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THE GRP METHODOLOGY:
AN APPROACH TO BUILD ROUTES BASED ON POINTS OF INTEREST

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Many research areas are developing applications that use the Global Positioning System (GPS) in order to improve human's life. In routing systems most of the studies are focused on time improvements. Despite they notify users the instructions that they should follow in their travels, they do not include support features that could be useful as landmarks or points of interest (POIs). In this paper, the Routing with Points of Interest (GRP) methodology is proposed. It is based on an application ontology that is used to describe POIs as shops, hospitals and schools, among others, located on the roadways of a case study.

The GRP gives the users instructions to go from one place to another, combining semantic geospatial analysis tools, web and mobile technologies. The routes begin in the mobile position and after applying a geospatial process; the user obtains a map with the route, POIs located on the route, and instructions to change the direction with visual references to help him on his trip. The GRP methodology provides a filter to let user select the kind of business that he wants to visualize, besides the route elements. The cartography used on this work allows the map visualization without an Internet connection.

Key words: Ontology, point-of-interest, routing, geospatial processing, mobile platform.

1 Introduction

The mobile computing allows users to access information from anywhere at any time if some requirements are satisfied [27], [8]. Routing with GPS data provide to the programmers opportunities to build routes to go from one geographic point to another. The use of GPS data has increased the precision of geospatial data in Geographic Information Systems (GIS). Despite of their low cost and developing time, GPS routing devices have some limitations; one of the most relevant is the use of directional and longitudinal measurements without objects to help users in their trip [5].

Several works have tried to include visual features in their routes like subway stations, and parks, among others, but these features are just part of the area where the routing devices are working, and they are not related to the routes generated. Most of the routing works are focused on the study of route distance and travel time [10].

The proposed methodology, by means of GPS data generates the route for going to a specific place, showing landmarks and POIs located on the route. It also uses an ontological model of roads classification in order to obtain points of interest according to the case study.

The rest of this paper is organized as follows: Section 2 describes the related work about GPS routing. Section 3 presents the GRP methodology and the stages that compose it. Section 4 depicts the results that were obtained applying the GRP methodology. In addition, this section includes a comparison between the GRP results and some commercial routing services [23].

2 Related work

Going to a specific place in a city can be a difficult situation, especially if either the area or precise destination is unknown, or whether the instructions to get there are not clear [15]. Currently, there are at least three options to solve the problem: 1) it is possible to ask for indications to someone who knows the area [25], 2) use a local map, or 3) use a GPS navigator. It is clear that the best option is the third, sometimes people in a determined place could be familiarized with the area, and obtain an updated map is not easy, since all the stores do not sell it.

2.1 Routing Algorithms for GPS

When a person chooses a GPS navigator, that person starts to working with a GPS signal processor. This kind of device works efficiently just when it is in an unobstructed area, it means without elements that wear out the signal of GPS system. In an ideal area, the GPS processor should have free transmission in all directions and 15 elevation grades from the antenna [6]. There are two ways for configure a GPS receiver in a car. The first is to coordinate the processor to work with the personal data assistant that some vehicles have, where the user has to input some information about travel, passengers and city where he is driving. In the second, the GPS processor works passively, it does not need interaction with users, because it obtains information about the routes automatically [4].

The algorithms that work in the GPS devices have changed at the same time that GPS has evolved. For example, they have raised their efficiency in routes calculation, accuracy of instructions, and have decreased their energy consume. These algorithms are classified according to their cyclic functions, their metric distribution, the accuracy of information that delivers to users, scalability and robustness [30]. Algorithms with elevated scalability and robustness are capable of working dynamically with the communication network and they also have a higher information backrest. Among the most important algorithms used in GPS devices are the Map Matching Algorithms (MM), which obtain deterministic information from roads and arcs represented in GPS. Despite the fact MM algorithm considers arcs continuity and connectivity, they do not guarantee the full usability of routes [2]. The Multiple Hypotheses Technique (MHT) connects the route segments designed by the MM algorithm to a geographic database at real time increasing the accuracy of data.

Other algorithms save the beginning point of the route in a search engine of the GPS with a group of candidate routes; each of them has a computed score that takes into account attributes such as distance, speed and the number of points and arcs presented in the route. The route with the highest score is then chosen and displayed [22]. The use of modeling algorithms to generate sets of potential routes was one of the first uses in mobile GPS routing. This algorithms use topological measures of the area, and temporal information like time and speed to compute the probability where each route point matches with the device data, while the user follows the route. On GIS searching algorithms, the queries related to range have progressed [32]. One of the improvements to execute range queries to identify objects of interest is the use of Voronoi networks [33].

Most of published reports are related to GPS data routing and particularly focused on time-longitude relation optimization and energy saving, but few of them use landmarks to help users. In order to define an element as a landmark or point of interest, it is necessary to consider some aspects such as the place it represents, if the point of interest is easy to identify by people, its structure and its relevance. The relevance depends directly on the person's perception [31]. Some GIS try to include support features in their routes as obstacles, but these are not user references [3].

Building personal maps from GPS data is a system proposed by Lin et al. [10]. It extracts places, recognizes activities related to them and determines the place where user wants to go by using the GPS data. The system learns specific route mistakes, mobility and transportation patterns by a hierarchical model. For obtaining a map personalization, the project defines significant places; it means those where users frequently spend long time. This makes possible the time measuring and GPS coordinates saving at a cluster.

Developing an algorithm for generating weighted routes semantically, project studied by Luna et al. [11], generates a set of routes based on users requirements as traffic lights, crime rate and traffic. Finally, with a semantic function applied to road ontology, it chooses the routes that match with the user requirements, giving him some options. The algorithm is programmed in a web environment.

Voronoi-Based Continuous k-Nearest Neighbour search in Mobile Navigation, is proposed by Zhao et al. [34]. It consists of analysing the relation between the mobile and interest points by means of the applicability of a path query and a Voronoi diagram.

In [35], Waluyo et al., describes the spatial queries requested by mobile devices, which are examined in [28]. *Path kNN query processing in Mobile Systems* [35], consider a number of interest points in order to find the shortest path that goes through them.

2.2 GPS routing applications

There are some commercial applications that provide routing service for mobile applications, despite their characteristics as precision and environment, they do not use points of interest as references to help users, they give their instructions by using measures and orientation terms that in some cases, are difficult to understand.

