New Applications based on collaborative geodata – the case of Routing

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Setting the scene

The successful collection of information by masses of volunteering individuals enabled by Web technology (otherwise referred to as Web 2.0) does not halt before the realm of geographic information. Information resources available for instance in the online-encyclopedia Wikipedia or the photo-sharing platform flickr are currently being extended with geographic information or geotags at an impressive rate.[1] Even more remarkable in the given context, several projects concentrating solely on the collection of geographic information have formed. Goodchild (2007) gives an overview of these global collaborations and calls the phenomenon Voluntary Geographic Information (VGI).

One of the most striking and sophisticated examples of VGI is the OpenStreetMap (OSM) project started in 2004. It aims at creating and collecting free vector geodata covering the whole planet. Its means are ordinary citizens vested with GPS-devices logging coordinates, out-of-copyright maps and aerial imagery provided by OSM-friendly companies (like Yahoo! Inc.). Deriving from these data sources geodata is then created. At the time of writing OSM counts ~60000 registered users: ~7000 of which have created or updated nodes and ~3000 have uploaded GPX tracks. Altogether the OSM dataset currently consists of roughly 270 Mio. nodes partly constituting 30 Mio. ways.[2] Haklay (2008) analysed the data quality of OSM data in England. One outcome of his analysis is the fact that against common expectation only very little quality assurance is being carried out upon the OSM data: Dividing England into grid cells of 1 km^2, it turns out that 50% of the area of England has been mapped by individual persons and 89.5% by only up to three individuals. Due to this and also due to its lack of completeness the dataset would not (yet) be suitable for more sophisticated purposes than 'cartographic products that display central areas of cities' (p.24).

However, in this paper we present an example of utilizing OSM data for a more sophisticated purpose. OpenRouteService (ORS) is a route service operating on OSM data (Neis 2008).[3] It has been launched in April 2008. The initial coverage of Germany has recently been extended to large parts of Europe including England (Figure 1). In this contribution we will first discuss ORS in further detail. This includes a brief evaluation of data fitness for routing as well as strength and problems of OSM data. Then we will detail a use case of ORS usage in an emergency management context followed by some key insights. Finally, future work and perspectives are presented.

OpenRouteService.org

The services available through the above URL implement open standards of the Open Geospatial Consortium (OGC), namely those defined in OpenGIS Location Services 1.1 (OGC 2005). Several Location-based Services are implemented. However, we focus on the Route Service implementation within this paper. ORS has been the first national route planner for pedestrian or bicycle routes making that option available even before companies like Google. Extending spatial coverage of the service is work in progress.

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[1] 2,7 million photos with geotags have been uploaded to http://flickr.com in the month of September 2008
[2] http://wiki.openstreetmap.org/index.php/Statistics
[3] http://www.openrouteservice.org

