Development of a Traffic Cellular Automaton Model for Highway Traffic

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General overview

- Statement of our goals
  - Different traffic regimes
  - Modeling of traffic flows
    - Traffic Cellular Automata (TCA)
    - Survey of classic models
  - Development of the STV TCA
    - Global approach and related problems
    - Challenges in development
- Conclusions

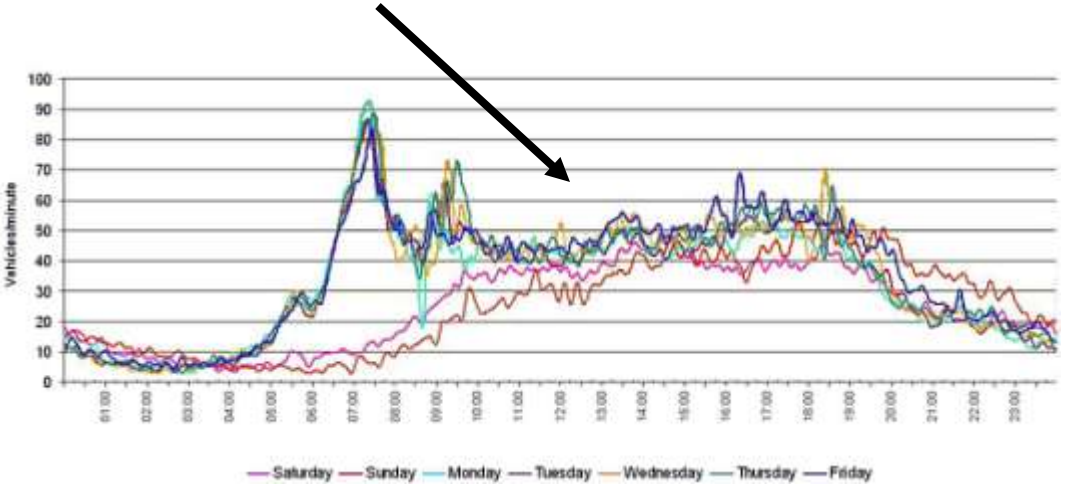
Statement of our goals

- Modeling of traffic flows is necessary:
  - *optimize* the usage of the existing road infrastructure.
- Construct a model for the simulation of traffic flows:
  - focus on the *cellular automata* programming paradigm,
  - **investigate the already existing models,**
  - formulate some basic model-related necessities, expected problems and challenges.
- Only consider highway traffic:
  - unidirectional flows,
  - no signalized intersections (i.e, only on-/off-ramps, weaving areas, …).

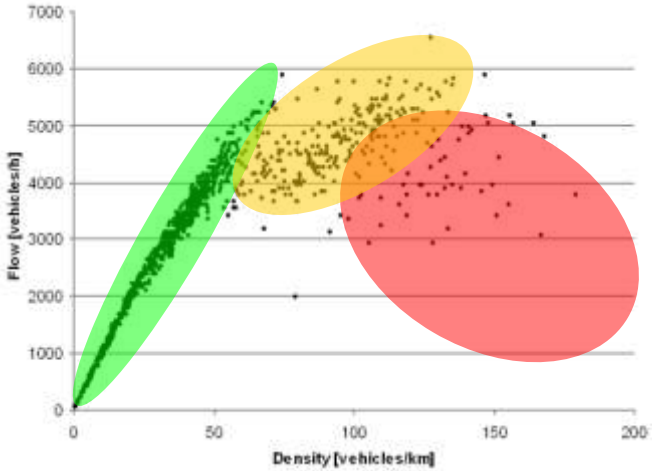
Different traffic regimes

- Time series of average speed, flow and density:

correlations lead to



fundamental diagrams



traffic regimes

- **free flowing traffic**
- **synchronized traffic**
- **congested traffic**

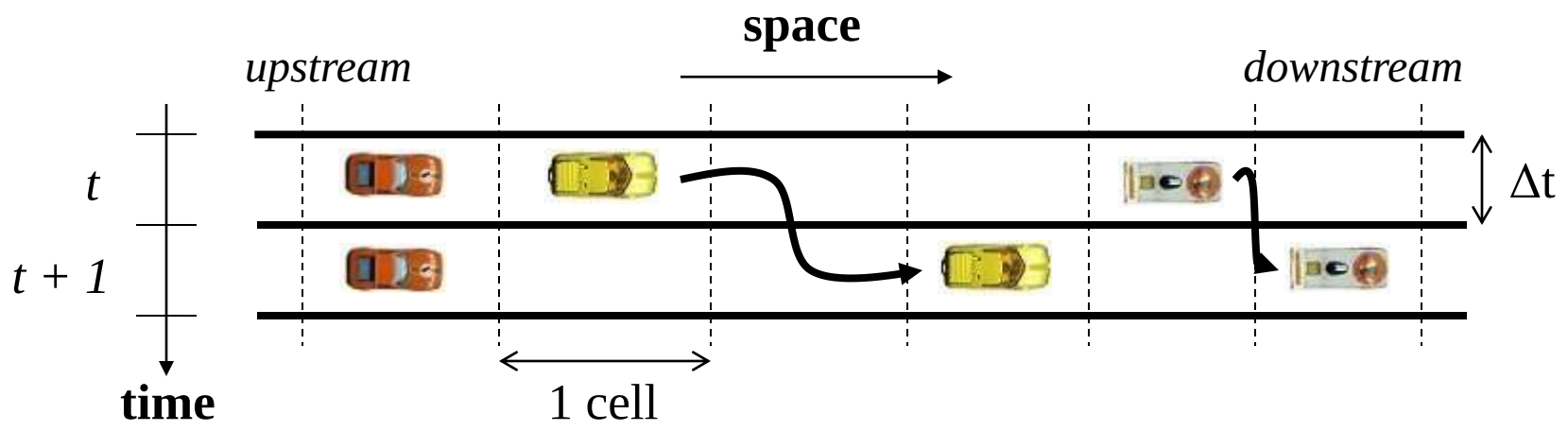
(metastable phases, hysteresis, …)

Modeling of traffic flows

- Two main approaches are possible:
  - **macroscopic**
    - ➡ *consider a traffic stream as a whole*
      - → partial differential equations { fluid-dynamic / gas-kinetic
  - **microscopic**
    - ➡ *consider each vehicle in a traffic stream individually*
      - → **2 submodels needed**
        - **car following** 
        - **lane changing** **(+ routing)**

Traffic Cellular Automata (TCA)

- Space is coarse grained (each cell in the **lattice** is 7.5 meter).
- **Rules** describe the evolution of the system each timestep (1 sec):

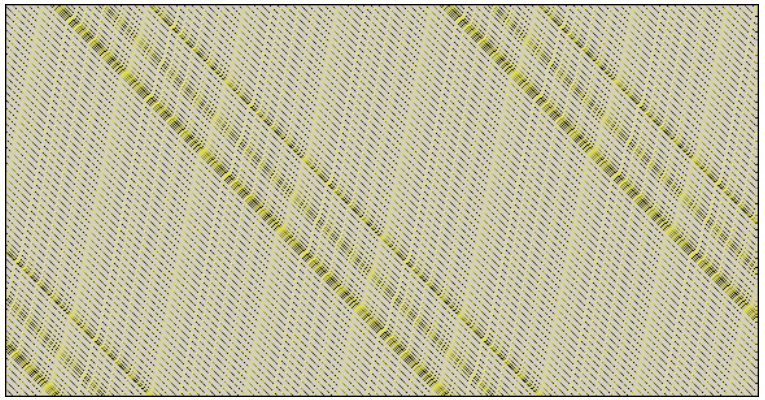


- At this stage : focus on the **car following submodel**.
- *Indianapolis scenario* : closed system (L cells, N vehicles).

The rules are consecutively applied to all vehicles in parallel.

Survey of classic models (1/2)

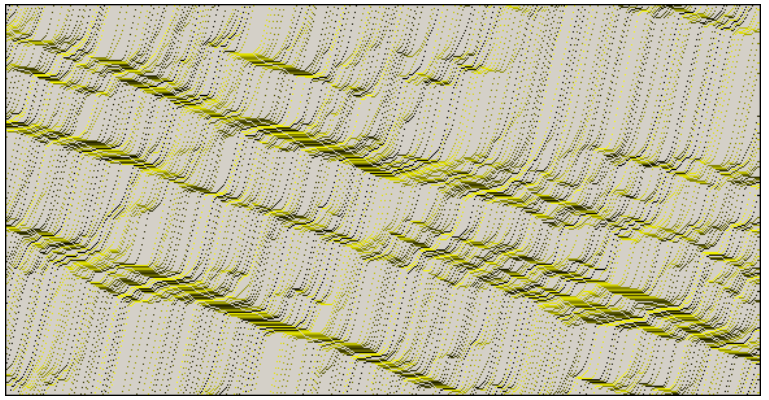
- **Wolfram rule CA-184**
  - \+ only theoretically used
  - – complete deterministic system
  - – strict periodicity



(time-space diagrams)

- **Nagel-Schreckenberg (NaSch)**

  (stochastic TCA)
  - \+ good for urban traffic
  - – too much noise
  - – many unstable jams



