible route. The study demonstrates that safety aware routing significantly improves user trust and reduces exposure to high risk areas, highlighting the importance of multi source safety data in navigation applications.

Chakraborty and Saha (2021) et al. [2] developed SafePath, a location aware mobile application designed to identify and visualize safe and unsafe zones using geotagged crime reports. Their system incorporates geofencing, real time notification services and community driven incident reporting to enhance situational awareness. The study shows that dynamic alerts and user feedback loops significantly improve route safety decision making, making it relevant for applications prioritizing user protection.

Gupta and Rani (2022) et al. [3] introduced a women's safety application integrating GPS tracking, emergency alert systems and risk zone identification. Their framework uses historical crime data and sentiment based hazard mapping to automatically notify trusted contacts in emergencies. The authors highlight that combining automated location monitoring with real time alert mechanisms creates a more proactive response framework for user safety, a concept directly applicable to route safety systems.

Kumar and Mishra (2023) et al. [4] presented an AI-based predictive route optimization system for personal safety in urban environments. Their approach leverages machine learning models to forecast potential risk zones using temporal crime trends, population density and user behavior patterns. The system dynamically adjusts route recommendations based on predicted threat levels, demonstrating the value of AI driven risk predictions for improving navigation safety and user confidence.

Tripathi and Banerjee (2020) et al. [5] explored geospatial data analytics to enhance safe city navigation through the integration of spatial clustering and heatmap generation. Their work identifies high risk zones by analyzing crime patterns and urban infrastructure gaps, providing an analytical foundation for constructing safety indices. The study's findings emphasize the importance of spatial statistical techniques in designing safer routing algorithms.

Chapter 3

Technical Background

The Women's Safety Route Companion integrates predictive machine learning techniques to estimate real time safety conditions in urban environments. The system employs supervised regression models to generate continuous safety related scores that contribute to an overall safety index used for safe route recommendation.

1. Crime Prediction Model – Random Forest Regressor

A Random Forest Regressor consisting of 100 decision trees is used to predict localized crime risk patterns. This ensemble approach aggregates the outputs of multiple decision trees, providing improved predictive stability and robustness.

Purpose: To estimate the likelihood of crime occurring in a specific area at a particular time.

Features Used:

- Hour of the day
- Day of the week
- Weather condition score
- Distance to the nearest police station
- Local population density

Output: A continuous crime risk score ranging from 0 to 100, where higher values indicate greater predicted risk.

2. Crowd Density Prediction Model – Random Forest Regressor

A second Random Forest Regressor with 50 decision trees is used to estimate crowd density levels, an important contextual factor influencing perceived safety in urban regions.

Purpose: To predict how crowded or isolated a location is at a given time.

Features Used: This model uses the same input features as the crime prediction model to maintain consistency across safety estimations.

Output: A continuous crowd density score between 0 and 100, where lower scores represent sparse or isolated areas.

3. Feature Normalization – Standard Scaler

Prior to training and prediction, all input features are normalized using a Standard Scaler, which standardizes the distribution of each feature by centering it around a mean of zero and scaling it to unit variance.

Purpose: To ensure numerical stability and prevent features with larger numeric ranges (such as distance to police stations) from dominating the model.

Function: Normalization improves training performance and ensures that all features contribute proportionally to the model's predictions.

