Collaboratively collected geodata to support routing service for disabled people

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Abstract.

One of the main topics of cities is mobility. Nowadays, Mobile phones can provide navigation instructions in real-time, accessing wireless the Internet so routing and navigation applications on the Internet, in cars or on personal smartphones are everyday tools for many people. The purpose of i-SCOPE project was to deploy, based on new generation urban city model, a set of services to support the improvement of life quality on urban areas. One of these services was a personalized routing service for disabled people.

Pedestrians need a specific set of features to represent the environment and other information including barriers, sidewalks accessibility along the way, points of interest, and even services for disabled people. Unfortunately commercial geodata providers do not offer this detailed information; therefore there is a lack on this data from digital city maps, yellow pages and travel information data sets.

This paper will explore the potential for the VGI community to improve data access and services in the field of disable pedestrian mobility computing. This allows collecting information about a network to be used in route-planning, real-time navigation or for both, by providing detailed information about the “best” individual route based on the user’s limitations.

Keywords. VGI, OLS, routing, OSM, smart cities

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1. Introduction

Cities are the part of the world where there is the highest concentration of population. The United Nations estimates that at beginning of 2019, it is expected that more people will live in cities than in rural areas. This implies, a big effort for administrator, scientists and citizen improving the quality of life within cities.

The emerging trend is going towards a unified urban-scale ICT platform transforming a City into an open innovation platform called Smart-City. A core component of this approach is using communication and collaboration technologies to manage city information. However cities are a very complex system and, in several cases, it is difficult to collect and maintain this information without expensive surveys and instruments.

One of the main topics of cities is mobility. Nowadays, Mobile phones can provide navigation instructions in real-time, accessing wireless the Internet so routing and navigation applications on the Internet, in cars or on personal smartphones are everyday tools for many people.

A challenges faced on by Smart Cities is how to improve access to city space for wheelchair users and other disabled people. Of course this has to be realized, from the structural point of view, eliminating barriers and making city spaces available but even providing smart tools to support their mobility. Routing network data is suitable for motorized and (for selected cities) non-motorized path finding applications. However, content and granularity of the information requested by pedestrians with special needs has to be based on more specialized dataset, and cannot utilize the provided commercial geo-information and require highly detailed ground-truth data (Neis & Zielstra 2013). Pedestrians need a specific set of features to represent the environment and other information including barriers, sidewalks accessibility along the way, points of interest, and even services for disabled people.

Unfortunately commercial geodata providers do not offer this detailed information; therefore there is a lack on this data from digital city maps, yellow pages and travel information data sets. Furthermore the collection of this kind of information is extremely expensive and time consuming so municipalities and public body typically avoid inserting they into the survey and mapping updating.

Volunteered Geographic Information (VGI), or Geospatial crowd-sourcing, grouping all those activities in which citizens (volunteers) contribute to collect data and information about the earth and environment that is explicitly or implicitly georeferenced and then disseminated via collaborative projects. One of the most established projects in the context of VGI is OpenStreetMap[1] (OSM).

This paper will explore the potential for the VGI community to improve data access and services in the field of disable pedestrian mobility computing. This allows collecting information about a network to be used in route-planning, real-time navigation or for both, by providing detailed information about the "best" individual route based on the user's limitations.

The work described in this paper is part of the co-founded European project i-SCOPE[2] and consists on the definition of methodologies and workflow an to collect geometrical features supporting routing services for pedestrian disable people, in order to overcome the abovementioned information lack. Furthermore a multipurpose routing services to for disabled people with special navigation information will be described.

The remainder of this article is structured as follows: Section 2 presents some background information and related research in the field of routing networks and way finding for disabled people. In Section 3, the methodology including data preparation and the generation of the tailored routing network is described. Section 3 also contains detailed information about the requirements and parameters that the generated network should inherit and the routing algorithm should take into account when computing a route. The article concludes with a discussion of potential algorithm limitations, a summary of the findings and an outlook on future research.

