Integrating SUMO in an urban digital twin - a case study from Munich

SUMO User Conference
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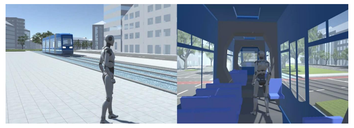
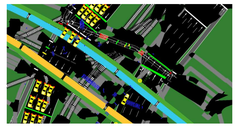
Introduction

- The presented work is part of the accompanying research for the city of Munich, namely the "GeodatenService", within the project Digital Twin Munich, DZ-M ("Digitaler Zwilling München"), which is funded by the Federal Ministry for Digital and Transport. For more information please visit:
- https://muenchen.digital/twin/ .

München. Digital. Twin.

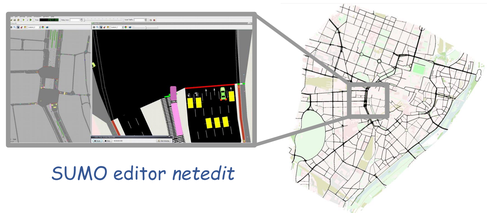
Interactive visualization example of induction loop records and predictions

- The city of Munich conducted a data collection campaign where data from aerial images and multiple on-ground sensors were fused to extract geographical data including road geometries and lane markings
- A convertor has been developed to extract the necessary attributes from the point cloud to generate SUMO-PlainXML files. Using the NETCONVERT, a SUMO network and its corresponding OpenDrive were generated, which was then used by another convertor to create a network based on the CityGML 3.0 standard
- The later format allows for integrating the network objects as well as the results of the simulation of the simulation in a wider set of geographical applications such as Cesium for not only 3D visualisations, but also storing the data in 3DCityDatabase (3DCityDB) or even coupling the simulation with game engines


Methodological Approaches Using SUMO

- OpenStreetMap-based **SUMO network** is **manually calibrated using semantic streetspace data** in order to be as accurate as possible

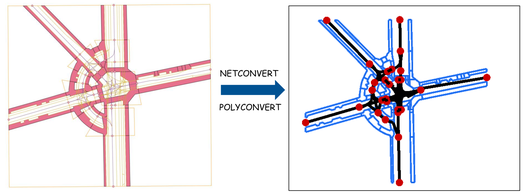


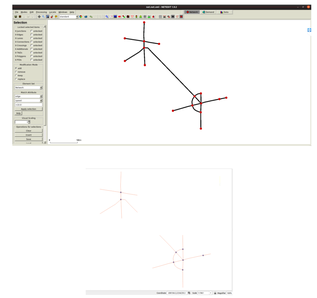
SUMO editor *netedit*

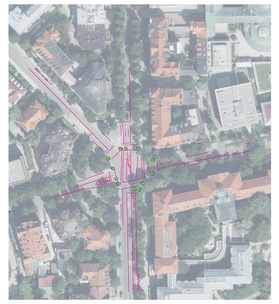
- Our typical SUMO data exports include information for certain **time-stamps** relative to the starting time of the simulation on
  - **location**
  - **orientation angle** (0-360 degrees), going clockwise with 0 at the 12 o'clock position
  - **type** of traffic member (cars, trucks, bicycles, etc.)

	A	B	C	D	E	F	G
1	time	id	x	y	angle	type	lane
2	0	0	11,583913	48,192072	175,83748	car	276642029#0_0
3	1	0	11,583914	48,192055	175,83748	car	276642029#0_0
4	2	0	11,583916	48,192025	175,83748	car	276642029#0_0
5	2	3	11,591208	48,189008	357,27886	car	549060#3_0
6	2	4	11,58247	48,186858	87,596445	car	152068752#6_0
7	3	0	11,583919	48,191977	175,83748	car	276642029#0_0
8	3	3	11,591185	48,189024	335,01492	car	:2973608071_10_0

Lanemodel conversion to SUMO network

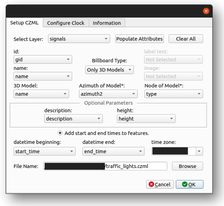






Dynamic web visualization of traffic light signals

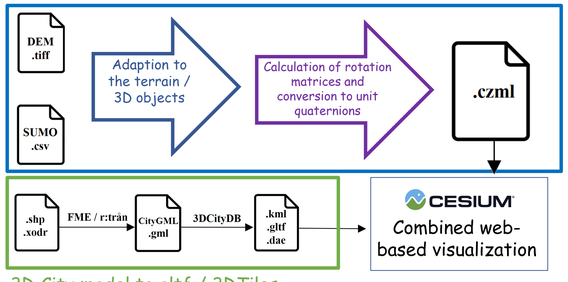
https://plugins.qgis.org/plugins/CZMLBillboardMaker/