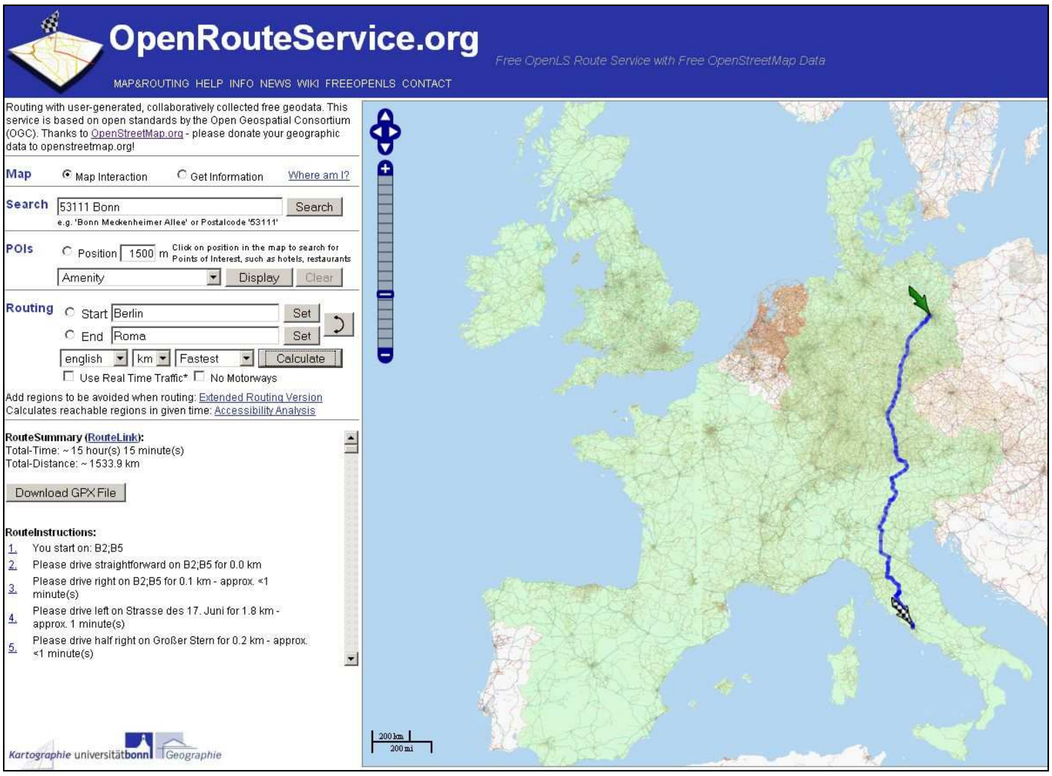


Figure 1: The OpenRouteService website with a route from Berlin to Rome. The light green overlay indicates coverage at the time of writing

Evaluation of data fitness for routing

Table 1 gives an overview of hits, total number of calculated routes and the number of failed route requests due to errors in street network since the service went online in April 2008. The percentage of failed route requests compiled from server log files gives a first indication of OSM data quality for routing. The decreasing percentage of failed route requests shows data quality has improved over time. Through the extension in service coverage to less well-mapped areas, this obvious trend is however somewhat obscured. The reduction of failed route requests can be ascribed to the use of ORS not only as a route planner, but also as a tool for data validation. Having noted this general trend of increasing data quality for routing, we discuss this issue in more detail. What are problems and strengths of the OSM dataset for a routing application?

Table 1: **ORS hits, route requests and failures due to errors in street network over the course of time**

Month/2008	**Hits**	**Route Requests**	**Failures**	**Percentage failed**
April	ca. 800	ca. 1.500[1]	ca. 150[1]	10%
June	ca. 4.200	ca. 5.700[1]	ca. 120[1]	2%
September	ca. 5.600	ca. 14.500[2]	ca. 650[2]	4,5%

[1]Routing in Germany
[2]Routing in Germany, Switzerland, Austria, Italy, Denmark, Liechtenstein, UK and Ireland

Problems and Strengths of the OSM dataset

At the core of each routing application is the routing graph. The routing graph represents the street network as a model of nodes and edges. It is critical that the graph is built from a topologically correct dataset: junctions are represented as nodes and streets are represented as edges between them. Junctions are only recognized as such, if the crossing streets have a common node at their intersection. **Fehler! Verweisquelle konnte nicht gefunden werden.** illustrates cases of unrecognized junctions.

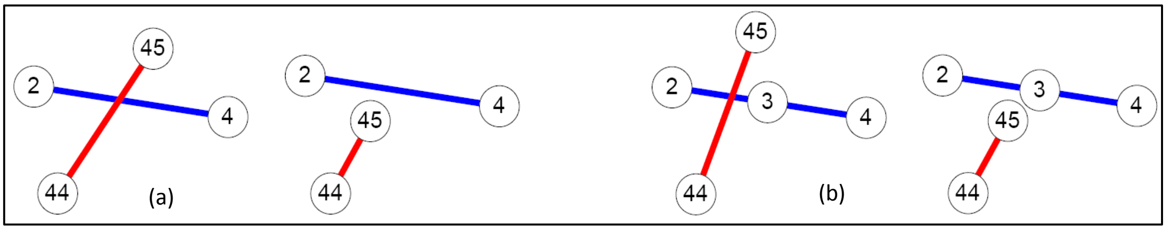
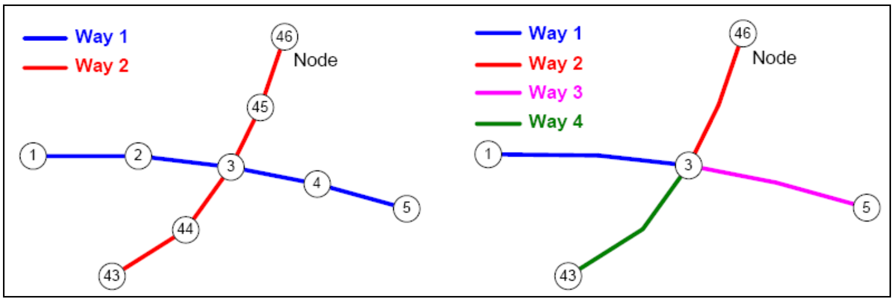