2. Related works

Disabled people rely on very detailed information about potential obstacles in their neighbourhood, so although the efforts spent in developing navigation systems for pedestrians, many users with special needs are mostly excluded due to a lack of appropriate geographical data such as sidewalks, steps, surface conditions, or obstacles.

Several researches report application of GPS and GIS to developing navigation maps for individuals with disabilities (Sobek & Miller, 2006, Matthews et al., 2003). However these systems have limited capabilities to provide

[1] http://www.openstreetmap.org (accessed on 27 May 2014).

[2] www.iscopeproject.net

real time routing information or they are tailored on specific barriers free paths.

Other works focus on the different geodata requirements between non-motorized traffic, such as pedestrians, and applications tailored to motorized traffic. For example, Beale (2000) developed, tested, and applied a GIS for modelling access for wheelchair users in urban areas.

Geo-data source prerequisites for a potential navigation system for pedestrians has been studied in several researches (Gaisbauer & Frank, 2008, Matthews et. al. 2003). This kind of information is often very time consuming and expensive to be collected by the municipalities and the result are used into customized systems.

However in the last years new technologies have created opportunities for citizens to interact with each other, form collaborative groups, collect and disseminate information about their social networks and the world around them, in realtime (Budhathoki, & Haythornthwaite, 2013). This trend became popular under the term VGI (Goodchild, 2007) when the contributions tend to be more casual or Public Participation Geographic Information Systems (PPGIS) in which volunteers collect geodata for a particular purpose.

One of the most popular and most manifold projects for VGI is the OpenStreetMap (OSM) project (Neis et al., 2007). In recent years several studies demonstrated the potential of OSM in a variety of Location Based Services (LBS) applications (Schmitz et al., 2008). In a number of major cities the volunteers collect information about sidewalks, road surfaces, road slope, pedestrian crossings, and tactile paving. The classic approach is to collect data with a GPS receiver, which afterwards can be edited with one of the various freely available editors, such as Potlatch or JOSM. This information are fundamental when considering the creation of a suitable routing graph for disabled people, such as wheelchair users or elderly people.

Even if several studies about OSM demonstrate that urban areas are better mapped than rural counter parts or, only objects of certain types (e.g. roads) have descriptive measurements; other analyses by Neis, Zielstra et al. (2012) and Zielstra and Hochmair (2011b, 2012) have shown that the OSM provides a comprehensive network for pedestrians in comparison to commercial or governmental dataset distributors.

The work presented in this paper explores the potential for the VGI community and PPGIS to improve data to support disabled mobility. The methodology we present in this paper start from these data collection in order to deploy routing services tailored on disabled people.

3. Motivation

The purpose of i-SCOPE project was to deploy, based on new generation urban city model, a set of services to support the improvement of life quality on urban areas. One of these services was a personalized routing service for disabled people.

The first item to be investigated is the level of detail essential when considering the creation of a suitable routing graph for disabled people, such as wheelchair users or elderly people.

The methodology proposed in our work consists in these steps:

- Definition of the recommended parameters that need to be implemented to enrich the final dataset;
- Collection and editing of the information;
- Design and deploy of the routing services.

During the first step, ontology for datasets is needed as a formal specification of the data model, which is applied exemplary on the digital map of the city of Vienna and Cles (province of Trento). The ontology is based on the OSM tagging schema, which is increasingly being developed into a complex taxonomy of real-world feature classes and objects, this is a core part of the OSM initiative and is community-driven. Any member of the community can contribute to and update the schema by proposing new key=value pairs.

After the initial data preparation, the second step involves the creation of the disabled friendly routing network, utilizing all relevant information that was retrieved from original OSM dataset in addition to the collected ones.

The overall system proposed in this work includes smart phone application, web routing services, and OSM open source map editor.

3.1. Data model

In order to produce a useful services for disabled people, several consideration about the features taken in account have to be done. Generally routing service are based on graphs composed by geographic objects which are modelled through nodes, ways, and relations, where nodes are described through a location on earth using a coordinate pair and attributes. Considering vehicles mobility the graph is usually constituted by the road network where each ways and nodes have several attributes[3] such as max speed limit, number of lanes.

