TED UNIVERSITY

Faculty of Engineering

Department of Computer Engineering

CMPE 491 - Senior Project Analysis Report

3D-EcoMap

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1. INTRODUCTION

In today's rapidly urbanizing world, optimizing travel routes is critical not only for cost savings but also for reducing environmental impact. As the number of vehicles on the road continues to increase, the urgency to reduce fuel consumption and emissions also increases. However, traditional navigation systems often rely on 2D maps that prioritize distance and traffic conditions only, ignoring the impact of road topography on fuel efficiency. 3D-EcoMap aims to address these issues by offering a flatter, slightly longer route rather than a shorter route with steep slopes, which can lead to significantly more fuel consumption. Our project offers an eco-friendly driving experience.

2. PROPOSED SYSTEM

2.1 Overview

3D-EcoMap is an innovative navigation system designed to improve fuel efficiency and environmental sustainability by integrating slope analysis into route optimization. The system detects road slopes by processing 2D satellite images into 3D models. These slopes are incorporated into algorithms that recommend the most fuel-efficient routes, helping drivers lower fuel costs and reduce their environmental impact. This web-based application offers a user-friendly interface for 3D map visualization, allowing users to interact with 3D models of their road routes and make eco-friendly navigation choices.

2.2 Functional Requirements

1. Image Processing & 3D Modelling: Use image processing algorithms and deep learning for 2D-3D transformations.
2. Slope Analysis Module: Create a module that analyses road slopes within the 3D models to assess their impact on fuel efficiency.
3. Fuel-Efficient Route Suggestions: Integrate slope data with pathfinding algorithms (such as Dijkstra and A*) to provide the most fuel-efficient routes.
4. 3D Visualization: Implement an interactive 3D map allowing users to explore routes and visualize slopes.
5. Web-Based Access: Design a responsive web platform where users can easily access and interact with all features.
6. Pathfinding Algorithms: Implement and optimize Dijkstra and A* algorithms using slope data to minimize fuel consumption.
7. Web Development: Build a web application using Spring Boot and WebGL-based 3D mapping libraries for cross-platform accessibility.

2.3 Non-Functional Requirements

1. Real-Time Response: Under typical load conditions, the system must process route computations and offer recommendations in less than five seconds.
2. Scalability: The system should support up to 100 concurrent users without a significant drop in performance.
3. Data Loading: The application should load and render 3D maps and routes in under 5 seconds for areas up to 50 square kilometres.
4. Ease of Use: The web interface must be intuitive, requiring no more than 5 minutes of user orientation.
5. Cross-Platform Support: The system should work seamlessly on major web browsers (Chrome, Firefox, Safari, Edge) and operating systems (Windows, macOS, Linux).
6. Language Support: English is the only supported language.
7. Authentication: Users must authenticate using a secure method (e.g., OAuth2).
8. Error Handling: In case of failures (e.g., unavailable satellite data), the application must notify users with a meaningful error message and suggest alternative actions.
9. Data Integrity: The system should prevent data corruption during 2D to 3D transformations and slope analysis.
10. Code Modularity: The codebase must be modular.
11. Documentation: Comprehensive documentation must be provided for all modules, including APIs, algorithms, and system architecture.
12. Compatibility: The application should be compatible with different hardware configurations, from low-end to high-performance systems.
13. Energy Efficiency: Optimize the application to minimize CPU and GPU usage during map rendering and slope analysis.
14. Resource Utilization: Use cloud resources efficiently to reduce energy consumption.
15. Ethical Use: The system must avoid misuse of geospatial data and ensure it is only used for eco-friendly routing purposes.
16. Automated Backups: Implement automated daily backups for all critical data, including user data and processed 3D models.
17. Disaster Recovery: The system must recover from catastrophic failures (e.g., server crashes) within 30 days.
18. Transparent Usage: Users must be informed about how their data will be used and given the option to opt out.
19. Promote Sustainability: Highlight the environmental benefits of choosing eco-friendly routes in the user interface.

2.4 Pseudo Requirements

1. Compatibility The system shall seamlessly integrate with the university's existing infrastructure and applications, eliminating the need for additional new applications.

2. Maintenance and Updates The system should be sustainable, allowing for regular updates and improvements based on feedback from drivers.

