Categorizing merging and diverging strategies of truck drivers using a trajectory dataset

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ToGRIP GRIP on Freight Trips

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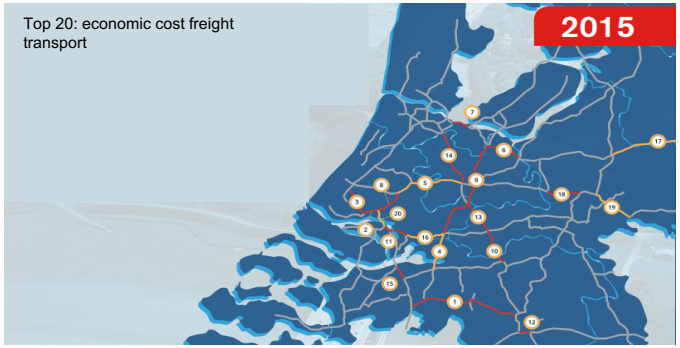
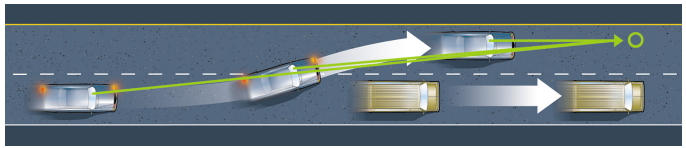
Introduction



(Source: TLN, EVO, TNO)

