Development of a Data-Driven Approach for ID Secondary Crashes

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A Real-World Challenge

- Traffic Crashes can induce heavy queues
- Interrupted traffic increase the risk of having more crashes

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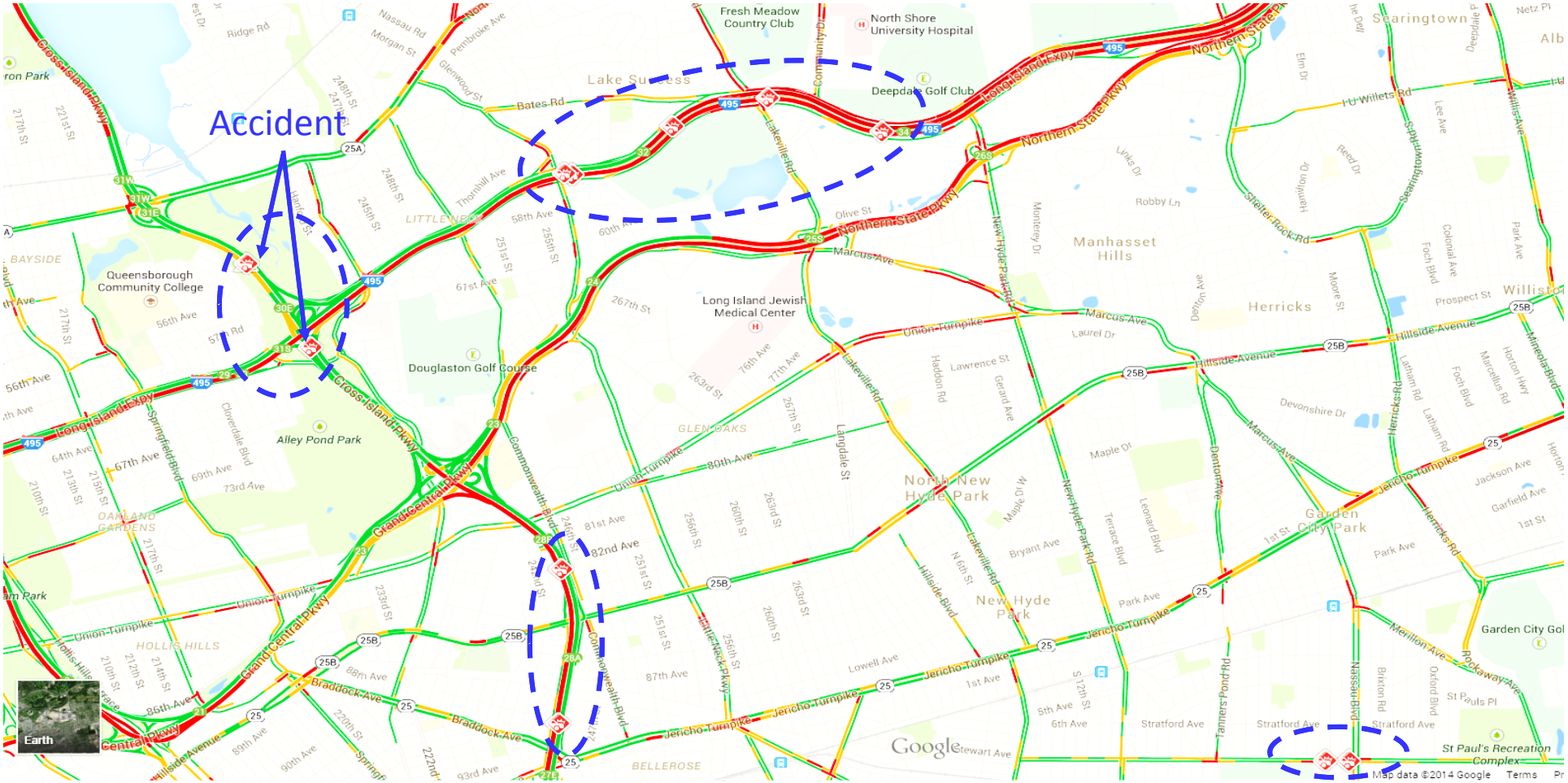
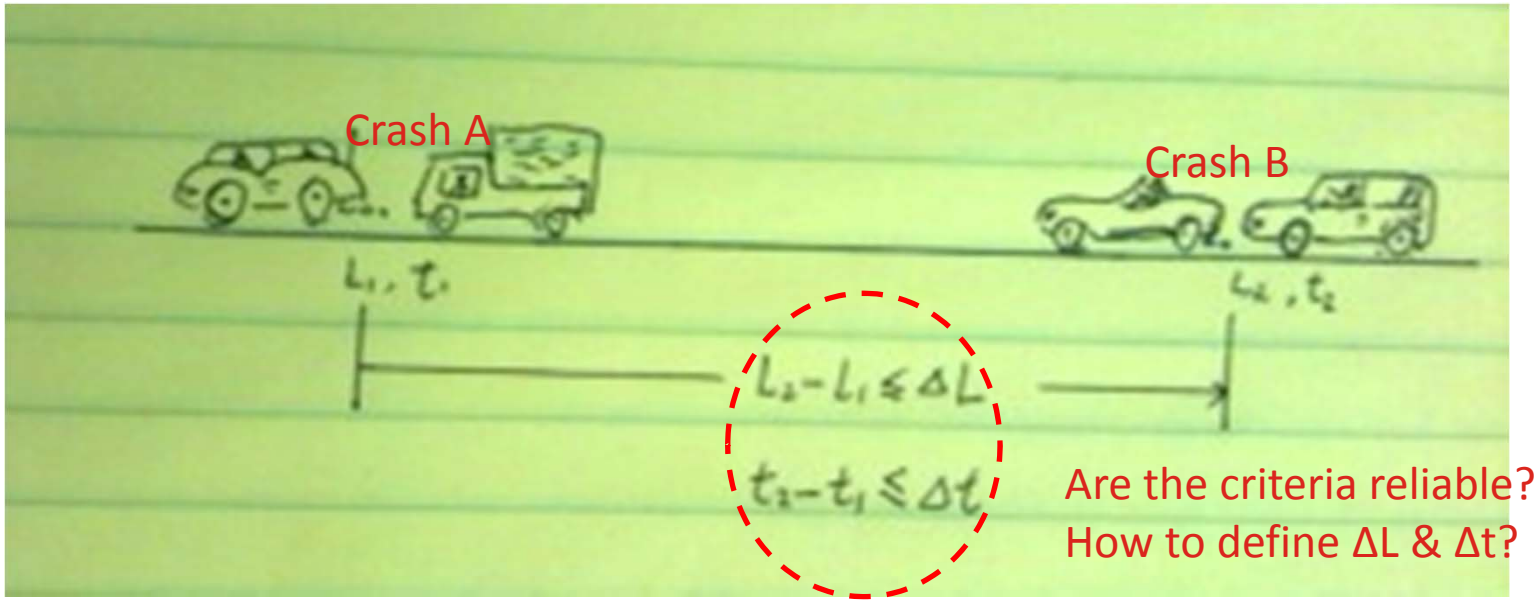


How Do We Know It Is A Secondary Crash?

