Poster: cOSMetic – Towards Reliable OSM to Sumo Network Conversion

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I. Introduction and Related Work

Realistic map data is the basis for meaningful simulation studies of Inter-Vehicle Communication (IVC) applications and protocols [1]. Synthetic scenarios such as isolated intersections or a perfectly laid-out grid do not feature the typical mix of low and high traffic density roads and can therefore not be used as a representative scenario for (sub)urban traffic [2].

Ideally, crowd-sourced geodata including streets, buildings, parking spaces, traffic lights, or bus stops is used to generate the required mobility. One possible source for this data is OpenStreetMap (OSM), a community-run project with the goal to create a free map of the world. Unfortunately, traffic simulators such as SUMO [3] are unable to directly operate on OSM maps but have to convert them first. However, the large number of contributors to OSM causes inconsistent modeling, making the conversion to SUMO maps a challenging task, often leading to broken intersections that can cause deadlocks.

This is the main reason why different research groups created public scenarios for the simulation of (IVC in) urban traffic. Uppoor et al. present a manually repaired map of Cologne, Germany and state that without manual correction of the OSM data, the results were "plain unusable" [4]. Similarly, Codeca et al. prepared a map of Luxembourg [5] including many features relevant for IVC simulation. Manually generating these maps is an extensive and time-consuming task, often not possible due to limited resources.

In this article, we present a new approach to convert OSM to SUMO networks: By limiting the complexity of the OSM network to an absolute minimum—only consisting of junctions and streets—we want to eliminate the source of conversion errors and find out what level of detail is required for the realistic simulation of vehicular networks. Reducing a road network obtained from OSM to only junctions and streets is a challenging task as we will show in this article.

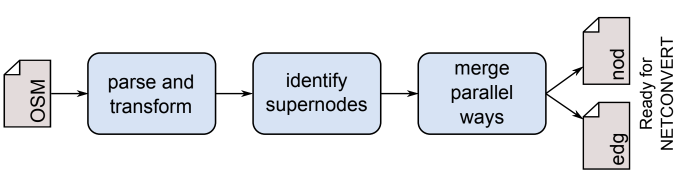


Figure 1. Conversion of OSM data to node and edge definitions.

II. OSM and Sumo Networks

There are slight but important differences in the way road networks are modeled in OSM and SUMO.

In OSM, road networks are represented by nodes and ways. While nodes are (annotated) points in two-dimensional space, each way is an ordered list of nodes with additional tags (key-value pairs). Roads are ways tagged as 'highway' and the type of street (e.g., 'primary', 'residential', etc.). By default, ways can be used in both directions, one-way streets are tagged.

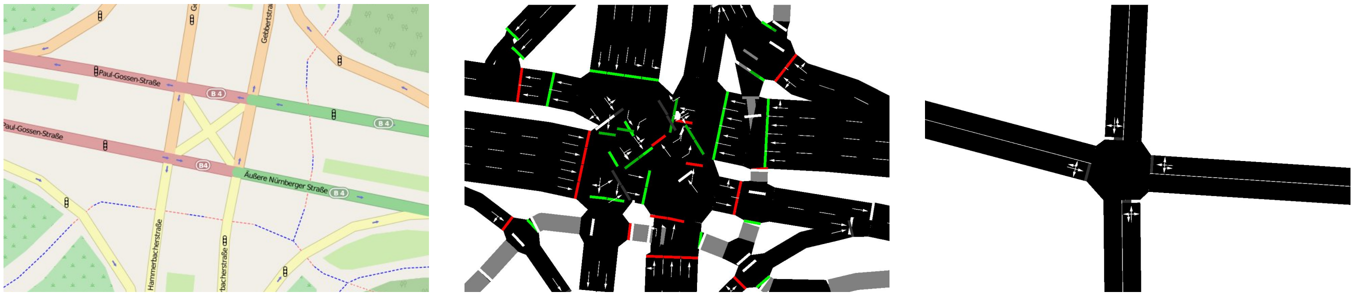
There is no explicit representation of intersections—they are simply given by nodes that are part of multiple ways. Turn lanes as well as dual carriageways (i.e., streets separated by a central barrier) are modeled as separate ways.

