IARE
INSTITUTE OF
AERONAUTICAL ENGINEERING

HIGH IMPACT PRACTICES (HIPS)
INTELLIGENT TRANSPORT SYSTEM
INFORMATION PACKET
2025 - 2026

INSTITUTE OF AERONAUTICAL ENGINEERING
25 YEARS 2000 2025

I appreciate IARE students who are showing interest in **Intelligent Transportation Systems (ITS)** Project Program at the Institute of Aeronautical Engineering!

A cornerstone project (CoP) is typically introduced during the early or middle stages of an academic program at the Institute of Aeronautical Engineering. It focuses on helping students build foundational skills and understand how to apply basic concepts to real-world scenarios. These projects are usually smaller in scope, moderately complex, and designed to strengthen practical understanding of core subjects.

The **ITS** Project team members work as part of a research group of students, research scholars, and faculty members to tackle novel research and design problems around a theme. The **ITS** project enables powerful capabilities that can significantly enhance the quality, efficiency, and adaptability of Intelligent Transportation Systems development. This project initiative brings together students, research scholars, and faculty members to collaboratively explore cutting-edge technologies in transportation systems and contribute to developing **smart, sustainable, and intelligent mobility solutions**.

Intelligent Transportation Systems (ITS) use emerging technologies—AI, IoT, ML, cloud computing, and real-time analytics—to **enhance safety, mobility, efficiency, and environmental sustainability** in transportation networks.

The goals of ITS projects include:

1. **Undergraduate Research in ITS:** Undergraduate research in Intelligent Transportation Systems refers to student-led or supervised academic projects that explore how IoT, cloud computing, AI/ML and real-time analytics can be integrated into the field of Civil Engineering to solve real-world problems, improve efficiency, and drive innovation in intelligent transportation systems.
2. **Improved Traffic Management:** Optimize traffic flow using AI-based prediction and control systems.
3. **Reduction in Emissions and Fuel Consumption:** Enable eco-driving, reduce idling times, and support low-carbon transport.
4. **Enhanced Road Safety:** Use sensors, CV (connected vehicles), and accident prediction models to reduce fatalities.
5. **Real-Time Monitoring and Control:** Enable smart signalling, emergency response, and dynamic routing using IoT.
6. **Traveler Information Systems:** Provide commuters with real-time updates via mobile apps or V2X communication.
7. **Autonomous and Connected Mobility:** Support vehicle automation and infrastructure communication for smart roads.
8. **Multimodal Integration:** Coordinate public transport, shared mobility, and non-motorized transport modes.
9. **Data-Driven Decision Making:** Leverage big data and simulations for infrastructure planning and urban mobility design.

The research theme of this AI based projects also focuses on the challenges presented by the Sustainable Development Goals (SDGs).

Sustainability Development Goals (SDGs) for Department of CE	
SDG 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
SDG #8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
SDG 9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
SDG 11	Make cities and human settlements inclusive, safe, resilient and sustainable
SDG 12	Ensure sustainable consumption and production patterns
SDG 13	Take urgent action to combat climate change and its impacts

The following research domains are recommended for HIPs-AI-ITS Projects, and selected students should find the research gap and frame the problem statements from any one of the themes below.

1. AI-Powered Urban Traffic Flow Optimization Using Real-Time Sensor Data *(SDG #9, SDG #11)*
2. Smart Parking Solutions Using IoT and ML *(SDG #11)*
3. Autonomous Vehicle Navigation and Safety Systems *(SDG #4, SDG #9)*
4. Green Mobility and Carbon Footprint Reduction Models *(SDG #13)*
5. Real-Time Incident Detection and Emergency Response *(SDG #4, SDG #11)*
6. AI-Based Predictive Modelling for Pavement Performance and Deterioration *(SDG #9, SDG #11, SDG #13)*
7. Multimodal Transport Planning Using AI *(SDG #11)*
8. AI-Based Public Transport Optimization and Scheduling *(SDG #11, SDG #13)*
9. Edge-AI Enabled Smart Traffic Signals for Congestion Reduction *(SDG #11, SDG #13)*
10. Digital Twin for Urban Transport Infrastructure *(SDG #8, SDG #9, SDG #11)*

In order to participate in AI-ITS Projects, you must formally apply and be accepted by the project coordinator. To proceed, please mail to the project coordinator, Dr. Praveena Rao, Assistant Professor, Department of CE, Email Id: praveenarao@iare.ac.in. This will bring up all available open positions tagged as AI- ITS projects. When submitting a project document and an updated résumé, include a statement regarding why you are interested in working with the team to which you are applying. Please note that participation by the AI- ITS project team requires registration for the accompanying research statement from any of the specified domains. More information will be provided to all selected AI- ITS project applicants who have been offered a position. If you have any questions about a particular team, please contact the team's faculty mentor(s). We encourage you to contemplate this fascinating new opportunity. We look forward to receiving your application submission.