- Typical procedure: to screen all crashes occurred on a given road & to denote the "nearby crashes" as secondary crashes



- Major drawbacks of the static threshold-based approaches:
  - Secondary crash can occur beyond the thresholds
  - Actual traffic conditions were not taken into account

Needs of a Reliable Approach for Identification

- A Real Example of Secondary Crash Occurred

Is it reliable for the selected static spatiotemporal threshold?

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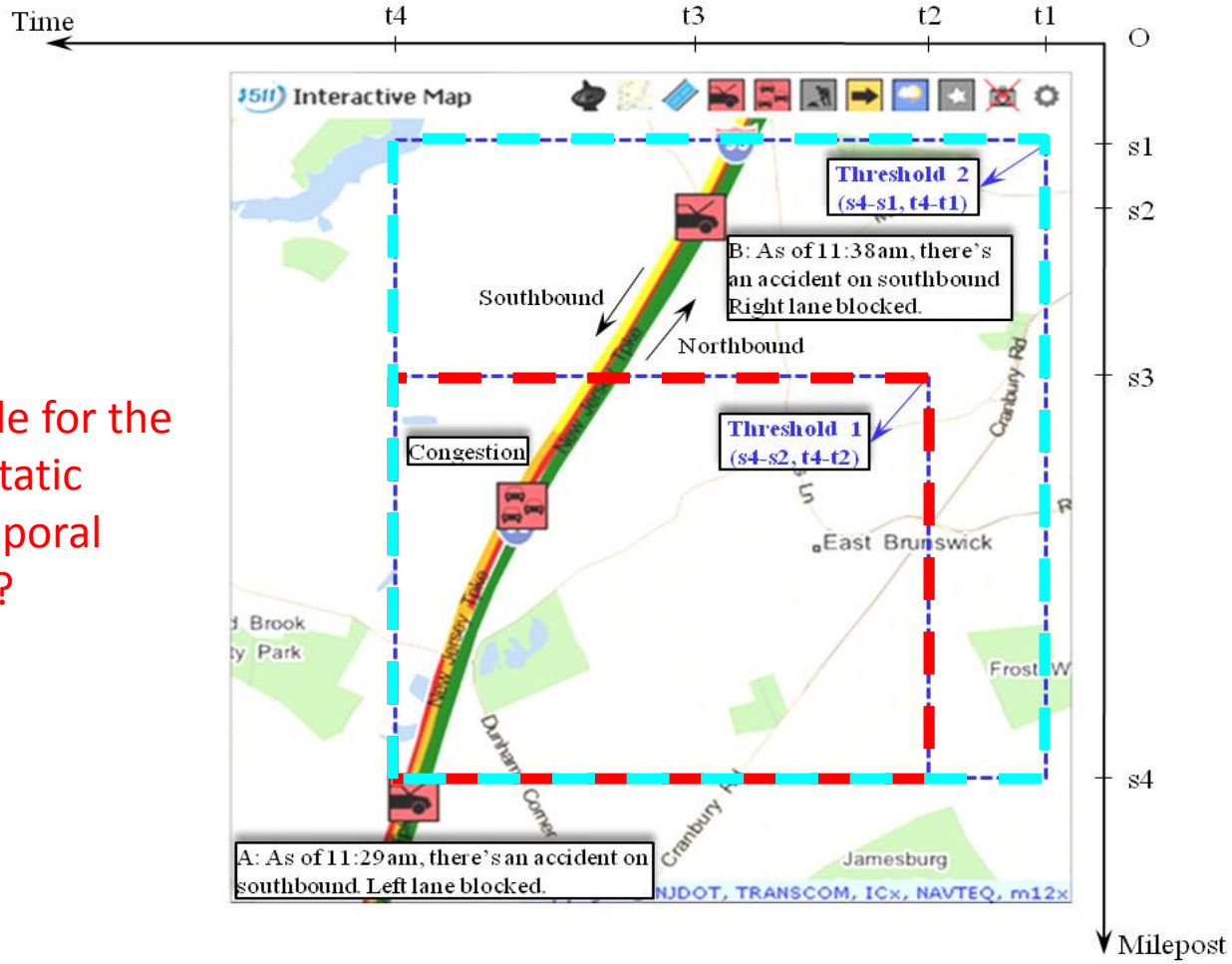
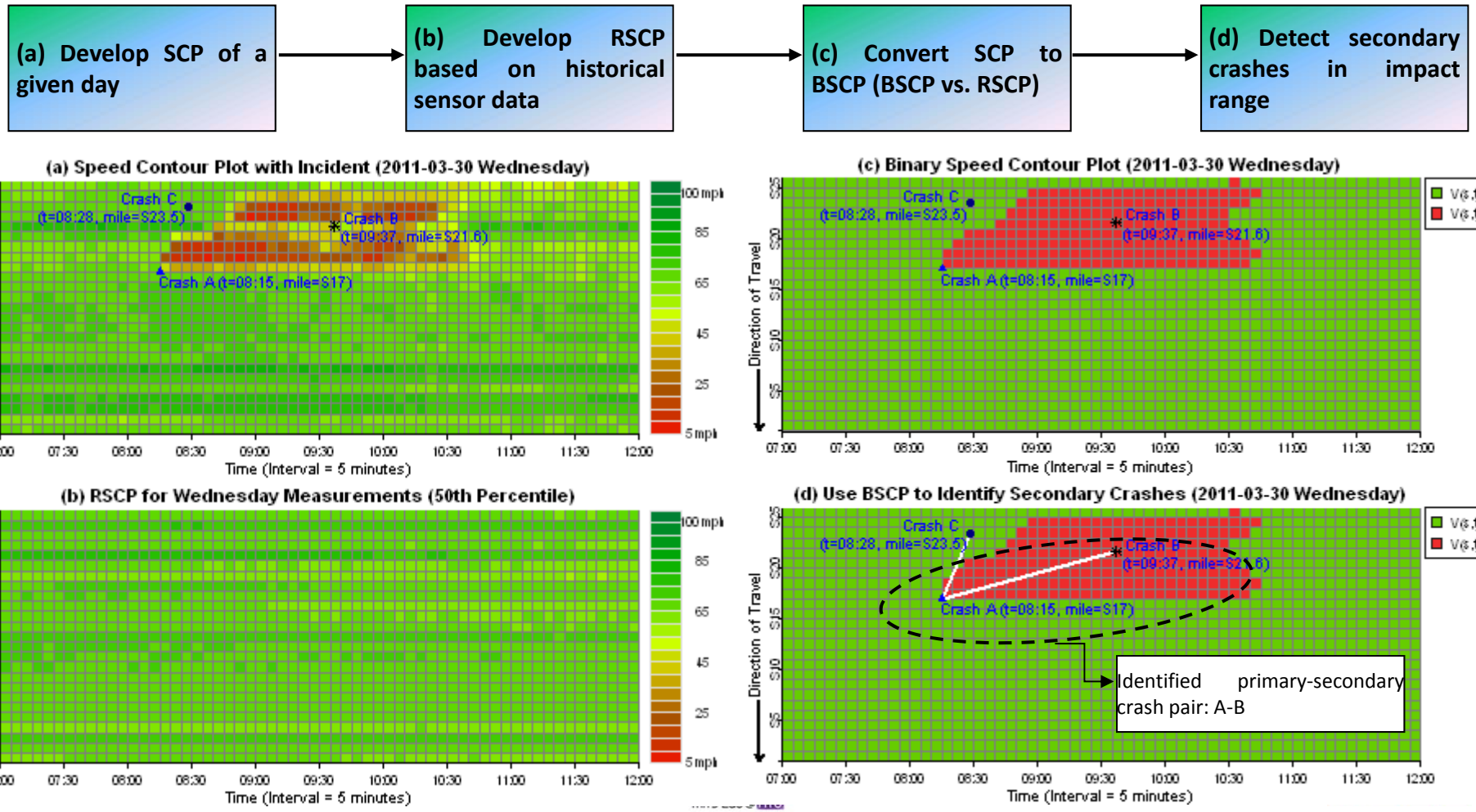


