DEVELOPING A USER GENERATED METHOD TO ADD LANDMARKS TO OPENSTREETMAP

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Declaration

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This is to certify that
(i) the thesis comprises only my original work towards the Masters
(ii) due acknowledgement has been made in the text to all other material used,
(iii) the thesis is 11417 words.
Abstract

The essential role of landmarks in human way finding motivated researchers to investigate options of integrating landmarks in navigation systems to generate automatic instructions that are close to human instructions. These attempts usually define methods to select landmarks from various datasets including cadastral maps and yellow pages. However, landmark selection in a volunteered geographic information database has never been tried before. In this research, Openstreetmap is used as a volunteered geographic information dataset to be used for adding landmarks. It is proposed to add landmarks with a user-generated method to Openstreetmap. A system is designed for this purpose and is tested in adding landmarks to Openstreetmap.
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Chapter 1 - Introduction

Assume you are driving in an unfamiliar neighborhood and you are using a car navigation system for finding your way. Being new to all the roads and the neighborhood you are driving in, the system directs you to turn left after 500 meters into a specific street where there are two street entries next to each other and it is hard to find their names. You get confused and you might end up turning into the wrong one. However, there is a gas station at the corner of the street you are supposed to turn into. If the system directed you to turn left into the street with the gas station at the corner, it would be easier for you to follow its instructions without confusion. That is what this research aims to achieve by introducing landmarks to Openstreetmap (OSM).

Openstreetmap is a volunteered geographic information (VGI) project that provides free maps and geographic data. The geographic information is uploaded by volunteers to a central database in the cloud and can be accessed and edited by anyone. Once a geographic feature is created in Openstreetmap, it can be tagged by additional information such as name.

Landmarks are standalone features in an environment that have characteristics which make them recognizable and memorable. Landmarks are important in mapping and navigation as humans tend to remember landmarks easier and use them more often than street names. Therefore, a navigation system that uses landmarks in giving directions is desirable. Landmarks are not currently a part of Openstreetmap and adding them to Openstreetmap will be an advantage for it to be used in navigation systems. The motivation for this research is to find a method to create a dataset of landmarks in Openstreetmap to be used for navigation purposes. This can be done automatically or with user-generated methods. Identifying and uploading landmarks by volunteers makes the dataset being based on human perception which is an important factor in landmark selection. In this research, the focus is on user-generated methods.

The research hypothesis is that it is technically possible to add landmarks to Openstreetmap with user-generated methods.

To test the hypothesis, an application is developed so that volunteers can select Openstreetmap features as landmark or add new features as landmarks to Openstreetmap. As being landmark is a relative attribute, identifying landmarks in the environment by volunteers can improve the quality of the database.

In order to develop this application the following steps are taken:
1. A taxonomy of landmarks is defined.
2. A method to add landmark properties to Openstreetmap is proposed.
3. The structure of the application is designed.
4. An application is developed based on the proposed design.
5. Landmarks are added to Openstreetmap using the proposed application.

It is expected to achieve a system that facilitates adding landmarks to Openstreetmap. Then this system can be used in collecting landmark information and the obtained dataset can be used in navigation systems.

Challenges in the mentioned process include designing an efficient system. The proposed system will be tested and iterationally modified to be as efficient as possible. Introducing the system to the Openstreetmap community is another challenge. As Openstreetmap is running on volunteers’ interest, landmarks, their importance in navigation and the system needs to be introduced to the community to draw volunteers’ attention to contribute in adding features as landmarks. Reaching a great number of volunteers is a key to achieve a growing dataset of landmarks which helps to achieve the final goal of this research, which is having a landmark dataset in Openstreetmap to be used in navigation services.

The existing literature is reviewed in Chapter 2 to identify landmark definitions and characteristics from previous works. Attempts on proposing landmark selection methods that can be used in navigation have been investigated to reflect the importance of landmarks in navigation. A background is mentioned on VGI and Opensteertmap as VGI. The Openstreetmap data structure is investigated to find a method to add landmarks to Openstreetmap. In Chapter 3, a taxonomy of landmarks is defined and a method of storing landmark information in Openstreetmap is proposed. The role of users in collecting landmarks is mentioned. Finally, it is discussed how collected landmarks can be used in a navigation system. In Chapter 4, the general design of an application that allows volunteers to add landmarks to Openstreetmap is discussed. Followed by that, an application is developed and its capabilities are described. In Chapter 5, the proposed application is used to add landmarks to Openstreetmap. In Chapter 6, the results of using this application in adding landmarks and the application’s limitations are discussed. In Chapter 7, conclusions and directions for future work in this area are presented.
Chapter 2 - Literature Review

Landmarks

Landmarks are prominent features in an environment that have characteristics which make them identifiable and memorable. They are also referred to as salient features in the literature (Sorrows and Hirtle, 1999). Winter et al. (2008) discussed that a feature is called salient if it is distinctive based on its visual, semantic or structural properties from its surrounding features. The definition indicates that being a landmark is environment dependent and is a relative property (Nothegger et al., 2004, Elias, 2003). A big shopping mall can be a landmark in a route that has only that one mall. On the other hand, if the shopping mall is located in a street that has several malls next to each other, the mall might not be a good choice of a landmark.

A classification of landmarks into three categories of visual, semantic and structural was first conducted by Sorrows and Hirtle (1999). Visual landmarks are objects that are memorable due to their visual contrast with their surroundings and prominence in their spatial location. A ten storey building among two storey buildings will form a visual landmark. Semantic landmarks have an outstanding meaning in their neighborhood and they are in contrast with their surroundings. A supermarket in an area with no other supermarkets will be categorized as semantic landmarks. Structural landmarks are objects whose location in the structure of space makes them distinguishable. A busy street intersection is in this category. This is the classification that is used in this research for landmarks.

Landmarks were defined as one of the elements of a city image by Lynch (1960). He classified contents of a city image into five elements:

1. Paths: Channels along which the observer moves.
2. Edges: Linear elements not used by an observer.
3. Districts: Two dimensional extents in a city, which an observer mentally enters inside of.
4. Nodes: Points in a city into which an observer can enter and from which he can travel.
5. Landmarks: Landmarks are external points of reference. They are physical objects including buildings, signs, stores and mountains. Lynch mentioned the physical characteristic that makes a landmark identifiable is its singularity which includes having a
clear form, being in contrast to the background and having prominence of spatial location.

