Traffic modeling and simulation by sparse data recovery and refinement

HU-MATHS-IN
Hungarian Service Network for Mathematics in Industry and Innovations

CHALLENGES

Smart, green and integrated transport

The Industrial Problem

Given as initial data the map of the city is available, estimate and simulate fluctuations of traffic and its characteristics, consistent with aggregated measurements from loop-detectors, that is, the number of cars passing certain lanes in total during each hour.

Traffic engineering in smart cities

Research group

HU-MATHS-IN Industrial and Financial Mathematics Consulting Group

Our group provides industrial mathematics solutions including modeling, algorithm design, programming and consulting.

Company

Magyar Közút Nonprofit Zrt.

Hungarian Public Roads is responsible for the operation and maintenance of nearly 32,000 km of national roads.

SZÉCHENYI 2020
MAGYARORSZÁG KORMÁNYA
Európai Unió
Európai Strukturális és Beruházási Alapok
BEFEKTETÉS A JÖVŐBE

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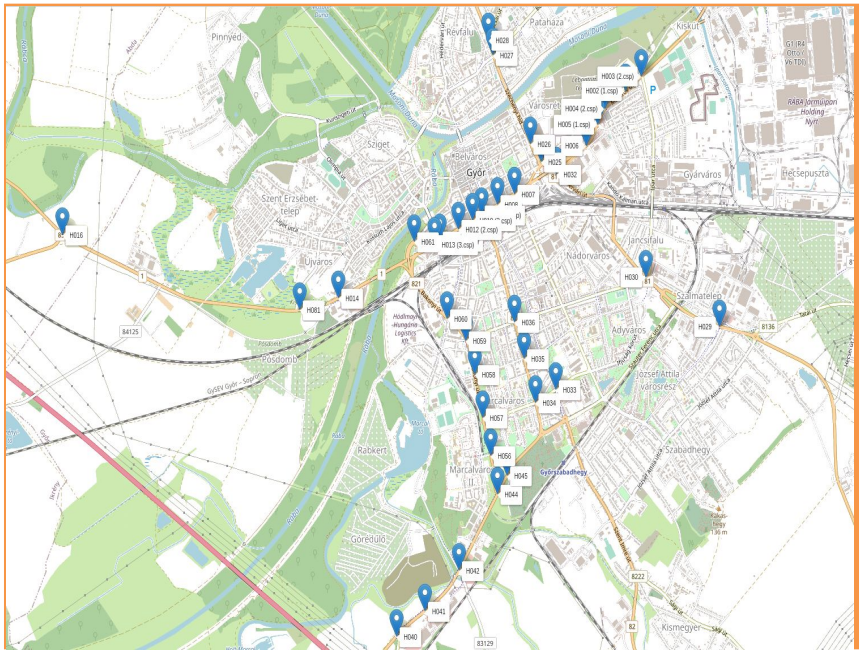
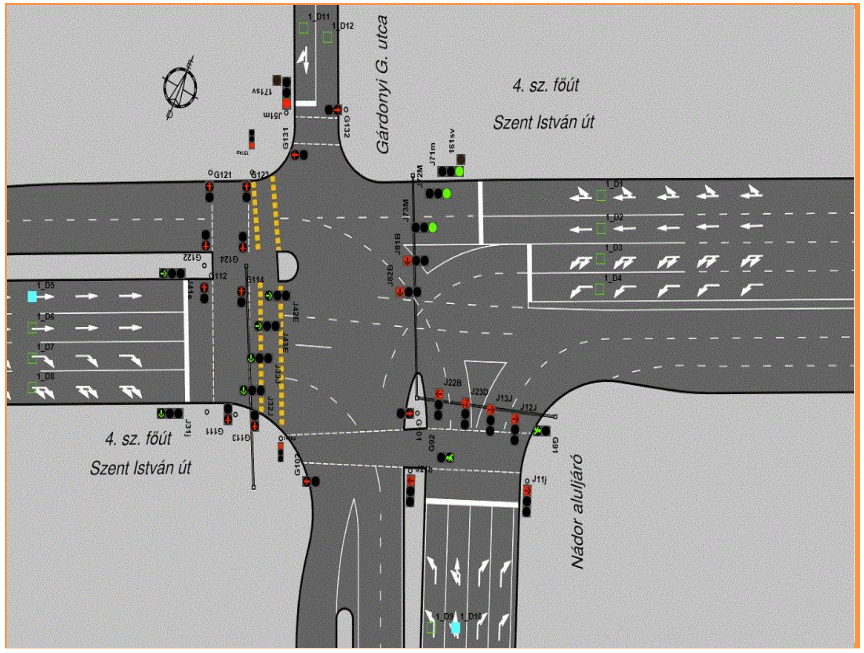
Challenges & Goals

CHALLENGES

Smart, green and integrated transport

- Given traffic sensor data, estimate the traffic in large transportation networks.
- The number of instantaneous parameters of speed, density on every road segment is incomparably larger to the dimension of the data.
- A model has to be composed that is both realistic in terms of traffic dynamics, and also stable for fitting to the sparse data available.





