Modeling vehicular traffic as a complex system

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Outline

Background

3 specific popular models used

Their results

Conclusions

Background

- As a driver, you want to reach your destination
- Additional conditions
  - Time efficient
  - Fuel efficient
  - Safely
  - Legally
- No central controller

Background

Emergent phenomenon appears

- Formation patterns
- Traffic jams

At crossings and parking lots for examples

Very hard to describe mathematically

Background

Improve the infrastructure of roads, cities

Better tools for predicting

Preventing accidents

Preventing traffic jams

Optimising efficiency

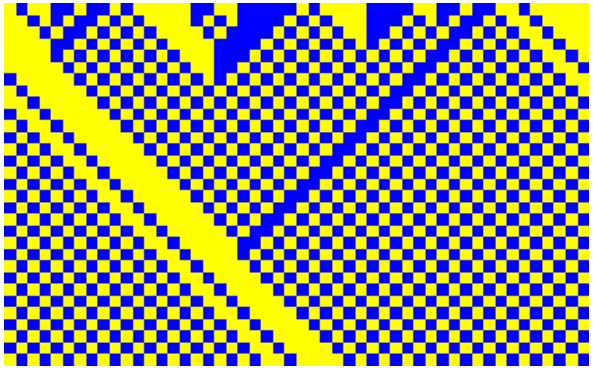
Three popular models

- Cellular automata
  - First 1992
  - K. Nagel and M. Schreckenberg
- Kinetic theory
  - Article 2007
  - A. BELLOUQUID et al
- Agent-based models
  - Article 2013
  - P. Gora and P. Wasilewski

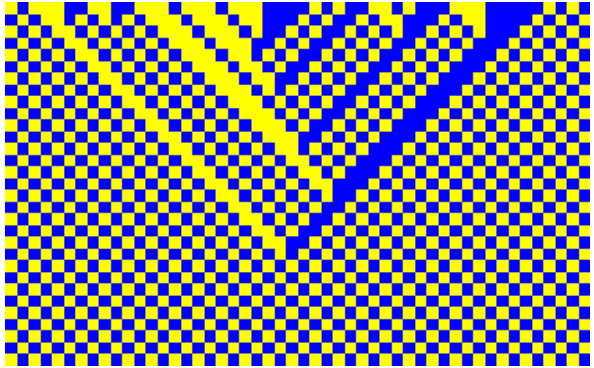
Cellular automata

- First 1992
  - K. Nagel and M. Schreckenberg
- Discrete time, space and velocity
- Simplest model
  - 1D array

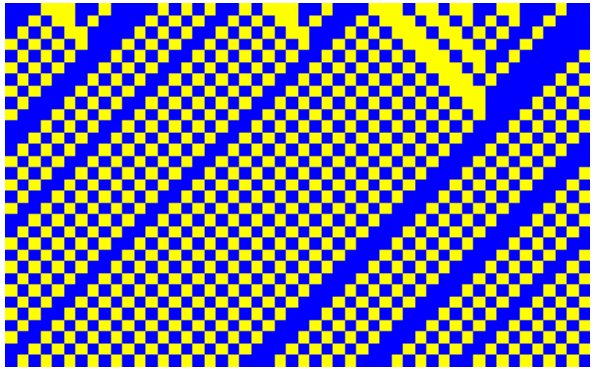
Cellular automata



free-moving state



critical state



jammed state

Cellular automata

- Extending the model
  - higher speed limit
- Able to reproduce some traffic jams and pattern behaviour
- Results
  - Jams depended on density parameter and velocity
  - $$\rho_c = \frac{1}{v_{max} + 1}$$

Kinetic theory

- Basic idea using thermodynamics
  - Particles in controlled or closed system
  - Every vehicle-driver is a particle
  - Non linear additive interactions
  - Stochastic games
- Article
  - TOWARDS THE MODELING OF VEHICULAR TRAFFIC AS A COMPLEX SYSTEM: A KINETIC THEORY APPROACH
  - A. BELLOUQUID

Kinetic theory

There are some major flaws

- Continuity of distributions
- Thousands of particles
- Human behavior
- Growing number of parameters

