

# Mobile Geotumba: Geographic information retrieval system for mobile devices

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## Abstract

*Current information retrieval (IR) systems are not designed to be used in mobile devices. This occurs, because existing IR systems only recently began to offer local services and largely ignore geo-spatial information that can be inferred from the analysis of Web pages and do not recognize the geographic context that can be extracted from the mobile devices.*

*In order to integrate the geographic context in the IR systems, new methods, algorithms and software architectures have to be proposed. This article presents mobile Geotumba, a geographic information retrieval system, describing the main challenges of designing user interfaces for mobile devices, new methods for defining the user geographical context and visualizing the retrieved information.*

## 1. Introduction

Over the past decade, mobile computing has gain an increasing interest has a research area. Several factors have contributed for these interest: the increasing processing and functionality capacity of mobile devices, the portability of this kind of devices and the proliferation of wireless communication infrastructures. Despite the evolutions on the architectures of mobile devices, they still do not have the characteristics needed to access the Web information in mobile environments.

Since the early nineties, search engines evolved from using classic Information Retrieval (IR) models to inferring relevance from the analysis of the Web graph [1]. Despite this evolution current IR systems are not fully optimized to help mobile device users. This occurs, because current IR systems have some limitations. They do not recognize the context information that is present in the Web pages, in particular, they do not explore the geographic information that can be inferred from their content and they do not explore

the geographic context that can be extracted from the mobile devices.

To mitigate the gap between current IR models and the capabilities of mobile devices, new Web IR models that integrate the context information that can be inferred automatically from the user environment have to be proposed, this models will allow a better guide of searches and an improvement of results ranking:

- Recent experiments reveal that approximately 4,5% of all Web pages, contain a postal code, 8,5% contain a telephone number and 9,5% contain at least one of the two [8];
- Many Web sources are relevant only for users that are in the geographic proximity of the places referred in the Web pages;
- Almost every Web information source is not designed to be accessed by mobile devices or the mobile devices do not have the characteristics needed to adequately use the information source.

The study of the adaptation of search engines to mobile environments is a recent research area. The current limitations point to the use of relevance models that explore the relative distance between the geographic context associated with Web pages and the user geographic context [2, 4]. This will allow the selection of the most important information according to the user preferences.

The GREASE (*Geographic REASONing in Search Engines*) project [11] researches methods, algorithms and software architecture for helping users find Web pages with a scope matching their current location from mobile devices. We designate as "location" the meta-data or knowledge about the geographic position and as "scope" the manually or automatically generated meta-data describing the area of interest of Web pages. As a proof of concept the project is developing Geotumba<sup>1</sup>, a geographic Web search engine that matches users queries by "joining" the pages

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<sup>1</sup>local.tumba.pt

information scopes and geographic data obtained from the user query.

Geotumba is composed by several components: GKB (Geographic Knowledge Base) [3] - Portugal geographic ontology, that consolidates information from several official information sources; CAGE (CApturing Geographic Entities) [11] - module that identifies the geographic entities present in the Web pages, using the GKB ontology and the Web pages present in the Tumba! repository [10]; SIDRA [3] - indexation and ranking module; Presentation module that gathers all the user interfaces designed to help users to find the most relevant Web pages according to the geographic context [5].

This article presents the development process of mobile Geotumba since the requirements specification until the evaluation of the developed prototypes, exploring new methods of geographic context definition and visualization of the retrieved information. The rest of this paper is organized as follows: Section 2 lists the requirements specification. Section 3 presents the prototypes developed. Section 4 presents the evaluation methodology and some preliminary results. Section 5 presents other projects addressing similar problems. Finally, Section 6 presents our conclusions and outlines for future work.

## 2. Requirements Specification

The development process of mobile Geotumba followed a user centered methodology [6]. The requirements analysis involved interviews with potential users, the construction of system sketches and the analysis of other projects addressing similar problems. The mobile Geotumba sketches and the interviews allowed the determination of the fundamental functionalities and the possible system interactions.

Based on this analyzes it was possible to extract the following basic requirements of the mobile Geotumba:

- The identification of the user geographic context and information need are performed in the mobile device - The awareness of the user geographic context and information need allows the retrieval of the most relevant documents according to the user context (for example: restaurants near the location were the user is).
- The identification of the geographical context of each Web page and the search tasks should be delegated to servers - This requirement is crucial, because the mobile devices characteristics demand the delegation of complex task to servers.

The mobile Geotumba interface will be composed by the following areas:

- Query formulation area;

- Disambiguation area;
- Results presentation area.

The query formulation area has the objective of specifying the query object (for example: restaurants, hotels), the geographic location (for example: Lisboa, Porto) and the semantic relation between the query object and the geographic location (for example: restaurants *in* Lisboa). The definition of the query object is usually done using natural language.

