SafeRoads Navigator

A Real-Time Road Hazards Monitoring with Dual Vetting Approach

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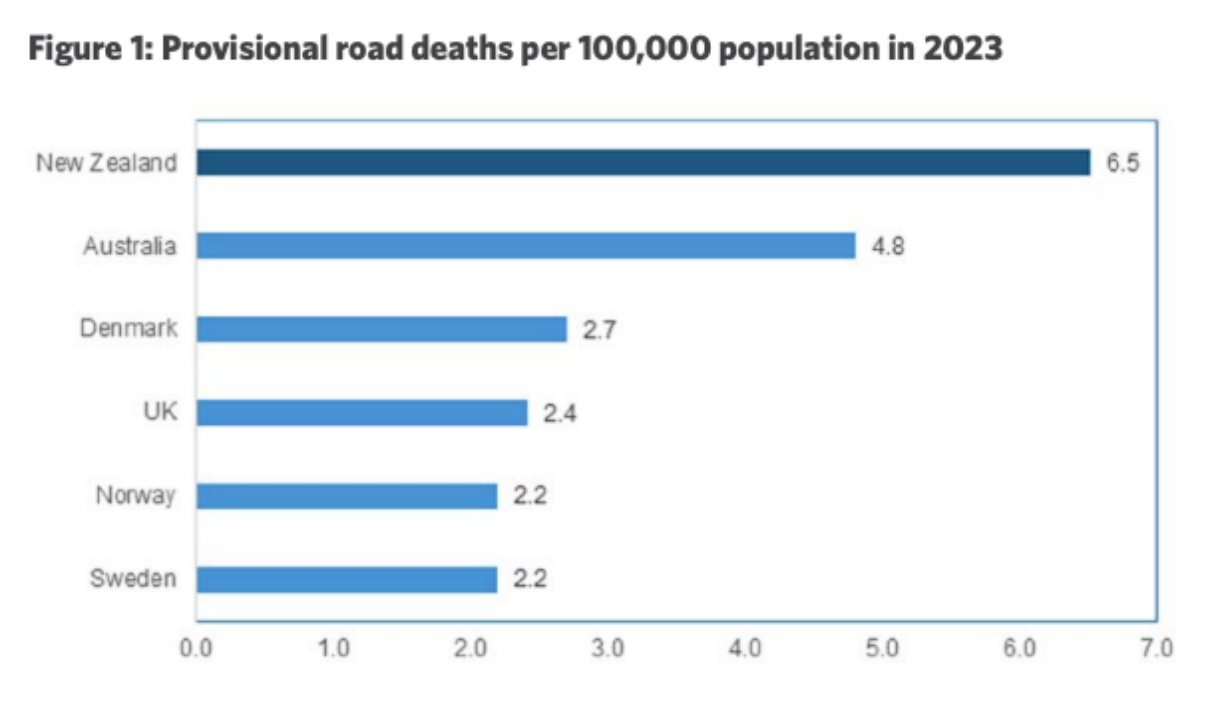
Introduction

- Road safety is a critical public health and transportation concern, with 1.19M global fatalities annually (WHO, 2023)
- NZ: 341 fatalities & 2,442 serious injuries in 2023
- NZ has one of the highest road death rates in the OECD (NZTA 2024, Fig. 1)
- Traditional inspections of road infrastructure are expensive, slow, reactive
- Crowdsourced reporting offers timely, wide coverage but suffers from data reliability challenges
- Proposed solution strives to introduce a dual vetting mechanism to ensure accuracy and reliability

Introduction



Literature Review

- Crowdsourced platforms like FixCyprus (Christou, et al., 2023) and EDDA+ (Olma et al., 2022) demonstrated improved hazard reporting coverage and timeliness. Both identified trust criteria as a limitation and suggested to introduce trust metrics or criteria to enhance the reliability and credibility of crowdsourced reports.
- Telima et al. (2023) used crowdsourcing platform to collect & analyze pedestrian safety within urban areas of Cairo, Egypt (spatial analyses using KDE to identify high-risk areas).
- Studies by Cafiso et al. (2022) & Bhoyar et al. (2023) used IoT-based sensors to monitor and assess urban road pavement conditions (focus on potholes). One enhancement suggested in the study is the addition of real-time data integration platforms for road maintenance agencies & introduce crowdsourcing to reduce variability and improve data reliability.

Literature Review

- A similar study by Carlos Pena-Caballero et al. focused on detection of a limited scope of road hazard classes, i.e. Manhole, Pothole, Blurred Crosswalk, & Blurred Street Line
- In a study by Kim et al. (2023), they explored the use of crowdsourced data collected through an app, Road Inconvenience Reporting System (RIRS), to evaluate the efficiency of road hazard maintenance performed by different regional agencies across South Korea (focus more on data analysis)

Problem Definition

Key Gaps:

- Unreliable crowdsourced data without robust vetting
- Lack of unified end-to-end hazard management
- Limited integration & use of analytics for policy insights

Research Questions:

- How to design a real-time alert system with dual-layer vetting to deliver timely, reliable road hazards information?
- What models enable seamless end-to-end integration?
- How to embed analytics & open-data interfaces for stakeholder insights and decision-making?