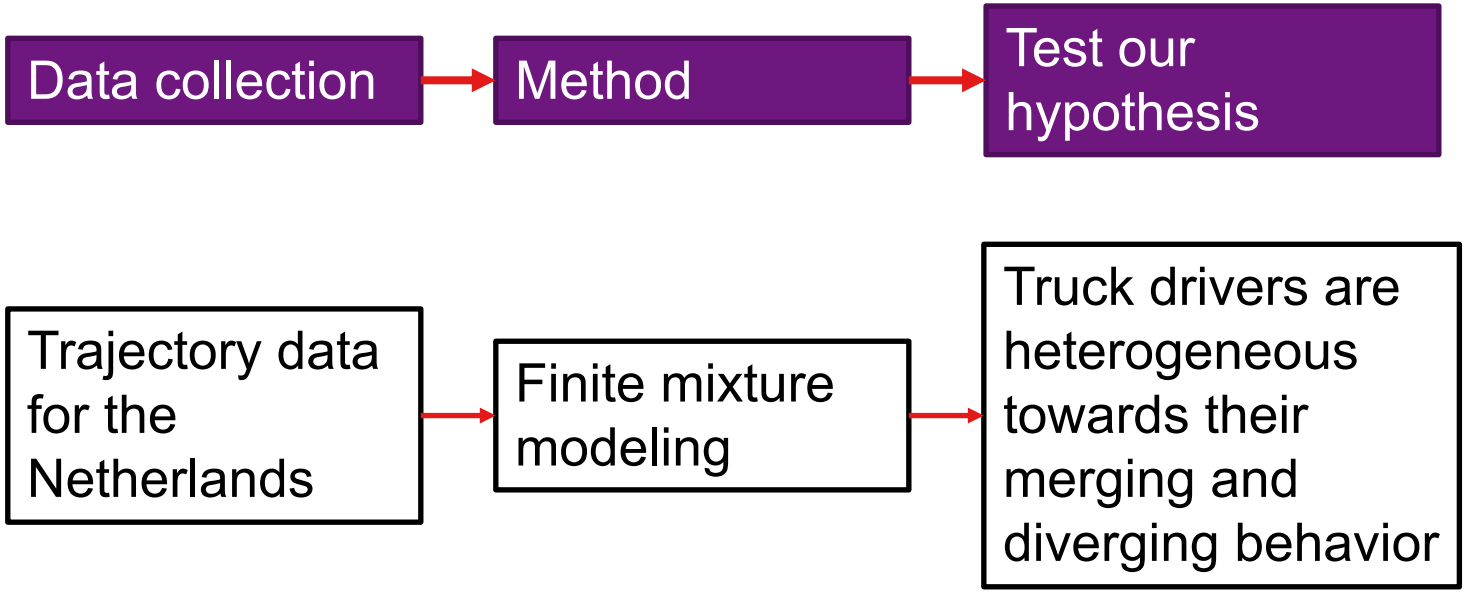
Source:INWEVA



Source: https://www.sgi.sk.ca/handbook/-/knowledge_base/drivers/changing-lanes

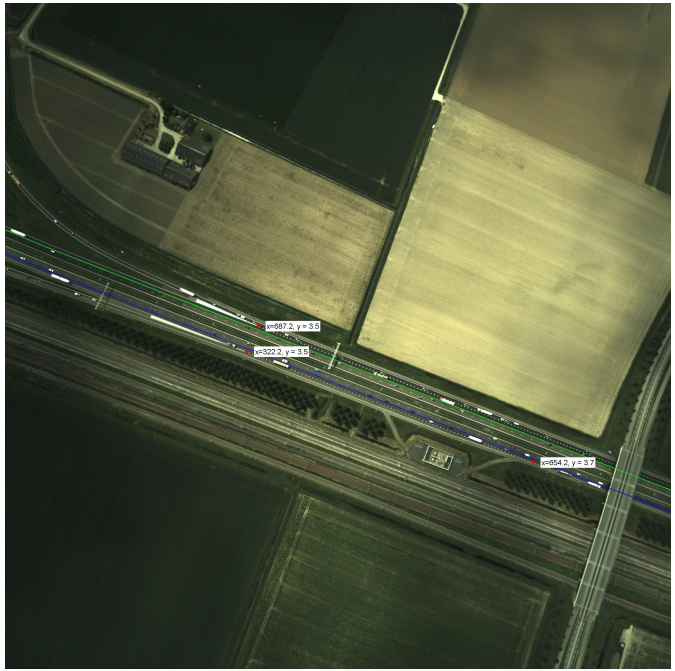
- Top 20 road sections:
  € 210 million economic cost freight sector due to congestion
- Especially on road sections with a high percentage trucks
- Lane changing influences traffic efficiency and safety
- Objective: Identify heterogeneity in the merging and diverging behavior of truck drivers.

Approach


Data collection
Method
Test our hypothesis
Trajectory data for the Netherlands
Finite mixture modeling
Truck drivers are heterogeneous towards their merging and diverging behavior

Trajectory dataset

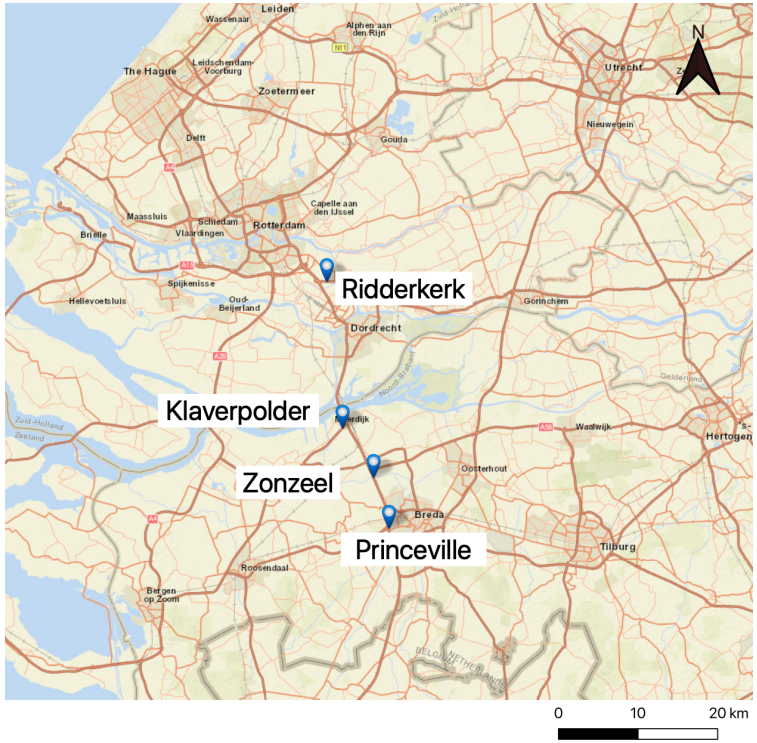
- Collected by helicopter method
- Ramps and weaving sections present in the Netherlands
- Open data: available online at 4TU repository