AI-Based Public Transport Optimization and Scheduling

Dr. Praveena Rao, Assistant Professor, CE – Faculty Mentor

GOALS

The primary objective of this project is to develop an AI-powered optimization system for public transportation scheduling and routing, aimed at improving service efficiency, passenger convenience, and operational sustainability. Using historical ridership data, real-time traffic inputs, and demand patterns, the system will dynamically generate optimal schedules and fleet routes to match commuter needs.

- **Demand-Responsive Scheduling:** Predict ridership demand across routes and times using AI, and adjust schedules to match peak and off-peak patterns.
- **Route Optimization:** Use ML and optimization algorithms to minimize travel time, fuel use, and transfers, while maximizing coverage and reliability.
- **Fleet and Crew Allocation:** Optimize vehicle assignment and crew shifts based on capacity, maintenance needs, and shift constraints.
- **Service Frequency Management:** Dynamically adjust service frequency for high-demand corridors using predictive analytics.
- **Passenger Experience Enhancement:** Minimize wait time, overcrowding, and missed transfers by synchronizing connections and reducing schedule conflicts.
- **Integration with MaaS & Smart City Systems:** Interface with multimodal transport platforms and city traffic control for holistic planning.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

- **Data Collection:** Aggregate real-time and historical data on passenger loads, boarding/alighting counts, GPS vehicle locations, and traffic congestion.
- **Time-Series Forecasting:** Use models like ARIMA, Prophet, and LSTM to predict passenger volumes at different stops and time slots.
- **Clustering and Pattern Recognition:** Apply clustering (e.g., K-Means, DBSCAN) to identify high-demand zones and temporal travel patterns.
- **Optimization Algorithms:** Use Linear Programming, Genetic Algorithms, or Reinforcement Learning for schedule optimization, route balancing, and load distribution.
- **Simulation and Testing:** Use transport simulators (e.g., MATSim, SUMO) to simulate and evaluate the impact of AI-optimized schedules.
- **Real-Time Control:** Enable integration with AVL (Automatic Vehicle Location) systems to adjust schedules in response to delays or disruptions.

Technologies & Tools

- **Programming & ML Libraries:** Python, TensorFlow, Scikit-learn, Keras, NumPy
- **Data Platforms:** PostgreSQL, Firebase, MongoDB
- **Routing & Scheduling APIs:** Google Transit API, GTFS, OSRM
- **Simulation Tools:** MATSim, SUMO, AnyLogic
- **Visualization Tools:** Power BI, Tableau, Plotly Dash
- **Mobile Integration:** React Native, Flutter (for passenger apps)

MAJORS & AREAS OF INTEREST

This project is ideal for students and researchers in the following areas:

Transportation Engineering & Urban Mobility

- Public transit planning
- Route efficiency analysis
- Service quality evaluation
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Artificial Intelligence & Predictive Modelling

- Demand forecasting
- Real-time optimization and adaptive scheduling
-

Data Science & Analytics

- Passenger flow analysis
- Load balancing and clustering
-

Computer Science & Software Systems

- Real-time data processing
- Scheduling algorithms and control systems
-

Urban Planning & Smart Cities

- Transit equity and accessibility
- Mobility-as-a-Service (MaaS) integration

MENTOR CONTACT INFORMATION

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AI-Powered Urban Traffic Flow Optimization Using Real-Time Sensor Data

Dr. Venu Malagavelli, Professor, CE – Faculty Mentor

GOALS

The primary objective of this project is to design and implement AI-driven models that dynamically optimize urban traffic flow using real-time data from road sensors, cameras, and IoT devices. The system aims to alleviate congestion, minimize travel time, reduce fuel consumption, and support adaptive traffic signal control through intelligent decision-making.

