Targeting Traffic Trouble:

Using Offence Pattern Visualisation to Make Better Road Safety Decisions

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Abstract

This project addresses the critical challenge of transforming complex traffic enforcement data into actionable insights for policy makers and law enforcement agencies. Using interactive web-based visualisation techniques, we analyse over 4.7 million traffic offence records from Australia's 2023 dataset to reveal patterns across geographic, temporal, and methodological dimensions. The resulting dashboard provides evidence-based decision support for resource allocation, strategic planning, and public transparency initiatives whilst maintaining accessibility for diverse user groups.

1 Introduction

1.1 Background and Motivation

Traffic enforcement constitutes a critical component of public safety infrastructure, yet developing strategic enforcement plans and optimal resource deployment remains challenging for government agencies and law enforcement organisations. Many enforcement teams struggle to accurately quantify, analyse, and interpret trends in traffic enforcement actions, making it difficult to make informed decisions about when, where, and how to deploy deterrents such as patrols, speed cameras, and public safety campaigns.

These challenges stem primarily from a lack of access to, and usability of, raw traffic enforcement data. Whilst extensive publicly accessible datasets exist, transforming this data into actionable insights requires considerable time and expertise that many organisations lack.

This visualisation project addresses this information gap by providing accessible visualisation tools relevant to policy analysts, road safety advisors, traffic enforcement teams, and urban planning departments. These stakeholders need to understand not only the volume and types of offences occurring, but also their geographic and temporal distribution, as well as the effectiveness of different detection methods.

The project employs an interactive, web-based dashboard to visualise Australian law enforcement data from 2023, offering intuitive navigation and actionable visual insights. Key advantages include:

- **Pattern Recognition:** Revealing unknown patterns in offence distributions across states and throughout the year
- **Outcome Analysis:** Illustrating the predominance of fines relative to other outcomes such as charges or arrests
- **Resource Planning:** Facilitating strategic planning by demonstrating which detection methods are most frequently employed
- **Transparency:** Showcasing accessibility and providing valuable information for both decision-makers and the general public

The visualisation supports high-level strategic functions including comparing states to establish regional enforcement trends, observing seasonal patterns to anticipate peak enforcement periods, assessing the effectiveness of different detection methods, and strategic planning for funding and resource allocation.

By replacing assumptions with evidence-based, visualised data, the dashboard empowers stakeholders to make calculated decisions that improve road safety and maximise public expenditure effectiveness.

1.2 Visualisation Purpose

The primary research question guiding this visualisation is: *"What impacts do time of year, geographic location, and detection method have on the frequency and distribution of traffic offence outcomes in Australia?"*

This question was formulated based on project requirements, tutor feedback, and established traffic safety research frameworks. The dashboard provides three complementary analytical perspectives through distinct tabs: Location, Time of Year, and Method.

Each section enables specific analytical capabilities:

Location Analysis: Features a choropleth map identifying states with highest offence counts, contextualised with population and land area statistics to enable per-capita analysis.

Temporal Analysis: Employs a line chart to establish seasonal trends and identify months with unusually high or low enforcement activity.

Method Analysis: Uses a bar chart to display offence distribution by detection method (mobile camera, fixed camera, police citation, etc.).

These three perspectives combine to provide a comprehensive view of how enforcement patterns evolve across both spatial and temporal dimensions.

Decision-Making Benefits:

- **Evidence-Based Budgeting:** Supporting data-driven patrol scheduling and camera installation decisions
- **Risk Mitigation:** Enabling targeted interventions during highest-risk periods and locations
- **Public Transparency:** Providing accessible information about traffic enforcement outcomes
- **Scalability:** Creating a framework that can accommodate additional data dimensions

This visualisation transcends academic exercise to serve as a practical decision-support tool, transforming static CSV data into a dynamic interface for agencies to explore patterns and make informed decisions that create safer roadways and optimise taxpayer investment.