To define the geographic location of the query, two main approaches can be used. The first approach uses natural language and it is the most commonly used in the IR systems. It is a good approach when the user knows the name of the location he is looking for. However, to implement this approach a disambiguation mechanism has to be built, because there could be several geographic scopes with the same name (for example: rua de são joão in Estoril and in Funchal), or several names for the same geographic scope (for example: Nossa Senhora da Conceição ou Conceição). The user can specify a geographic scope using several notations: postal codes, names of places and geographic coordinates. The geographic coordinates can be specified manually by the user, or automatically by a global positioning system (GPS).

The definition of the geographic scope using maps, is very useful if the user does not know the name of the geographic scope but is able to identify it in the map. The map interface should support at least the following operations: zoom, pan and scope selection.

Several semantic relations between the geographic scope and the search object can be used, for example: *in*, *adjacent to*, *outside of*, *north of*, *south of*, *east of* and *west of*.

After the query formulation the system should perform two operations: a syntactic verification of the query (object and geographic location), and a disambiguation procedure of the query geographic location. If the geographic scope is unique the search is submitted to Geotumba and a list of relevant documents is presented to the user, if the geographic location is invalid the user should be alerted, and if several geographic features have the same name of the query geographic location a list with the alternatives should be presented to the user.

The results presentation area presents the search results according to the user query. The results should be presented using a textual list or using maps that signalize the geographic location of each result.

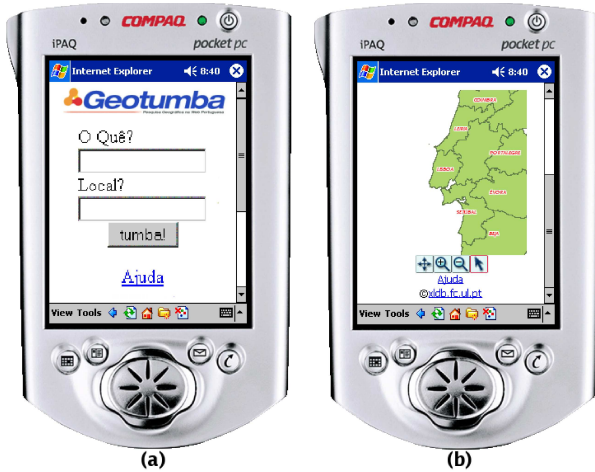
## 3. Prototype

The mobile Geotumba prototype was developed using the evolutionary technique [6]. The process began with a

base prototype that was evaluated and redesigned in several cycles until the final prototype was reached.

The mobile Geotumba prototypes were implemented has Web interfaces using *Java Server Pages*, that generate XHTML code that follows the WAP 2.0 norm defined by the OMA<sup>2</sup> *Document Type Definition (DTD) xhtml-mobile10.dtd*<sup>3</sup>. The XHTML code was validated by the W3C<sup>4</sup> and follows the *Web Content Accessibility Guidelines*<sup>5</sup> defined by the WWW consortium.

The mobile Geotumba prototype is composed by the query formulation area, the query disambiguation area and the results presentation area. The query formulation area



**Figure 1. (a) Query formulation area. (b) Query formulation area with maps.**

(Figure 1 (a)) is composed by two text fields: a text field to input the query object (What?) and the other to input the geographic location of the query (Where?). The specification of the geographic scope can also be done using an interactive map (Figure 1 (b)) that supports *zoom*, *pan* and *scope selection* operations. The prototype only supports the semantic relation *at* between the query object and the query geographic scope (for example: restaurants in Porto) and the user can use postal codes, geographic coordinates and place names to specify the query geographic location. At this moment the CAGE module only classifies Web pages on a municipalitie level. It is necessary to convert the geographic location of each query to the corresponding municipalitie (for example: the query restaurants in Saldanha is converted to restaurants in Lisbon). The geographic scope disambiguation area (Figure 2 (a)) is only displayed when

<sup>2</sup><http://www.openmobilealliance.org/>

<sup>3</sup><http://www.openmobilealliance.org/tech/DTD/index.htm>

<sup>4</sup><http://validator.w3c.org>

<sup>5</sup><http://www.w3.org/TR/WCAG10/>



**Figure 2. (a) Query disambiguation area. (b) Results presentation area.**

the user submits the query and if the query has a geographic scope that has several matches in the GKB ontology, in this case we only present to the user the first five matches that have the greater population. This occurs in order to simplify the use of the prototype in small screen devices that only have a keyboard has input. The population is used has a disambiguation factor, because statistically its more likely that a user is looking for a place with a large population. After the query formulation and verification, the query is



**Figure 3. Application for automatically capturing geographic coordinates.**

submitted to Geotumba, the returned results are displayed through a textual list (five results per screen) (Figure 2(b)).

We do not present the results in the map because the classification level of each page is very wide (municipalities) and we only support the semantic relation *in*.

The module that automatically captures the geographic coordinates from a GPS device connected to the mobile device (Figure 3), was developed using the Windows Mobile platform. The application displays a interface similar to the query formulation interface with an additional button that retrieves the geographic coordinates from the GPS device. When the user submits the query the platform Web browser is called to display the results using the Web interface. The geographic coordinates retrieval is done using the protocol NMEA 01386<sup>6</sup>, that is supported by the major GPS devices. The module was build using the Windows Mobile platform, but can easily be exported to other platforms.