- **Real-Time Congestion Detection:** Monitor live traffic conditions using embedded road sensors, GPS data, and CCTV feeds to detect bottlenecks instantly.
- **AI-Based Traffic Signal Control:** Develop machine learning models that adjust signal timings dynamically based on real-time traffic density and flow patterns.
- **Predictive Traffic Modelling:** Forecast traffic conditions over short-term intervals using historical and current traffic data for proactive control strategies.
- **Vehicle Routing Optimization:** Suggest alternate routes for users and traffic authorities based on congestion levels, incidents, and weather conditions.
- **Integration with Smart City Systems:** Enable seamless integration with smart infrastructure like connected vehicles (V2X), emergency vehicle prioritization, and transit systems.
- **Environmental Impact Reduction:** Lower greenhouse gas emissions and fuel usage by minimizing idling time and optimizing traffic movement.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

The development of this system involves several key methods:

- **Data Collection:** Gather real-time traffic data from loop detectors, cameras, GPS trackers, mobile apps, and weather APIs.
- **Data Preprocessing:** Clean, filter, and synchronize heterogeneous data; extract traffic features (vehicle count, speed, density, occupancy).
- **Model Training & Validation:** Train ML models (e.g., Random Forest, LSTM, CNN, XGBoost) for traffic prediction and congestion classification.
- **Optimization Techniques:** Use Reinforcement Learning or Genetic Algorithms to optimize traffic signal phase timing and vehicle routing.
- **Simulation and Testing:** Validate models using traffic simulation tools (SUMO, VISSIM, AIMSUN) under different traffic scenarios.
- **Deployment & Visualization:** Integrate with smart traffic controllers or dashboards for city planners using web or mobile interfaces.

Technologies Used

- **Programming:** Python (Pandas, Scikit-learn, TensorFlow, Keras), MATLAB
- **Traffic Simulation:** SUMO, VISSIM, OpenTrafficSim
- **Visualization:** Power BI, Tableau, Dash/Plotly
- **IoT Integration:** Arduino/Raspberry Pi, Node-RED, MQTT
- **Cloud/Edge Platforms:** AWS IoT, Google Cloud IoT, ThingSpeak

MAJORS & AREAS OF INTEREST

This project is highly interdisciplinary and is ideal for students and researchers from the following domains:

Civil & Transportation Engineering

- Urban mobility systems
- Traffic flow theory
- Signal timing and control systems

Artificial Intelligence & Machine Learning

- Supervised and reinforcement learning
- Real-time inference systems
- Model training on spatio-temporal data

Internet of Things (IoT) & Embedded Systems

- Traffic sensors and wireless communication
- Real-time data acquisition and edge computing

Data Science & Analytics

- Time-series forecasting
- Traffic data clustering and anomaly detection
- Interactive dashboards and visualization

Urban Planning & Smart Infrastructure

- Intelligent Transport System (ITS) integration
- Public transit modelling
- Policy and environmental analysis

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Smart Parking Solutions Using IoT and ML

Dr. Venu Malagavelli, Professor, CE – Faculty Mentor

GOAL

The aim of this project is to develop an intelligent, sensor-based smart parking system that uses IoT and Machine Learning (ML) to provide real-time availability, automated monitoring, and optimized parking space usage in urban environments. The system targets traffic congestion reduction, driver convenience, and smart city integration.

- **Real-Time Parking Availability Detection:** Monitor and update parking space occupancy using IoT sensors and edge devices.
- **Predictive Parking Demand Forecasting:** Use ML models to predict parking space availability based on historical trends, time-of-day, and events.
- **Smart Navigation and Reservation:** Guide drivers to available parking spots through a mobile/web interface and allow advance booking.
- **Dynamic Pricing Models:** Implement intelligent fare adjustment mechanisms based on demand, duration, and time, enhancing revenue and availability.
- **Traffic Congestion Reduction:** Reduce search time for parking, which contributes significantly to inner-city congestion.
- **Integration with Urban Mobility Platforms:** Link parking data with ride-sharing, public transport, and MaaS systems.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

- **Sensor Deployment & Data Acquisition:** Use ultrasonic sensors, IR sensors, or cameras for real-time occupancy detection of individual parking slots.
- **Cloud & Edge Processing:** Collect and process data at edge devices or cloud servers for quick response and analytics.
- **ML-Based Prediction:** Train ML models (e.g., Decision Trees, LSTM, or SVM) to predict parking availability and demand.
- **Smart App Development:** Build a user-facing application to show parking availability, pricing, navigation, and booking.
- **Optimization Algorithms:** Use AI optimization techniques (e.g., ACO, Genetic Algorithms) for space allocation and pricing strategies.