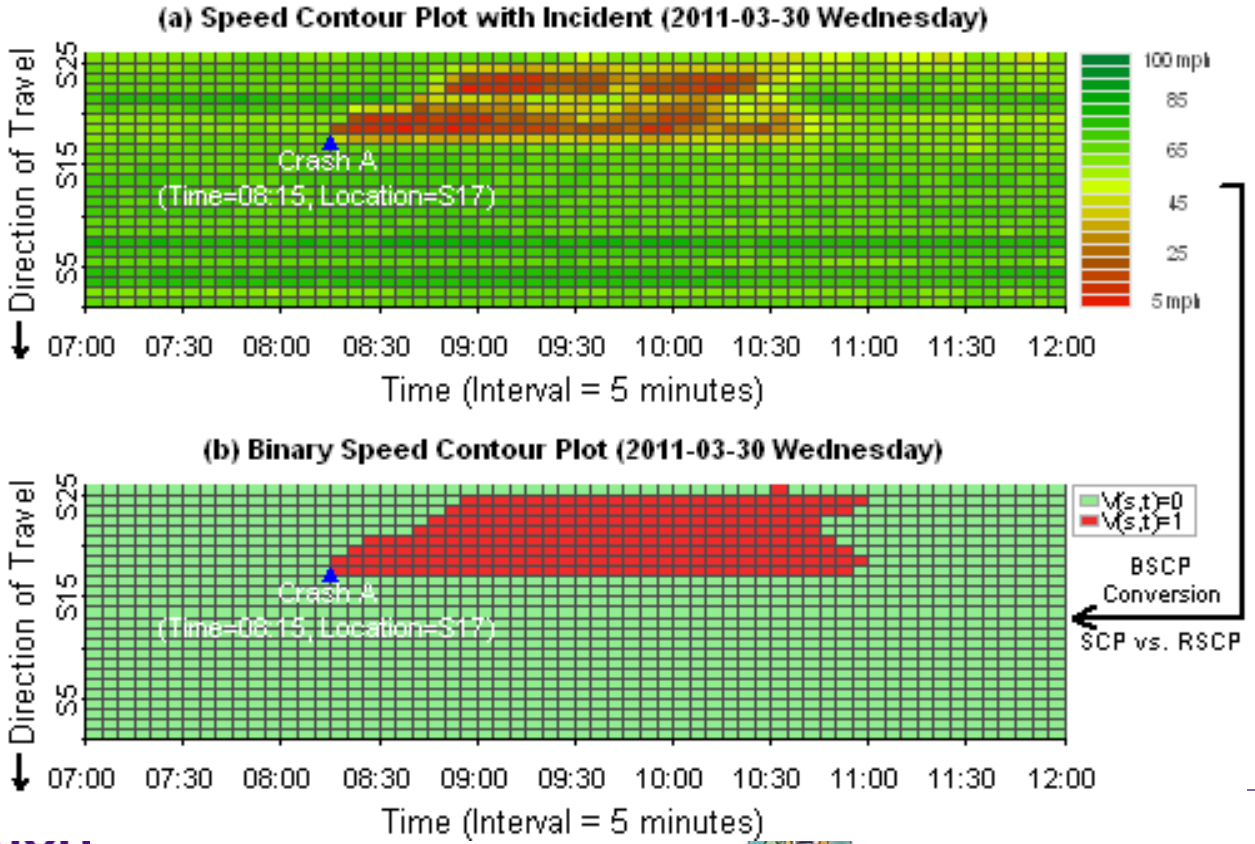
Data-Driven Identification Approach

- Identify the impact range of a prior crash by mining sensor data, and to detect secondary crashes within the impact range



Key Step: Developing Binary Speed Contour Plot

- Compare the speed measurements from SCP with the representative speed measurements from RSCP
- Obtain binary speed contour plot (BSCP) based on speed reduction



