A Project Report

on

"Navigation for railways station facilities and location"

Submitted in partial fulfillment of the requirements
For the award of the degree of Bachelor of Technology in Computer Science and Engineering

AKS UNIVERSITY, SATNA

B.Tech. CSE (AI&DS) 4th Semester

Submitted by

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CERTIFICATE

This certify that the project report entitled "**Navigation for Railway Station Facilities and Locations"** submitted by partial fulfilment of the requirement for the degree of Bachelor of Technology in Computer Science and Engineering in **Jan-June 2025** AKS University, Satna is a Bonafide project work carried out by **Sachin Kumar Sahu (B2255R10195010)** under my supervision. The subject of the project report has been approved by supervisor. This is also to certify that it is his/her original work and no part of this project is report has been submitted for any other degree/diploma.

All the assistance help received during the course of the investigation has been duly acknowledged.

1. I am satisfied that the report presented by **Sachin Kumar Sahu** is worthy of consideration for award of the degree.
2. I certify:
   i) That he/she pursued the prescribed course for project.
   ii) That he/she bears good moral character.

Place: AKSU, Satna **External Signature**

Date: …./…./….. **…….**

……. ……

Supervisor **Head of Department**

Ms. Pragya Shrivastava **Dr. Akhilesh A. Wahoo**

(Asso. Dean, Professor, CS/IT)

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Supervisor **Head of Department**

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CERTIFICATE BY THE CANDIDATE

I certify that the project report entitled "**Navigation for Railway Station Facilities and Locations"** is my own work conducted under the supervision of Ms. Pragya Shrivastava (Supervisor), Department of Computer Science & engineering, AKS University, Satna (M.P.) for partial fulfilment of the requirement for the Bachelor of Technology in Computer Science and Engineering in **Jan-June 2025 .**I further certify that to the best of my knowledge and belief the project report does not contain any part of this work which has been submitted for the award of any degree either in this university or in any other University/ Deemed University/ Institutes.

- Sachin Kumar Sahu (B2255R10195010) - B. Tech CSE(AI&DS), 4th Semester

Place: AKSU, Satna
Date: …./…./……..

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Signature of Candidate

Sachin Kumar Sahu

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- Atul Sahu(B2255R10195044) - B. Tech CSE(AI&DS), 4th Semester

Place: AKSU, Satna
Date: …./…./……..

……..

Signature of Candidate

Atul Sahu

SELF DECLARATION

I hereby declare that the work presented in this project entitled "**Navigation for Railway Station Facilities and Locations"** towards the partial fulfilment of the requirement for the award of **Degree in B. Tech CSE(AI&DS)** in Department of Computer Science, **AKS University, Satna (M.P.)** is an authentic record of my own work.

I have not submitted the matter embodied in the project for the award of any other degree or diploma to any other institute or university.

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Signature of Candidate

Sachin Kumar Sahu

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Signature of Candidate

Atul Sahu

ACKNOWLEDGEMENT

It is a great for me in taking this opportunity to express my sincere thanks and ineptness to **Dr. Akhilesh A. Wahoo**, Head of the Department of CSE, AKS University, Satna (M.P.)

I consider myself lucky enough to have such a great project. This project would add as an asset to my profile.

At this moment of accomplishment, first of all I pay homage to my guide, **Ms. Pragya Shrivastava** Head of the Department of CSE from AKS University Satna (M.P.). This work would not have been possible without his guidance, support and encouragement. Under his guidance I successfully overcame many difficulties and learned a lot.

I am deeply and forever indebted to my parents for their love, support and encouragement throughout my entire life.

We would like to express our sincere gratitude to all those who have contributed to the development of this Result Prediction System project. Without their support, dedication, and expertise, this project would not have been possible.

First and foremost, we would like to thank the entire development team for their hard work, creativity, and collaboration throughout the project lifecycle. Each team member brought valuable skills and insights to the table, contributing to the success of the project.

We are also grateful to our mentors and advisors for their guidance, encouragement, and feedback at every stage of the project. Their wisdom and expertise have been invaluable in shaping our vision and refining our implementation.

We extend our appreciation to the open-source community for providing tools, libraries, and resources that facilitated the development process. Their contributions have significantly enhanced the functionality and usability of our Navigation for railway station facilities and locations.

Special thanks to our friends and family for their unwavering support and understanding

during the project. Their encouragement and encouragement have been a source of motivation and inspiration throughout the journey.

Last but not least, we would like to thank the users and testers who provided valuable feedback and insights during the testing phase. Their input helped us identify and address issues, ensuring a better user experience for everyone.

Thank you to everyone who has played a part in bringing this Navigation for railway station facilities and locations project to fruition. Your contributions have made a difference, and we are truly grateful for your involvement and support.

ABSTRACT

Students' academic performance is a critical issue as it decides his/her career. It is pivotal for the educational institutes to track the performance record because it can help to enhance the standard of their quality education. Thus, the role of the academic result prediction system comes into existence which uses semester grade point average (SGPA) as a metric. The proposed work aims to create a model that can forecast the SGPA of students based on certain traits. It predicts the result in the form of SGPA of computer science students considering their past academic performance, study, and personal habits during their academic semester using different machine learning models, and to compare them based on different accuracy parameters. Some models that are widely used and are found effective in this field are regression algorithms, classification algorithms, and deep learning techniques. The results conclude that deep learning techniques are the most effective in the proposed work because of their high accuracy and performance, depending upon the attributes used in the prediction.

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INTRODUCTION

India's railway network plays a pivotal role in the daily transportation of millions of people, serving as the backbone of long-distance and suburban travel. With over 7,000 railway stations and more than 13,000 trains operating daily, the Indian Railways is not only vast in scale but also complex in its operations. While technological advancements have transformed various aspects of railway operations such as online ticketing, train tracking, and digital timetables, **the navigation within railway stations and access to passenger-centric facilities has not evolved at the same pace.**

Passengers, especially those who are elderly, physically challenged, or new to a station, often struggle to find basic facilities like ticket counters, restrooms, waiting rooms, platforms, and emergency services. The signage is either limited or unclear, and the sheer size and crowd density of major stations add to the confusion. Language barriers and lack of staff availability further worsen the passenger experience.

In response to these challenges, this project introduces a **Smart Railway Station Navigation and Facility Recommendation System** leveraging the power of **Artificial Intelligence (AI)** and **Machine Learning (ML).** The goal is to offer passengers a seamless and interactive experience where they can navigate the station with ease, locate necessary amenities, and receive personalized recommendations based on their preferences, proximity, and context.

The system is designed to be platform-independent, with a web-based interface developed using **Streamlit** and a backend powered by **Flask APIs**. It integrates machine learning models that have been trained on real facility data to recommend the nearest and most relevant services to the user. In addition, it features map-based visualizations using **Folium**, allowing users to view facility locations, get directions, and even report missing or malfunctioning amenities.

Beyond assisting passengers, this system also provides significant value to railway authorities by enabling them to monitor facility usage trends, identify infrastructure gaps, and plan better resource allocation based on real-time data. The project is an important step toward modernizing station infrastructure and aligns with the broader vision of smart cities and intelligent public transport systems.

In conclusion, this project aims to bridge the existing gap between technological advancement and user experience in railway stations. By integrating AI and ML with intuitive UI/UX, the system aspires to make Indian railway stations more navigable, accessible, and commuter-friendly.

OBJECTIVE OF THE PROJECT

The core objective of this project is to design and implement a **Smart Railway Station Navigation and Facility Recommendation System** that improves commuter experience by providing real-time, AI-powered indoor navigation and intelligent facility suggestions within railway station premises.

As railway stations become increasingly crowded and complex, passengers often face significant difficulties in finding the right services—such as ticket counters, platforms, food courts, restrooms, help desks, and emergency assistance. These difficulties are compounded in large or unfamiliar stations where signage is limited or unclear. This project aims to solve this challenge by integrating **Artificial Intelligence (AI)** and **Machine Learning (ML)** technologies into a centralized navigation system that can be accessed via both **web and mobile platforms.**

The specific objectives of this project are outlined below:

- **To facilitate real-time indoor navigation** within railway stations using digital maps, enabling passengers to locate and reach key facilities with minimal effort and time.

- **To create an intuitive and interactive user interface** using tools such as Streamlit for web deployment and potential integration with mobile platforms for widespread accessibility.

- **To develop a Flask-based backend API** that serves as the communication bridge between the frontend interface, the machine learning models, and the underlying facility data.

- **To implement machine learning algorithms** that analyze station layout, facility usage patterns, and user behavior to deliver context-aware facility recommendations. These recommendations are designed to adapt dynamically based on user type (e.g., differently abled, senior citizens), current location, and time of day.