Figure 2: Examples of unrecognized junctions: No intersection node present (left, a), intersection node not

During collection and maintenance of OSM data, topology is already considered an important aspect by the voluntary mappers. Tests have shown that the above cases are only rarely encountered in the dataset. Thus, they have been neglected during the completion of the mandatory and decisive task of building the routing graph from OSM data. Here, the existing topology of OSM data is examined regarding the occurrence of street intersections with common nodes, i.e. junctions. At those common nodes, streets are divided into individual edges (ways). The number of edges in the routing graph is usually higher than the number of streets in the original dataset (Figure 3).



(a) Original OSM Data

(b) Modified OSM data

Figure 3: Building the routing graph from OSM data

Another challenge is inconsistencies in the OSM dataset with regard to attribution of the geometries. This is particularly true for street names and poses a problem for the generation of useful route descriptions. For instance, abbreviations are used or spelling differs for the same street. Those problems were solved in a pre-processing step that harmonized inconsistent street naming. A comprehensive list of street types used for the different types of routing is available in the OSM Wiki.[4] While attribution inconsistencies and topological omissions can be regarded as problems of the OSM dataset that needed special treatment, it also offers some unique strength. One is the enormous data richness that in places even beats commercial providers. This allows for new applications that due to a lack of data were not easily possible before. Examples are national pedestrian and bicycle routing as well as routing in formerly uncommon domains (Figure 4). Furthermore, the quick response time for data corrections should be mentioned as unrivaled also among commercial data providers.

Use case Disaster Management

Weeks after hurricane „Ike"– that killed over a hundred people and left tens of thousands homeless - has devastated Haiti the situation is still tense. Because of flooded and destroyed streets and bridges the humanitarian operations lead by the US for the over 650.000 affected people the situation remains difficult. In order to avoid famine and epidemics the people need to be supplied by food, medicine and other goods and the rebuilding of the infrastructure needs to be organized.