Siegel and White (1975) and Golledge (1999) later discussed that all the mentioned elements by Lynch can be a landmark.

Landmarks play a major role in building a mental representation of space in human cognition (Michon and Denis, 2001). They help organizing space and they are used in giving routing instructions where a navigational decision has to be made (decision points) (Golledge 1999). Lovelace et al. (1999) described elements of giving good route directions. They mentioned that referring to landmarks along the route as well as referring to them at decision points is one of the elements that improve a routing instruction. Landmarks are used by people when giving route instructions more often than street names (Tom and Denis, 2003). Giving directions to people unfamiliar to environment with street names is less effective than the ones using landmarks (Tom and Denis, 2003).

Having this in mind, various researchers have aimed to characterise landmarks to be used for navigation and to find methods to automatically extract landmarks and use them for navigation purposes.

Route adaptive landmark selection was conducted with different factors. Advanced visibility was introduced by Winter (2003). Advance visibility of a feature should be considered in addition to its saliency when selecting a landmark for a route. It means that a feature should be visible in advance when going towards it from a route. Structural salience was formalized by Klippel and Winter (2005). Winter et al. (2008) proposed a model of hierarchy of salience for automatic landmark extraction. Duckham et al. (2010) proposed a model that used types of landmarks and their spatial characteristics within the route to formalize automatic landmark selection.

Burnett et al. (2001) proposed five characteristics for a good landmark for navigation: permanence (likelihood of landmark being present, associated with its form and label), visibility (being visible in all conditions), usefulness (being close to decision points), uniqueness (not being mistaken with other objects) and brevity (the conciseness of description associated with it when giving directions).
Raubal and Winter (2002) proposed salience measures based on visual, semantic and structural properties of features. For visual attractions they listed properties including façade area, shape, color, visibility, texture and condition (age and cleanness) that can make an object prominent. For semantic attraction they listed cultural or historical significance, prototypicality, identifiably by explicit and implicit marks. For semantic attractions they mentioned that nodes, edges and districts (in Lynch’s elements of the city) can be structural landmarks. They decided not to include texture, condition, prototypicality, implicit marks and areas in their model for measuring salient objects as they were hard to identify. Nothegger et al. (2004) proposed a formal model of saliency based on visual and semantic properties of features. Raubal and Winter (2002) and Nothegger et al. (2004) considered one type of landmarks – buildings – in their studies.

Elias (2003) proposed a data mining method to extract landmark information automatically. She also considered a small range of landmarks - buildings - in her investigation. The attributes of the buildings she used include building use, size of the building, number of immediate neighbors, orientation towards the road, distance from the road and height of the building.

Some of the automatic landmark selection theories were tested (Peters et al., 2010) in order to help navigation systems to find best methods to generate routing instructions close to human descriptions.

All the mentioned efforts indicate the importance of landmarks in navigation. All studies tried to characterise landmarks, some route independent and some route dependent, to perform automatic landmark selections. Although some common properties are used for landmark selection, the properties they worked with and their selection methods vary from one approach to the other. The main common factor among them is that they have mainly used buildings as landmarks and they have just looked at automatic landmark selection methods to come close to human landmark selection. No investigation has analysed the potential of using humans themselves to identify landmarks and have an automatic selection from list of landmarks provided by humans. These gaps can be identified by going through existing landmark literature. In the next section, the concept of gathering information from a large number of people will be explained.
Volunteered geographic information

Mapping and geographic data collection was a specialized task until recent technological advancements. Each country has its own mapping organization(s) that performs geographic data collection by trained employees and creates geographic datasets and maps. The produced data is expensive, authoritative and keeping it up-to-date takes time and cost. Moreover, data is not always available and accessible for individuals. With technological changes and introduction of systems like the Global Positioning System (GPS) that allows untrained people to collect geographic data with reasonable accuracy, people started to collect geographic data and share it on the web in order to provide free and up-to-date accessible geographic data. Volunteered Geographic Information (VGI) is a term used by Goodchild (2007) for the first time to describe the phenomenon of contributions of the public in creation of geographic information systems. Crowdsourcing (Surowiecki, 2004) and user generated content (Krumm et al., 2008) are more general terms, indicating performing a task by a large number of users without any special knowledge and training and any central authorization.

Openstreetmap is one of the VGI attempts that aims to provide free access to geographic data worldwide and will be described in more detail in the next section.

Openstreetmap

Openstreetmap (http://www.openstreetmap.org/) is a project that allows people to contribute to geographic information collection and provides user-generated content maps (Haklay and Weber, 2008). The project was initiated in 2004 at University College London (UCL) by Steve Coast. Since then, it has grown rapidly in the number of users and the geographic data it provides. Figure 2.1 shows the Openstreetmap main page.
Openstreetmap’s geographic data is mainly collected by volunteers using GPS, free satellite images and free data sources. Moreover, some organizations, local and national governments have donated geographic data to Openstreetmap that helped to complete data in some areas of the world. Gathered data and their properties are uploaded to Openstreetmap by volunteers. Each volunteer needs to have a username and password to be able to edit data. This has been conducted to allow tracing the source of data in case of copyright dispute. Users are able to add any type of information associated with geographic data. Any volunteer can edit the existing geographic data and its attached information if they are wrong, out of date or not accurate enough. The geographic data contains a variety of features including roads, buildings, points of interest, rivers and administrative boundaries.

