Simulating Traffic Networks

Driving SUMO towards digital twins

Axel Schaffland, Jonas Nelson, and Julius Schöning
14/05/2024
Completely without personal reference

The modern way of drawing
The modern way of drawing - Prompt Engineers: The new artists?

Idea from: https://www.linkedin.com/posts/manuel-villavieja-beck-1714a023a_are-so-called-prompt-engineers-the-new-activity-7049459145556598784-wSCC (10/04/2024)
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Ooohh! An artist!

Wow!

I wonder what he's painting...

he draws...

... me?

two years ago

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Intelligent Intermodal Commuter Traffic

The research project and its aim
Intelligent Intermodal Commuter Traffic

Motivation: Increase in individual and commuter traffic in
- Osnabrück (pop. 165,000 / 128,700 commuters)
- Münster (pop. 317,700 / 219,400 commuters)

Solution approach:

- Merging official and publicly available traffic data with sensor technology, crowdsourcing and citizen participation
- Protection of privacy through anonymized data collection
- Development and testing of business models oriented towards the common good with a focus on the intelligent use of different means of transport
Simulating Traffic Networks

Data of a crossing
Data of a crossing

Bus:
- # passengers
- delay in min
- position
- route

Bus Stop:
- # passengers
- delays in min
- position
- routes

Pedestrian lights:
- # pedestrians

Bike lane:
- # bicycles
- direction
- lane quality

Intersection:
- # right turners
- # left turners
- # trucks / min
- # cars / min

Parking lots:
- occupancy status
- type

Environmental sensors:
- temperature
- precipitation
- wind
- pollutant concentrations

Source: City of Osnabrück
Data of a crossing

Car:
- route
- origin-destination

Bike:
- ride history
- origin-destination

Source: City of Osnabrück
Data of a crossing

Source: City of Osnabrück
Data of a crossing

Source: City of Osnabrück
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Source: City of Osnabrück
Simulating Traffic Networks

Sensor-based traffic simulation
Motivation: Sensor-based traffic simulation

- improving public transportation
- reduction of environmental pollution
- human-centered urban planning
- traffic flow optimization
- improving the quality of life
- accident prevention
- real-time traffic management
- ...

- pedestrian
- cyclist
- bus R42
- truck (40 tons)
- car (3 passengers)
Motivation: Sensor-based traffic simulation

S. Tsubohara (2007). The effect and modification of the Traffic Circulation Plan (VCP)

Supermanzana Barcelona

Leezenflow Münster

Traffic Circulation Plan Groningen

Solutions: Sensor-based traffic simulation - GPS tracker
Solutions: Sensor-based traffic simulation - Video cameras
Solutions: Sensor-based traffic simulation - Sensors

- 2 persons, 0 car
- 1 person, 1 car
- 4 persons, 40 cars, 3 trucks
- 2 persons, 2 cars, 2 busses, 2 cyclists
- 2 persons, 0 car
- 1 person, 1 car
Simulating Traffic Networks

Driving SUMO towards digital twins
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Simulating Traffic Networks

Static data
Static data: Fusion

- embedding all data sources in the GIS

- utilization:
  - creation of the traffic network
  - definition of new sensor positions
  - assignment of sensor position, masts, locations
  - ...

- publication as WMS / WFS for integration into other GIS systems

- publication as a website for direct use in the browser
Static data: Fusion
Static data: Network generation

• recording your own 360° videos
• update and correction of OpenStreetMap data
• conversion of OpenStreetMap data to SUMO mesh
• renewed correction of OpenStreetMap data
• conversion of OpenStreetMap data to SUMO mesh again
• final adjustments to the SUMO network
• assignment of the signal programs to the individual signal systems
Static data: Network generation

Creation of missing static data
Static data: Signal systems

Modeling of signaling systems and dependencies
Simulating Traffic Networks

Dynamic data
Static data: Sources

- Intersection Side Maps
- 360° Video
- Aerial / Satellite Data
- Open Map Data
- Municipal Map Data
- Traffic Light Schedules
- Streetview Data

- Passive Infrared Sensors
- Smart Cameras
- Automatic number-plate recognition
- Data Donation via App

- Macroscopic Sensor Data
- General Data Protection Regulation Compliance

Network Generation

Real Data Integration

Computed Microscopic Route Data

Real Microscopic Route Data

Evaluation

Simulation

Static data: Sources

Passive Infrared Sensors
  • traffic volume measurement
  • measurement of traffic speed
  • differentiation of different road users by vehicle length

Smart Cameras
  • measurement of turning behavior at individual intersections
  • AI-based differentiation of different road users

Further sensor technology for
  • public transport: capacity utilization, delay...
  • shared mobility: positioning, availability...
  • non-motorized individual transport: bicycles, pedestrian walkways...

Dynamic data: Positioning of smart cameras

Depends on requirements

- turning behavior at intersections
  - two cameras per intersection, each measuring two directions of travel
  - viewing direction diagonally across the intersection
  - traffic light pole

- speed, flow
  - measurement in free flowing traffic
  - viewing direction away from the intersection
  - traffic light pole or lamppost.
Dynamic data: Data output

- sensors send data to traffic computer
- data is copied to high-performance timeseries database
- SUMO and other applications access the database
Dynamic data: Database
Dynamic data: Routing and demand modeling

- sensors only measure macroscopic count data

- microscopic simulation means
  - simulation of all road users as individuals
  - individuals drive from origin-destination
  - all individuals follow fixed routes

⇒ How can routes be generated from count data?
Dynamic data: Routing and Demand Modeling

SUMO Demand Modeling Algorithms

- assignment of sensors to positions in the traffic network
- retrieving sensor data for the simulation period from the database
- data cleansing and conversion (routes to lanes, units)
- generation of routes for each vehicle so that
  - # vehicles measured at the measurement points matches the simulation
  - avg. simulated speeds with the avg measured speeds match the measured speeds
  - excess vehicles leave the network at other positions or missing vehicles start at other positions
- estimation or randomization of
  - individual routes and speeds
  - driving behavior: Overtaking, acceleration, safety distances
  - vehicle parameters: dimensions, consumption, environmental impact
Simulating Traffic Networks

Outlook
Outlook

Next Goals
• collection and fusion of traffic data
• analysis, simulation and forecasting

Motivation
• identification of possibilities for promotion of alternative means of transport
• development of effective solutions to improve traffic flow and mobility in cities
• contributing to the creation of more pleasant and environmentally friendly urban traffic environments

Challenges
• data situation, fusion, metadata
• macroscopic data vs. microscopic simulation
Completely without personal reference

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Without any personal reference!

But close to reality!

today