Waze is a mobile application designed to show users the traffic in their city, according to its community user's data. The system has been programmed for users that are traveling in a vehicle; its routing process gives the route with less traffic, not only the shortest one, but also the route with less time consuming. Each Waze member is able to edit maps and help some others to find new ways to avoid car accidents and traffic jams. The system is useful when the person is interested in time improvement, but in some cases is difficult to understand its visual elements because the traffic signals are mixed with the Waze's users representations on map [29].

Google is one of the biggest industries that work with maps and users location, since it has been accepted by customers to be used as a web routing and mapping service, has develop Google Maps. Google Maps for Android is the implementation of Google Maps in mobile devices. This program shows users the route to go from one point to another in a determined area, lets user know its position on the map can show traffic at real time, and by its social network allows members to interchange comments about places and routes.

One important characteristic of Google Maps is that makes possible to search information about places that are interesting for user. It is important to note that an Internet connection is necessary in order to access to Google Maps services.

3 The GRP Methodology

The GRP methodology shows landmarks, called points of interest or reference points, located on a computed route using GPS data. This methodology is organized in three stages, Acquisition, Routing and Semantic process. The *Acquisition* determines the beginning and the ending of the route by a mobile application. These data are used in the *Routing* stage to generate the trip by applying a set of geospatial operations on the roadways of the case study. The *Semantic* process stage searches points of interest as schools, shops, hospitals and some other business from application ontology, specially designed for GRP, and shows users the obtained results on a map. Figure 1 shows methodology general schema.

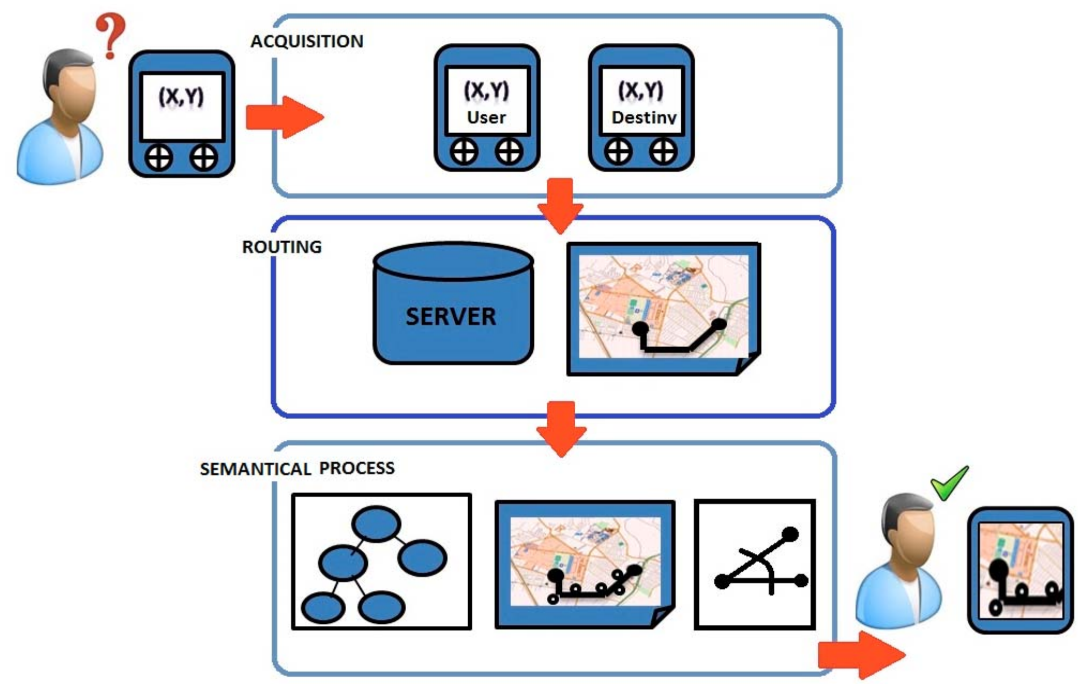

Figure 1. Methodology diagram of routing with points of interest.

3.1. Acquisition stage

This stage is in charged of obtaining user position coordinates and the name place where user wants to go. For this purpose, an Android [1] application of two modules has been programmed. It has been used Android because nowadays, is one of the most important mobile platforms, it is easy to manipulate for users and is the operative system in many mobile devices with a GPS integrated.

The first module (figure 2) is connected to the GPS device to obtain user's actual position. It has a textbox, where user writes the final place name in; the textbox has an autocomplete function to avoid user's mistakes. Additionally, user is able to deactivate the GPS device when touching "Wifi-Loc" and obtain the user location by Wi-Fi connection. By touching the word "Map" is possible to send the obtained data to the GRP server.

To start the process, user has to activate the GPS device by touching the "Activate GPS" button; in case there is no GPS signal available, user has the option to obtain its coordinates by the Wi-Fi location service, touching the button "Wifi-Loc", as mentioned above. On "Final place" text box, user has to write the place name where he pretends to go, the options saved on the system belong to interesting places on the study area as schools, hospitals, parks, subway stations, research centres, restaurants, movie theatres, etc.

On "Filter", user will choose the kind of business that he wants to visualize. Filter is a useful tool because let user to know where are some businesses that result interesting for him but that could not be on his road. Filter options are places such as schools, taxi bases, grocery stores, pharmacies, and workshops.

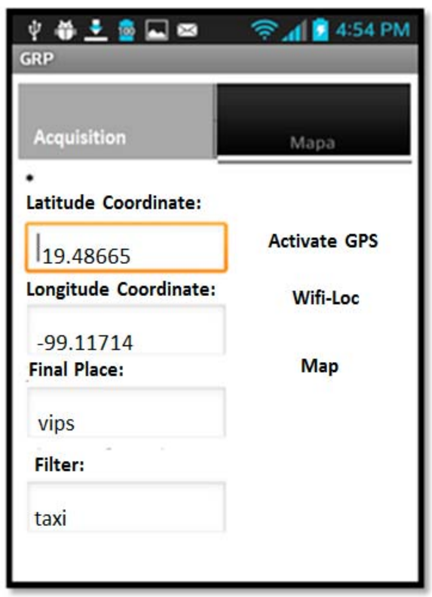

Figure 2. First mobile application module.