There has been an ongoing debate on the quality of data provided by VGI and a concern about its credibility (Flanagin and Metzer, 2008) in general and the accuracy and completeness of Openstreetmap data in specific. Haklay et al. (2010) proposed that quality of data in an area grows with increase in the number of contributors in that area. Girres and Touya (2010) discovered that the number of Openstreetmap features in an area increases when the number of volunteers in the area increases. Some research has been conducted to check how accurate and complete is the data in different countries (Haklay and Ellul, 2010, Ather, 2009, Kounadi, 2009, Haklay, 2010). All of them have gained similar results. After comparison with official datasets,
the data was found to be as accurate as the official data. They discussed that the data in urban areas is more complete. Going away from large cities the number of contributors and correspondingly, mapped areas decrease. However, by its dramatic growth in number of users, the mapped areas are expected to increase rapidly. They have found that in some areas with large number of contributors, Openstreetmap even had a more complete and up-to-date dataset. These findings indicate that in areas with a large number of contributors, Openstreetmap can be a reliable and complete dataset.

Openstreetmap data has been used for different purposes. Various software and applications have been developed using Openstreetmap or editing its data. Landmarks have not been introduced to Openstreetmap so far. In this project a method is proposed to add landmarks to Openstreetmap. In order to integrate landmarks into Openstreetmap, it is required to briefly explain the Openstreetmap data structure.

Openstreetmap is made up of three basic elements that are its data primitives: nodes, ways and relations (OSM, 2011a). In addition to these elements, tags that are used to describe properties of elements, and changesets that are used to save all the editing history will be explained.

Node: node is the simplest geographic feature which is a point with geographic coordinates. Nodes are the building structure of ways and relations. Nodes can represent stand-alone geographic features including buildings, telephone booths and trees. In addition, they can be a part of a way and then have no meaning by themselves.

Way: way is a list of minimum two nodes connected together to form a linear geographic feature. These features include roads, railways and rivers. Openstreetmap does not have a polygon structure for showing areas. Closed ways, which are ways with the same starting and ending node, are used to indicate areas.

Relation: relation is used to group nodes, ways and even other relations to describe the same property among these elements. Polygons with holes and long roads that require more than the maximum allowance of consisting nodes for a single way (2000) are examples that are represented by relations.
Tag: tag is a key-value pair (OSM, 2011a) that describes the properties of an element including its name. A geographic feature can have as many tags as required to efficiently describe its properties. An element is not recognizable and verifiable without its tag. There is no rule on what to use as a tag, but it is recommended to use tags that are agreed on in the Openstreetmap community for a common data interpretation and display (OSM, 2011c). Although many tags are documented in the Openstreetmap wiki (http://wiki.openstreetmap.org/wiki/Main_Page), there are many tags used, widely or not, that have no documentation which makes interpretation of these tags for other users difficult. Users rather not add new tags unless there is no tag for a specific use. In this case it is suggested to add a new tag description and use in the Openstreetmap wiki and introduce the tag to the community (Bennet, 2010). Tags and values are commonly written in lowercase and have no space but underline for readability if required (Bennet, 2010). A key cannot have more than one value, thus if it is needed to add more, a prefix or suffix can be added to key, separated by a colon.

Changeset: a set of edits that are done by one user in a certain time is called changeset. For any edit, a changeset needs to be opened, edits are done within the changset and then it is closed. Changesets facilitate identifying changes in Openstreetmap data. According to Bennet (2010), with the growing rate of popularity of Openstreetmap, changeset is one of the tools that keeps the data away from vandalism.

**Landmarks and points of interest in Openstreetmap**

**Landmark**

Searching the Openstreetmap wiki for Landmark, two applications of tags that specifically use the term ‘landmark’ are discovered:

1. seamark = landmark, landmark = * (OSM, 2011b)
   These two tags are used for every nautical landmark. The first tag indicates that the object is a nautical landmark and with the second tag, a user defined value can describe the landmark. As this landmark tag is used in marine tagging, it is far away from the definition of landmark in this research.

2. naptan:landmark = * (OSM, 2010b)
NaPTAN is a dataset for public transport stops in the UK that is going to be made available to the Openstreetmap dataset by the UK Department for Transport and Traveline (OSM, 2010a). This tag will be used to describe the nearest landmark, for instance a street crossing name or a library, to the stop which makes that stop distinct from other surrounding stops. The term landmark here is used for every distinct intersection or building. Thus it is a limited definition for a landmark. Furthermore, as it is looking for landmarks near stops in the UK, it is case specific and cannot be used as a world-wide tagging for landmarks.

**Points of interest**

Point of interest (POI) is a specific point on the earth that is interesting or useful for a certain task or application. For instance, speed cameras are points of interest in navigation as people tend to be informed about their location in order to prevent speeding and getting fined. The closest playground is a point of interest for a family that is searching for a playground for their kids. According to Nothegger et al. (2004) although currently points of interest are used as a substitute of landmarks in navigation, there are three major differences between them. A point of interest is user objective and context dependent, it is defined based on commercial interests and a fixed dataset of points of interest is not complete enough for every route. A user may not have any interest in the closest playground. A playground may not be a distinct feature in the neighborhood to help people in giving directions. A speed camera is not a distinct object in the environment at all. Although having all of the restaurants as points of interest can help someone who is looking for one to find the closest, in giving direction one at a corner might be recognizable and useful and another might not be identifiable. There might be two or more points of interest around when giving directions. With a fixed set of points of interest and having no method to measure their salience, they cannot be a replacement for landmarks.

Even though points of interest are not recommended to be used instead of landmarks, because they are used widely in Openstreetmap and currently they are the closest definition to landmarks in Openstreetmap, their use in Openstreetmap is discussed in this section.

Points of interests in Openstreetmap are mostly single nodes that are categorized into six different types in the Openstreetmap wiki (OSM, 2011g). The types are:
1. Churches, schools, town halls, distinctive buildings
2. Post offices, shops, postboxes, telephone boxes
3. Pubs
4. Car parks
5. Speed cameras
6. Tourist attractions

There are two major problems with this categorization and definition. First, the focus is on point features and second, the categories are incomplete.

Based on the ‘one feature, one OSM element’ (OSM, 2011f) practice in Openstreetmap, it is recommended that buildings be mapped as areas rather than points unless their shape is unknown. Therefore, whenever a building is considered as a point of interest, and it is represented by an area, point of interest tags should be assigned to that and the area should be a point of interest. There are lots of areas that are mapped in such a way that there is a node inside a closed way and both features represent the same building or area. It is recommended to delete the node inside and assign all the tags to the area. However, POI software deal with points of interest as nodes and have the ability of editing tags for a point of interest node or add a node as point of interest. This indicates an inconsistency of the ‘one feature, one OSM element’ practice that encourages deleting the extra points with POI editors that encourages adding nodes.