van Beinum, A. (2018) Motorway turbulence - empirical trajectory data.
doi: 10.4121/UUID:6BE1AEFA-0803-4CE2-91B2-CAAA7982ABCD.

Sites

- **On-ramp**
  - Zonzeel-north: 340 m
- **Off-ramp**
  - Zonzeel-south: 230 m
- **Short weaving**
  - Klaverpolder-north: 610 m
  - Klaverpolder-south: 530 m
  - Ridderkerk-north: 740 m
- **Long weaving**
  - Princeville-east: 1000 m
  - Princeville-west: 1130 m

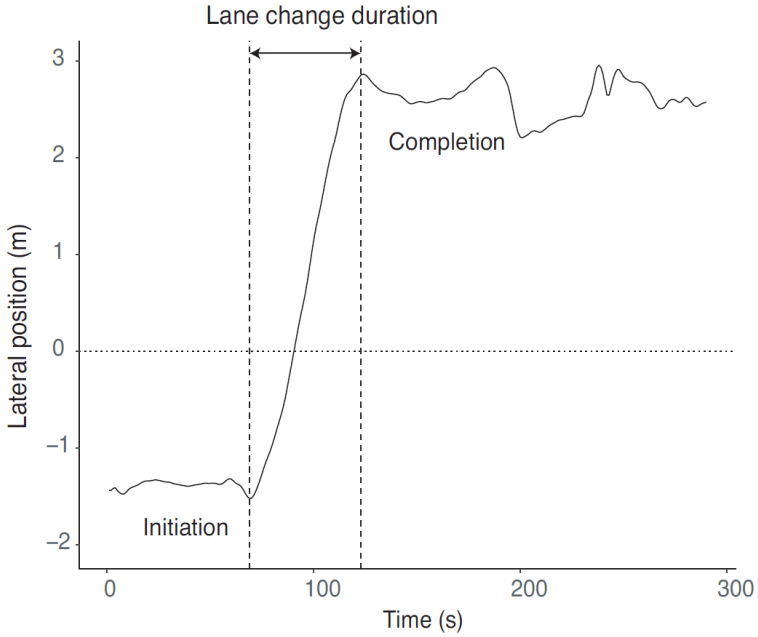


Method

- Finite mixture modeling
  - The overall population heterogeneity results from the underlying two or more distinct homogeneous subgroups or latent classes of individuals.
  - Expectation maximization algorithm
- Bayesian information criterion (BIC) to select the best model $BIC = -2\ln(LL) + K\ln(n)$

