DATA 61

Traffic Flow Modelling with Point Processes

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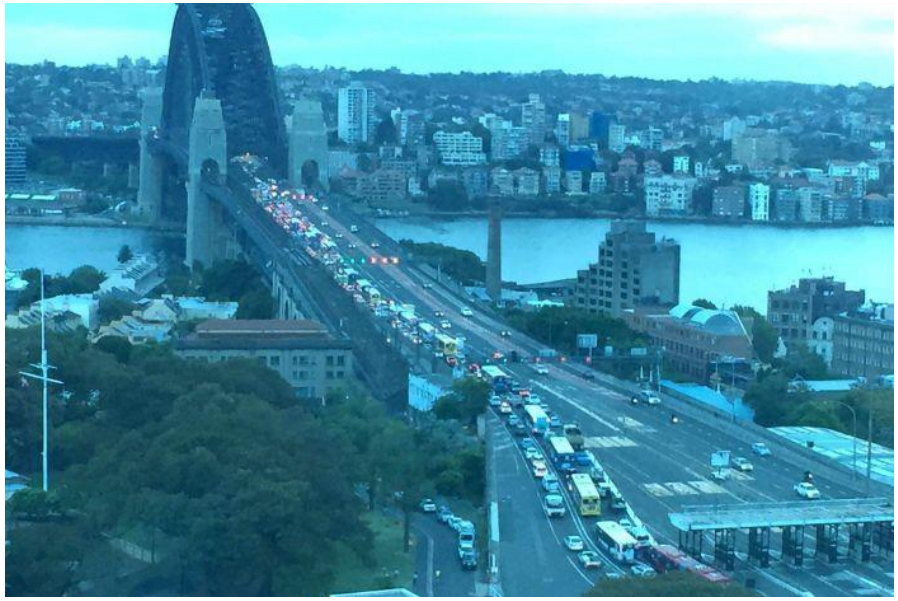
Why Model Traffic Flow?

Congestion in Sydney

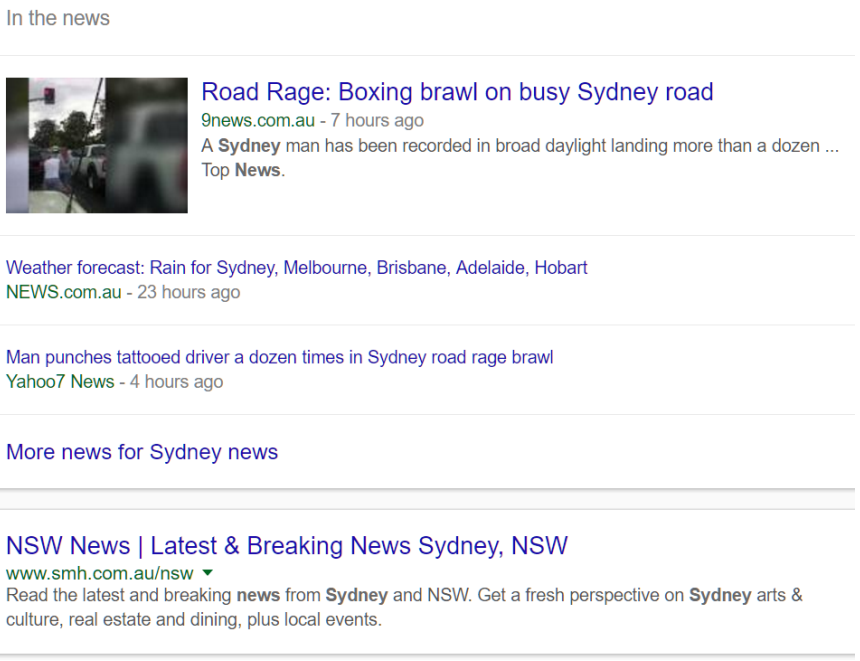
- Economic Cost
  - Congestion costs Sydney $4.6 billion a year.
- Business Impact
  - Lost productivity, higher operational cost, and lower business attractiveness.



