Smart Intersection Vis Proposal

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Introduction

Since the inception of the automobile, traffic congestion has increased dramatically on urban roads, increasing vehicles on the road, causing billions of dollars of financial loss and untold hours lost in traffic every year [1]. One of the countermeasures to the problem is Traffic Monitoring and Management using intelligent transportation such as GPSs, cameras and LiDARs. The previous two methods receive their fair share of criticism due to accuracy, deployment cost and privacy concerns. Compared with the other two devices mentioned above, LiDARs are accurate and collect no private or potentially sensitive data. However, the application of LiDARs has been limited due to the cost of the sensor and deployment until recently. With the 5G telecommunication revolution, using LiDAR to monitor traffic conditions becomes a promising solution for many major cities - allowing them to draw insights from traffic flows to develop infrastructure or other more immediate countermeasures and observe potential hazards anomalies in real-time. The benefits are evident when using LiDAR sensors coupled with 5G infrastructure for Traffic Monitoring and Management purposes.

The City of Kelowna, together with Rogers and the UBC Radio Science Lab, plans to install LiDARs on intersections better to understand pedestrians, cyclists, and vehicles' movements. This information can help improve road safety, enable near-miss and conflict analysis. In summer 2020, they installed two LiDARs on two intersections to assess the merits of 5G-enabled LiDAR sensors for traffic monitoring. The current problem that we attempt to solve for our project partners is the visualization of the LiDAR data and traffic flows in a way that is intuitive, interactive and comparable across many different parameters (time of day, certain days of the week, select intersections, evening rush hours on Thursdays and Fridays in the downtown core, intersections along a specific street scheduled for an additional lane)

Related Work

Using sensors at intersections for traffic analysis has been prevalent due to technological advances. Banerjee [2] uses fish cameras and high-resolution signal data to show trajectory patterns by drawing them directly onto the intersections and crosswalks. This method is straightforward at showing an object's movement but not efficient for aggregate data count and analysis.

Song [3] proposed a visualization for intersection traffic flow data using a radial layout. He uses circles to represent the number of vehicles, and different colours represent vehicles from different directions. He also creatively uses a radical layout to present the vehicle flow in 24 hours for seven days. However, using rings inside the circle makes the data near the center of the circle hard to read. We will see if we have any chance to improve this visualization method.

The idea of the necklace map [4] is placing a necklace around the map region to present statistical data instead of presenting it directly on the map. This method saves precious space inside the map for other visualizations, and the symbols on the necklace are customizable. We utilized the necklace idea in our proposed solution to potentially show other information around the intersection.

Ocupado [5] is a tool for visualizing location-based count over time across buildings. It provides a comprehensive set of tools to compare data under different scenarios, including the zoomable binned time series chart, which helps compare intersection data under different time intervals and show trends. The spatial heat map is useful in locating high-volume intersections for users quickly.

Data and Task Abstraction

A Co-op Team has been working on the data acquisition task and creates an API to fetch the output data of aggregate counts for pedestrians and vehicles. Currently, we have access to aggregate vehicle count for 12 directions and pedestrian count for eight directions in every 15 min interval.

The dataset we have is a static tabular dataset. The attributes we have are time interval (sequential and hierarchical, starting from summer 2020), vehicle counts on each direction (categorical) and pedestrian count on each direction (categorical). The vehicle count has 12 directions in total (each direction has three ways to go), while the pedestrian count has eight directions in total (each crosswalk has two directions). Here the key is the time interval while the values are the vehicle and pedestrian counts in every direction.

Our users' tasks are to present the data to monitor the traffic flow across the intersections. The users can also search values by looking up specific time interval, locating extreme date and time such as when and where traffic volume is unusual, browsing traffic data around long weekends and even exploring the full traffic data.

The scale of our dataset is roughly 24*4=96 items every day. Ideally, we will store the data for five years. Then it comes to 95*365*5=175200 items. Each item should have 21 attributes.

Solution

A Sankey diagram will be used as the base visualization with 12 arrows per intersection; 4 directions per intersection with three smaller arrows of (i) 'From Left Turn,' (ii) 'From Right Turn' and (iii) 'From Straight Away' for each combining to form one arrow as the output of that direction. The arrows show vehicle count with four hues representing each direction of the intersection and the arrow width representing the vehicle's magnitude and pedestrian count. Therefore, the main mark of the visualization is a single output arrow composed of 3 input arrows, (i) - (iii) from above. The channel for representing the intersection direction is hue. The design decision of using four fully saturated hues of red, blue, green, and yellow to represent the intersection's four directions is based on chapter 10 of the 'Visualization, Analysis and Design' textbook. More specifically, "a good set of initial choices are the fully saturated and easily nameable colours, which are also the opponent colour axes: red, blue, green, and yellow" and "colormaps for small regions such as lines should be highly saturated, but large regions such as areas should have low saturation [6]". The arrows are sufficiently small to be considered 'small regions' when compared to a multiple -intersection visualization view, but it is noted that in a zoomed-in view of a single intersection, a less saturated version of the hue may have to be used to compensate for the larger area of the arrow in this view.