$V(t,s) < \omega \times V_{i,p}(t,s) \quad ?$

Y

N

$\hat{V}(t,s) = 1$

$\hat{V}(t,s) = 0$

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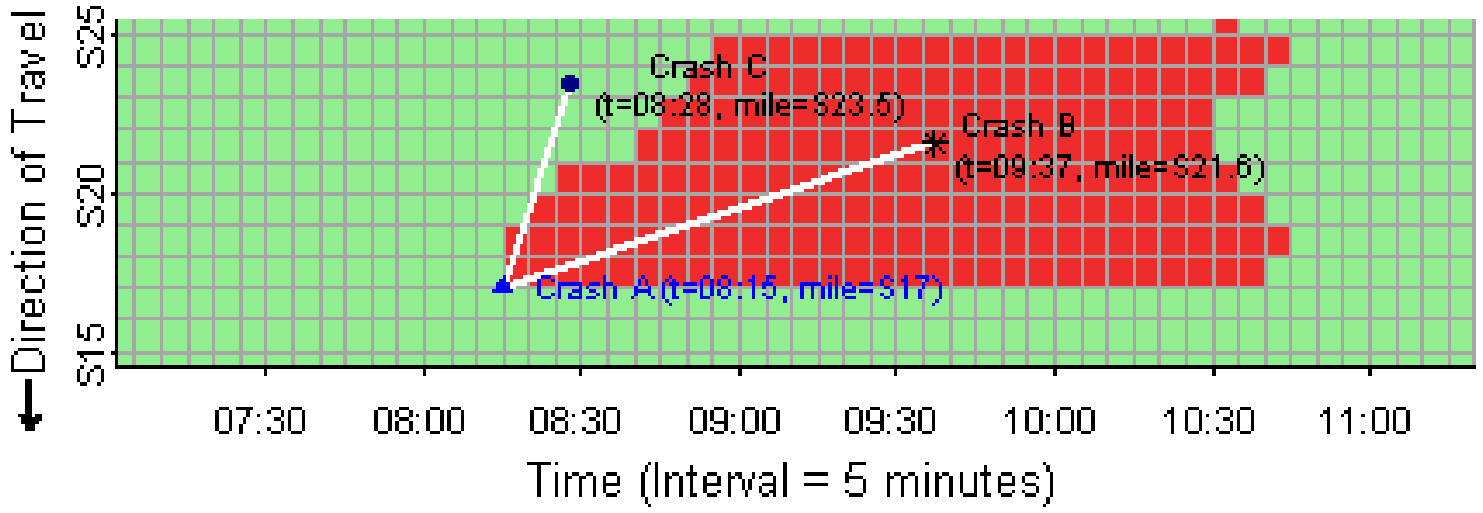
Key Step: Identifying Secondary Crashes

- It is time consuming to identify secondary crashes visually
- We have developed an algorithm to automatically identify the potential secondary “crash B”
  - ❖ Estimate the Equation of a Straight Line between a Pair of Crashes

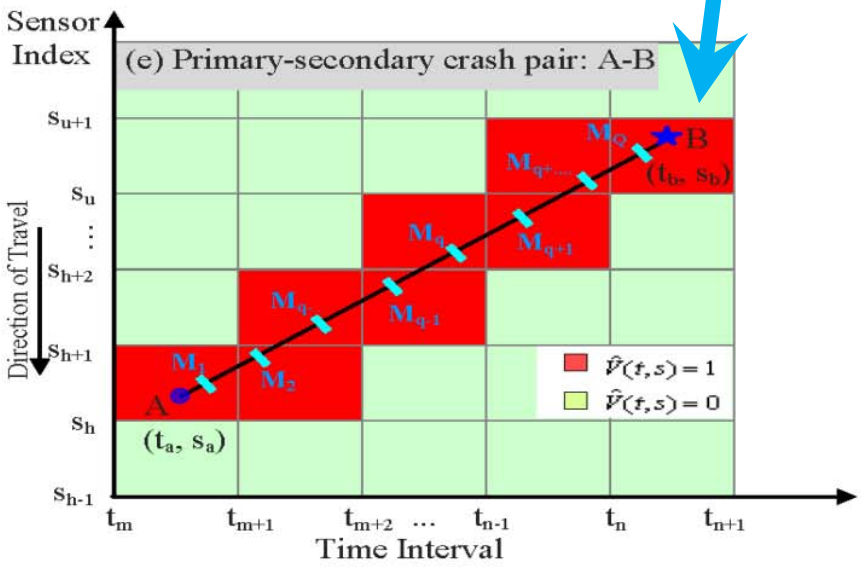
Line AB: $s_x = \frac{(s_B - s_A)}{(t_B - t_A)} \times (t_x - t_A) + s_A$ Line AC: $s_x = \frac{(s_C - s_A)}{(t_C - t_A)} \times (t_x - t_A) + s_A$



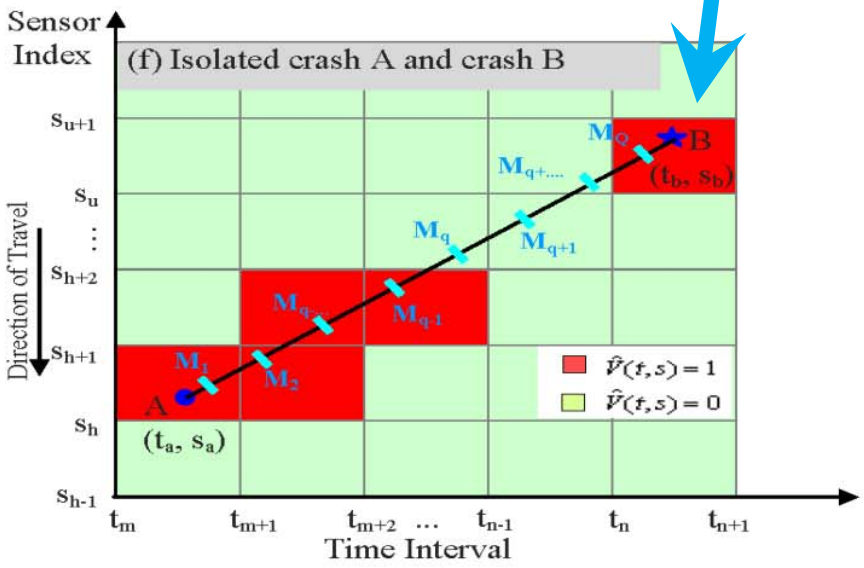
Key Step: Identifying Secondary Crashes

- If a part of the line is not located in the impact range of the prior incident, we have $\sum_{q=1}^{Q} \hat{V}_q(t_R, s_L) < Q$
- Alternatively, the later crash is not affected by the prior one if a portion of the line is out of the impact range

