Modeling unsignalized intersections at macroscopic and micrsocopic scales: issues and proposals

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On-field data

- Free-flow

  - search for acceptable headways

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gap-acceptance theory
Grabe (1954), Harders (1968), Siegloch (1973)

- Congested

  - no respect of the give-way rule (Troutbeck, 2002)
  - alternating behaviour between both streams (Cassidy and Ahn, 2005)

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supply-demand framework
Daganzo (1995), Lebacque (1996, 2003), Jin and Zhang (2003)

Reference outputs for evaluation

- Goal:

outputs of the reference models {free-flow, congestion} ↔ outputs of simulation models {macroscopic, microscopic}

- Choice of the outputs:
  - steady-state level
    - capacity curve:
  - dynamic level
    - dynamic flow allocation: $(q_1, q_2) = \phi(\Delta_1, \Delta_2)$
      $= (\phi_1(\Delta_1, \Delta_2), \phi_2(\Delta_1, \Delta_2))$
    - delays: $d(\Delta_1, \Delta_2)$

Reference model in free-flow regime

GAP-ACCEPTANCE MODEL

- headway distribution: $f(t)$
- insertion rules → no. of insertions within a headway t: $g(t)$

- capacity curve:

- dynamic capacity allocation:

  - priority to major road

- delay formula: accounting for randomness in arrivals and service times

Reference model in congestion

DEMAND-SUPPLY FRAMEWORK

- optimization in capacity (Ω) allocation
- priority ratio γ

- capacity curve:
- dynamic capacity allocation:
  - shared priority/priority to minor road
- delay formula: deterministic arrivals and service times

Goals of this study

Benchmark models	Simulation tools	
	microscopic	macroscopic
free-flow: gap-acceptance	classical microscopic models	no delay when $\Delta_2 < C(\Delta_1)$ no dynamics in queue length
congested: demand-supply	no insertion when Ω too low q_1/q_2 not constant	Daganzo's model (1995)

MICROSCOPIC SIMULATION MODELS

Issues in free-flow

- Simulation time-step Δt = scanning frequency

  - inconsistent capacity estimates!

- Assessing insertion rules within Δt: as done in classical microscopic models

  - capacity estimates independent on Δt
  - simulated capacity and delays in agreement with the benchmark model

Issues in congestion

simulation time-step → numerical viscosity

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errors in vehicle's trajectories

↓

↓

errors in the insertion decision process

Issues in congestion

interactions
car-following/insertion rules → minimum values for distance criteria

↓

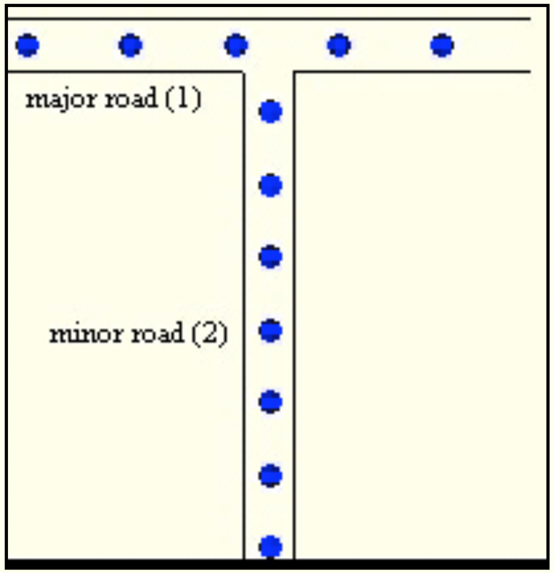
no insertion when the equilibrium spacing too short

Issues in congestion

- q_1/q_2 depends on Δt
- lack of available spacings when Ω decreases

Proposal for a solution

- Decorrelation between the car-following algorithm and the insertion rules
  - Bernoulli process at each Δt of probability: $\Phi_2(\Delta_1,\Delta_2)\ \Delta t$
  - relaxation model (Laval and Leclercq, 07; Cohen,04)



- insertion even if short spacings
- q_1/q_2 independent on Δt

MACROSCOPIC SIMULATION MODELS

In congestion

- In macroscopic models: easy to implement the demand-supply framework through a distribution scheme

- Daganzo's model (1995): well adapted!
  - invariance principle (Lebacque and Khoshyaran, 1996)
  - capacity sharing