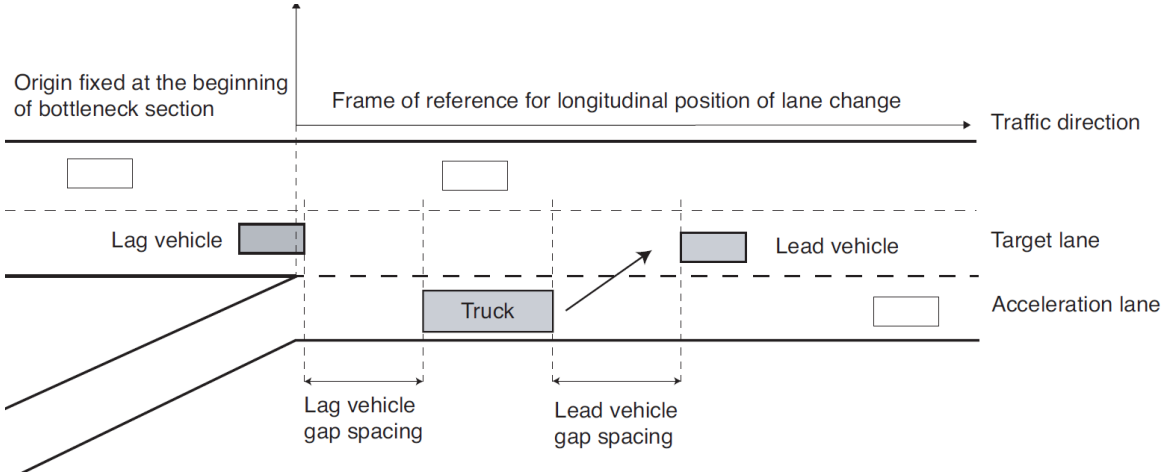
Indicator variables

- Spatial
  - Location of lane change initiation relative to the beginning of bottleneck
- Temporal
  - Lane change duration
- Kinematic
  - Truck driver's speed at the instant of lane change initiation



Indicator variables

- Gap acceptance
  - Lead and lag gap spacing at the time of lane change initiation
  - Whether a truck driver has accepted largest available lead or lag gap spacing
    - We store all the available gaps until lane change initiation



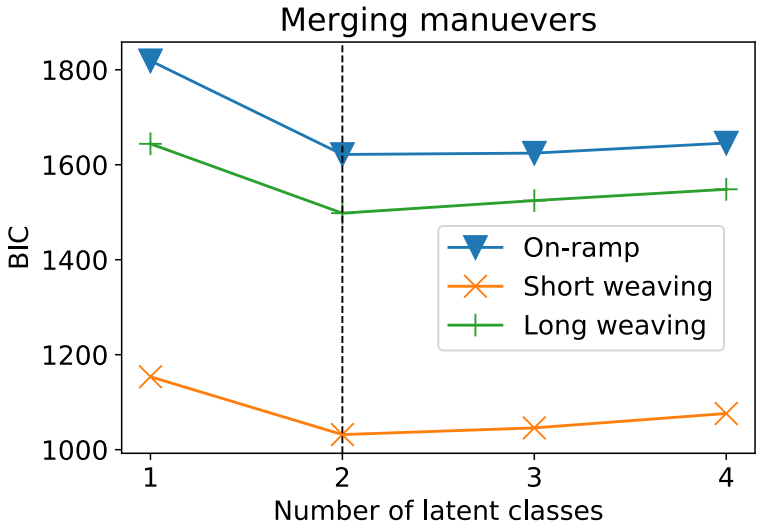
Data

Merging		Diverging	
Sites	**Data points**	**Sites**	**Data points**
On-ramp	50	Off-ramp	47
Short weaving	30	Short weaving	80
Long weaving	48	Long weaving	43

