Testing and Validating Autonomous Vehicles using PTV Vissim Traffic Simulator with a Case Study in Dubai

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www.sdcongress.com
Experience and expertise.
PTV Vissim
product introduction
What is PTV Vissim?

Multimodal microscopic traffic flow simulation

- Individual entities
  - Cars, trucks, busses, bikes, pedestrians

- Traffic flow model which moves each participant according to sophisticated movement model
- Full traffic control model (traffic signals, VMS, etc.)
Traffic Simulation

- Multimodal
- Test before implementation / real world tests
- Evaluate impact on
  - Throughput
  - Traffic flow
  - Safety
- Optimize Signals
SIMULATING DRIVING BEHAVIOUR

The modelling of driving behaviour is the core of traffic simulation. Vehicle movement models are a key element in being able to replay dynamics in a realistic manner.

A distinction is made between three models:

1. FREE DRIVING
The driver proceeds at his or her desired speed provided there are no obstacles in front of him or her. Such obstacles may include, for example, slow moving vehicles or traffic lights or potential collisions with vehicles changing lanes.

2. APPROACHING
The driver recognizes that there is a slow moving vehicle in front of him or her and brakes within the desired gap in PTV Visum. It is possible to define different driver and vehicle characteristics for different vehicle classes and types, such as the rate of deceleration when approaching the vehicle in front.

3. FOLLOWING
The driver tries to maintain his or her distance from the vehicle in front. When following it, however, the distance between the two vehicles oscillates - sometimes the speed is slightly higher, sometimes lower.

4. BRAKING
If a vehicle reduces its speed downstream, then the vehicle behind must also brake. For each vehicle, Visum checks in each simulation step the distance and the differences in speed in relation to the vehicle in front.

LANE CHANGING

There are two different types of lane changing:

1. FREE LANE CHANGING
Free lane changing takes place when overtaking slow moving vehicles, i.e. when an individual's desired speed is higher than the person in front. Attention must be paid to ensure that vehicles in the other lane are not unduly affected by this.

2. NECESSARY LANE CHANGING
This occurs if the driver needs to change lane, e.g. in order to follow a route. The closer the driver gets to the decision making point, the more aggressively the driver behaves and is prepared to accept the hindrances posed by other drivers. Other vehicles also cooperate in order to allow the driver to change lanes.

LATERAL BEHAVIOUR WITHIN A LANE

ONLY IN PTV Visum

NON-LANE BASED BEHAVIOUR
The choice of position within a lane is always important if vehicles are able to overtake each other in particular lanes and are able to be side-by-side. This is the case on cycle paths or on regular streets in certain regions, for example.

http://vision-traffic.ptvgroup.com
Traffic Engineering

Capacity analysis

- Proof that performance (traffic flow) is ensured

Testing of signal controllers

- Ensure quality of signal controllers of traffic responding signals

Visualization

- Demonstrate new infrastructure solution to non-engineers, e.g. decision makers

Traffic is very stochastic: Not interested at single scenarios / situations → all possible scenarios

Monte Carlo simulations with different situations
  e.g. driver characteristics, varying demand (AM/PM peak), weather conditions, etc.
Requirements

Traffic engineer

- Important: Road capacity
- Sacrificing: individual behavior, e.g. acceleration

Automotive, change in priorities

- Important: realistic individual behavior
- Not-important: road capacity
CoEXist is a European project (May 2017 – April 2020) which aims at preparing the transition phase during which automated and conventional vehicles will co-exist on cities’ roads.

The mission of CoEXist is to systematically increase the capacity of road authorities and other urban mobility stakeholders to get ready for the transition towards a shared road network with an increasing number of automated vehicles, using the same road network as conventional vehicles.

CoEXist aims at enabling mobility stakeholders to get “AV-ready” (Automated Vehicles-ready). To achieve its objective, CoEXist develops a specific framework and both microscopic and macroscopic traffic models that take the introduction of automated vehicles into account.

