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ProZeit: An Automated Workflow of Optimizing Geometric Design of Railway Alignment for Travel Time Saving

Abstract

Railway is an important mean of regional passenger transportation and serves as a crucial infrastructure for the regional development as well. A successful timesaving of a scheduled railway route, e.g., 5~10 minutes, is of great interest in the railway industry, which could lead to an increase of the transportation capacity, a new railway station in a built-up area and enhancement of railway's competiveness among different transportation modes (Yang & Meng, 2011). However, the complexity of the railway system (Pyrgidis & Kontaxi, 2011) and the non-open nature of the design of railway infrastructure prohibit local industry initiatives to evaluate the desired improvements on the local railway infrastructure during early planning stage.

In this paper, we propose a novel workflow, *ProZeit* (Yang et al., 2013), to achieve the minute-level travel timesaving through optimizing the geometric design of the railway alignment at the early planning stage, which is a joint effort from both a cartographic department and a railway engineering department at TU Munich. With *ProZeit*, we attempt to answer following questions, which are 1) What data need to be collected? 2) Which level of construction is necessary to achieve minute-level travel timesaving? 3) What constraints should be taken into account? and 4) How to convey the proposed solution using geo-visualization techniques?

ProZeit comprises 6 steps, namely railway track surveying, track element detection, geo-context labelling, train performance simulation, maintenance site selection and geo-visualization. 1) Railway track surveying is to measure the geometric parameters of the railway track, e.g., curvature, length of the gauge, super elevation (cant), odometer and the coordinates of where measurements are taken, etc., which is done by Eurailscout using track surveying car SIM11. 2) With the track geometry data, a single railway track is modelled as a linear sequence of geometric elements, namely straight line, circular curve and transition curves among previous two, which enable further evaluation of speed-up performance of the train after changing the geometric parameters. 3) Based on the geometric representation of the existing railway alignment, geo-context information such as inhabited area, railway station, bridges, tunnels etc. are enriched manually in Google Earth. Since in real-world practise, not only technical regulations are to be satisfied, but also environmental impact of the increased of travel speed of the train need to be

taken into account, e.g., noise increase. 4) With concerns of both technical constraints and environmental impacts, maximum allowable speed and its required change of geometric design is calculated. Then, individual contribution to the total timesaving of the changed geometric elements is simulated using a Train Performance Calculator (TPC). 5) Furthermore, all geometric elements is ranked based on the benefit on time reduction and the corresponding cost of the maintenance work, i.e., tamping. For specified timesaving, minimum amount of the changed elements are selected. 6) In order to intuitively convey the proposed maintenance plan, cost-benefit of the individual changes on the track elements are visualized in Google Earth.

The workflow has been successfully applied in the planning of in total 7 railway routes in Bayern, Germany and has received quite many positive feedbacks from the industry partners. In the future development, we will focus on 1) developing a more sophisticated model to manage multiple linear attributes along the railway alignment using linear referencing; 2) using a robust filtering technique in track element detection which takes into account multiple measurements simultaneously, i.e., Kalman filter; 3) including vertical alignment for energy consumption estimations.

Keywords

Railway Engineering; Train Performance Calculator; Geometric Design; Site Selection; GeoVisualization

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