- **To visualize station data and facility locations on dynamic maps** using Folium, providing users with visual markers, tooltips, and pop-ups for enhanced spatial understanding.

- **To allow passengers to report missing, malfunctioning, or inaccessible facilities**, feeding into a feedback loop that can improve the dataset and assist authorities in maintenance planning.

- **To provide a scalable and reusable architecture** that can be adapted to different railway stations across the country with minimal configuration.

- **To empower railway management authorities with actionable insights** by logging and analyzing user interactions, common navigation paths, frequently accessed facilities, and service gaps.

- **To demonstrate the practical application of AI/ML in smart public infrastructure**, reinforcing the role of technology in improving public service delivery under the vision of "Digital India" and "Smart Cities."

- **Through the completion of these objectives**, the project aims not only to simplify station navigation but also to contribute to the modernization of Indian railway infrastructure by leveraging the latest advancements in data science and intelligent system design.

SCOPE OF THE PROJECT

The Smart Railway Station Navigation and Facility Recommendation System has a broad and impactful scope that addresses the real-world needs of both railway passengers and station authorities. The system is designed to work across different types of railway stations—ranging from small rural stops to large metropolitan junctions—and can be scaled to accommodate varying infrastructure layouts, facility types, and passenger volumes.

The project's scope covers the **development, deployment, and potential enhancement** of a comprehensive indoor navigation solution integrated with intelligent recommendation features. It offers a modular and extensible framework that can be implemented at any railway station with minimal modifications.

The major components within the scope of the project include:

1. Passenger-Focused Navigation Interface

- A responsive, map-based user interface that helps passengers find their way around a railway station using an interactive and visually intuitive map.

- The system allows real-time search and selection of destinations within the station premises (e.g., ticket counters, food courts, restrooms, waiting rooms).

- Step-by-step path guidance will assist passengers in moving from their current location to their destination with clarity and convenience.

3. **AI/ML-Based Facility Recommendation**

- Implementation of machine learning algorithms that analyze spatial and behavioral data to recommend nearby and relevant facilities.

- The system personalizes recommendations based on factors such as location, time of day,

user type (e.g., senior citizen, general passenger), and commonly accessed services.

- Facility recommendations adapt dynamically to changes in crowd density or service availability.

3. Backend Infrastructure with API Integration

- A Flask-based REST API provides endpoints for retrieving station data, facility lists, location coordinates, and ML predictions.

- The backend is capable of interacting with a live database and handling updates in real-time, ensuring that users always get the latest station layout and facility information.

4. **Web-Based User Interface Using Streamlit**

- A frontend developed in Streamlit allows users to access the navigation and recommendation features through any web browser.

- Integrated Folium maps display the location of facilities with interactive markers and pop-ups.

- The web interface includes filter and selection tools to refine the user experience and provide smooth interactivity.

5. **Support for User Feedback and Facility Reporting**

- Users can report missing or broken facilities through the interface, enabling railway authorities to receive timely maintenance alerts.

- The system logs user inputs and interactions to continuously improve recommendations and optimize layout understanding.

6. Administrative and Analytical Insights (Future Scope)

- The system can be extended to include an admin dashboard for station managers to monitor facility usage and manage infrastructure.

- Analytical tools can offer insights such as most visited areas, peak usage times, and recurring complaints.

7.Technologies Used:

Frontend: Streamlit (Python), Folium (Map rendering)
Backend: Flask API
ML/DL Libraries: Scikit-learn, Keras, TensorFlow
Geolocation: Geopy, Latitude/Longitude based distance calculations
Data: CSV/Database-based storage of facilities and locations

8.Real-Time Feedback and Reporting Mechanism:

- Allows users to report broken or missing facilities through the web interface.

- Helps in building a live database of issues that station authorities can monitor and act upon.

- Improves accountability and enhances the service quality of station facilities.

9.Interactive Indoor Navigation System:

- Helps passengers find paths within the railway station using a visual map-based interface.

- Displays facilities like ticket counters, platforms, food courts, restrooms, escalators, elevators, and emergency contact points.

- Allows point-to-point navigation within the station premises using coordinate-based route plotting.

DEFINITION OF PROBLEM

India's railway stations are among the busiest public spaces in the country, serving millions of passengers each day. While the Indian Railways has made significant strides in modernizing ticketing systems, online bookings, and real-time train status tracking, a major gap still remains in how passengers navigate within the railway station premises and access essential services. **Navigational confusion, lack of proper guidance systems, and unawareness of facility locations continue to cause inconvenience and delays for commuters**—especially for those who are new to the station, elderly, differently abled, or traveling with young children.

Most railway stations in India are large and complex in structure, featuring multiple platforms, entry and exit points, and diverse amenities scattered across vast areas. However**, there is often inadequate signage or static maps that are not user-friendly,** especially during crowded peak hours. Passengers often resort to asking others for directions, which can be ineffective, time-consuming, and unreliable. The issue is further compounded by language barriers and a lack of consistent digital solutions to assist with wayfinding and facility discovery.

Furthermore, there is no intelligent system in place to **suggest optimal facilities** based on user preferences or current location. For example, a passenger may not know which restroom is closest, which food court is less crowded, or where to go during an emergency. The absence of digital infrastructure for reporting broken or missing facilities also leads to long-standing service issues that go unnoticed by station authorities.

From the perspective of railway management**, there is no centralized digital platform to monitor facility usage patterns,** identify bottlenecks, or gather real-time feedback from users. This prevents data-driven decision-making for infrastructure planning, maintenance prioritization, or crowd management.
In summary, the key challenges this project seeks to address are:

Lack of real-time indoor navigation for passengers within the station environment.

Difficulty in locating essential services such as ticket counters, platforms, waiting rooms, food outlets, and restrooms.

Absence of intelligent facility recommendation systems based on proximity, user type, or time of day.

No support for real-time reporting of faulty or missing infrastructure by users.

Limited digital engagement between passengers and railway authorities regarding station services.

No centralized mechanism for facility management insights and analytics for authorities.

Currently, most railway stations suffer from the following critical issues:

- No Real-Time Indoor Navigation
- Difficulty in Finding Key Facilities
- Lack of Personalized Facility Recommendations
- Inability to Report Missing or Faulty Services
- No Data-Driven Monitoring by Authorities

BENEFITS OF THE PROJECT

The Smart Railway Station Navigation and Facility Recommendation System offers transformative advantages for both passengers and railway administrators by enhancing navigation, accessibility, and the intelligent use of infrastructure. Through the strategic application of artificial intelligence, machine learning, and digital mapping, the system addresses long-standing challenges in the railway ecosystem. The following sections elaborate on the tangible and strategic benefits delivered by the project:

1. Seamless Intra-Station Navigation

Passengers are often unfamiliar with station layouts, which can be large and confusing. With this system, users are able to:

- Access station layouts interactively.
- Navigate from one facility to another (e.g., entry gate to platform) in real-time.
- Reduce confusion and dependency on station personnel for directions.
- This creates a smoother travel experience, especially during emergencies, peak hours, or for travelers in a hurry.

2. Smart Recommendations Based on User Context

The use of ML and DL algorithms enables the system to:

- Recommend the nearest usable facility depending on the passenger's real-time location.
- Suggest appropriate services based on user profile (e.g., accessibility needs).
- Adapt to changes in passenger flow, time of day, and service availability.

- This personalization enhances passenger satisfaction by making the experience feel tailored and intelligent.

3. Enhanced Passenger Safety and Support

Safety is a key concern in crowded public places. This system contributes to it by:

- Helping passengers quickly locate emergency services (e.g., RPF support, medical rooms).
- Integrating emergency contacts into the platform interface.
- Minimizing unnecessary crowding by distributing passengers evenly via optimized routes.

4. Efficient Resource Allocation for Station Management

For railway authorities, the platform offers:

- Real-time insights into facility usage patterns.
- Data-driven dashboards to understand which services are underused or overcrowded.
- Logs of reported issues which help prioritize maintenance and budget allocation.
- This aids in infrastructure planning, reduces wastage, and improves public service delivery.

5. Promotion of Digitally Inclusive Infrastructure

The system supports the idea of a “Digital Railway Station”, aligning with broader national goals like Digital India and Smart Cities. It helps bridge the gap between traditional

infrastructure and modern user expectations by:

- Supporting multilingual interfaces (planned in future versions).
- Planning voice-guided navigation for visually impaired users.
- Encouraging user participation through feedback and facility reporting.

6. Environmentally and Economically Efficient

- Reduces reliance on printed signs, maps, and paper-based assistance.
- Automates services that would otherwise require additional human resources.
- Enables predictive maintenance, reducing the environmental and financial cost of emergency repairs.