[3] http://en.wikipedia.org/wiki/Geographic_Data_Files

Pedestrian mobility is more complex: pedestrian can move in in different spaces (sidewalks, roads, cycleway and pedestrian areas) and they can move from a space to another almost continuously so pedestrian routing geometrically has to consider many interconnected graphs. Furthermore the number of attributes to fully describe in particular disable people routing are very huge (curbs, slope, paving, width, crossing etc.).

Several data models have been developed to describe mobility and to support routing service: the already mentioned Geographic Data File (GDF) is mainly oriented to automotive segment, Graph Integration Platform (GIP) is another data model, primarily designed for outdoor environments. It provides the basis for traffic management, intermodal routing, and traffic modeling in Austria however is intermodal traffic graph core is rather complex.

CityGML data models is an emerging standard for modelling of buildings and landscapes in 3D, and i-SCOPE project bases its development on this standard for 3D buildings; however even if it is theoretically possible to extend the complex structure of the standard to support transport features, any implementation has been yet implemented and it is quite difficult to use it for practical implementation. Anyway a CityGML application domain extension for disabled routing has been implemented even if it will be not used for the technical implementation of the services.

The data model on the base of the i-SCOPE routing service has been developed on top of OSM data model. The OSM project has the goal to create a detailed map of the world based on VGI in vector data format. The information is collected by many participants, collated on a central database and distributed in multiple digital formats through the World Wide Web. Objects and their attributes are coded through tags in the form of key-value pairs, for example `highway = 'steps'` (object) and `step_count = '#_of_steps'` (attribute).

The spatial representation of the defined objects and structures is facilitated by matching the verbal descriptions of the i-SCOPE data model with the OSM based data model. Where possible existing OSM key-value pairs were used to describe the content of the catalog, otherwise In order to support disabled people routing an extension of the existing tags already developed in other similar projects[4] has been done..

[4] Wheelchair routing: http://wiki.openstreetmap.org/wiki/Wheelchair_routing#Sidewalks

Element	Type	Attributes
Road network	Line segments	Traffic barriers
		Width
		Number of lanes
		Longitudinal slope
		Direction
		Name
Sidewalk network	Line segments	Tactile paving
		Obstacles and their position
Pedestrian crossings	Line segments	Traffic lights and their type
Pedestrian network	Line segments	Tactile paving
		Type
		Obstacles and their position
		Longitudinal slope
		Name

Table 1 Example of data model routing features and related attributes.

Table 1 reports some feature already existing on OSM data model, some of the related attributes are an extension to this data model proposed by i-SCOPE. The data model includes some mandatory and optional attributes that are functional to the development of the routing service.

3.2. Data collection

Once defined the data model the main objective of the work was to collect the needed data within the pilot area. To due the complex nature of the required information the data collection task is very challenge and it has required an accurate study of the methodology. Also in this case the already existing initiative have gave to the project the right input in to find an feasible way to achieve the result.

The overall process could be schematized in four main steps:

- Awareness and motivation of volunteers;
- On-field survey;

- Data elaboration;
- Services deployment.

The first item is for sure the most challenge ones and moreover without a full involvement of volunteers it is impossible to achieve good results. Furthermore a good awareness of the volunteers lets to obtain useful data during the on-field survey and post processing elaboration.

In order to support the on-filed operation a mobile application has been developed. The application allows the user to collect the information about the features geo-localizing them directly on field, using the GPS embedded on the devices or, in case of bad GPS signal, to directly edit the feature on the map.

The app uses Wi-Fi where a wireless access point is available; in the field it uses mobile data access through 3G or 4G provided by the service provider. Web Services enable interaction between the smart phone and other components in the model. Web Map services (WMS) is consumed by the mobile app to display the OSM as background map. HTTP web service is used for user authentication, to send non-spatial attributes to the central repository. The non-spatial Database contains the information collected including images and info about the users.

