Comparison of the accuracy of OpenStreetMap for Ireland with Google Maps and Bing Maps

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***Abstract*—We describe a comparison of the accuracy of OpenStreetMap for Ireland with Google Maps and Bing Maps. Five case study cities and towns are chosen for this comparison. Each mapping system is analysed for accuracy under three main headings: spatial coverage, currency, and ground-truth positional accuracy. We find that while there is no clear winner amongst the three mapping platforms each show individual differences and similarities for each of the case study locations. We believe the results described in this paper are useful for those developing Location-based services for countries such as Ireland where access to high-quality geospatial data is often prohibitively expensive or made difficult by other barriers such as lack of data or access restrictions.**

Keywords: OpenStreetMap, Google Maps, Bing Maps, Ireland,

Introduction

When choosing a free-to-access web-based mapping system for navigation, location-based services, or general information there are three dominant services: Google Maps, Bing Maps, and OpenStreetMap. These web mapping platforms are the most popular web map sources for use in location-based services with specific emphasis on pedestrian navigation, tourist guide applications, and other location-based search applications. Which mapping system is currently the most accurate for Ireland is an open question. This paper attempts to fill a gap in the literature in regards to the evaluation of web-based mapping platforms for use by location-based services using Ireland as a case-study. Anecdotal evidence suggests that Google Maps and Bing Maps are the most popular and heavily used. However this evidence appears to be strongly correlated with the side of the argument one is on. Those interested in free and open access to spatial data in Ireland point to high quality OpenStreetMap (OSM) in Dublin, Maynooth, and Cork as examples of OSM's success. Others argue that Google Maps and Bing Maps have better overall coverage to the point where their usage is almost ubiquitous. We describe an extensive manual visual comparison between the three mapping systems for five urban locations in Ireland.

A. Related Work

Currently there is very few peer-reviewed reports and articles which look to compare OpenStreetMap with proprietary web mapping systems. This is potentially due in no small part to the difficulty of accessing vector data from proprietary systems such as Google Maps and Bing Maps. Haklay (2008) provides a detailed comparison of OSM for the UK against vector data from the Ordnance Survey UK. Otherwise a gap in the literature exists. This has resulted in many of the available comparisons of these systems relying on visual comparison rather a more analytical metric-based comparison. One of the several online tools for comparing Google Maps and OpenStreetMap is provided by Geofabrik (2010) where Google Maps and OpenStreetMap are presented in a split-pane browser window allowing visual comparison as the user pans and zooms around the map. O'Brien (2010) shows a very recent visual comparison of OSM and Ordnance Survey Meridian 2 data. In Gorman (2008) some work is shown with the results of a subjective analysis of OpenStreetMap and Google/Teleatlas. Maps from both systems were ranked 0 (if the map was blank) and 5 (if it appeared nothing was missing from the map). This ranking showed OSM as "well ahead" of Google in Europe. This claim has been challenged in some blog comments on two fronts: firstly due to the fact that the creators of the study are well known OSM volunteers and secondly because the metrics for comparison are not clear. Captial cities are only studied. Haklay (2010) blogs results of a comparison between OpenStreetMap and Google Map Maker for post earthquake Haiti. Map Maker allows the download of Google Map vector data – a facility not available for Ireland or indeed most countries in Europe and North America. By looking at the amount of road data available in 1km square grids Haklay shows that there are some areas where both systems provide high quality, high volume data. Then there are many examples of where OSM is strong and the Google is weak and vice versa. The rest of the paper is organised as follows. The next section describes the experimental setup for this comparative analysis of Google Maps, OpenStreetMap, and Bing Maps in Ireland. A detailed discussion of the results for each case-study location is provided in the results section. The paper closes with a discussion of some of the key conclusions drawn from this work with some outlines of future work provided.

Experimental Setup

As explained above it is not possible to obtain access to vector data for either Google Maps (Teleatlas) or Bing Maps (Navteq) in Ireland. Consequently a quantitative vector-

based comparison between OpenStreetMap and Google Maps and Bing Maps is not possible. We took the following approach. OSM data for Ireland was downloaded in OSM XML format in March 2010 from Cloudmade (Cloudmade, 2010). Using the osm2pgsql tool this OSM XML was imported into a PostGIS database. This provides us with access to all OSM data for Ireland in a relational spatial database. The ogr2ogr tool from the GDAL library provides command-line functionality to allow the output from SQL queries of PostGIS be converted to spatial formats such as Shapefile and KML. We designed a set of SQL queries perform the following actions: (1) extract all roads, streets, lanes, etc to KML format for each individual study location, (2) extract all POI for each individual study location to KML. These POI KML were further subdivided into POI classification ie pubs, hotels, shopping, etc. Each KML file was centered on the point designated as town or city center – in our case the location of the town or city hall. Using the ST_EXPAND function in PostGIS a 4 km2 rectangle was generated centered on this location. Only lines, polygons, and points inside, on, or interesting this rectangle were considered and represented in the KML files.