Openstreetmap POI editor software

There are several software tools that enable users to edit Openstreetmap data. There are three major editing software tools, JOSM (http://josm.openstreetmap.de/), Potlatch (http://wiki.openstreetmap.org/wiki/Potlatch) and Merkaartor (http://merkaartor.be/) which are used for editing Openstreetmap data. These tools are used to edit geometry and tags of Openstreetmap data. Although they can be used to add or edit POIs, they are not specifically designed for this task. A few POI specific editors are discussed in this section:

1. Amenity Editor (http://ae.osmsurround.org/ae/index) is a web based platform that allows users to edit or add POIs to Openstreetmap. It simply has selected a group of tags that represent points of interest and shows them with different symbology. User can add a node of these types or add information to existing nodes.
2. Mapzen POI Collector (OSM, 2011d) is an editor for android and iPhone that allows users to edit POIs or add new ones. Similar to the Amenity editor, a predefined number of tags and POI types are supported.

3. Mobile POI Collector (OSM, 2011e) is a project under development that aims to provide a web based POI editor that can be used in all phones. Currently its test versions are available online that have the ability to add new POIs.

All mentioned POI editors, as discussed before, deal with points of interests as node elements. Furthermore, they assume that points of interest are mainly buildings or objects like phone booths, post boxes or speed cameras. Therefore not all types of nodes including road intersections are covered.

**Adding landmarks to VGI**

Considering Openstreetmap properties and growth, as a case of VGI, raises the question of integrating landmarks in VGI. Data sources that are required for automatic landmark extraction are not always available and accessible. These data sources include digital city maps, rectified images of each building façade, ortho images, yellow pages, cultural heritage databases and digital cadastral maps (Raubal and Winter, 2002, Nothegger et al., 2004, Elias, 2003). Some information about each feature cannot be derived from existing datasets or might lead to wrong decisions. For instance, for an old building that has been renovated, if its age, derived from a dataset, be considered as a salient factor, the results will be misleading. Furthermore, the datasets may not be as up-to-date as VGI repositories.

As landmark selection is a cognitive process, having a landmark database that is created based on human perception can be beneficial. This is possible with introducing landmarks to a VGI project and letting the crowd to do the rest.
Chapter 3 - Theory

In the previous chapter, it was identified that no attempt has been made to create a VGI landmark database. In this chapter, the fundamental definitions for introducing landmarks to VGIs, in the case of this research, Openstreetmap, are mentioned. Landmark definition for this research and the properties that are going to be associated with the landmarks are defined. A desired system from a user’s perspective is discussed. Finally, an insight on how the collected landmarks can be used in a navigation system is mentioned.

As mentioned earlier, the classification of Sorrows and Hirtle (1999) for landmarks is applied. Landmarks are not narrowed down to buildings and point like objects. All Lynch elements of a city - paths, edges, districts, nodes and landmarks - (1960) are considered to be landmarks based on visual, semantic and structural characteristics that makes them memorable and distinct in their environment.

Landmark properties

The properties that are going to be associated with each landmark are described below:

1. Name: any object in an environment usually has a name that is used by people when they are referring to it. Nevertheless, sometimes an object name is not clear for everyone or the object has no name. In these situations, people usually describe the object by its characteristics. For instance, they can say when you reach the park, turn left, or the post office is next to that tall gray building. Even though a feature’s name is not required for categorizing it as a landmark, because it is a measure to identify the feature, it is decided to be in the properties list of a landmark (if it has a name).

2. Type: using the name of a feature alone does not usually help people to identify a feature. The second measure that is helpful for an observer to know what he/she is looking for, is to know the type of a feature. Knowing that you are looking for a street, which is a linear feature, a lake or a school makes a huge difference. Type is a diverse list including theater, post office, restaurant, church, street intersection, square, bridge, park and river.

3. Identifiable factor: the characteristic that makes a feature stand alone in its environment to become a landmark is called identifiable factor in this research. This characteristic can be
visual, semantic and structural. From the literature review, it is clear that in each previous research, different properties were selected to describe a landmark. Among this wide range of properties, ten are selected to be used to identify features as a landmark. Six are visual properties of a feature, three are semantic and one is structural. For a feature to be a landmark, it has to have at least one of these properties. However, some features have much more than just one.

3.1. Visual characteristics

3.1.1. Shape: when shape of an object is significantly different from its surrounding objects, it makes the object being easier to remember and being recognized by humans. In an area with cubic buildings, a conical object is distinguishable. An example can be Melbourne Central Station in Melbourne that has a conical roof which makes it recognizable when moving toward the building.

3.1.2. Size: size of a feature is another visual measure that is useful in recognizing it. A tower in the middle of few storey buildings is a distinctive feature. Saint Paul’s Cathedral in Melbourne is a massive building in comparison to buildings around it.

3.1.3. Visibility: if a feature is visible from different directions and from a long distance, the possibility that it is used by people as a landmark will increase. Saint Paul’s Cathedral in Melbourne is visible from all the directions, and can be used as a landmark.

3.1.4. Color: a colorful feature or a feature with a different color from its environment draws human attention. A black building in an environment with white and gray buildings has the potential to be landmark. A Westpac bank branch in Melbourne at the corner of Collins and Swanston Streets can be used as a landmark because of its red color.

3.1.5. Texture: Texture is another factor that can be used in identifying a distinct building. A building made with brick is clearly different in appearance in comparison to buildings made with cement. Manchester Unity Building, at the corner of Swanston and Collins Streets in Melbourne can be an example of having different texture in an environment.
3.1.6. Age: last but not the least; age is the final visual measure that is used in this study for being a landmark. A street with old buildings and old structure in a suburb with modern structure can be easily recognized by any viewer. Flinders Street Station in Melbourne can be an example of an old building that draws everyone’s attention.