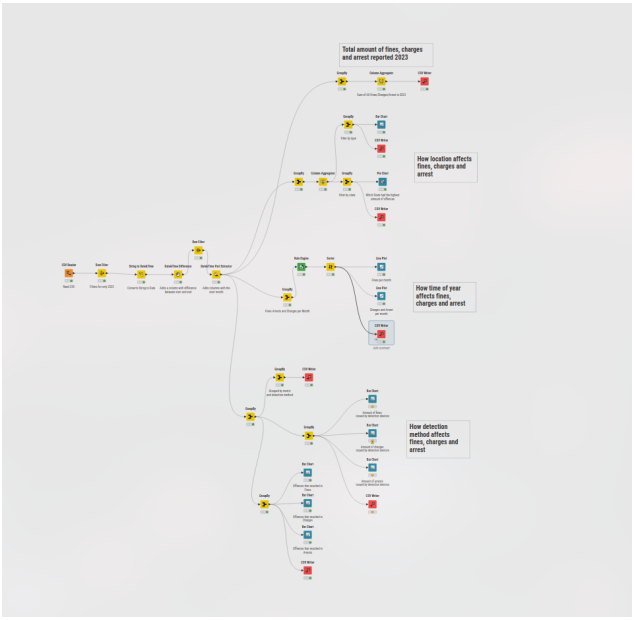

Figure 1: Knime Overview

2 Data

2.1 Data Source and Governance

The dataset originates from the Australian Government Open Data Portal [1], providing comprehensive access to law enforcement and traffic offence data for calendar year 2023. This dataset encompasses offence types, detection methods, dates, and geographic locations across all Australian states and territories.

The dataset contains over 4.7 million entries, predominantly traffic violations, published annually as open-access data conforming to ethical research standards.

2.1.1 Data Governance Framework:

Collection Methodology: Data is aggregated from state and territory law enforcement databases, centrally processed, and made available through the government's open data platform.

Quality Assurance: Initial quality assessment revealed well-structured data with consistent formatting. Quality checks confirmed categorical consistency and absence of data corruption or character encoding errors.

Security, Privacy, and Ethics: The dataset contains no personally identifiable information (names, licence numbers, addresses). Data is fully anonymised and complies with privacy legislation and ethical guidelines. As aggregate-level public policy data, specific consent requirements are not applicable.

2.2 Data Processing and Analysis

Data processing was conducted using the KNIME Analytics Platform, utilising a modular, node-based workflow for data cleaning, transformation, and analysis.

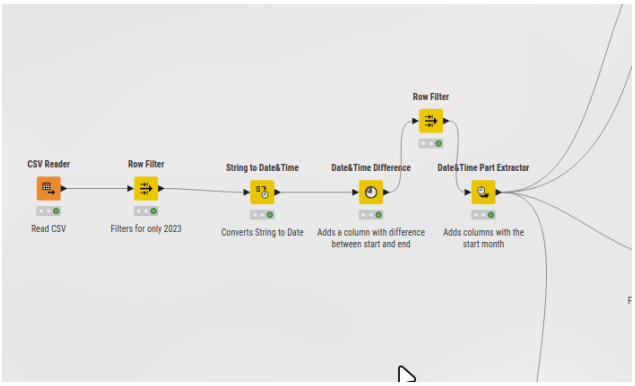

Figure 2: Cleaning and Transformation

The objective was to produce three cleaned, structured datasets optimised for specific visualisations: location-based, temporal, and detection method analyses.

The workflow employed a three-branch structure, each utilising a common global pre-cleaning stage to ensure consistent processing across all outputs.

2.2.1 Initial Cleaning and Transformation:

Prior to branch-specific processing, several foundational cleaning operations were applied:

- **Column Standardisation:** Corrected and standardised column names using Column Rename and String Manipulation nodes
- **Missing Value Handling:** Identified and removed records with missing values in critical fields using Row Filter nodes
- **Duplicate Removal:** Eliminated duplicate entries using Duplicate Row Filter to ensure unique offence records

Attribute	Type	Description
Offence Category	Categorical	Fines, Charges, Arrests
Detection Method	Categorical	Mobile Cameras, Fixed Cameras, Police Issued, etc.
State	Nominal	ACT, VIC, NSW, QLD, SA, WA, TAS, NT
Date of Offence	Interval	Full date in DD/MM/YYYY format
Count	Quantitative	Total number of offences per category