The KML files can be easily overlayed on Google Maps and Bing Maps. A special web application was developed using OpenLayers which allows us to view the KML files overlayed over the following mapping platforms: OpenStreetMap (Mapnik and Osmarender), Google Maps (streets, satellite, and hybrid), and Bing Maps (roads, birds eye, and hybrid). The AJAX functionality provided by OpenLayers saved a great deal of time in the work of comparing the three mapping platforms due to the ability to easily switch between base-layers for a given KML file without losing positional context (map center, current zoom level, KML overlay, etc). This also provided each of the authors with an opportunity to carry out comparison assessments individually on their own computer and then collate the results of these assessments to obtain an agreed upon overall quantitative analysis for each location.

Results

In the tables below we show the results of the analysis of each of the five case-study locations. Each table shows the results for a different location. For each location the following road features were counted: motorways, national primary roads, roundabouts on national primary routes (Nat Rnd), regional roads, roundabouts on regional routes (Reg Rnd), streets and roads in housing estates (Estates) and roundabouts on housing estates roads (Estate Rnd). As stated above only road features which are inside or intersected the 4km square are included in the statistics in the tables below. Some of the case study locations does not include all road features – if this is the case this row is omitted from the table for clarity. We use a simple scoring system in each table. If a mapping systems displays a given road feature then "All" is inserted into the table cell. For each serious error which includes: incorrect streetname, incorrect road or street designation, incorrect physical placement of road feature with respect to ground-truth and local knowledge a score of -1 is deducted from that mapping provider. In the case were the three map providers differ on the coverage of road features (in particular housing estate roads) then the number of road features within the 4km square is shown. We begin with the results from Ennis (in Table 1). Ennis is a large town in the south-west of Ireland with a population of approximately 25,000.

Table 1: Visual comparison results for Ennis

Ennis	Bing	Google	OSM
National	All	All	All
Nat Rnd	All	All	All
Regional	-1	-2	-3
Reg Rnd	4	8	10
Estates	107	127	134

There are some clear differences between the three mapping systems in Ennis but we feel that in Ennis OSM is a clear winner. The -3 score for OSM for regional is a result of missing names of regional routes which could be easily repaired. Coverage of housing estates, cul-de-sac roads, and regional road roundabouts is superior to the other systems. This could indicate that OSM contains more temporally accurate data.

Table 2: Visual comparison results for Drogheda

Drogheda	Bing	Google	OSM
Motorway	All	All	All
National	All	-1	All
Regional	-3	-4	-1
Reg Rnd	6	4	6
Estates	95	97	51
Estates Rnd	5	7	2

In table 2 the results for Drogheda are shown. Drogheda is a town with population 35,000 located in the north-east. This location also shows variation amongst the three map providers. It is the one location where OSM performs very poorly. Figure 1 shows OSM overlayed onto Google Maps. Several estate roads are missing from OSM. While OSM provides accurate mapping of the motorway and national road network in the town the lack of OSM activity in Drogheda is shown by the fact that OSM contains almost 50% less estate roads than either Google or Bing. The negative scoring for regional roads is a result of a serious problem with the R166 regional road passing through the town center. Ground-truth verification shows OSM has the most accurate and up-to-date spatial data on the R166. This road was reclassified from a national route to a regional route about 12 months previous. This is an example of where the proprietary mapping systems find it difficult to provide the most current and up-to-date data.



Figure 1: OSM is overlayed on Google Maps for Drogheda. This example highlights the lack of OSM mapping in some high population housing estate areas of the town

Maynooth	Bing	Google	OSM
National	All	All	All
Regional	-1	All	All
Reg Rnd	2	2	3
Estates	24	26	29

Table 3: Visual comparison results for Maynooth

In Table 3 the results for our own university town location Maynooth (population approximately 10,000) are shown. In Maynooth OSM activity is high due to work carried out by our research group (see Ciepluch et al, 2009). and consequently OSM compares favorably with Bing and Google. Some recently completed housing estate roads are not visible in Bing or Google. Update of OSM for Maynooth happens regularly often at fortnightly intervals.

Table 4: Visual comparison for Waterford city

Waterford	Bing	Google	OSM
National	All	All	All
Regional	-4	All	All
Reg Rnd	11	13	14
Estates	133	156	155
Estates Rnd	4	5	8

Waterford is a large city in the south easy of Ireland and has a population of approximately 60,000. OSM performs well for roundabout road features in Waterford many of which have been completely in the last year. This is partially due to the currency of the Google and Bing Maps for the city. Figure 2 and Figure 3 show OSM in KML format overlayed on Bing and Google respectively. Bing does not have the estate road network linking with Belmont Road. Google fairs slightly better here. However both Google and Bing do not have roundabouts mapped for this location.



Figure 2: OSM overlayed on Bing Maps for Waterford - Estate road roundabout is not displayed in Bing



Figure 3: OSM overlayed on Google Maps for Waterford - this is the same estate road as Figure 3.

