A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion

Presentation by Junfeng Xu

Who? Chunggi Lee, Yeonjun Kim, Seungmin Jin, Dongmin Kim, Ross Maciejewski, Senior Member, IEEE, DavidEbert, Fellow, IEEE, and Sungahn Ko, Member, IEEE

When? November 4, 2019

Summary

We present an interactive visual analytics system that enables traffic congestion exploration, surveillance, and forecasting based on vehicle detector data.

Fig 5. C. Lee et al., "A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion," in IEEE Transactions on Visualization and Computer Graphics. doi: 10.1109/TVCG.2019.2922597

Tasks

Quoted from the paper:

- Analysis of congestion patterns, changes, and trends with historical data;
- Real-time congestion surveillance across the city;
- Real-time congestion propagation estimation;
- Real-time predictive analysis of near-future congestion conditions, and
- Real-time maintenance of malfunctioning vehicle detectors.

C. Lee et al., "A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion," in IEEE Transactions on Visualization and Computer Graphics. doi: 10.1109/TVCG.2019.2922597

Tasks

- On a higher level: *analyse* congestion patterns, *discover* places of interest, and *derive* prediction of future congestions
- On a lower level: *locate* and *explore* congested roads, and *query* the historical and temporal congestion information of roads

Data

Source of Data

The raw time-series data are collected by sensors installed in Ulsan, South Korea.

- DSRC data: road name, road location, and vehicle speed. Resolution: every minute.
- Inductive loop data: road name, road location, direction, speed, and volume. Resolution: every 15 minutes.

There is a historic dataset over a total period of over two years, as well as real-time dynamic stream data.