How we Model Traffic Flow?

Modelling with Point Processes

- A point process models a series of events (e.g. traffic flow) that can be treated as a point in time (and space).
- Can capture the clustering effect of events (one excites another).
- We model the occurrence of traffic flows as modulated by external events such as news and tweets.



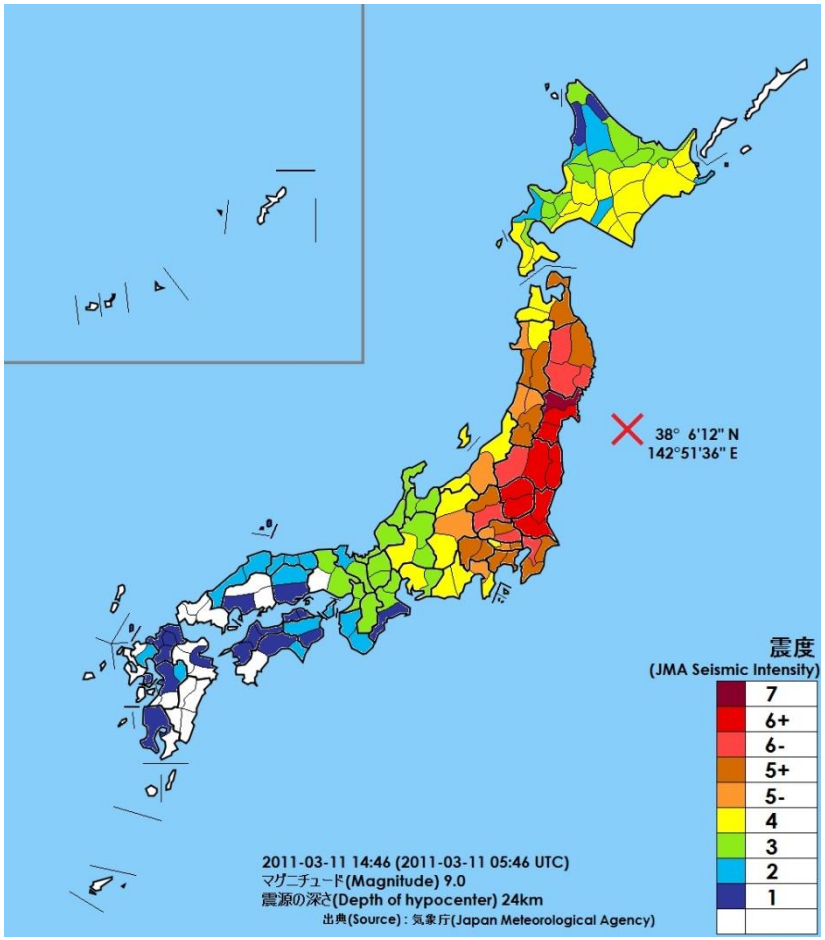
Point Process – Overview

Intensity Function

- Describes the rate of occurrence of an event.
- The higher the intensity at one point, the higher the chance of seeing an event at that point.
- We let the intensity of traffic flow to be 'excited' by an external event (such as news).