Technologies Used

- **IoT Hardware:** Arduino, ESP32, Raspberry Pi, ultrasonic sensors, IR sensors, cameras
- **Programming:** Python, C/C++, Node.js
- **ML Libraries:** Scikit-learn, TensorFlow, Keras
- **Databases:** Firebase, MongoDB, InfluxDB
- **Cloud Platforms:** AWS IoT, Google Cloud, Azure IoT Hub

MAJORS & AREAS OF INTEREST

This project offers rich opportunities for students from multiple disciplines:

Civil & Transportation Engineering

- Urban mobility analysis
- Parking infrastructure planning

IoT & Embedded Systems

- Sensor-based monitoring
- Wireless communication protocols

Artificial Intelligence & Machine Learning

- Classification and time-series prediction
- Dynamic pricing and resource optimization

Computer Science & Application Development

- Backend/frontend development
- Real-time systems and data APIs

Data Analytics & Visualization

- Traffic and parking pattern analysis
- Real-time dashboard creation

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Smart Pavement Design Using Reinforcement Learning for Life-Cycle Cost Reduction

Dr. R Ramya Swetha, Associate Professor & Head, CE – Faculty Mentor

GOAL

The main goal of this project is to develop a smart pavement design system powered by Reinforcement Learning (RL) that minimizes life-cycle costs (LCC) by optimizing pavement thickness, material combinations, and structural layers. Unlike conventional deterministic models, this project aims to build an adaptive, learning-based design framework that factors in long-term performance, maintenance frequency, and cost-effectiveness under diverse loading and environmental conditions.

- **Life-Cycle Cost Minimization:** Optimize total costs over the lifespan of pavement, including initial construction, maintenance, and rehabilitation.
- **Performance-Based Design:** Incorporate pavement performance parameters like fatigue life, rutting resistance, deflection, and serviceability into the design process.
- **RL-Based Design Policy Learning:** Train an agent to make design decisions (e.g., layer thickness, material grade) that result in minimal total costs over time.
- **Uncertainty Handling:** Integrate probabilistic variations in traffic loads, climate exposure, and material degradation.
- **Sustainable Material Use:** Promote the use of alternative or recycled materials when advantageous in life-cycle cost-benefit analysis.
- **Intelligent Decision Support:** Create a tool that can assist highway agencies and designers in selecting cost-optimal pavement strategies.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

- **Data Collection:** Compile historical pavement performance datasets (e.g., LTPP), material properties, and cost data from local and national transportation departments.
- **State-Action Design:** Model the RL environment where each state represents a pavement design scenario, and actions are changes in thickness, material, or maintenance schedules.
- **Reward Function Design:** Define rewards based on inverse of total life-cycle cost, penalizing poor durability and frequent maintenance.
- **Reinforcement Learning Algorithms:** Implement algorithms like Q-learning, Deep Q-Networks (DQN), or Policy Gradient Methods for decision learning.
- **Life-Cycle Cost Analysis (LCCA):** Integrate standard LCCA models (e.g., FHWA approach) into the RL feedback loop.
- **Simulation & Evaluation:** Simulate pavement performance using fatigue and rutting models under different design policies and compare RL-based designs with traditional ones.

Technologies Used

- **Programming & Libraries:** Python, TensorFlow, Keras, OpenAI Gym, NumPy, Scikit-learn
- **Simulation Tools:** MATLAB (for mechanistic pavement modelling), HDM-4, BISAR or KENPAVE
- **Visualization:** Tableau, Power BI, Matplotlib
- **Cloud Computing:** Google Colab / AWS for RL model training at scale

MAJORS & AREAS OF INTEREST

This project combines cutting-edge topics across several domains:

Civil & Transportation Engineering

- Pavement material and structural design
- Highway economics and cost analysis
- Infrastructure sustainability

Artificial Intelligence & Reinforcement Learning

- Policy optimization and agent training
- Environment modelling and simulation

Data Analytics & Cost Engineering

- Life-cycle costing models
- Sensitivity and scenario analysis

Construction Management & Sustainable Engineering

- Decision frameworks for resource allocation
- Long-term asset management strategies

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Green Mobility and Carbon Footprint Reduction Models

Mr. K Anand Goud, Assistant Professor, CE – Faculty Mentor

GOAL

The objective of this project is to develop AI-enabled green mobility models aimed at minimizing transportation-related carbon emissions and promoting sustainable travel choices. The system integrates environmental analytics, traffic data, public transit options, and mobility behaviour insights to model, predict, and recommend low-carbon travel alternatives.

The focus is on guiding infrastructure development and individual commuter behaviour toward eco-friendly, low-emission, and shared mobility solutions by leveraging machine learning, optimization algorithms, and mobility datasets.