Chapter 4

System Design

4.1 Architecture Diagram

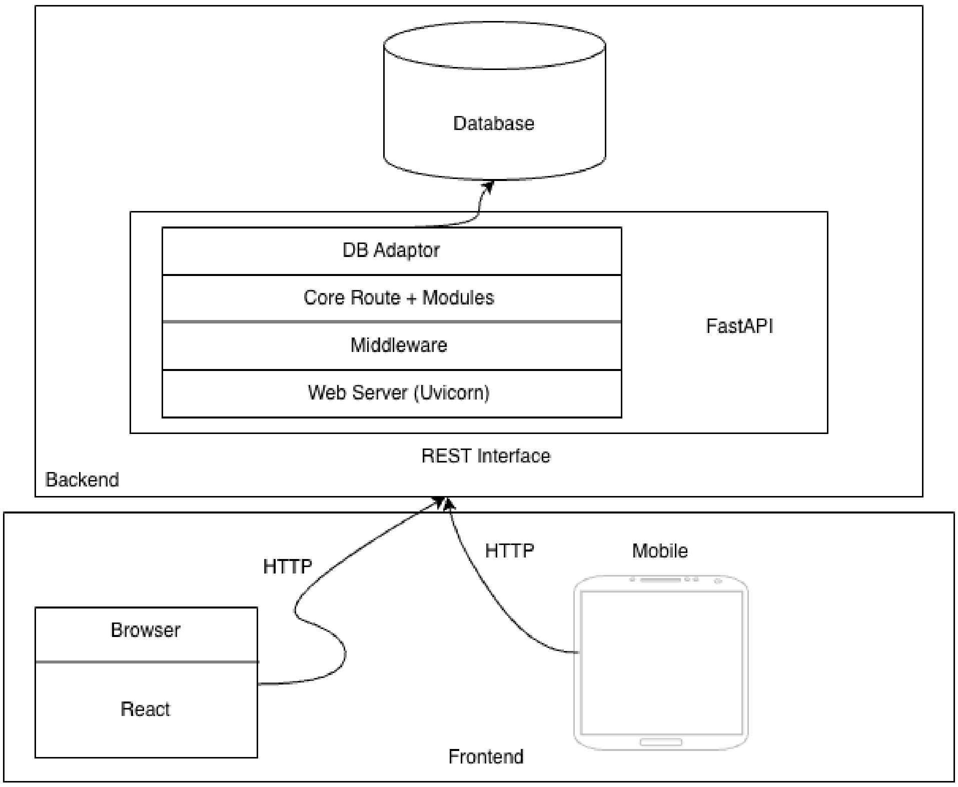

Figure 4.1: Architecture Diagram.

1. Presentation Layer (Frontend – React.js)

The frontend provides the user interface, displaying maps, safe routes and alerts. It also supports incident reporting and live location sharing. It communicates with the backend through API requests and is designed for both mobile and desktop use.

2. Application Layer (Backend – FastAPI)

The backend handles core processing, including authentication, route safety evaluation, incident management and notifications.

a. Route Safety Engine Predicts crime and crowd density using machine learning models, normalizes inputs, calculates safety indices and retrieves route options via the Google Maps API.

b. Incident Management Service Processes incident reports, stores them and supports admin review and moderation.

c. Notification Service Sends WhatsApp alerts and emergency messages through the Twilio API and provides real time safety updates.

3. Data Layer (PostgreSQL)

This layer stores user data, incidents, safety scores and geospatial information. PostGIS supports spatial queries and indexing, enabling fast retrieval and efficient route and safety analysis.

4.2 Dataflow Diagram

The Data Flow Diagram illustrates how information moves through the Women's Safety Route Companion System. The process begins when the user requests a safe route or submits an incident through the frontend interface. This request is sent to the backend, where services such as route safety analysis and incident management process the data. The backend retrieves crime records, incident reports and geospatial data from the PostgreSQL/PostGIS database and collects route options from the Google Maps API. After calculating the safety index, the system returns the safest route or notifications to the user. This flow ensures accurate, real time safety information.

4.3 Class Diagram

The Class diagram of the Women's Safety Route Companion shows how the different parts of the system work together. It represents the system using three main components: the Presentation Layer, Application Layer and Data Layer.

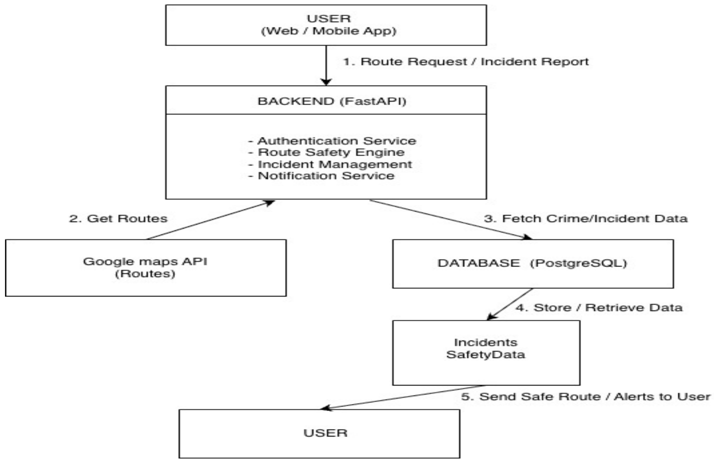

Figure 4.2: Dataflow Diagram.