Table 1: Dataset Attributes Example

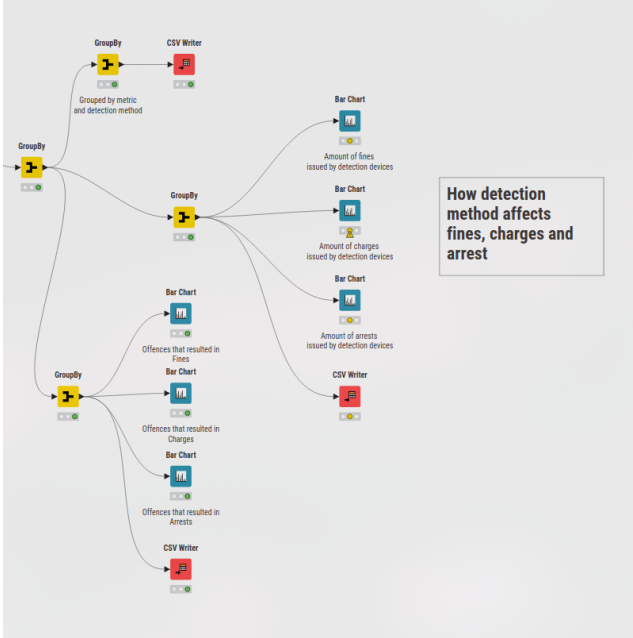

Figure 3: Knime Exploration

- **Percentage Calculation:** Created additional columns for calculating percentage shares within visualisation categories

2.3 Data Exploration

Comprehensive exploratory analysis was conducted within KNIME to identify key patterns, trends, and anomalies, establishing the foundation for final visualisations and ensuring optimal presentation of relevant insights.

2.3.1 Key Findings:

Outcome Distribution: Analysis revealed that fines constitute 98.7% of all traffic offences, with charges and arrests representing minimal proportions. This finding confirmed the appropriateness of focusing the visual narrative primarily on fines.

Seasonal Patterns: Clear temporal trends emerged, with December and January showing above-average offence rates due to increased holiday travel. This pattern justified the selection of a line chart for demonstrating month-to-month variations.

Geographic Distribution: Queensland recorded the highest number of fines, followed by New South Wales and Victoria. This geographic variation informed the design of the choropleth map for state-level visualisation.

Detection Method Analysis: Mobile and fixed cameras showed significantly higher utilisation rates compared to other detection methods, supporting the inclusion of detection method analysis in the Method tab bar chart.

Data Quality Issues: Minor inconsistencies in detection method labelling and some low-volume entries were identified and resolved during the cleaning phase. Overall, the exploratory analysis confirmed data quality and readiness for visualisation implementation.

3 Visualisation Design

3.1 Website Design

The website architecture provides users with intuitive navigation from broad overview to detailed, filterable analysis. The landing page presents a comprehensive project overview featuring a title, subtitle, and summary donut chart displaying total offences categorised as Fines, Charges, and Arrests. [2]

3.1.1 Layout and Structure:

- **Navigation System:** Consistent horizontal navigation bar enables seamless movement between analytical perspectives
- **Visual Hierarchy:** Clear, prominently positioned headings provide immediate context
- **Responsive Design:** Charts are centrally aligned and responsive across all screen sizes
- **Information Architecture:** State statistics and chart tooltips positioned adjacent to visualisations

User Flow Design:

1. Landing Page: Users encounter national offence data summary
2. Tab Selection: Users select specific analytical perspective
3. Interactive Exploration: Users engage with visualisations
4. Detail Access: Users access specific statistics
5. Cross-Analysis: Users navigate between tabs to explore different data dimensions

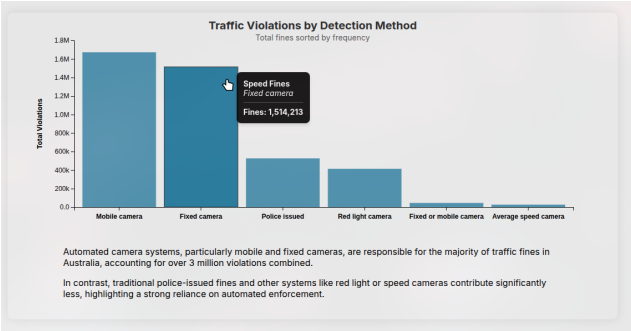

Figure 4: Bar Chart

Figure 5: Line Chart

3.2 Visualisation Design

The dashboard employs carefully selected chart types optimised for clear communication of key data dimensions, enabling users to derive insights with minimal statistical expertise. [3]

Chart Selection Rationale:

Donut Chart (Summary Page): Selected for its effectiveness in displaying proportional relationships and immediate visual impact. The circular design effectively communicates the overwhelming dominance of fines whilst providing clear magnitude perception.

