Location Based Services of University Town Based on OpenStreetMap: NUI Maynooth as an example

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***Abstract*— The university campus of NUI Maynooth forms a substantial part of Maynooth town. Location based services (LBS) could be important for visitors to the campus and town in assisting them to make the most of their stay, particularly if they are not familiar with the town. In this paper we discuss an LBS application for Maynooth university campus and Maynooth town based on OpenStreetMap. The solution uses open source software and public participation rules to build its database. The work provides a prototype LBS system for NUI Maynooth which is currently under active development. The paper mainly describes some completed components of the work: data acquisition and pedestrian navigation algorithm design. Future work on path optimization and 3D applications is also discussed.**

Keywords: location based services, pedestrian navigation, walking area, path planning, OpenStreetMap, university town

I. INTRODUCTION

University towns usually are situated in a quiet environment and beautiful scenery. These characteristics attract visitors to tour university towns. As strangers, these tourists could use a powerful and convenient Location Based Service (LBS) to help them get familiar with the unfamiliar environment and lead them to the interesting sites. Such applications need accurate spatial data and detailed geographical attribute information. Such products are not usually provided by mapping and cartography companies as this attribute information is often expensive to collect. Without these data and information products the problem of pedestrian navigation cannot be solved satisfactorily. We describe a system that adopts and integrates Web 2.0 technologies and open source tools as a promising way to serve LBS applications for pedestrian navigation. We take the university town of Maynooth in Co. Kildare Ireland as a case study example.

The work is part of the eCampus project, which is constructing a major test bed for StratAG, the Strategic Research Cluster in Advanced Geotechnologies (www.stratag.ie) at National University of Ireland Maynooth. It focuses on constructing a university campus related information system including diverse location-based services.

II. FUNCTION DESIGN AND SYSTEM ARCHITECTURE

Visitors can use the LBS applications from two types of terminals. The first type is through a standard desktop computer interface using an Internet browser. The other is mobile terminals which can acquire LBS information through wireless communication networks. In terms of the delivery of content, the location based services for a university town are similar to other LBS applications. The major types of service include highlighting and querying Point of Interests (POI) and pedestrian navigation. Figure 1 displays the system architecture in outline. The main functionality can be described as:

POI services

- Where am I?
- Where is an organization or a place located?
- Where is nearest ATM or other type of POI?
- etc

A. *Pedestrian navigation*

- 2D & 3D navigation;
- Outdoor & Indoor navigation
- Navigation inside & outside walking areas
- User preferred route planning
- Natural language description
- etc

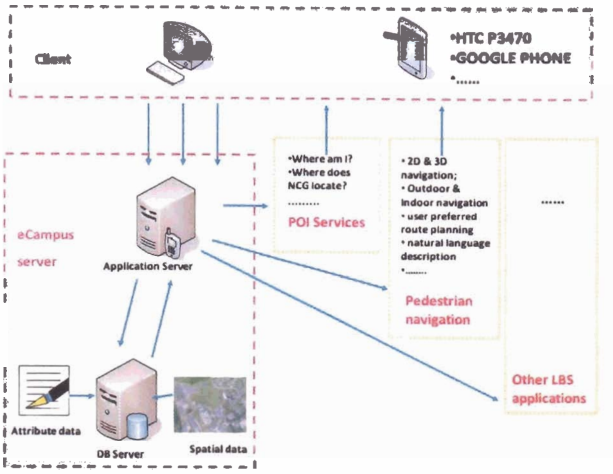

Figure 1 system architecture

III. DATA COLLECTION

Accurate spatial data and detailed geographical attribute information are the basis of LBS applications for any environment including university towns. In Ireland there are generally no suitable free data that can be directly used for such applications. In Maynooth, for example, Google Earth does not provide good resolution remote sensing images for navigation. Also Google Maps does not provide attribute data for POI queries and pedestrian navigation. Furthermore, obtaining high resolution remotely sensed imagery from commercial companies would incur a large financial cost that the project cannot support.

Beginning in 2008 a cost effective method for creating a map of the campus was sought for NUI Maynooth and the surroundings area. This map creation task was necessary because this map data was required for use in the prototyping pedestrian navigation application. The fastest way to solve this problem would have been to use an "out of the box" mapping system like Google Maps or Virtual Earth. The other more costly option was to purchase the data about streets and paths in this area from a company which prepares maps for GPS devices.

For pedestrian navigation a very detailed map of the campus area is required. This map must, by default, include all streets on which it is possible to drive but the map must also include pedestrian ways (paths, lanes, walkways, trails). A quick, efficient, and accurate solution to this problem was to create the map ourselves. OpenStreetMap is a free and open map of the world.

