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MKiosk

A Mobile Kiosk for Tourists

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Resumo

O segmento do turismo representa um sector de negócio de grande actividade e crescimento. Igualmente, o avanço tecnológico evidenciado na área da computação móvel e a disponibilização de plataformas para o desenvolvimento de aplicações proporcionaram uma considerável proliferação de serviços móveis de localização com especial utilização no âmbito do turismo.

Porém, a maioria das soluções actuais apresenta símbolos visualmente pouco informativos e sobrepostos em zonas com grande densidade de informação, assim como carece de informação geograficamente distante do utilizador. Além disso, por vezes, o utilizador depara-se com Pontos de Interesse e Pontos de Utilidade que não se encontram referenciados *in loco* e em mapas ou guias turísticos.

Neste sentido, propomos uma nova abordagem para a pesquisa, introdução e visualização de informação turística, baseada no reconhecimento do conteúdo de fotografias georreferenciadas de Pontos de Interesse, e na procura de informação em função de uma dada distância, localidade ou zona geográfica. Por outro lado, permitimos a visualização de descrições detalhadas sob a forma de lista, mapa ou galeria, assim como a introdução *in loco* de Pontos de Utilidade no nosso sistema.

Para validar a nossa abordagem, criámos um protótipo e realizámos testes experimentais com utilizadores. Primeiro, fizemos uma avaliação informal com utilizadores para melhorarmos o protótipo. Depois realizámos testes formais em condições reais de utilização de uma solução deste tipo. Concluímos que a nossa abordagem é adequada à resolução dos problemas vigentes, e que 75% dos utilizadores aprovaram a aquisição de informação turística, através do reconhecimento de fotografias de Pontos de Interesse.

Palavras-Chave: Turismo Móvel, Recuperação de Imagens Baseada no Conteúdo, Serviços Baseados em Localização, Ponto de Interesse, Plataforma Android

ABSTRACT

Tourism is a highly active and growing sector of the economy. In tandem, the advances in technology in the field of mobile computing have made platforms available for developing a wide array of mobile GPS services which can be turned to very good use within the tourist sector.

Most current solutions, however, use visual symbols that provide little information and overlap in areas that are dense with information. They also lack geographical information that is far away from the user. There are also Points of Interest and Utility Points that cannot be found *in loco* and on maps or tourist guides.

With this in mind, we propose a new approach for the search, insertion and visualisation of touristic information based on the recognition of contents in geo-referenced photographs of Points of Interest, and for the search for information based on a specific distance, site or geographical area. Moreover, we provide, for the visualisation of detailed descriptions, list, map or gallery views, along with the *in loco* insertion of Utility Points in our system.

We created a prototype and carried out tests to assess our approach. First, we made an informal assessment with users to improve the prototype. Then we carried out formal tests for a solution of this type under real conditions. We concluded that our approach is adequate to tackle existing problems. In addition, we found that 75% of users approved the acquisition of tourist information through the recognition of photographs of Points of Interest.

Keywords: Mobile Tourism, Content-Based Image Retrieval, Location-Based Services, Point of Interest, Android Platform

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LIST OF ACRONYMS

API	Application Programming Interface
CBIR	Content-Based Image Retrieval
EXIF	Exchangeable Image File Format
GIS	Geographic Information System
GPL	General Public License
GPS	Global Positioning System
HCI	Human-Computer Interaction
J2ME	Java Micro Edition
LBS	Location-Based Services
MCV	Mobile Computer Vision
MUG	MKiosk User Group
PC	Personal Computer
POI	Point of Interest
SDK	Software Development Kit
UP	Utility Point

1 INTRODUCTION

We begin the first chapter by introducing the scope of this thesis and related issues. Then, we expose objectives determined to address the problem identified, along with a description of the solution proposed. In addition, we also refer to the contributions derived from the present thesis. To end up this chapter, we briefly describe the outline and the structure of this document, from the research carried out to experiments performed.

1.1 MOTIVATION

Recently, the tourism industry has been gaining significant worldwide relevance. Present day low cost agencies allow people, in particular last minute tourists, to travel regularly and inexpensively. As a result, major cities have revealed an evident increase on overseas visitors' flow [Conrady 08]. Emerging technologies have been also increasingly exploited to support and enable a more enjoyable and creative experience through tourism related activities [Goh 09], and leaflets with detailed information and guidebooks are likely to be superseded by digital resources displayed on mobile devices. Indeed, tourism will certainly become one of the most influenced application domains within the mobile computing field [Hpken 09]. Regarding the mobile phone industry, we have noticed a continuous and significant expansion lately. Generally, mobile phones represent an essential role in daily life. With the pervasive use of camera mobile phones, the embedded camera has been considered as a promising Human-Computer Interaction (HCI) mobile approach. The Global Positioning System (GPS) technology is becoming as well widely available for mobile phones. Until recently, the generality of mobile developers did not have an easy access to mobile development platforms. To give them the possibility to freely create their own mobile applications, Google has launched the Android[1] development platform enabling worldwide developers to exploit mobile solutions targeted for diversified aims. In addition, the emergence of location-based mobile applications was likely to increase due to Android's GPS and web services support, in particular Google Maps [2] services.

Despite tourism industry evident growth and the development of e-Tourism services [Tan 07], some tourists still remark for the lack of information about Points of Interest (POI) and Utility Points (UP) while sightseeing, especially *in loco* and map touristic references. Usually, people while travelling on business do not have the time also to promptly get the descriptions on what they see and what they really need. Regarding existent mobile solutions, there are still drawbacks to overcome and improvements to undertake. Most of

[1] Android: http://www.android.com/
[2] Google Maps: http://maps.google.com/

current applications do not provide rich-contents involving POI illustrations and adequate descriptions. The visualization of symbols is also a main concern due to their overlapping on camera and digital map views, and to the absence of icon-based symbols. Further, searching for POIs and UPs regardless of user's current position is neglected by the Location-Based Services (LBS) we have researched. The generality of image-retrieval based mobile solutions are also exploited under restricted places and do not consider the use of GPS functionality. In concern to Mobile Computer Vision (MCV) field, according to [Wright 09], future Smartphone will provide information via a live video feed about locations at which the phone is pointed. Based on the aforementioned facts, we attempted to exploit recent mobile phone technologies and development platforms, as well as to perform research centered on current mobile applications and present day user's needs, to design a solution that allows tourists to carry out location-based activities efficiently.

1.2 OBJECTIVES

As previously stated, most of touristic resources and mobile applications do reveal a lack of functionality and detailed information regarding POIs and UPs references. In addition, technological advances lead people to demand for more efficient means to access information about their surroundings, when touring around abroad. To address these issues, we next refer to the aims determined for the present thesis. Our main goal focus on reviewing and expanding the processes of touristic information acquisition, insertion and visualization using a mobile phone. We aim to give users the ability to acquire and visualize POI-based descriptions through distinct approaches: taking photographs to a POI; using proper location-based features. We plan as well to enable *in loco* insertion of geo-referenced information into a remote system. To achieve this objective, user's willingness is crucial. Thus, it is relevant to go deeper on designing an approachable solution to enable *in loco* insertion of geo-referenced information. In more detail, we attempt to answer users' demands by processing the contents of photographs captured to POIs. We also intend to enable customizable search queries within nearby and faraway locations. Providing users icon-based symbols concerning the POIs and UPs available in the system, is likewise essential. For *in loco* insertion of UPs, we plan to design a solution that allows users to insert and contribute to the system with an UP founded in the outdoors.

In short, the primary objective of this thesis consists in providing users a well-suited mobile solution to search, insert and visualize POI and UP related descriptions, based on the recognition of a photograph and on well-defined search methods. Through experiments we also aim to observe and register user's behaviours while performing tasks using our solution. Moreover, along the user profile study and the system design stage, we were attended by a restricted group of potential users, designated the MKiosk User Group (MUG).

1.3 SOLUTION

In this section, we point out current mobile application issues and we give a brief overview on the solution proposed, focusing the primary features from user's standpoint. Most of Content-Based Image Retrieval (CBIR) mobile applications, do not exploit spatial data to narrow searches into restricted geographical regions. Also, current location-based mobile applications denote a lack of flexibility in the sense of disallowing faraway or map-region based search queries. In regard to insertion and visualization solutions, the generality of existent approaches do not provide the means to insert geo-referenced information when facing POIs or UPs *in loco*. Instead, they resort to proper web browser applications running on common personal computers (PC) to collect the geo-referenced information inserted by users. With our solution we aim to overcome and improve some constraints evidenced by present day mobile applications, in particular those focused on the tourism sector. We therefore allow users to capture geo-referenced photographs to POIs, by means of the mobile phone embedded camera and the GPS functionality together. Once captured, we deliver a list of POIs ordered by distance and containing similar results followed with descriptions and illustrations.

To search for POIs and UPs, we designed a search component providing users a range of inputs, e.g., POIs and UPs based filters, list and map view definition, nearby and faraway location setting, traceable geographical regions, as well as inputs for distances and the number of results. In other words, we are aiming to give users the possibility to perform search queries defined by distances, localities and map regions, and to visualize POIs and UPs either through list or map display. Moreover, users when tapping symbols are presented with an additional visualization mode consisting of an image gallery, jointly with related descriptions. We also created a location-based component to support *in loco* insertion of geo-referenced information. Thus, users when touring and using our solution are able to select an UP by resorting to a well-defined UP based list, and next to the selection, they are displayed an interactive map view to place the UP according to its physical location.

1.4 CONTRIBUTIONS

According to the objectives and solutions previously described, the primary contribution of this thesis aims to provide a new mobile approach to enable the capture and geo-based recognition of POIs, to perform search queries based on nearby and faraway locations and to support *in loco* insertions of UPs. We also gathered relevant results on nowadays users' needs and behaviours when using our prototype through experiments. We next refer to the contributions derived from this thesis, enhancing the main features designed and findings produced during formal testing sessions with users:

- Geo-Referenced Image-Retrieval Mobile Platform – With this work we have designed a mobile solution to jointly support GPS based features with CBIR systems. The spatial component of our solution improves the performance and effectiveness of these systems, thus providing reliable results;

- *In loco* UP Insertion – Enables users to insert geo-referenced UPs in a remote system, directly from their physical location;

- Nearby Search Query – Our solution permits searching for POIs and UPs within a range of closer distances given by default. The search process is carried out according to user's current geographical position. Users may chose to view results on list or map and to define the number of results displayed;

- Faraway Search Query – We also allow the execution of search queries regardless of user's current position and performed on well-defined localities given as input;

- Map-Region based Search Query – Contrarily to common search methods analysed through the research, we introduce an innovative proposal to perform search queries based on geographical regions. Using a touchable screen, we enable users to trace map-region based search queries regardless of distance inputs;

- Multiple Visualization Mode – In order to avoid overlapping symbols, the map view is supported with a list component which orders results by closest distances from user's position. Additionally, we present an interactive gallery view associating images with related descriptions;

- Multiple Filter Component – For the search feature, we introduce two distinct filters based on POIs and UPs. Users may customize their search queries combining multiple POI or UP, and both.

In addition to the features developed, experiments carried out in a realistic environment leaded to a higher rate of credibility on gathered results. According to findings, we realized that most users were willing to photograph POIs to acquire related information, rather than querying manually. Regarding search queries, users were successful when performing nearby and advanced search queries considering faraway localities and traceable map regions. The majority of participants did also insert UPs in the system using our approach.

Findings on this proposal bear out as well the intuitiveness and space awareness when performing map-region based search queries for large distances. Subjective results revealed that users leaned toward map display view to visualize delivered information rather than list display view. Also, while browsing maps and selecting symbols, users used frequently zoom controls, in particular to enclose within screen bounds the targeted symbols.

1.5 Thesis Outline and Organization

Our solution is amply described and explained in this thesis. Throughout the present document we begin by discussing the related work in Chapter 2, enhancing well-known fields of study. Section 2.1 refers to computer vision based mobile applications, while analyses concerning location-based mobile applications are addressed in section 2.2. We plan with this discussion to evidence problems detected in current applications and hence to formulate our objectives and solutions.

In Chapter 3 we expound the procedures undertaken to conduct the user profile study, and we discuss related results. Participants' recommendations on design and functionality aspects are also addressed. In Chapter 4 we explain in detail the overall architecture of our solution regarding all components involved. We next refer to the system implementation process, describing each stage of design. Technology issues detected during development are also remarked.

Upon a fully description over the system design and the system implementation, we introduce, in Chapter 6, the experiments conducted to assess our solution, and we analyse and discuss gathered results. Through Chapter 7 we point out achieved conclusions, mentioning primary contributions separately. Finally, we address the future work section.

2 Related Work

The present chapter covers a detailed analyses on the related work researched. As stated in Chapter 1, we are aiming to design a solution based on two different approaches to acquire information: taking photographs to POIs and executing search queries. Thus, we lined up related works according to well-known fields of research: Mobile Computer Vision (MCV) and Location-Based Services (LBS). For the MCV section, we focus our analyses on different methods to track and recognize objects using mobile phones. We also refer to visualization issues on acquired information upon the recognition process. For the LBS section, we describe recent location-based applications, enhancing search and insertion queries based on geo-referenced contents. In addition, we remark usability and interface constraints in regard to the visualization of information, like for instance overlapping symbols on map view. Upon describing and pointing out existing approaches, we join together the problems detected and introduce an appropriated solution, clarifying our contribution. Based on the proposed solution, we conclude this chapter by presenting clear objectives and the contributions we are expecting to produce.

2.1 Mobile Computer Vision

The following mobile applications suggest different approaches to address object tracking and recognition. Elements such as buildings, small exhibits, barcodes and dot based maps are representations of recognizable objects introduced on indoor and outdoor environments. Through this section we also refer to underlying tracking and image retrieval drawbacks, and usability and interface considerations.

2.1.1 Agamemnon

Agamemnon [Ancona 06] is a tourist-oriented project focused on the cultural heritage field. Its primary purpose is serving mobile phone users with information about archaeological constructions, thus enabling them for a customized and detailed multimedia tourist guide. This project embraces interesting features such as dynamic generation of itineraries, support for user contribution by registering visit events in various multimedia formats, text-to-speech voice synthesis technology, and the recognition of photographed constructions using embedded cameras of mobile phones. In Agamemnon, the image recognition process consists of the following steps: taking a picture to a monument; despatching it to a remote server through a local network, where image computations are processed remotely; deliver related information to the end-user.

Figure 2.1: Image recognition of archaeological monuments [Ancona 06]

Agamemnon development lasted for significant months due to its complexity. Still, progressive evaluations are been carrying out with the purpose to enhance a few features. Despite the project elaboration, the image retrieval process could be improved by integrating a geo-referenced platform to ensure reliable results. The current approach forces an overall analyses over data stored in the remote server, thus affecting queries performance. To enhance this process, a reasonable approach would consist on limiting constructions within the archaeological site. In Agamemnon, delivered results are displayed to the end-user disregarding similar matches, i.e., only one result is returned, hence leading users to be likely displayed with wrong matches. With respect to visualization purposes, Agamemnon supports list and map views, however, evidencing a lack of additional information, such as listed descriptions followed with images.

2.1.2 PhoneGuide

Contrarily to previous project, PhoneGuide [Föckler 05] is focused on indoor environments, more precisely museums. There are still museums where personalized devices are designed for their purposes, thus increasing costs of acquisition and maintenance. For this reason, PhoneGuide developers exploited recent mobile phones potentialities for developing an application directly focused on museum visitors needs. PhoneGuide developers had as technical issues image recognition effectiveness and network traffic. For image recognition effects, they followed an approach based on neuronal networks.