Identified Secondary crash

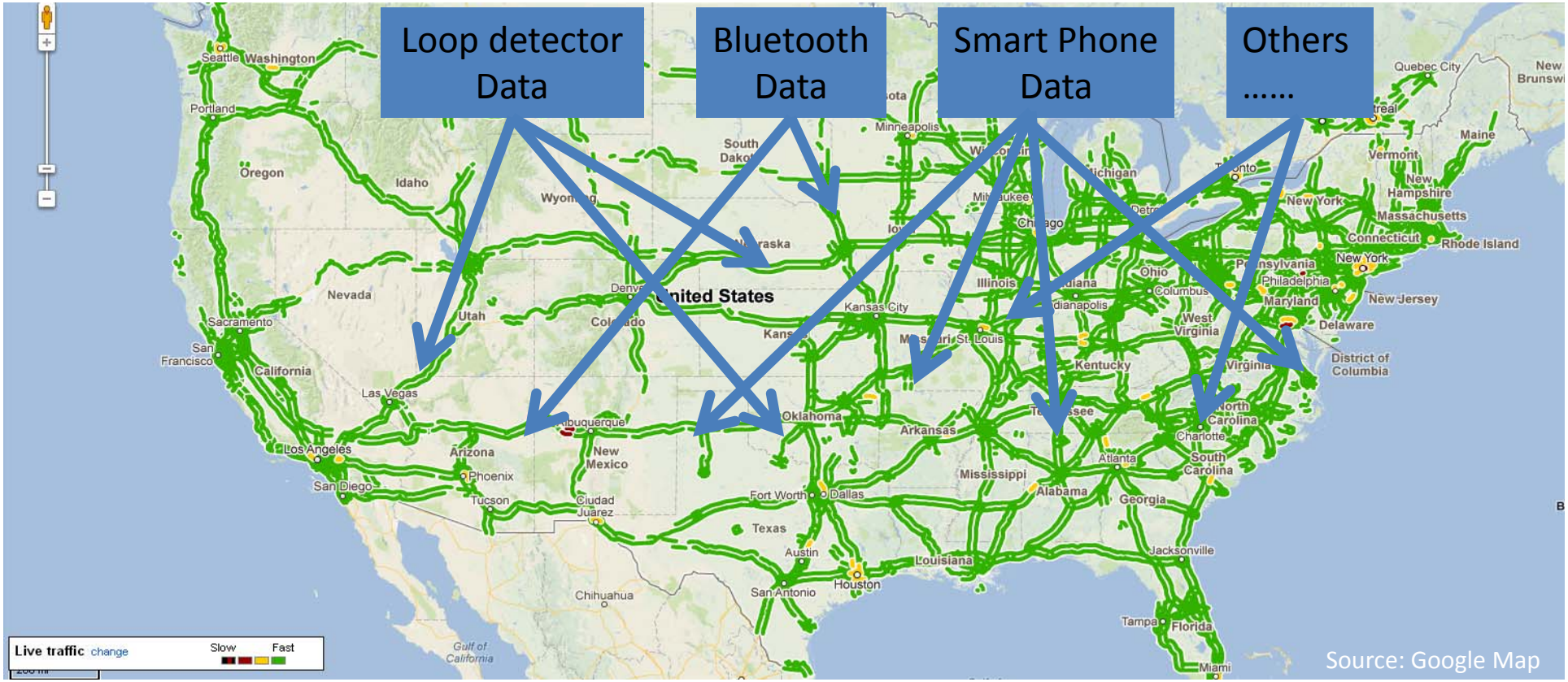


Non-Secondary crash



Massive Private Sector Traffic Data

- Not all highways are instrumented with detectors
- Massive Private sector traffic data are available now

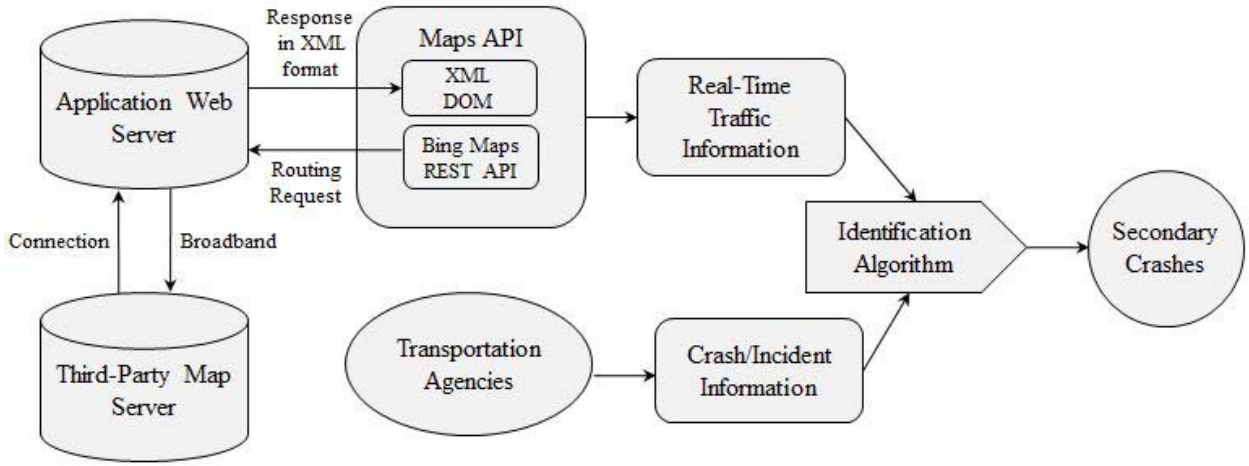


- Can we use these data for identifying secondary crashes?

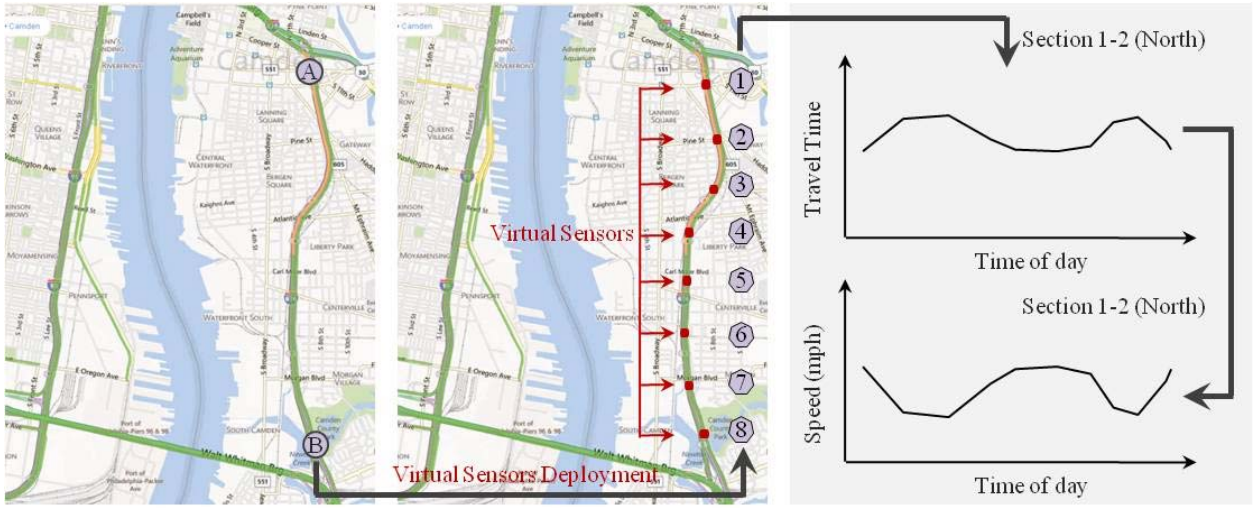
Large-Scale Online Identification Approach