OpenStreetMap allows users to upload GPS data, aerial photography, and other spatial sources for inclusion on the OpenStreetMap (OSM) map of the world. There are many documents on the OSM Wiki pages to get started with map creation. A GPS logger device was obtained for GPS coordinate collection. A GlobalSat® DG-100 GPS Data Logger was used. This device is not a complicated GPS device. It contains a button for on/off and three diodes which show current status and a simple trigger to allow the operator to choose how frequently the measurement of position is captured and recorded into the device's internal memory. This device is very widely use by the OpenStreetMap community. It is very easy to use this device with Linux servers as drivers are available using an application called GPSbabel [1]. Based on the same code, a special plug-in for an OSM editor called JOSM was manufactured by the OpenStreetMap community which downloads routes of journeys directly to a spatial data editor.

At the initial stages of map creation for Maynooth, it was decided that we would collect as much geographical data and information as possible about the vicinity. The final versions of the maps could be used then by members of the local Maynooth community and for us in university projects such as this project on pedestrian navigation. We are hopeful that the "open access to data" philosophy of OSM [2] will mean that it will not be necessary for other projects requiring mapping to re-invent the wheel and collect their own data. The OSM map can be continually updated and edited as geographical features change in the area or as more detailed or new geographical data is collected and uploaded to OSM. Due to this work, at present the OSM map of Maynooth better represents the geographical reality of the area than Google maps or Virtual Earth. It also offers the University the opportunity to quickly add or remove geographical features to the OSM map to accurately reflect changes in the physical campus structure – for example new footpaths or the relocation of facilities such as postboxes.

OSM data can be accessed in XML format. The XML format is verbose and shows all of the attributes for a line (roads, streets, paths) or point (Point of Interest, shop, amenity) feature on the map. An example is shown below for one point of interest (POI) which is Brady's Public House on Main Street of Maynooth. The subset of the XML is shown as follows.


```
<osm version="0.5" generator="OpenStreetMap server">
<node id="344721377" lat="53.3815013" lon="-6.5902968"
user="Blazejos" visible="true" timestamp="2009-02-
13T11:06:12+00:00">
<tag k="created_by" v="Merkaartor 0.12"/>
<tag k="amenity" v="pub"/>
<tag k="name" v="Brady's"/>
</node>
</osm>
```


In graphical format Brady's pub is displayed on a graphical map tile by the Mapnik software package (figure 2).

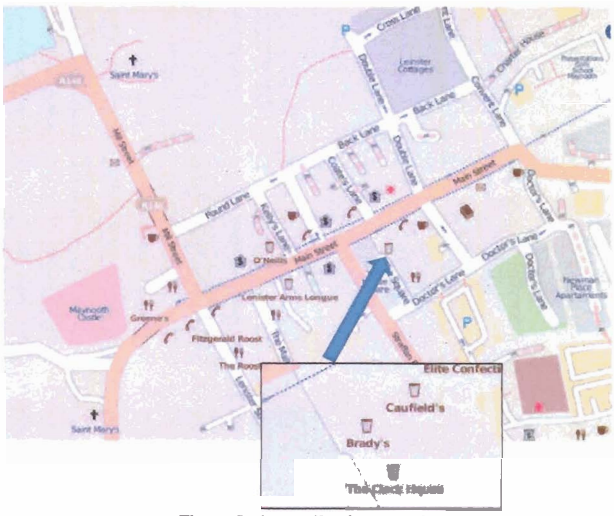

Figure 2 data collection sample

The first step in building the OSM map starts with traveling along streets, lanes and paths, in the town and capturing GPS coordinates for these features. This is a time consuming process. Before map data collection began the Maynooth town area was divided into small manageable segments. The process of data collection, editing, and final production upload to the OSM servers took between two and three days for each segment. In Ireland it is difficult to access high resolution aerial imagery without incurring a very large cost. This meant that the only method to capture high resolution data was to physically visit every geographical feature in Maynooth which we would like to have on the map.

The typical procedure was to travel the streets and lanes by bicycle to capture their shape in GPS coordinates. Data capture by bicycle was useful for several reasons. Firstly there were some examples of footpaths hidden between trees and bushes and could only have been captured using ground survey. The bicycle also allowed travel along pedestrian-only streets and lanes. At the same time the relative location of the geographical details was captured of all other important information particularly POIs such as speed bumps, street lights, bus stops and shops. Photographs were taken with a digital camera to enhance the accuracy of the placement of these POIs on the map and in their physical description.

Upon returning to the laboratory the data from the GPS logger were uploaded. Street and line feature data was uploaded first followed by adding information on POIs. The Java OpenStreetMap (JOSM) [3] editor was used for this task. The JOSM has a special plug-in which allows the editor to match digital photographs taken during the survey with points on the line representing the line feature. This is done by comparing points on the GPS coordinate line with the time stamps of the JPEG photographs taken by the digital camera.