3.2. Semantic Characteristics

3.2.1. Type: Type of a feature is categorized as a semantic characteristic because it conveys the content. A park in a residential area full of buildings, a restaurant in a street full of clothing shops, a street full of restaurants surrounded by streets with no shops, all can be landmarks. Novotel Hotel in Collins Street, Melbourne can be a landmark as there is no other hotel around it in the same street.

3.2.2. Cultural significance: some features are meaningful to a culture. A KFC fast food is culturally identifiable among people. When it is mentioned as a landmark, everyone knows what to look for even if the fast food is not mentioned in the name. Degraves Street can be a landmark in Melbourne as lanes that are full of restaurants and pubs are a part of culture of Melbourne.

3.2.3. Historical significance: a feature that is popular among people for its historical background can form a landmark. A historical church in a city can be used as a point of reference. Saint Paul’s Cathedral in Melbourne is an example of such a historic building that can be referred to as a landmark.

3.3. Structural Characteristics

Structural significance: being a well-known part in the structure of the space can make that part a landmark. A busy square or street intersection can be memorable points in the environment. Flinders Street Station in Melbourne can be such a point of reference as it is a central station in Melbourne Central Business District (CBD) and all the trains from the CBD run from there.

4. Image: Having an image associated with a landmark makes recognizing that landmark easier for humans. If two historical buildings are located at an intersection and one of them is used as a landmark, having a visual representation of the chosen one makes it easier to be recognized.
Figure 3.1 shows all the mentioned properties of a landmark that are used in this study.

![Landmark properties diagram]

It is worth mentioning that all the examples indicate possible landmarks. In cases that there are more than one feature that can be a landmark at a point, e.g. Saint Paul’s Cathedral and Flinders Street Station and Federation Square, that are all in different corners of a street intersection in Melbourne, their identifiable factors will be compared as well as taking into account route characteristics and the direction the observer is going toward them to identify the best feature as a landmark. However, in this research the focus is on gathering landmark information that is route independent. Further research can be performed to add route adaptive information to current work.
Saving landmark properties in Openstreetmap

Now that properties that are going to be assigned to each landmark is defined, it is required to find a way for adding them to Openstreetmap. It is decided to take advantage of the fact that being a landmark is a relative property. Instead of saving the actual values for identifiable factors, e.g. color: green, it is decided to save whether being a landmark is because of a specific factor, e.g. color: yes. Collecting the actual values for each of these factors is not always easy and possible. However, the relation between the identifiable factor of a specific feature and features around are easy to collect. It might not be possible to identify what actually a material of a building façade is, but it might be quite obvious that it significantly differs from its surroundings and that is what makes it memorable. In finding the best landmark, it is not essential to know the exact factors as long as it can be identified correctly and be used for the desired purpose. Therefore, any of the identifiable factors that contribute toward building a feature as a landmark, is recorded as its name followed by yes to show what is/are the distinct characteristics of a chosen landmark.

Investigating Openstreetmap data structure specified that each feature is represented as geometry with a list of tags to describe it. Thus, it is proposed to save landmark properties as tags in Openstreetmap. If the landmark geometry exists in the database, landmark tags are added to the feature. Otherwise, a new feature, node or way, is created first as the landmark and then its properties are added using tags.

Role of users in adding landmarks to Openstreetmap

After deciding on how to save landmarks in Openstreetmap, the next step is to decide on a method to start collecting landmarks. Generally these methods can be divided into three groups of automatic landmark selection, user-generated landmark selection and a combination of the previous two. Automatic selection methods can use existing Openstreetmap data and other data sources to create a set of landmarks and add them to Openstreetmap. With user-generated methods, users are allowed to identify landmarks and add them to the dataset. With a combination, a primary set of landmarks can be created by automatic methods and then users can edit the existing landmarks or create new ones in the dataset. As it is indicated earlier, it is hypothesised that it is technically possible to add landmarks to Openstreetmap with user-
generated methods. Due to the VGI nature of Openstreetmap and advantages of user-generated methods it is proposed to let the crowd collect landmarks and add them to Openstreetmap. Moreover, the results can be interesting as they are based on human perception of the environment.

In developing a system that is working with VGI, attracting users and the system’s user interface are as important as technical capabilities. A system that cannot draw users’ attention can fail in spite of its technical capabilities. Users need to realize the importance of a project to start to contribute to it. Landmarks can be added to Openstreetmap using Openstreetmap general editing software tools, e.g. JOSM. However these tools are not specifically designed for collecting landmarks. For a user who is just interested to collect landmark information, the preferable option is an easy-to-use interface that allows adding a new landmark, editing existing landmarks and saving changes in the dataset. This can be achieved with developing a desktop, mobile or web based application. A desired option can be a mobile application that when clicked on, is able to locate the user, has access to Openstreetmap data around that location, displays the data, allows user to select a feature as a landmark or add a new feature as a landmark or edit an existing landmark and saves it to Openstreetmap. An easy to use application installed on mobile phones lets the user add a landmark or change properties of an existing landmark as soon as identifying it.

In order to increase the number of users, an Openstreetmap wiki page can be created for downloading the application with an explanation on why landmarks are important and documentation on how to use the application. Volunteers’ experiences using the developed system can be discussed in mailing groups and their suggestions can be used to improve the system applicability. Moreover, the importance of landmarks in navigation and the proposed application can be introduced to the community using Openstreetmap conferences.

To sum up, to be successful to provide a user-generated landmark dataset, it is required to plan to communicate well to the volunteers’ community and help them to realize the significance of landmark data collection.

**Using Openstreetmap landmark dataset in navigation services**

Having gathered landmark data in Openstreetmap, the next step is to find a method to use them in a navigation service. Landmarks are distinguished by their tags. Therefore, in order to
identify existing landmarks, it is required to search the dataset for features that have at least one of the identifiable factor tags. The dataset can be queried based on this tag to identify landmarks while giving directions. The problem that can be encountered here is how to identify the most salient feature if there is more than one landmark at one point. The number of identifiable factors cannot be a good option as a feature with one identifiable factor can be more recognizable by humans than a feature with more than one. A tall building (identified by its size) at an intersection can be a better option than an old restaurant (identified by its age and type). The selection of most salient features can also be done with user-generated methods. A tag can be added for selecting a feature as the most prominent one when more than one landmark exists. An automatic way of doing that can be using the editing history of a feature. A landmark that has been edited more has the potential to be more popular among the users and therefore more recognizable.

