Traffic dynamics: complex systems, clever solutions

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26 January 2018
Relevance

- Cost of traffic jams: €3,400 mln/jr
- Cause: traffic demand exceeds capacity
- Traffic works well up to capacity, but for higher demand, self-organisation is quite bad…. 
A lack of passion can do more harm than simple inexperience: Introduction to principles of traffic flow theory
Traffic flow theory: macroscopic view
Scales of traffic description

- Microscopic: individual level
- Macroscopic: road level
- Higher level: network level
Car-following models

- Correct simulation tools:
- Predictions for unknown roads
- Driver assistance systems, e.g. Adaptive Cruise Control (ACC), ultimately autonomous vehicles
  - What feels most natural?
  - What impact does it have
Car-following models: two components

- Free flow: how do you accelerate to your free-flow speed (and how fast is that)
- Congestion: how do you react to your predecessor?
- Often occurring problem: minimum headways are larger when coming out of congestion
Capacity = $1/(\text{min headway})$

- Traffic jams are upstream of a bottleneck:

- Capacity is determined by the minimum headway when driving out of the queue.
- Larger headways = lower capacity => capacity drop due to queue
Lane-changing

- When traffic gets busier, more people take the left lane
- Right lane under-utilized
Traffic flow theory: macroscopic view
Relationships variables

Holds for a road, but on average also for a zone!
Build up of congestion
Fitting a functional form

Homogeneous traffic situation

Inhomogeneous traffic situation
Fitting a functional form
Fitting a functional form

Different traffic conditions

![Graph showing production vs. accumulation with inhomogeneity on the x-axis and production on the y-axis.](image)
Empirical evidence
Suitable for any queuing application?
Suitable for any queuing application?

How about the Centre for Complex Systems Studies?
Challenges

1) Incidents
   => detection?
   => prevention?

2) Use of automated vehicles
   => vehicle operations?
   => network use?

3) Balancing space for target lanes (microscopic, macroscopic)
   => Multi-lane traffic (dynamically?)
   => Multi-class traffic?

4) Network control
   => Global optimum of traffic lights?
   => Agent-systems?

5) Non-vehicular modes:
   => How to influence active-mode users (pedestrians, cyclists?)
   => combine with public transport
      (scheduling, interactions with car traffic (desired?))