- **Emission Analytics:** Quantify and model carbon emissions from various modes of transportation (e.g., private vehicles, public transit, non-motorized transport).
- **Green Route Recommendation:** Suggest eco-optimal travel routes based on congestion, road gradient, vehicle type, and emissions data.
- **Behavioural Modelling:** Analyse commuter choices and promote shift toward sustainable modes through recommendation systems and incentive modelling.
- **Policy Impact Simulation:** Evaluate how traffic restrictions, fuel taxes, or EV incentives affect urban mobility emissions.
- **Fleet Optimization:** Reduce emissions from commercial transport and delivery networks through route and load optimization.
- **Urban Planning Support:** Provide carbon-based mobility planning insights for smart cities and municipal authorities.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

- **Data Acquisition:** Collect real-time and historical mobility data, vehicle emission rates, travel demand patterns, and GIS information.
- **Carbon Modelling:** Estimate emissions using standard models (e.g., COPERT, MOVES, EMFAC) and integrate with local data.
- **AI & ML Models:** Use regression, classification, and reinforcement learning models to predict travel demand, carbon output, and optimize route selection.
- **Multi-Modal Integration:** Build models that compare emissions from various combinations of walking, biking, buses, metro, and ride-sharing.
- **Optimization Techniques:** Apply Linear Programming, Genetic Algorithms, or Particle Swarm Optimization for emission-aware fleet and route optimization.
- **Simulation Tools:** Use traffic simulation platforms (e.g., SUMO, MATSim) to evaluate policy impacts and user behaviour shifts.

Technologies Used

- **Programming:** Python, R, MATLAB
- **ML Libraries:** Scikit-learn, TensorFlow, PyTorch
- **GIS Tools:** QGIS, ArcGIS, OpenStreetMap API
- **Simulation Tools:** SUMO, MATSim, AnyLogic
- **Emission Databases:** IPCC, EPA MOVES, NREL datasets

- **Visualization:** Tableau, Power BI, Dash/Plotly
- **Cloud Platforms:** AWS, Google Cloud, ThingSpeak (for IoT integration)

MAJORS & AREAS OF INTEREST

This project spans civil engineering, sustainability science, and AI domains, suitable for students from:

Environmental Engineering & Sustainability

- Urban air quality and GHG modelling
- Sustainable mobility systems

Transportation & Civil Engineering

- Traffic modelling and infrastructure planning
- Public transport systems and modal analysis

AI, Data Science & Optimization

- Predictive analytics
- Decision support and recommendation systems

Urban Planning & Public Policy

- Climate-resilient city design
- Green policy impact forecasting

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AI-Powered Real-Time Incident Detection and Emergency Response

Dr. R Ramya Swetha, Associate Professor & Head, CE – Faculty Mentor

GOAL

The primary goal of this project is to design and implement an AI-powered real-time incident detection and emergency response system for urban and highway transportation networks. The system will detect road accidents, vehicle breakdowns, or hazardous events (e.g., wrong-way driving, stalled vehicles) using sensor networks, CCTV feeds, and crowdsourced data, and initiate rapid emergency response actions**.** The solution aims to reduce incident detection time, enable automatic alerting of emergency services, and improve road safety and traffic recovery through intelligent monitoring and decision-making.

Key goals include:

- **Automated Incident Detection:** Identify accidents, congestion, or road blockages in real time using video analytics and sensor data.
- **Multi-Source Data Fusion:** Integrate feeds from CCTV cameras, loop detectors, GPS-enabled vehicles, and mobile crowdsourcing apps.
- **AI-Based Event Classification:** Differentiate between traffic jams, minor collisions, major crashes, and non-incident anomalies using machine learning.
- **Emergency Response Automation:** Notify traffic control centers, ambulances, police, and fire services through API triggers and alert systems.
- **Incident Severity Prediction:** Estimate the impact and required response time based on vehicle count, speed differential, and location risk level.
- **Dynamic Traffic Rerouting:** Provide alternate routes to drivers and adjust signal timings to divert traffic away from the affected zone.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

- **Computer Vision:** Use convolutional neural networks (CNNs) and object tracking models (e.g., YOLOv8, DeepSORT) for vehicle detection and crash recognition in video feeds.
- **Sensor Data Analysis:** Analyze real-time data from inductive loops, radar, and accelerometer sensors for abnormal vehicle behaviors.
- **Crowdsourcing Integration:** Leverage mobile apps, vehicle telematics, and social media reports for incident confirmation.
- **Machine Learning Models:** Train supervised models (e.g., SVM, Random Forest, XGBoost) to classify and verify incident types and severity.
- **Response Management System:** Build automated alert dispatch modules using SMS, APIs, or cloud-based notification services.
- **Simulation and Testing:** Use traffic simulators like SUMO or AIMSUN to test response strategies and incident propagation under different scenarios.