Similarly, SUMO road networks can be generated using node and edge definitions. Again, nodes are two-dimensional points, however, roads are modeled using edges consisting of exactly one start node and one end node. In addition, edges may contain an additional list of positions specifying their shape. Contrary to OSM, edges in SUMO are unidirectional, traffic in both directions requires a second edge with mirrored origin and destination nodes.

The biggest difference is that in the final SUMO network (created using nodes and edges) intersections are not modeled using normal nodes and edges, but are defined by the junction and connection tags. The problem is identifying which nodes and ways in the OSM network really represent junctions and streets, and which are just auxiliary elements within an intersection.

III. Conversion Process

cOSMetic is a collection of Python scripts for converting OSM map data to simple node and edge definitions for the SUMO NETCONVERT tool to generate maps (see Figure 1). The internal architecture can be seen as a pipeline in which each component acts as a filter on its input, removing unwanted complexity from the network. The idea behind our work is to use NETCONVERT with such a simplified version of the road network so that the generation of the SUMO map is trivial—while still preserving the approximate road topology. This is illustrated in Figure 2: In OSM the shown intersection is modeled using multiple nodes and ways to account for lane connections and turn restrictions. Feeding this OSM map directly to NETCONVERT results in a broken intersection that cannot be used for traffic simulation. Although NETCONVERT



(a) Original OSM map[1] (b) SUMO Map without cOSMetic (c) Fully simplified with cOSMetic

Figure 2. The complex modeling of intersections in OSM leads to broken SUMO maps that can be fixed using cOSMetic.

does have many parameters and switches, we were unable to configure it in a way so that the intersection is properly converted. In the rightmost figure, we show the intersection as modeled using cOSMetic with minimum detail, where all nodes and dual carriageways are merged.

When parsing the OSM XML file, nodes and ways are extracted and node coordinates are transformed into Cartesian coordinates. The challenging part is to identify clusters of nodes that conceptually form an intersection (in Figure 2a, an intersection is modeled using over a dozen nodes). The goal of cOSMetic is to substitute all nodes in such a cluster with one supernode henceforth representing the entire intersection. This is done by consecutively merging nodes of the cluster until only one remains. The position of this supernode will be set to the center of the area spanned by all merged nodes.

Identifying which nodes belong to the same cluster is done by making use of the street names that are usually included in the OSM network. The existence of street names is a requirement for cOSMetic to work properly. If the set of street names connected to one node is a subset of another node within close proximity, the nodes are merged as the first one is very likely an auxiliary node to model lane-to-lane connections. In a second step, nodes near the newly generated supernode are merged into the supernode if the intersecting set of street names for both nodes is not empty, i.e., if there is at least one street going through both nodes. Eliminating these additional nodes in an intersection already leads to a considerable improvement in map quality when using NETCONVERT.

We found that the proximity parameter plays an important role for the proper deletion of redundant nodes. However, a fixed value for all intersections will lead to undesired effects. We therefore chose a value depending on the type of street, using a greater radius for freeways and smaller one for residential crossings.

Next, we attempt to merge dual carriageway roads that are mapped using two (almost) parallel ways in OSM. These are roads where opposite traffic flows are physically separated by a guard rail or a median strip. This separation is not needed in the simulator as vehicles can neither swerve into oncoming traffic, nor can they turn when there is no lane-to-lane connection.

We found that many intersections are converted erroneously when dual carriageways are involved. To detect these roads, all ways using our newly generated supernode are examined and compared to each other. If the angle between two ways lies below a certain threshold and both ways share the same street name, they are merged. In Figure 2c, the simplified intersection is then no longer served by parallel edges.

After all obsolete nodes and streets have been merged, the remaining ones are written out into edge and node XML definition that can be used as an input to NETCONVERT.

IV. NEXT STEPS

Our goal is to create maps as simple as possible while still containing the detail necessary for IVC simulation. cOSMetic does not discard the necessary information for this during the conversion of OSM networks and can be configured to incorporate speed limits, lane count, turn restrictions, and even traffic lights into the XML output. By gradually increasing the level of map detail, we want to find the ideal balance between simplicity and detail. This can be done by evaluating different metrics and comparing them in validated scenarios such as LuST [5]. Depending on the research interest, these metrics can be traffic-related such as travel times or CO_2 emissions, but can also include metrics from a networking perspective such as neighbor count of a vehicle or even packet loss.

cOSMetic will be made available under a non-restrictive open-source license.

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