Data

Source of Data

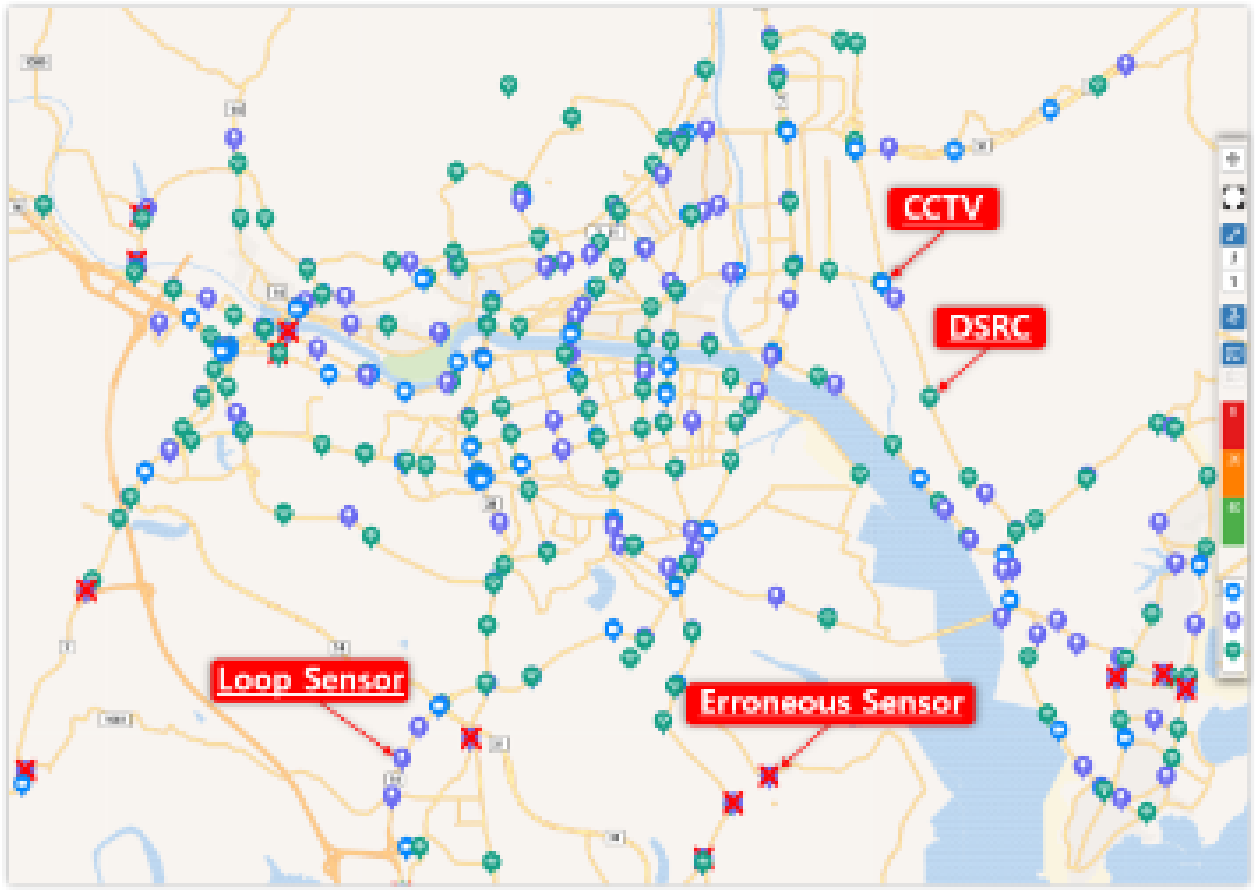


Fig 1. C. Lee et al., "A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion," in IEEE Transactions on Visualization and Computer Graphics. doi: 10.1109/TVCG.2019.2922597

Data

Data Visualised

- Congestion information: 2D Spatial time series data
  - Geographical position of the roads
  - Traffic speed in each direction
    - Aggregated into three intervals (0-20, 20-40, above 40)
  - Traffic volume in each direction
- Congestion propagation: a network where each links hold information about propagation of congestion
  - Direction of congestion propagation
  - Duration of congestion
- Nodes in the network correponds to ends of road segments on the map

Data

Derivation of Data

The data is derived from the following sources:

- The historical dataset collected by sensors
- Real-time data stream from sensors
- Prediction given by a machine learning model trained using historical data

View

Overview (pun not intended)

- Linked views
- Putting everything on the map was considered, but previous studies have shown that this is less effective.