Figure 3 data collection sample

This approach to map creation is not perfect as it is difficult to capture the shapes (plan view) of buildings. It is possible to create reasonable approximations to the shape of large buildings by simply walking around then and recording coordinates with the GPS device. However this is not suitable for all buildings as it is often the case that not every corner or side is accessible by pedestrians. Therefore, the National Centre for Geocomputation (NCG) at NUI Maynooth provided us with an aerial photograph of the Maynooth campus.

The dimensions of this image are 7113x8810 pixels and it was resolution-rectified using the on-line tool "Map wrapper" [4]. The aerial photograph does not cover all of Maynooth. However the photograph has allowed us to create a complete map of Campus buildings and campus path ways. 'Map wrapper' provides a Web Map Service (WMS) which, in combination with the JOSM plug-in, allows a direct connection. It was then a simple task to place this aerial photograph as a background in JOSM and simply transfer the necessary features onto the map. The final result of this map production work is a high quality map of our university campus as figure 3).

The map offers greater resolution and more geographical attribute detail than maps offered by Google Maps or Microsoft Virtual Earth for the same location. The map of Maynooth (town and campus) is presented by the OSM public server but can be used freely by any third party. In particular, university research projects can use this map without constraints of map license structure or map purchase/usage costs. OSM is far from being "the finished article" for Ireland. Many locations in Ireland are very poorly mapped and contain little or no geographic detail. It is our intention to disseminate our knowledge of OSM and map production widely to other researchers and the general public in Ireland. It is hoped that this will help inspire other citizens to become part of the OSM community and assist in improving the representation of the island of Ireland in OSM. This data collection solution makes the geographical data updating of the OSM maps a very minimal cost exercise. It provides an opportunity for users to add new POI or other information into the database. For pedestrian navigation it is very important to have the information updated frequently.

IV. PEDESTRIAN NAVIGATION

When visitors use LBS applications in a university town most of their travel mode is walking. Pedestrians are not constrained to the road network (for example the lanes, turn restrictions, one-way streets) unlike vehicle drivers [5], [6]. In addition there are some special features that are unique to pedestrian navigation. These include "walking areas" where pedestrians can walk freely such as squares, grassland, parks and open ground. This is one of the key differences compared with the road networks used for vehicle navigation. We define a walking area in 2D Euclidean space as an area where pedestrians can walk at random without using fixed paths. A walking area is generally represented by a polygonal feature. Zheng [6] discussed data modeling of pedestrian networks including walking areas. In former work [8] we classified walking areas into three types with orthogonal attributes including the character of their boundaries and entrances, concave-convex characteristics of their shape and the presence of impenetrable islands. Walking areas can be divided further into three subtypes derived from the access character of the boundaries and entrances: fixed entrances, open boundary (free entrance), and open boundary with restrictions. Considering the subtypes of the other orthogonal factors in characterizing polygon shapes there should be 12 general situations. For developing robust pedestrian navigation services the entire set of situations must be taken into account.

Pan [7] put forward an algorithm generating optimal paths within a polygon (a walking area) with interior obstacles. This algorithm was based on Dijkstra's algorithm. This work also provided some solutions for the special behaviors of pedestrians, such as preference for easy walking routes and preference for indoor routes.

Zheng [8] describes a Two-Level Path Planning Algorithm for pedestrian navigation. In a related paper currently under peer review the author describes the solution for pedestrian navigation with open boundary areas. The solution solves the problem to represent the link passing through open boundaries in any directions by building up the connecting relationships between the open boundary area and other related spatial nodes (including simplified adjacent open boundary areas). At the first level this takes an open boundary area as one node of a link-node network for path planning outside walking areas. The second level is used for optimal path planning inside the walking areas. The detailed algorithm will be published in the near future.

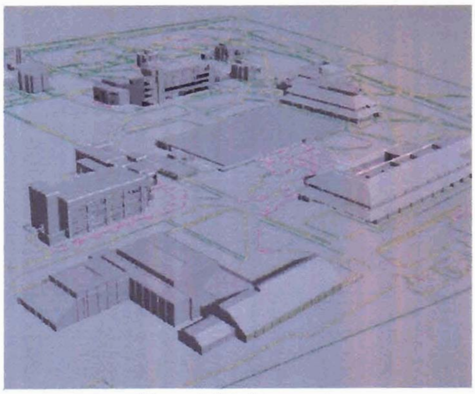

Figure 4 3D data sample

V. CONCLUSION AND FUTURE WORK

Our goal is to obtain a cost effective way for data collection and software deployment for LBS applications for the case study of pedestrian navigation in a university town. A 2D data collection solution has been adopted based on OpenStreetMap. This paper has described our preliminary work so far. Future work will focus on better optimal path representation for various topographic situations. Furthermore, we will develop test applications for mobile terminals to allow user testing to be performed. Figure 4 shows a 3D data sample of NUIM campus obtained as part of the StratAG project. The extension of pedestrian navigation to 3D scenarios (for example, inside buildings) will also be investigated.

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