An Interactive Map-based dashboard for Urban Traffic Collision Analysis

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Abstract. This paper introduces an interactive map-based dashboard for collision analysis across citywide, neighborhood, and school-zone contexts. Linked views combine severity-aware maps, temporal filtering, demographic summaries, and buffer-based school risk trends. A corridor-based commute risk estimator provides route-level exposure summaries. Together, these modules create a coherent exploratory environment that reduces visual clutter, supports smooth transitions across scales, and enhances users' ability to interpret safety patterns and make data-informed decisions.

Keywords: Road Safety · Geovisualization · Coordinated Multiple Views · Spatio-temporal Analytics · Safe Route Planning.

1 Introduction

1.1 Background and Motivation

Urban traffic collisions are a persistent public safety challenge. With increasingly detailed crash and urban context data, interactive visualization can help stakeholders understand when, where, and why risks emerge. However, collision patterns vary by scale: event-level records reveal severity and local context, neighborhood aggregates expose socio-demographic disparities, and street- or school-adjacent summaries support location-specific interventions. Because these scales are interdependent, meaningful analysis requires fluid transitions across them. Yet most public dashboards visualize only one layer (e.g., hotspots or choropleths), preventing users from synthesizing multi-level patterns or identifying actionable insights.

1.2 Problem Statement

Despite numerous visualization tools, several gaps remain:

1) **Single-scale views limit reasoning across levels**
   Existing systems focus on only one spatial scale, preventing coherent multi-level reasoning (city $\rightarrow$ community $\rightarrow$ street).

2) **Limited contextual explanation**
   Many dashboards show where collisions occur but not how demographic or environmental context relates to elevated risk.
3) **Lack of actionable safety support**
   Tools rarely address decision-making needs such as interpreting school-zone risk or comparing potentially safer areas.

1.3 Our Approaches and System Objectives

We design a coordinated multi-granularity system that addresses these gaps by enabling:

1) **Macro-level**
   Citywide exploration of point-level and temporal patterns.
2) **Meso-level**
   Neighborhood profiling through demographic-linked summaries.
3) **Micro-level**
   School-zone assessment using buffer-based collision metrics.

Together, these modules form a coherent workflow that supports multi-level reasoning.

1.4 Core Contributions

This work makes the following contributions:

1. **A coordinated multi-scale visualization framework** linking point, neighborhood, and school-zone levels into one analytical workflow.
2. **A commute tool** shows how dangerous a route is by checking past crashes along the roads between a chosen start and destination.
3. **Context-enriched spatio-temporal analysis** that supports anomaly-focused temporal reasoning.
4. **Integration of heterogeneous safety-related attributes**(severity, premises type, victim demographics, neighborhood indicators) for interpreting why risk differs across communities.
5. **A school-zone risk assessment module** using configurable buffers and comparative summaries to highlight hazardous areas without complex route modeling.

These contributions advance geovisual analytics by enabling interpretable multi-scale reasoning beyond traditional hotspot maps.

2 Related Work

2.1 Spatio-Temporal Collision Visualization

Objective accident risk often influences mobility behavior more strongly than perceived safety, underscoring the need for tools that clearly convey actual risk conditions[1]. Spatial techniques such as heatmaps, KDE, and graduated symbols, combined with time-series summaries, support basic inspection of collisions. Linking spatial and temporal views further enhances exploratory analysis and helps detect anomalies [2].

2.2 Coordinated Multi-Granularity and Multi-Source Geovisual Analytics

Coordinated Multiple Views (CMV) enable linked interactions across heterogeneous datasets, supporting deeper reasoning across perspectives. Although widely used in urban analytics, CMV dashboards rarely integrate multiple spatial scales. Roberts' overview highlights the value of linking views to facilitate exploratory insight [3] . Our system extends CMV principles by linking point-, neighborhood-, and school-level perspectives.

2.3 Risk-Based Routing and Decision Support

Risk-based visualizations often summarize collisions at the segment level or within school-zone buffers. Contextual factors—such as demographics or road environment—can improve interpretation, but they are seldom combined within a unified interface. Our school-zone module incorporates such contextual signals, providing interpretable comparisons without requiring full route optimization.