When user selects on filter the interesting places, these are searched by its classification word on the ontological model, to be shown on map with the road and the points of interest that belongs to the route. These elements are useful to show the user the businesses located near his route, that will satisfy its necessities. Once information is ready (as shown in figure 2), user has to touch "Map" button to send data to server, where the routing process will be developed.

The second Android module is related to the third stage. It shows a map with instructions to arrive to the landmark, the device coordinates and the points of interest on the route (see figure 3).

Mapsforge is an open source library to visualize OpenStreetMap cartography in mobile devices, without a permanent Internet connection, it was used to show the map on the application [12], Mapsforge is in continuous developing; its use requires the change of an OpenStreetMap file [14], from .osm to a .map format. Merkaartor OpenStreetMaps editor was used to download the study area map and edit its components [13]. The study area map in format .osm is shown in figure 4.

Figure 3. Mobile application map.

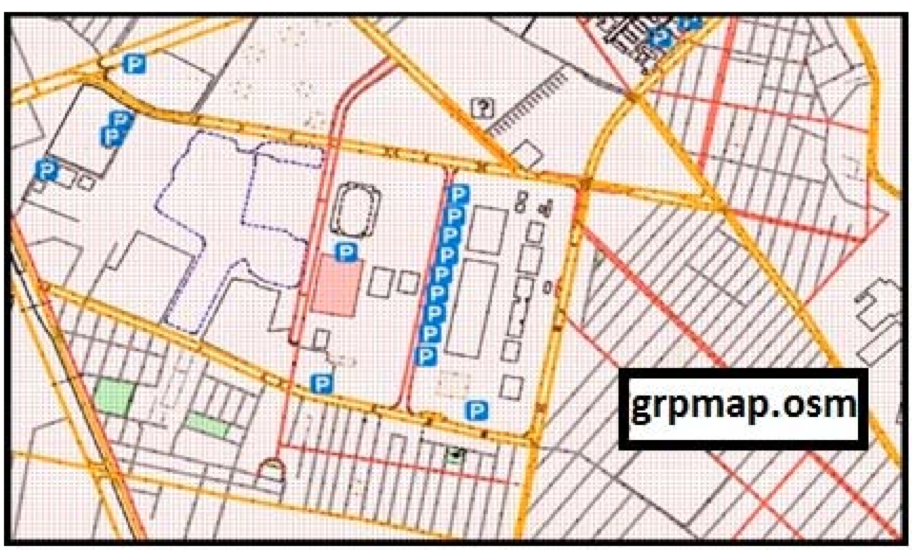

Figure 4. Study area map in .osm format.

3.2. Routing stage

To make the routing, the roadway shapefile of the case study was imported to project database allocated in the database manager Postgresql [19], by its spatial database extender tool PostGIS [18], which adds Postgresql support for geographic objects. It is possible to apply a set of spatial functions and SQL queries on data to make them available to work with Pgrouting [17] after the shapefile's importation.

Once database has been created, the system handles its information and applies spatial functions on data, by using SQL sentences on PostgreSQL Editor. When the shapefile is imported to PostgreSQL by PostGIS, the generated table will contain all the file information fields and an extra column named "the_geom", where data spatial representation is allocated. In figure 5 the roads shapefile data is shown on a PostgreSQL table.

street_nam character varying(254)	target numeric(10,0	x1 numeric	y1 numeric	x2 numeric	y2 numeric	the_geom geometry	startpoint geometry	endpoint geometry
AVENIDA BENITO JUAREZ	40230	480344.297680	480217.398746	2157213.68585	2157265.83942	0105000020E61	0101000000B4F	0101000000FE
VIVEROS DE LA COLINA	25131	476613.382126	476591.393161	2158231.75724	2158256.12937	0105000020E61	01010000002A	010100000046
AVENIDA JESUS REYES HER	31826	481485.062605	481484.055261	2157443.75109	2157455.92439	0105000020E61	0101000000B11	0101000000F1E
AVENIDA BENITO JUAREZ	40259	480415.621379	480379.940002	2157185.95713	2157199.25794	0105000020E61	0101000000DD	0101000000CE
AVENIDA ADOLFO LOPEZ M.	35627	477706.672708	477674.146665	2157378.32522	2157406.01628	0105000020E61	0101000000ED	010100000021
ANDADOR CABO DE HORNC	55936	481102.037626	481139.917193	2157399.89312	2157501.64589	0105000020E61	01010000027E	0101000000A6

Figure 5. Shapefile roads on Postgresql table representation.

Pgrouting is the PostGIS tool for computing routes with PostgreSQL data. By the *Pgrouting* A* stars the routing algorithm, then the methodology obtains the route between user position and the final target. In the GRP the shortest path is always shown, because the relevance of the work is to use points of interest to provide alternative routes.

To have a link between the mobile application and Postgresql database, a web service has been programmed by a PHP [16] code. This code obtains the mobile application information and save it into the database where it is manipulated. The data interchange is done by using the JSON data structure [7].

The GRP methodology is described as follows. Spatial functions as buffer, and intersection are used to identify the routes beginning and ending of the route.

1.-Coordinates from the mobile application are obtained.

2.-Point A=user. User coordinates are represented as a point

3.-Coordinates of name place are obtained from server.

4.-Point B= final place. Final place coordinates are represented as a point.

5.-Intersection 1(Point A, roadways). Intersection between user position and roadways is calculated.

If (Intersection 1==null)then:

While (Intersection 1== null)

Point A1 = increase the Point A area by using a dynamic buffer.

Intersection 1(Point A1, roadways).

If (Intersection 1!=null), save intersection point.

End While.

End If.

6.-Intersection 2 (Point B, roadways). Intersection between target and roadways is calculated.

If (Intersection 2==null), then:

While (Intersection 2== null)

Point B1 = increase the Point B area by using a dynamic buffer.

Intersection 2(Point B1, roadways).

If (Intersection 2 !=null), save intersection point.

End While.

End If.

7.-Obtain route between Intersection 1 and Intersection 2, by A algorithm usage.*

8.-Calculate angle between route segments.

9.-Identify direction change on route by angles value to define instructions.

10.-Consult ontology from mobile application.

11.-Get street name and points of interest name and coordinates from ontology.

12.-Draw route and map ontology data on map.