1. Presentation Layer (Frontend – React.js)

This layer represents everything the user sees and interacts with. It shows maps, routes, safety alerts and forms for reporting incidents. It sends requests to the backend and receives processed route and safety data.

2. Application Layer (Backend – FastAPI)

This layer contains the core logic of the system. It handles user authentication, processes route safety calculations, manages incident reports and sends notifications. The backend also uses machine learning models to predict crime risk and crowd density and it communicates with the Google Maps API to obtain route information.

3. Data Layer (PostgreSQL)

This layer stores all the data used by the system, such as user information, incident reports and safety scores. PostGIS provides geospatial support so the system can work with map coordinates and run location based queries.

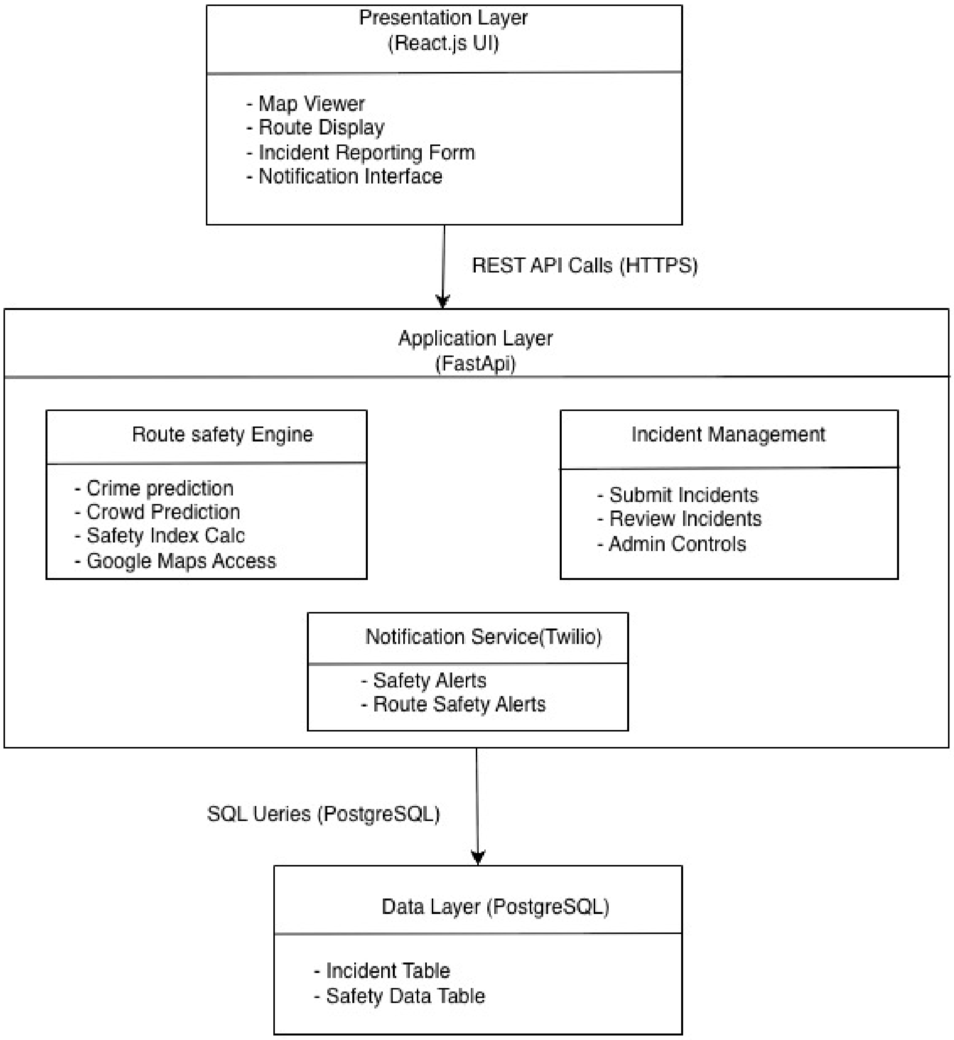

Figure 4.3: Class Diagram.