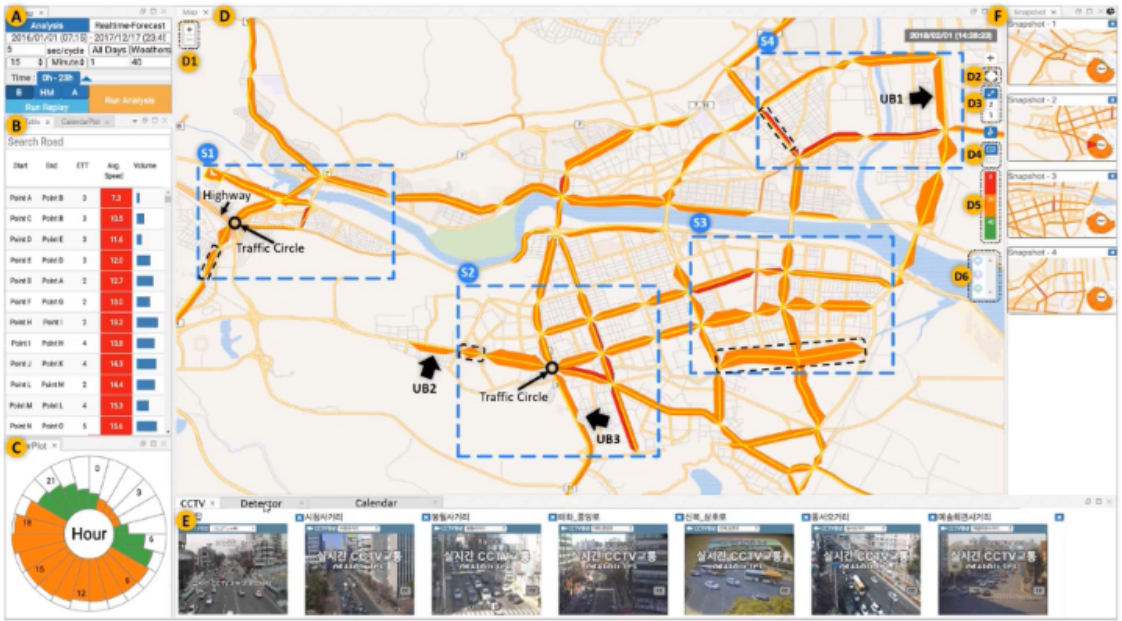


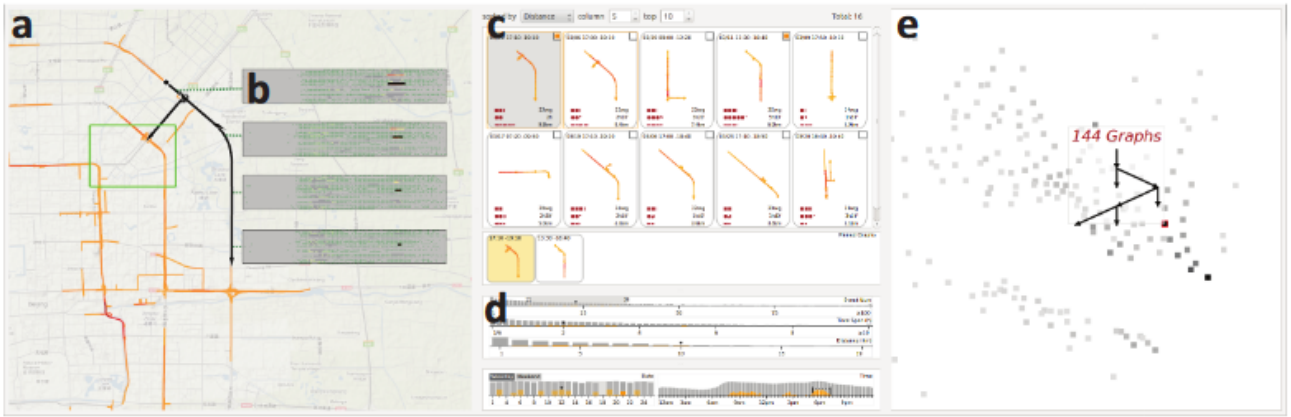
Fig 5. C. Lee et al., "A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion," in IEEE Transactions on Visualization and Computer Graphics. doi: 10.1109/TVCG.2019.2922597

View

Existing Systems

Visual Traffic Jam Analysis Based on Trajectory Data

Zuchao Wang, Min Lu, Xiaoru Yuan, *Member, IEEE*, Junping Zhang, *Member, IEEE*, and Huub van de Wetering



Linked views have been used in traffic visualisation in the past, but for different tasks.

Z. Wang, M. Lu, X. Yuan, J. Zhang and H. v. d. Wetering, "Visual Traffic Jam Analysis Based on Trajectory Data," in IEEE Transactions on Visualization and Computer Graphics, vol. 19, no. 12, pp. 2159-2168, Dec. 2013. doi: 10.1109/TVCG.2013.228

View

Existing Systems

A Visual Reasoning Approach for Data-driven Transport Assessment on Urban Roads

Fei Wang, Wei Chen, Feiran Wu, Ye Zhao, Han Hong, Tianyu Gu, Long Wang, Ronghua Liang and Hujun Bao

F. Wang et al., "A visual reasoning approach for data-driven transport assessment on urban roads," 2014 IEEE Conference on Visual Analytics Science and Technology (VAST), Paris, 2014, pp. 103-112. doi: 10.1109/VAST.2014.7042486

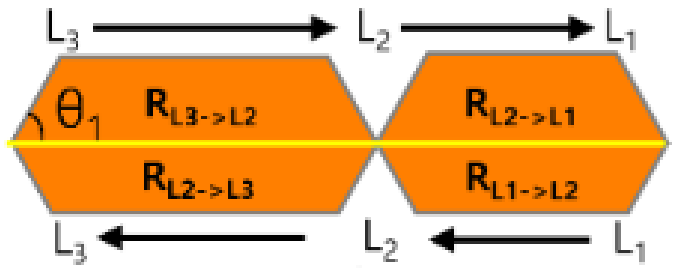
View

VSRivers

'VSRivers' stands for 'Volume-Speed Rivers': large volume and low speed means high importance.

- Lines on a geographic map
- End of road indicated by drop of thickness

- Width: traffic volume
- Colour: traffic speed



Excerpt from fig 6. C. Lee et al., "A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion," in IEEE Transactions on Visualization and Computer Graphics. doi: 10.1109/TVCG.2019.2922597

View

Colour map

Traffic speed encoded as a sequential colour map.

Green over $40\mathrm{km/h}$: unimpeded

Orange between 20 and $40\mathrm{km/h}$: slow

Red below $20\mathrm{km/h}$: impeded

Which are ‘conventions in the domain’.