7. Improved Accessibility for Differently-Abled Passengers

The platform considers diverse mobility needs by:

- Highlighting accessible restrooms, ramps, and elevators.
- Filtering facility recommendations based on accessibility features.
- Making stations more welcoming to all user groups and ensuring compliance with accessibility standards.

8. Reduced Crowd Congestion and Better Crowd Management

Through route optimization and smart facility suggestions:

- The system prevents bottlenecks in high-traffic areas.
- It can dynamically redirect users to less crowded or alternate facilities.
- Over time, the system helps improve the flow of foot traffic, especially in multi-platform stations.

9. Technological Scalability and Integration

Built using scalable, open-source tools and APIs, the system:

- Can be deployed to any number of stations with configuration changes.
- Supports integration with real-time train data (e.g., IRCTC APIs).
- Allows for the addition of future modules (like AR navigation, IoT devices, etc.)

MAIN MODULE

The proposed system is designed as a modular and scalable platform where each component performs a specific role, allowing for maintainability, adaptability, and parallel development. The following are the primary modules of the Smart Railway Station Navigation and Facility Recommendation System:

1. User Interface Module (Web Frontend)

Technology Used: Streamlit (Python-based web framework)

Function: Provides a visual and interactive interface for users to navigate the system.

Features:

Dropdown filters to select railway stations.

Display of facilities using dynamic map rendering (Folium).

Facility search, selection, and marker-based interaction.

Display of recommendations and feedback submission options.

2. Map Visualization and Navigation Module

Technology Used: Folium, Leaflet.js (via Folium)

Function: Renders an interactive map with markers showing various facilities within the selected railway station.

Features:

Visual markers for different types of facilities (ticket counters, restrooms, etc.).

Centering and zooming based on selected station.

Popup tooltips and icon indicators.

Route visualization (future enhancement using indoor path plotting).

3. Backend API Module (Flask API)

Technology Used: Flask (Python), REST API principles

Function: Serves data between frontend and data layers including facility data, coordinates, and predictions.

Features:

Endpoints to fetch list of facilities by station.

Endpoint to update or add new facilities.

Secure access to data using simple authentication (optional).

Can be extended for live integration with railway databases.

4. Data Management Module

Technology Used: Pandas, CSV/Database Integration

Function: Manages the datasets related to station facilities, coordinates, categories, and accessibility metadata.

Features:

Storage and processing of facility names, types, lat/long, accessibility, and usage logs.

Ability to read, preprocess, and clean input data files.

Ensures consistent data structure for ML model input.

5. Machine Learning Recommendation Module

Technology Used: Scikit-learn (Random Forest), LabelEncoder, TensorFlow/Keras

Function: Predicts and recommends facilities based on user's current location and profile.

Features:

Facility recommendation using a trained classification model.

Suggestions adapt based on user location (lat/long) and context.

Future integration planned for behavioral data to improve accuracy.

Trained offline and deployed through API for real-time inference.

6. Deep Learning Module (Optional/Prototype)

Technology Used: TensorFlow, Keras

Function: Enhances prediction performance through multi-layer neural networks.

Features:

Trained on latitude and longitude to classify optimal facility types.

Provides backup or complementary predictions to the ML module.

Experimental use for comparative analysis of model performance.

7. Feedback and Reporting Module

Function: Enables users to submit feedback, complaints, or facility issues.

Features:

Form inputs to report broken or missing infrastructure.

Data logging for administrative review.

Helps improve dataset quality and infrastructure monitoring.

8. Accessibility and Emergency Support Module

Function: Provides easy access to emergency services and accessible facilities.

Features:

Filters for showing wheelchair-friendly restrooms or ramps.

Integration of contact options for station master, security, or RPF.

Designed with future voice-gui

TECHNICAL OVERVIEW

The Smart Railway Station Navigation and Facility Recommendation System is an integrated, intelligent platform designed using a multi-layered architecture. It combines modern web technologies, geospatial visualization, machine learning, and real-time user interaction mechanisms to deliver a smart navigation and facility discovery experience within railway stations. The system is engineered to be highly modular, allowing individual components to be scaled, extended, or replaced based on evolving project requirements or technological advancements.

1. System Architecture

Layer	Description
Presentation Layer	Streamlit frontend for user interaction and dynamic map visualization
Business Logic Layer	Flask backend APIs handling requests and managing ML model interactions
Data Processing Layer	Pandas for data cleaning, transformation, and preprocessing for ML models
ML Layer	Machine learning and deep learning models that generate facility predictions
Data Storage Layer	CSV-based data storage; expandable to SQL/NoSQL databases like Firebase

This layered structure ensures separation of concerns, enhances maintainability, and supports future microservices deployment.

2. Technology Stack Details

Component	Technology	Function
Web Frontend	Streamlit	User interface with controls for station selection and map interaction
Backend Server	Flask (Python)	RESTful API to connect frontend and ML models
Map Visualization	Folium, Leaflet	Location plotting and interactive tooltips
Machine Learning	Scikit-learn	Random Forest Classifier for facility recommendation
Deep Learning	Keras + TensorFlow	Multi-class facility prediction using dense layers
Geolocation Engine	Geopy	Distance calculation between user and nearby facilities
Data Management	Pandas, NumPy	Handling facility data from CSVs, filtering and transformation
Storage	CSV (offline)	Stores facility metadata and location data; upgradable to cloud DB

System Components

1.Frontend (Web Interface) – Streamlit:

- Built using Python's Streamlit framework for rapid deployment.
- Allows station selection, displays facility recommendations, and renders Folium maps.
- Simple, responsive interface that works on any device with a browser.

2.Backend Server – Flask API:

- Receives requests from the frontend and sends back relevant data.
- Hosts ML models and handles prediction calls for facility recommendations.
- Manages data routing, user feedback, and dynamic map updates.

3.Map Generation – Folium:

- Uses geolocation data (latitude and longitude) to display station maps.
- Adds markers for each facility along with tooltips and popups.

- Supports user interaction (zooming, clicking, tooltips).

4.Machine Learning Pipeline:

- Trains on facility usage data, location, and accessibility.
- Encodes categorical variables using LabelEncoder.
- Predicts suitable facilities based on real-time location inputs.
- Integrated into Flask for live recommendation requests.

5.Deep Learning Extension (Prototype):

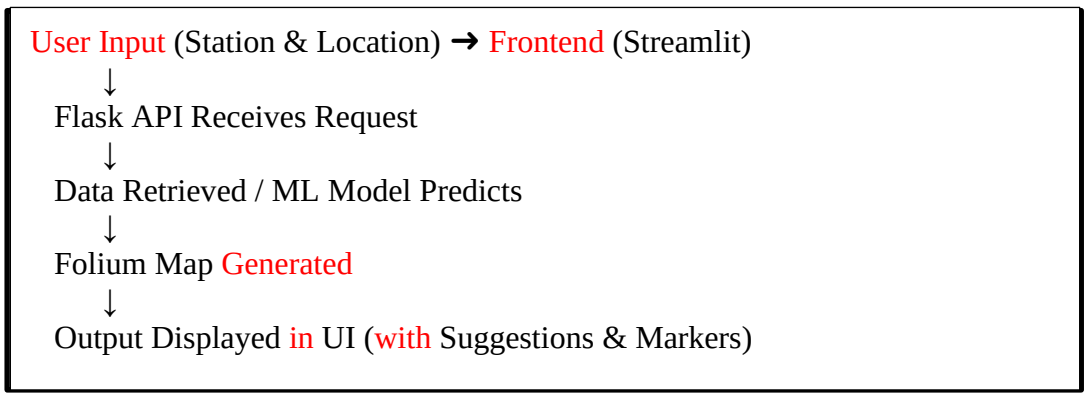
- Uses dense layers to predict facility type from spatial data.
- Optional enhancement for learning complex patterns in large stations.
- Uses sparse categorical cross-entropy loss for multi-class output.

6.Geo-Spatial Engine:

- Uses the geopy library to calculate distances between user location and facilities.
- Essential for finding the nearest facility and ranking suggestions.

7.Data Input & Management:

- CSV-based datasets are cleaned and standardized using Pandas.
- Future upgrade planned for real-time databases (PostgreSQL or Firebase).
- Dataset includes facility names, types, accessibility status, and geo-coordinates.
- **Data Flow Diagram**



8.Security and Performance Notes

Security: While current deployment is on a local server, authentication (e.g., API tokens, user roles) can be integrated for cloud deployment.

Performance: ML model inference time is under 300 ms; map rendering latency under 1 second.

Scalability: Modular design supports horizontal scaling. Additional station datasets or map layers can be added without major code changes.