Chapter 5

Implementation

Implementation Details

The implementation of the Women's Safety Route Companion combines modern web technologies, machine learning models, geospatial tools and external APIs to deliver safe route recommendations and real time safety alerts. The system follows a modular design, enabling flexible development and easy integration of new features.

1. Software Components and Frameworks

The implementation was carried out using open source technologies, ensuring flexibility and reproducibility.

Component	**Description**
React.js (Frontend)	Builds the user interface, displays maps and safe routes and supports incident reporting.
FastAPI (Backend)	Handles authentication, route safety logic, incident management and external API communication.
Random Forest Models	Predict crime risk and crowd density using contextual features to produce safety scores.
Google Maps API	Provides routes, coordinates and travel data for safe route evaluation.
Twilio WhatsApp API	Sends safety alerts and emergency notifications to users.
PostgreSQL + PostGIS	Stores user, incident and geospatial data enables spatial queries for route analysis.

Table 5.1: Software Components and Frameworks

2. Integration Workflow

- The frontend sends route requests or incident reports to the FastAPI backend.
- The backend retrieves route options from Google Maps and safety data from PostgreSQL.
- Crime risk and crowd density models generate predictions for each route segment.
- A combined safety index is calculated and returned to the frontend.
- Twilio sends alerts if the user enters a high risk area.

3. System Deployment

The project uses Docker containers to package the frontend, backend and database into isolated environments, ensuring consistent deployment across systems. The containers communicate through a Docker Compose managed network.

Chapter 6

System Testing

6.1 Testing Objectives

- To verify that all system features function correctly when integrated.
- To ensure the route safety engine generates accurate safety scores.
- To confirm that incident reporting and retrieval operate as expected.
- To validate communication with external APIs such as Google Maps and Twilio.
- To ensure data is stored and retrieved correctly from the database.

6.2 Test Cases

TC ID	Name	Objective	Expected Result
TC-01	Route Request	Check if routes are generated for user inputs.	System displays route options with safety scores.
TC-02	Safety Index Calc.	Verify crime and crowd scores are computed.	System outputs safety scores (0–100).
TC-03	Safest Route	Ensure safest route is selected.	Route with highest safety index is shown.
TC-04	Incident Reporting	Check if user can report incidents.	Incident is saved and visible for review.
TC-05	Notifications	Verify WhatsApp safety alerts are sent.	User receives alert in high-risk areas.
TC-06	Database Check	Ensure data is saved and retrieved properly.	Data stored and fetched correctly.

Table 6.1: System Test Cases

Chapter 7

Results and Discussion

The Women's Safety Enroute Companion was tested across all major modules to evaluate functional accuracy, system performance and reliability. Each module was provided with defined inputs and the corresponding outputs were validated against expected behavior. The results demonstrate that the system is capable of generating safe routes, predicting risk levels, processing incident reports and delivering real time alerts effectively.

7.1 Results Obtained from Each Module

7.1.1 User Interface

The User Interface provides supervisors with an intuitive dashboard to monitor realtime PPE compliance across the industrial site. It displays live detection results, alerts and employee information in a clean and organized layout. Users can upload images for manual checks, view violation history and export reports for documentation. The interface ensures smooth navigation and quick access to critical safety data, enabling fast decision making.