Figure 2.2: On device image recognition for museums exhibits [Föckler 05]

PhoneGuide introduces an approachable means to access museum exhibits using a mobile phone. Nevertheless, it features some drawbacks that could be circumvented using different approaches. To restrict exhibits while performing computations in the mobile phone, using geo-referenced information could not work properly due to indoor conditions. Instead, RFID or Bluetooth cells could provide a well-suited approach regarding indoor conditions. In this sense, visitors would not have to be aware of local server accesses to download the required information. Although the successful performance of PhoneGuide, mobile phone users willingness to photograph exhibits to access for related information while visiting museums, is critical, because, generally, these spaces do provide visitors detailed information in form of text-based panels and audio or video productions. Rather, PhoneGuide could be exploited for outdoor places comprising large amounts of POIs, where some do not present related descriptions.

2.1.3 On the Go

The primary aim of On the Go [Adeormann 07] consists in providing mobile camera phone users with information about a commercial product according to its barcode. On the Go developers created a real-time recognition system of barcodes using a mobile phone real-time camera. Moreover, the barcode’s relative orientation to the mobile phone was also considered to select different options. Regarding the recognition process, when a barcode is recognized, additional descriptions are returned to the user, via GPRS or Bluetooth. Also, barcode’s relative orientation allows users to select different menu items by rotating the phone in relation to a determined barcode.

Figure 2.3: A barcode capture and recognition example of a product [Adeormann 07]

On the Go application presents an advantageous tool targeted for today’s consumers. Real time recognition has benefits such as processing a set of multiple images per second. Nevertheless, most images may get blurry or distorted due to user’s movements together with mobile phone sensitiveness. For this reason, it is favourable a single and clear capture, rather than capturing multiple images and performing recognition processes simultaneously. Regarding usability issues, in spite of the intuitive manner to perform actions, it limits the application to two different operations, tilting left or right. This approach could not fit properly if we wanted to access additional options. Further, in case of recognition failure, users are presented one single barcode description, instead of a list containing most similar results.

2.1.4 WikEar

WikEar project [Schöning 08] seeks to generate dynamic narratives across a determined path specified over an appropriated map surface. WikEar, generates custom, location based guided tours. It uses also a magic lens-based interaction scheme allowing the continued use of paper maps. In this way, mobile users, by means of a physical dotted map and a camera-phone, are able to define a start and end location by sweeping the mobile camera device over the map. The device is tracked relative to the paper map using tiny black dots printed on the maps.

Figure 2.4: Capture of a POI depicted in the map [Schöning 08]

WikEar features an innovative way of generating guided tours, supported by audio narratives. Despite the use of physical maps which avoids GPS costs, using paper resources may be nuisance and unfavourable when sweeping the mobile phone over the map. Further, today's digital maps are periodically updated, differently from physical resources, and the use dot-based maps disallow as well the use of common maps. In addition, the lack of controls to manage audio narratives forces tourists to listen audio samples from their beginning to the end. WikEar developers could also display textual audio comments, due to the adverse hearing conditions while walking in crowed cities.

2.1.5 Memoria Project

Memoria Mobile [Jesus 08] was developed jointly by the Interactive Multimedia Group of DI/FCT/UNL, in Caparica and the Multimedia and Machine Learning Group from ISEL. This work introduces a system for navigating and browsing digital memories registered on physical locations, such as historical or cultural heritage sites, by means of mobile devices.

The system is supported by a retrieval engine and a mobile user interface enabling capture and automatic metadata generation. In Memoria, a mobile device with support for GPS communication is required to provide to the application coordinates data for labeling purposes. Image retrieval system enables different types of queries, such as using pictures, map-region images and texts, which are performed by simply dragging and dropping elements into a query box.

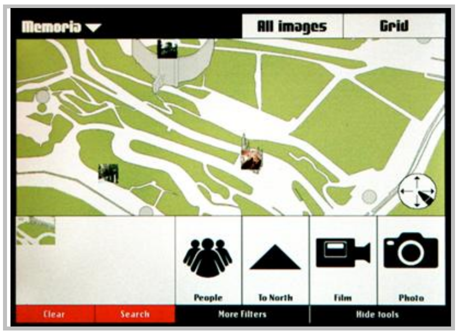


Figure 2.5: An overview on Memoria interface [Jesus 08]

Memoria introduces an image retrieval system based on geo-referenced captured pictures. Contrarily to Agamemnon approach, Memoria exploits the GPS technology to structure properly images and enhance system performance. Nevertheless, map-region based queries are performed by recognizing cultural and heritages digital map segments using the image retrieval system. Using worldwide digital maps would allow map-region based search queries within a global context. Furthermore, performing geographical search methods would provide a greater performance than carrying out map-region recognition processes.

2.2 Location-Based Services

The current section aims to present and discuss mobile solutions concerning location based activities. Throughout the following paragraphs we analyse and remark drawbacks and achievable improvements on geographical aspects and interface constraints.

2.2.1 GeoPix

GeoPix [Carboni 06] integrates recent web technologies and geo-referenced concepts, on a single mobile and location-based application. In GeoPix, mobile users are able to produce geo-referenced pictures, by means of their mobile phone, sharing them with Web users. On the internet, users may access an online database and experience a smart navigation based on maps.

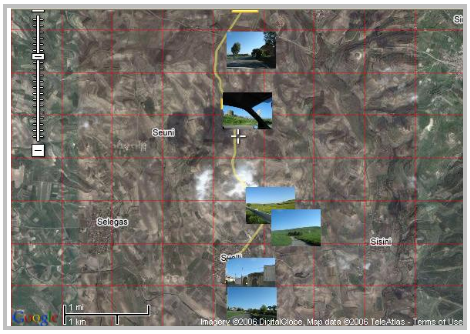


Figure 2.6: Browser view of published pictures by on-the-road users [Carboni 06]

As previously mentioned, user's insertion of geo-referenced information consists in posting online captured photographs. Nevertheless, the insertion process could be enhanced in the sense of providing auto-generated spatial metadata rather than inputting manually the geographical coordinates. Also, using location-based features to search for nearby posted contents would benefit the experience on the outdoors.

2.2.2 Wikitude

Wikitude project [Mobilizy 09] was developed by Mobilizy, a company specialized in software for Smartphone. The aim of Wikitude is providing users geo-referenced information, like for example POIs, in regard to their current position. Users are able to customize nearby search queries, setting search distances and selecting their desired POI categories prior to the begging of the search process. Wikitude introduces an innovative mobile application in the sense of enabling an augmented reality camera view. Users while pointing the mobile phone in a well-defined direction are presented with POIs. This process is supported by GPS and compass functionalities. In addition to the mobile application, Wikitude allows users to contribute for the system by inserting POIs descriptions and comments through a desktop tool provided by Mobilizy.

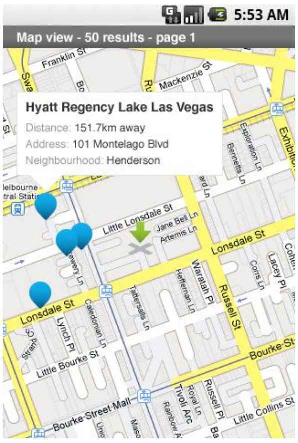


Figure 2.7: A marked point of interest with related information [Mobilizy 09]

Wikitude is a location based application focused on giving users the ability to search for POIs descriptions, in particular from Wikipedia. The system only performs search queries for nearby locations. Search queries based on different locations are not in harmony with Wikitude. Map-region based search queries are likewise not considered. Regarding the symbols displayed either on map, list or camera view, Wikitude do not distinguishes POIs by their category. To insert POIs descriptions, users have to resort to an additional application running over a web browser and suitably accessed by a desktop PC, rather than inserting directly through the mobile application, when walking in the street.

2.2.3 REXPLORER

REXplorer [Ballagas 07] application consists in a leisure and tourism related application. The main goal of REXplorer is walking along a circumscribed area around the city, by passing through specific hotspots representing important buildings, monuments or relevant context information to play a game. In each of these hotspots, a REXplorer tourist will have to accomplish different challenges based on context information.

Figure 2.8: The REXplorer device and hotspots presented on a mock-up [Ballagas 07]

REXplorer had certainly draw the attention, not only of young tourists, but also of adult. It is an entertaining experience to learn better the history of the city and related constructions. Nevertheless the mobile device, which in fact is a reproduction of a real mobile phone, does not favour users in terms of interface interaction and visualization needs, as we can in Figure 2.8. Due to the increasingly integration of GPS receivers on mobile phones, in the present day, users would be able to play this game in their own mobile phones, hence providing a familiar experience. Considering digital maps in mobile phones, they could be able to search maps according to their current position, and supported with nearby descriptions, for instance when facing a monument across the game path.

2.2.4 Point-to-GeoBlog

Point-to-GeoBlog [Robinson 08] is a system targeted for tourists marking POIs along their journeys. The project consists of a mobile phone application and a route generation desktop application. The mobile phone supports GPS service and includes additional equipment consisting of a small wireless device incorporating several features such as accelerometers, magnetometers and angular rate sensors. Using Point-to-GeoBlog, users are firstly displayed a map according to their current position, so they can start marking POIs while touring. At the end of a tour, a set of geo-referenced POIs remain stored on mobile phone memory for further analyses in the desktop application. The desktop-oriented application was developed with the purpose of generating an interactive map, based on the points registered by the user on-the-road. Upon POIs generation, they are linked with internet references, such as sites and images.

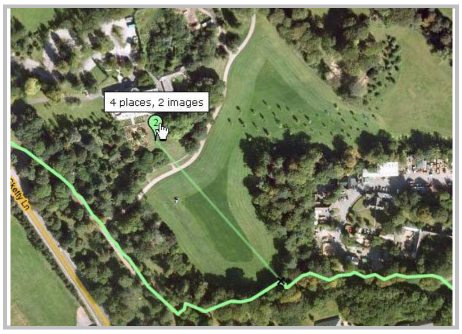


Figure 2.9: A marked point of interest with related information [Robinson 08]

Point-to-GeoBlog application revealed a reasonable method to register POIs while walking. However, its developers did not regard an important aspect: users when exploring outdoor locations are not able to access *in loco* the information associated to the marked POIs. Demanding for real-time information is a relevant requirement for location-based applications when users face unreferenced POIs. For the desktop application, symbols when overlaid in the map view remain uniform, i.e., they are not categorized according to distinct POIs. In addition, Point-to-GeoBlog could allow users to search for POIs from their current location.

2.2.5 Layar

Similarly as Wikitude, the Layar project [Sprxmobile 09] enables augmented reality visualization of POIs. The aim of this project relates to provide users with location-based information. The global information source involves well-known entities, such as Wikipedia, Twitter, Flickr and many others. Layar enables mobile users to point their mobile devices through a determined direction and acquire information regarding the distance and POIs requested.

Figure 2.10: The augmented reality view in Layar [Sprxmobile 09]

Currently, Layar is a commercial application oriented for Android mobile phones. This application features a significant range of available information sources. However, Layar does not discern delivered information according to POI symbols as can be seen in Figure 2.10. The selection of multiple POIs is also impracticable for the version we have evaluated. With regard to search features, Layar disables users to search locations according to the number of results demanded. Additionally, the application does not consider faraway search queries based on address input or map-region areas.

2.3 Overall Discussion

Upon analysing MCV and LBS solutions and capabilities, we are able to synthesize and discuss relevant features and issues in regard to the related work. Table 2.1 introduces a feature overview encompassing the aforementioned works. We next remark features and issues on the MCV applications described.

Agamemnon project is based on an image retrieval system which deals with computations regardless of geographical data. Demanded results concern one single result, i.e., the most similar image. In addition, Agamemnon provides some location-based features to search for nearby constructions and to generate routes within a restricted area. Returned results are displayed in form of a rudimentary list or a sketchy map. Similarly, PhoneGuide performs image retrieval processes disregarding geographical data. In contrast with Agamemnon, this application is designed for indoor environments. Concerning the visualization of results derived from the recognition process, PhoneGuide displays a list containing the most similar results, hence enabling users to select the image matching the museum exhibit. The On the Go project considers an image retrieval system which handles real-time image capture. The capture process is carried out through real-time camera multiple capture, instead of a single capture. Moreover, On the Go, does not list results according to image similarity rate. WikEar application provides Wikipedia audio narratives based on text-to-speech techniques. Also, the generation of routes is demanded through map-based tracking methods using a proper dotted map and the mobile phone embedded camera. Differently from previous MCV applications, Memoria enables geo-referenced image retrieval. Images are interactively dragged to a search box to carry out image-retrieval computations. Memoria allows also map-region queries through the recognition of map-based images.

The analyses over MCV applications evidenced that the generality of computer vision based systems disregard geo-referenced information, and are suited for restricted places. Moreover, real-time multiple image capture does not likely confer reliable results due to mobile devices sensitiveness together with user's shaking movements. Instead, we thing that aiming the camera to an observable object and performing one single capture, leads to a higher recognition rate. With regard to map-region based search queries, we have seen that current solutions perform it using an image-retrieval based solution, as well as using dotted maps on paper. Contrarily to these approaches, exploiting on-mobile geographical functionality would assure higher levels of performance and accuracy. Also, present day location-based methods enable geographical queries in a uniform and wider scale. We therefore consider that using digital maps directly on a mobile phone, is favourable than resorting to physical resources that quickly fall out-of-date. Regarding the visualization of delivered results, Agamemnon and On the Go rely on one single result, i.e., the most similar to the captured image. Nevertheless, varying lighting situations, like for instance shadows and highlights, may significantly decrease the recognition rate. We suppose that it would be reasonable providing a set of results, containing most similar images. In this sense, users would be successful on getting information, even when facing adverse environmental conditions.

Throughout section 2.2 we have referred to LBS applications. We next introduce current location-based features on the mobile applications researched. We start with GeoPix. The GeoPix application offers users the ability to make up image based routes by marking geo-referenced images while walking. Despite of enabling POI marking, users are not able to search for POIs. Instead, only desktop users are allowed to access on-field users' contributions. Wikitude features a distinct approach from previous solution. Rather than rendering information using an image retrieval approach, Wikitude combines geographical and compass data. Users are able to carry out nearby search queries, although Wikitude disallows searching locations regardless of users' current position or map-region based search queries. Wikitude enables as well the insertion of POIs into a remote system. Yet, the insertion process is performed by means of a desktop web based application, thus disabling POI insertion in physical locations.

	Content-Based Information Retrieval			**Location-Based Features**					**Information Display**			**Mobile OS**
	Photo	Compass	GPS	Nearby Search	Farway Search	Map Search	Add Geo-Content	Multiple Filter Selection	Map	List	Real-Time Camera	Android
Mobile Computer Vision												
Agamemnon	•			•					•	•		
Phone Guide	•									•		
On The Go	•										•	
WikEar	•					•			•			
Memoria	•		•	•		•	•		•			
Location-Based Services												
Geo Pix			•				•		•			
Wikitude		•	•	•			•	•	•	•	•	•
REXplorer			•	•								
Point-to-Geoblog			•				•		•			
Layar		•	•	•					•	•	•	•

Table 2.1: A feature overview about related work application and MKiosk

Differently from general LBS, REXplorer aims to provide POI information to users, while they play a mobile game in a narrowed area. The application allows users to access touristic and historical contents when facing POIs. However, it is improper to execute common location-based features and to display results in list or map view, due to mobile device constraints. GeoPix, as Point-to-GeoBlog enables users to create POI-based routes while gathering geo-referenced information across travelled paths. Whilst GeoPix developers allow the GeoPix community to access on-field inserted references, Point-to-GeoBlog stores collected references in memory, and thus prevents POIs to be shared. Layar project introduces a solution based on GPS and compass functionalities like Wikitude. Users may search for information according to their current position, yet only locally. However, Layar does not support the selection of multiple POIs through search filters.