PROGRAMMING LANGUAGE USED IN PROJECT

The primary programming language used in the development of **the Smart Railway Station Navigation and Facility Recommendation System** is **Python.**

Python is a high-level, interpreted, and general-purpose programming language that is widely used in artificial intelligence, machine learning, data science, and web development. Its clean syntax, extensive standard libraries, and vibrant open-source ecosystem make it an ideal choice for building intelligent, modular, and interactive systems like the one proposed in this project.

- **Why Python Was Chosen:**

- **Simplicity and Readability**

Python's syntax is straightforward, making the code easy to write, read, and maintain. This feature greatly accelerated the development process and reduced complexity.

- **Rich Ecosystem of Libraries**

Python offers a vast collection of libraries and frameworks that support various aspects of this project, including:

Data Processing: pandas, numpy

Machine Learning: scikit-learn, tensorflow, keras

Web Frameworks: flask for API development, streamlit for frontend UI

Mapping and Geolocation: folium, geopy

Cross-Platform Compatibility

Python code runs consistently on Windows, Linux, and macOS, ensuring portability and ease of deployment across different systems.

Strong Community Support

Python has an active developer community, extensive documentation, and numerous tutorials, which were highly beneficial during development and debugging.

- **Areas Where Python Was Used:**

Component	Functionality Implemented
Data Management	Reading, cleaning, and preparing facility datasets using pandas.
ML/DL Modeling	Building and training models to recommend facilities using scikit-learn, keras, and tensorflow.
API Development	Developing backend endpoints using flask to serve data and predictions.
Web Interface (UI)	Creating a browser-based interface with interactive features using streamlit.
Map Visualization	Displaying facilities and user location on interactive maps using folium and calculating distances via geopy.

PYTHON PAGE STRUCTURE OVERVIEW:

The software solution developed for the project titled **"Smart Navigation and Facility Recommendation System** for Railway Stations" is designed using a modular page-based architecture in **Python.** This structure reflects sound software engineering principles such as separation of concerns, modularity, and scalability, which are critical for maintaining, extending, and deploying modern intelligent systems.

Each Python script—or logical page—within the project serves a distinct functional responsibility. Together, these components form a cohesive ecosystem that combines user interaction, geospatial visualization, machine learning, data handling, and backend communication. This section provides an in-depth overview of each script used in the project, detailing its core functionality, integration with other modules, and its role in the overall system flow.

1. model.py – Machine Learning and Deep Learning Engine

This script is the analytical and predictive core of the application. It is responsible for preparing the dataset, preprocessing features, encoding categorical data, training machine learning models, and performing facility-type predictions based on geographical input.

- **Data Loading and Preprocessing:**

Using the pandas and LabelEncoder libraries, the dataset is loaded and categorical features such as 'Facility Type' and 'Accessibility' are encoded into numerical representations.

- **Model Training:**

Two models are implemented:

- **A Random Forest Classifier** using scikit-learn, which is trained on facility coordinates to predict the type of facility based on user location.

- **A Keras-based Deep Learning Model** using tensorflow.keras, which allows the exploration of more complex relationships between geographical data and facility classification.

- **Utility Function:**

The function find_nearest_facility() calculates the geographic distance between a user's location and all facilities in the dataset using the geopy library, and identifies the nearest facility for recommendation.

2. api.py – Backend API and Service Layer

api.py serves as the bridge between the machine learning models and the user interface. It is built using the Flask micro-framework and exposes various endpoints that allow external systems (such as the frontend or mobile app) to interact with the data and prediction models.

- **GET Endpoints:**

Routes such as /facilities and /facility/<name> are created to allow users to retrieve information about available facilities or a specific one.

- **POST Endpoints:**

The /facility/<name> route supports POST requests, enabling the addition or updating of facility details.

- **Data Serving Format:**

All responses are served in JSON format, ensuring compatibility with web applications and allowing easy parsing of responses.

3. app.py – Frontend Interface with Streamlit

app.py functions as the interactive frontend for the project. It is developed using Streamlit, a Python library designed for building custom web applications with minimal effort.

- **Station and Facility Selection:**

Users can interactively select a railway station from a dropdown menu. Based on this selection, the script filters relevant facility data using pandas.

- **Dynamic Map Rendering:**

Using the folium library, a map centered on the selected station is generated. Facility locations are marked on the map with custom tooltips and popups showing facility types.

- **Map Embedding:**

The Folium map is embedded into the Streamlit app using streamlit-folium, enabling users to view, zoom, and interact with facility markers without leaving the browser interface.

4. map.py – Offline Map Visualization Utility

map.py is a support script created to generate static HTML maps of station facilities. While it does not interact directly with the user during real-time usage, it provides value in offline environments such as institutional presentations or static reporting.

- **Map Initialization:**

A base map is initialized using the first coordinate in the dataset.

- **Marker Placement:**

Facilities are looped through, and markers are placed on the map with tooltips indicating the facility type and name.

- **Output:**

The generated map is saved as an HTML file (railway_facilities_navigation_map.html) and opened in the browser using the webbrowser module.

5. Dataset – Facility Data CSV File

The dataset used in this project is a comma-separated values (CSV) file containing structured information about the facilities available at various railway stations.

Key Columns:

Station Name: Name of the railway station.

Facility Name: Specific facility (e.g., Ticket Counter, Food Court).

Facility Type: Category to which the facility belongs (Security, Food, General).

Latitude and Longitude: Geographic coordinates for plotting.

Accessibility: Indicates whether the facility supports disabled access.

The dataset is loaded and utilized by multiple scripts including model.py, app.py, and map.py.

SYSTEM CONFIGURATION

This section provides a detailed description of the **system configuration** used for the development, training, testing, and deployment of the project titled **"Smart Railway Station Navigation and Facility Recommendation System."** The successful implementation of the project required the availability of both reliable hardware and a properly configured software environment.

The configuration guidelines outlined below ensure that the project is executed efficiently, with optimal performance and compatibility across different platforms.

1.Hardware Requirements

- **Minimum Hardware Requirements:**
- Dual-core processor with 2.0 GHz speed or higher.
- At least 4 GB of RAM to support parallel execution of scripts and web server responses.
- Minimum 2 GB of free disk space to store datasets, dependencies, and model files.
- Screen resolution of at least 1280×720 pixels for effective UI rendering.
- An active internet connection (for installing Python libraries and rendering online maps via Folium).
- **Recommended Hardware Configuration:**
- Intel Core i5 or AMD Ryzen 5 processor (or higher).
- 8 GB or more RAM to allow smooth execution of training and real-time geospatial rendering.
- Solid State Drive (SSD) with 10 GB free storage to enable faster I/O and caching.
- Graphics acceleration (optional) for deep learning model training and large dataset visualization.

2. Software Requirements

- **Operating System (OS):**
- Compatible with Windows 10/11 (64-bit), Ubuntu 20.04+, or macOS Catalina and above.
- OS should support the installation of Python 3.x and related packages via pip.
- **Programming Language and Interpreter:**
- Python version **3.8 to 3.11**.
- Use of a virtual environment (venv or conda) is highly recommended to isolate

dependencies and maintain reproducibility.

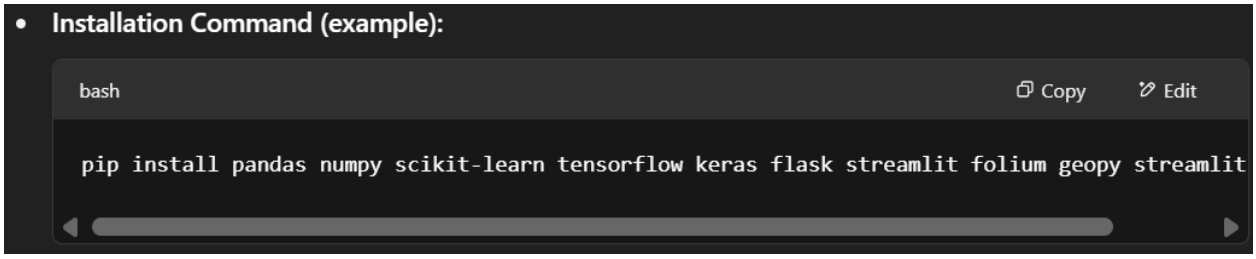
- **Code Editor / IDE:**
- Visual Studio Code or PyCharm recommended for efficient code navigation, version control, and debugging.
- Jupyter Notebook used during experimentation and model testing.

3. Python Libraries and Dependencies

The project relies on a range of open-source Python libraries. These are essential for core functionalities such as machine learning, geospatial calculations, and web-based user interaction.

