Cohesive routing service for indoor and outdoor navigation

Tao Feng, Joran Jessurun, Theo Arentze

Eindhoven University of Technology, The Netherlands

Abstract
Routing services play a fundamental role in the development of navigation systems. For indoor routing specifically, it allows the navigation among multiple floors and generates turn-by-turn navigation guidance. In the paper we present the proposed routing system, which has been developed in the context of the European i-Locate project. We discuss the extensions required for seamless outdoor-indoor routing and an application to illustrate the new system.

Keywords
IndoorGML, Turn-by-turn Navigation, Multi-modal routing, Navigation Graph, Indoor Geocoder

1 Introduction
Routing services play a fundamental role in the development of navigation systems. With given start and end locations, these services calculate the optimal route. Similar to outdoor route planning and navigation which has been well developed, indoor navigation has great potential of market benefits regarding way finding in public buildings. However, the development of indoor navigation has been delayed for long because of the different limitations in techniques for indoor localization. Nowadays, with the emergence of new localization techniques, it becomes highly interesting for different stakeholders to have the indoor navigation service on board to better address desires and needs of people regarding indoor navigation.

The main barriers which limit the use of hybrid indoor and outdoor location-based service (LBS) are the i) lack of indoor maps available as open data, ii) lack of technological ecosystems that can use this data for innovative location, routing and asset management services within indoor & outdoor scenarios, and iii) limited support to indoor/outdoor LBS by current GI standards. iLocate consortium is such a team who tackles all these issues in a comprehensive manner. Within the scope of iLocate project, we developed the routing service for both outdoor and indoor environments based on OpenTripPlanner (OTP) an open source platform for multi-modal (outdoor) routing. The new routing service developed in the context of i-Locate works for both indoor and outdoor routing, with specific added value to indoor routing and indoor graph building. The routing service supports multimodal routing from door-to-door in a seamless way across outdoor and indoor environments. It allows the navigation among multiple floors by incorporating stairs, elevators, open spaces, etc., and...
generates turn-by-turn navigation guidance which is specific for indoor routing.

2 Indoor and outdoor routing service

The routing service is built upon the combination of different datasets, including the Open Street Map (OSM), General Transit Feed Specification (GTFS) and indoorGML. The OSM and GTFS compromise the bases of multimodal routing for outdoor environment, while the indoorGML serves the routing for indoor environment. An integrated graph combining the three types of data is built for the cohesive outdoor and indoor routing service.

Specific to the outdoor routing, the indoor routing service we developed incorporates the standard of indoorGML data defined by OSG. A structured metadata set which includes all possible elements in an indoor environment is pre-defined according to the requirement of navigation graphs and path-finding algorithms. A graph builder is made to let the OTP import the indoorGML data, combine multiple indoor/outdoor graphs and build the navigation graph for indoor/outdoor navigation. The graph builder reads a configuration file using Spring Framework, allowing the flexibility of setting various parameters. It also embeds a special functionality which connects to the online i-Locate portal and catches the needed information for the indoor graphs. In this way, the indoorGML files can be on the local disk or if a URL is used it can be downloaded from a server.

2.1 Navigation graphs

An integrated navigation graph is then built by connecting the outdoor and indoor networks through pre-defined anchor nodes (building entrances). Depending on the different attributes of the anchor nodes, multiple indoor/outdoor graphs are interconnected to obtain one single graph. We implement new vertices and edges for indoor graphs as an extension of known types for outdoor routing, and apply the existing routing algorithm to find routes in the combined outdoor-indoor network.

2.2 Indoor geocoder

As additional support of indoor routing, we also developed an indoor geocoding service. Extending the existing outdoor geocoder, the indoor geocoding facility uses an extended indoor address to find the unique indoor location in terms of building floor level and X, Y coordinates which can be used for indoor routing. The extended geocoder looks into the properties stored in the indoorGML file.

3.3 Compliance with OpenLS

The routing service receives input parameters from clients as a routing request, finds the optimal route and sends it back together corresponding turn-by-turn directions to clients as a response. The request parameters are input to the routing API which is bundled as a Java Servlet on the web server. The routing algorithm requires time and location information from clients to find the specific optimal route. The start and end locations are represented as longitude, latitude and floor identifier (for indoor navigation). In addition, the routing service also represents preference parameters and/or constraints one may have in reality. We present the proposed routing system, which has been developed in the context of the European i-Locate project. We discuss the
extensions required for seamless outdoor-indoor routing and an application to illustrate the new system. A framework of the system for indoor and outdoor routing service is shown as below.

**Routing System - Data and API**

![Diagram of routing system](image)

**Figure 1: Framework of the indoor and outdoor routing service.**

**References**

- ✔ OTP, OpenTripPlanner, an open source multi-modal trip planner: [http://www.opentripplanner.org/](http://www.opentripplanner.org/)
- ✔ OSM, OpenStreetMap: [http://wiki.openstreetmap.org/wiki/Main_Page](http://wiki.openstreetmap.org/wiki/Main_Page)