$$\lambda_t = a + \sum_{j=1}^{J_t} X_j \, e^{-\delta(t-s_j)}$$

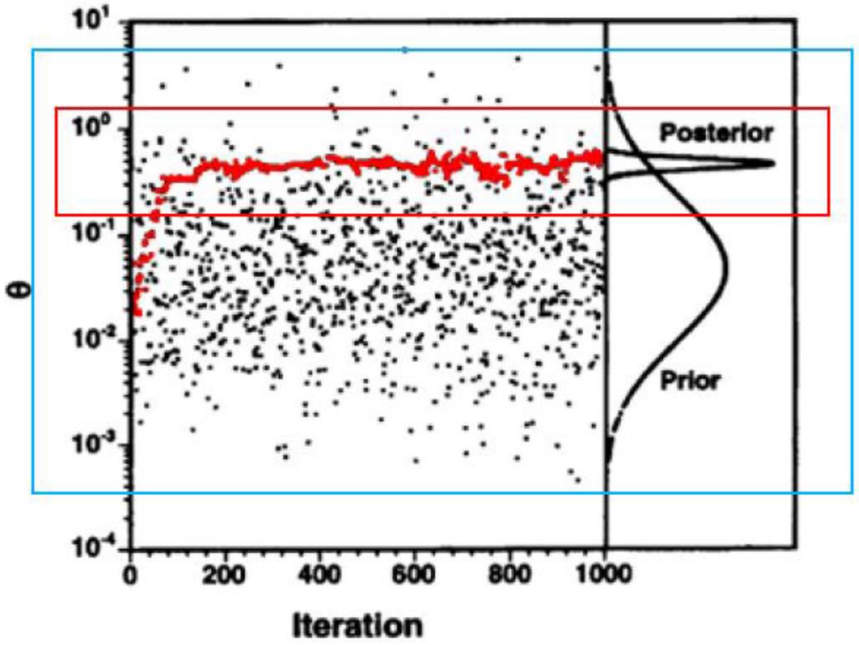
- (our intensity is a function over time)



Learning the Intensity Function

Bayesian Inference

- A hybrid of Markov chain Monte Carlo methods.
  - Gibbs samplers.
  - Metropolis-Hastings algorithm.
- Find the posteriors of the parameters - i.e. what is the most probable given data and also prior information.
- Posterior = Likelihood x Prior



$$\mathbf{P}(a, \mu, \delta, \alpha, \beta, \mathbf{X} \,|\, \mathbf{t}, \mathbf{s}) \propto \mathbf{P}(\mathbf{t}, \mathbf{s} \,|\, a, \delta, \mathbf{X})\, \mathbf{P}(a, \mu, \delta, \alpha, \beta)$$

Getting the Data

Traffic Flow Data

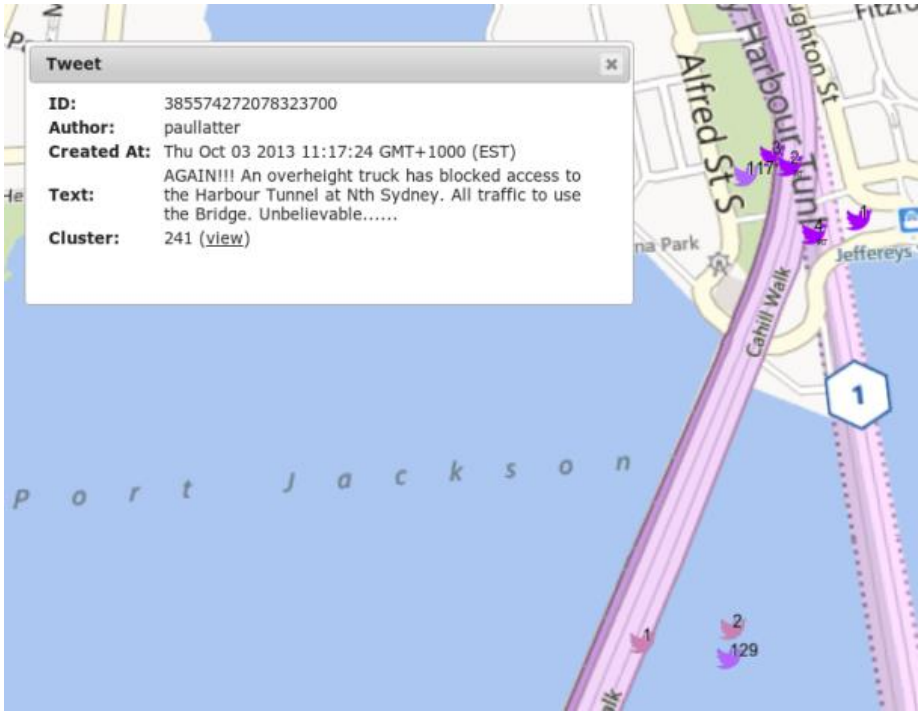
SCATS - Intelligent Traffic Management

- Data from SCATS (Sydney Coordinated Adaptive Traffic System).
- Vehicles passing through intersections are observed by detectors (numbered in figure).
- We process the data and treat each vehicle passing as an ‘event’ for the point process.