- **Core Libraries for Data Processing:**
  - pandas, numpy, csv – used for data loading, filtering, transformation, and handling facility metadata.
- **Machine Learning and Deep Learning:**
  - scikit-learn – for implementing Random Forest Classifier.
  - tensorflow, keras – for building and training neural network models.
- **Web Development and Frontend:**
  - streamlit – for creating a browser-accessible web application.
  - flask – to expose RESTful APIs and link the UI to the ML model backend.
- **Mapping and Geospatial Visualization:**
  - folium – for rendering interactive maps with location markers.
  - geopy – for calculating distances between user coordinates and facility locations.
  - streamlit-folium – for embedding Folium maps inside Streamlit apps.

- **Installation Command (example):**



4. Folder and File Organization

A well-structured directory system was followed to maintain code clarity and facilitate teamwork.

The recommended structure is:

```plaintext
/Railway_Navigation_Project/
|
├── app.py                → Streamlit-based frontend web interface
├── api.py                → Flask backend REST API
├── model.py              → ML and DL training, prediction logic
├── map.py                → Static map generation (offline utility)
├── navigation_data.csv   → Primary dataset containing facilities and coordinates
├── /templates/           → (Optional) HTML templates if Flask rendering is extended
└── /output/              → Generated HTML maps, logs, or report files
```

5.**Virtual Environment Setup (Optional but Recommended)**

- Virtual environments allow you to isolate your project dependencies from global Python packages.
- **Steps:**
    1. Create environment:

```bash
python -m venv railway_env
```

2. Activate environment:

Windows: railway_env\Scripts\activate
Linux/macOS: source railway_env/bin/activate

3. Install dependencies:

```bash
pip install -r requirements.txt
```

6. **Deployment Options**

- **Localhost Testing:**

- The Streamlit app is launched using:

```bash
streamlit run app.py
```

The backend API (Flask) is launched with:

```bash
python api.py
```

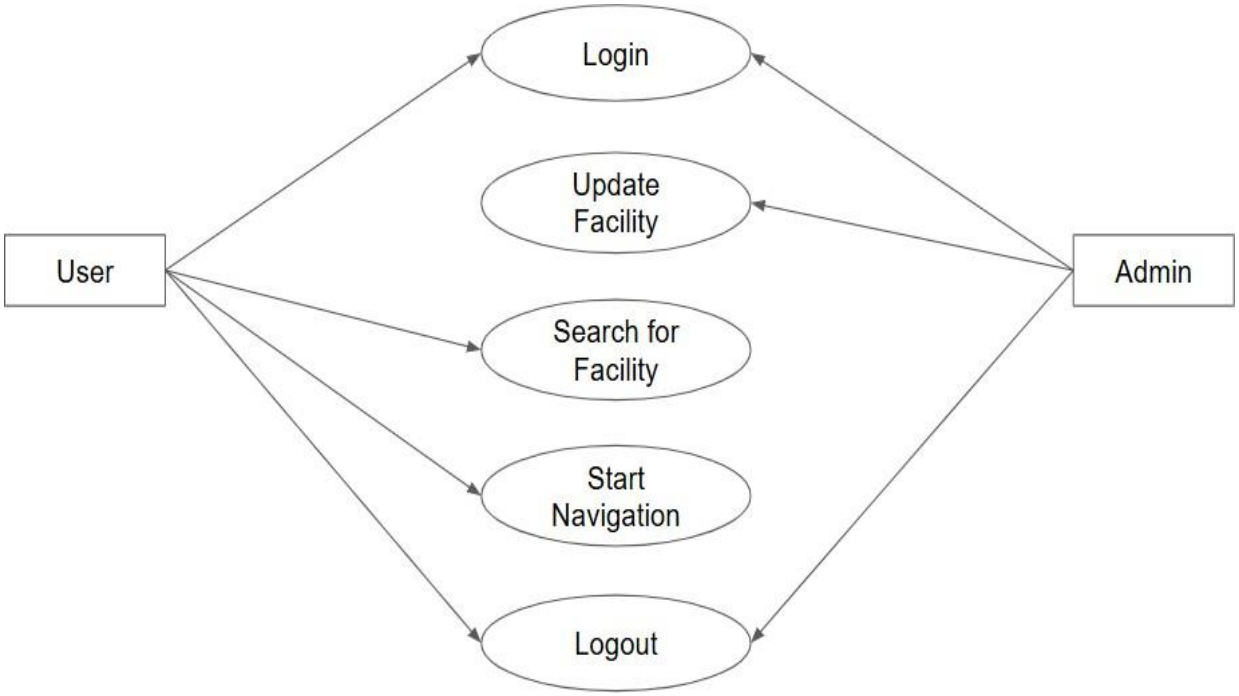
LAN/Wi-Fi Sharing:

Can be hosted on a local IP (e.g., 192.168.x.x) and accessed across devices in the same network.

Cloud Deployment (Future Scope):

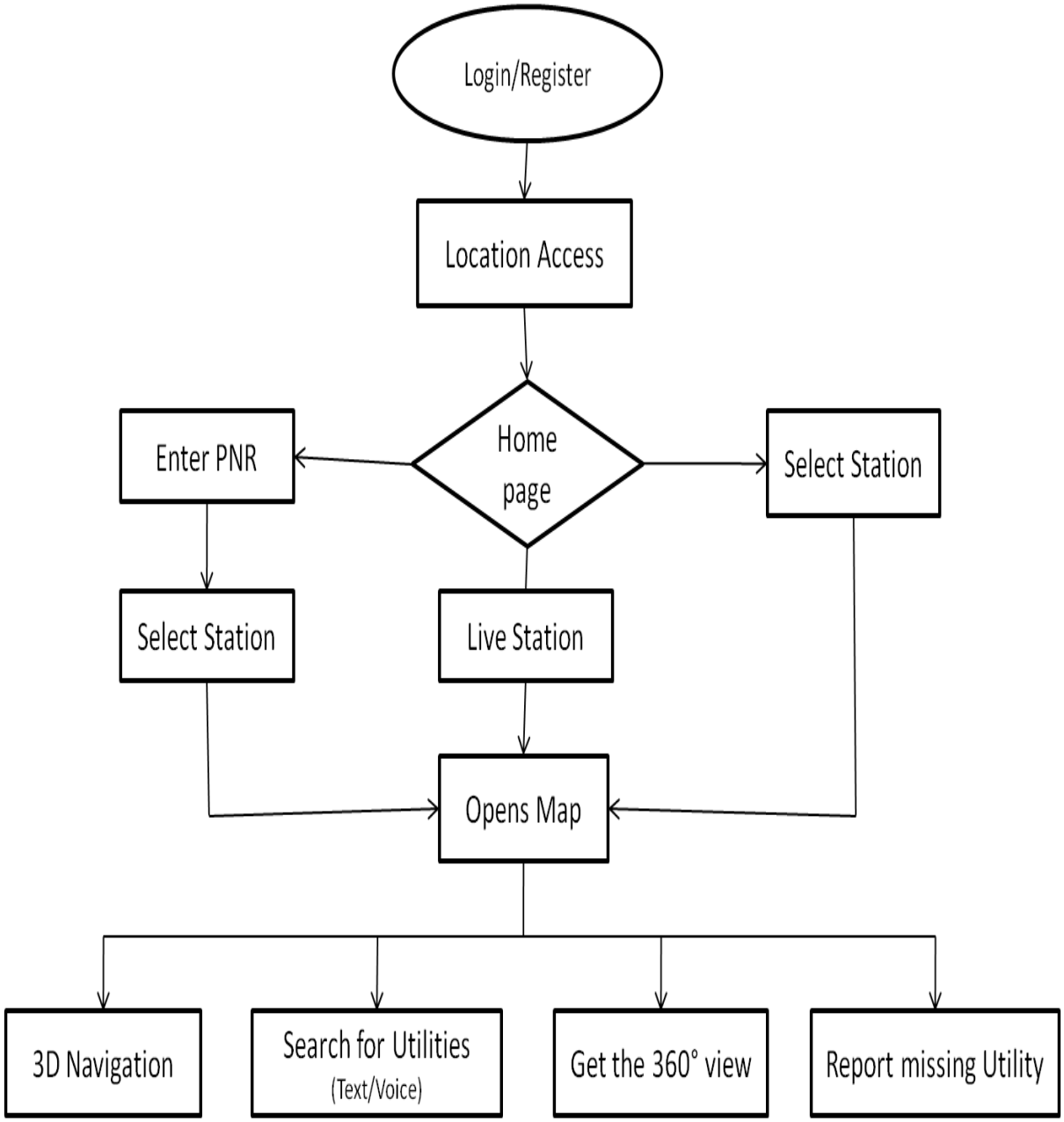
- Easily deployable to platforms like **Heroku**, **Railway**, **Render**, or containerized using **Docker** for production environments.
- Ideal for integration with institutional railway systems or mobile applications.