Choropleth Map (Location Tab): Optimal for geographic comparison, utilising colour gradients to enable rapid identification of high-offence states. Interactive functionality reveals detailed state-level statistics. (see Figure 6)

Line Chart (Time of Year Tab): Ideal for temporal trend visualisation, clearly displaying seasonal peaks and valleys throughout the year. This format facilitates identification of enforcement patterns and seasonal variations. (see Figure 5)

Bar Chart (Method Tab): Effective for categorical comparison, enabling straightforward assessment of detection method frequency and relative technology utilisation. (see Figure 4)

3.2.1 Design Principles Implementation:

- **Graphical Integrity:** All axes appropriately scaled to prevent distortion

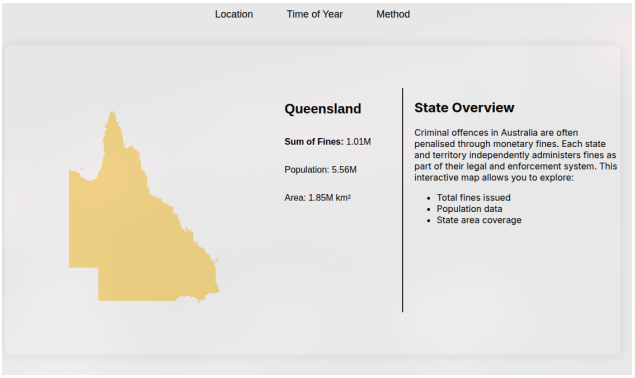

Figure 6: Choropleth Map

- **Consistency:** Uniform fonts, labels, and styling across all visualisations
- **Accessibility:** Colour schemes utilise colourblind-friendly palettes with sufficient contrast ratios
- **Proportional Accuracy:** All visual elements proportionally sized to accurately reflect underlying data values
- **Interactive Enhancement:** Tooltips provide detailed information whilst eliminating visual clutter
- **Responsive Implementation:** Layout adapts to various screen sizes whilst maintaining clarity

3.3 Interaction Design

Interactive functionality serves as a cornerstone of the dashboard design, enhancing usability and user engagement through intuitive exploration capabilities. [4]

Navigation System: Tab-based architecture enables users to examine data from three distinct analytical perspectives, supporting comprehensive data exploration tailored to specific interests.

State-Level Interaction: Choropleth map click functionality instantly updates detail panels with state-specific statistics, combining spatial visualisation with contextual information for enhanced analytical insight.

Hover Effects: Line and bar charts employ hover tooltips displaying exact numerical values, minimising visual clutter whilst providing precise data access.

Filtering Capabilities: Dashboard includes filtering options between fines, charges, and arrests, enabling users to customise visual output according to specific analytical focus.

Data Export Functionality: "Download Data" button enables CSV export for independent analysis or reporting purposes, extending dashboard utility beyond interactive exploration.

Responsive Interaction Design: All interactive elements function consistently across devices and

screen sizes, ensuring accessibility for users with varying technical backgrounds whilst maintaining intuitive, enjoyable user experience.

4 Iteration and Validation

4.1 Testing and Refinements

The development process involved extensive iterative refinement based on user feedback and technical challenges encountered during implementation.

Initial Design Evolution: Early dashboard versions displayed fines, charges, and arrests without clear differentiation. Given that fines comprised over 98% of the dataset, the decision was made to centre the visualisation narrative on fines, resulting in more coherent and relevant analytical conclusions.

Visual Design Improvements:

- **Colour Palette Refinement:** Updated to a consistent interpolateBlues scale in D3.js
- **Legend Clarification:** Enhanced legends and labels for improved user comprehension
- **Information Hierarchy:** Repositioned state summary boxes for improved visibility

Technical Challenge Resolution:

- **Server Integration Issues:** Mercury server integration problems resolved through careful verification of data file uploads
- **Chart Type Optimisation:** Transitioned from scatter plot to line chart for temporal analysis
- **User Interface Enhancements:** CSS improvements addressed spacing issues and enhanced text contrast

Accessibility Implementation:

- High-contrast labels for improved visibility
- Keyboard-accessible tab navigation
- Descriptive alt text for screen reader compatibility
- Comprehensive legends for all charts
- Hover tooltips providing exact values without visual clutter

4.2 Usability Evaluation

A structured usability evaluation was conducted with a diverse user group comprising both technical and non-technical participants to assess dashboard effectiveness and identify improvement opportunities.