Tweets on Traffic

Traffic Watch

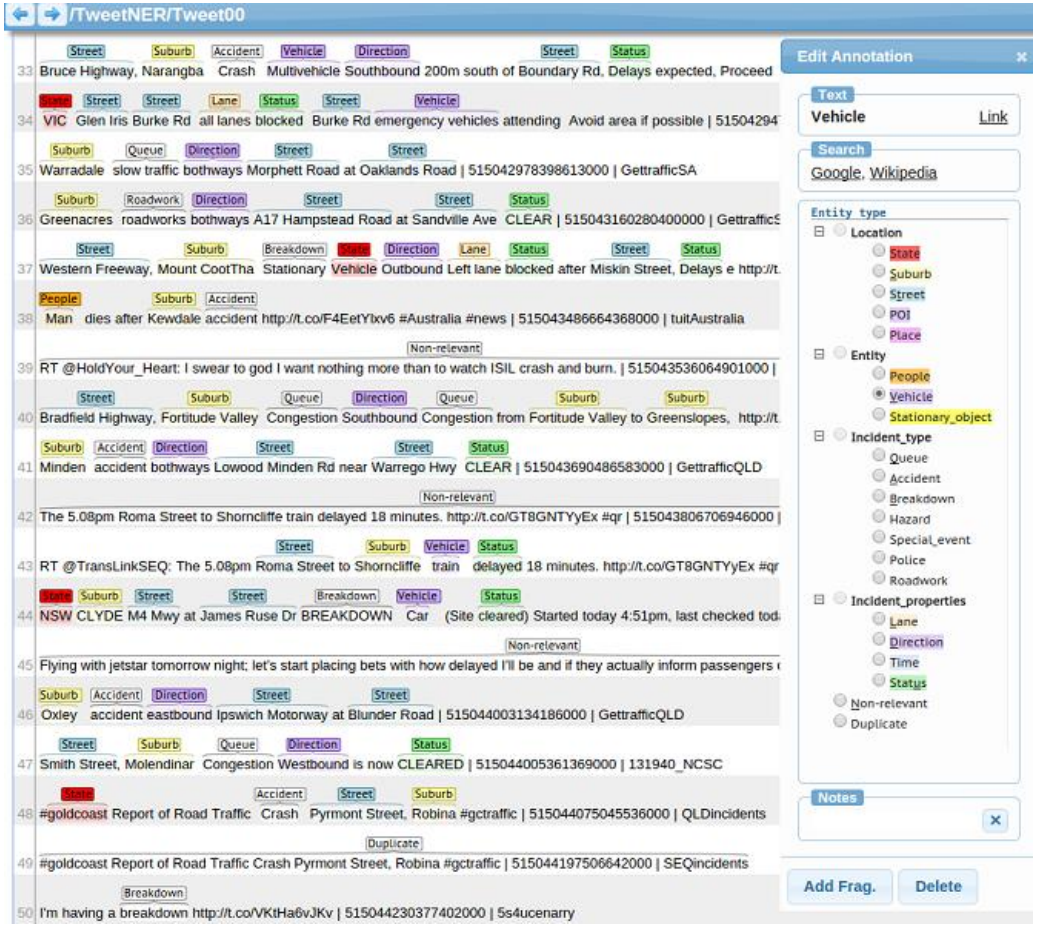
- Tweets are collected and are categorised to be traffic related or not using the Traffic Watch system.
- Traffic related tweets are treated as ‘external events’ for the point process.



Traffic Watch Annotation System

More Examples

- Name entity recognition (NER) is used to detect type of roads and the parties involved.
- SVM classifier is used to determine whether a tweet is relevant to traffic or not.