Finally, we present the results of the analysis for capital city Dublin. The 4Km grid included all of Dublin city center and provided a major task to conduct our manual visual survey of all roads, streets, roundabouts, etc.

Table 5: Visual comparison for Dublin city

Dublin	Bing	Google	OSM
Motorway	All	All	All
National	-1	-3	All
Regional	-8	-4	-5
Estates	All	All	-2

In table 5 there is variation between the three mapping systems. In the case of national roads the negative scores for Bing and Google represent incorrect naming and extent of national roads mostly the N11 which terminates within the

city center. Amongst the regional roads the problems are varied. They include: incorrect designation of roads and one-way street systems and the marking of regional roads as service roads. For OSM there is missing roads at major regional road crossroads and junctions – physically gathering mapping data may be difficult for volunteers at these locations due to high traffic levels. The counting of estate roads for Dublin city is different to the other four examples. Given the high density of housing and apartments Google and Bing do not follow their normal cul-de-sac/estate road schema. It is not easy to designate roads and streets as estate roads for our analysis. In table 5 we include local roads as estate roads. One of the problems encountered here for OSM are housing access roads which are controlled by security gates – when manually sampling and collecting data the OSM volunteers cannot access these areas. Bing and Google extract such detail from a combination of ground-level collection campaigns and high resolution satellite imagery.

We also attempted to compare Points of Interest (POI) in the three systems. POI (for pubs, hotels, etc) are easily extracted from OSM database and converted to KML format. POI queries for Bing and Google Maps rely on manual search from the web-page queries. We then compare the results of these queries to the actual placement of POI from OSM. For this part of the work we assume the OSM provides the ground-truth correct placement of the POI. This part of the work was more difficult to provide a quantitative analysis for. However there are a number of key issues which arose. (1) Hotel results are very difficult to filter in Google Maps. In Maynooth the Glenroyal hotel is shown as a POI in 7 different locations. The Carton House hotel is shown inside the university campus which is approximately 2km from it's actual location. (2) Bing Maps has little in the way of pubs, hotels, and businesses POI for the five locations. (3) In the case of Dublin city Bing Maps has far less coverage in terms of POI in comparison to Google or OSM. In many cases the POI in Bing Maps is returned using text searches but is not shown on the corresponding map. (4) Many of Google Maps' search results are geocoded locations extracted from KML files users have placed under public availability in the "My Maps" feature of Google Maps. There is a serious problem with the KML file is wrong or out-of-date. (5) Finally, when a POI search is performed in Google Maps it is often the case the address of the business/tourist spot, etc is geocoded on the fly and then a marker is placed there in the search results. The actual location is not 'mapped' in Google Maps but displayed on map-based search results.

Conclusions and Further Work

We have shown the results of an extensive manual comparison of the accuracy of OpenStreetMap, Google Maps, and Microsoft Bing Maps for Ireland. Accuracy was judged based on: completeness of the map, currency of the spatial information, and correctness in relation to ground-truth and local knowledge. There appears to be no consistent accuracy for any of the three mapping systems over all five case study locations – each location providing some very obvious examples of inconsistencies. For example the N25/N24 road intersection in Waterford was opened in September 2009. This falls just outside our 4km square for Waterford city. OpenStreetMap and Google Maps provide the updated and current road configuration. However we estimate that Bing Maps is more than one year old. In Dublin the Samuel Beckett Bridge (opened in December 2009) over the River Liffey and now a major traffic link is currently not shown in Bing Maps. Only in the past number of weeks have Google Maps updated to include the bridge. In Maynooth the Railpark housing estate is mapped accurately in OpenStreetMap and Bing Maps – the KML overlay from Maynooth OSM fits almost perfectly onto Bing Maps for the same area. However Google Maps shows a complete shifting north-wards of approximately 10 meters on average all line features in this area. We feel that this may be an artifact of automated tracing over a low resolution aerial image of the area because adjacent housing estates to Railpark are not subject to this shifting. In the example of Drogheda town large sections of the town are completely unmapped despite being areas of high population density. Our paper has shown that OpenStreetMap has shown many positive and negative characteristic in terms of providing a comprehensive and accuracy mapping resource in Ireland. As our work has shown the coverage and accuracy of OpenStreetMap is loosely connected with: the number of volunteers mapping a given area and the location of the mapping locations. As stated in Haklay (2008) there is evidence to suggest that there are "areas where nobody wants to map". If this is a widespread problem in OpenStreetMap it represents a significant obstacle to improving accuracy and coverage. This is an area where Google Maps and Bing Maps have a distinct advantage. In Haklay (2008) the author provides one of the first quantifiable study of the accuracy of OSM data – in this case against Ordnance Survey data in the UK. We feel that for OSM to be taken seriously as a source of spatial data metrics must be developed to allow the measurement of both accuracy and coverage at neighbourhood/county/country levels both of which need to be quantifiable for the data for it to be accepted (and used) widely in the geo-community.

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