Upon a briefly analyses on some LBS applications, we may advance that most of solutions does not provide an advanced search support in the sense of performing faraway or traceable search queries for instance. Table 2.1 expresses also that features like faraway search query and multiple filter selection are unavailable for nearly all applications. Additionally, we found out that Memoria, GeoPix, and Point-to-Geoblog support *in loco* insertion of geo-referenced information into a remote system, yet they disregard searching for same information. For information display, Wikitude, Layar and Agamemnon, support multiple visualization mode. In contrast, remaining applications provide map display exclusively. Providing multiple displays to visualize information may overcome some issues concerning overlapping symbols.

2.4 Solution

According to previous discussions on MCV and LBS highlighted features and issues, we may infer an adequate mobile solution to address the primary features mentioned in Table 2.1. Differently from general MCV applications, we aim to integrate an image-retrieval system with a geographical-based system to increase the performance of the recognition process. Contrarily to our approach, the solution described for Memoria is suited for restricted sites. We seek to support worldwide information, defining the data base framework according to different locations, i.e., cities or municipalities. We also aim to perform map-region based search queries over worldwide digital maps on mobile phones. Our approach implies traceable map regions that are processed dynamically using geographical-based methods, rather than using image-retrieval systems to perform the recognition of paper maps, as WikiEar does. In respect to the visualization of POIs descriptions, we plan to enable multiple visualization modes to avoid additional efforts when handling large amounts of POIs.

The overall discussion expresses also that LBS applications focus on POI elements mostly. In order to support additional information, we introduce the utility point (UP) concept which refer to geo-referenced elements regardless of descriptions, such as WC or phone booths. We are considering to exploit the UP concept particularly for the insertion of geo-referenced elements into our system.

2.5 Objectives and Expected Contributions

So far, we have analysed the state of the art in regard to computer vision and location-based mobile applications. We pointed out as well related issues on current image retrieval and location-based systems, in particular concerning the visualization of information. According to previous discussion and remarks, we now may address and formulate the objectives and expected contributions derived from the present thesis. With our solution, we aim to design a mobile application to complement physical resources, such as paper maps, and to enable searching, inserting and visualising POIs and UPs. We therefore plan to comprise different approaches to manage information over an *all-in-one* application. From the related work discussion, we realized that a geo-referenced image retrieval system considering worldwide physical locations, would be one of the primary contributions. In addition, we address other relevant proposals in order to enhance location-based processes and to overcome detected drawbacks. Table 2.2 encompasses our objectives and corresponding specifications.

Objective	**Specification**
Geo-Referenced Image Retrieval System	To support the recognition of geo-referenced photographs taken in the outdoors, by means of a mobile application;
UP On-Field Insertion	To enable accurate UP insertions, through an UP based list and an interactive map view;
Nearby Search Query	To perform search queries regarding nearby distances selected from a proper list;
Faraway Search Query	To perform search queries across Google Maps related addresses;
Map-Region Based Search Query	Differently from previous search methods, to carry out search queries according to traced geographical areas;
Multiple Visualization Mode	To introduce a flexible visualization based on list and map views, covering delivered POIs and UPs. To provide also a gallery view;
Multiple Filter Component	To define POIs or UPs prior to the search process, and to enable multiple POIs or UPs selection, as well as POIs combined UPs.

Table 2.2: Targeted objectives sustaining the solution proposed

We suggest to provide users a means to take geo-referenced photographs using their mobile phones. Instead of performing on-mobile image retrieval computations, we plan to forward user’s requests to a remote server. In response, we aim to list the closest results, along with descriptions and illustrations. With respect to the UP On-Field Insertion, our goal consists in enabling a proper list component, including the available UPs on the system. In addition, we plan to present a map-based interactive view with the purpose of enabling the placement process of an UP. The Nearby Search feature aims to search for a determined number of POIs and UPs within well-defined ranges. To set distances and results, we have in mind to provide list components containing values by default. For the Faraway Search, we suggest a text input component to allow well-defined location entries. We aim as well to resort to the Google Maps service in order to handle inputted locations by users. With the Map-Region Based Search query, we mean to enable a creative approach to perform queries by tracing geographical regions. Our proposal suggests a well-defined set of procedures to trace a region on a map: one would have to press the map to set the geographic location for the trace process; still pressing, trace an area over the map; once traced, release the map and confirm the search area defined; finally, order the application to retrieve results within the traced area. According to [Matos 07], symbol overlapping issues are a main concern in common location-based applications. With this in mind, we aim to provide a flexible visualization mode to interactively and dynamically load results over list and map views. In addition, we plan to design well-defined symbols in order to enhance the selection process. We also attempt to display delivered images and descriptions through a gallery view. In order to define POIs and UPs for the search, we propose a list component containing several references. We also intend to allow multiple selection for POIs and UPs, as well as for both in simultaneous.

2.5 SUMMARY

In the present chapter, we have performed a research concerning recent mobile solutions, in the context of MCV and LBS. The problem identified addressed to the lack of solutions to search, insert and visualize geo-referenced POIs and UPs. Upon discussing gathered results and identified common issues, we have proposed a solution to the problem determined. We suggest a mobile approach to complement traditional paper resources, displaying updated information and enabling different means to demand it: taking photographs to POIs or performing search queries to POIs and UPs. Additionally, we introduce a insertion query to enable UP on-field insertion in our system. Our mobile application will support additional features, like for instance executing nearby, faraway and map-region based search queries. We also introduce a flexible approach based on distinct modes of visualization, e.g., list and map. So far, we have carried out the research on current mobile solutions. In the following chapter we introduce and describe the research on the user profile study, enhancing the methods performed and discussing related findings.

3 USER PROFILE STUDY

The current chapter describes how we structured and performed the user-centered design to determine present day user's needs and habits connected to tourism. First of all, we mention and explain the procedures undertaken to carry out the study. We next describe in detail the contents of the user profile study. We begin by explaining the structure of the administered online survey, followed by considerations on contextual inquiries. Then, we analyse and discuss gathered results separately. In a final stage, we refer to users' recommendations and design ideas. We depict and interpret as well designed paper prototypes according to their suggestions.

3.1 THE STUDY

The user profile study stage was carried out during one month sensitively. It consisted of three distinct stages: administering an online survey addressing users' habits and demands in regard to the scope of the present work; performing a contextual inquiry in order to capture important details, clarifying some of the online answers; analysing gathered results from online surveys and contextual inquiries, highlighting participants' impressions and design ideas remarked through paper prototypes sessions.

3.1.1 PROCEDURE

The online survey was broadcasted to 200 respondents, though only 165 answered the survey entirely. The primary reasons that led us to employ this technique were due to the easiness to gather a significant number of responses and to the quickness to conduct and acquire highly generalized results. Appendix A contains the online survey employed and related results. Upon collecting and consolidating online findings, we carried out contextual inquiries, involving 8 potential users, with the purpose to capture information throughout a semi-structured interview covering the structure of the online survey. Interviewed users are given additional attention across the system and experimental design phase. We refer to interviewed users as to the MUG. The final stage consisted in collecting and analysing results. We also tested design ideas with the MUG prior to system design. Paper prototypes were used to perceive users' considerations on interface aspects, as well as the understanding of this work. In Appendix B we present some of the paper prototypes produced during sessions. Next sections describe in more detail the structure defined for both capture techniques employed: the online survey and the contextual inquiry.

3.1.2 Online Survey

In order to collect results on user’s needs and habits according to different contexts, we structured the survey as follows:

- First section intended to collect personal information about user’s gender, age group and educational background;
- Second section concerned user’s habits while touring on places with a reasonable amount of cultural buildings;
- Since the present work implies the use of mobile phones, a third section was included to better understand user’s habits, abilities and skills when performing some common tasks in mobile phones;
- Finally, centred on overcoming design and implementation issues, we included a set of open-ended questions to address the underlying primary issues of our proposal.

3.1.3 Contextual Inquiry

The contextual inquiry consisted in interviewing eight users personally, in order to better understand what are their tasks, values, opinions and expertise using mobile phones and digital resources, like for example digital maps. We decided to focus interviews on the fourth section of the survey, i.e., a the fictional mobile application scenery. Participants answered the same questions as they did for the online survey. Thus, along the contextual inquiries performed, we were able to carefully attend some crucial aspects that helped us to clarify some results derived from surveys. In the next section we analyse and discuss the results produced with the present study.

3.2 Results

Through this section we feature data collected and discuss results concerning the most influent questions answered along the previous stages of the current research. We start by referring to user’s habits and behaviours, followed by remarks and suggestions resulted from open-ended questions and contextual inquiries.

3.2.1 User Habits and Behaviours

Upon concluding the online survey stage and collecting related results, we analysed data and produced some charts according to the structure of the online survey. Figure 3.1 presents an overview on respondents that have done tourism.

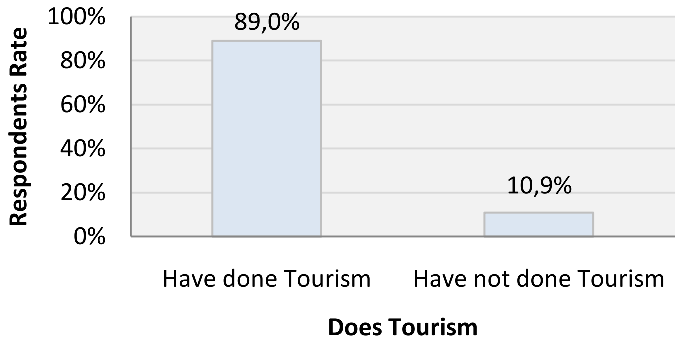


Figure 3.1: Respondents that have ever done Tourism

As we can see, the generality of respondents does tourism or has already done it. Additional results, in Appendix A, evidence that respondents travel between once to five times per year. Figure 3.2 depicts results regarding the preferred elements to photograph while touring.

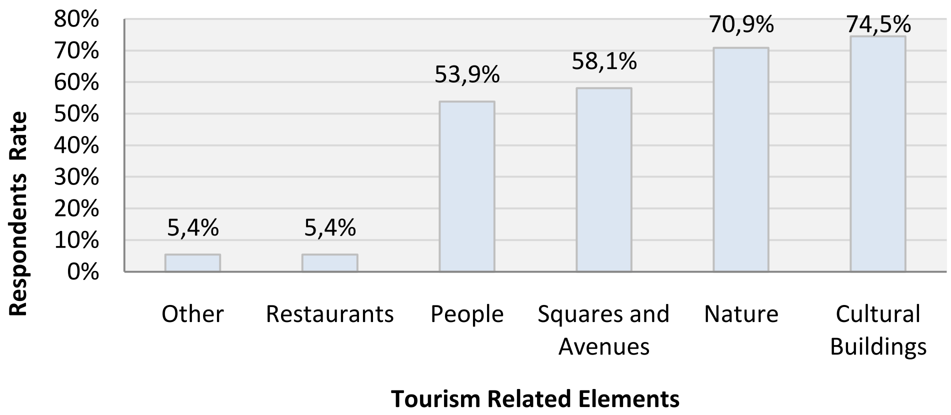


Figure 3.2: Respondents' most photographed elements while sightseeing

Figure 3.2 expresses that respondents are willing to photograph monuments and related cultural buildings. Also, nature elements, squares and avenues represent relevant findings for capture purposes.

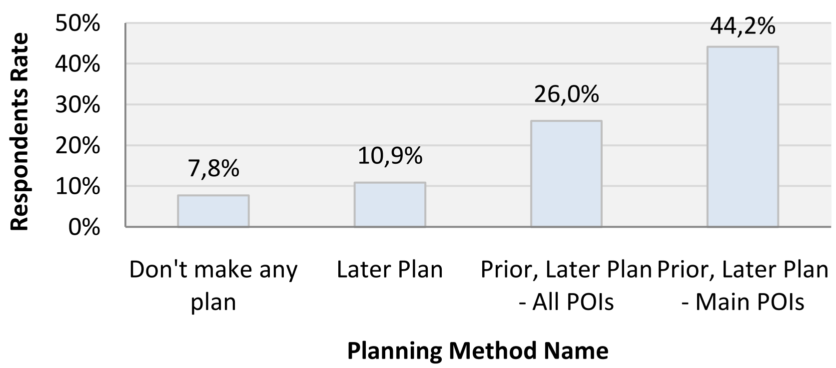


Figure 3.3: Travel Planning methods: Later Plan - *On the destination, search for the POIs to visit*; Prior, Later Plan – All POIs - *Before travelling, make a plan containing all POIs to*

visit; Prior, Later Plan – Main POIs - *Before travelling, make a plan containing main POIs to visit and search for remaining at destination*

Considering different methods to plan trips, Figure 3.3 presents and describes distinct plans commonly followed by respondents. These results concern on how do people plan their travels in regard to POIs to visit. It also shows that a significant parcel prefer to plan the main POIs before departing, leaving some to define at destination. This draws us to the conclusions that a source of information is essential to guide and inform users when looking for remaining POIs. We have also asked respondents about which tourism related resources they prefer.

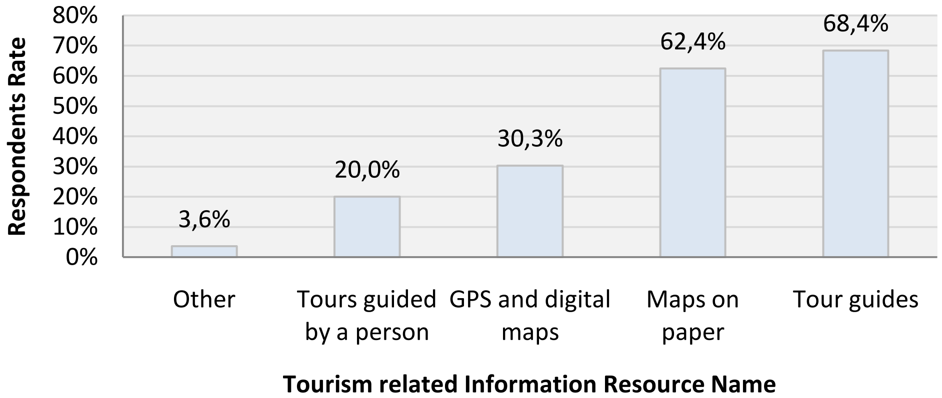


Figure 3.4: Respondents' preferred tourism resources to get information about POIs

Figure 3.4 reflects respondents' preferences on information resources of POIs. By analyzing the results, we may see that only a minor parcel chooses to be guided by someone. We may note as well that the use of paper-based resources, e.g. tour guides and maps, is generally preferred by respondents. An additional finding refers also that 30% of respondents are willing to use mobile device equipped with GPS functionality and digital maps. Apart from tourism related activities, we have also considered to inquire respondents about mobile device's habits and expertise. Collected results provided us a better perception on respondents' mobile experience.