In the next chapter, a system is designed and developed to collect landmarks in Openstreetmap.
Chapter 4 - Implementation

In this chapter the general design of a desired system for adding landmarks to Openstreetmap is mentioned. Then this design is implemented by developing an application. A flowchart of desired system capabilities is illustrated in Figure 4.1. These capabilities include downloading Openstreetmap data or being able to edit live, displaying data, selecting an existing feature as a landmark, adding a new landmark, adding landmark tags and saving a feature as a landmark.

![Flowchart of desired system capabilities](image)

Figure 4.1. Required capabilities of an application for adding landmarks to Openstreetmap

As mentioned in the previous chapter, the preferable application would be a mobile application that locates the user, accesses Openstreetmap data automatically and provides a user-friendly interface for adding and updating landmarks. This type of application would encourage users to contribute more to the landmark dataset in Openstreetmap. However, in this research, in order to test the design, a simpler approach is taken. A desktop based platform is developed that aims to facilitate collecting landmark information and add them to Openstreetmap. Furthermore, the option of associating an image with a landmark is not investigated.

The programming language that is used to develop this application is Python (http://www.python.org/). A few programming modules needed to be used in conjunction with
python. GTK+ (http://www.gtk.org/) which is a toolkit for creating a graphical user interface and pyGTK (http://www.pygtk.org/) which makes the GTK+ toolkit available for Python are applied to create the application’s graphical user interface. Tl.geodrawing Python package (http://pypi.python.org/pypi/tl.geodrawing/0.1) is used to convert pixel coordinates to geographic coordinates and vice versa for drawing Openstreetmap data. Finally, PythonOsmApi (http://wiki.openstreetmap.org/wiki/PythonOsmApi) is used for accessing Openstreetmap data.

The application has a simple graphical user interface with the main window consisting of ‘Select Landmark’, ‘Add Landmark’ and ‘Exit’ buttons as well as an area that maps the Openstreetmap data. By clicking on ‘Select Landmark’ and ‘Add Landmark’ buttons, their corresponding windows are opened that are explained later in this chapter. By clicking on the ‘Exit’ button, the application is closed. The application main window is shown in Figure 4.2.

Figure 4.2. The application main window
The capabilities mentioned in the system design are implemented as following:

1. Download Openstreetmap data: Using PythonOsmApi, when the application runs, the program downloads data for a given Openstreetmap username and password and a given location (longitude and latitude). The location needs to be in decimal degrees. The data is downloaded in a bounding box with this location as its center and 0.006 decimal degrees (approximately 666 meters) as its each edge length. This number resulted from trying different numbers and visualizing data in the application. The aim was to use a number to cover all the area shown in the display window and not to download unnecessary data that is not going to be displayed that makes the application run slower.

   Downloading data was chosen over editing live as editing live is a slow process.

   After the data is downloaded, the main window is opened and the downloaded data is displayed on it.

2. Display data: the data is displayed in a 600 by 600 pixels window. It is drawn using downloaded nodes and ways coordinates. No annotations and symbols are used in displaying the data. In order to make a more readable map, some classifications are done in displaying data.

   Nodes are divided into three categories: nodes without any tags, nodes with landmark tags and other nodes. Nodes without tags are the ones that contribute to making a way, so they have no meaning by themselves. They are drawn in black and smaller in order not to be visible. Nodes with landmark tags are drawn bigger and in a different color, orange, to be easily identifiable. Other nodes are drawn in a size between the previous two and in black, as they are an indication of an object in the map.

   Ways are also divided into three categories: closed ways, ways with landmark tags and other ways. Closed ways indicate a building or generally an area; therefore they are drawn thicker and in black to be different from other ways which are mainly streets. Ways that are categorized as landmarks are drawn in orange, with the same
line width of closed ways. Other ways are drawn in black and with a smaller line width.

3. Select a feature as a landmark: The application has the ability to select any type of feature as a landmark. The way this selection works is that, for a point landmark a user needs to click on the point and then ‘Select Landmark’ button. For a street or an area, a user needs to click on one of its nodes and then click on ‘Select Landmark’ window. The application automatically finds the landmark’s name and type and displays it for the user. The ‘Select Landmark’ window is shown in Figure 4.3. In the ‘Select Landmark’ window, all ten identifiable factors are displayed with check buttons. A user selects all the relevant factors to the selected landmark and clicks on the ‘Save’ button. By clicking on ‘Save’, that feature’s information will be updated in Openstreetmap dataset with a changeset that is automatically created in the application.

![Select Landmark](image)

Figure 4.3. ‘Select Landmark’ window
If a user does not click on the map or clicks where there is no node and then clicks on ‘Select Landmark’ window, the window will show the message ‘No landmark selected’ instead of name and type. This is illustrated in Figure 4.4.

Figure 4.4. ‘Select Landmark’ window when no landmark is selected

Landmark names are retrieved from three tags: tags with name, description and building as their key. If a landmark has name and description keys in its tags, their values are both displayed in ‘Select Landmark’ window as the landmark’s name. If it has one of them, the value of that key is displayed. For closed ways if there are no name and description keys in tags, but the way is tagged with ‘building = yes’, ‘Building’ is displayed instead of the name. In other cases, no name will be displayed.

Landmark types are retrieved from five tags: tags with leisure, amenity, shop, tourism and railway as their key. Tags with leisure as key have values like park, swimming pool and stadium that indicate some of the places people go in their leisure time. Values for amenity key include a wide range of amenities like restaurant, pub, library, parking, bank and university. Shop values describe different
shop types and include bakery, convenience, mall and newsagent. Tourism key is used for tourist attractions and its values include hotel, museum and zoo. And railway key is used for anything associated with railway like a railway station. If a landmark has any of these keys among its tags, the value of that key is displayed as the landmark’s type. Initially it was considered to add highway key as well. However, as street names are self-explanatory, e.g. Latrobe Street or Flinders Lane and highway key consists of values like primary, secondary and motorway that mainly describes the road type or speed camera that describes node features related to roads and are not usually of interest for selecting a landmark, highway key is not included.