13.-Write direction change instructions with points of interest located on each change.

14.-Show map on the mobile application.

First from JSON structure, the server obtains user coordinates, final place name and the filter option; the place name is matched with its latitude and longitude coordinates and it is represented as a spatial point by a PostgreSQL's function in the server; then user coordinates are represented as spatial points too. Both points are saved on a table called Points.

After that, the beginning and ending points are intersected with the roads data to identify route's beginning and ending geometric points. In case of a null result from the intersections, the point area will be increased until the intersection returns a positive value. The buffer to increase the areas is created by a PostgreSQL function, which is executed in the server and is represented on a table. The maximum increase in area is 30 meters radius, if the intersection is null despite the maximum radius, GRP asks for a new user location. Once the geometric beginning and ending are known, it is possible to apply the *Pgrouting* A* algorithm to obtain the shortest route between points. The result gives a set of segments with attributes as id, latitude, longitude, reverse cost, shape and street name of the road represented (see figure 6).

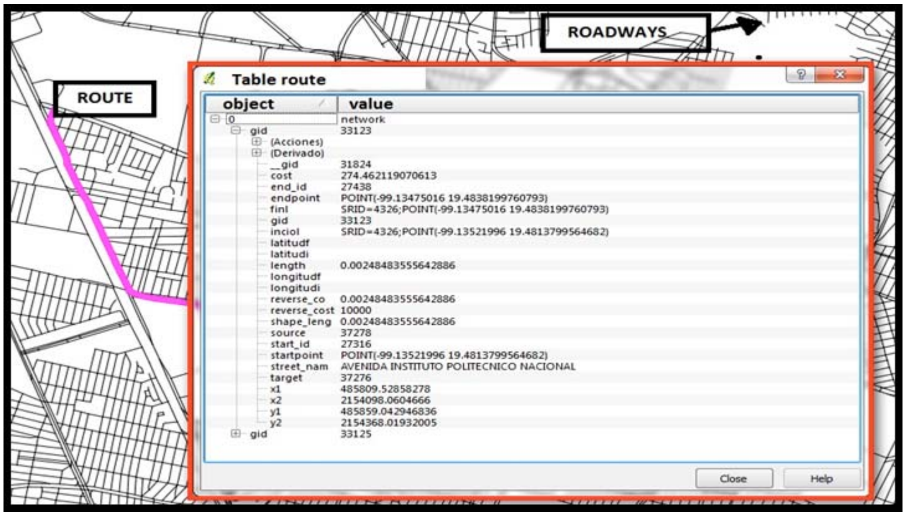

Figure 6. Route segment data table.

3.3. Semantic process stage

3.3.1. Direction change instructions

To determine direction changes, user must follow to arrive to his final place, the angle between route consecutive segments is computed. According to the [-14, 14] interval, GRP determines if it is necessary to notify a directional change or not. This interval is needed because segments are not completely linear and each street is divided into multiple lines. Relation between angles is shown in figure 7.

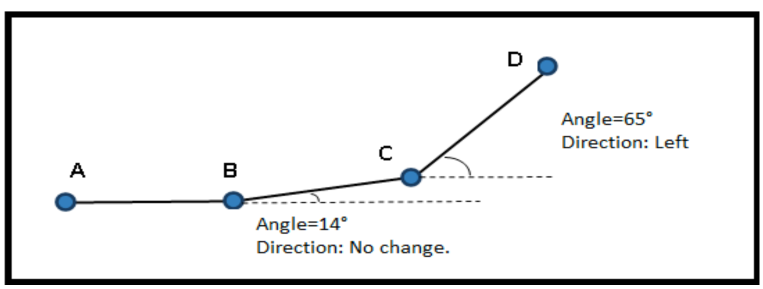

Figure 7. Diagram that show a direction change to left.

To compute angles, we use Equation (7), which features are computed by applying Equations (1) to (6). It is necessary to deduct A latitude coordinates from B latitude coordinates, and take A longitude coordinates from B longitude coordinates. Subtractions are shown in Equations (1) and (2).

$$Ry = CoordBx - CoordAx \qquad (1)$$

$$Rx = CoordBy - CoordAy \qquad (2)$$

The Angle between A and B points results by applying Equation (3).

$$\theta 1 = atanRy/Rx = tan - 1Ry/Rx \qquad (3)$$

To obtain the angle between C and A points, the arctangent of A coordinates form C coordinates deduction is done, as Equation (6) presents. Equation (4) shows the latitude coordinates subtraction; equation (5) shows the longitudinal coordinates subtraction.

$$Sy = CoordCx - CoordAx \qquad (4)$$

$$Sx = CoordCy - CoordAy \qquad (5)$$

$$\theta 2 = atanSy/Sx = tan - 1Sy/Sx \qquad (6)$$

Finally to determine the direction's change, the deduction of θ_1 from θ_2 is done, as shown in Equation (7).

$$\theta = \theta 2 - \theta 2 \qquad (7)$$

3.3.2. Ontology model

By using the ontology model, points of interest located near the direction change point are added to the instructions.

We used Methontology, a methodology for ontology's development based on IEEE 1074 standard [26], it was taken into account to generate the GRP ontology model. Lars Kulik work [9], mentioned the relation between polygonal curves, their semantic weight at a particular context and their polygonal and geometric attributes, this characteristics have been added to the ontology structure.

The main class called *Vial Infrastructure* is divided into four subclasses that are composed by entities, in order to form the GRP ontology. Each entity has its own instances, which information is based on *Secretaría de Transportes y Vialidades* (SETRAVI) data from Mexico, a governmental department for roads and vial management. The ontology implementation was made in *rdf* format in Protégé, an ontology editor [20]. The general ontology schema is depicted in figure 8.

The instances have a hierarchical level, and three attributes: business name, latitude and longitude coordinates. By using the latitude and longitude coordinates, the ontological feature is represented in the GRP map as a point. A semantic query made from the mobile application to the ontological model, the ontology searches the street name of each route segment, and sends as a result to the mobile application, the entity attributes. The businesses obtained by the query and which location is in an fifteen meters interval from the direction changes coordinate, are mentioned on the instructions to help user during his trip.

The same process occurs with the filter option, in the ontological model the kind of businesses asked for user is searched by an SQL query, if there are not such businesses on the route, the ontology sends to the application, the businesses located near the route that satisfies the query, in order to be represented as points on the map.