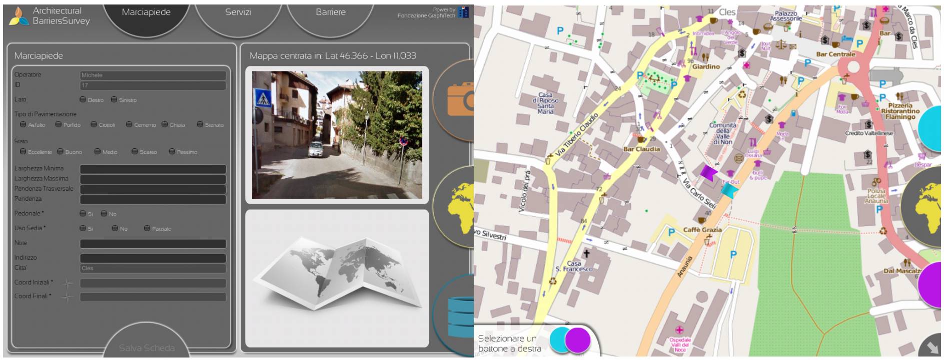

Figure 1 The interface of the mobile application for the architectural barrier[5] survey

Several application as been designed to collect geo-information directly on field increasing the crowd source data collection approach, however the main purpose of these application is to collect information which are typically modelled using a point of interest (PoI) approach.

Routing services on the other hand rely on very well geometrically structured graphs where node represents junction between two or more arcs. It

[5] https://play.google.com/store/apps/details?id=it.graphitech.iscopenew&hl=en

is obvious how it be impossible to obtain so well structured information using mobile application during the on-field campaign. For this reason the third phase is related to the post processing editing of the graph needed for the routing service purpose.

The rational behind the i-SCOPE routing data is to enrich the data model provided by OSM with the additional information coming from the specific volunteer surveys realized using the mobile application on field. This implies three main advantages: i) to exploit the existing information already existing on the OSM database, ii) to exploit the commitment of the OSM community in order to assess and verify the uploaded information, iii) to put within the loop additional information which can be reused from different users.


```xml
<?xml version="1.0" encoding="UTF-8"?>
<osm version="0.6">
  <node id="143" lat="44.8356588646678" lon="11.6191821217" user="team01" visible="true" version="1" timestamp="14-04-2014 8:50:36"/>
  <node id="-143" lat="44.8358954324033" lon="11.6193430703011" user="team01" visible="true" version="1" timestamp="14-04-2014 8:50:36"/>
  <way id="12" user="team01" visible="true" version="1" timestamp="14-04-2014 8:50:36">
    <nd ref="143"/>
    <nd ref="-143"/>
    <tag k="name" v="corso martiri della liberta, ferrara"/>
    <tag k="highway" v="footway"/>
    <tag k="footway" v="sidewalk"/>
    <tag k="foot" v="yes"/>
    <tag k="surface" v="sett"/>
    <tag k="smoothness" v="good"/>
    <tag k="sidewalk" v="right"/>
    <tag k="est_width" v="0.5 m"/>
    <tag k="incline" v="0 %"/>
    <tag k="barrier" v="yes"/>
    <tag k="wheelchair" v="yes"/>
  </way>
```


Figure 2 Example of OSM file export from architectural barriers survey database ready for editing within JOSM.

The editing phase is realized within typical OSM editing tools (i.e. JOSM[6]); in order to facilitate the communication between the mobile application and the editing phase it is possible for the user to export the information from the central database directly in OSM format.

Once edited and saved on OSM the information can be downloaded from OSM website and imported on the i-SCOPE routing database for supporting disabled people routing requests.

3.3. Routing Services

The last component of the whole chain is the routing service engine. The disabled people routing service (or Inclusive Routing service) is a routing service aiming to serve people with disabilities and aid them move in urban environments. It is based on an existing OpenLS-compliant routing service,

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[6] https://josm.openstreetmap.de/

and relies on OpenStreetMap data. Specifically it supports the following user categories:

- People with visually impairments
- Wheelchair users
- Pedestrians

The Inclusive Routing service also provides support for directions using and extending existing service technologies developed in the context of AmauroMap[7], which allows defining semantically-rich text-based description of environmental features based on vector GIS data.