The tools developed in the framework of CoEXist are tested by road authorities in the four project cities: Helmond (NL), Milton Keynes (UK), Gothenburg (SE) and Stuttgart (DE) in order to assess the “AV-readiness” of their local-designed use cases.

https://www.h2020-coexist.eu
CoEXist – WP2: AV-ready microscopic and macroscopic traffic modelling tools

- Demand Modelling
  - Capacity
  - Volume – Delay Function
Data collection & validation of AV-ready microscopic traffic flow simulator

Collect data of two CAV on the public test site for validation of microscopic modelling tool
Results

Safety distance without connection much higher than in the communication case.
Automated vehicles simulation

Addition of new driving behaviors to replicated connected & automated vehicles.
Platooning

- Major Platoon Changes
- Advanced Following
- Vehicle Class dependant behavior
- Platoon Interaction
- Lane based behavior
- Platoon Creation
- Vehicle Leaving Platoon
North entry: autonomous vehicles (AVs)
Cycle time: 53 / 60

East entry: mixed flow (AVs & CAVs)
Cycle time: 53 / 60

West entry: conventional cars only
Cycle time: 53 / 60

South entry: connected autonomous vehicles (CAVs)
Cycle time: 53 / 60

Fuel Consumption
- S-N (CAVs)
- E-W (AVs + CAVs)
- N-S (AVs)
- W-E (cars)

Number of Stops
- S-N (CAVs)
- E-W (AVs + CAVs)
- N-S (AVs)
- W-E (cars)
CoEXist – WP4:
Demonstration of CoEXist tools in road authorities

Milton Keynes
TRL & University of Cambridge

Gothenburg (VTI)

Helmond (TASS)

Stuttgart
University of Stuttgart

Microscopic

Macroscopic
Why co-simulation?
Challenges

- Inclusion of unexpected or non-connected objects
- Scenario completeness
- Self organization of vehicles
- Unrealistic/Unachievable scenario
Solutions

- Vehicle sensing (object detection)
- Vehicle communication (other vehicle or pedestrian's intent)
- Running different scenarios taking into account intentions
- Real-world physics
- Results analysis and visualization
- Vehicle dispatching
Solutions

- Vehicular Communication
- Vehicle Dynamics
- Vehicle dispatching
- Traffic Simulation
- Vehicle Sensing
- Results analysis

Information Classification: General
Simulation package PTV Vissim

PTV Vissim provides traffic in the simulation tool chain and a link to:

- Sensor simulation like PreScan, ...
- Vehicle dynamics like CarMaker, VTD...
- Visualization with rFpro, ...
DrivingSimulator.DLL Interface

Applications

- External vehicle control
  - Human-in-the-loop (HITL) → Driving simulator
  - Software / Hardware-in-the-loop (SIL / HIL)

- Positions in world coordinates are exchanged, the external vehicle can be moved completely freely inside the network.

- Existing example for Unity

Unity

AR windshield

- prognosed trajectory
- greenband for signals
- route in automated mode
Example: Co-Simulation Vissim + CarMaker
Case Study: City Walk, Dubai
Study Location

Intersection of Al Safa Street with Al Mustaqbal Street in City Walk, Dubai.
Simulation Results

It is expected that increasing AVs fleet will manage to decrease the delay in the model. In the first case study scenario, the average network delay in the base model (0% AVs) is 57 seconds. The number goes down as the AVs percentage goes up.

<table>
<thead>
<tr>
<th>AV Percentage</th>
<th>Base model Average Delay [s]</th>
<th>AV Average Delay [s]</th>
<th>Network Difference</th>
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</thead>
<tbody>
<tr>
<td>0%</td>
<td>57</td>
<td>57</td>
<td>0%</td>
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<tr>
<td>20%</td>
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<td></td>
<td>-20%</td>
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<td>80%</td>
<td>41</td>
<td></td>
<td>-28%</td>
</tr>
<tr>
<td>100%</td>
<td>35</td>
<td></td>
<td>-39%</td>
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</tbody>
</table>
Simulation Results

When platooning is active, the simulation results shows better results for the overall network average delay.

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<td>100%</td>
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<td>26</td>
<td>-55%</td>
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</tbody>
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Simulation Results

Impact of Platooning on Network Delay

Average Delay

With Platooning
Without Platooning

CAV/AV Percentage
Platooning Parameters

Platooning in Vissim has different parameters to be set by the user depending on his or her preference. In this scenario, the following parameters were used to model a suitable platooning:

• **Maximum number of platoon vehicles;**
  5 vehicles

• **Maximum platoon approach distance;** 50 m

• **Maximum platoon desired speed;** 70 km/hr

• **Platooning follow-up gap time;** 0.1

• **Platooning minimum headway;** 0.5
Questions?