Technologies Used

- **Programming:** Python, OpenCV, TensorFlow, PyTorch
- **CCTV Integration:** RTSP/ONVIF protocols, IP camera interfacing
- **ML Tools:** Scikit-learn, Keras, YOLOv8, DeepSORT
- **Databases & APIs:** Firebase, Twilio, Google Maps API, Open511

- **IoT Hardware:** Loop detectors, vibration sensors, GPS trackers
- **Visualization Tools:** Grafana, Tableau, custom dashboards

MAJORS & AREAS OF INTEREST

This interdisciplinary project fits students and researchers from:

Civil & Transportation Engineering

- Traffic operations and incident impact modelling
- Emergency management and intelligent systems

Computer Vision & AI

- Video anomaly detection
- Deep learning and object tracking

IoT & Embedded Systems

- Sensor network design
- Edge computing for incident detection

Data Science & Analytics

- Predictive modelling and real-time classification
- Incident clustering and pattern mining

Software Engineering & Mobile Systems

- Notification systems
- Real-time response app development

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AI-Based Predictive Modelling for Pavement Performance and Deterioration

Dr. U Vamsi Mohan, Professor, CE – Faculty Mentor

GOAL

The main objective of this project is to develop AI-based predictive models that can forecast pavement performance and deterioration over time under varying environmental, loading, and material conditions. The project aims to move beyond traditional empirical models by utilizing machine learning (ML) and time-series techniques to predict critical pavement distress indicators such as cracking, rutting, IRI (roughness), and deflection**,** thereby enabling more informed decisions for maintenance and rehabilitation.

- **Deterioration Forecasting:** Predict pavement condition indicators such as cracking, potholes, rutting, and surface roughness over time.
- **Performance Modelling:** Build data-driven models that correlate design, material, traffic, and environmental variables with pavement life.
- **Intelligent Maintenance Planning:** Recommend maintenance actions and schedules based on predicted performance curves.
- **Historical Data Utilization:** Leverage field-collected data (LTPP, PMS databases, SHM sensors) for training and validating AI models.
- **Visualization of Pavement Life:** Generate performance trend plots and deterioration maps to support asset management systems.
- **Support Sustainable Infrastructure:** Optimize life-cycle maintenance interventions to minimize costs, delays, and environmental impact.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

- **Data Collection:** Use historical pavement management systems (PMS) data, traffic loading (ESALs), climate records, and in-situ testing results.
- **Data Preprocessing:** Handle missing values, perform normalization, extract features (e.g., layer modulus, moisture content, deflection data).
- **Model Development:** Apply ML algorithms like Random Forest, XGBoost, Support Vector Regression (SVR), and Long Short-Term Memory (LSTM) networks for time-series forecasting.
- **Model Evaluation:** Use k-fold cross-validation, RMSE/MAE metrics, and comparison with traditional deterioration models (e.g., HDM-4, AASHTO).
- **Explainability & Sensitivity:** Use SHAP/LIME to understand feature importance and model behaviour under variable conditions.
- **Deployment & Visualization:** Build dashboards for engineers to view predicted deterioration trends and recommended interventions.

Technologies Used

- **Programming & ML Libraries:** Python, Pandas, Scikit-learn, TensorFlow, Keras, XGBoost
- **Statistical Tools:** R, MATLAB (for model comparison)
- **Visualization Platforms:** Power BI, Tableau, Plotly Dash
- **Pavement Software:** HDM-4, KENPAVE (for benchmarking)
- **GIS Tools:** QGIS or ArcGIS (for deterioration mapping)

MAJORS & AREAS OF INTEREST

This project is ideal for students and researchers in the following domains:

Civil & Transportation Engineering

- Pavement materials and design
- Structural condition assessment
- Maintenance scheduling and infrastructure durability

Artificial Intelligence & Machine Learning

- Supervised learning and time-series forecasting
- Predictive analytics for infrastructure

Data Science & Visualization

- Trend analysis and performance visualization
- Model interpretability and reporting

Geospatial Analysis

- Pavement deterioration mapping
- Integration with smart asset management systems

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Multimodal Transport Planning Using AI

Dr. Praveena Rao, Assistant Professor, CE – Faculty Mentor

GOAL

The goal of this project is to develop an AI-driven decision support system for multimodal transport planning, integrating various transport modes—such as buses, trains, bicycles, ride-sharing, walking, and private vehicles—into a unified, efficient, and user-centric mobility model. The system will use AI algorithms to optimize route selection, reduce travel time, lower carbon emissions, and improve commuter experience.