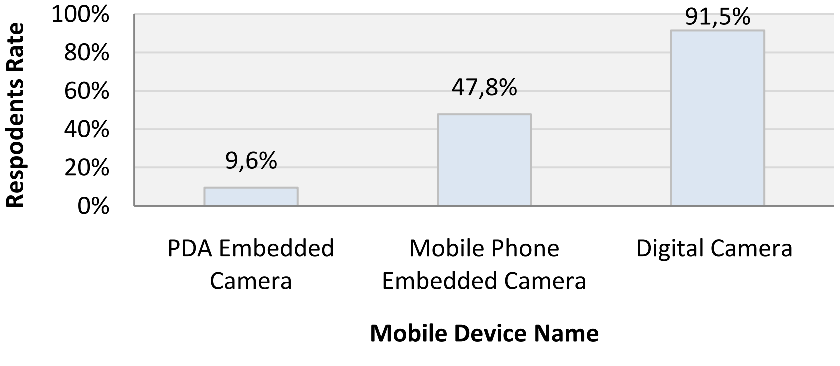


Figure 3.5: Respondents' preferred means to take photographs

The results concerning GPS and camera enabled mobile phones, confirmed that 22% of respondents states to have mobile phones equipped with GPS. As referred in first chapter, the GPS technology has been integrated in mobile phones. In contrast, digital cameras are widely integrated in present day mobile phones. Figure 3.5 depicts respondents' preferred camera resources to take photographs. As we can see, the generality of responses considers the digital camera as the primary device for capture effects. In spite of that, mobile devices reveal a significant result together, in particular the mobile phone embedded camera.

The fourth section of the survey deals with a fictional user experience, considering the use of a mobile application within a touristic context. Survey's respondents were asked to suppose an excursion to a location with a significant amount of POIs. Figure 3.6 depicts the answers about different approaches to acquire information when facing a museum.

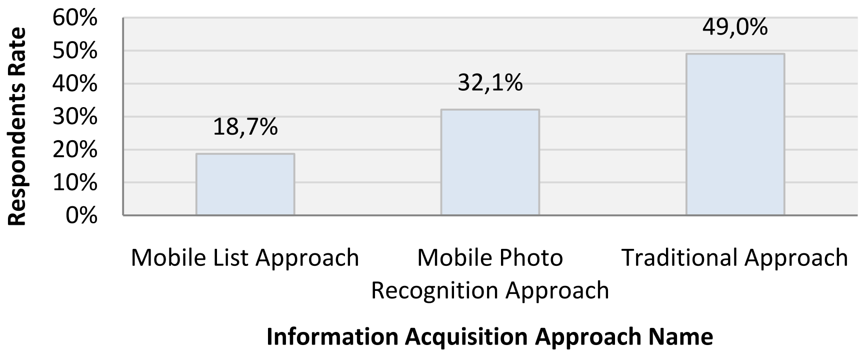


Figure 3.6: Information Acquisition methods: Mobile List Approach - *By means of a mobile phone, access a list of nearby POIs and find the concerned museum to access related information*; Mobile Photo Recognition Approach – *Photograph the museum with your mobile phone camera and view related information*; Traditional Approach – *Search around for a source of information, e.g., museum's leaflet, a person or a descriptive panel*

Figure 3.6 represents the findings to one of the critical issues derived from our proposal. More specifically, we aim to perceive the most appropriated method to deliver users the information of an observable museum. According to results, we may note that the traditional approach, i.e., disregarding the use of a mobile phone to seek for a source of information, like for instance a person, a leaflet or a tourist guide, remained ahead from mobile approaches.

We noticed that some answers given through the online survey revealed some disparities according to the answers concerning this simulation. We therefore believed that some respondents did not focused properly on the simulation, thus leading them to aim for the traditional approach. In order to find out the causes of this reaction, we discussed this issue across performed contextual inquiries. Upon performing the contextual inquiries, we realized that users were doubtful about the use of a mobile phone to acquire the description of a museum. In addition, some were unsure about the achievability of the photograph recognition process. We next refer to a remark done by an interviewee, mentioning:

"To find out the most proper and efficient way to call someone, it would be simple to chose on whether using a personal mobile phone or looking for a phone booth. On the other hand, in order to promptly get the information about an observable museum, choosing between using a mobile phone or seeking for a tourism office, at first glance, it would be logical considering the second option."

The statement above confirmed that some participants were not aware of the feasibility to exploit a mobile phone in order to take photographs and to recognize related contents. As a consequence of this detection, we performed further discussions, enhancing the capabilities of recent mobile phones, and carried out in-person simulations with some users of the MUG. According to the generality of reactions, we realized that the use of the photograph recognition approach could be advantageous due to:

- Avoidance of time-loss;
- Full-time information access, i.e. permanent information;
- The museum's name is needless;
- Few steps to request information, i.e., one single capture to the museum;
- In addition, the museum could be closed, people around could not recognize it and foreign languages could be a major barrier.

Next, Figure 3.7 shows respondents' answers about the proper order of museum related information along the mobile phone screen.

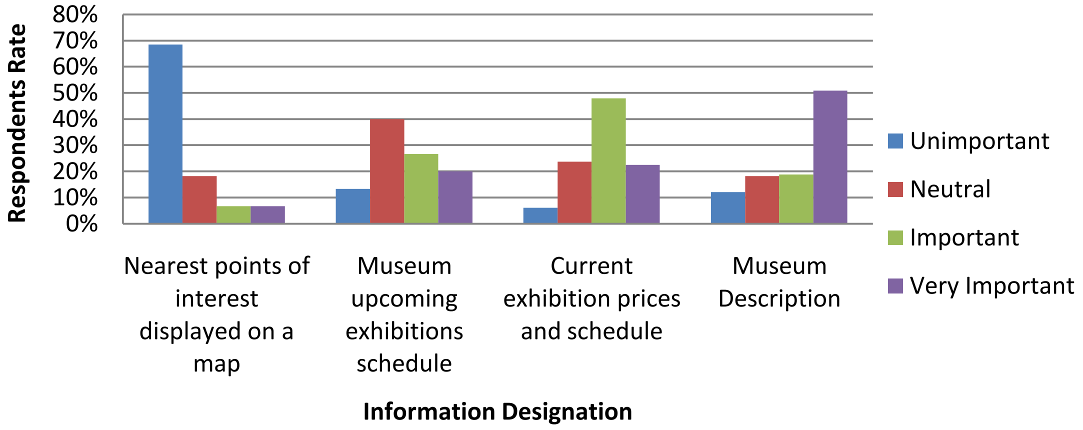


Figure 3.7: An overall view on respondents' considerations to museum related information arrangement on the mobile phone screen

In addition to referred information acquisition approaches, it is also important to address the visualization of delivered information along the screen. Figure 3.7 depicts the order of importance that respondents assigned to each option. As we can see, a description about what is being seen is definitely the primal choice, along with prices and schedules, and upcoming exhibitions. The least voted option refers to the visualization of the nearest POIs. According to the objectives determined for the present thesis, this fact caused particular apprehension. Additional discussions with the MUG revealed that participants were exclusively focused on ordering museum related information, hence disregarding unrelated information.

3.2.2 User Recommendations

In the previous section we described results on user's needs and habits. The present subject features participants' suggestions considering relevant types of information, features and design remarks. Table 3.1 introduces some suggestions on different types of information. It comprises the recommendations given on POIs and UPs, and related functionality. Upon gathering the results derived from the online survey and the contextual inquiry, we merged and mapped the results over this table, mentioning their description and occurrences accordingly.

Types of Information	Occurrence
POI current rating	5
Indication of transport stations, e.g., bus, metropolitan	4
Multiple route generation from current location to desired destination	4
Toilets and ATM services	3
Restaurants and esplanades	3
Emergency phone numbers	3
User's current location over the map supported by compass orientation	3
Indoor images about photographed elements, e.g., museums, hotels	2
Multiple map view, i.e., street and satellite mode	2
A list containing preferred locations for a given range in map	2
Currency exchange store	1
Flight schedules	1

Table 3.1: Participants' suggestions about relevant types of information

Results in Table 3.1 indicate that POI rating, transport stations and route generation are the main contributions. Participants suggested as well to provide well-defined POIs and UPs references, as well as different map views and indoor photographs of some POIs, like for example museums and churches. Table 3.2 suggests important features.

Additional features
Collect and display comments submitted by other users
Zoom the map and extract a desirable area as an image
Store received information, e.g., descriptions and images, in memory
Advanced search engine for POI
Note book to register events occurred while touring
Auto-Generation of a photo album
Filtering information according to user profile

Table 3.2: Additional features suggested by participants during the study

Table 3.2 presents suggestions concerning different features to enhance tourism related experiences. In addition to the objectives formulated, we may add or combine some of these additional features with ours. For future work, we also refer to user's recommendations that were not considered during the design of our solution.

3.2.3 Design Implications

In this section we address design considerations remarked along the user profile study. Additionally, we present screen paper prototypes according to users' ideas and advices.

The recognition of monuments, museums and related buildings constitutes one of the aims specified for our work. Therefore, it is crucial reviewing the capture process and issues on information display. Throughout the survey and contextual inquiries performed, users were asked about some design considerations, like for instance the line-up of screen items. In section 3.2.1, Figure 3.6 manifests balanced results for the mobile phone approaches described: accessing information through a list component; the same by taking a photograph to a POI. For this reason, we consider both proposals during the design of the system. We were also suggested to produce further prototypes, such as listing closest results in case of recognition failure, as Figure 3.9 shows.

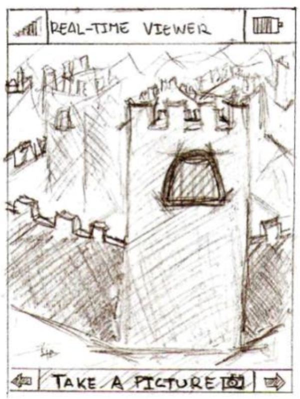


Figure 3.8: The capture process sketch

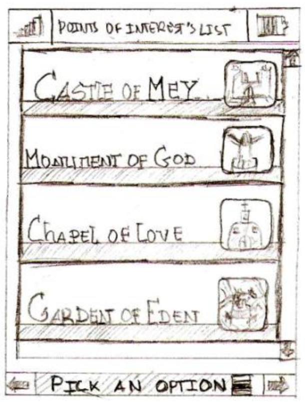


Figure 3.9: A list containing similar

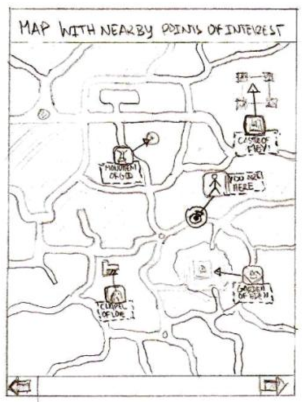


Figure 3.10: An illustration containing POI symbols

In contrast, Figure 3.8 illustrates a screen concerning the real-time capture view. In addition to the recognition process, we have determined constraints on the visualization of maps which indeed represents also an important piece of our work. Participants during the user profile study were asked on whether presenting a satellite detailed map or a common map would be appropriated. Those choosing for a satellite map declared that a detailed map would be favourable for space awareness. On the contrary, respondents leaning toward a casual street map stated that the fewer map based elements involved, the easier and more clear the symbols differentiation. Given that either satellite view as street view were relevant, we consider both approaches during system design stage. Upon reasoning about the aforementioned observations, we sketched a screen with a map containing landmarks. Figure 3.10 shows one of these representations.

For the visualization of information delivered to the user, i.e., POIs descriptions and additional contents, respondents were inquired in regard to the information arrangement along the screen. According to results from Figure 3.7 in section 3.2.1, POI descriptions preference is comparably higher than remainder information. We therefore gave particular consideration to the placement of descriptions. Two solutions were suggested during this present study. Figure 3.11 shows an overall view encompassing museum related information. Also, we highlight the description section at the top.

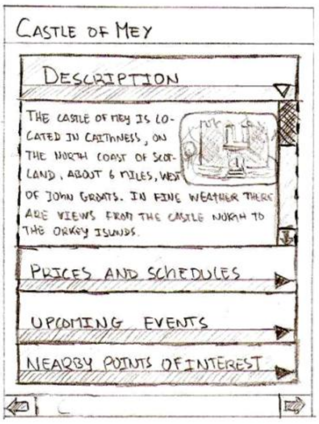


Figure 3.11: A proposal to display information separated by tabs

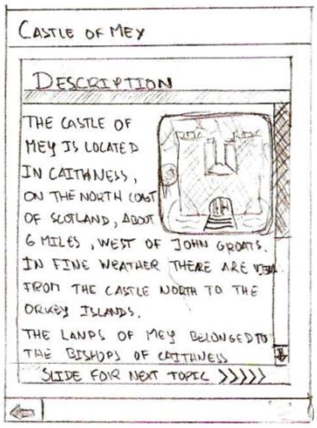


Figure 3.12: An approach suggesting single screen information display

On the other hand, Figure 3.12 presents a different approach. Participants did state that screen size constraints could influence reading information. Thence, we have split information tabs in Figure 3.11 into a sequence of screens as shown in Figure 3.12. According to MUG, it is reasonable displaying a description and a related illustration together due to screen limitations. Thus, we decided to follow this approach during the system design stage.

3.3 SUMMARY

In this chapter we thoroughly described the user profile study performed, as well as interpreted related findings. We started by explaining how we organized the study, mentioning three distinct phases: the online survey, the contextual inquiry and the analyse of results. First of all, we described the established procedures in regard to each phase, followed by a definition of their structure. Upon carrying out first two phases, we confirmed that the participants of this study were willing to photograph POIs in order to acquire for related information. We noticed as well that most of respondents revealed habits on using digital resources, as also taking photographs with their mobile phones. Additionally, we mentioned users' contributions on a range of well-defined information and related features. We also presented and described the paper prototypes designed according to the remarks done by participants, in particular by the MUG. Once identified the problem of current mobile applications and determined objectives and solutions, we have concluded the research study with a user profile study to find out user's needs and behaviours using mobile phone and performing tourism related activities. In the next chapter we introduce and overview on the solution proposed according to the findings of our research.

4 System Design

In the previous chapter we introduced a modular representation of the proposed solution and described the main components involved. For the present chapter, we analyse our solution, considering technical aspects and explaining the methods undertaken to address the objectives of this thesis. We begin by introducing an overall representation of our framework, along with a concise description on underlying modules. The next sections refer to the MKiosk module, the GeoFinder module and lastly to the PhotoFinder module. In addition, we also refer to some paper prototype considerations. We carefully describe MKiosk associated features jointly with detailed illustrations of interface screens and particular solutions. Upon explaining the MKiosk component, we focus on the GeoFinder module, referring to relevant aspects, like for instance the database framework and the query representation. Finally, we describe the PhotoFinder module referring to particular aspects, such as employed queries to perform image retrieval requests and defined database to link GeoFinder contents.

4.1 Overview

The solution we introduce is consistent with the objectives and requirements described in Chapter 2. In addition, findings derived from the user profile study allowed us to clearly understand user's demands and behaviours when using mobile phones to perform camera and location-based activities, particularly addressed to the tourism. Regarding our solution, we aim to handle location-based operations combined with CBIR processes in order to perform the recognition of a photograph. We therefore established well-defined modules on the framework sustaining our solution. Figure 4.1 depicts a modular overview. We named the geographical component as GeoFinder.