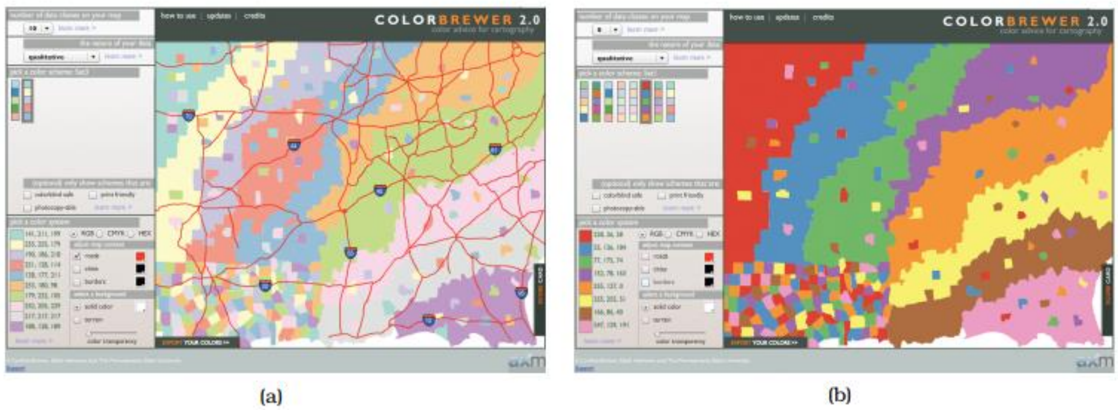

Figure 10.7. Saturation and area. (a) The ten-element low-saturation map works well with large areas. (b) The eight-element high-saturation map would be better suited for small regions and works poorly for these large areas. Made with ColorBrewer, http://www.colorbrewer2.org.

Figure 1 Figure 10.7 from VAD Ch.10 on "Saturation and Area."

The other channel used in this Sankey diagram of an intersection is the arrow; it is used to encode or represent the vehicle's magnitude or pedestrian counts. It is to be noted that the comparison of widths of these arrows (explicitly without magnitudes labelled on them, and especially at scale with multiple intersections that are not adjacent to each other) can be a limitation of this visualization approach. We address this limitation with proportional bubbles in the form of *Necklace Maps.*

One overlay selected in our proposed visualization tool will be proportional bubbles with numerical values of passenger or vehicle count magnitudes in the form of a necklace map. Necklace maps are used in this context to discern information more efficiently and intuitively with contrast to arrow thickness in the Sankey Diagram; especially concerning anomalies like a very high count that would now be represented as a sizeable proportional bubble visible to the end-user - even at a scaled view of the visualization with many intersections being observed simultaneously on a single map. Necklace maps were chosen for three primary reasons: (i) Clearer, intuitive visualizations of the actual magnitude of vehicle and passenger count via proportional necklace symbol sizes and magnitude values displayed within the symbol, as opposed to on or beside a smaller and more crowded arrow, as "necklace maps appear clear and uncluttered and allow for comparatively large symbol sizes [4]". (ii) We have sufficient design and development space for additional data variables to visualize that may result from the other research team’s data processing effort, e.g. if speed can be extracted, then the necklace map can show the vehicle count with the size of the symbol and be broken down as pie-chart to show the speed distribution of these vehicles. (iii) The simple and clean geometry of the intersection lends itself to be not be intruded upon or by necklace symbols, or have a weaker region to symbol association if there are 12 distinct symbols placed evenly around a necklace that would surround and intersection, as “the advantages of necklace maps come at a price: the association between a symbol and its region is weaker than with other types of maps.”

Milestone

Stage I	Meet with the Rest of the Research Team, Understand Their Goals and Acquire a Complete Dataset.	Done as of October 18th
Stage II	Integrate the Rest of Team’s Goals and Update Initial Visualization Proposal and Solution Appropriately.	Done as of October 22nd.
Stage III	Build Stankey Map (base case visualization) complete.	Goal: Tue. November 15th. Timeframe: 22 days.
Stage IV	Build Necklace Map Overlay and Time Series View. Note: Stage III and Stage V are higher priority/critical to the visualization tool’s end goals.	Goal: Tue. November 23rd. Timeframe: 8 days.
Stage V	Comparison and Interactivity Component of the Visualization Tool.	Goal: Tue. December 7th. Timeframe: 14 days.

Bibliography

[1] D. Schrank, "2019 Urban Mobility Report - Texas A&M University," *2019 Urban Mobility Report*, 2019. [Online]. Available: https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-report-2019.pdf. [Accessed: 23-Oct-2020].

[2] T. Banerjee, K. Chen, X. Huang, A. Rangarajan, and S. Ranka, “A Multi-sensor System for Traffic Analysis at Smart Intersections,” *2019 Twelfth International Conference on Contemporary Computing (IC3)*, Aug. 2019.

[3] W. Song, C. Huang, and B. Jiang, “Visual methods for time-varying intersection traffic flow data,” *2017 4th International Conference on Systems and Informatics (ICSAI)*, 2017.

[4] B. Speckmann and K. Verbeek, “Necklace Maps,” *IEEE Transactions on Visualization and Computer Graphics*, vol. 16, no. 6, pp. 881–889, 2010.

[5] M. Oppermann and T. Munzner, “Ocupado: Visualizing Location-Based Counts Over Time Across Buildings,” *Computer Graphics Forum*, vol. 39, (3), pp. 127-138, 2020.

[6] T. Munzner, *Visualization analysis and design*. Boca Raton: CRC Press, 2015.