3 Data and Preprocessing

Three public datasets support the dashboard. The City of Los Angeles Traffic Collision Data from 2010 to Present provides event-level crash records with time, location, and severity attributes. The Neighborhood Council Boundaries (2018) from LA GeoHub and the City of Los Angeles Census Data by Neighborhood Council provide spatial units and socio-demographic context. The LA County Schools, Colleges, and Universities dataset provides school locations.

Collision records were cleaned for missing or invalid coordinates and standardized to consistent spatial and temporal formats. Spatial joins assigned collisions to neighborhood council polygons, and multi-resolution aggregates were computed for the citywide and neighborhood views. For school analysis, buffers were generated around each institution and collisions within each buffer were summarized with year-by-year trends. For commute exploration, corridor-based summaries between user-defined origins and destinations were used to estimate exposure without route optimization.

4 Approach and System Design

4.1 Design Philosophy

The interface is organized into three granularities—citywide, neighborhood, and school-zone—to avoid visual overload while maintaining continuity through shared encodings and filters. This mirrors how analysts naturally move from broad patterns toward localized concerns.

Gen AI was used to refine phrasing and assist with prototype-level code drafting. All design decisions, implementation, and final writing were verified and finalized by the authors.

4.2 System Architecture

The dashboard is implemented with Streamlit for rapid prototyping and interaction, Pydeck for spatial rendering, Altair for interactive charts, and GeoPandas for spatial operations. All filtering occurs client-side; spatial preprocessing was performed offline. Figure 1 summarizes the overall pipeline.

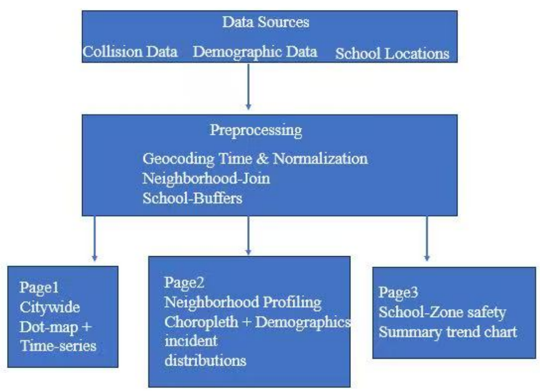

Fig. 1. System architecture illustrating data sources, preprocessing workflow, and analytical modules.

4.3 Citywide Exploration (Page 1)

At the citywide level, a severity-colored dot map shows individual collisions across the full study area and linked to an interactive time-series chart. This pairing helps users spot seasonal patterns, unusual spikes, or quiet periods and then see where in the city those changes occur. On the same page, a navigation-style commute panel lets users pick a start and end location and see how risky that route is based on past collisions. A buffer is drawn along this route, and all collisions within that corridor are counted and summarized. The commute view reports simple, practical metrics like the number of collisions along the route, the share of citywide crashes they represent, and the top nearby hotspots. This gives users a direct way to answer questions like “How safe is my usual way to work?”.

4.4 Neighborhood Profiling (Page 2)

A choropleth map visualizes area-level collision rates. Selecting a neighborhood shows standardized incident summaries (age groups, sex distribution, premise type) along with ranked comparisons. This supports hypothesis formation about community-level risk factors.

4.5 School-Zone Safety (Page 3)

Schools are displayed with color-coded safety ratings based on average collisions within a walkable buffer. Selecting a school reveals summary metrics and trend charts. A coordinated school table supports quick cross-comparison and situational awareness.

5 Evaluation and Discussion

We conducted heuristic evaluation and task walkthroughs to assess whether the system supports multi-scale reasoning. Results indicate that distributing tasks across three granularities reduces clutter while shared encodings preserve analytical flow. Page 1 effectively supports temporal exploration, Page 2 facilitates area comparison, and Page 3 clearly communicates school-zone safety.

Major limitations include the absence of expert user studies and lack of automated routing. Future work includes formal evaluation, integrating real-time data, and extending school-zone analysis with path-based risk computation.

6 Conclusion

We presented a coordinated multi-granularity system linking citywide, neighborhood, and school-zone safety views. By combining point-level exploration, demographic context, and localized summaries, the system supports clearer reasoning across scales without overwhelming the user. Future work will incorporate expert evaluation, automated safe-route options, and real-time mobility data to strengthen decision-support capabilities.

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