3. Cost Efficiency The system shall aim to be as economical as possible, achieving high performance with the fewest possible computation to maximize effectiveness and stay within system limits

2.5 System Models

2.5.1 Scenarios

Scenario 1

The user opens the web-based application and logs in.

The user inputs their starting location and desired destination.

The system processes the inputs and uses satellite data to generate 3D slope models of the possible routes.

The system calculates the fuel efficiency for each route based on slope, distance, and environmental impact factors.

The user views a list of suggested routes, ranked by fuel efficiency.

The user selects the preferred route.

The system displays the 3D visualization of the selected route, including slope details and estimated fuel savings.

Scenario 2

The user opens the web-based application and logs in.

The user inputs their starting location and desired destination.

The system processes the inputs and uses satellite data to generate 3D slope models of the possible routes.

The system calculates the fuel efficiency for each route based on slope, distance, and environmental impact factors.

The user navigates to the "View 3D Map" section of the application.

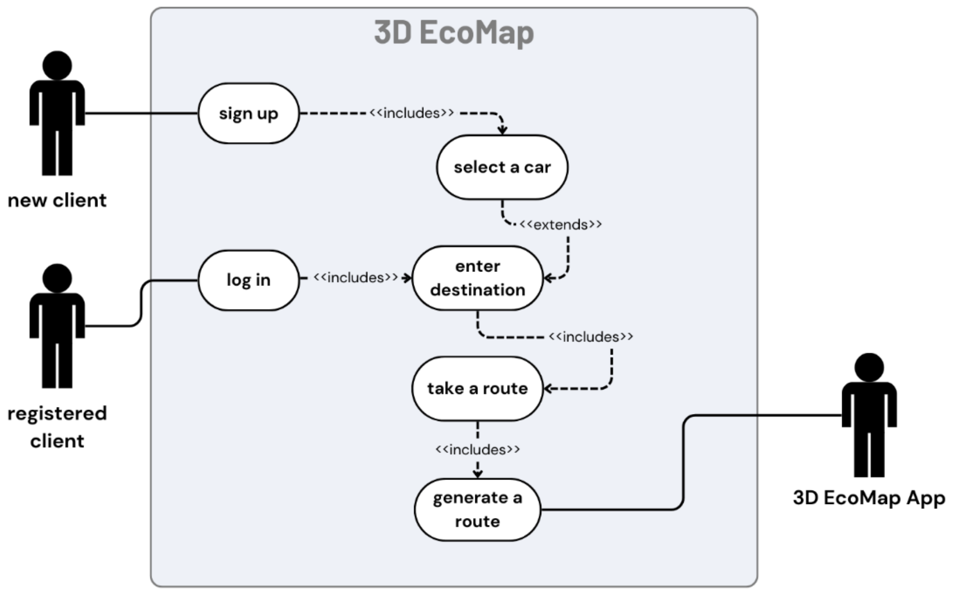
The system loads a 3D visualization of the current road network or the user's route.

The user interacts with the map using tools like zoom, rotate, and pan.

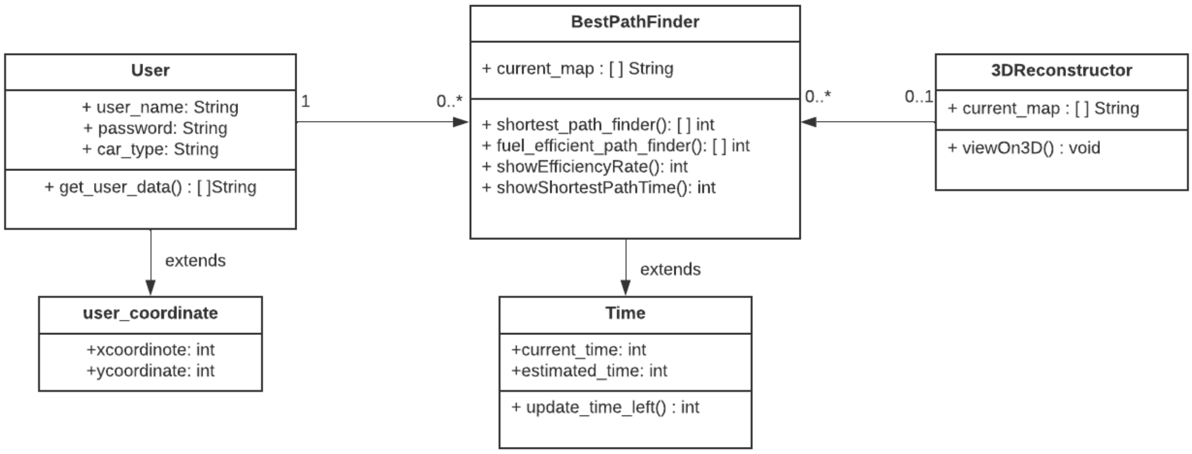
The user highlights specific areas on the map to view detailed slope information or alternate paths.