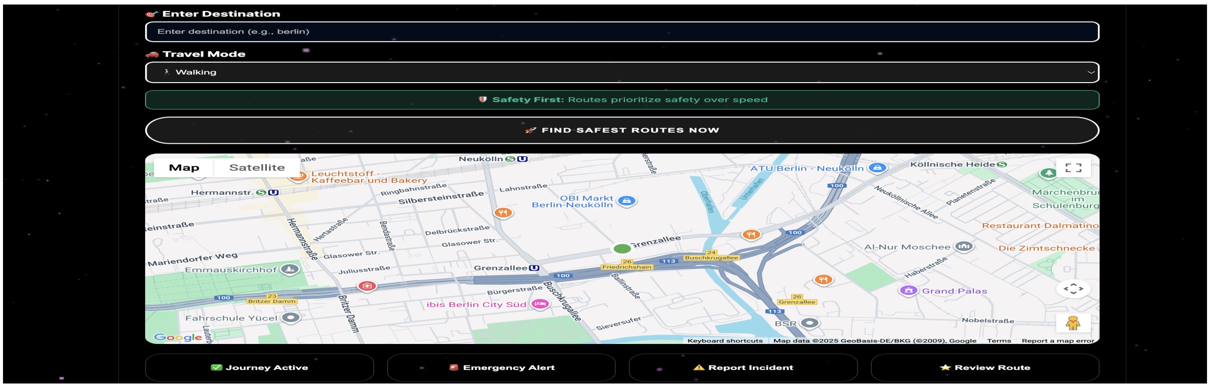

Figure 7.1: Dashboard.

7.1.2 Input Data

The system receives a variety of structured inputs across its core modules to generate safety aware navigation results. The Route Safety Engine processes origin and destination coordinates, Google Maps route options and contextual model features such as time of day, weather scores, distance to police stations and population density. The machine learning modules use these same environmental features to estimate crime risk and crowd density scores. The Incident Reporting module receives user submitted incident details including location, type, description and timestamp. The Notification Service is triggered based on the user's entry into a high risk zone, while the database layer continuously receives updated user data, incident reports, safety scores and geospatial coordinates. These diverse inputs ensure the system can assess situational factors holistically and provide accurate safety recommendations.

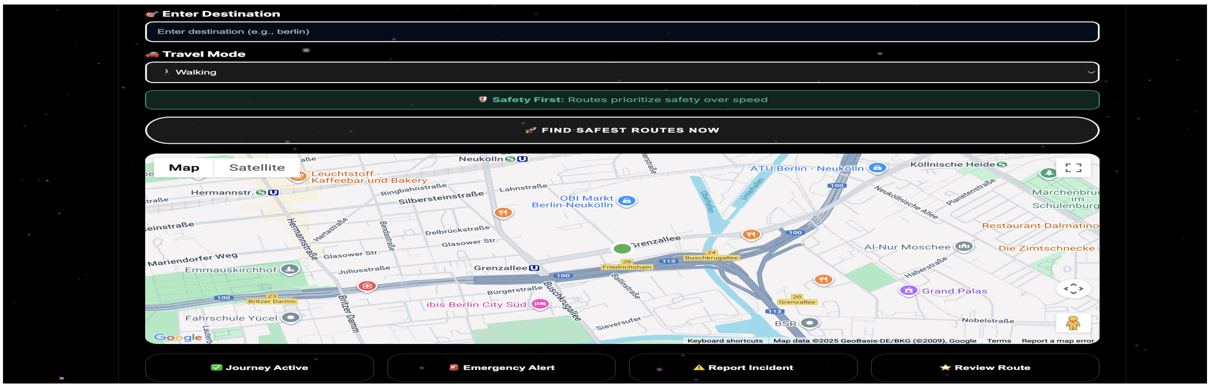

Figure 7.2: Searching Route.

7.1.3 Output

Across all modules, the system produced reliable and consistent outputs aligned with expected behavior. The Route Safety Engine generated safety indices for each route segment, highlighted the safest route and displayed intuitive color coded risk indicators. The Crime Risk Prediction module delivered stable crime scores and the Crowd Density module effectively predicted density variations, both contributing to a refined safety index. The Incident Reporting module successfully stored reports in the PostgreSQL/PostGIS database and displayed them on the map for user and admin visibility. The Notification Service achieved timely WhatsApp alerts within seconds, providing real time safety warnings to users. The database layer maintained accurate storage and retrieval of structured and geospatial data, enabling smooth and efficient route calculations. Collectively, these outputs validate the system's ability to deliver dependable safety-related insights and timely navigation support.