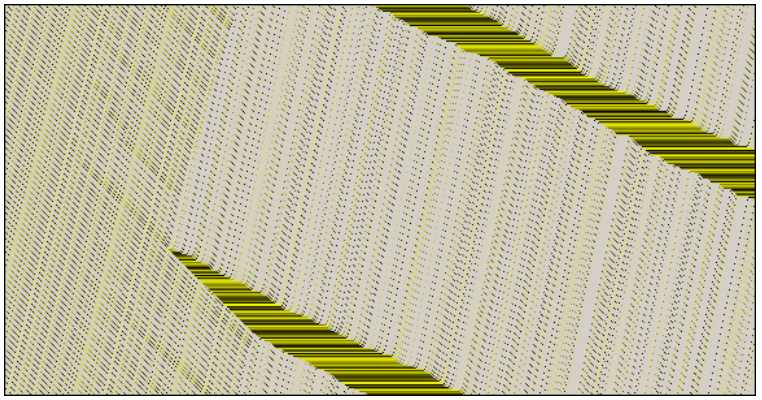
Survey of classic models (2/2)

- **VDR TCA**

  (velocity dependent randomization)

  \+ stable jam (*phase separation*)

  – no stop-and-go traffic



(time-space diagrams)

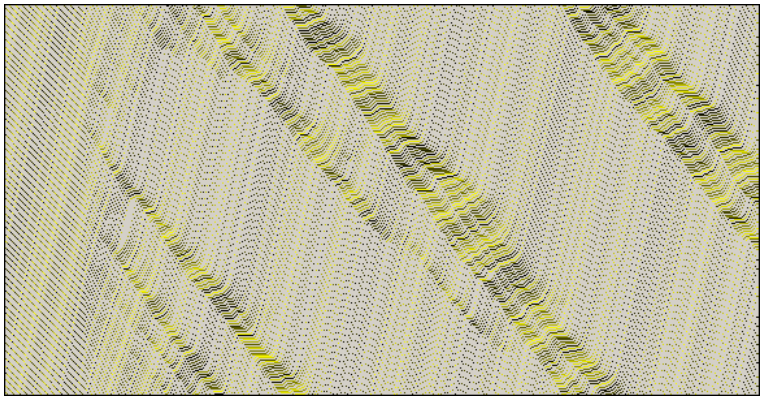
- **Time Oriented TCA**

  \+ formation of stable jam

  \+ stop-and-go traffic

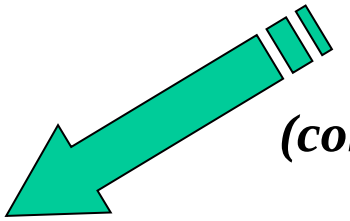
  – unrealistic inflow to jam

  – (too) many parameters



Development of the STV TCA (1/2)

- The existing models each have their deficiencies, as well as **specific characteristics**.



(combine these characteristics)

S → stochasticity is a necessity

T → incorporate time based behaviour

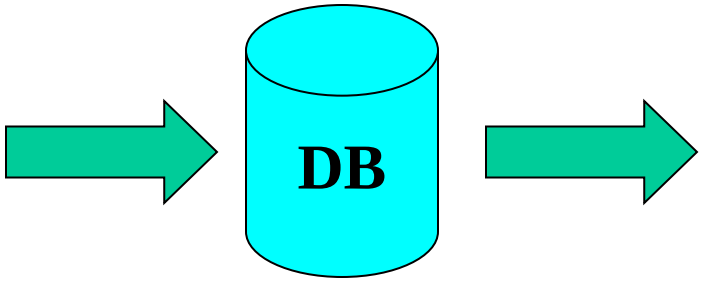
V → stimulate formation of stable jams

(using the VDR TCA's framework)

Development of the STV TCA (2/2)

- Construction of the STV may seem trivial, **BUT**:
  - pursue *feasible calibration* of the model's parameters,
  - *reproduce* characteristic *phases* of traffic (i.e., free flowing, synchronized and congested regimes).

- There's also a nasty "side problem":



cleansing and filtering in order to obtain usable sensor data

(bad sensor data)

Challenges in development

- Multi-lane traffic, different vehicle classes, …
- Implement parallelism through distributed computing.
  → allow large-scale simulations (country wide)
- Achieve a rigorous mathematical calibration.
  → coupling between MATLAB and Java
- Usability for *real-time* control problems ?
  → might not be achieved → hybrid approach

Conclusions

- Cellular automata provide *computationally feasible* microscopic models for traffic flows.

- **Intensive study into existing models:**

  ⇒ *They have several deficiencies.*

- Development of an adequate TCA model:
  - more information regarding the different traffic regimes (phases) is needed,
  - rigorous calibration will prove to be a difficult task.