- simulated capacity and delays in agreement with the benchmark model

Issues in free-flow

- Stochastic interactions between vehicles are not taken into account

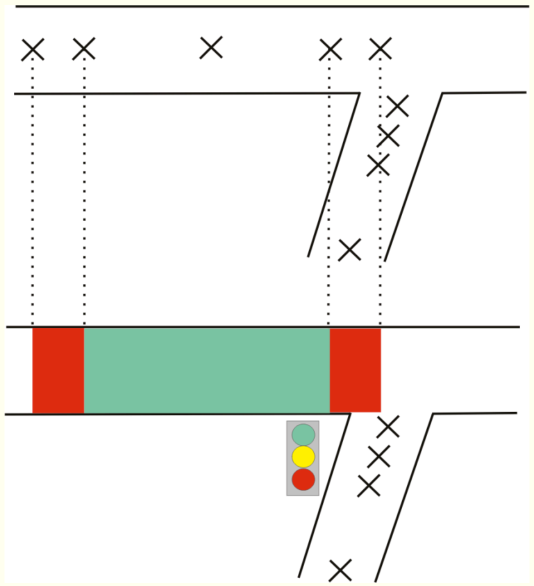
accurate average delay

but no dynamics in queue length

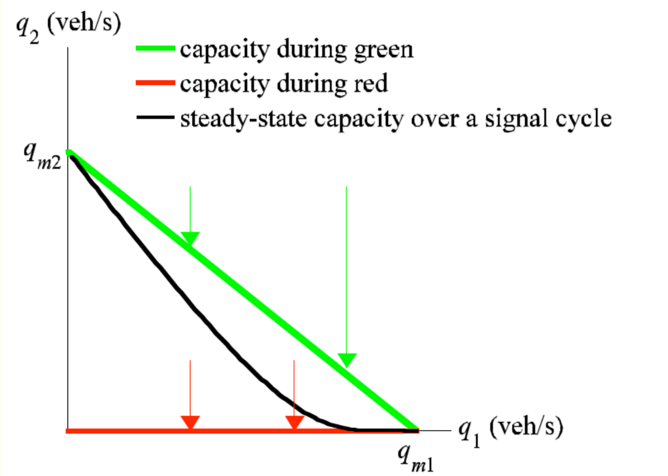
no delay

Proposal for a solution

- Modeling the average effects of a stochastic gap-acceptance process through a fictive trafic light (Chevallier and Leclercq, 2007)
  - average period available for insertion=green
  - average period of blocks=red

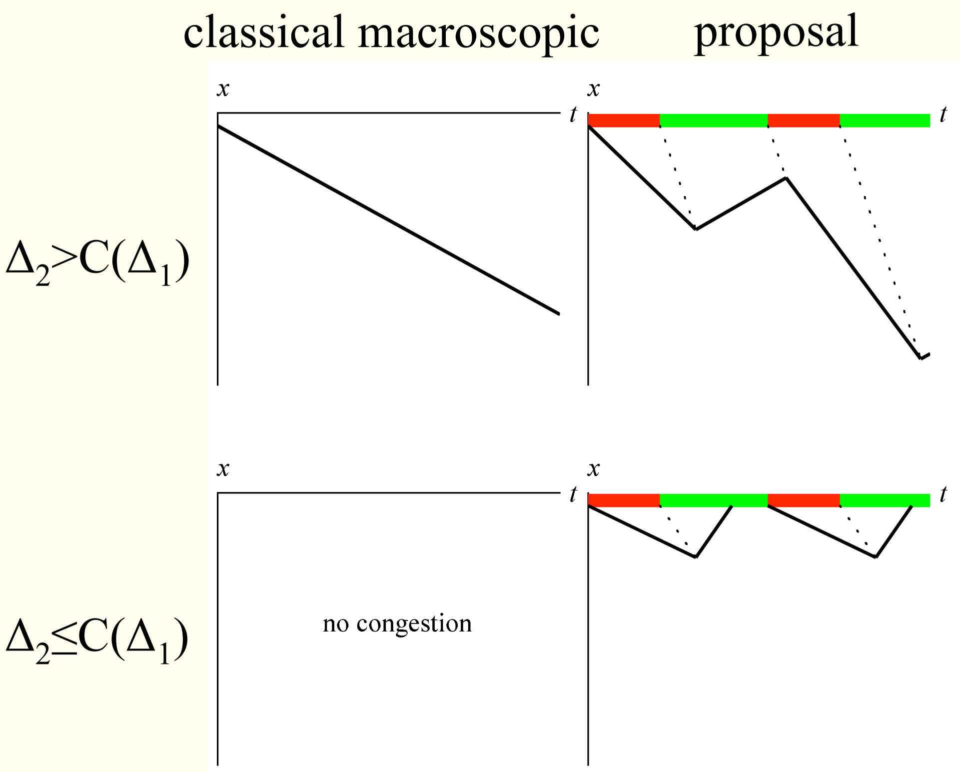


Results



- simulated capacity over a fictive cycle length:

  relevant with the benchmark model



- simulated delays/ queue lengths:

  relevant with the benchmark model

CONCLUSIONS

Goals of this study

Benchmark models	Simulation tools	
	microscopic	macroscopic
free-flow: gap-acceptance		average period of block due to stochastic arrivals
congested: demand-supply	release interactions: car-following/insertion	

THANK YOU FOR YOUR ATTENTION!