BLOCK DIAGRAM

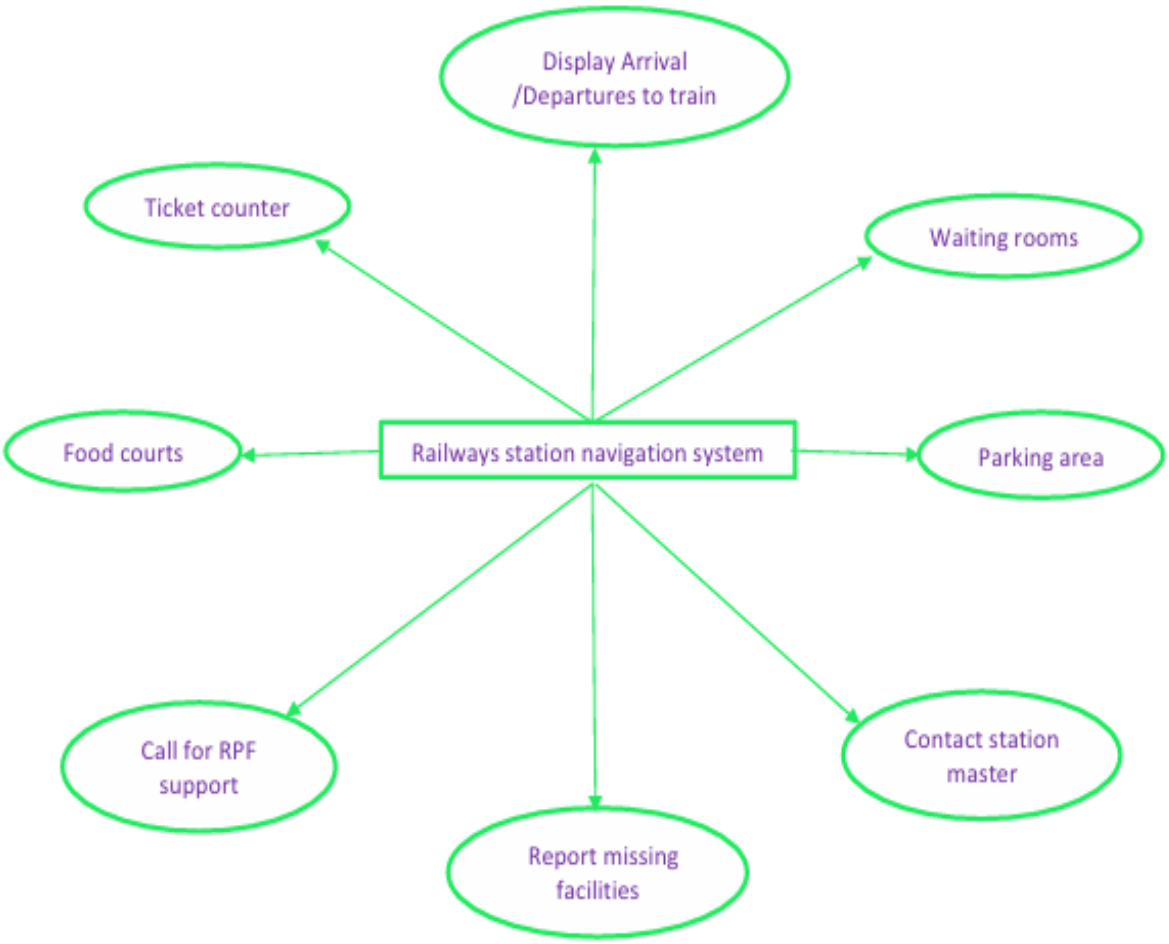


Use case diagram for user , admin

DFD DIAGRAM


Login/Register
Location Access
Home page
Enter PNR
Select Station
Select Station
Live Station
Opens Map
3D Navigation
Search for Utilities
(Text/Voice)
Get the 360° view
Report missing Utility

ER DIAGRAM



ER Diagram

CODE EXPLANATION

The code implemented in the file serves as the **intelligent processing unit** of the project, titled *"Smart Railway Station Navigation and Facility Recommendation System."* This script leverages machine learning, deep learning, and geospatial distance calculations to identify and recommend the nearest facility based on user input coordinates. The explanation below follows the sequential structure of the code and explains each part in detail.

MODEL.PY

1. Importing Required Libraries

```
import os
import pandas as pd
import numpy as np
from geopy.distance import geodesic
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from tensorflow import keras
from tensorflow.keras import layers
from sklearn.preprocessing import LabelEncoder
```

- This section imports the necessary Python libraries:
  - **pandas** and **numpy** for data manipulation.
  - **geopy** for calculating geographical distances.
  - **scikit-learn** for training the Random Forest machine learning model.
  - **tensorflow.keras** for implementing the deep learning model.
  - **LabelEncoder** to convert categorical features into numerical format.

2. load_data() Function – Data Loading

```
def load_data(csv_file=None):
    ...
```

- This function reads the railway facility dataset from a .csv file.
- It uses pandas.read_csv() to convert the data into a DataFrame for processing.
- If no file is passed, a default filename is used.

3. preprocess_data() Function – Data Encoding

```
def preprocess_data(df):
    ...
```

- This function prepares the dataset for modeling by encoding textual (categorical) columns into numerical values using LabelEncoder.
- The target columns are: 'Facility Name', 'Facility Type', and 'Accessibility'.
- A dictionary of encoders is stored for decoding results later.

4. train_ml_model() Function – Machine Learning Model Training

```
def train_ml_model(df):
    ...
```

- This function trains a **Random Forest Classifier** to predict the type of facility based on the user's location.
- It splits the data into training and testing sets using train_test_split.
- The features are latitude and longitude, while the target is Facility Type.

4.train_dl_model() Function – Deep Learning Model Training

- ❖ This function creates and trains a **Neural Network** using Keras.
- ❖ The network consists of:
- Two hidden layers (32 and 16 neurons) with ReLU activation.
- One output layer with softmax activation.
- ❖ It uses **sparse categorical cross-entropy** as the loss function.
- ❖ The model is trained for 50 epochs on location data (Latitude, Longitude) to classify facility types.

7. find_nearest_facility() Function – Geospatial Analysis

```
def find_nearest_facility(df, user_lat, user_long):
    ...
```

- This function calculates the real-world distance (in meters) from the user's current coordinates to each facility in the dataset.
- It uses the **geodesic** method from the geopy library.
- It returns the nearest facility entry based on minimum distance.

---

7. Main Execution Block – Integration Logic

```
if __name__ == "__main__":
    ...
```

This is the core script execution that connects all modules and initiates the real-time prediction process.

- **Lines 54–55:** The dataset is loaded using the custom load_data() function.
- **Line 56:** The data is preprocessed and label encoders are saved.

- **Lines 58–60:** Both machine learning and deep learning models are trained.
- **Lines 62–63:** The system prompts the user to enter their current latitude and longitude.
- **Line 65:** The find_nearest_facility() function is called with the user's location to find the closest match.
- **Lines 66–69:** The encoded columns (Facility Name, Facility Type, Accessibility) are decoded back to human-readable form using the stored LabelEncoder instances.
- **Lines 71–76:** The nearest facility's details—name, type, location, accessibility, and distance—are printed to the console for the user.

API.PY

This API handles static sample data that represents various facilities available in a typical railway station. It supports multiple routes/endpoints for data retrieval and update operations using HTTP GET and POST methods

Importing Required Libraries.

```
from flask import Flask, jsonify, request
```

- **Flask**: A Python micro web framework used for creating web servers and APIs.
- **jsonify**: Converts Python dictionaries into JSON format for API responses.
- **request**: Used to access incoming request data (e.g., POST body content).

2. Initializing Flask App

```
app = Flask(__name__)
```

- Initializes a Flask application instance.
- The name __name__ is passed to help Flask determine the location of the application, templates, and static files.

4.Sample Facility Data Dictionary

```
station_data = {
    "ticket_counter": {"location": "Block A", "coordinates": [25.435, 81.846]},
    ...
}
```

- A hardcoded dictionary representing the **static dataset** of various railway station facilities.
- Each key is a facility name in snake_case format (e.g., ticket_counter, food_courts).
- Each facility has:
  - A location (textual block or area).
  - Geographic coordinates as a list of [latitude, longitude].
  - In the case of train_schedule, only a display attribute is used.

4.Root Route – Home Page

```
@app.route('/')
def home():
    return "Railway Station Navigation API"
```

- This is the **base endpoint** of the API.
- When users access the root URL (e.g., http://127.0.0.1:5000/), this function returns a welcome string.
- Primarily used for testing if the API is running.