Figure 8. Vial Infrastructure ontology.

One of the GRP ontology advantages is that it can be expanded to be used in some other related systems or to increase the information of some other ontologies.

3.3.3. Giving instructions to user

GRP has a special characteristic, it can communicate the instructions to the user by two modes, the first one is by showing all the instructions on the mobile screen; the second one, is giving the instructions one by one. To make this individual instruction notification possible, a geographic fence (geo-fence), a radius around the points of interest located on the route is used; when the user coordinates are near the fence boundaries, the system receives a notification and the instruction appears on the screen until the next fence boundaries are achieved. Geo-fencing is useful to identify the movements of persons on a certain area, it has been used since 2004 in this kind of mapping applications, according to Vinay Rawlani [24].

GRP geo-fence boundaries form a square round of a point of interest, which corners are defined using the change direction coordinate described previously, in Equation (8) to Equation (11). When GPS mobile coordinates are inside of the geo-fence area, the change direction instruction is sent to the screen.

Geo-fence upper latitude = point-of-interest latitude + 0.0014 (8)

Geo-fence lower latitude = point-of-interest latitude − 0.00115 (9)

Geo-fence upper longitude = point-of-interest longitude + 0.00163 (10)

Geo-fence lower longitude = point-of-interest longitude − 0.00089 (11)

The geo-fence is used to sense user movements near change direction points that were programmed in Android (see Table 1). In addition, its performance is presented in figure 9.

Table 1. Geo-fence programming.

```
Public int GeoFence (double neglat, double neglong){
                      double lat1, lat2,long1,long2;

                          lat1=neglat+0.0014;
                          lat2=neglat-0.00115;
                          long1=neglong-0.00089;
                          long2=neglong+0.00163;

               While(r==0){
                 latitudperson=Double.parseDouble(datolat);
                 longpersona=Double.parseDouble(dtolong);
                 If((latitudperson<=lat1)&&(latitudperson>=lat2))
                 If((longitudperson>=long1)&&(longitudperson<=long2))
                                     {
                                         return r=1;
                                     }
               }
     }
```

Figure 9. Geo-fence performing, to identify user's position.

1. Geo-fence is computed round the point of interest where a change direction has been identified.
2. When the user is inside the geo-fence, the system is authorized to notify the direction change on mobile screen.

4 Experimental results

In this section, an example of GRP methodology application is described. Suppose that a researcher visits the Centre for Computing Research in Mexico (*CIC*). After a conference he decided to go to a restaurant with Wi-Fi available connection to check his mails, so a student provides him the GRP application and suggest him going to "Vips restaurant". When the researcher asks to the GRP mobile application a route, the system retrieves his actual position with the GPS device, and the end point name as shown in figure 10. These data are sent to the web server to initialize the GRP methodology.

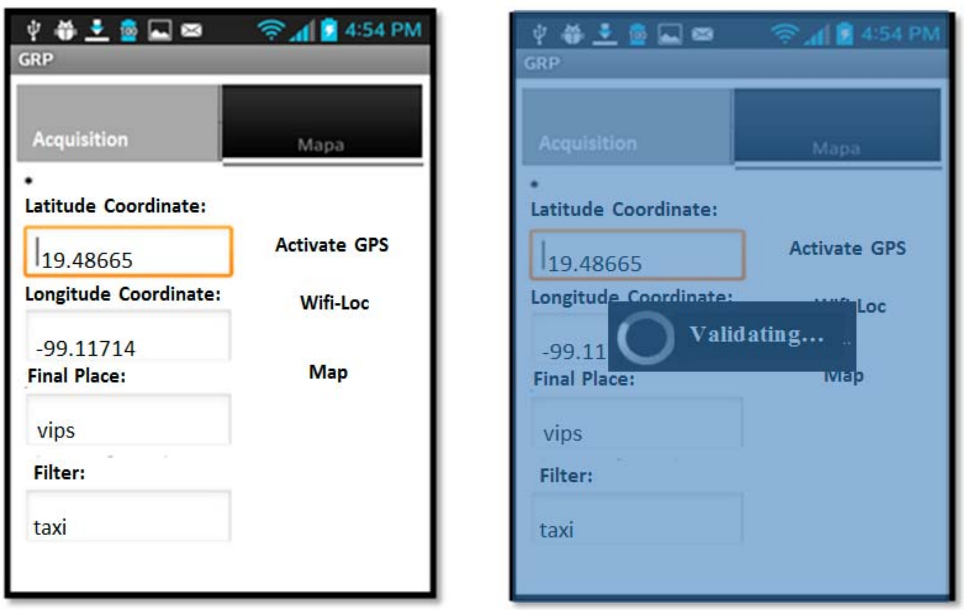

Figure 10. GRP mobile application interphase to obtain users coordinates.

In the server, the place name is matched to its latitude and longitude coordinates that are represented as a point, as the user location into the Points database table. GRP will intersect user location and the final place points with the roads shapefile, just in case there is no intersection in one or both points, GRP will apply a buffer on the point until the intersection between roads and points is possible; then the A* algorithm is applied in the PostgreSQL table that contains the study area roads to obtain the shortest path to connect user and aim place. In figure 11, the computed route represents a table of PostgreSQL.

The processed data can be visualized on the server by using QGIS [21], a GIS that can be connected to PostgreSQL server (see figure 12). The GRP computes the angle between route segments to determine the direction changes, then it searches for the business located on the route in the Vial Infrastructure ontology.