- **Integrated Mobility Planning:** Coordinate multiple transport modes within a single trip to provide seamless journey experiences.
- **AI-Based Route Optimization:** Use real-time and historical data to recommend multimodal routes based on time, cost, carbon footprint, and user preference.
- **Travel Demand Forecasting:** Predict travel behaviour and mode choices using AI models, enabling smarter capacity and scheduling decisions.
- **Smart Scheduling:** Optimize transfer points, wait times, and intermodal connections using predictive analytics.
- **Environmental Impact Minimization:** Promote low-emission mobility choices and suggest green alternatives to private car use.
- **User-Centric Personalization:** Provide customized journey plans using user profiles, preferences, accessibility needs, and past behaviour.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

- **Data Collection:** Aggregate multimodal data from GPS traces, public transit schedules (GTFS), traffic APIs, and user mobile app logs.
- **Data Fusion & Processing:** Merge spatial-temporal data from various transport sources and preprocess for route matching, transfer detection, and congestion indicators.
- **ML-Based Prediction:** Apply ML models (e.g., Random Forest, LSTM, Gradient Boosting) for demand forecasting and route efficiency estimation.
- **Optimization Algorithms:** Use Reinforcement Learning, A*, or Genetic Algorithms to determine optimal multimodal route configurations and dynamic transfer adjustments.
- **Behavioral Analysis:** Use clustering and classification to group commuters by travel patterns, mode choice, and temporal preferences.
- **Real-Time Recommendation System:** Build an intelligent interface for route and mode selection, dynamically updated with traffic, transit, and user feedback.

Technologies Used

- **Programming & ML Libraries:** Python, Scikit-learn, TensorFlow, Keras, NetworkX
- **APIs & Datasets:** Google Maps API, OpenStreetMap, GTFS, Uber APIs
- **GIS & Mapping:** QGIS, ArcGIS, Leaflet.js
- **Simulation Tools:** MATSim, SUMO (for testing urban travel patterns)
- **Mobile/Web Interfaces:** Flutter, React Native, Node.js
- **Visualization Tools:** Power BI, Tableau, Dash/Plotly

MAJORS & AREAS OF INTEREST

This project appeals to students and researchers across domains such as:

Transportation & Urban Planning

- Public transit integration
- Travel behaviour modelling
- Sustainable mobility networks

Artificial Intelligence & Machine Learning

- Time-series forecasting
- Routing and recommendation systems

Civil Engineering & Infrastructure

- Intermodal facility design
- Traffic network optimization

Computer Science & Software Development

- Real-time journey planner systems
- Backend and frontend app development

Data Science & Analytics

- Multimodal travel pattern clustering
- Visual analytics for transport dashboards

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Edge-AI Enabled Smart Traffic Signals for Congestion Reduction

Ms. B. Bhavani, Assistant Professor, CE – Faculty Mentor

GOALS

The goal of this project is to design and implement Edge-AI enabled smart traffic signal systems capable of reducing congestion by dynamically adapting signal timing based on real-time local traffic conditions. By deploying AI models directly on edge devices at intersections, the system minimizes latency, enhances responsiveness, and supports decentralized, data-driven traffic control—especially in bandwidth-limited or infrastructure-light environments.

Key goals include:

- **Real-Time Traffic Adaptation:** Dynamically adjust signal timings based on current traffic density, queue lengths, and vehicle movement.
- **Edge Processing for Low Latency:** Use embedded AI models on edge devices to eliminate the need for cloud-based decision-making delays.
- **Congestion Detection & Mitigation:** Identify congestion patterns and pre-emptively decongest intersections with optimized signal phasing.
- **V2I Integration:** Enable future-ready communication between vehicles and traffic infrastructure (Vehicle-to-Infrastructure).
- **Scalability for Smart Cities:** Create a modular, decentralized system that can be deployed across urban intersections without full cloud connectivity.
- **Environmental Benefits:** Reduce fuel consumption and vehicular emissions through reduced idling and smoother traffic flow.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

- **Sensor Integration:** Use real-time inputs from cameras, loop detectors, infrared sensors, or radar to measure vehicle count and movement.
- **AI Model Training:** Train lightweight computer vision models (e.g., MobileNet, TinyYOLO) to detect vehicle density, lane occupancy, and pedestrian movement.
- **Edge Inference & Signal Control:** Deploy trained models on edge devices (e.g., NVIDIA Jetson Nano, Raspberry Pi) to execute traffic control logic locally.
- **Adaptive Signal Algorithms:** Implement Reinforcement Learning or Dynamic Programming to optimize green/red light cycles based on traffic feedback.
- **Feedback Loop:** Monitor outcomes (e.g., queue length, wait time) and retrain/update models periodically for improved performance.
- **V2I Protocols:** Use MQTT, DSRC, or 5G-V2X protocols for future-ready connected vehicle integration.