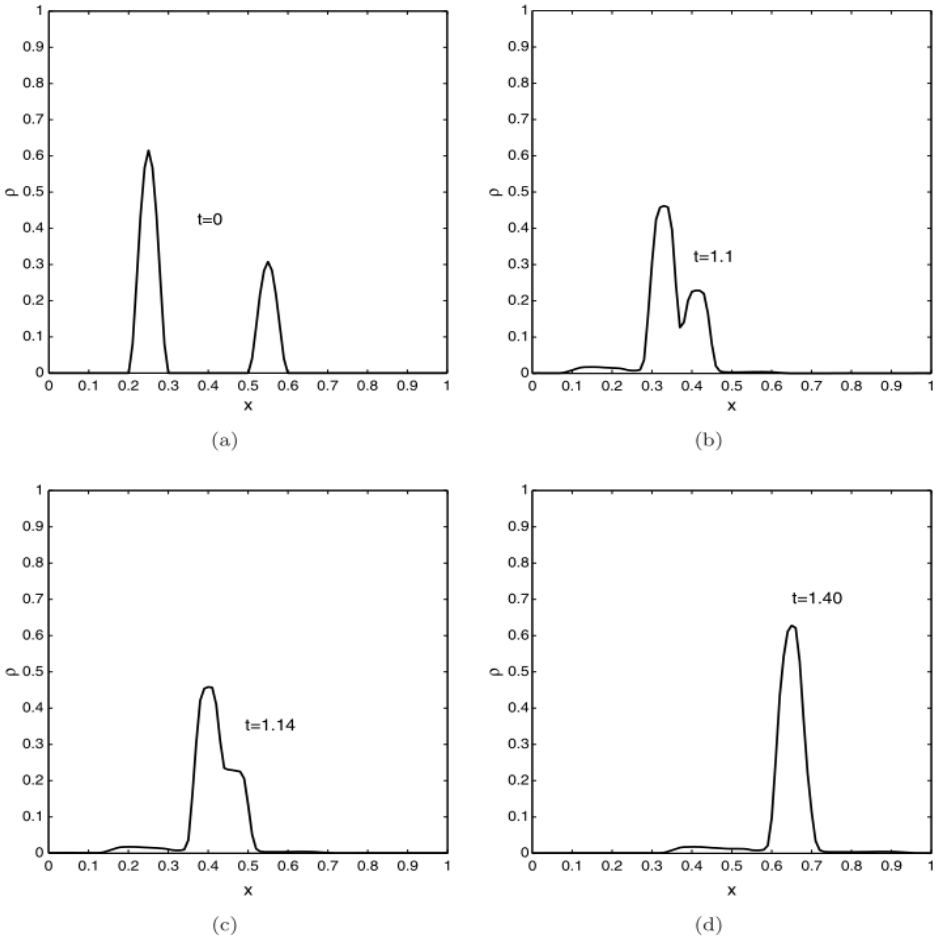


Fig. 4. Evolution of two clusters of vehicles in the case of bad road condition: a merging case.