shape_leng double precision	street_name character varying	reverse_co double precision	the_geom geometry	id serial	campo geometry	latitud double precision	longitud double precision
0.000156115678888	EJE 4 NTE	10000	0105000020E61	4	0101000020E61	19.4833900762214	-99.13104
0.000771048677628	EJE 4 NTE	10000	0105000020E61	5	0101000020E61	19.4834900806753	-99.13115988
0.000921956031126	EJE 4 NTE	10000	0105000020E61	7	0101000020E61	19.4846200078117	-99.13365
0.000191132923830	EJE 4 NTE	10000	0105000020E61	8	0101000020E61	19.4848200151199	-99.13455
0.004309584662048	EJE 4 NTE	10000	0105000020E61	9	0101000020E61	19.484840049794	-99.13474008
0.000417411863306	EJE 4 NTE	10000	0105000020E61	10	0101000020E61	19.4856100245649	-99.13898016
0.000414617240677	EJE 4 NTE	10000	0105000020E61	11	0101000020E61	19.4856899930664	-99.13938984
0.002036773283737	EJE 4 NTE	10000	0105000020E61	12	0101000020E61	19.4858300651859	-99.13978008
0.001510954740318	EJE 4 NTE	10000	0105000020E61	13	0101000020E61	19.4861599557662	-99.14178996
0.000136054641802	AVENIDA LAZARO CA	10000	0105000020E61	14	0101000020E61	19.4866299170857	-99.14321988
0.000497828885987	AVENIDA LAZARO CA	10000	0105000020E61	15	0101000020E61	19.4867599711666	-99.14325984
0.000869188119108	AVENIDA LAZARO CA	10000	0105000020E61	16	0101000020E61	19.4872200833196	-99.14344992
0.000551520066785	AVENIDA LAZARO CA	10000	0105000020E61	17	0101000020E61	19.4880199282711	-99.14379012
0.000791300658122	AVENIDA LAZARO CA	10000	0105000020E61	18	0101000020E61	19.4885299525545	-99.144
0.000946991307938	AVENIDA LAZARO CA	10000	0105000020E61	19	0101000020E61	19.4892700281757	-99.14428008
0.000206108952222	AVENIDA LAZARO CA	10000	0105000020E61	20	0101000020E61	19.4901499989314	-99.14463
0.000752810294673	AVENIDA LAZARO CA	10000	0105000020E61	21	0101000020E61	19.4903399823354	-99.14470992

Figure 11. PostgreSQL's table with GRP route data.

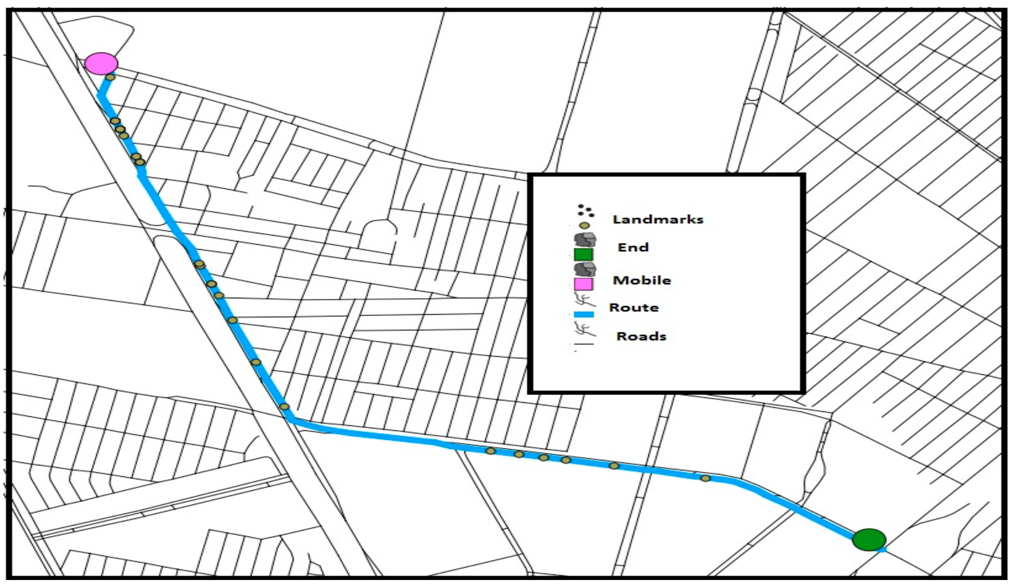

Figure 12. Visualization in QGIS of GRP data.

The instance "Axis North 4", one of the route segments, is searched by its classification as Road Axis on the ontological model, it is shown in figure 13, Road Axis is an entity of Arterial Road, and finally a Primary Road subclass with its own instances.

In the map application, points of interest are represented with blue and green circles, the route is drawn as a dashed red line, and the instructions to the user are written on the screen top (see figure 14). Each change of direction is represented on the screen by the black icon, blue circles represent the points of interest and finally the green circles represent businesses associated to the filter, in order to make easier its identification.

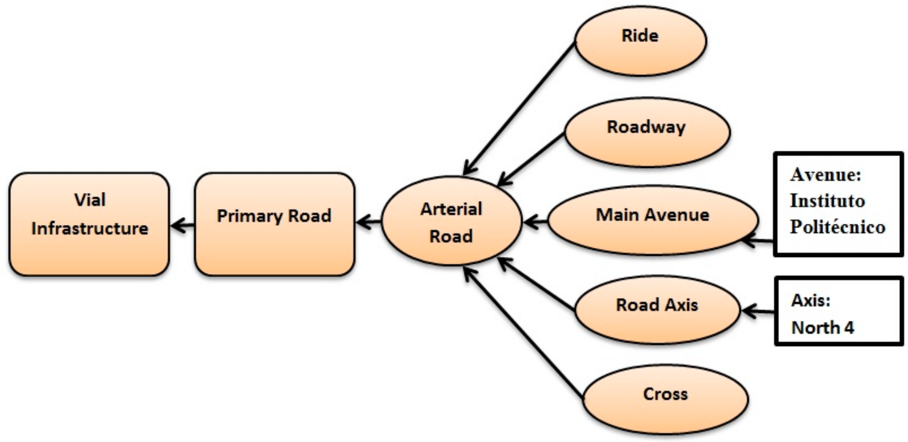

Figure 13. Vial Axis entity ontological classification.

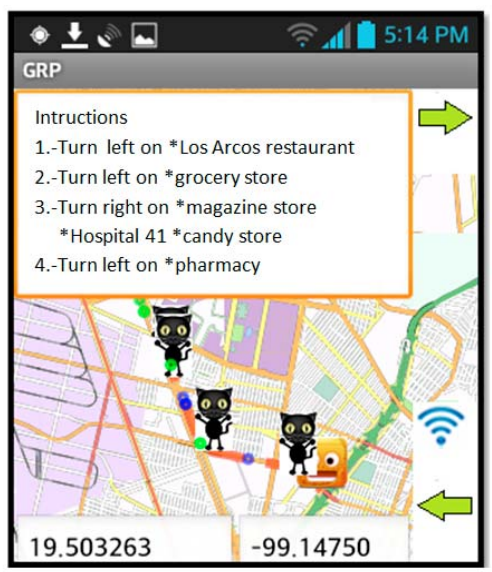

Figure 14. Mobile application results.