## 4. Evaluation

The evaluation of the mobile Geotumba prototype was done through an usability test using two different techniques: interviews and questionnaires. The usability test was composed by an pre-interview questionnaire, interview with script and observation, post-interview questionnaire (or satisfaction questionnaire) based on the *Questionnaire for User Interaction Satisfaction (QUIS)*<sup>7</sup> and the System Usability Questionnaire (SUS)<sup>8</sup>.

The pre-interview questionnaire was used to obtain information about the user experience on using computers, Internet, search engines and geographic search engines. The interview with script and observation had the objective of testing the prototype functionalities through 6 specific tasks. The post-interview questionnaire was used to measure the user satisfaction level. Finally the SUS questionnaire was used to obtain a normalized evaluation of the mobile Geotumba prototype.

The interview with script and direct observation were carried by two evaluators, one of the evaluators conducted the interview and the other produced the annotations. The evaluation were made using a Compaq IPAQ 3700 with the Windows CE 3.0 operating system. Five participants were used to run the evaluation. According to the Jakob Nielsen [9] observations the application of usability tests in a reduced numbers of participants is sufficient to detect coarse usability errors.

The pre-interview questionnaire revealed that all the participants use mobile devices regularly but they rarely use it for Internet access. Non of the participants had experience on using geographic search engines. Some usability problems were detected on the results presentation area (users complained that the results list was very large), and on the

disambiguation area (in the beginning users felt a little confused with the options displayed in the disambiguation list). To improve the usability of the results presentation area we reduced the document summary of each result to 50 characters, and to improve the disambiguation area we passed to display only the 5 geographic scopes that had the greater population. Despite the prototype usability problems, it obtained a good usability level in post-interview questionnaires, 7.5 points in the QUIS questionnaire (in a scale of 1 to 9) and 92.5% in the SUS questionnaire.

## 5. Related Work

This section describes the characteristics of the main geographic information retrieval (Geo-IR) systems for mobile devices.

The SPIRIT project [7] is being developed by a consortium of European universities whose objective is to develop a Geo-IR system that regards an interface for mobile devices. The project documentation about the interface for mobile devices is very scarce and there is only available a semi-functional prototype. The interface for mobile devices is composed by two areas: query formulation and results presentation. The search results comes from the SPIRIT geographic search engine server. In the query formulation area the user can specify the query object and the query geographic location is always the current geographic location of the mobile device, there is no description of how the current geographic location is captured from the mobile device. After the search is submitted the search results are present through a textual list or through a map.

Local Google Mobile<sup>9</sup> is a Geo-IR search engine with an interface adapted to mobile devices. The system is still beta and only supports queries whose geographic scope belongs to the USA. The results are obtained through the Google directory. The mobile device interface is composed by the query formulation area and the results presentation area. In the query formulation area the user has to specify the query object and the geographic scope. In the results presentation area a map and a textual list of results is displayed. Local Google uses a fully automatic disambiguation procedure, however there is no description of how this is achieved.

Local Yahoo Mobile<sup>10</sup> is very similar to Local Google mobile. The only difference is the disambiguation procedure which is fully manual (the user has to choose an option from a list with all the disambiguation options).

All the systems presented have undeniable value, because they provide information about several entities according to a geographic criteria that is adapted to mobile devices. However this systems are based in directories, whose information is maintained manually. The need to develop

<sup>6</sup><http://www.nmea.org/pub/0183/>

<sup>7</sup><http://www.lap.umd.edu/QUIS/index.html>

<sup>8</sup><http://usability.serco.com/trump/documents/Suschart.doc>

<sup>9</sup><http://www.google.com/xhtml?site=local>

<sup>10</sup><http://mobile.yahoo.com/search/wapdemo>

automatic Web IR systems that explore the geographic context of the Web pages and of the user, has it is described in this paper, is very important.

## 6. Conclusions

This article presented the main requirements for designing IR systems adapted to mobility environments. We were able to identify several characteristics that are fundamental for designing this type of systems, namely: the representation of the user geographic context; the use of geographic classification methods that allow the identification of the geographic scope of each Web page; the delegation of complex operations to servers. It was also described, the development process of the mobile Geotumba, a search engine for mobile devices, since the requirements specification until the evaluation.

To support information retrieval on mobile devices, its fundamental that the Web page geographic classification is very accurate and the classification of each Web page is a very narrow region (for example: cities, streets). This is one of the aspects that we have to further improve.

To improve the usability levels of mobile Geotumba, the following functionalities have to be extended:

- Support of geographic query's with multiple geographic scopes (for example: Porto and Lisboa);
- Support of complex semantic relations between the query object and geographic scope (for example: near Lisboa, outside Funchal, adjacent to Guimarães, north of Portimão);
- Employ the user disambiguation history to improve the geographic disambiguation;
- Support the clustering of results using the geographic information;
- Generate document summaries, that would allow the user to visualize the most important information of each result, without consulting the full document.

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