[4] http://wiki.openstreetmap.org/index.php/OpenRouteService

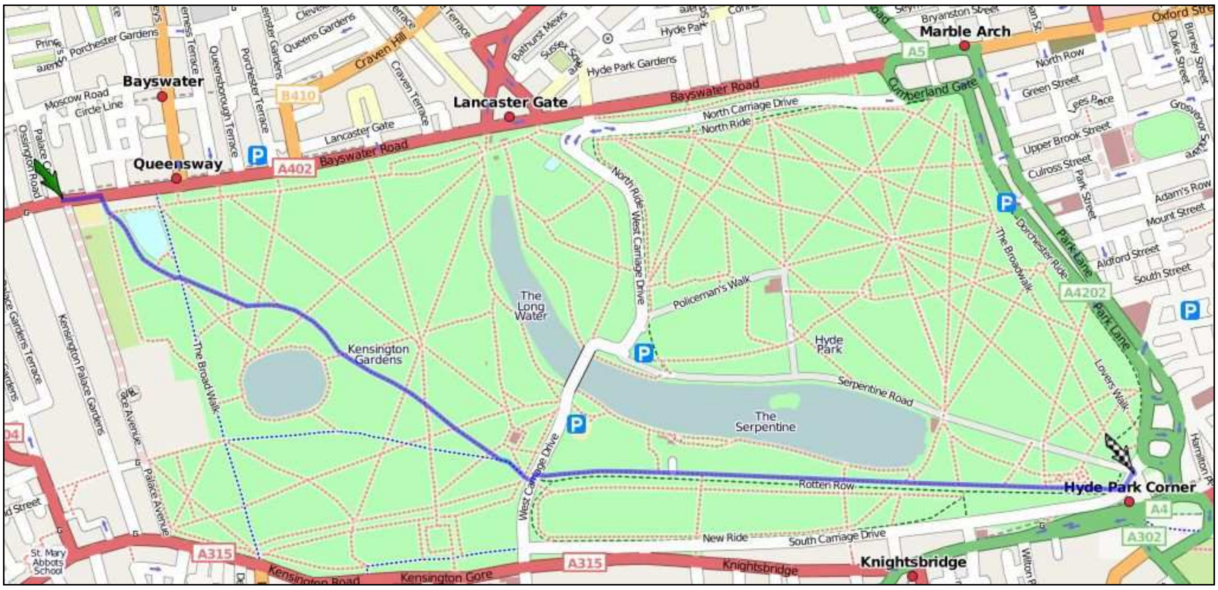


Figure 4: Pedestrian routing with ORS through Hyde Park, London

The UN Joint Logistics Center (UNJLC) – a unity hosted by the World Food Program (WFP) – organizes the logistics for the UN operations for the humanitarian and disaster management operations after hurricane Ike. The UNJLC defines and implements the UN SDI-T which constitutes the transport-related branch of the United Nations Spatial Data Infrastructure (UNSDI) under development. For the current operation is information about the actual condition of the streets very important, as well as information about hindrances, danger areas and the situation of the infrastructure at large. In that context we were asked by UNJLC to support the implementation of a route planning service for Haiti that takes the actual street condition into account. An important feature of OpenRouteService.org for the disaster management operation was to consider blocked areas or streets when routing. This means that streets inside those regions a not used for routing. The OGC standard implemented in ORS, the Open Location Services Route Service, defines so called „AvoidAreas", which can be used to realize such a functionality.

OpenRouteService.org offers two alternatives for using this: The first one is available through the GUI of OpenRouteService.org, where a user can draw those AvoidAreas interactively on the map. Those areas are avoided when this user calculates a route. But as the polygons are only available on the client side other users do not have access to them. Therefore a second option was realized that allows staff from the organizations involved to upload spatial data sets that represent those AvoidAreas into the geodatabase of ORS-Haiti though the Web-interface. Those areas then are available for any users of the site. They can be activated for routing through clicking an option on the web page. A similar approach is used for considering information about traffic jams or construction works based on RDS-TMC data in Germany (Mayer et al. 2008). While a lot of improvements regarding functionality and usability seem sensible first feedback from users in Haiti has confirmed that the service is a valuable help for the disaster management work in Haiti even in such a quickly released first prototype.

Insights

OSM data can be used for such sophisticated purposes as routing. The increasing interest in the website shows the service provides useful results to the general European public that uses ORS. The decreased percentage of failed route requests implies an increase in OSM data quality.

In the context of the highly dynamic and still quickly growing OSM dataset, a rather obvious and simple principle seems well worth mentioning: given a working routing algorithm implementation, routing quality and future possibilities scale with data quality and richness. Apparently, the more complete and up-to-date the dataset, the better routing results will be. On the other hand, the more attributes contained in the dataset, i.e. the richer it is, the more possibilities for domain-specific route calculation arise. Clearly, the dataset is the limiting factor. In the case of OSM this dataset is collected by a 'horde' of 60.000 volunteers. The question as to what limits them remains open. Haklay (2008) gives one possible direction: a lack of quality assurance among OSM mappers had been a surprising result of his study. To our minds, this is where a service like ORS comes into play. To a certain degree, its availability and implementation details regulates OSM collaborative mapping in the context of routing. Tags that are used in ORS will prevalently be mapped. As ORS allows for simple, easy and satisfying testing of OSM data in terms of routing, it can be considered a means of quality assurance. The specialized version of OpenRouteService for the Haiti UN disaster management operation shows that open data and open standards offer a sensible approach for realizing geographical applications in particular in the case of disaster management.

Perspectives & Future work

Future possibilities can be split into two categories. First, the currently available service can be further refined by mashing-up OSM data with other (proprietary) geodata. This already happens with the inclusion of Shuttle Radar Topography Mission (SRTM) data for the generation of route altitude profiles of ORS routes (Schilling et al. 2008). The use of SRTM could be extended by allowing steepness as a request criterion for routes. Another example for this category is the inclusion of near real-time traffic jam data from the Traffic Message Channel (TMC) (Meyer 2008) and very similarly the consideration of impassable roads when calculating routes in the Haiti Use Case described. The second category of future possibilities subsumes all cases where the existing, rich OSM dataset is further utilized to develop routing for specific user-groups. Depending on the attributes that already are and possibly will be contained in the dataset, those user-groups can be manifold. Imagine special routing for hiking, skiing, indoor navigation, public transport or heavy trucks. Or think of routing especially targeted at disabled people (wheelchair, blind). Classical car routing can be enhanced by the consideration of turn restrictions that are partly contained in the OSM dataset. As outlined above, this is expected to boost their capture by OSM mappers. It has been argued above that services operating on OSM have a regulative and quality assuring effect. It remains future work to statistically prove their mutual dependency by correlating considered tags in ORS and their capture in OSM. Quality assurance of OSM data calls for another future work item. Being a project based on collaboration, it lives of accessing the knowledge of its community. In order to optimize this, the OSM dataset and thus ORS would strongly benefit from an efficient routing error reporting tool embedded onto the ORS website as an extra layer. This assumption is based on the general Open Source mantra that 'given enough eyeballs, all bugs are shallow' (Raymond 2000, p.8). A similar application exists for OSM in general, but not yet directly connected to routing.[5] Apparently, ORS is one among many other services offering routing on the web. In order to provide additional motivation to map even more exact and capture even more attributes, it seems promising to build a routing comparison tool that lets a user easily request routes against different (commercial) services and compare the results.