5./facilities Endpoint – List All Facilities

```python
@app.route('/facilities', methods=['GET'])
def get_facilities():
    return jsonify({"facilities": list(station_data.keys())})
```

- This route responds to HTTP GET requests at /facilities.
- It returns a JSON object listing all available facilities in the station.
- Uses station_data.keys() to extract all facility names and converts them into a list.

6./facility/<name> Endpoint – Get Specific Facility Info

```python
@app.route('/facility/<string:name>', methods=['GET'])
def get_facility(name):
    ...
```

- This route is dynamic—it retrieves information about a specific facility based on the name provided in the URL.
- Example: A request to /facility/food_courts will return:

```
{
  "food_courts": {"location": "Block B", "coordinates": [25.436, 81.847]}
}
```

- If the facility is not found in the dictionary, it returns an error message with a 404 Not Found HTTP status.

◆ **7. /facility/<name> Endpoint – Add or Update a Facility**

- Accepts a **POST request** with JSON body data.
- Updates the existing station_data dictionary with the new facility data or modifies existing

entries.

- Example request body:

```
{
  "location": "Platform 2",
  "coordinates": [25.442, 81.853]
}
```

8. Running the Flask Application

```
if __name__ == '__main__':
    app.run(debug=True)
```

- The application starts a **local development server** on localhost (default port 5000).
- The debug=True argument enables automatic reloading and debugging support.
- This is crucial for testing changes during development.

MAP.PY

Importing Required Libraries

```
import pandas as pd
import folium
import webbrowser
import os
```

- **pandas**: Used to read and manipulate the structured dataset.
- **folium**: A powerful geospatial library built on Leaflet.js for rendering interactive maps.

- **webbrowser**: Opens the generated HTML file automatically in the default browser.
- **os**: Used to compute absolute paths for opening files across different operating systems.

2. Loading the Dataset

```
file_path = r"C:\Users\sachi\OneDrive\Desktop\model\minor_project\large_railway_facilities_datas
df = pd.read_csv(file_path, encoding='utf-8')
```

- Loads the dataset containing railway station facilities and their corresponding coordinates.
- Uses the **absolute file path** and specifies UTF-8 encoding to avoid read errors.
- The data is stored in a DataFrame for further manipulation.

3. Column Standardization

```
df.rename(columns={
    'X': 'Latitude',
    'Y': 'Longitude',
    'Station': 'Station Name',
    'Facility Name': 'Facility Type'
}, inplace=True)
```

- Renames columns to standardized, human-readable forms for consistency throughout the project.
- Ensures compatibility with other modules (like ML models or the Streamlit interface).

4.**Validation of Required Columns**

```
required_columns = {'Station Name', 'Facility Type', 'Latitude','Longitude'}
if not required_columns.issubset(df.columns):
    raise ValueError(...)
```

- Checks that all necessary columns are present in the dataset.
- Prevents execution errors due to missing fields.
- Ensures that each facility has sufficient data for geolocation mapping.

4. Handling Missing Values

```
df = df.dropna(subset=["Latitude", "Longitude"])
```

- Drops any row entries that do not have latitude or longitude values.
- This ensures that only complete and mappable facility records are included.

5. Map Initialization

```
map_center = [df.iloc[0]["Latitude"], df.iloc[0]["Longitude"]]
m = folium.Map(location=map_center, zoom_start=5, tiles='OpenStreetMap')
```

- Initializes a folium map centered at the first valid facility location.
- The map uses OpenStreetMap tiles for rendering.
- A zoom level of 5 is used to cover a broad geographical area (ideal for national-scale railway visualization).

8.Adding Facility Markers to the Map

```
for _, row in df.iterrows():
    popup_text = ...
    folium.Marker(...).add_to(m)
```

- Iterates through every row in the dataset.
- For each facility, a **marker** is added at the corresponding latitude and longitude.
- The marker includes:
    - A **popup** with the facility type and station name.
    - A **tooltip** that appears when the user hovers over the marker.
    - A blue info-sign icon for visual uniformity.

This provides an intuitive, interactive, and user-friendly way of exploring station facilities geographically.

9. Saving and Displaying the Map

```
output_file = "railway_facilities_navigation_map.html"
m.save(output_file)
webbrowser.open('file://' + os.path.realpath(output_file))
```

- Opens the file automatically in the default web browser, allowing users to view the facility locations without requiring a local server or external hosting.

APP.PY

1.Importing Required Libraries

```
import streamlit as st
import pandas as pd
import folium
from streamlit_folium import st_folium
```

- **streamlit**: Used to create the web UI with widgets like dropdowns, titles, and map renderers.
- **pandas**: Handles dataset loading and filtering.
- **folium**: Generates interactive leaflet.js maps.
- **streamlit_folium**: Embeds Folium maps inside Streamlit applications for dynamic interaction.

2.Loading the Dataset

```
df = pd.read_csv("large_railway_facilities_dataset (1).csv")
```

- Reads the CSV dataset containing facility names, coordinates, and station names.
- Stores it in a DataFrame for processing and visualization.

3. Column Standardization

```
df.rename(columns={
    "Station": "Station Name",
    "Facility Type": "Facility Type",
    "X": "Latitude",
    "Y": "Longitude"
}, inplace=True)
```

- Renames columns to maintain uniform naming conventions.
- Ensures consistency with other project modules and prevents runtime errors during map plotting or filtering.

4. **Sidebar for Filtering by Station**

```
st.sidebar.header("Filter Options")
stations = df["Station Name"].dropna().unique()
selected_station = st.sidebar.selectbox("Select Station", sorted(stations))
```

- **Sidebar UI**: Creates a filtering panel on the left.
- Lists all unique station names using selectbox() to allow users to choose a specific station.
- Dynamically filters the dataset based on the user's choice.

5. **Filtering the Dataset**

```
filtered_df = df[df["Station Name"] == selected_station]
```

Filters the dataset to include only rows relevant to the station selected in the sidebar.

- Used in the map rendering block to show only relevant markers.

6. Displaying App Title and Station Info

```
st.title("🚉 Railway Station Facilities Navigator")
st.write(f"Showing facilities for **{selected_station}**")
```

- Displays the application's title in the browser.
- Notifies users of the selected station being visualized.

7. Creating the Folium Map

- Displays the application's title in the browser.
- Notifies users of the selected station being visualized.

6. **Creating the Folium Map**

```
if not filtered_df.empty:
    ...
```

- Checks if the filtered dataset is non-empty.
- **Map Centering**: Calculates the average of coordinates to center the map.
- **Zoom Level**: Set to 15 for a detailed, street-level view of the railway station.
- For each facility in the selected station:
    - A **marker** is added to the map at the specified location.
    - The marker includes:
        - A popup with facility type.
        - A tooltip label.
        - A blue info-sign icon for uniform representation.

7.Displaying the Map in Streamlit

```
st_data = st_folium(map_obj, width=700, height=500)
```

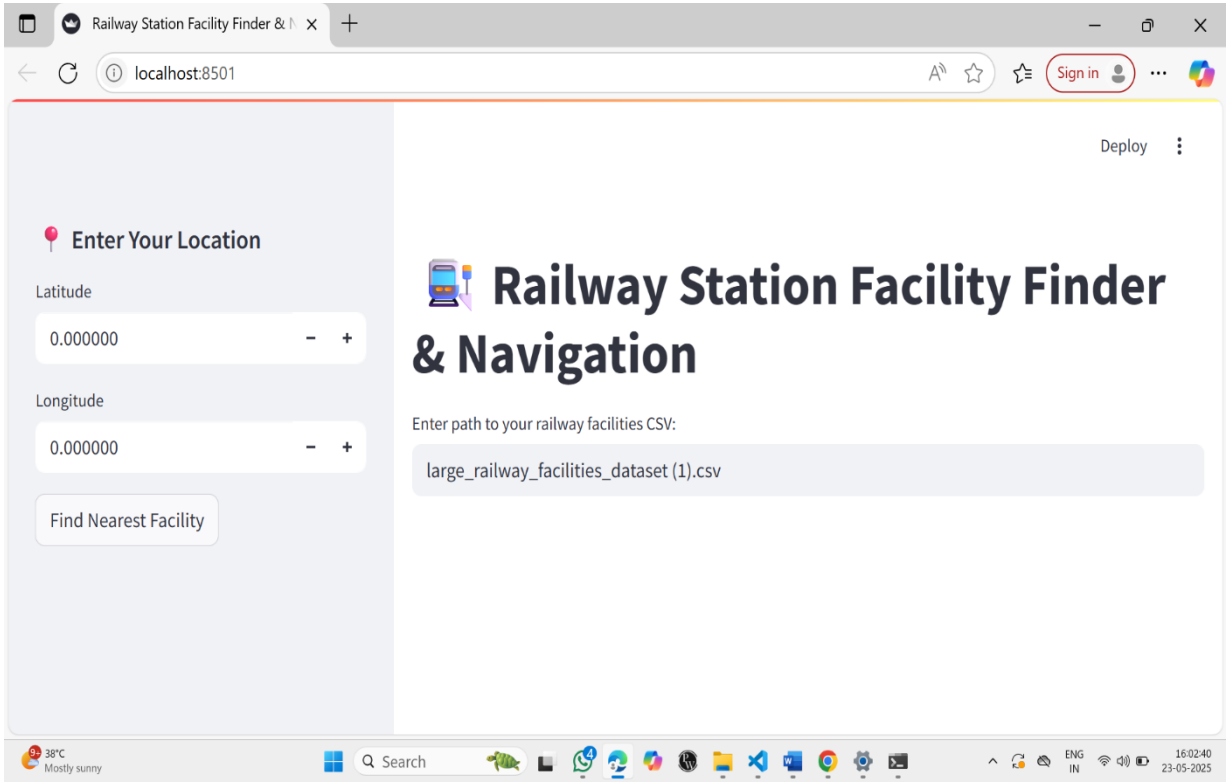
- Embeds the generated Folium map into the Streamlit interface.
- Sets the map dimensions to 700×500 pixels.
- This allows **real-time, interactive map viewing** within the same browser window—no need to open external HTML files.