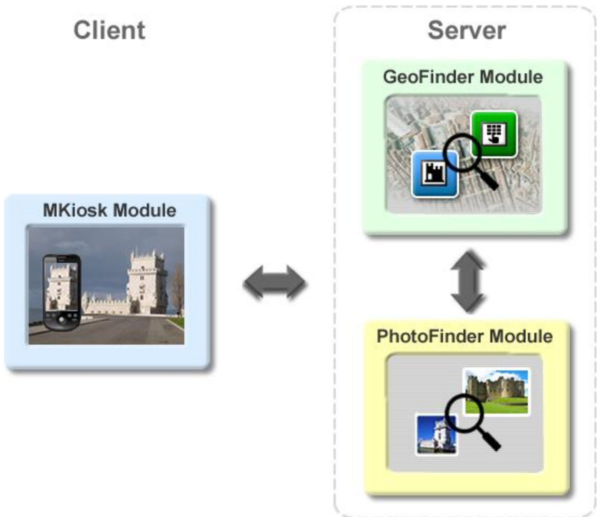


Figure 4.1: A modular overview of the proposed solution

In contrast, the CBIR system, designated PhotoFinder, derives from a recent contribution achieved by [Pimenta 08]. To properly assess GeoFinder and PhotoFinder capabilities together, as also to give users the ability to fully exploit them, we have designed an interface component, named MKiosk. As can be seen in Figure 4.1, the interconnected modules of our solution jointly follow a client-server architecture. MKiosk component constitutes the client side of the system. GeoFinder and PhotoFinder modules operate in the server side.
Considering geo-referenced CBIR requests, GeoFinder and PhotoFinder carry out computations together. In contrast, geo-referenced based requests are handled regardless of PhotoFinder. Through next sections we succinctly describe each module with particular focus on their primary aims.

4.2 Solution

Figure 4.2 presents an outline of our framework according to a well-defined modular scheme. Yet, the overall solution in this section introduces additional components. The Mediator component handles outputs produced by GeoFinder and PhotoFinder. Also, the Mediator listens to MKiosk events continuously, forwarding requests to the corresponding modules. The database server layer consists of two linked databases in the sense that data derived from both components is implicitly correlated. We established this relation by linking Geo and Image ID, as Figure 4.2 depicts.

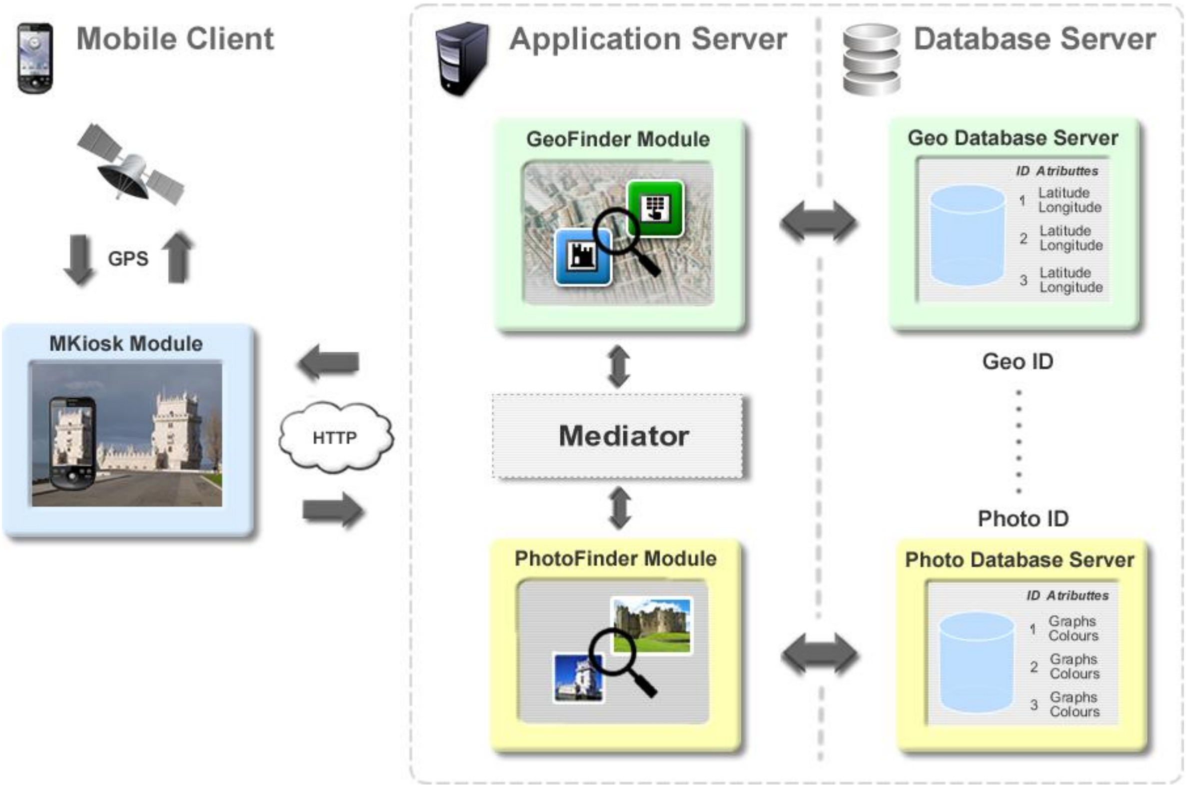


Figure 4.2: Overall representation of the solution proposed for our work

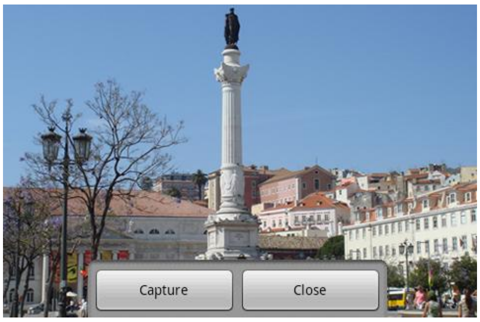
The data involving images and their geographic references was previously inserted in the PhotoFinder and GeoFinder databases, accordingly. Further experiments and tests were carried out considering this information. The following sections address the primary components developed and describe thoroughly their features and related processes.

4.3 MKiosk Module

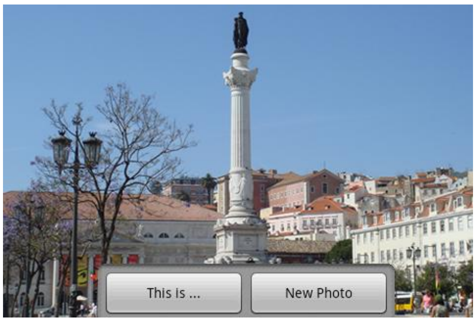
The MKiosk component constitutes the main piece of the present work. Development carried out through this module did demand an attentive research in order to revise existent issues and to determine well-suited solutions. Given that users represent one of our primary targets, we also performed additional experiences to find out their requirements and habits (see Chapter 3). Additionally, we conducted an informal user study with the MUG to enhance prototype features, and thus to effectively attend user's needs, usability aspects and objectives determined (see Chapter 6). The under mentioned sections fully explains the features we developed for MKiosk, along with interface illustrations.

4.3.1 Geo-Referenced Image Retrieval Platform

The current section concerns the image recognition process carried out from the client side to the Mediator component which relies on the server side. Regarding the MKiosk module, we present an appropriated real-time camera interface to allow users to capture photographs and to request for associated information. We also enable recapturing photographs, *New photo* option in Figure 4.3 (*b*), in case of photograph distortion and blurriness.



(*a*) Real-time capture screen



(*b*) Captured photography preview

Figure 4.3: Real-time camera based interface

Figure 4.3 depicts an interface sequence concerning the capture process in the client-side. Upon pressing the *This is...* option, as Figure 4.3 (*b*) suggests, MKiosk requests the remote server for descriptions on the captured photograph. Through the *http* request definition stage, MKiosk considers essential parameters for further computations based on geographical and image data. User's geographical coordinates and current location name are auto-generated in *http* header fields. In contrast, the contents of the captured photograph are properly formatted to the *http* body section. Figure 4.4 presents an abstract view on *http* request parameters and components involved.

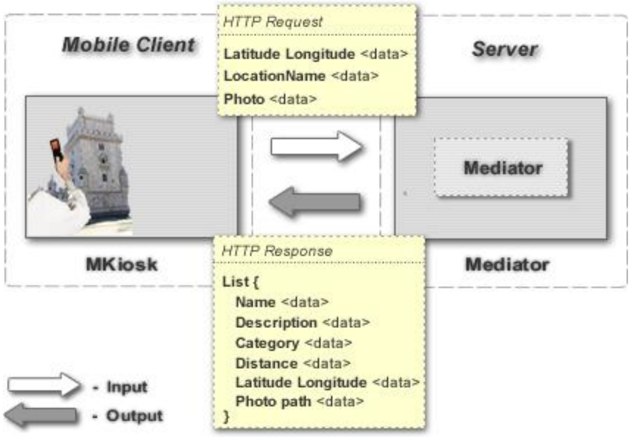


Figure 4.4: An abstract overview of *http* data exchange between client and server

In the server-side, the Mediator component manages requests carried out through GeoFinder and PhotoFinder. Upon their computations, the Mediator merges results from both modules and extracts the closest distances according to matching Geo IDs and Photo IDs, as Figure 4.5 illustrates.

Geo ID	Geo Distance	Photo ID	Photo Distance
3	0.012	14	0.019
7	0.021	1	0.024
1	0.023	8	0.026
15	0.037	7	0.031
11	0.039	22	0.033

ID	Geo Distance	Photo Distance
7	0.021	0.031
1	0.023	0.024

Figure 4.5: An example of merged results concerning similar ID references

Once merged, we use a weight-based equation (4.1) to determine a single similarity value based on both geographical and photograph distances. To ponder and balance the similarity distance resulted from *f*(*x*), we define independent weights. By setting weights W_1 and W_2 values ranging from 0 to 1, we are able to give distinct levels of importance to geographical and photograph distances.

$$f(x) = W_1 \times g(x) + W_2 \times h(x) \qquad (4.1)$$

Consequent to the generation of final similarity values, the Mediator delivers corresponding POIs to the mobile client, ordered by proximity.

4.3.2 Multiple Filter Selection

When requesting information through location-based features, we need to setup some preferences for POIs and/or UPs elements prior to the beginning of the search process. We therefore enable a filter component based on well-defined POIs and UPs. Figure 4.6 presents an illustration containing both filter components.

(a) Setting multiple POI based elements (b) Selecting UP Exchange store

Figure 4.6: POI and UP based filter components

In addition to the user profile study performed, we were advised by the MUG on usability issues during an informal study. Filter components presented in Figure 4.6 are result of an enhanced prototype. Now users are allowed to manage filters in a range of controls, and we also allow selecting and deselecting every element at once. Saving controls are available as well to confirm changes performed. We also support multiple selection, in contrast to recent location-based applications that only allow one single selection. Moreover, our solution allows advanced queries by combining both POIs and UPs elements.

4.3.3 Nearby Search Query

Upon describing filter components and related categories, we may now explain the overall execution of particular search queries, involving the MKiosk and GeoFinder components. The current section addresses search queries regarding closest results to user's position. In order to set search distances according to user's position, we introduce a distance list component containing well-defined distances, where users may select distances given by default to limit the Nearby Search query. Figure 4.7 presents in (*a*) the selection of a default value, while Figure 4.7 (*b*) presents the Search Preferences screen with the predefined value for the distance. Listed values are presented by pressing the distance component, as Figure 4.7 (*b*) shows. In addition, the Search Preferences screen presents a set of interactive objects which allow setting different visualization modes, as well to notify MKiosk on the location where the search is performed.

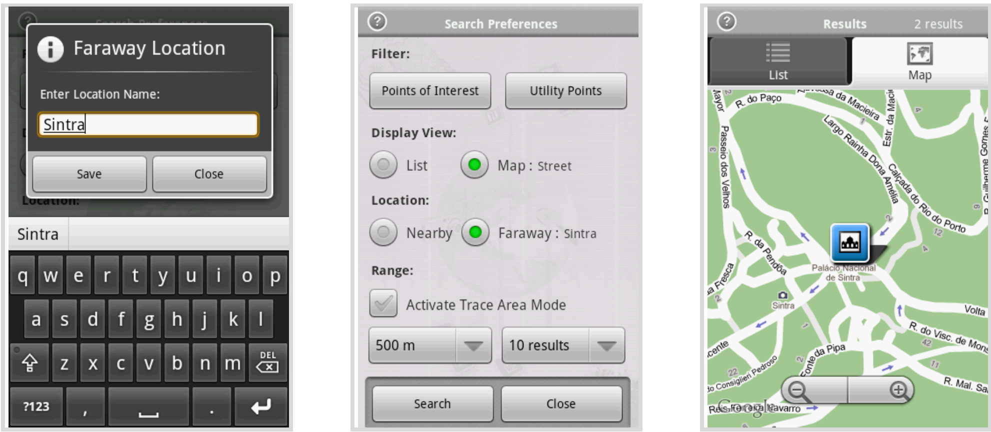
(*a*) Values by default (*b*) Accessing the distance list component

Figure 4.7: Settings for the nearby search query

For this particular case, we load the list mode and set a nearby location. Upon defining settings, MKiosk gives order to the Mediator to compute the nearest results according to given inputs. Location-based functions are then processed remotely through the GeoFinder. Once finished, the Mediator component forwards to MKiosk a set of nearby geo-referenced elements.

4.3.4 Faraway Search Query

In contrast with previous search query, the faraway search query, as its designation suggests, performs search queries regardless of user’s current position. Thus, MKiosk attempts to give users the ability to carry out distant search queries in order to prepare their journeys when touring. Nevertheless, when inputting the faraway location users are forced to know in advance for the name of the concerned location. Figure 4.8 in (*a*), depicts this situation for a particular location, named *Sintra*.



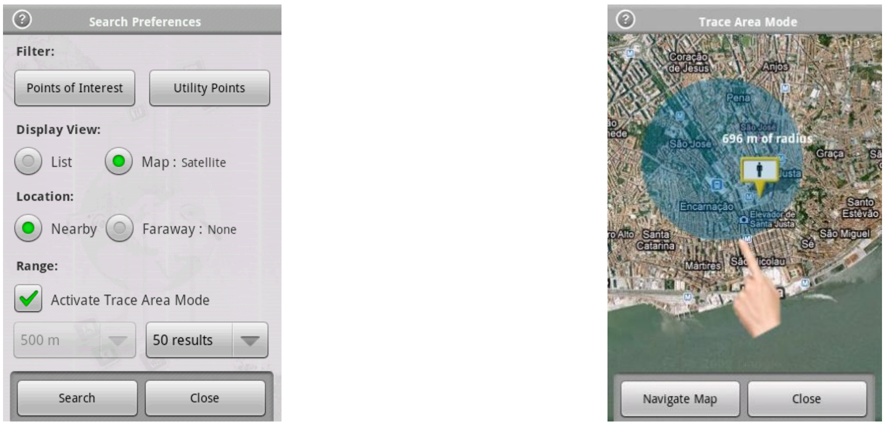
(*a*) Text input box and a well-defined location (*b*) Map street view and faraway location settings (*c*) Delivered result according to the preferences defined

Figure 4.8: Steps performed to execute the faraway search query

This can be approved by providing a list of well-known locations, allowing users to select their desired location. The MKiosk location definition is handled by geocoding which refers to the process of transforming an address into a geographical coordinate. This process is supported by the Google Maps back-end service, in charge of performing translations.