The system dynamically updates the visualization to display detailed terrain or road slope characteristics.

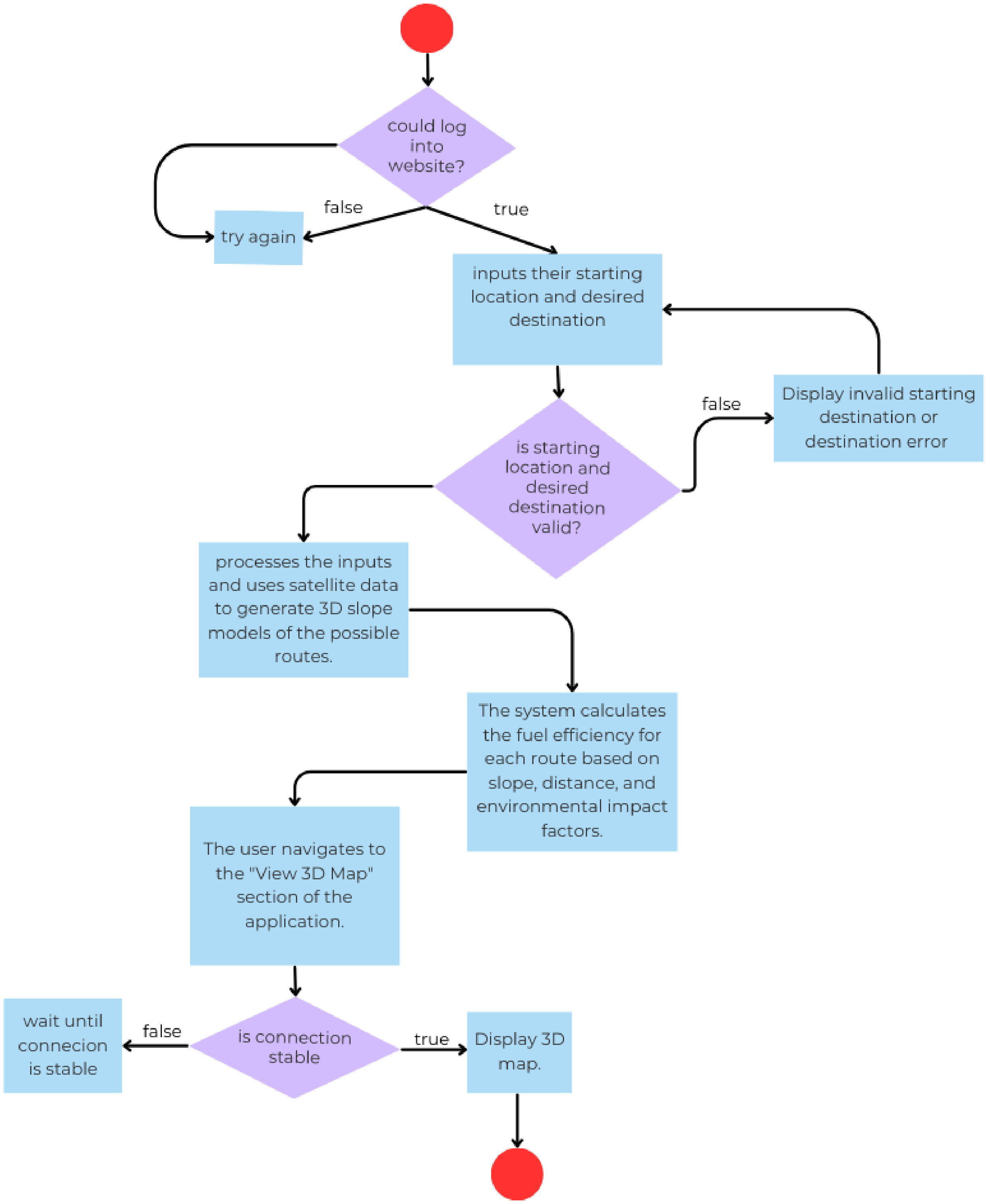
2.5.2 Use Case Model

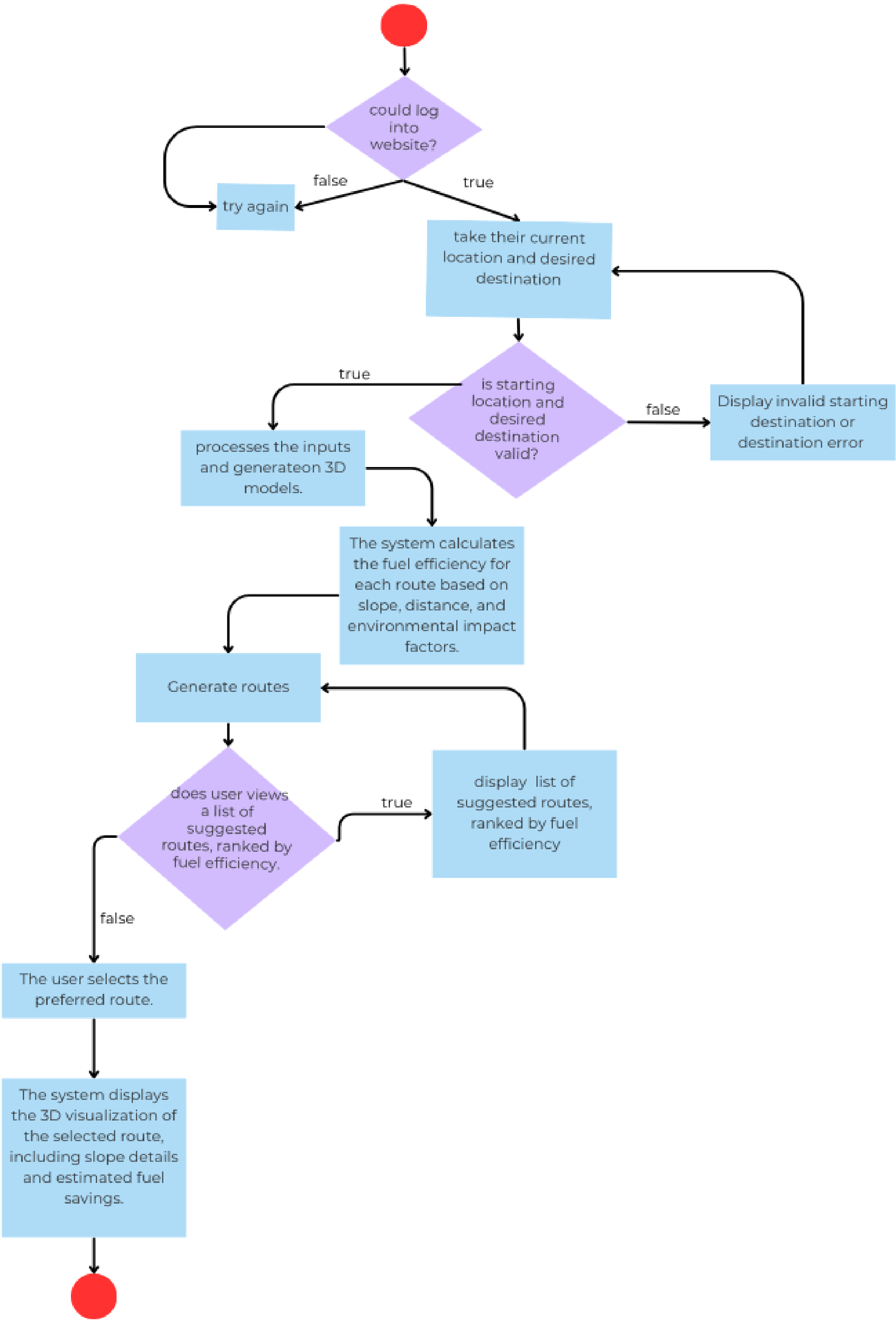


2.5.3 Object and Class Model

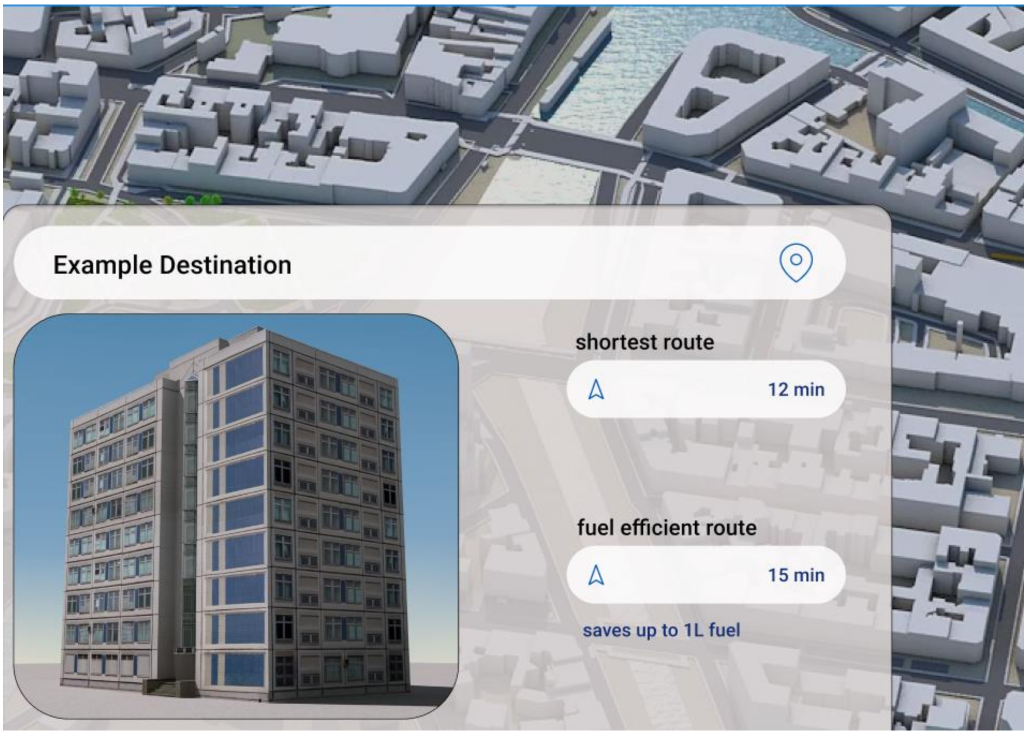


2.5.4 Dynamic Models




could log into website?
false
true
try again
take their current location and desired destination
true
is starting location and desired destination valid?
false
Display invalid starting destination or destination error
processes the inputs and generateon 3D models.
The system calculates the fuel efficiency for each route based on slope, distance, and environmental impact factors.
Generate routes
does user views a list of suggested routes, ranked by fuel efficiency.
true
display list of suggested routes, ranked by fuel efficiency
false
The user selects the preferred route.
The system displays the 3D visualization of the selected route, including slope details and estimated fuel savings.