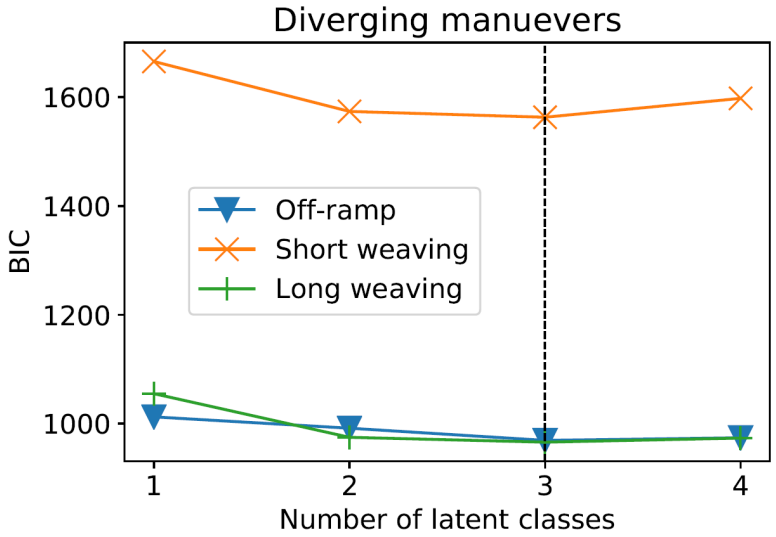
Indicator variables	Distribution
Location of lane change initiation	Gaussian
Lane change duration	Gaussian
Speed at lane change initiation	Gaussian
Lead and lag gap spacing	Gaussian
Whether accepted a largest available lead/lag gap	Binomial

Results

2 types of merging strategies



3 types of diverging strategies



Segmentation is consistent over different bottlenecks

Merging strategies

Site	Class I (%)	Class II (%)
On-ramp	61.02	38.98
Short weaving	69.90	30.10
Long weaving	65.21	34.79

- Class I truck drivers want to merge at the earliest available opportunity.
- Class II truck drivers either intentionally merge late or could not find suitable gaps initially.

Diverging strategies

Site	Class I (%)	Class II (%)	Class III (%)
Off-ramp	19.30	46.85	33.85
Short weaving	75.00	7.50	17.50
Long weaving	52.89	32.56	14.55

- Class I truck drivers initiate exit maneuvers before the beginning of a bottleneck.
- Class II truck drivers initiate exit maneuver just after the beginning of a bottleneck.
- Class III truck drivers initiate exit maneuvers a little late although gap acceptance has no role in this process.

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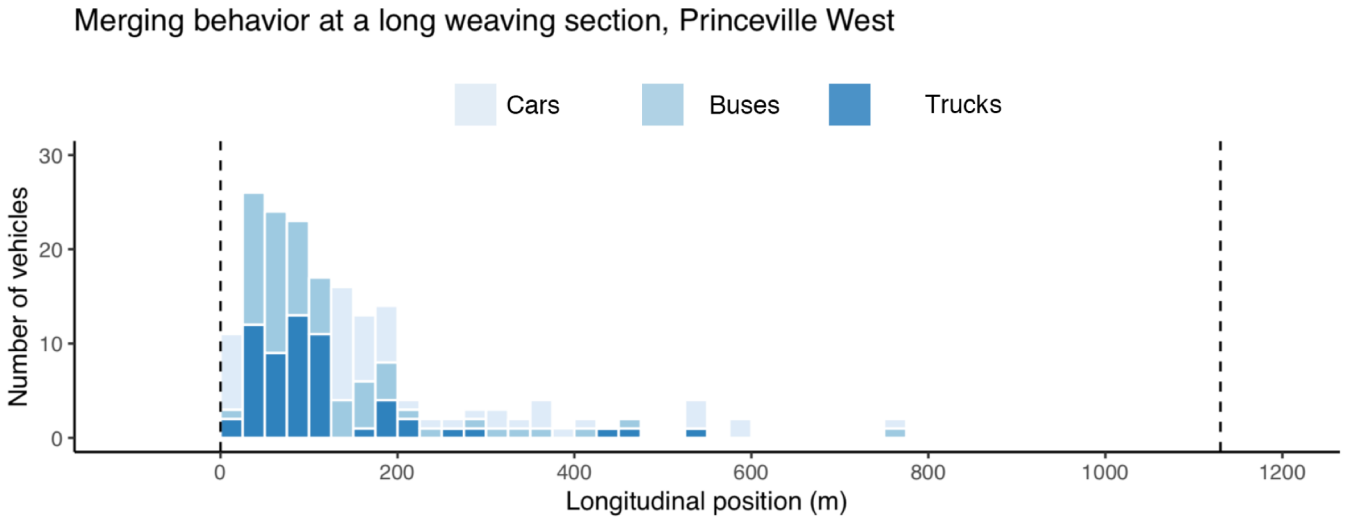
Role of truck drivers to turbulence