The main important feature of this service is that, relying on OSM data enriched by the information collected through the volunteers campaign, it is able to provide instructions tailored on specific user behaviour. To achieve these results a number of factors have been identified in an urban environment facilitating or obstructing mobility for wheelchair users and visually impaired people. These factors have been modelled within the data model described on section 3.1.

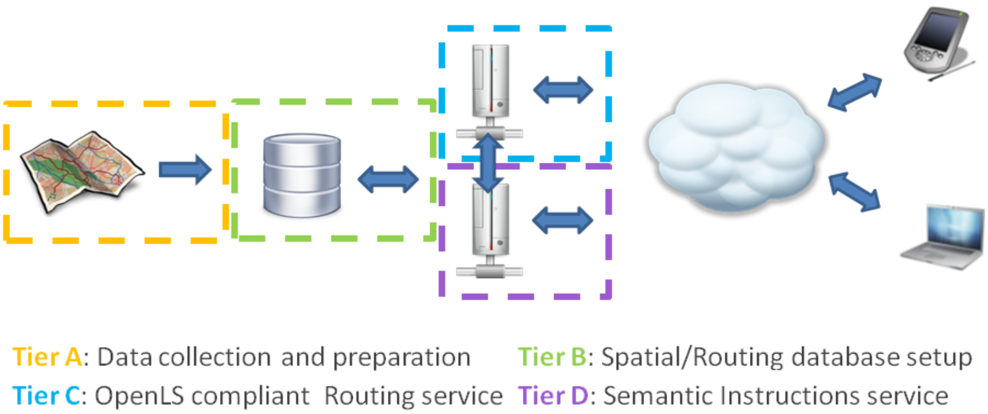

Figure 3 System Architecture

The global system architecture of the service is based on a typical three layer Service Oriented Architecture: at the bottom there is the data layer composed by the database containing the routing weighted networks and the POIs from the different pilot regions, the middleware is composed by a

[7] http://www.amauro.map.at/

OpenLs compliant service; and at the application layer there are a web and a mobile able to perform the request and visualize the output.

In order to cater with the Inclusive Routing services particularities the OpenLS schema was extended. For instance values `"Wheelchair"` and `"VisuallyImpaired"` are added as possible values (along with `“Shortest”`, `“Fastest”`, `“Pedestrian”`).

One of the main important element of the service are the weight assigned to the features in order to obtain the more appropriate path based on the different input parameters. The set-up of these weights is very complex because there are many parameters to take in account: length, slope, type, paving condition, presence of obstacles etc. At the moment we are in the testing phase where the users testing the services providing feedback on the output path, reporting strange behaviours due to the wrong weight assignment.

4. Conclusion

This paper report the results of the EU project i-SCOPE; in this project it has been deployed a routing service to support the pedestrian mobility of the diversely able people. The main characteristic of the work is that the whole chain starting from data collection to the services deployment has been considered.

Disabled people mobility indeed requires a lot of information about the path elements, and in many cases these are not available at all, in other they are not available in appropriate data model to support routing service.

Furthermore the collection of these information is very expensive and time consuming and the municipalities often have not enough resources to collect them. The work proposes methodologies and tools to collect and update the information using VGI approach.

Motivating specific groups of interest people and giving them appropriate instruments it is possible to collect a huge umber of information in a very short time. A specific mobile application for collecting information on field has been developed; through this application it is possible to survey the features to describe pedestrian mobility. The features are collected according to a data model, which extends the OSM data model. Then the data collected are edited in order to create a graph and used as base for the routing service.

The main difficult is related to the mobilisation of people for data collection; this is a very challenge topic and there is not an unique solution. In this project relying on OSM platform, data model, and community, we would to enlarge the audience and facilitate the operation for the data collection. Furthermore the possibility to reuse the collected information for other purpose outside the project through the open data format can put in contact different organization to the data collection.

Figure 4 Example of two different returned path based on different request, above shortest path below wheelchair path.

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