View

PropagationView

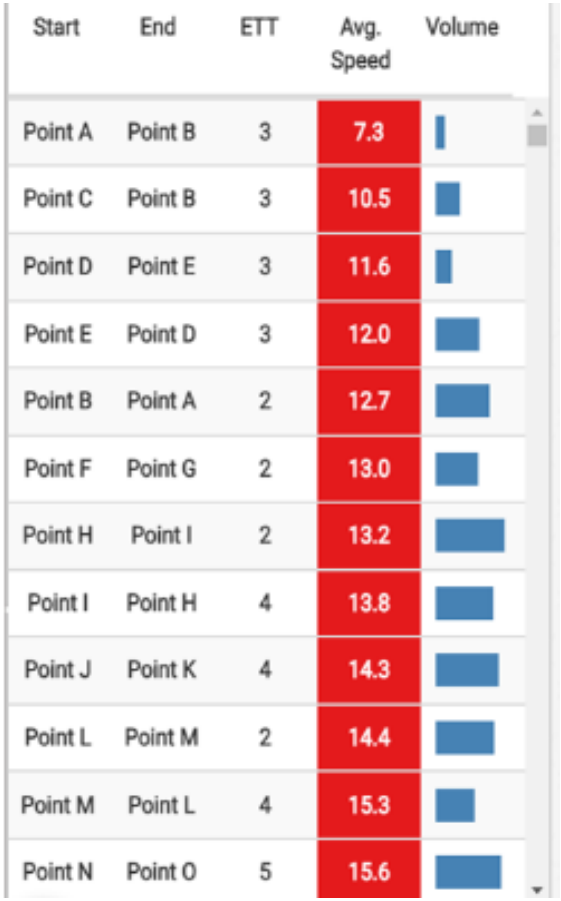
- Node-link graph + spatial positioning
- Arrow: direction of propagation of congestion
- Brightness: severity of congestion
- Blue circles indicates 'root causes' of congestion

Fig 7. C. Lee et al., "A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion," in IEEE Transactions on Visualization and Computer Graphics. doi:

View

Data for individual roads

- Speed encoded as colour and displayed directly
- Volume encoded as length of bars
- Can be sorted: good for searching congested roads



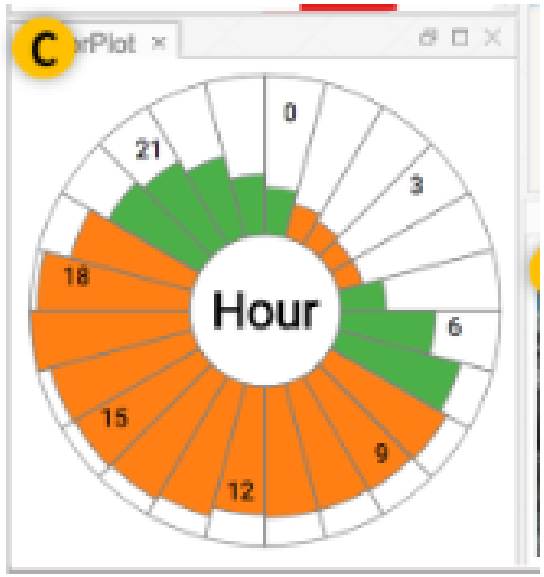
Start	End	ETT	Avg. Speed	Volume
Point A	Point B	3	7.3	
Point C	Point B	3	10.5	
Point D	Point E	3	11.6	
Point E	Point D	3	12.0	
Point B	Point A	2	12.7	
Point F	Point G	2	13.0	
Point H	Point I	2	13.2	
Point I	Point H	4	13.8	
Point J	Point K	4	14.3	
Point L	Point M	2	14.4	
Point M	Point L	4	15.3	
Point N	Point O	5	15.6	

Excerpt from fig 5. C. Lee et al., "A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion," in IEEE Transactions on Visualization and Computer Graphics. doi: 10.1109/TVCG.2019.2922597

View

Clock view

- Positions on the diagram corresponds to times on a clock
- Volume encoded as length of bars
- Speed encoded as colours