Identifiable factor is introduced as a new key for a tag to Openstreetmap. Based on the Openstreetmap tag structure that was mentioned in Chapter 2, the tags are introduced as ‘identifiable_factor: followed by the factor = yes’. Table 5.1 shows these factors’ keys and their values.

<table>
<thead>
<tr>
<th>identifiable_factor:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>type</td>
<td>yes</td>
</tr>
<tr>
<td>shape</td>
<td>yes</td>
</tr>
<tr>
<td>size</td>
<td>yes</td>
</tr>
<tr>
<td>color</td>
<td>yes</td>
</tr>
<tr>
<td>texture</td>
<td>yes</td>
</tr>
<tr>
<td>age</td>
<td>yes</td>
</tr>
<tr>
<td>visibility</td>
<td>yes</td>
</tr>
<tr>
<td>cultural_significance</td>
<td>yes</td>
</tr>
<tr>
<td>historical_significance</td>
<td>yes</td>
</tr>
<tr>
<td>structural_significance</td>
<td>yes</td>
</tr>
</tbody>
</table>

Table 4.1. Identifiable factor tags

4. Add a new node as a landmark: with this application a user is able to click anywhere on the map and then click on ‘Add Landmark’ button. The location that is clicked by the user is considered as the location of the new node. In this window, the application asks for the new landmark name and type which is shown in Figure 4.5.
Name is written by the user and type is selected from a dropdown list of types. The type list is a selection of values from amenity, leisure, shop, tourism and railway keys that are shown in Table 5.2. When a user selects one of these types, the application detects which key that value belongs to.

<table>
<thead>
<tr>
<th>Key</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>amenity</td>
<td>restaurant, food_court, fast_food, pub, bar, cafe, school, college, library, university, bank, pharmacy, hospital, arts_center, cinema, theatre, courthouse, place_of_worship, police, post_office, townhall</td>
</tr>
<tr>
<td>leisure</td>
<td>sports_center, golf_course, stadium, park, playground, garden</td>
</tr>
<tr>
<td>shop</td>
<td>bakery, beauty, toys, supermarket, sports, shoes, books, alcohol, mobile_phone, kitchen, furniture, convienience, car, butcher</td>
</tr>
<tr>
<td>tourism</td>
<td>hotel, motel, bed_and_breakfast, museum, zoo</td>
</tr>
<tr>
<td>railway</td>
<td>station</td>
</tr>
</tbody>
</table>

Table 4.2. List of types for new landmark

After adding the name and selecting the landmark type, the user clicks on the ‘Save’ button. By clicking on the ‘Save’ button, a new node with two tags is created. First key is the name with the user defined value and the second one is the corresponding key to the landmark’s type and its value. The node is drawn with the
same symbology as node landmarks on the map; however it has not been yet uploaded as a new feature to Openstreetmap dataset. Then the ‘Select Landmark’ window is opened automatically. In this window the user selects the landmark characteristics and saves them which this time leads to uploading the created landmark node with its associated tags in Openstreetmap.

After the implementation of the design into this application, the application is used for adding landmarks to Openstreetmap dataset. The results are discussed in the next chapter.
Chapter 5 - Results

In this chapter, the application is tested for adding landmarks and selecting existing features as landmark. For adding a landmark, a salient feature in Melbourne that did not exist in the Openstreetmap dataset was selected and for selecting landmark, four salient features in Melbourne were used.

Add landmark

Immaculate Conception Church located at the corner of Glenferrie Road and Burwood Road, Hawthorn is selected as a landmark. The church is a standalone feature at the intersection. It is recognizable because of its type, size, shape, texture and cultural significance. Figure 5.1 shows the location of the church at the intersection.

Figure 5.1. Location of the Immaculate Conception Church (Copyright: GoogleEarth)

The church was not a part of the Openstreetmap dataset, therefore in order to select it as a landmark a user needed to add it to Openstreetmap first and then assign landmark tags to it. Figure 5.2 shows Openstreetmap and downloaded data before adding this church to the dataset.
By clicking on the map, where the church is located and clicking on the ‘Add Landmark’ button, the church’s name and its type were created. Then in the ‘Select Landmark’ window that is opened automatically, the characteristics that make the church a landmark, were selected. By clicking on the ‘Save’ button the church was uploaded to Openstreetmap dataset. Figure 5.3
illustrates the process of adding the church as a landmark and Figure 5.4 shows the dataset after the landmark has been added.

Figure 5.3. Adding the Immaculate Conception Church as a landmark to Openstreetmap
Figure 5.4. Openstreetmap dataset, corner of Glenferrie Road and Burwood Road, after adding the Immaculate Conception Church

As it can be seen in Figure 5.4, the landmark has been added successfully as a node.
Select a landmark

Saint Paul’s Cathedral, Federation Square and Flinders Street Station are selected as landmarks at the intersection of Swanston and Flinders Streets, Melbourne. Figure 5.5 shows the area before selecting these features as landmark.

Figure 5.5. Intersection of Swanston and Flinders Streets, before adding landmarks

Saint Paul’s Cathedral is identifiable because of its type, shape, size, age, visibility, cultural and historical significance. Figure 5.6 shows the process of selecting Saint Paul’s Cathedral as a landmark.
Flinders Street Station is identifiable because of its type, shape, size, visibility, cultural, historical and structural significance. The process of selecting it as a landmark is illustrated in Figure 5.7.
Federation Square is identifiable because of its type, cultural and structural significance. The process of selecting it as a landmark is illustrated in Figure 5.8.
Figure 5.8. Adding Federation Square as a landmark

Figure 5.9 shows the intersection after selecting all the landmarks.
In order to cross check that the data is uploaded correctly to Openstreetmap, Flinders Street Station tags were checked in Potlatch. All the added landmark tags can be identified in the tags section after selecting Flinders Street Station and are shown in Figure 5.10.
The next feature that is selected as a landmark is a KFC in Racecourse Road, Flemington. The feature is a node feature; therefore it can test the ability of the application in selecting nodes as a landmark. This KFC is distinguishable because of its type, visibility and cultural significance. Figure 5.11 shows the map before selecting the feature as a landmark and Figure 5.12 shows the map after selecting it as a landmark.