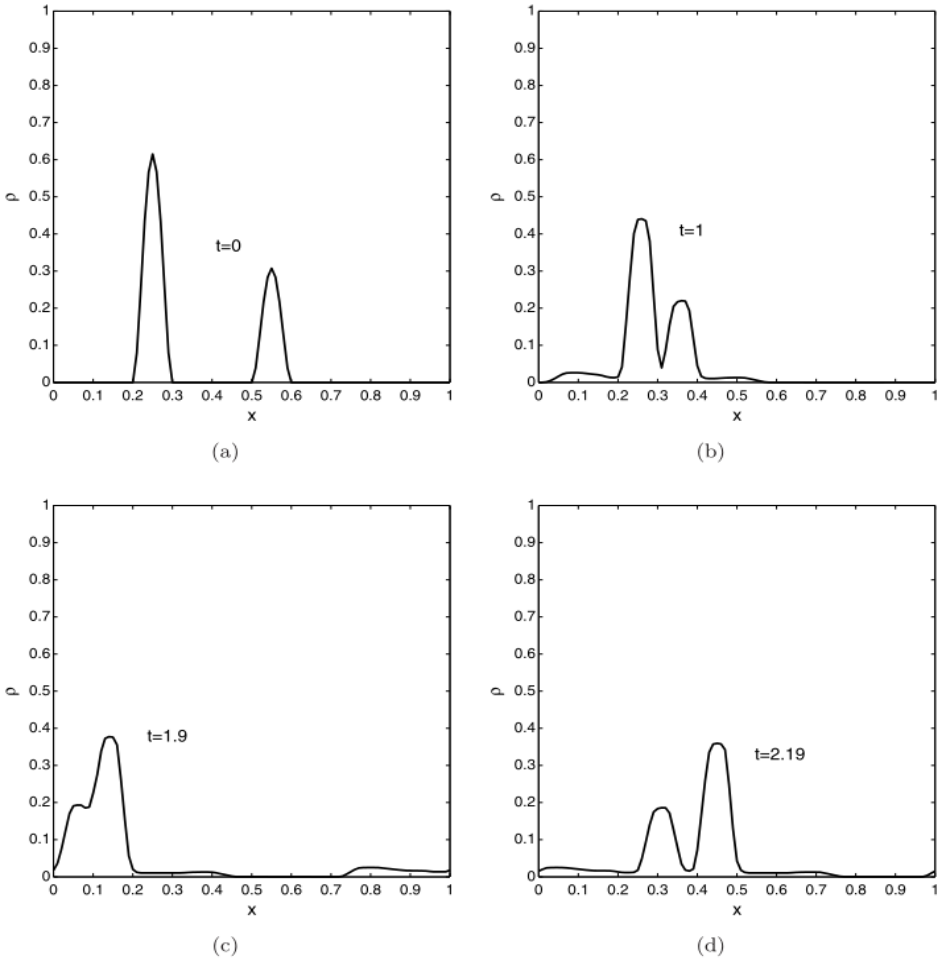


Fig. 5. Evolution of two clusters of vehicles in the case of optimal road condition.

Kinetic theory

Results are promising showing resemblance of empirical data

Has laid a big and stable foundation for further research

Able to extend the model further

Applicable to pedestrian case

Agent based models

- Inducing models of vehicular traffic complex vague concepts by interaction with domain experts
  - Paweł Gora
  - Piotr Wasilewski
- Basic idea
  - Using machine learning
    - classifiers by training (humans)
  - Simulating an agent based model
    - Traffic Simulation Framework
      - Based on real maps
  - Using real time data

Agent based models

There are major difficulties

- How to gather data
  - Data is real time changing / streaming
- Generalising algorithm for
  - the environment of the model
  - evolving code for data changes during simulation