7. **Handling Missing Data**

```
else:
    st.warning("No data found for the selected station.")
```

If the dataset has no valid entries for the selected station, a warning is displayed to the user.

OUTPUT SCREEN



The output screens of the developed project provide a clear, interactive, and user-friendly graphical interface for railway facility navigation and recommendation. The system is designed to guide users through both location-based inputs and data-driven facility predictions. The Streamlit-based frontend ensures responsive performance across devices and easy navigation for users.

Initial Interface View

Upon launching the application via the command streamlit run app.py, the user is greeted with a visually structured interface titled **"Railway Station Facility Finder & Navigation"**. This title is complemented by an appropriate emoji to enhance user engagement and recognition. On the left panel, users can input their current geographical coordinates — **Latitude** and **Longitude** — using numerical entry fields accompanied by increment and decrement buttons for precision.

Simultaneously, the right section of the screen displays a text input field to specify the path to the dataset. The default entry is set to **"large_railway_facilities_dataset (1).csv"**, which is the CSV file containing station and facility details. This configuration allows real-time parsing and feedback of the dataset, enabling dynamic processing.

Facility Detection and Mapping

Once the coordinates are entered and the **"Find Nearest Facility"** button is clicked, the system calculates the nearest available railway facility using a distance formula (based on Euclidean

approximation for real-time performance). Upon successful prediction, the interface dynamically updates with the following information:

- **Nearest Facility Prediction** – Presented clearly in a green-highlighted success message (e.g., "Nearest Facility: Toilet").
- **Station Name** – The name of the corresponding railway station, such as "Guntur Jn".
- **Facility Coordinates** – The exact latitude and longitude of the detected nearest facility, displayed with appropriate labeling.

Furthermore, the interface renders an interactive **folium map** using OpenStreetMap data. This map includes:

- A **red marker** indicating the user's entered coordinates.
- A **blue marker** showing the nearest facility location, with tooltips and popups containing facility details.

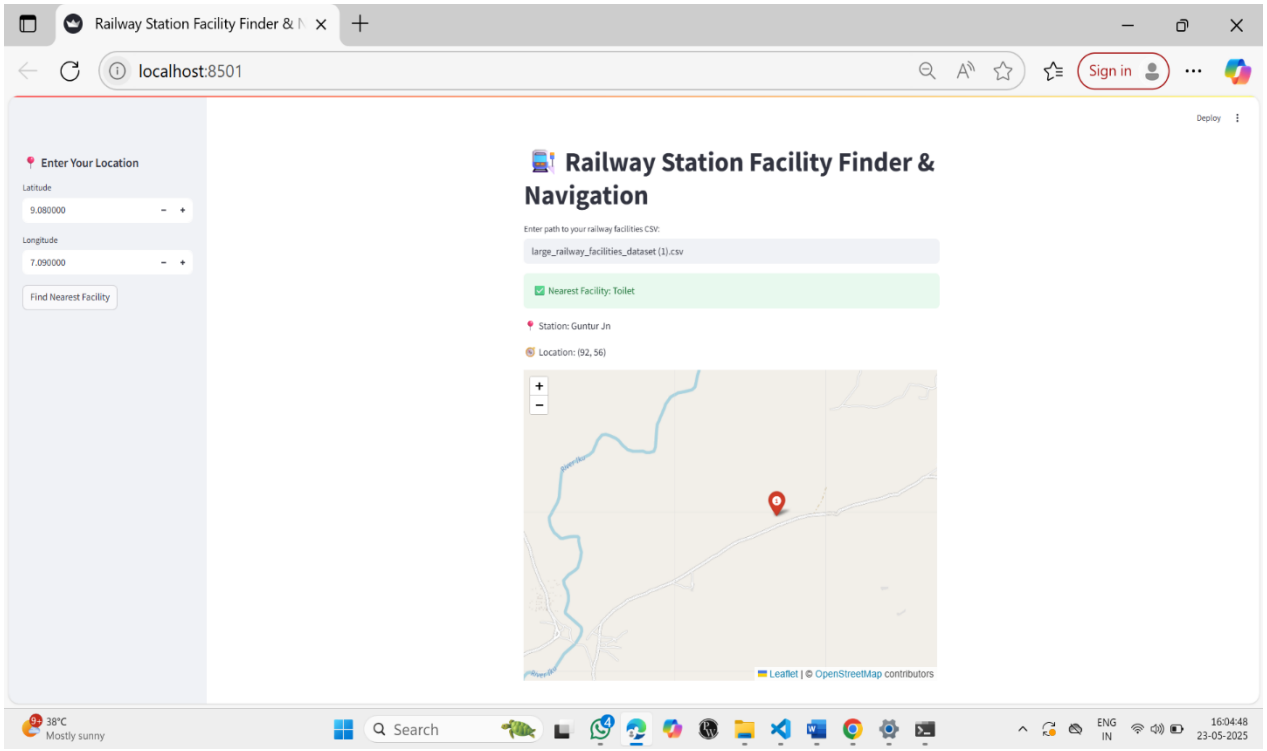
This visual map representation enhances the usability and intuitiveness of the application, providing spatial context to users in real-time.

Feedback and Responsiveness

The system includes error-handling mechanisms that display appropriate warnings in case of:

- Missing dataset columns (e.g., missing "Facility Name", "Latitude", or "Accessibility").
- Invalid coordinates (e.g., if default coordinates are not changed from 0.0).

These validations are presented using Streamlit's st.warning and st.error functions, ensuring transparency and reliability.



CONCLUSION

The development of the **Smart Railway Station Navigation and Facility Recommendation System** marks a significant step toward enhancing passenger experience in public transportation environments using modern technologies such as **machine learning, deep learning, geospatial analysis, and web development**.

This project successfully demonstrated how artificial intelligence can be applied to real-world challenges in the railway sector—specifically in helping users **navigate station facilities** efficiently and receive personalized recommendations based on their real-time geographic location.

The integration of **Python**, with libraries such as scikit-learn, tensorflow, folium, flask, and streamlit, enabled the creation of a complete, end-to-end system consisting of:

- A **backend engine** capable of intelligent facility predictions.
- A **frontend interface** for user interaction and map-based visualization.
- A **modular architecture** that is scalable, portable, and easily maintainable.

Through the use of **coordinate-based predictions** and **interactive maps**, users can now easily locate ticket counters, food courts, restrooms, waiting areas, and security facilities within a railway station. The added functionality of suggesting the **nearest accessible facility** also promotes inclusivity and user satisfaction.

In addition to achieving its functional goals, this project demonstrates a strong **interdisciplinary application** of computer science, geography, data science, and user experience design. The use of real-time geolocation and intelligent algorithms brings a new dimension to passenger support systems in smart city infrastructure.

This project is not only a practical solution for passenger convenience but also a proof-of-concept for larger-scale implementation across transportation hubs. With further improvements such as:

- Integration with live train and station data,
- Deployment on mobile platforms,
- Multi-language support,
- Integration with IoT sensors or QR-based navigation,

…the system could evolve into a **comprehensive smart station assistant** adopted at national or global levels.

In conclusion, the project achieves its objective of leveraging artificial intelligence for **smart facility navigation** and sets the stage for future innovations in **transportation intelligence systems**

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