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Web-based visualization of static and dynamic HD road traffic map layers

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Abstract:

So called high-definition road maps (Elghazaly et al. 2023) are considered an essential pre-requisite for cooperative, connected and automated mobility (CCAM). In contrast to standard-definition (SD) road maps, high-definition (HD) road maps represent the road environment at centimetre-level precision with additional semantic information at lane-level. HD road maps are typically composed from raw survey vehicle data, either using an automated process (Bellusci et al. 2024; Bao et al. 2022) or a semi-automated process (Rehrl et al. 2022). For digitally representing HD road maps, different HD map formats are in use such as ASAM OpenDRIVE© (ASAM 2020) or Lanelet2 (Poggenhans et al. 2018). While the map formats provide a comprehensive set of map features, it is still discussed, which map features are supporting which use cases. At least, typical HD road maps contain the following static map features (Rehrl et al. 2022): (1) Lanes for different types of motorized vehicles including shapes and types of lane borders, (2) lanes and areas for non-motorized traffic such as bicycle lanes or pedestrian areas and crossings, (3) topological information (e.g. allowed left or right turns) and (4) traffic regulations (e.g. traffic signs, traffic signals). Beside representing the static road infrastructure, HD road maps may also be enhanced with additional dynamic or semi-dynamic features or attributes such as (1) real-time accessibility of lanes or areas, (2) signal states of traffic lights linked to the regulated lanes and (3) real-time or predicted driving states and intentions of motorized or non-motorized traffic participants

While HD road maps are typically interpreted by automated driving systems (ADS), there exist several use cases where a 2D or 3D visualization is needed (Beil et al. 2020). An example use case is concerned with quality assessment, e.g. visually inspecting positional accuracy of map elements or the correctness of semantic information of map features. Another example use case is concerned with the visualization of real-time or historically captured data for assessing and interpreting driving situations. Given different use cases, the requirements for visualizing a HD map may change. While assessing precision of map features requires an accurate spatial visualization, interpreting driving situations requires to accurately visualize the real-time state at a specific moment or timespan including additional information such as signal or driving states as well as predicted information. When it comes to visualization of HD maps with GIS technologies, the elements of the logical HD road map formats must be transformed to a GIS model based on open formats (Scholz 2020). In addition, Cudoro (2018) as well as Beil et al. (2020) discuss different visualization approaches.

Web-based rendering of static and dynamic HD road map layers

Our proposed approach for a Web-based visualization of dynamic HD road traffic maps uses different static and dynamic map layers. The static vector tile layers are styled with Maputnik[1] according to the MapLibre Style Spec[2] and served by a GeoServer[3]. The data for generating the static map layers is accessed via a PostGIS datastore from the database used by Graphium HD[4], which is an HD extension to the open-source software Graphium for managing transport networks. The Graphium HD data model extends the Graphium data model with lane-level semantics such as stop lines, lane border styles, bicycle paths, pedestrian crossings or turn information. The data for the internal static lane-level model of an intersection (Figure 1) is converted from a Lanelet2 file to the Graphium HD model. Currently, only the conversion from Lanelet2 to the Graphium HD model is supported, in the future, converters for other formats like ASAM OpenDRIVE© can be added as well.

[1] https://maputnik.github.io/
[2] https://maplibre.org/maplibre-style-spec/
[3] https://geoserver.org
[4] https://github.com/graphium-project

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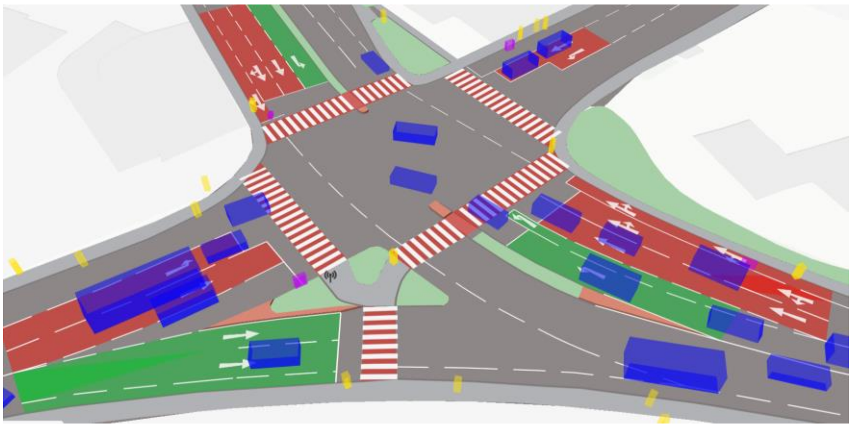

Figure 1. Example of static (lanes, cycling lanes, pedestrian crossings) and dynamic (signal states, vehicles in blue, pedestrians in yellow, 2-wheelers in magenta) road map layers styled with Maputnik and rendered as vector tiles by a GeoServe

The dynamic map layers (signal states, current traffic state) are generated in real-time and either change the styling of static layers based on dynamic attributes (e.g. signal states for turn lanes or pedestrian crossings) or as dynamic overlays (e.g. bounding boxes for vehicles, two-wheelers or pedestrians). The signal states are transmitted every second from a traffic light controller as signal phase and timing (SPAT) messages (Wágner et al. 2023), traffic states at the intersection are generated by a LIDAR-based multi object tracking (MOT) system as collective perception messages (CPMs) (Schiegg et al. 2020).

The talk addresses different challenges and findings in the context of Web-based visualizations of static and dynamic HD road map layers, e.g. keeping track between static and dynamic map information (e.g. which traffic signal state corresponds to which turn lane), interactively selecting static and dynamic layers for different use cases, establishing an appropriate real-time data pipeline for high frequency data sources (e.g. several times per seconds for CPMs) or visualizing semantic attributes at lane-level accuracy. The work contributes to a more detailed understanding of visualizing HD road traffic maps and provides the foundations for different applications in the field of CCAM.

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