4.3.5 MAP-REGION BASED SEARCH QUERY

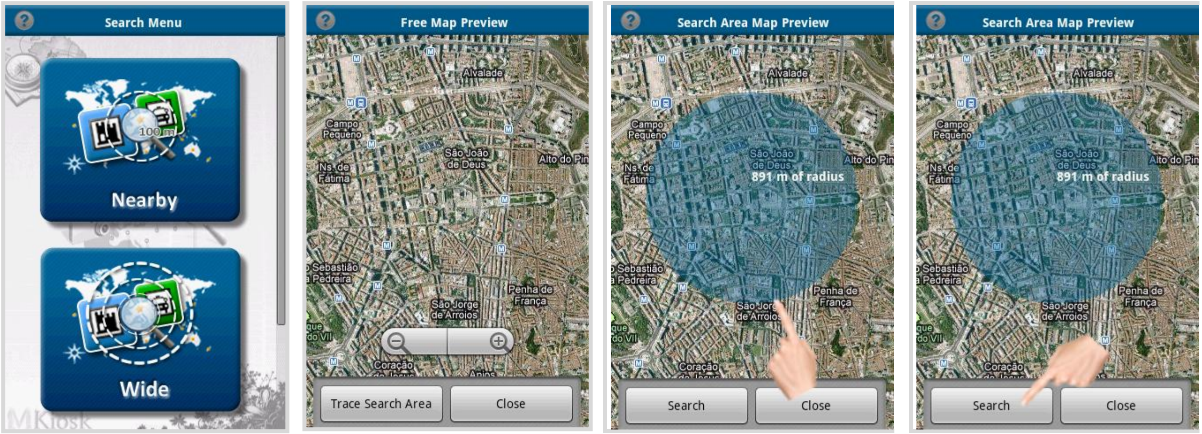
Additionally to distance-based search queries, our solution also enables search queries based on map regions. To achieve this process, MKiosk provides touch screen traceable queries to delimit particular regions. Thus, users may demand for specific areas by activating the *trace area* mode as shown in Figure 4.9 (*a*). When enabling the *trace area* mode and pressing the *search* control, users are presented with a map view to trace a search area Figure 4.9 (*b*) and to visualize results within bounds defined. In order to trace over a different map region, the *navigate map* option allows dragging and zooming the map to adjust the map view to the region desired. Iterations performed during tracing area process involves three well-defined steps: pressing over the map to fix the targeted geographical coordinate; dragging out over the map in order to expand the search area; releasing the map to immediately request the current search query to the server-side.



(*a*) Activated trace area mode (*b*) Tracing an area

Figure 4.9: Steps performed for map-region based search query

User studies carried out concerning usability improvements, revealed that the first prototype demanded to many steps to perform map-region based search queries, Figure 4.10. Indeed, the informal user study revealed that the MUG apprehended map-region based iterations and interactions in first uses. For this reason we have decreased the steps required to complete this particular search query, as earlier presented in Figure 4.9. To test and confirm our proposal, we asked the MUG also about different touch screen based approaches to trace search areas.



(*a*) *Wide* option to perform traceable search queries (*b*) First step to refine the location in the map (*c*) Second step to trace the search area (*d*) Third and last step to invoke request by pressing *search*

Figure 4.10: Steps for map-region based search query in the first prototype

According to users' statements, the drag method provides an accurate control to determine search area bounds compared to a *double-touch* method. Furthermore, in the drag approach, real-time radius information is displayed during the traceable process, giving a clear perception on area and distance aspects together.

4.3.6 Multiple Visualization Mode

The previous sections concerned search queries and related filters. In this section we address different modes for the visualization of delivered descriptions and symbols. In order to provide users with a flexible and detailed visualization of results returned, our solution enables different approaches based on list, map and gallery concepts.

(*a*) POI and UP elements listed (*b*) Symbols over map view (*c*) Gallery approach (d) A Wikipedia layout generation

Figure 4.11: Different views provided in our solution

Images (*a*) and (*b*) in Figure 4.11, depict a list and a map component regarding the same content. When switching to list view, users are displayed a set of elements according to closest distances from their current position. In addition to distances, this component provides categories and ratings assigned by users. Related illustrations are also displayed, hence aiming users to identify elements in the outdoors. As opposed to the list view, the visualization of elements through the map approach only presents only their corresponding symbols. However, users are able to identify in advance displayed POIs and UPs by category due to the icons used, rather than by selecting a symbol to access the related content. During the design stage, the MUG did remark that some symbols were not in accordance with common symbols found in tour guides. Thus, we attempted to design appropriated symbols according to well-defined POI and UP categories. The gallery mode Figure 4.11 (*c*) is activated once elements, presented in Figure 4.11 (*a*) and Figure 4.11 (*b*), are tapped. The gallery view introduces a description jointly with interactive images of POIs. Users may select images to access their preview in a larger scale. Moreover, when dragging images, descriptions are dynamically updated. In addition to the previous views, we allow another screen for the visualization of additional information, Figure 4.12. To access this screen, users have to press the *More Info* button as Figure 4.11 (*c*) depicts. To generate the layout of the Additional Information screen, we defined a set of well-defined tags. Thus, we are able to set tagged lines concerning information associated to BUS references, contacts or Wikipedia sites. MKiosk module interprets these lines and dynamically generates appropriated layouts. Parsing *Wikipedia<splitinfocontent>Site: <split>http://en.wikipedia.org/wiki/ Restauradores_Square*, generates a Wikipedia layout as Figure 4.11 (*d)* illustrates. We chose to use tagged information to make easier the insertion of additional information in future.

4.3.7 UP On-Field Insertion

The insertion of geo-referenced UPs into our system represent an additional feature of this work. To allow users to perform *in loco* geo-referenced insertions, we have developed a solution to enable the insertion of UPs directly from our mobile application. To do that users have to select an UP from the list of UPs and place it in a proper location. In contrast to filter list components, the insertion list accepts only one single selection as input, instead of multiple elements. Figure 4.12 (*a*) illustrates the contribution with an ATM service reference into MKiosk. Next to the selection, an interactive map view Figure 4.12 (*b*) is displayed according to our current position. To place the ATM symbol in the correct location, we tap over the specific zone according to the physical location of the UP.

(*a*) A list containing acceptable UPs in the system

(*b*) An interactive map approach to place UPs according to their physical location

(*c*) Message displayed when submitting an UP successfully

Figure 4.12: Steps performed for UP Insertion effects

4.4 GeoFinder Module

The present section features some concepts connected with the spatial component of our solution. Through this section we describe the GeoFinder module, giving prominence to the database framework and query representation defined.

4.4.1 Database Framework

The GeoFinder component was designed to handle location-based queries requested by MKiosk. In addition to the queries, GeoFinder holds POIs and UPs related information, with particular focus on the geographical data. Figure 4.13 depicts an overall representation of our database structure. We have designed an architecture which enforces the assignment of distinct databases to different locations. The main reasons for this decision were due to performance and consistency issues. Thus, when using MKiosk in Lisbon, GeoFinder considers the database associated to Lisbon. On the other hand, when using the application in Oporto, GeoFinder accesses the database addressed to Oporto city. This way the maintenance and update tasks will be easier to be performed. Figure 4.13 presents the general framework of our database. It is decomposed according to a POI section and a UP section. Each section encompasses different tables concerning general and additional information, and geographical and image references. The general information table comprises names, descriptions or categories for distinct POIs. In contrast, for UPs we only consider the category and submissions, since UP elements, such as Phone Booths or ATM services, do not require associated descriptions.

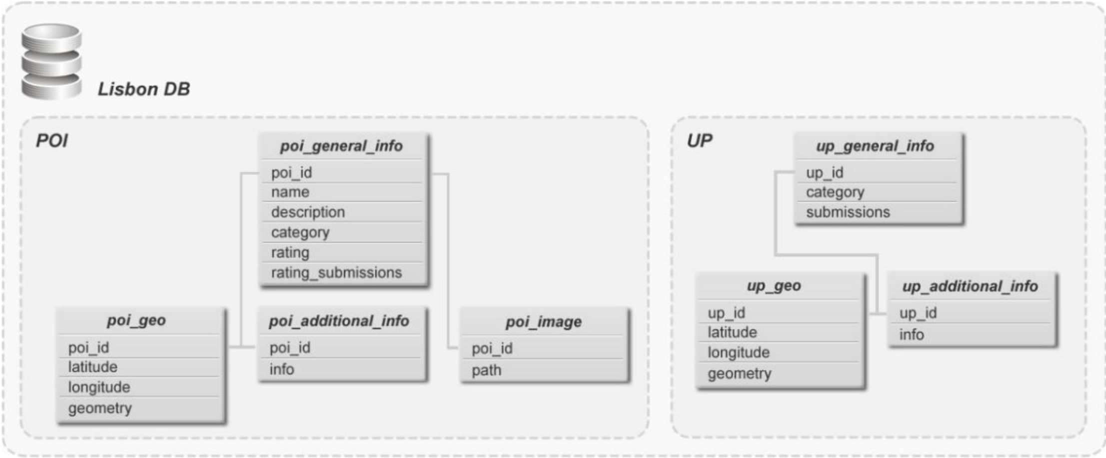


Figure 4.13: GeoFinder database overview

Geographical data is held by geo-based tables which include latitude and longitude values, as well as associated geometries. Tables containing additional information, cover well-defined tagged lines (see Section 4.3.3). Upon describing the database framework and related contents, we may refer to the query representation and underlying geographical references.

4.4.2 Query Representation

In this section we describe and point out aspects on queries defined for GeoFinder. As previously mentioned, we have designed two different queries: a search query and an insertion query. Figure 4.14 shows a piece of code concerning the search query for POIs.

```
#Search query

SELECT poi_id,name,description,category,rating,distance
FROM poi_general_info, poi_geo
WHERE setsrid(makepoint(longitude, latitude),srid) &&
expand(geometry,range) AND category='ATM'
ORDER BY ST_Distance(geometry, setsrid(makepoint(longitude, latitude),
srid)) as distance
LIMIT k_results
```

Figure 4.14: The search query for POI elements

The query in Figure 4.14 is in charge of searching and retrieving a set of POIs according to a given range. As a result, this query returns descriptions, categories, ratings and distances for POIs within a determined area. When searching for POIs the current query also accepts as input different categories, such as an ATM. In addition, we have defined a set of variables based on geographical coordinates and geometries. Table 4.1 presents in more detail the meaning for each variable and function assigned to the search query.

Name	Description
srid	A Spatial Reference Identifier. Our srid is 4326. Its scope refers to the standard WGS 84, used by the GPS satellite navigation system;
latitude	The value for the latitude;
longitude	The value for the longitude;
makepoint	Define a latitude-longitude point in order to setsrid function generate an associated geometry;
setsrid	Sets a SRID for any geometry. This function returns the new SRID-based geometry;
geometry	A candidate geometry from *poi_geo* table to be expanded range units;
range	The number of units in meters we want to limit our search;
expand	Takes the bounding box of a geometry and expands it out range units in all directions;
&& operator	Activates the first phase indexed search. This operator means *bounding boxes overlap*;
ST_Distance	Calculates the minimum Cartesian distance between two spatial objects;

Table 4.1: A description overview on search variables and related functions

With regard to the insertion process, we considered particular issues. In the case of having multiple ATM insertions for the same area, we check for an existent ATM service in the same location and decide its acceptance or not. This way we avoid multiple references for the same UP. In addition, the UP approval is based on a voting system approach that helps preventing the visualization of unsuitable UPs in the mobile client. Thence, the more ATM services assigned to a specific area, the more likely an ATM to be displayed. During experiments we set GeoFinder to accept a determined UP at first insertion by users. Thus, upon inserting an UP in MKiosk, users were able to immediately search for the UP they had just inserted. Nevertheless, we are considering to display a determined UP in the mobile client from the second or third insertion. Therefore, differently from the search query, the insertion process requires further analyses, like for instance verifying whether the UP to be inserted does already exist in the database. Figure 4.15 introduces code segments containing relevant instructions for the insertion process.

```
#Insertion query

CREATE OR REPLACE FUNCTION insert_up(text, double precision, double
precision, integer)
  RETURNS void AS
...
  BEGIN
    SELECT INTO result check_up
(up_category,up_latitude,up_longitude,up_srid);
      IF result = -1 THEN
        INSERT INTO up_general_info (category,submissions) VALUES
(up_category,1);
        INSERT INTO up_additional_info (info) VALUES ('na');
        INSERT INTO up_geo (latitude,longitude,geometry) VALUES
(up_latitude,
up_longitude,setsrid(makepoint(up_longitude,up_latitude),up_srid));
    ELSE
        PERFORM update_up_submissions (result);
```

```
    END IF;
  END;
...
ALTER FUNCTION insert_up(text, double precision, double precision,
integer) OWNER TO postgres;
```

Figure 4.15: The UP Insertion query

The insert query accepts as input an UP category and a geographic coordinate. Based on this values, the GeoFinder verifies if an UP already exists within a well-defined area. If so, we increment its reference through our voting approach. Otherwise, we insert a new reference into the GeoFinder database. We defined some additional functions to handle these actions, such as the *check_up* and the *update_up_submissions* functions. To better understand the meaning of the aforementioned functions and instructions to perform the insertion process, Table 4.2 introduces a brief description for each reference.

Name	Description
check_up	Verifies if the concerned UP exists in the system according to well-defined area around user's geographical position. If true, the number of submissions for this UP is updated by *update_up_submissions*. Otherwise, the UP is added to the system;
up_general_info	Inserts first UP element in the database with number of submissions equal to 1;
up_additional_info	In this version, we are not accepting text info, such as additional descriptions for a BUS station;
up_geo	Updates the geo-based table with UP geographical coordinates and geometries;
update_up_submissions	In case of been already added to the system, the number of submissions is incremented for the current UP.

Table 4.2: Descriptions of functions and tables underlying the insertion query

Upon introducing the database framework and the main queries supporting the spatial component, we conclude the analyses and descriptions for the GeoFinder module.

4.5 PhotoFinder Module

The PhotoFinder component is in charge of finding similar images, in particular by analysing well-defined parts of the image submitted. This system features an approach which uses colour blobs and their topological relationships to perform the overall image retrieval process. Images are segmented into blobs according to a number of iterations, i.e., with different levels of details to describe their content. Once segmented, each region is identified and its spatial relationships are extracted. In turn, resulting information is converted into descriptors and stored for later finding and retrieval. More information about PhotoFinder can be found in [Pimenta 08]. Concerning the aim of our work, we use PhotoFinder to support the recognition of photographs taken to POIs. Previously, we depicted and described the database components involved in the GeoFinder module. In

Figure 4.16 we illustrate data correlations, regarding to the database framework defined for each module.