Traffic sensor locations in Győr (Hungary). In the city (left) and at an intersection (above).

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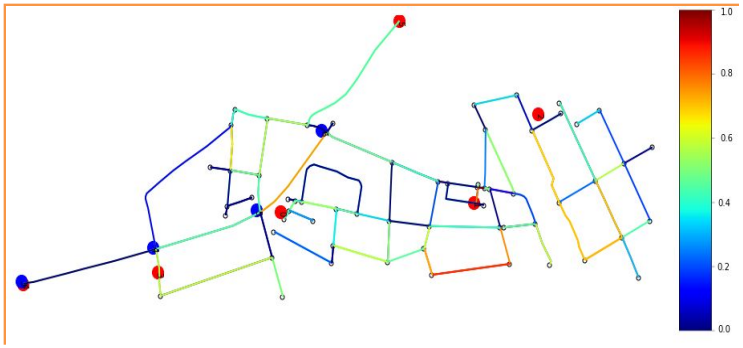
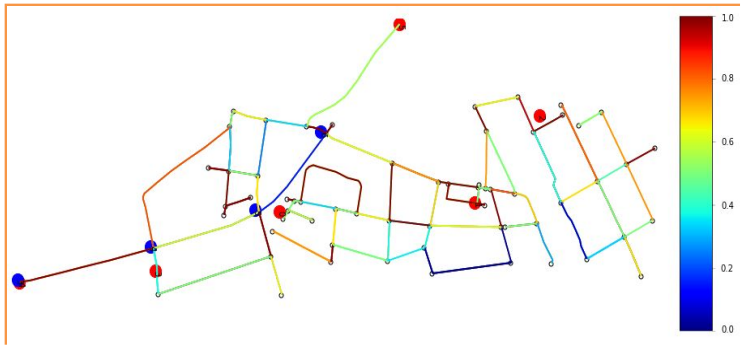
Mathematical and computational methods and techniques applied

- We used the Python package called OSMnx to access and manipulate freely available data from OpenStreetMap.
- We designed a semi-heuristic algorithm to infer priority rules at intersections from OpenStreetMap data.
- We created a vector-valued vehicular transport model describing the traffic on the whole road network taking into account the effect of traffic lights and priority rules.
- We proposed a simple Bayesian data assimilation algorithm for fitting the state vector to data.



Traffic congestion simulation in Győr (Hungary). Edges are colored according to their relative saturation.



Traffic congestion simulation in Győr (Hungary). Edges are colored according to the v/v_{max} ratio.

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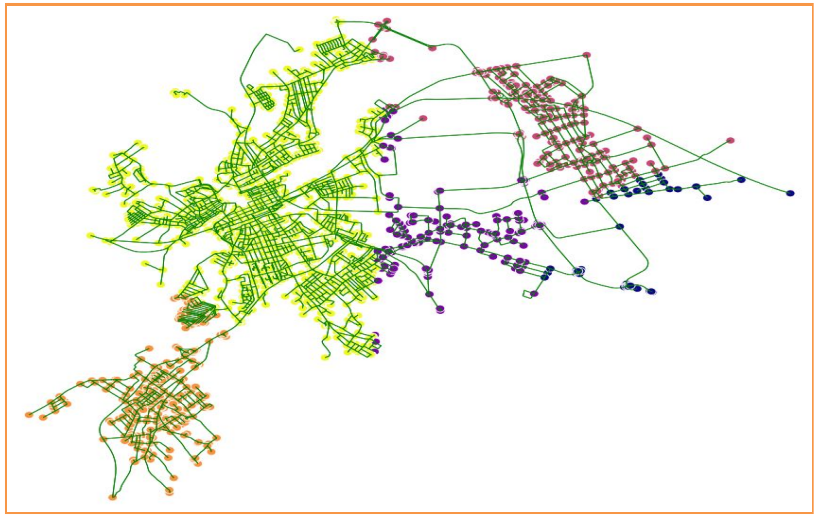
Results & Benefits to the company

- Results
  - Theoretically sound and complete mathematical model developed.
  - Multiple innovative elements embedded.
  - Functional prototype implemented.
- Benefits
  - Emission estimation waits ahead.
  - Can serve as guide for city traffic management.
  - Testing modified traffic city plan is possible before implementation.



Clustering of Győr (Hungary).

Our solution supports emission prediction and simulation for urban areas which could serve as a tool for related decision makers.