- Virtual Sensor Data for Identifying Secondary Crashes

Framework

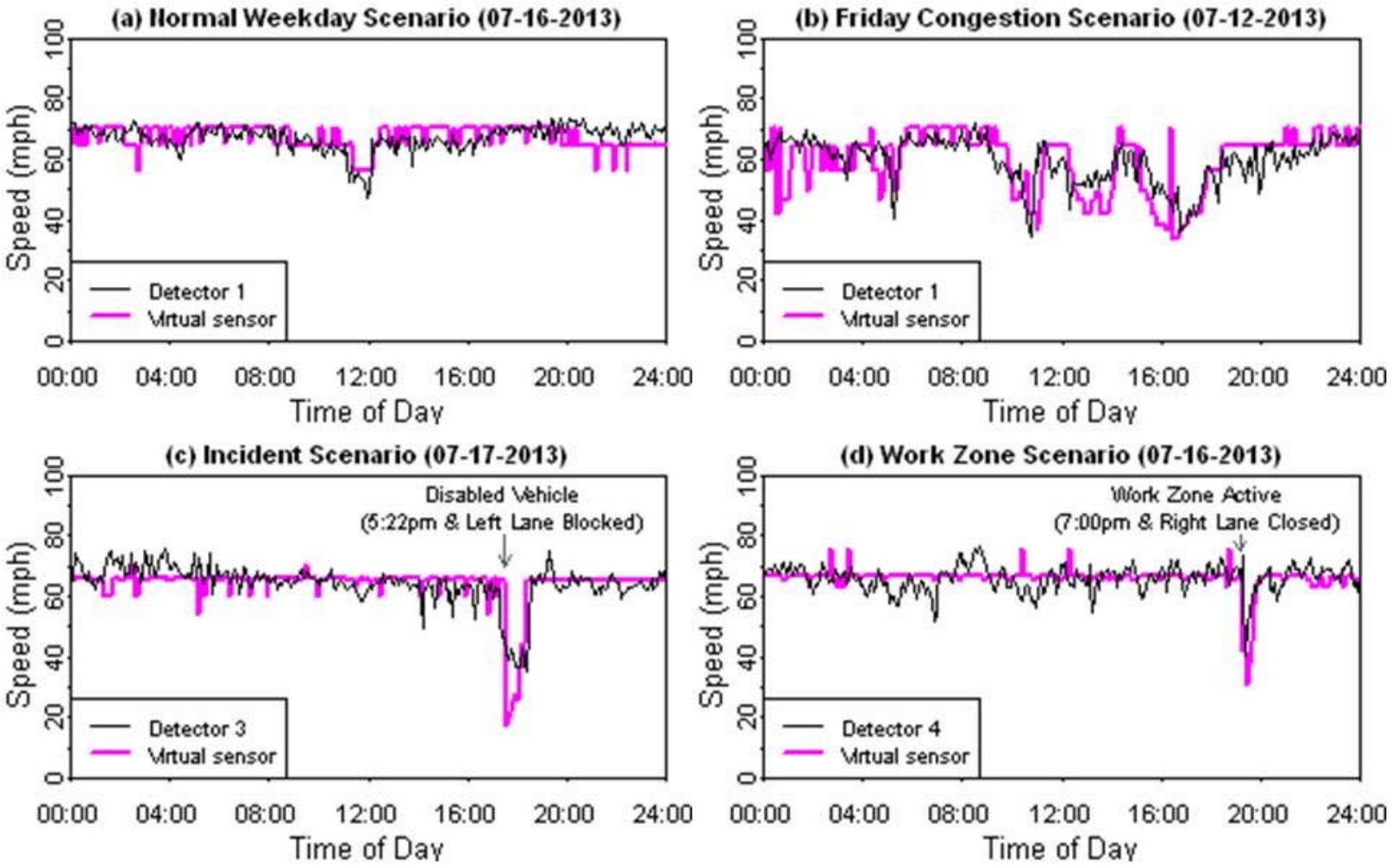


Implementation



Validation of Virtual Sensor Data

- Comparisons between Virtual Sensor data and RTMS data



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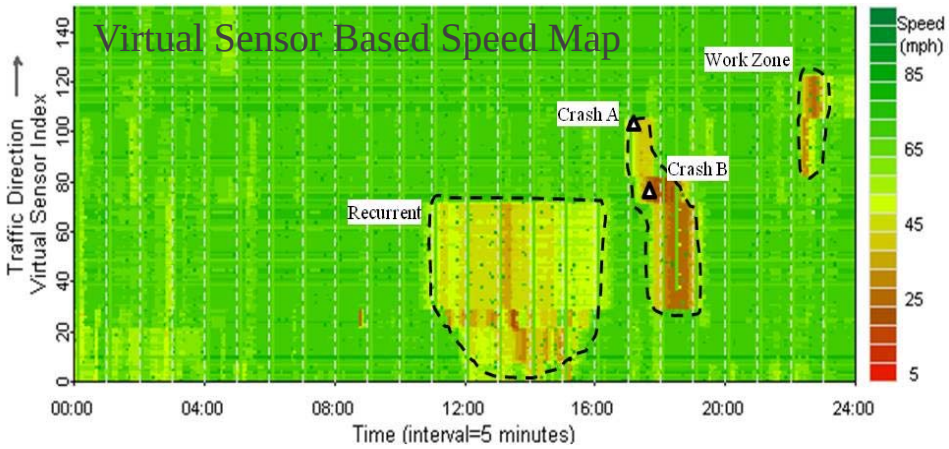
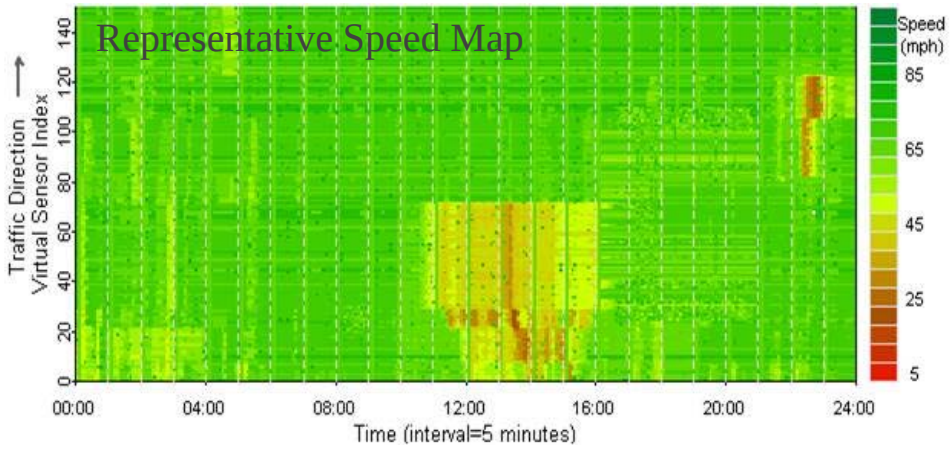
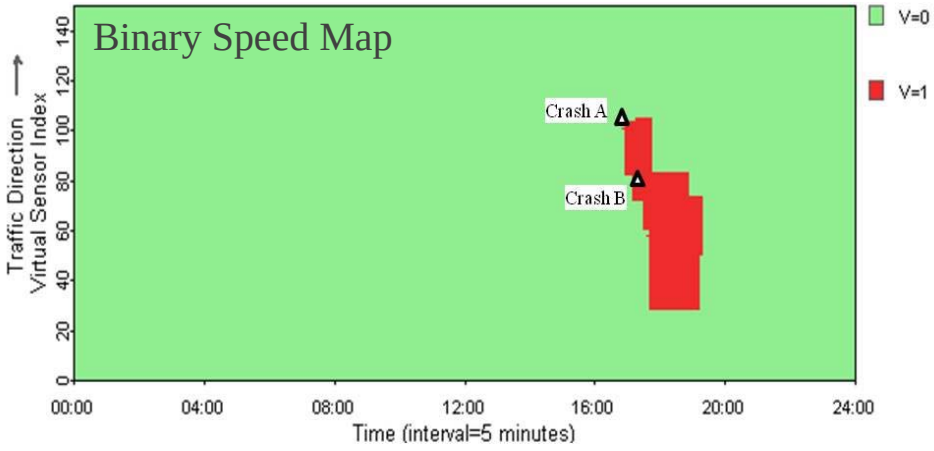