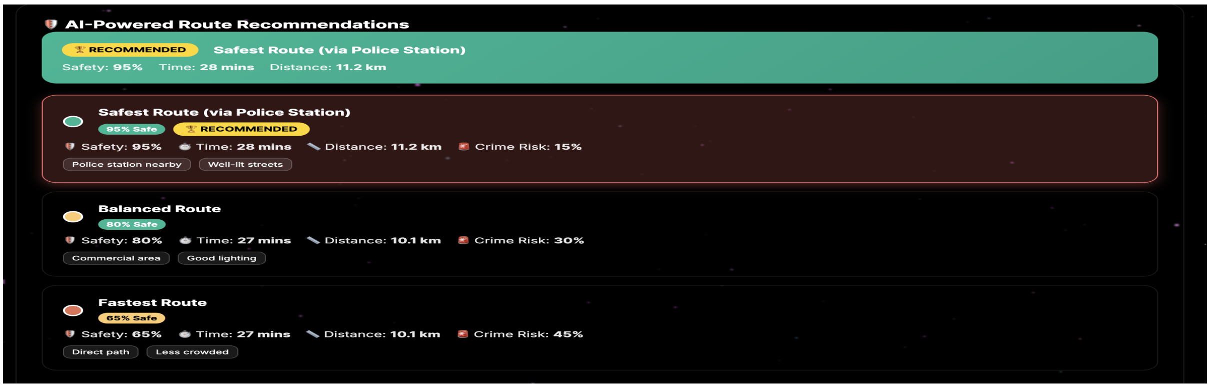

Figure 7.3: Safety Route.

Chapter 8

Challenges and Ethical Impact

Challenges

The system faces several challenges, including inconsistent real time data, limited availability of accurate crime records and dependency on external services such as Google Maps and Twilio, which may affect performance during outages. Machine-learning predictions can be less reliable in areas with sparse data and real time geospatial processing may increase computational load. Additionally, user dependent incident reporting may reduce the accuracy of safety insights when participation is low.

Ethical Impact

The project introduces important ethical considerations related to user privacy, as continuous location tracking and incident reporting involve sensitive information. Secure data handling and transparent data policies are essential. Machine learning models may also exhibit bias if trained on incomplete datasets, potentially affecting certain communities unfairly. Over reliance on automated safety scores can create false reassurance, while public visibility of incidents must be managed carefully to avoid stigmatizing specific areas.

Chapter 9

Conclusion and Future Work

Conclusion

The Women's Safety Enroute Companion demonstrates how machine learning, geospatial tools and real time communication can work together to enhance personal safety during travel. By combining crime and crowd prediction models with safe route calculation, incident reporting and WhatsApp alerts, the system provides users with reliable guidance and timely warnings in potentially risky areas. Testing across modules shows strong performance, accurate safety assessments and smooth integration between system components. Overall, the project offers a practical and impactful solution to support safer mobility for women in urban environments.

Future Work

Future enhancements may focus on incorporating real time data streams such as live crowd updates, official crime feeds, or environmental sensors to improve prediction accuracy. More advanced machine learning models, including deep learning or spatiotemporal forecasting, could further refine risk assessment. Developing a dedicated mobile application with offline functionality, background safety monitoring and personalized alert settings would enhance usability. Additionally, expanding the platform to new cities, improving community based incident reporting and providing multilingual support would broaden accessibility and strengthen the overall impact of the system.

Glossary of Key Terms

- **Admin:** User responsible for managing incident reports and safety datasets.
- **Backend:** Server-side logic implemented using FastAPI/Python.
- **Crowdsourced Data:** User-submitted safety information that enhances route safety evaluation.
- **Database:** Stores user accounts, incident reports, and safety-related data (PostgreSQL).
- **Frontend:** Web-based user interface built using React.js.
- **Incident Report:** User-submitted report describing an unsafe event or location.
- **Mapping API:** External service used to retrieve maps and routes (e.g., Google Maps).
- **MVP (Minimum Viable Product):** The initial functional version of the system containing core features.
- **Real-time Alerts:** Notifications informing users about unsafe areas or safer route options.
- **Route Planner:** Component responsible for calculating routes using distance and safety metrics.
- **Safety Index:** Numerical score representing the safety level of a route.
- **Technical Debt:** Pending improvements or features deferred to future development cycles.
- **User:** Individual using the system to plan routes or report incidents.
- **Womap:** Web application providing safe travel routes for women.

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