Proposed Solution

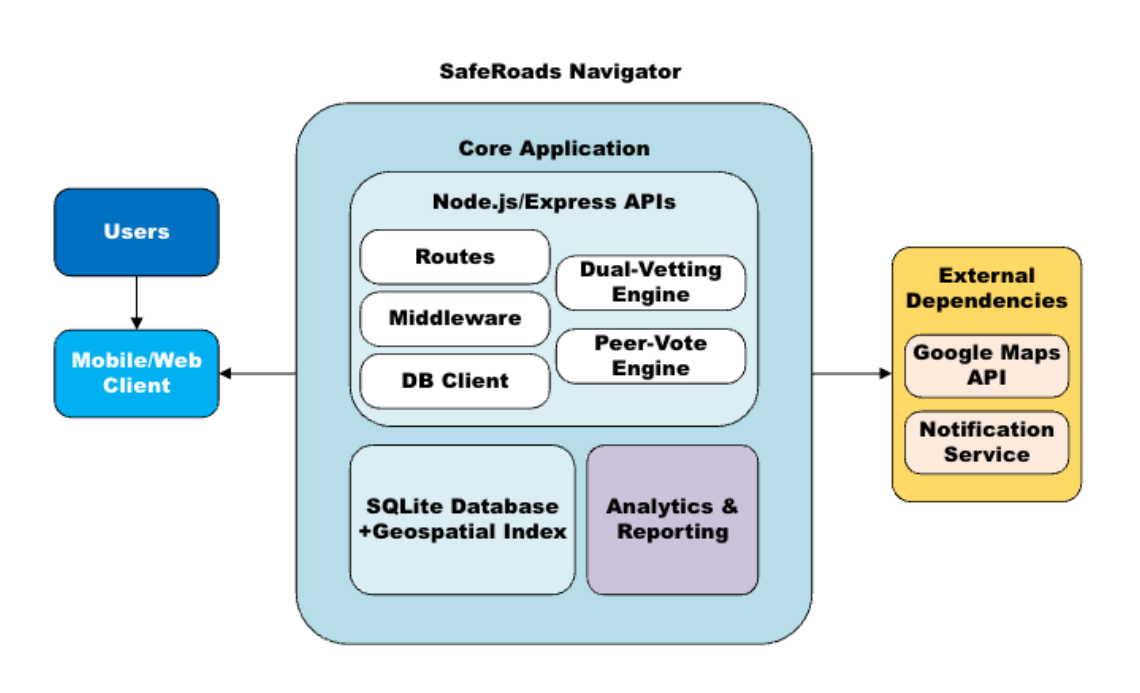
Objectives:

- Implement dual-layer verification to enhance data trustworthiness
- Develop a unified platform: reporting, verification, response, analysis
- Embed dashboards & open-data exports for stakeholder decision-making

Solution:

- SafeRoads Navigator: A web-based system that features crowdsourced hazard reporting, dual vetting (peer & admin), interactive map, heatmap analytics, admin dashboard
- React front-end & Node.js/Express back-end
- SQLite database & Google Maps API integration
- Real-time map markers, heatmaps, and alerts
- Admin dashboard for verification & analytics

Proposed Architecture Diagram



Methodology

This capstone project will employ a design and development methodology typical of software engineering projects. The approach can be outlined in several phases:

- Requirements Analysis
  - Functional/non-functional requirements, data requirements, data flows, formulate the use cases
- System Design and Architecture
  - Design system architecture, API endpoints, database schema, user interfaces, prepare 3rd-party components
- Implementation (Iterative Development)
  - Implement the APIs, code the user interfaces, simulate the use cases
- Testing and Evaluation
  - Test the components, unit testing, integration tests, functional tests
- Project Management and Milestones / Deliverables
  - Work with supervisor, monitor deliverables against project timeline

Project Timeline

- Month 1: Design & Requirements
  - ***Milestone(s)**: Requirements & Design Document finalized; development environment set up (Node.js server skeleton, SQLite schema created)*
- Month 2: Core Implementation
  - ***Milestone(s)**: By end of Month 2, internal demo of the system showing multiple users reporting and confirming hazards, with the map updating live*
- Month 3: Feature Completion & Refinement
  - ***Milestone(s)**: Feature–complete beta version of SafeRoads Navigator by end of Week 12. At this point, all primary use cases can be executed on the system*
- Month 4: Testing, Evaluation & Finalization
  - ***Milestone(s)**: Week 15, project completion. Deliverables include the final research proposal document, a working prototype deployed for demonstration, and a presentation for the academic panel*

Evaluation Plan

The evaluation of SafeRoads Navigator will concentrate on three core dimensions:

- Accuracy and Reliability
  - Precision & recall of verified hazards vs. ground truth, i.e. field inspections
  - False Positive Rate (FPR) or the proportion of flagged hazards that are not real
  - False Negative Rate (FNR) or the proportion of real hazards missed by dual vetting
- System Integration & Performance
  - API response times, i.e. throughput under simulated workloads
  - Throughput, i.e. maximum reports processed per second under load
  - System Uptime, i.e. percentage over evaluation period, i.e. target $\geq 99.5\%$
- Analytical Utility & Stakeholder Impact
  - Dashboard Usage, i.e. number of dashboard sessions by planners/authorities
  - Data Export Count, i.e. number of CSV/API exports performed
  - Policy Actions Triggered, i.e. number of maintenance actions initiated via system alerts

Conclusion

SafeRoads Navigator bridges community reporting and authority action thru dual vetting for trusted, proactive road safety management. Specifically:

- SafeRoads Navigator aims to improve road safety through crowdsourced vigilance
- Dual vetting enhances trust without sacrificing speed
- Interactive analytics empower stakeholders for data-driven decisions

Expected outcomes: improved road safety, increased crowd participation, informed decision-making for road safety, and ***fewer road fatalities/deaths & accidents***

Thank You!

Do you have any questions?

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