- Lane change maneuvers in the vicinity of motorway ramps and weaving sections are primary contributors to the turbulence.
- Turbulence = number of lane changes
- Identify the role of truck drivers to the turbulence

van Beinum, A., H. Farah, F. Wegman and S. Hoogendoorn (2018) Driving behaviour at motorway ramps and weaving segments based on empirical trajectory data, *Transportation Research Part C: Emerging Technologies*, **92**, 426 – 441.

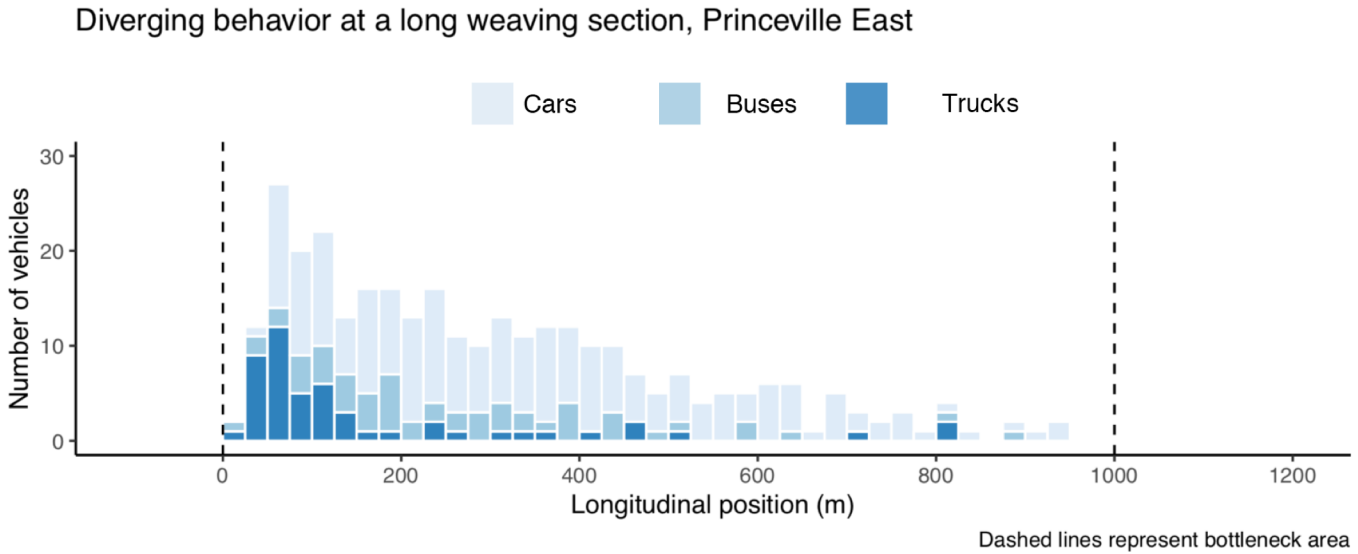
Turbulence due to merging

- High lane changing activity (>85%) within initial 25% of ramp or weaving segment length due to class I truck drivers



Turbulence due to diverging

- High lane changing activity (>78%) within initial 25% of ramp or weaving segment length due to class I and class II truck drivers



Conclusions and future works

- Truck drivers have
  - two types of merging strategies
  - three types of diverging strategies
- Truck drivers do not fully utilize the available ramp and weaving segment length
  - Contribute more to the turbulence at the beginning
- The findings can be implemented in the existing microscopic simulation packages
- Design a control strategy to reduce the impact of lane changes (or turbulence) in the vicinity of motorway bottlenecks

Acknowledgements

Thank you!

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