Development of a Data-Driven Approach for ID Secondary Crashes

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Nov. 2014
A Real-World Challenge

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

10/28/2014 5:20 PM @ NY
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.

![Diagram showing two crashes and the distance between them, with the criteria for secondary crash definition highlighted.]

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

\[ L_2 - L_1 \leq \Delta L \]  
\[ t_2 - t_1 \leq \Delta t \]
Needs of a Reliable Approach for Identification

- A Real Example of Secondary Crash Occurred

Is it reliable for the selected static spatiotemporal threshold?
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

(a) Develop SCP of a given day
(b) Develop RSCP based on historical sensor data
(c) Convert SCP to BSCP (BSCP vs. RSCP)
(d) Detect secondary crashes in 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
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

\[
\begin{align*}
    & s_X = \frac{(x_B - x_A)}{(t_B - t_A)} \times (t_X - t_A) + s_A \\
    & s_X = \frac{(x_C - x_A)}{(t_C - t_A)} \times (t_X - t_A) + s_A
\end{align*}
\]
Key Step: Identifying Secondary Crashes

- If a part of the line is not located in the impact range of the prior incident, we have $\sum_{q=1}^{Q} \hat{\gamma}_q(t_a, t_b) < 0$
- Alternatively, the later crash is not affected by the prior one if a portion of the line is out of the impact range
Massive Private Sector Traffic Data

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

Loop detector Data
Bluetooth Data
Smart Phone Data
Others ......

• Can we use these data for identifying secondary crashes?
Large-Scale Online Identification Approach

- Virtual Sensor Data for Identifying Secondary Crashes
Validation of Virtual Sensor Data

- Comparisons between Virtual Sensor data and RTMS data
Online Identification of Secondary Crashes

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

The proposed method reduces incorrect classifications & captures secondary crashes missed by traditional static methods.
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:
  
  
  
  
  
Thank you very much for your time!

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