- QGIS plugin developed (openly available)
- Read point based vector layers
- Set start and end times
- Set time intervals in which objects should be visible (color phases green / yellow / red)
- Specify 3D models according to types (pedestrian / vehicle)
- 36 traffic signals of a selected intersection exported to CZML files

Converting SUMO simulation results to the Cesium Language (CZML) (2)

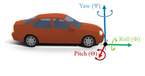
Traffic flow simulation results to CZML



3D City model to gltf / 3DTiles

Converting SUMO simulation results to the Cesium Language (CZML) (2)

time	id	x	y	angle	type	lane
0	0	11,583913	48,192072	175,83748	car	276642029#0_0
1	0	11,583914	48,192055	175,83748	car	276642029#0_0



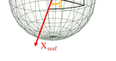
Set local **Yaw** (orientation) and **Pitch** (slope) angles

⇩

Convert to unit quaternions (Q1)

⇩

Repeat for each time stamp



Convert local **longitude** and **latitude** to corresponding Euler angles, so that 3D model is placed on **local tangent plane**

⇩

Convert to unit quaternions (Q2)

⇩

Multiply resulting quaternions (Q1 x Q2)

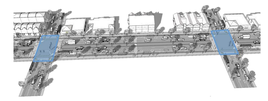
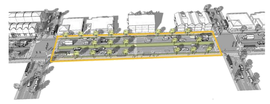
⇩

⇨

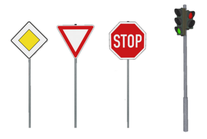
```
"orientation" : {
"epoch" : "2021-10-18T09:03:49.449Z",
"unitQuaternion" : [
[ 0.0, -0.2107110123792602, -0.3013600122118491,
  -0.6864276860642915, -0.6273755109476252,
  1.0  -0.2162193200048801B, -0.2974324100098577,
  -0.6978521288546177,  -0.6146426387242255,
  ...
```

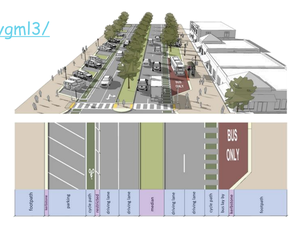
Modeling the street space using CityGML

- International OGC standard for modelling semantic 3D city models
- Concepts for representing the street space (roads, city furniture, vegetation)
- Tools for deriving efficient web-based visualizations (e.g. 3DCityDB)

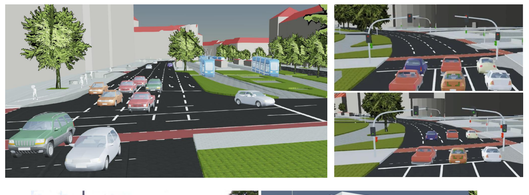



- https://tum-gis.github.io/road2citygml3/





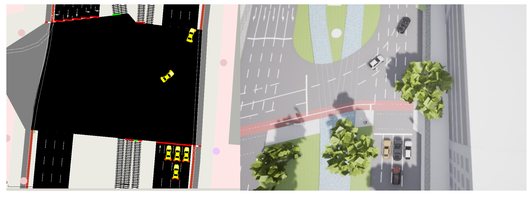
Selected Visualization Examples: Dynamic and web-based 4D visualization of traffic simulations



Access videos, demos and more information here:

http://go.tum.de/132082

Interfacing SUMO with Game Engines – VR Simulators and Demonstrators



Tested interfaces with Unity 3D and CARLA for the scenario of Sonnenstraße in Munich


Videos on VR applications, demonstrators and simulators:

References

Beil, C., Kendir, M., Ruhdorfer, R., & Kolbe, T. H. (2022). DYNAMIC AND WEB-BASED 4D VISUALIZATION OF STREETSPACE ACTIVITIES DERIVED FROM TRAFFIC SIMULATIONS AND SEMANTIC 3D CITY MODELS. ISPRS Annals of Photogrammetry, Remote Sensing & Spatial Information Sciences, 10.

Beil, C., Ruhdorfer, R., Coduro, T., & Kolbe, T. H. (2020). Detailed streetspace modelling for multiple applications: Discussions on the proposed CityGML 3.0 transportation model. ISPRS International Journal of Geo-Information, 9(10), 603.

Amini, S., Ambühl, L., Tilg, G., Bogenberger, K., & Menendez, M. (2020). Generating and calibrating large-scale, mesoscopic SUMO networks. In SUMO User Conference 2020.

Keler, A., Amini, S., Lindner, J., & Bogenberger, K. (2023). Introducing Data-Format-Dependent Road Network Conversion Techniques – Lessons Learned from the Digital Twin Munich. In GISRUK 2023.

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