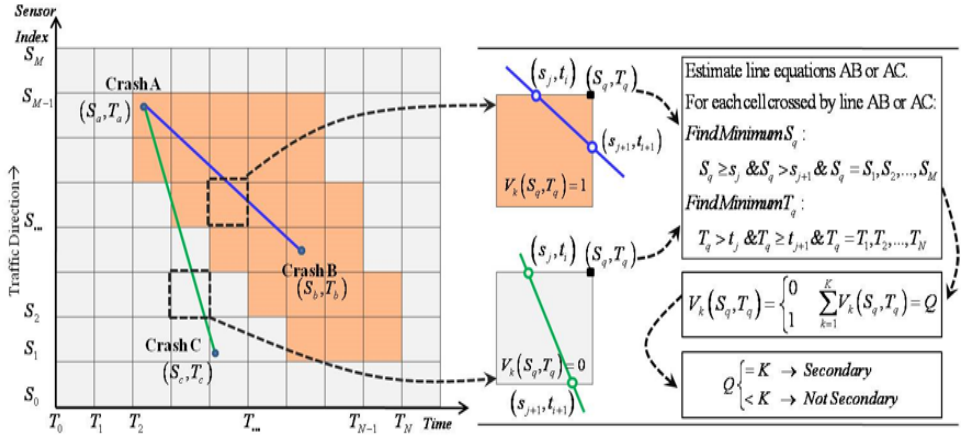
Online Identification of Secondary Crashes

- Sensor data-based method can be extend to deploy online identification with the use of virtual sensor data





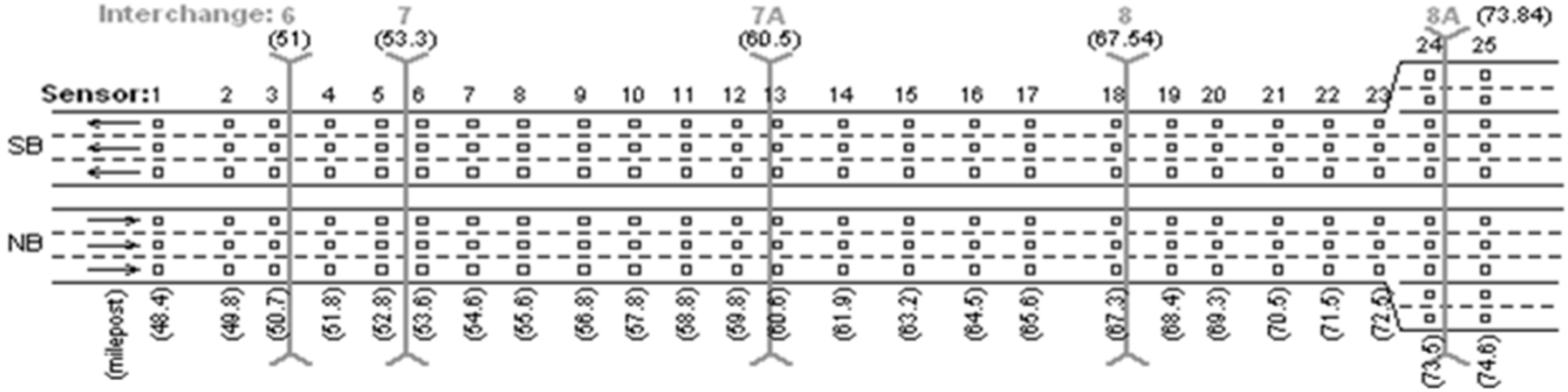




Identification Algorithm

A Case Study

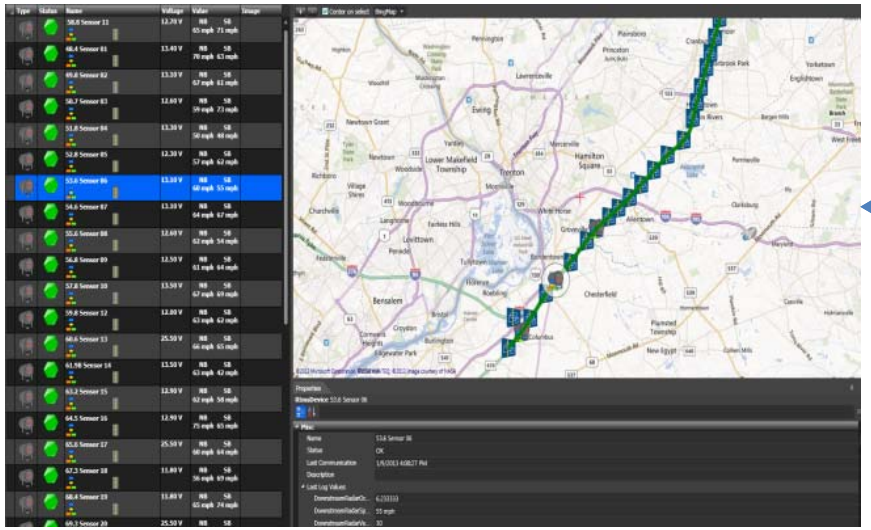
- A 27-mile section of the New Jersey Turnpike (NJTPK) between interchanges 5 and 9 was used as a case study