Potential of Extending OpenStreetMap to 3D

Schilling et al. (2008) show how to integrate free OSM data with the open source Shuttle Radar Topography Mission (SRTM)1 data to construct a digital elevation model for Germany. That can be used for 3D visualizations through Web Services such as the OGC Web 3D Service draft specification

[5] http://www.openstreetbugs.org

as realized in Schiling et al. (2007) and also 3D routing similar to Neis et al. (2007). The result is a 3D application for a whole country (first case: Germany) based completely on collaboratively collected free geodata and open standards using several OGC services from routing to geocoding and directory services (POI search). The service will be available soon at www.gdi-3d.de. Figure 5 gives a first example on what can be reached with such an approach.

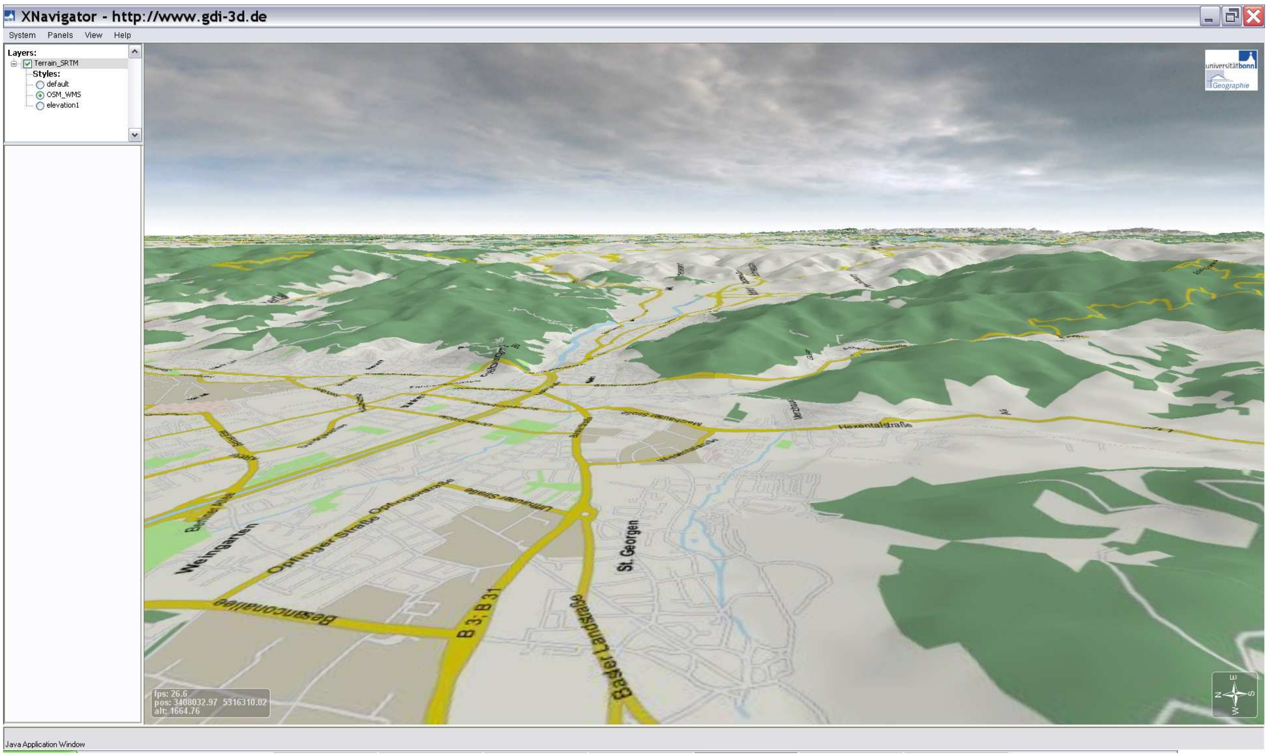


Figure 5: Web based 3D service based on open data (OSM & SRTM) and open services

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