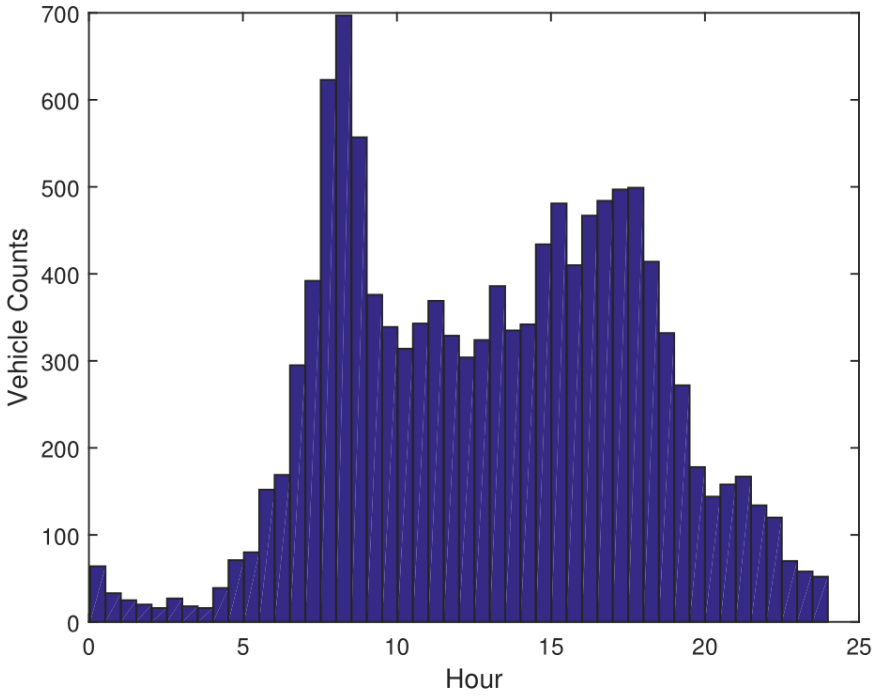


Some Results

Sydney Traffic Flow

Traffic Flow Data (from SCATS)

- Traffic flow on south of NSW, far away from city, on 30th March 2015.
- About 12k events observed.
- Histogram shows that the traffic flow volume is not uniform through time.



Modelling Results

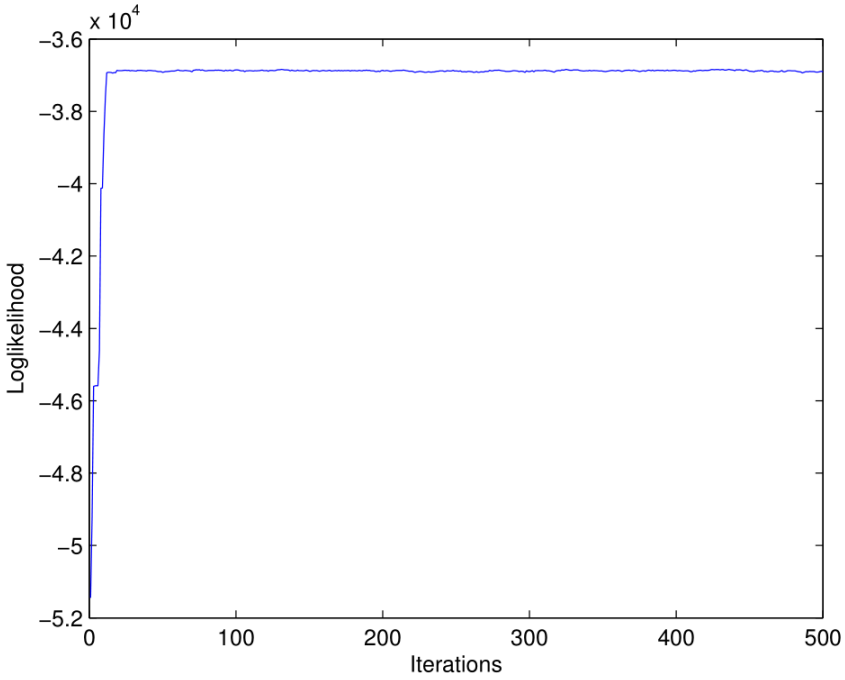
Parameters Learning

- Learned parameter values:

$$\hat{a} = 0.1440 \qquad \hat{\mu} = 0.0005$$

$$\hat{\delta} = 3.0334 \qquad \hat{\beta} = 3.4104$$

- What does this mean?
  - We expect on average 0.144 vehicle per second, or about 9 vehicles per minute.
  - Each tweet generates an expected number of 0.09666 vehicle.

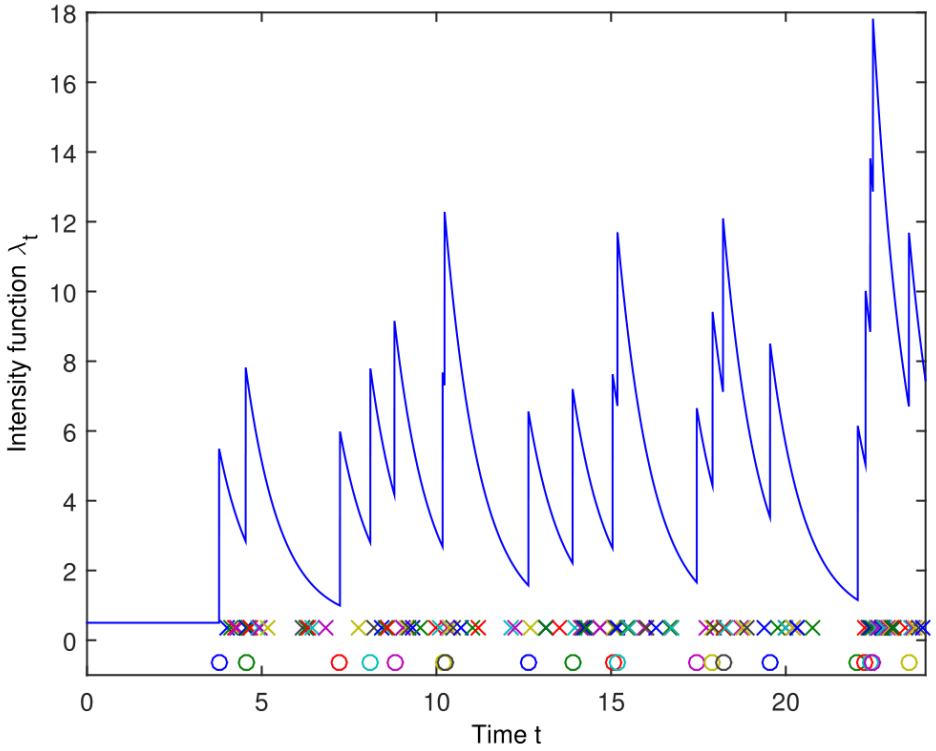


Loglikelihood Trace – algorithm converged quickly

Simulations of Traffic Flow

Using Learned Parameter Results

- The learned parameters are used to forecast and predict future traffic flows in Sydney.
- A simulation example is shown on the right.
  - Circles are external events that ‘excite’ traffic flows.
  - Crosses are traffic flow ‘events’.
  - Each occurrence of external events triggers an increase of ‘intensity’ which in turn leads to traffic flows.



Our Aims

Intelligent Transport System

- To incorporate traffic flow modelling for intelligent transport system as part of smart cities management.
- Smart planning and optimisation to reduce economic cost and business impact from congestion.
- To lower stress in drivers and pedestrians caused by traffic conditions.

Future Work

Improving Traffic Flow Modelling

- Incorporate other type of event data:
  - Calendar events, e.g. festivals.
- Use Natural Language Processing (NLP) to understand text and its influence.
- Stochastic excitations
  - Model the ‘excitations’ as a stochastic process – events that come first have greater influence.