

Microscopic Simulations of Oversaturated City Traffic: Features of Synchronized Flow Patterns

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- Traffic patterns in a city: empirical examples
- Simulation model
 - Speed Adaptation Effect
- Simulation results



- Oversaturated city traffic:
 - Not all vehicles of the queue can pass during the next green phase
 - Vehicles stop more than once

Empirical Synchronized Flow Patterns at Traffic Signal

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Vertical red lines: time instant when vehicle passes traffic signal



- Empirical examples:
 - TomTom single vehicle probe GPS data (anonymized)
 - 5-second data intervals
- Recently predicted by Kerner et al. [1]
- Speed is lower than in Free Flow
- Vehicles don't stop more than once in front of traffic signal

[1] B. S. Kerner, S. L. Klenov, G. Hermanns, P. Hemmerle, H. Rehborn, M. Schreckenberg: "Synchronized Flow in Oversaturated City Traffic", *Phys. Rev. E*, **88** (5), (2013).

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Oversaturated City Traffic: Main Empirical Patterns

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Vertical red lines: time instant when vehicle passes traffic signal

Synchronized Flow



- Qualitatively different traffic patterns:
 - Sequences of Moving Queues (MQ)
 - Synchronized Flow Pattern (SP)
 - Mega Queues
- Mixtures of MQ, SP found

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Classical Moving Queues



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 g_{safe} = safety gap S = states of synchronized flow G = synchronization gap

Synchronization Gap:

- Vehicle adapts to speed of leading vehicle
- But it can do so in an arbitrary distance within certain distance margin ("synchronization gap")
- Competition between two effects:
 - Over-acceleration (OA)
 - Speed adaptation (SA)
- OA leads to jam dissolution
- SA leads to traffic breakdown



Speed Adaptation:

- Weak speed adaptation: smaller distance to leader
- Strong speed adaptation: greater distance to leader

Kerner-Klenov Simulation Model:

- Stochastic
- Microscopic
- Calibrated with empirical data
- Adapted for simulation of city traffic [2]

[2] Kerner, B. S., Physica A, Vol. 397, 2014, pp. 76–110

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Simulation Results: Strong Speed Adaptation (1)

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Simulation Results: Strong Speed Adaptation (2)

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Simulation Results: Strong Speed Adaptation (3)

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Impact on Energy Efficiency

Impact of Synchronized Flow patterns on energy efficieny:

- Talk by <u>P. Hemmerle</u>: "Impact of Synchronized Flow in Oversaturated City Traffic on Energy Efficiency of Conventional And Electrical Vehicles"
 - Energy consumption is considerably larger in moving queues than in synchronized flow patterns
 - Wednesday, Session 3B





- Poster by <u>M. Koller</u>:
 - "Traffic phase dependent fuel consumption"

Summary



- Qualitatively different traffic patterns in oversaturated city traffic
- Synchronized flow found in empirical data in city traffic
- Speed adaptation effect plays key role in emergence of congestion
- Simulation model can reproduce traffic patterns, including synchronized flow

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