Evaluation Methodology: Participants completed specific tasks including identifying the state with highest fine totals, using line charts to interpret seasonal trends, comparing detection methods through bar chart analysis, and accessing state-specific statistics via map interaction.

Key Findings:
Positive Feedback:

- Navigation structure was intuitive and easy to follow
- Tooltip functionality was highly valued for accessing exact values
- Overall visual design was appealing and informative

Areas for Improvement:

- Some users initially overlooked clickable navigation tabs
- Map state interactivity was not immediately obvious to all users

Implemented Improvements:

- Enhanced Tab Visibility: Increased font size and spacing for navigation tabs
- Visual Feedback Enhancement: Improved colour contrast for map states
- User Interface Refinement: Adjusted layout spacing based on user navigation patterns

Overall Assessment: Users rated the dashboard 4.5/5 for clarity, simplicity, and usability, confirming that the iterative refinement process successfully addressed major usability concerns whilst maintaining analytical effectiveness.

5 Conclusion and Future Improvements

This project successfully demonstrates how interactive data visualisation can transform complex Australian traffic enforcement data into accessible, actionable insights. By focusing on three key analytical dimensions—location, temporal patterns, and detection methods—the dashboard provides a comprehensive yet navigable platform for exploring over 4.7 million traffic offence records from 2023.

5.1 Key Achievements:

The visualisation effectively communicates that fines constitute the overwhelming majority (98.7%) of traffic enforcement outcomes, establishing their dominance over charges and arrests. Each visualisation component was strategically designed to facilitate intuitive data exploration whilst maintaining analytical rigour.

Technical Implementation Success: The iterative development process successfully addressed both technical challenges and user experience requirements. Improvements in colour schemes, tooltip implementation, responsive design, and accessibility features resulted in a robust, user-friendly platform suitable for diverse audiences.

Analytical Impact: The dashboard enables evidence-based decision-making by revealing patterns not immediately apparent in raw data, including seasonal enforcement trends, geographic distribution variations, and detection method effectiveness comparisons.

Future Enhancement Opportunities:

Advanced Filtering Capabilities: Implementing real-time filtering allowing users to toggle between fines, charges, and arrests across all visualisations would enable more nuanced comparative analysis.

Temporal Expansion: Adding year-over-year comparison functionality with animated transitions would provide historical context and trend analysis capabilities.

Demographic Integration: Incorporating additional data dimensions such as demographic information and socioeconomic indicators could provide deeper policy insights and support more targeted intervention strategies.

Enhanced Geographic Analysis: Adding regional subdivision analysis and per-capita normalisation options would enable more sophisticated geographic comparison capabilities.

Automated Insights: Implementing algorithmic pattern detection and automated insight generation could assist users in identifying significant trends and anomalies.

The project establishes a solid foundation for ongoing development, with the modular design architecture supporting future enhancements whilst maintaining the core strengths of clarity, accessibility, and analytical utility that make it valuable for evidence-based policy development and public transparency initiatives.

References

[1] A. Government, *Traffic offence data*, Australian Government Open Data Portal, Accessed: 2025, 2023.

[2] T. Software, *Design guidelines*, Tableau Documentation, Design best practices for data visualisation, 2024.

[3] Anonymous, *Building dashboards that actually work in public policy*, Medium Blog, Best practices for policy dashboard development, 2024.

[4] W. W. A. Initiative, 'Web content accessibility guidelines (wcag) 2.1,' World Wide Web Consortium, Tech. Rep., 2023, Web accessibility standards and guidelines. [Online]. Available: `https://www.w3.org/WAI/standards-guidelines/wcag/` (visited on 08/06/2025).

Appendices

Generative AI Declaration

Selected portions of report text structure and section headings were developed with AI writing tool assistance under direct supervision. All content has been thoroughly reviewed, edited, and adapted to ensure originality, accuracy, and academic integrity. No visualisations or data analyses were generated using AI tools.

Usability Evaluation Materials

Test Tasks Provided to Participants:

- Determine which state recorded the highest total number of fines
- Utilise monthly trend visualisation to identify peak activity periods
- Compare detection method effectiveness using aggregate offence data
- Access state-specific statistics through interactive map functionality

Evaluation Notes: Users found tabbed navigation intuitive and tooltip interactivity valuable. Some participants initially missed interactive map functionality; visual feedback was enhanced to address this issue. Feedback resulted in improved font sizing and layout spacing optimisation. Overall clarity, simplicity, and usability rating: 4.5/5.