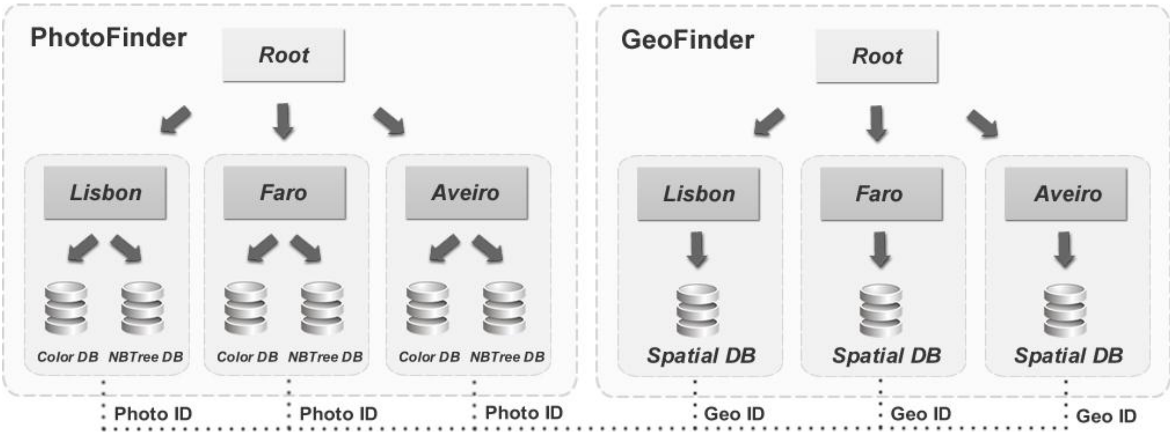


Figure 4.16: An overall illustration over the existent databases and correlations in our solution

Figure 4.16 depicts the database framework we designed to support our solution. According to the illustration, PhotoFinder and GeoFinder follow an identical structure concerning the localities. Their databases, however, are defined for different purposes: databases for PhotoFinder hold information on POIs image data; on the other hand, databases for GeoFinder hold spatial data for the same POIs. In order to associate both image and spatial data for a specific POI, we establish an ID relation for each POI in PhotoFinder and GeoFinder databases, as Figure 4.16 shows. The overall framework defined for our database involves therefore two databases with distinct aims: one adapted to hold image contents; other to support contents based on geographical data. Another reason that influenced this decision was due to the effortless integration of different and improved CBIR systems in the future.

In addition to the database structure, we organized as well the images photographed according to the same hierarchy. In Figure 4.17 we may see how we structured image folders for different locations. As we can see above, the arrangement of localities folders and associated images is consistent with the database framework illustrated previously for PhotoFinder and GeoFinder. Such modules hold information on image system paths, yet for different purposes: PhotoFinder for image recognition and GeoFinder to deliver mobile users images depicting POIs.

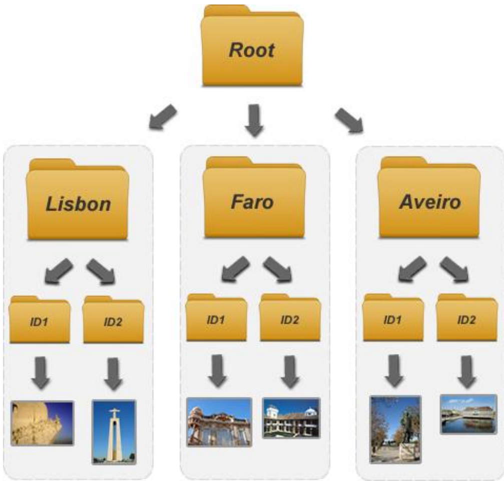
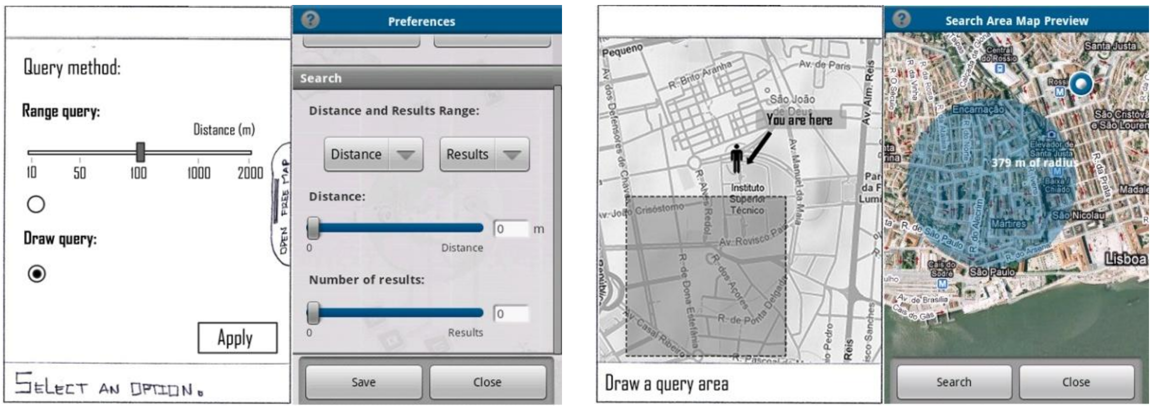


Figure 4.17: The folder framework concerning POI images for different locations

4.6 Paper Prototype Considerations

Prior to the system implementation phase, we performed sessions based on paper prototypes in order to find out design implications in small-sized touch screens. We were able to test our design ideas and especially user's design ideas. We produced alternative solutions to study user's needs in regard to the visualization of information displayed in the mobile phone screen. Through the paper prototype design stage, we have designed some screens according to the objectives established for our work. Once created, we evaluated them. To that end, we were supported by the intervention of the MUG which recommended us on some design ideas and considerations. Figure 4.18 shows two different illustrations designed along the user profile study and the system design accordingly. More images of the Low Fidelity prototype can be seen in Appendix B.



(*a*) Distance settings design (*b*) Search map region design

Figure 4.18: Our solution based on the paper prototypes designed along the user profile study.

In addition to the paper prototype sessions, we carried out also informal sessions with the

MUG during the implementation of our solution. Images depicted to the right, in Figure 4.18 (*a*) and (*b*), are screens from the first iteration of the prototype design. In Chapter 6 we describe in detail the informal evaluation performed to assess our first prototype, along with user's recommendations, as well as testing sessions using a real touch screen device.

4.7 SUMMARY

Throughout the present chapter we fully described the components involved in our solution, enhancing as well primary features. To introduce our approach, we first presented an illustration covering a detailed overview on the solution proposed. We next described in more detail the main components of our solution: the MKiosk, the GeoFinder and the PhotoFinder module. We began by explaining MKiosk features, steps and methods performed to address the objectives earlier established. In addition to descriptions, we presented several illustrations to support the solutions we decided to employ. Upon describing the MKiosk features, we focused on the GeoFinder module. The database framework was described and illustrated, as well as the primary queries of our solution, designated search and insertion queries. We also gave a table analyses on variable and function descriptions. The PhotoFinder module was then described, regarding its main concepts and procedures to perform the recognition process. In addition, we explained how we associated data from GeoFinder and PhotoFinder databases, along with a folder structure concerning photographs for different POIs. We ended up this chapter by referring to the paper prototypes designed through the user profile study. Moreover, we described some steps and assessment performed with users in order to materialize their design ideas in a prototype. In the next chapter we describe the system implementation according to independent stages. We also address the technology issues encountered through the design stage, in terms of module integration, mobile platforms and communication protocols.

5 SYSTEM IMPLEMENTATION

In the present chapter we refer to the system implementation process and underlying technology issues. We firstly explain the implementation of our solution according to a set of well-defined stages. In addition we introduce an illustration covering the phases of this process. After the system implementation process, we describe some inconveniences on technology aspects derived from the overall design. We begin by addressing the reasons that led us to chose for a determined mobile development platform and a spatial database. Regarding the components of our solution, we mention the integration issues in concern to the GeoFinder and PhotoFinder modules. Finally, we point out constraints related to data exchange involving the mobile client and the server-side.

5.1 IMPLEMENTATION

The stages of implementation, concerning the system previously described, are introduced in this section. We begin by presenting an overview on the implementation process. The next section presents a further description for each stage performed along the design of our solution.

5.1.1 OVERVIEW

We start by explaining the first experiments concerning the client-server data exchange. Next phases are connected to server-side development and testing. We describe GeoFinder and PhotoFinder module integration in addition to the Mediator component.

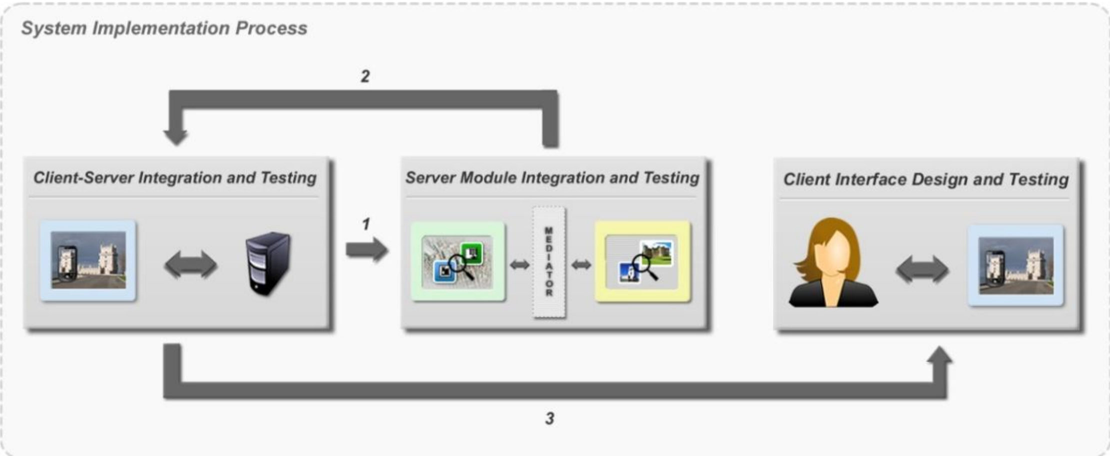


Figure 5.1 An overview on system implementation steps.

Upon testing the integration on both modules, we proceed to the client-side where further client-server development and testing is done. Through the client development stage, we give particular focus on the interface design in order to properly bridge server-side outputs with the end-user mobile phone. We also point out the support given by MUG during the design of our solution. Finally, we mention informal testing sessions performed to enhance the prototype on usability and interface features. Figure 5.1 introduces a modular diagram embracing stages and steps performed during system implementation. As Figure 5.1 presents, the implementation of our system crossed four stages. We initiated the implementation process in the *Client-Server Integration and Testing* stage, followed by the *Server Module Integration and Testing*. Again, we performed client-server integration and testing, regarding previous developments on the server-side. The final steps of the implementation occurred in the *Client Interface Design and Testing* stage.

5.1.2 Implementation Stages

The first stage concerns the *Client-Server Integration and Testing* module. Upon determining an adequate mobile platform to support established objectives, we learned and experimented related functionality resorting to a proper Application Programming Interface (API). To ensure the effectiveness on client-server data exchange, our primary tests involved image and a text data transfer involving a mobile client and a virtual machine, functioning as a server. Once established this goal, we carried on with server-side development.

The *Server Module Integration and Testing* represents the second stage. The first step consisted in setting the Mediator to request the PhotoFinder module for similar results according to a test image given as input. Next to PhotoFinder definition, we focused on the GeoFinder component. Upon choosing an appropriated spatial database to hold geographical data and to perform geographical-based operations, we exploited the spatial API to develop queries regarding our primary objectives. Through the Mediator component, we performed tests to the GeoFinder module by invoking particular functions like for instance searching and inserting geo-referenced data. We also did further development for Mediator in order to merge GeoFinder and PhotoFinder outputs simultaneously, as well as handling data coming from the client side. Next to performing and confirming tests on both server modules, we configured the mobile client to properly acquire GeoFinder and PhotoFinder generated outputs.

The third stage of the system implementation process occurred again in the *Client-Server Integration and Testing* module. During this phase, we improved the mobile application in terms of *http* request definitions. To demand and receive geographical and image data as well as related descriptions, we defined proper *http* header fields and developed adequate methods to handle incoming *http* requests from the Mediator. Additionally, we were able to use the mobile phone embedded camera to simulate the capture process and to auto-generate geographical information.

The *Client Interface Design and Testing* module constitutes the final stage of the implementation process. Upon defining and testing the basis of this work, we centred on the mobile interface design. Throughout this stage, we designed the interfaces required to enable user's interaction with the system. Proper controls were defined. Additionally, we included list and map based views in order to support the visualization of geo-referenced information. The MUG did have an important intervention during the prototype design. Informal testing sessions with the MUG produced relevant findings addressing usability and interface issues. We improved the prototype in terms of screen iterations, controls and labels associated. Finally, we tested the enhanced prototype version in outdoor testing sessions according to well-defined procedures.

5.2 Technology Considerations

Next to the description of the system implementation, we point out some technology issues encountered during the design stage. The current section addresses mobile related technology, in particular development platforms. Additionally, it refers to *http* protocol constraints and to the lack of compatibility, revealed by our virtual machine, with recent spatial databases. In concern to the module integration of our solution, we experienced difficulties to integrate GeoFinder and PhotoFinder.

5.2.1 Mobile Development Platform

During the research phase, we have explored for suitable mobile development platforms that supported the achievement of the main objectives defined. Android, iPhone[3] and Java Micro Edition[4] (J2ME), were well-known mobile platforms. To the development of MKiosk prototype we picked the Android Software Development Kit (SDK). The primary reason for this decision was connected to Android been made available as open source, thus giving us the rights to create applications using Android code. Also, Google provided a range of versions supporting different operating systems (OS), such as Windows, Linux and Mac OS X. By comparison, developing applications for the iPhone requires a Mac. Moreover, the iPhone SDK was not licensed under the Apache License[5], version 2.0. Prior to picking Android, we resorted to the J2ME SDK due to software-based malfunction in Android 1.1 SDK. Additionally, we have developed and tested a primitive prototype with J2ME. Nevertheless, J2ME did not enabled touch-based functionality to support some of our

[3] iPhone SDK: http://developer.apple.com/iphone/
[4] Java ME: http://java.sun.com/javame/index.jsp
[5] Apache License v2.0: http://www.apache.org/licenses/

objectives, differently from Android. Fortunately for us, Google launched the Android 1.5 SDK, providing a fuller documentation, enhanced features and resolved software-based issues. During the prototype development stage, we find out that Android did not include Exchangeable image file format [6](EXIF) libraries. Thus, we were not able to employ the EXIF standard for Android generated JPEG files in order to add geographical metadata contents. Moreover, once acquired the HTC Magic, an Android enabled mobile phone, and performed experiments with MKiosk, we faced memory issues. In fact, HTC Magic evidences a lack of functionality due to onboard memory limitations.

5.2.2 Spatial Database Platform

In order to carry out location based features in MKiosk, we had to resort to a proper spatial component. We did further investigation on existent spatial databases. During research, we considered SQL Server 2008 Spatial[7], PostGIS[8] and MySQL GIS[9]. Upon an overall analysis, we choose PostGIS. Given the fact that our solution does not demand advanced location based concepts, we leaned toward an accessible and easy-to-use spatial database. PostGIS considered both facts. In contrast, SQL Server 2008 Spatial and MySQL GIS were not in accordance. Further, PostGIS consisted in an open source software licensed under the GNU GPL. In the scope of this work, PostGIS included the primary features to support our solution. A compatible version with our Linux-based virtual machine was also available.