![Figure 5.11. Racecourse Road, Flemington KFC before being selected as a landmark](image-url)
Figure 5.12. Racecourse Road, Flemington KFC after being selected as a landmark

In the next chapter, the results and the limitation of the designed application are discussed.
Chapter 6 - Discussion

All the mentioned five examples in Chapter 5 indicated the ability of the system to add nodes as landmarks and to add landmark tags to existing features in Openstreetmap successfully. However, the system has some limitations.

In adding the Immaculate Conception Church as a landmark, it is preferable to add this church as a building rather than a node. That requires the application to provide an option for adding ways. For this purpose, the application needs to be able to upload GPS tracks to draw a way. This is what the designed application lacks and can be modified later to improve its usability.

In adding nodes, due to visual selection of the location of the new node in the map instead of using precise coordinates, the probability of making mistakes in deciding on the location is high. As it can be realized in Figure 6.1, the node for the Immaculate Conception Church is close to but not on the actual building. Figure 6.1 is a screenshot of the Immaculate Conception Church in Potlatch. All the tags can be seen in the window left side of the map.

![Figure 6.1. The Immaculate Conception Church in Potlatch](image)

While adding landmark tags for Saint Paul’s Cathedral, the user faces the inconsistency of data in Openstreetmap. A node representing the cathedral is located inside the building. A user
needs to be careful not to add landmark tags to the node. An application that is able to delete these types of nodes from Openstreetmap can be of great advantage. Figure 6.2 shows Saint Paul’s Cathedral and the node inside that represents the cathedral.

Figure 6.2. A node inside Saint Paul’s Cathedral representing the building

The Racecourse Road, Flemington KFC that is chosen as a landmark, is compared with a KFC in Melbourne CBD that is shown in Figure 6.3. The Racecourse road, Flemington KFC is located in a residential area with no other restaurant or fast food next to it. However, the CBD one is located in Elizabeth Street, a busy street with lots of restaurants and shops next to each other. In a car navigation context, this KFC does not stand out from its surrounding buildings and therefore cannot be marked as a good landmark. However, it is needed to be mentioned that even though this KFC might not be a good option for being a landmark in car navigation, as it is the only KFC in that street, it can be still a good option for a meeting point for pedestrians. This is an indication that emphasizes that landmarks are identified in relation to their environment and the
purpose for which the landmark is selected is also important and counting on just the type of a feature cannot lead to a good decision for a landmark.

![Image of a map with a popup window for selecting landmarks.](image)

Figure 6.3. KFC in Elizabeth Street, not a good choice of a landmark for car navigation

In dense areas with a large number of nodes representing different features or areas with nodes located on the corners of the buildings selecting features can be problematic. A user needs to click several times on the nodes to find the desired node. Moreover, selecting a building might not be possible at that corner at all. Another issue regarding selecting nodes in dense areas is that, a user knows the approximate location of a node, but because there are a large number of nodes close to each other without any label or different symbol, the user needs to click on each of them to find a desired point. Different solutions to this problem can be adding labels to the map, adding different symbols based on node types to the map or providing a zoom function that are not covered in this application. Figure 6.4 provides an overview of some areas that a user might have trouble selecting a node or a building in.
Another problem that a user might encounter is that because a subset of tags is used for defining the type, if a feature neither has a name nor has a tag indicating its type, when it is selected, in the ‘Select Landmark’ window, both its name and type will be empty strings. Thus a user will not get any information about the selected feature. In order to fix this problem, either these nodes should not be selectable or all the associated tags of a feature should be displayed. These items are not covered in the current application design. Figure 6.5 indicates an example of such a feature.
Another example that shows data inconsistency in Openstreetmap is when a user wants to select the State Library of Victoria as a landmark. This has been illustrated in Figure 6.6. The building is mapped properly, but the only tag associated with it is ‘building = yes’. All State Library tags are associated with a node inside the building. As it is preferable to select the building as a landmark when it is available, the problem that the application user encounters is that no name or type tag can be added to this building. In other words, the application does not have the ability to add any other tags except landmark tags to an existing feature.
Finally, another issue regarding the application is that it does not provide a user with the option to modify tags for an existing landmark. That can be neglectable at this early stage where no landmark exists in Openstreetmap, but as the number of landmarks grows, the need of being able to modify existing landmarks will also grow.

Although this research is just a start for adding landmarks to Openstreetmap, the designed application and it being successful in adding landmarks to Openstreetmap indicates that the hypothesis of this research is accepted.
Chapter 7 - Conclusion

In this research the goal was to introduce landmarks to Openstreetmap and investigate the possibility of adding them to Openstreetmap with a user-generated method. In order to achieve this goal, a taxonomy of landmarks was defined. Followed by that, an application was designed to enable users to add landmarks. The desired option was to develop a mobile application. However, because of python programming language limitations on mobile platforms, a desktop application was designed. The application was tested and proved to be able to add landmarks to Openstreetmap. This application needs to be transferred to a mobile application before being able to be used practically in adding landmarks.

This study does not provide a measure for finding the most suitable landmark when there is more than one landmark at one point. Therefore, although a good dataset of landmarks can be derived by this method, further study needs to be done in order to find a method for the selection of the most salient feature.

The application can be adapted to be able to add ways as a landmark. It can be adapted to have a more elaborated map interface, showing images at the background, having zoom and pan and adding texts to the map. It can be modified in order to show all the tags and edit existing landmarks when required. Moreover, a web based platform can be developed that runs on mobile phones and have all the mentioned abilities to facilitate adding landmarks to Openstreetmap.

The system can be introduced to the Openstreetmap community and be used for gathering landmarks. If the system becomes successful, research can be done on applying Openstreetmap with landmarks in a navigation system. Further research can be conducted in testing how reliable this volunteered landmark information is in navigation and how this can be improved.
References


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