Inference of road traffic congestion from sensor events

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Background

• UK Department for Transport - *T-TRIG* grant
• Aim - make better use of road sensor data
  • Currently historic reporting on the state of strategic routes
  • Quasi real-time?
• Inspired by Rude and Beard (2012) - “High level event detection in spatially distributed time series”
  • Can high level events be detected from low level, primitive events?
    • Traffic congestion
    • Storms
Identifying primitive events from a sensor

parameter

Initiating event

Body event

Terminating event

time
Major event

- Sensor for parameter A
- Sensor for parameter B
- Rate of change and its direction
Our use case

• **Rude and Beard**
  • Two indicators of congestion
    • Vehicle speed
    • Vehicle density (no. vehicles / km / lane)
  • Simulated
• **Etihad football stadium, Manchester, UK, January 13th 2016**
• **Data Sources**
  • Journey times on links
    • Bluetooth sensors on traffic lights
  • Vehicle counts at points
    • Induction loops buried in road
    • Indirection indicator
• **Non-recurrent congestion**
Bluetooth sensors used

City Centre
Example Journey Time sensor pair
Abnormal journey times - towards stadium
Abnormal journey times - detail

13th January

19:45  21:35

‘typical’ days
Sample volume sensors

City Centre

Etihad Stadium
City Centre

Sample volume sensors
Volume - site: 1095 - West 2016-01-13

Example volume - towards stadium
Example volume - away from stadium
Identifying primitive events

Parameter

Initiating event

Body event

Terminating event

time

Journey time

Exceptional Sequence

- study day data - exceptional value
- study day data - un-exceptional value

1 s.d. above mean of typical days

Sequence = 3 or more consecutive points outside 1 s.d.
Identifying clusters of primitive events

Spatio-temporal clustering (Birant & Kut, 2007)
Limitations

• Identifying sequences
  • No quasi real time
  • Need to know earlier

• No directions

• Generalised links as points (mid-points)

• Want *formalisation* not visualisation
  • not going to keep checking a map when driving.
Context

• What does “Journey time of 102 seconds on the link between X and Y in the SE direction” tell us?

• Relative values
  • Magnitude
  • Location
  • Direction

• Reclassified
  • Journey time - very low, low, normal, high, very high in relation to typical days
  • Location - very near, near, far - in relation to stadium
  • Direction - towards, away from, neutral - in relation to stadium
Classifying journey time magnitudes

Mean of journey time readings on ‘typical’ days for this link at this time slot

- 2 standard deviations below mean
- 1 standard deviation below mean
- None
- 1 standard deviation above mean
- 2 standard deviations above mean

Journey time magnitude:

- Very low
- Low
- None
- None
- High
- Very high
Processing in R

• Using DAISY generate dissimilarity matrix
  • magnitude, direction, location

• Using AGNES generate hierarchical clusters for each 10 minute time slot

• Kaufmann and Rousseeuw, 2005
Abnormal journey time clusters 15-5 minutes before kick off
Abnormal journey time clusters 15-25 minutes after full time
Next steps...

• To respond to congestion we need...
• ... *diagnosis*
• Cause and characteristics of congestion *(Lécué et al. 2012)*
• Report on current state of network is not enough
  • “*Congestion caused by football match that will start in 5 minutes*” is better
• We need context of congestion
• Context is part of the semantics of a domain
• Semantics can be encapsulated in an ontology *(Kavouras & Kokla, 2008)*.
Defining a football match

• Extend the *Transport Disruption* ontology (Corsar et al. 2015)

- EventBrite API (Lécué et al. 2012)
- Greater Manchester Road Activities Permit Scheme (GMRAPS)
Next steps... other events

Unpredictable
Next steps... other events

Unpredictable?
Next steps... sink hole in Mancunian way

- Location?
- Direction?
Summary

• Semantic approach - productive
  • Favoured by TfGM
    • “richer descriptions”
  • Cross system
    • “High journey times” in Tokyo is different from “high journey times” in Manchester
• Allows for diagnosis?
Acknowledgements

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References