When the user touches the green arrow located on the screen right corner, the instructions will be given one by one each time the user is walking inside the geo-fences on route. In figure 15 and figure 16, the screenshots with the individually given instructions are shown; every time the application is monitoring the GPS device coordinates and showing them on the screen. In the case of Internet connection were lost, the user will be able to see the map with the route, interest points, and instructions of the last request done.

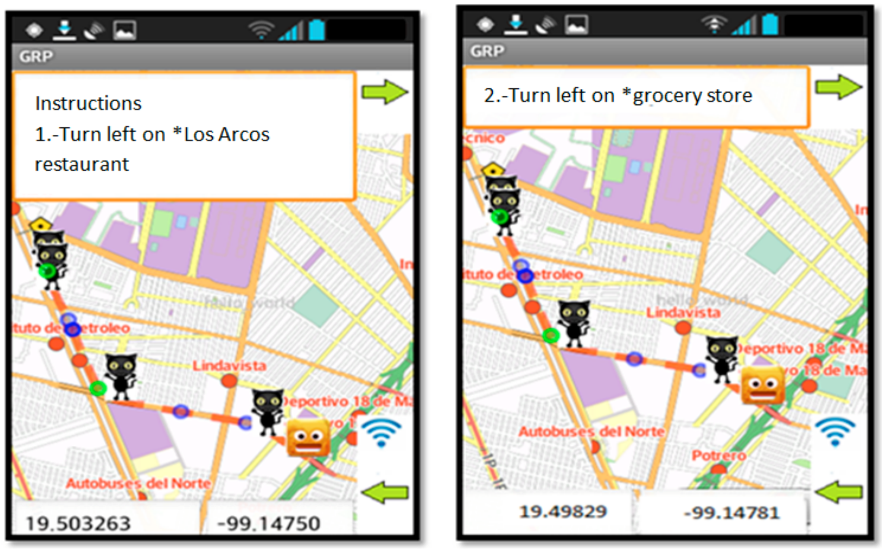

Figure 15. Screenshots of instructions 1 and 2 given one by one.

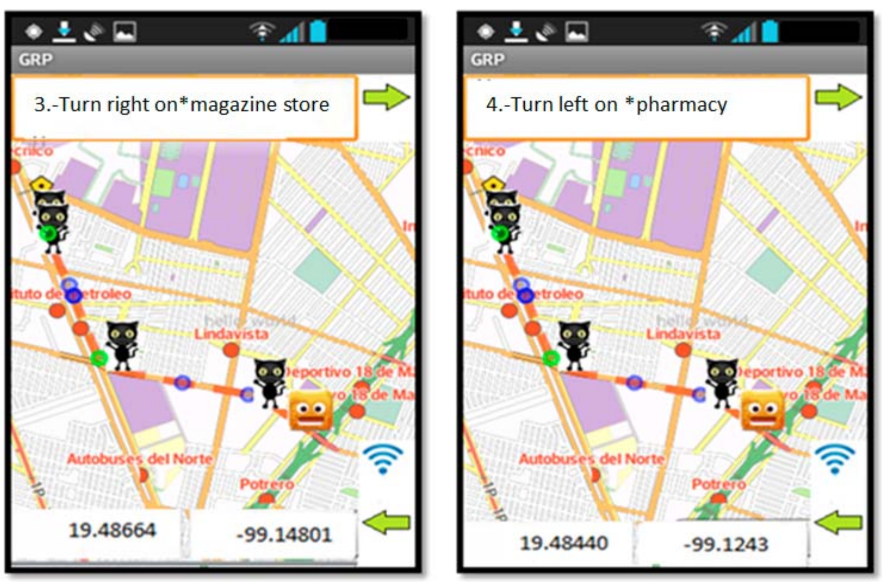

Figure 16. Screenshots of instructions 3 and 4 given one by one.

The instructions are short but they try to be useful for the user, giving the businesses located near the direction changes; in the case of no business near, the instruction only indicates the change of direction, represented by the black icon on the map. To make a new request, the user only has to touch the green arrow located on the screen's bottom.

If the user lost its web connection while walking on the route, he could visualize the GRP map with the route and points of interest, because of the Mapsforge offers the visualization without permanent connection.

4.1. Comparison of results

In order to test the routing with points of interest, the GRP methodology is compared with the results provided by Google Maps for Android service.

The studied route at the results section was demanded to Google Maps for Android, the routing done by this application is shown in figure 17.

Google Maps gives as result two routes, in this case the one that is similar to the GRP resultant is analysed. The instructions to the users are notified by using the streets names where the person is walking, arrows which try to show the direction user must follow and the meters before the direction change; the duration of the trip is also shown.

The use of street names at the instructions is not always functional, because in some cities, street names are not correct or are not in a visible place, if a person is following those instructions and he does not know the area, he could get lost or could be following the instructions in an incorrect roadway. The use of distances on instructions is not always a good idea, since for an on-going person it is difficult to have a real perception about the real distances.

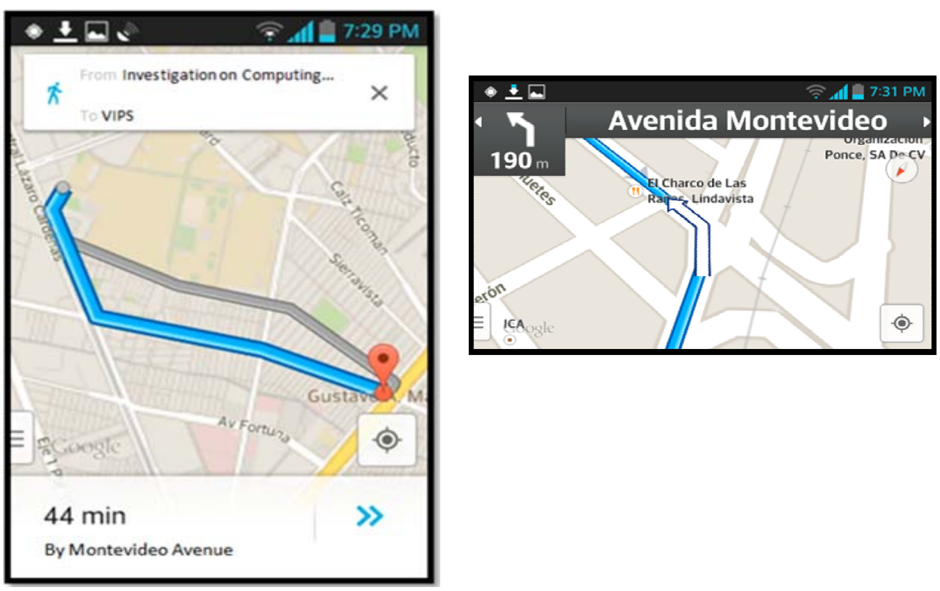

Figure 17. Results of Google Maps for Android.