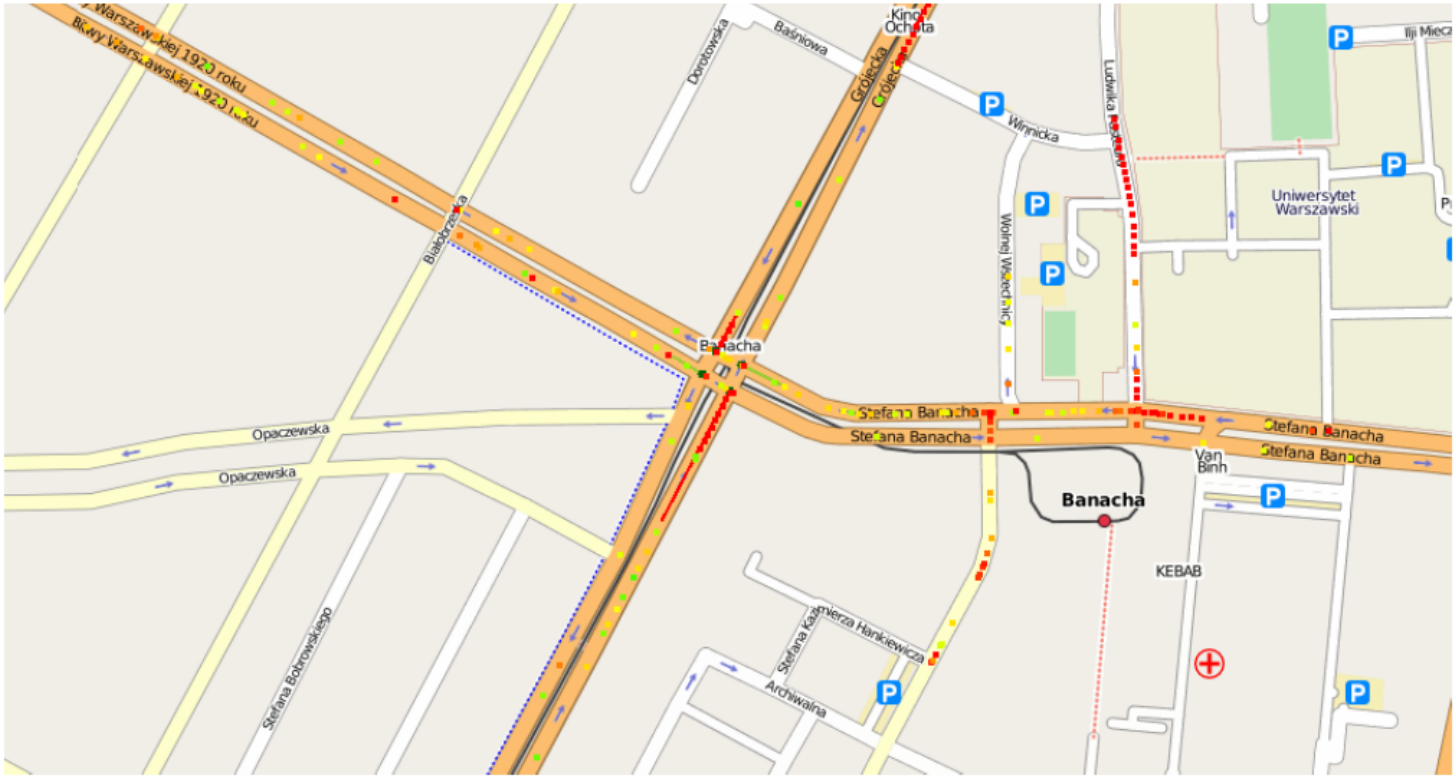


Figure 5. Crossroad of streets Banacha, Grójecka, Bitwy Warszawskiej

Conclusions

Several models able to produce acceptable results

Hard to describe the phenomenon

Really hard to model the human behaviour

Can model and simulate jams, patterns and how these can be avoided

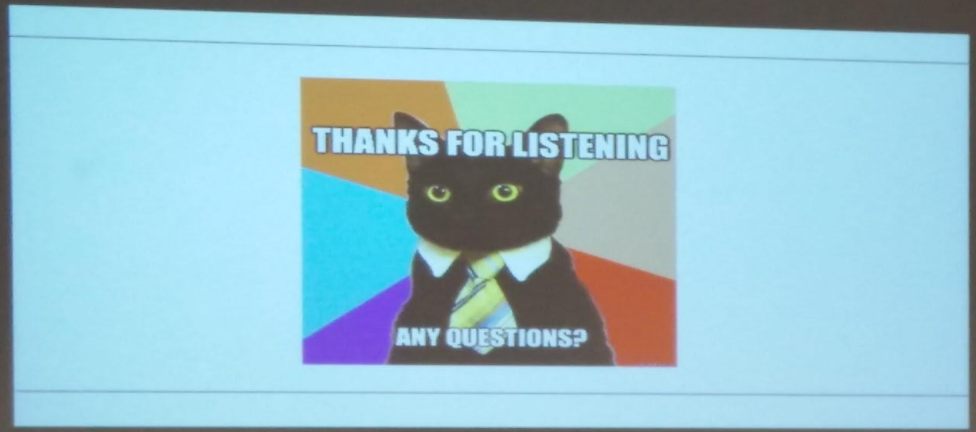
Conclusions

Providing better tools for

- city planning
- road planning
- infrastructure

Scientific approach to the problem

Problem scalable so are the models


THANKS FOR LISTENING
ANY QUESTIONS?