Technologies & Tools

- **Edge Hardware:** NVIDIA Jetson Nano, Raspberry Pi 4, Google Coral
- **Programming Languages:** Python, C++, TensorFlow Lite, OpenCV
- **Computer Vision Models:** YOLOv4-Tiny, MobileNet-SSD, Edge-optimized CNNs
- **IoT & Communication:** MQTT, Node-RED, LoRa, Zigbee, or 5G
- **Traffic APIs & Datasets:** OpenTrafficCam, City flow datasets, SUMO for simulation
- **Control Logic Implementation:** Arduino/STM32 microcontrollers for signal control

MAJORS & AREAS OF INTEREST

This interdisciplinary project is suitable for students in:

Civil & Transportation Engineering

- Signal design and traffic control theory
- Urban congestion management

Artificial Intelligence & Machine Learning

- Computer vision on edge devices
- Reinforcement learning for control optimization

IoT, Embedded & Edge Computing

- Edge deployment
- Sensor integration and communication protocols

Data Science & Real-Time Analytics

- Queue analysis and anomaly detection
- Time-series forecasting for congestion trends

Smart Cities & Urban Infrastructure

- Intelligent traffic systems
- Integration with city-wide mobility plans

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Digital Twin for Urban Transport Infrastructure

Mr. K.Anand Goud, Assistant Professor, CE – Faculty Mentor

GOALS

The primary objective of this project is to develop a Digital Twin of urban transport infrastructure, enabling real-time monitoring, simulation, and optimization of roads, intersections, transit systems, and pedestrian pathways. A digital twin acts as a virtual replica of the physical transport system, integrating live sensor data, geospatial models, traffic analytics, and AI predictions to support smart urban mobility management, infrastructure planning, and emergency response.

Key goals include:

- **Virtual Modelling of Infrastructure:** Create 3D and data-driven models of road networks, transit lines, bus stops, and critical intersections.
- **Real-Time Data Integration:** Synchronize live feeds from traffic sensors, GPS-equipped public transport, and CCTV systems into the digital twin.
- **Predictive Simulation:** Simulate traffic congestion, transit delays, and infrastructure strain under various conditions (e.g., peak hours, road closures, weather).
- **Decision Support & Visualization:** Provide city planners and transport authorities with interactive dashboards for congestion heatmaps, system health, and what-if analysis.
- **Maintenance & Asset Management:** Track degradation of roads, signals, and other assets, and plan predictive maintenance using AI models.
- **Public Engagement & Transparency:** Enable citizens to access selected parts of the twin (e.g., crowding forecasts or route reliability) through apps or web portals.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

- **Data Integration:** Combine GIS data, IoT sensor streams (traffic flow, air quality), historical transport records, and BIM models.
- **3D Urban Modelling:** Use tools to construct accurate geometries of roads, intersections, and transit hubs for visualization and simulation.
- **AI-Enabled Forecasting:** Implement ML models to predict traffic patterns, congestion hotspots, and transit delays based on real-time and historical data.
- **Simulation & Scenario Analysis:** Simulate emergencies, events, or policy changes (e.g., pedestrianization, tolling, lane reduction) to assess outcomes.
- **Cloud/Edge Connectivity:** Use edge devices for real-time data capture and cloud platforms for centralized processing and visualization.
- **BIM + GIS Integration:** Combine Building Information Modelling (BIM) with spatial datasets for detailed infrastructure behaviour modelling.

Technologies & Tools

- **3D Modeling & GIS:** Autodesk InfraWorks, Unity3D, QGIS, ArcGIS CityEngine
- **Data Platforms:** PostgreSQL/PostGIS, Firebase, AWS IoT, Azure Digital Twins
- **Programming & ML:** Python, R, TensorFlow, PyTorch, OpenCV
- **Traffic Simulation:** MATSim, SUMO, AIMSUN
- **Visualization Dashboards:** Power BI, Tableau, Dash/Plotly

MAJORS & AREAS OF INTEREST

This advanced project is well-suited for interdisciplinary learners from:

Urban Planning & Civil Engineering

- Infrastructure asset modelling
- Road network simulation and design

Artificial Intelligence & Machine Learning

- Predictive analytics and anomaly detection
- Integration with time-series and geospatial data

Geospatial Engineering & Remote Sensing

- GIS-based modelling
- City-scale spatial data visualization

IoT, Embedded Systems & Smart Infrastructure

- Sensor integration and edge data processing
- Real-time system monitoring

Data Science & Visualization

- Urban mobility data analytics
- Scenario simulation and trend forecasting

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