GRP considers these aspects and gives to the user two ways to obtain instructions, the first consists of showing the route with icons at each change of direction, the points of interest near the route and all the instructions that should be followed, notifying the points of interest located at each direction change as references (see figure 18). The second way shows the entirely route and gives the instructions one by one so that the person approaches to each direction change, preserving the points of interest at the instructions.

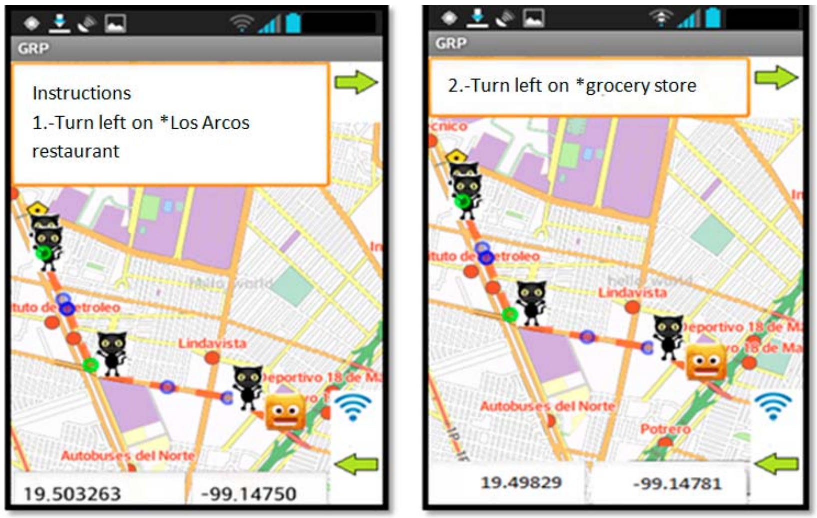

Figure 18. Instructions given by GRP methodology.

Another important routing application for mobiles is Waze, which is a system designed to show the traffic and vehicular movements of its users on a map. Waze users can obtain a group of routes to improve their driving time and they are able to edit maps and help some others giving them advice and alternative routes. This system is useful for those users, who drive in big cities (see figure 19).

Figure 19. Waze map to show routes to users.

A Waze inconvenient is that in a mobile screen, it is not difficult to be distracted by the users located on the route, the system tries to give routes with less traffic as possible changing routes every moment and the system gives a lot of instructions to the users, as we can see in figure 20. Note that the Waze query was made for a route in Mexico City, so the instructions given by Waze are in Spanish and some of them had been translated to English for this article.

Figure 20. Instructions given by Waze.

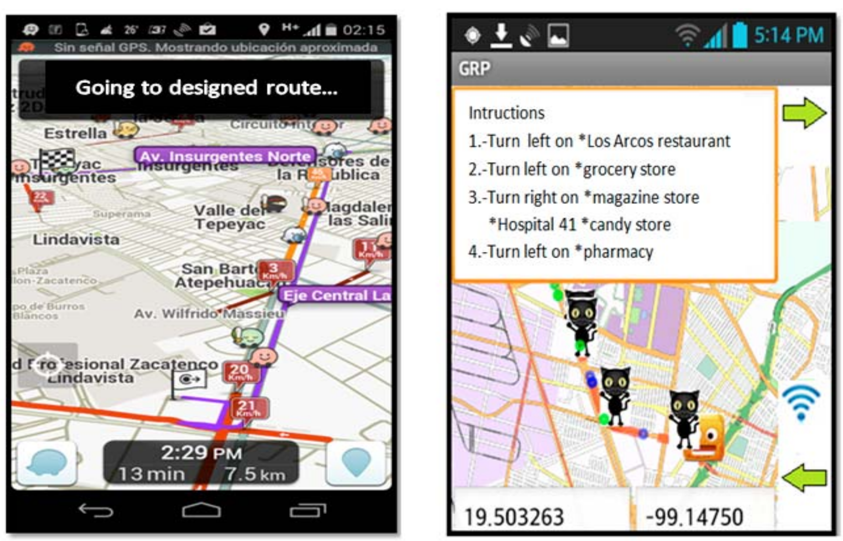

Figure 21. Comparison of route instructions given by Waze vs GRP methodology.

By making a comparison between the results of Waze and GRP approach (see figure 21), it is possible to observe that GRP map has been designed to show the visual characteristics of the route, without considering some other users location. In contrast, the GRP instructions are accurate, while the Waze ones require a special interpretation to understand its signals. Waze is not useful for people who are walking or pedestrians, because it provides the route with less traffic, without taking into account the shortest one.

5 Conclusions

The GRP methodology for generating routes with points of interest is proposed. It is an option to provide routes with descriptive instructions and points of interest by using an application ontology and mobile technologies. The GRP combines many tools of geospatial processing, web and mobile development software in its performance. The ontology model designed for the GRP to obtain the interest points is the application ontology of Vial infrastructure that classifies roads into primary, secondary, tertiary and walking classes, in which each class is also divided into entities as streets, avenues, road axis, etc., with attributes like name, business, and geographic coordinates. The GRP has a mobile application programmed in Android that has two modules; the first obtains the mobile coordinates and the name of the place where the user wants to go, the second shows a final map with the route and instructions to the person that should follow to go from one place to another, and the points of interest located on the route.

The data used to generate routes belong to district *Gustavo A. Madero*, which is a territorial division of the Mexico City, and information for the business and POIs that are part of the statistics directory of economic units (*DENUE*).

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