2.5.5 User Interface- Navigational Paths and Screen Mocks-Ups



3. GLOSSARY

3D Model
A digital shape that shows the height, width, and depth of something.

A Algorithm*
A way to find the best path between two places, using some guesses to make it faster.

Authentication
Checking if someone is allowed to use the system.

Cloud Resources
Online tools and storage that help run programs without needing a powerful computer.

CPU (Central Processing Unit)
The "brain" of the computer that runs programs and handles tasks.

Dijkstra's Algorithm
A method to find the shortest way between places on a map.

Fuel Efficiency
How much fuel a vehicle uses to travel a certain distance.

Geospatial Data
Information about where things are on a map.

GPU (Graphics Processing Unit)
A part of the computer that helps make graphics look good, especially for 3D models.

OAuth2
A safe way for users to log in without sharing their passwords directly.

Pathfinding Algorithm
A way to figure out the best route from one place to another.

Satellite Imagery
Pictures of Earth taken from space.

Slope Analysis
Checking how steep a road or hill is and how it affects things like fuel use.

Topography
How the land looks, including hills, valleys, and flat areas.

WebGL
A tool that helps show 3D graphics in a web browser.

3D-EcoMap
The project that finds the best routes by looking at road slopes and fuel use.

Environmental Impact
How human actions affect nature, like pollution or cutting down trees.

Route Optimization
Finding the best way to get somewhere while saving time, fuel, or both.

Scalability
How well a system can handle more users or bigger tasks.

Slope Data
Information about how steep the roads are.

User Interface (UI)
The buttons and screens people use to interact with an app.

4. REFERENCES

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