2011 Crash Data & RTMS Data

--In total, 1,188 crashes were examined

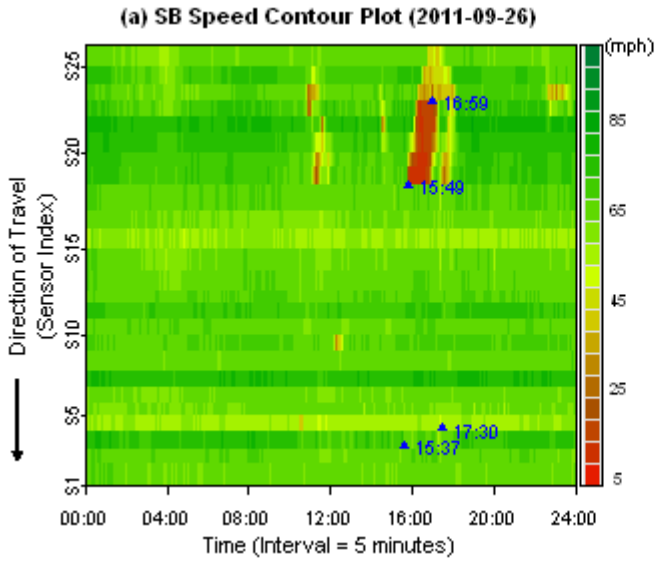
--Sensor speed data were aggregated in 5-min interval (Flow, Speed & Density)

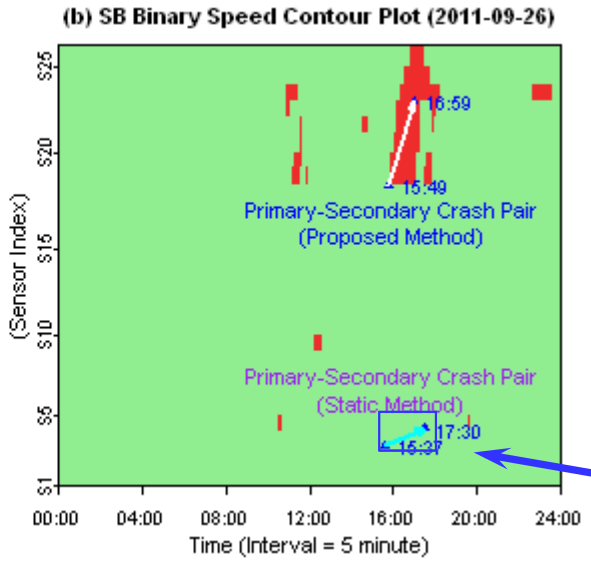


Traffic Monitor System

Secondary Crash Identification Results

- Demonstration of the Identified Secondary Crashes

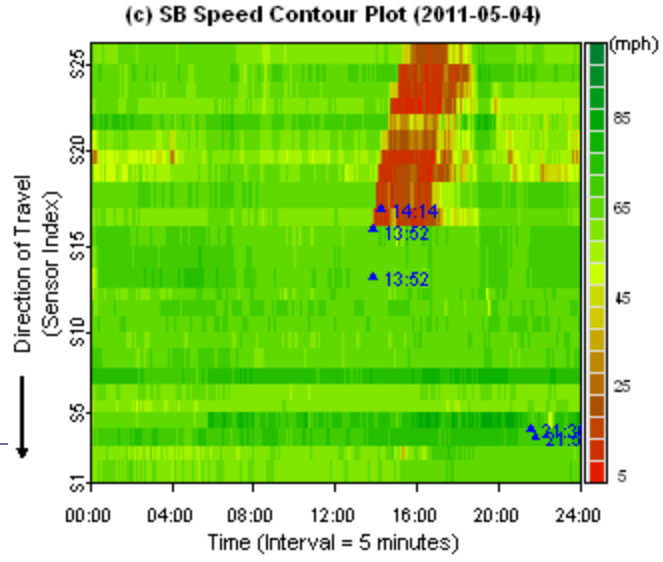


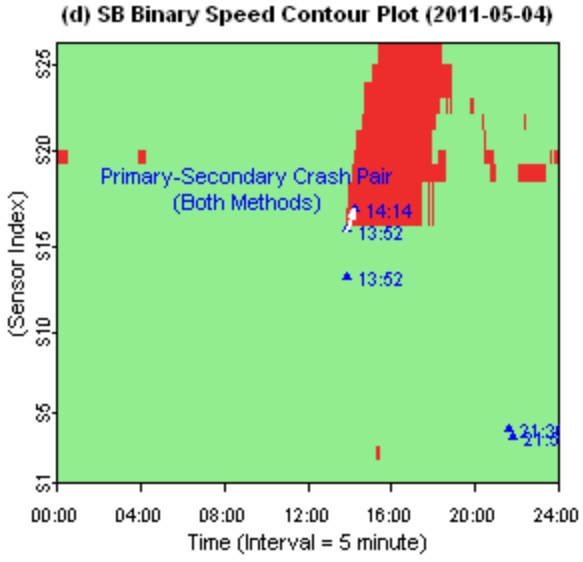


71 primary crashes were found to induce 100 secondary crashes (note: one primary crash may cause multiple secondary crashes).

Misclassification by static method

The proposed method reduces incorrect classifications &captures secondary crashes missed by traditional static methods.





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Summary

- A new approach using of sensor data for identifying secondary crashes was proposed.

- An extension of the work further developed a large-scale online approach using the virtual sensor data for identifying crashes on highways without instrumented detectors was developed.

- The proposed approaches provide a better way to identify secondary crashes, which offers the basis of further understanding the characteristics and modeling the risk of secondary crashes.

References

- This presentation summarizes of the work presented in our studies on secondary crashes:
  - Yang, H., Bartin, B. ,Ozbay, K. (2013). *Use of Sensor Data to Identify Secondary Crashes on Freeways.* Transportation Research Record: Journal of the Transportation Research Board, No. 2396, pp. 82-92.
  - Yang, H., Bartin, B., Ozbay, K. (2013). *Investigating the Characteristics of Secondary Crashes on Freeways.* Transportation Research Board's 92nd Annual Meeting, CD-ROM, Washington, D.C., 2013 (TRB13-4866).
  - Yang, H., Bartin, B., Ozbay, K. (2014). *Mining the Characteristics of Secondary Crashes on Highways.* Journal of Transportation Engineering, 140(4), 04013024.
  - Yang, H., Ozbay, K., Xie, K. (2014). *Assessing the Risk of Secondary Crashes on Highways.* Journal of Safety Research, Vol. 49, pp. 143–149.
  - Yang, H., Ozbay, K., Morgul, E.F., Bartin, B., Xie, K. (2014). *Development of an On-line Scalable Approach for Identifying Secondary Crashes.* Transportation Research Record: Journal of the Transportation Research Board, TRB14-1689, in press).

Thank you very much for your time!

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