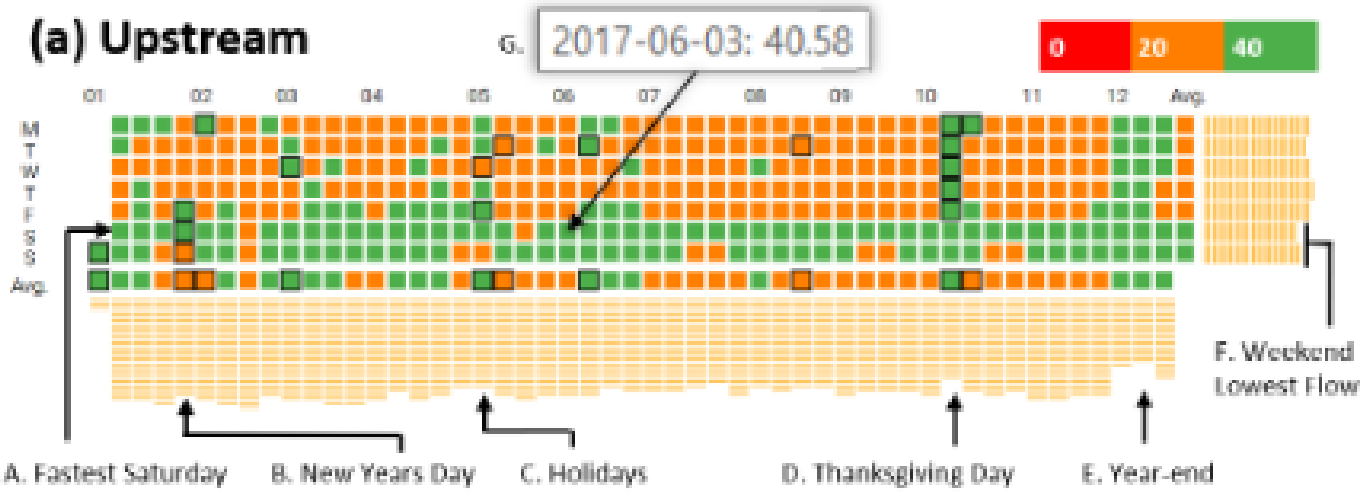


Excerpt from fig 5. C. Lee et al., "A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion," in IEEE Transactions on Visualization and Computer Graphics. doi: 10.1109/TVCG.2019.2922597

View

Calendar view

- Y-axis: days in a week; X-axis: weeks in a year
- Speed encoded as colours
- Holidays highlighed using black outlines
- Aggregated speed and volume for each week and each day in a week shown at the end of the calendar

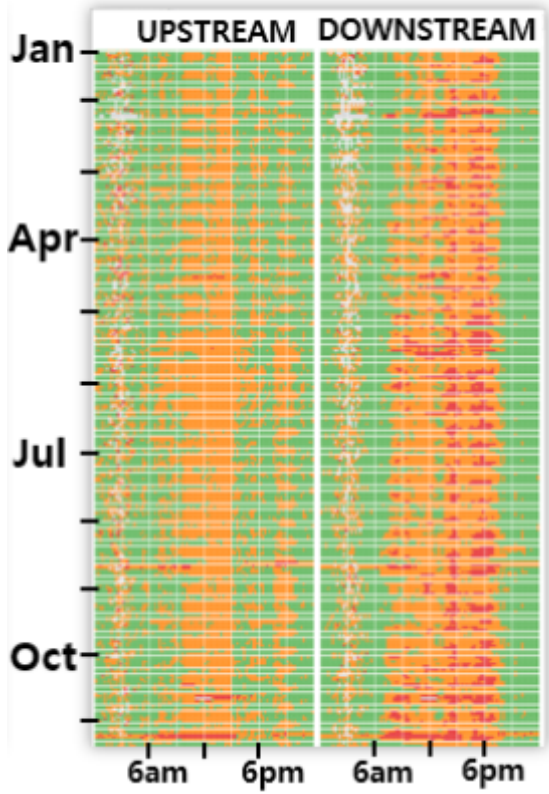


Excerpt from fig 8. C. Lee et al., "A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion," in IEEE Transactions on Visualization and Computer Graphics. doi: 10.1109/TVCG.2019.2922597

View

In-detail view

- Speed encoded as colours
- Highest resolution



Excerpt from fig 11. C. Lee et al., "A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion," in IEEE Transactions on Visualization and Computer Graphics. doi: 10.1109/TVCG.2019.2922597

View

'Snapshots'

- Segments of the main map highlighed
- Linked to main map

Excerpt from fig 5. C. Lee et al., "A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion," in IEEE Transactions on Visualization and Computer Graphics. doi: 10.1109/TVCG.2019.2922597

View

Linked view

- Map and table of roads: shared data, different encoding
- Map & table: subset of data; clock & calendar: detailed data
- Linked navigation

Fig 5. C. Lee et al., "A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion," in IEEE Transactions on Visualization and Computer Graphics. doi: 10.1109/TVCG.2019.2922597

Evaluation

- Three case studies
  - ‘Understanding City Traffic Congestion Patterns’
  - ‘Investigation on Congestion Improvement Projects’
  - ‘Broadcasting Traffic Congestion Conditions’ - in real time
- Expert interview

C. Lee et al., "A Visual Analytics System for Exploring, Monitoring, and Forecasting Road Traffic Congestion," in IEEE Transactions on Visualization and Computer Graphics. doi: 10.1109/TVCG.2019.2922597

Critique

Strengths

- Design process with a focus on tasks
- Massive item reduction to improve visual clarity
- Interlinked views makes navigation easy

Critique

Weaknesses

- Do we really want to perform real-time and retrospective analysis using the same application?
- Colour map - low resolution and accessibility issues
- Evaluation - would a quantitative study be possible?

Thank you!

Any questions?