A Railway Simulation Landscape Creation Tool Chain Considering OpenStreetMap Geo Data

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Overview

- Motivation
  - Railway driver’s cab simulation RailSET
  - OpenStreetMap (OSM)

- Approach
  - Defining OSM Layers
  - The OSM-4-Railway tool chain
  - Excursus: railML infrastructure
  - The SimWorld tool chain
  - Adapting the SimWorld tool chain

- Implementation

- Summary
Motivation
Railway Driver’s Cab Simulation RailSET*

- **Purpose:** Human Factors analyses for train drivers
- **Requires:** realistic 3D model of the railway line to be used for simulation (topology, geometry)

* RailSET = Railway Simulation Environment for Train Drivers and Operators
Motivation

Initial Situation

- Simulation in the RailSET laboratory is based on ZUSI
Motivation

Initial Situation

Simulation in the RailSET laboratory is based on ZUSI

Source: www.zusi.de
Motivation
Initial Situation – Problems

- The number of lines to be simulated within the RailSET laboratory environment is limited
- The generation of tracks/lines for simulation is expensive (time, students)
- Zusi does not consider the combination with existing real geo data, e.g. digital terrain models
- Currently, it is not possible to model/visualize/simulate arbitrary lines in short term

- **Goal:** to model, visualize and simulate arbitrary tracks within the RailSET laboratory environment
- **Task:** Concept and implementation of a process chain for simulation-based scenario and landscape generation using existing geo data sources
Motivation
OpenStreetMap

- OpenStreetMap (OSM) project was founded in 2004
- Goal: free world map

<table>
<thead>
<tr>
<th>#users</th>
<th>1,591,275</th>
</tr>
</thead>
<tbody>
<tr>
<td>#GPS points</td>
<td>3,938,715,439</td>
</tr>
<tr>
<td>#nodes</td>
<td>2,301,912,824</td>
</tr>
<tr>
<td>#ways</td>
<td>228,191,041</td>
</tr>
<tr>
<td>#GPX files 14.04.2014</td>
<td>224</td>
</tr>
<tr>
<td>Size Planet.osm</td>
<td>&gt;400 GB (29 GB compressed)</td>
</tr>
</tbody>
</table>

Sources:
- OpenStreetMap stats report run at 2014-04-15 00:00:14 +0000; http://www.openstreetmap.org/stats/data_stats.html
- Planet.osm; http://wiki.openstreetmap.org/wiki/Planet.osm
Motivation
OSM Data Model

- OpenStreetMap (OSM) project was founded in 2004
- Goal: free world map
- Data model: “the simplest thing that could possibly work” (Ramm, 2010)

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Tag: Key-Value pair
e.g. Key = “railway“, Value = “subway“

TABLE I
The basic OSM data types and their attributes

<table>
<thead>
<tr>
<th>nodes</th>
<th>ways</th>
<th>relations</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>id</td>
<td>id</td>
</tr>
<tr>
<td>version</td>
<td>version</td>
<td>version</td>
</tr>
<tr>
<td>timestamp</td>
<td>timestamp</td>
<td>timestamp</td>
</tr>
<tr>
<td>changeset ID</td>
<td>changeset ID</td>
<td>changeset ID</td>
</tr>
<tr>
<td>visible</td>
<td>visible</td>
<td>visible</td>
</tr>
<tr>
<td>latitude</td>
<td>{wayNodes}</td>
<td>{relationMembers}</td>
</tr>
<tr>
<td>longitude</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tile</td>
<td>+ tags</td>
<td>+ tags</td>
</tr>
</tbody>
</table>

Motivation
OSM Railway Tag

- Railway data are not that exactly modelled like roads and streets
- There are 388 different values for the tag „railway“ [4]

<table>
<thead>
<tr>
<th>abandoned</th>
<th>construction</th>
<th>disused</th>
<th>funicular</th>
</tr>
</thead>
<tbody>
<tr>
<td>light_rail</td>
<td>miniature</td>
<td>monorail</td>
<td>narrow_gauge</td>
</tr>
<tr>
<td>preserved</td>
<td>rail 52.8%</td>
<td>subway</td>
<td>tram</td>
</tr>
<tr>
<td>halt</td>
<td>station</td>
<td>tram_stop</td>
<td>buffer_stop</td>
</tr>
<tr>
<td>derail</td>
<td>crossing</td>
<td>level_crossing</td>
<td>turntable</td>
</tr>
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Motivation
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<tr>
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<td>cross</td>
<td></td>
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</tr>
</tbody>
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Map-matching / routing: There is no clear topological and geometrical map representation.

- How to use these data e.g. for building a simulation environment?
Approach

OSM Layers

Regarding the OSM data model there are only three „layers“:

- Nodes
- Ways
- Relations

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Approach

OSM Layers

Regarding the OSM data model there are only three „layers“:

- **Nodes**
  - Coordinates Layer

- **Ways**
  - Referencing nodes

- **Relations**
  - Referencing nodes, ways and relations
Approach
New OSM Layers

➔ We want to define topic-specific layers:

Nodes
➔ Coordinates Layer

Ways
Referencing nodes

Relations
Referencing nodes, ways and relations

Topology
Geometry
Approach
New OSM Layers

→ We want to define topic-specific layers:

**Nodes**
- Coordinates Layer

**Ways**
- Referencing nodes

**Relations**
- Referencing nodes, ways and relations

- New topic-specific tags for the nodes
- New topic-specific layers with new tags for the ways and relations
Approach
Layer-specific OSM tags

Table 1: Keys for railway topology modelling

<table>
<thead>
<tr>
<th>node</th>
<th>way</th>
<th>relation</th>
</tr>
</thead>
<tbody>
<tr>
<td>topologyName</td>
<td>topologyName</td>
<td>topologyName</td>
</tr>
<tr>
<td>dir</td>
<td></td>
<td>type = “connection”</td>
</tr>
<tr>
<td>length</td>
<td></td>
<td>course</td>
</tr>
</tbody>
</table>
We define 37 tags for the description of the railway track network as needed by most of the railway geodata applications.
Approach
The OSM-4-Railway Tool Chain

- **Topology Verification** …extract railway network and verify its topology (node edge model)
- **Railway Data Enhancement** …add layer-specific tags to the railway elements in the map
Approach
The OSM-4-Railway Tool Chain

- **Import** (enhanced) railway relevant data from OSM export into geo data base
- **Export** railway infrastructure data in exchange format railML version 2.2
Excursus

railML®

- Railway Markup Language
- XML-Schema-based description language
- Generic data exchange format for better communication between different IT applications in railways
- railML.org-Initiative
  - European railways (infrastructure managers and undertakers)
  - Software and consulting companies
  - Research facilities (universities, institutes)
- Sub-schemas:
  - Infrastructure
  - Timetable
  - Rollingstock

www.railML.org
Excursus: railML®
What is railML® Infrastructure?

- Track Topology
- Track Geometry
- Track Topography and railway service-relevant data

... Graph with Nodes and Edges
Excursus: railML®
What is railML® Infrastructure?

- Track Topology
- **Track Geometry**
- Track Topography and railway service-relevant data

... straight lines, curves, increasing/decreasing slope
Excursus: railML®
What is railML® Infrastructure?

- Track Topology
- Track Geometry
- Track Topography and railway service-relevant data

... signals, platforms, tunnels, electrification etc.

*Pictures: Böhringer, F.: Gleisselektive Ortung von Schienenfahrzeugen mit bordautonomer Sensorik; Dissertation; Karlsruhe, 2008*
Approach
SimWorld / Virtual World

Goal of project “Virtual World”:

- Create a *Digital Atlas* capable to describe multimodal metropolitan areas (road, rail, development, environment, infrastructure, ...)  
  - The *Digital Atlas* in the context of the project *Virtual World* will contain data about Braunschweig as a demonstration area as virtual test site (see also *AIM*) and will keep growing during project duration...

- Create a *tool chain*, that is able to generate automatically virtual worlds and logical road descriptions for driving and traffic simulations.

Approach
The SimWorld database

- database design (central component of integration platform)
  - designing database structure based of scene graph concept and OpenDRIVE
  - design of data interfaces for data import form various sources and for data export for applications using or refining this data

- database implementing
  - realising database in PostgreSQL / PostGIS
  - realising the exporters with OpenSceneGraph

- concept and prototype about integration and realising (including high grade of automation)
Approach
The SimWorld Tool Chain

- adding new data sources (from partners)
- adding new targets (for partners or third party use)

- full reuse of tool chain possible
- additional data in driving simulation available
Approach
Adapting the SimWorld Tool Chain

- Use Vires Track Editor to create railway lines for the RailSET simulation
- The result of the Track Editor is a 3D model of the railway line, which is fused with the 3D landscape model in the Trian3D-Builder software.
Implementation
RailSET Simulation Laboratory Environment

- The RailSiTe/RailSET laboratory is being adapted from ZUSI to Vires

Source: www.vires.com

- Vires-based simulations are used already in the Automotive Department of the Institute
Implementation
OSM-4-Railway tool chain

- The railway line from Braunschweig to Gifhorn has been selected for testing the tool chain implementation.
- Additionally, Vires built the railway reference line Braunschweig-Gifhorn within the AIM project for being used in the RailSET laboratory environment can be used as reference.
Implementation
OSM-4-Railway tool chain

- Export OSM data
Implementation
OSM-4-Railway tool chain

- OSM-4-Railway data verification and enhancement
Implementation
OSM-4-Railway tool chain

- Import into simulation scenario editor
Implementation
Vires Track Editor

- The resulting railML infrastructure file is imported into the Vires Track Editor
- Purpose: create a 3D railway line model based on the given topology and geometry.
Implementation

Result
Summary

- The current simulation environment of the railway driver’s cab laboratory RailSET is not able to include existing geo data from various sources.
- OpenStreetMap provides a free world map and an alternative to conventional geodata sources, which often lack of actuality or availability.
- The OSM data model is very simple defining only three basic data types: nodes, ways and relations; elements are parametrized by arbitrary tags, which are not sufficient for many applications, e.g. routing.
- **Layer approach**: we defined new topic-specific tags (layers), which enable OSM data usage providing track topology and track geometry; Many of the new tags can be calculated using existing OSM data.
- By adapting the SimWorld tool chain, spatial data from various sources can be fused for building an integrated model of the railway line.
- Future work will focus on the comparison of the OSM-based with the manual railway simulation landscape creation.
Thank you for your attention!

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