5.2.3 GeoFinder and PhotoFinder Integration Issues

Regarding the server components of our work, we experienced problems during GeoFinder and PhotoFinder integration phase. The MKiosk image recognition process involved both modules. Considering the overall server-side recognition process described in Chapter 4, GeoFinder firstly retrieves a set of POIs according to user's geographical position. PhotoFinder, instead of considering these POIs for image retrieval purposes, it holds every POIs, within a determined location, during the image retrieval process. Only upon performing this process, we are able to access image references, rather than acquiring it prior to the retrieval process. The main reason for this limitation derives from PhotoFinder underlying modules. We therefore developed GeoFinder regardless of PhotoFinder framework, thus enabling the integration of other CBIR systems. Additionally, PhotoFinder was developed under a virtual machine running Linux. In order to easily integrate GeoFinder avoiding integration incompatibilities, we decided to join both modules in the same virtual machine. We also took advantage of a web-based component adapted for

[6] EXIF standard: http://www.exif.org/
[7] SQL Server 2008 Spatial: http://www.microsoft.com/sqlserver/2008/en/us/spatial-data.aspx
[8] PostGIS: the spatial extension for PostgreSQL: http://postgis.refractions.net/
[9] MySQL GIS: http://dev.mysql.com/doc/refman/5.0/en/spatial-extensions.html

PhotoFinder to perform requests between the web-server and the mobile client, running over Windows Vista.

5.2.4 Communication Protocol Issues

In concern to data transfer processes, we have encountered some constraints, in particular related to the *http* protocol. The client-server data exchange process raised some difficulties at the MKiosk client acquisition phase. Differently from text data acquisition, the process of image data acquisition forces MKiosk to perform a request per image, instead of requesting all at once.

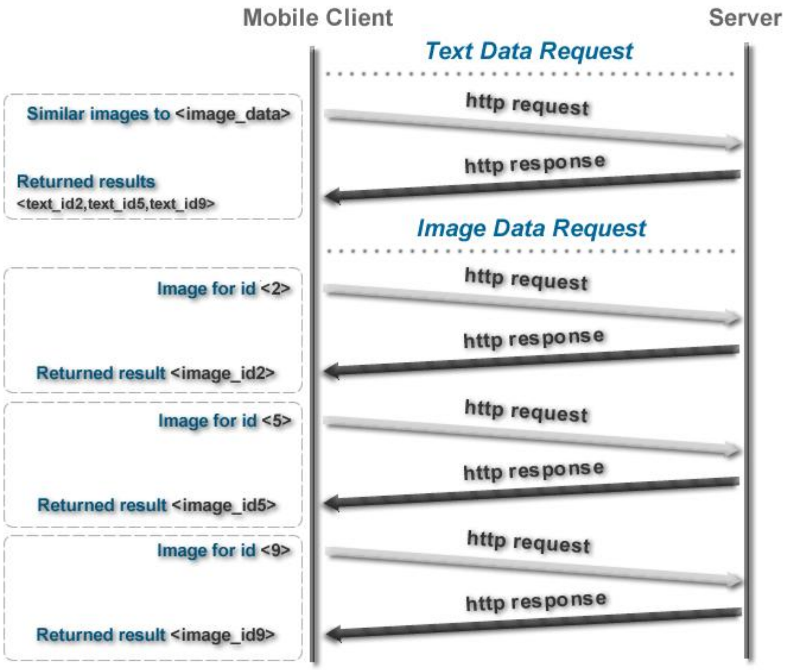


Figure 5.2: An *http* request-response protocol scener

In more detail, MKiosk demands the Mediator for some POI related information. In response, MKiosk receives descriptions. To receive related images, MKiosk does need to made requests as the number of upcoming images. Figure 5.2 illustrates this process. Indeed, the *http* protocol refers to a request-response standard of a client and a server. Thus, we were not able to perform a single request involving a set of well-structured image data in an *http* request. To resolve this issue we performed a request for each image lying on the server side, as Figure 5.2 suggests.

5.3 Summary

In this chapter, we have fully described the implementation of our solution, referring to well-defined stages of implementation. We first explained how we conducted the development of MKiosk, GeoFinder and PhotoFinder modules, across different phases, and followed with an illustration on the overall implementation process. Next to the system implementation process, we addressed technology related constraints detected through the development of our solution. Firstly, we mentioned and explained the chosen mobile development platform. Then, we pointed out existent spatial databases, explaining as well the primary reasons that led us to pick PostGIS. Regarding the components of our solution, we encountered some inconveniences on GeoFinder and PhotoFinder module integration. Additionally, communication protocol issues were evidenced, in particular the *http* protocol. Throughout system related chapters, we have introduced and described the solution developed in accordance with the objectives formulated for this thesis. We gave an overview on the framework proposed, along with a detailed description on technical features. In addition to the solution designed, we analysed its implementation from first client-server experiments to user's considerations on usability and interface aspects. In the next chapter we describe the informal and formal experiments undertaken with our prototype and derived results.

6 EXPERIMENTAL EVALUATION

The present chapter addresses the studies performed through the MKiosk assessment. Firstly, we introduce the aims of the study and describe the tasks and experimental variables determined. We next describe in detail the experiments carried out in order to improve and assess our application. We first explain the informal user study performed with the MUG to test and enhance the prototype in terms of usability and interface aspects. Upon this phase, we refer to the formal user study involving a group of users unaware of the tasks and MKiosk. We end up this chapter with an overall analysis and discussion on the results gathered through the study.

6.1 THE STUDY

The present study aims to evaluate our proposal for MKiosk and answer to the objectives formulated in the first chapter. During experiments we have attempted to find out users' behaviours while interacting with MKiosk in a real life scenario to ensure realistic results. The study was carried out with an HTC Magic, an android-powered mobile phone.

6.1.1 PROCEDURE

Prior to experiments, we have gathered, during two days, POIs and UPs references, such as geographical coordinates, descriptions, addresses and photographs, directly from the field. Once collected, we set up our spatial database in order to proceed with experiments. To assess our approach, we have developed a prototype and determined a set of experimental variables and tasks. Our study was based on two stages. First of all, we have performed an informal user study with the aim to enhance MKiosk and hence, to properly exploit the prototype during the formal evaluation. In the second phase, we have conducted the full user study which included a comparative experiment and a study entirely focused on MKiosk. Upon completing tests, subjects were administered a post-study questionnaire and asked some questions. Finally, we have analysed and discussed objective and subjective findings.

6.1.2 COMPARATIVE APPLICATION

In the sense of proving the validity of our solution, we conducted a comparative evaluation with a similar application. Regarding works described over the related work chapter, we have investigated for applications that were in accordance with MKiosk features to conduct a similar evaluation based on a single set of tasks. However, none of the applications did entirely meet MKiosk requirements. For this reason, we were not capable to perform a fully comparative study. Confirming that, table 6.1 presents an overview on the features designed for each application, including MKiosk.

	Content-Based Information Retrieval			**Location-Based Features**					**Information Display**			**Mobile OS**
	Photo	Compass	GPS	Nearby Search	Farway Search	Map Search	Add Geo-Content	Multiple Filter Selection	Map	List	Real-Time Camera	Android
Mobile Computer Vision												
Agamemnon	•			•					•	•		
Phone Guide	•									•		
On The Go	•										•	
WikEar	•					•			•			
Memoria	•		•	•		•	•		•			
Location-Based Services												
Geo Pix			•				•		•			
Wikitude		•	•	•			•	•	•	•	•	•
REXplorer			•	•								
Point-to-Geoblog			•				•		•			
Layar		•	•	•					•	•	•	•
MKiosk	•		•	•	•	•	•		•	•		•

Table 6.1: A feature overview about related work application and MKiosk

Nevertheless, a partial comparative evaluation, considering the core of MKiosk, seemed practicable. In this sense, we picked the most similar applications according to corresponding MKiosk features. As pointed out in table 6.1, the Mobile OS was a significant constraint due to the lack of porting to the Android OS. Fortunately, Wikitude and Layar, android based mobile applications, were applications that regarded the generality of MKiosk technical features, in particular the location-based features. Among these two applications, we discarded Layar. The reasons that aimed us to this decision were due to the greater number of location based features introduced by Wikitude, thus enabling a more comprehensive comparative study. Hence, we have chosen Wikitude as the comparative application to evaluate the primary features of MKiosk, though Wikitude did not support searching localities, tracing search areas and inserting geo-referenced information *in loco*.

6.1.3 Tasks

Our experiment was designed considering distinct studies. We have assigned each study different tasks due to Wikitude constraints previously mentioned. In this sense, the comparative user study was based on two tasks. In contrast, the MKiosk user study addressed three tasks. Table 6.2 below summarizes both comparative and MKiosk experimental tasks.

Comparative User Study			
Task	**Task Type**	**Task Name**	**Description**
T1	*Exploratory*	*Description of an observable POI*	Present a description about an observable POI
T2	*Known-item*	*Nearby Search Query*	Obtain an address for a restaurant within 1000 meters of distance
MKiosk User Study			
Task	**Task Type**	**Task Name**	**Description**
T3	*Exploratory*	*UP Insertion Query*	Verify the existence of an UP. If not present, add to MKiosk
T4	*Known-item*	*Advanced Nearby Search Query*	Search the nearest 10 churches and museums. Preview a picture of a given result.
T5	*Known-item*	*Faraway Search Query*	Search, in Sintra, for palace’s tour prices

Table 6.2: Tasks designed for both studies

Table 6.2 distinguishes tasks by type, i.e., known-item and exploratory. A known-item task means a well-defined task with clear directions. On the contrary, exploratory tasks are ill-defined tasks that demand additional user’s mental acts and interactions to explore the application successfully. To estimate step-by-step completion times while performing search query based tasks, we have disjoined the search tasks into two parts. Thus, we designated a sub-task as *Prior-to-Search Task* (ST1) and a second sub-task as *Upon-to-Search Task* (ST2), Table 6.3.

Sub-Tasks for Search Query based Tasks		
Sub-Task	**Sub-Task Name**	**Description**
ST1	*Prior-to-Search*	Prior to perform a search query, set search preferences;
ST2	*Upon-to-Search*	Upon performing a search query, select a delivered result over map, list or camera view, and visualize related contents.

Table 6.3: Sub-Tasks for search-based tasks

The first sub-task consists in loading settings, like for example defining distance and the number of results, prior to the search process. On the contrary, the second sub-task consists in, upon the search process, selecting a symbol as result and visualizing its contents. Although task T1 nature does not directly refers to a search task, it may be performed by executing the search feature of our solution. Thus, ST1 and ST2 sub-task results represent search tasks, T2, T4 and T5, as well as the observable task T1.

6.1.4 Experimental Variables

In order to measure participants' behaviour while performing tasks, we determined a set of experimental variables. These variables are included in two different categories, independent and dependent variables. Table 6.4 shows their meaning in more detail.

Experimental Variables		
Variable	**Variable Type**	**Description**
V1	*Independent*	Mobile Application
V2	*Dependent*	Task Completion Time
V3	*Dependent*	Number of taps performed

Table 6.4: The Experimental Variables defined for the present study

As may be seen in Table 6.4, variables are arranged according to variable type. The *Mobile Application* variable (V1) differs between two different levels, Wikitude and MKiosk. Regarding dependent variables, we first have *Task Completion Time* variable (V2) which consists in the time elapsed to perform the overall task. In contrast, the *Number of taps performed* variable (V3) counts the occurrences of tap events and steps performed while performing tasks.

6.2 Informal User Study

Before performing the full user study, we have conducted an informal testing session with users and, especially with the MUG, to test the usability of MKiosk and the experiment fairness under indoor and outdoor environmental conditions.

6.2.1 Procedure

A preliminary user study was carried out in an indoor environment. Users tested our solution and explored available features while accomplishing tasks. Upon their completion, we performed an informal interview covering tasks and usability constraints. Each interview lasted between 10 and 20 minutes. During the redesign of our solution, we have strictly followed our user group recommendations in order to improve the prototype. Once changes were applied, we recruited a MKiosk well-informed and conditioned user to perform a pilot-test with the enhanced prototype in a real-life scenario, following well-defined procedures. The results gathered along this trial provided us a basis for comparison purposes to the full user study.

6.2.2 Usability Issues

When performing interviews, during the informal user study, we were advertised about several issues. According to users' opinions, the search process should be almost immediate. The need to pass through various menus led to a significant task completion time. Users seemed also confused while selecting options due to buttons similarities between menus. Figure 6.1 depicts in (*a*) a menu sequence concerning location-based tasks in first prototype.

(*a*) Menus in first prototype

(b) All-in-one menu

Figure 6.1: Menu differences in different versions of the prototype

According to users' suggestions, we discarded the last two menus in Figure 6.1 (*a*) and hence minimized the effort to perform the overall search process as Figure 6.1 (*b*) illustrates. Search preferences setup was likewise complex and slightly stressful. Most of users did not get along with the sliding bar components to set distance and result ranges. Further, the lack options to enable different views, such as list or map display, including satellite and street mode, was significant as well. In regard to address search, users stated that rather than locating *Sintra* by dragging the map, demanding the application to immediately present for a specific map region would be more convenient. Another constraint was related to the *trace area mode*. Users stated that this option should be always accessible through search preferences, rather than behaving only for faraway searches. We were advised as well to reduce the number of steps to trace a search area, otherwise users would only access distance list in order to set distances. We were also remarked that rather than manually access to Search Preferences to redefine parameters prior to the search process, users should be automatically displayed the Search Preferences when begging the search process. Thus, we have considered users' advices and changed the application to allow for a more flexible range of inputs through Search Preferences screen.

(*a*) Previous Version (*b*) Enhanced Version (*c*) Original filter (*d*) Improved Filter

Figure 6.2: Search Settings differences

Figure 6.2 presents two different search preferences approaches. In Figure 6.2 (*a*) users did not have the ability to set their preferred views and to search distant locations as opposed to Figure 6.2 (*b*). Also, sliding components were replaced by a list containing distances by default, and the vertical scrolling bar was removed since information remained hidden in the bottom of the screen. Due to the presence of multiple interactive objects, users were also unable to effectively perform touch screen scroll operations. Regarding the *trace area mode* in approach Figure 6.2 (*b*), distance list option remained inactive as this mode is selected. Further adjustments were also done in respect to filter components. Figure 6.3 shows also two different filter version. In Figure 6.2 (*c*), users complained about the lack of options to manage simultaneously existing items. Furthermore, elements were alphabetically disarranged, thus causing an additional mental effort to select certain points. We therefore gave users the ability to select or deselect list elements at once as illustrated in Figure 6.2 (*d*). In the next section, we describe participants' profile and procedures carried out to conduct the full user study.

6.3 User Study

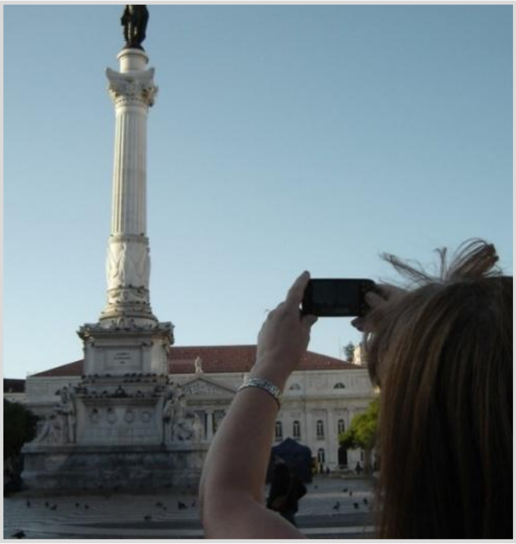
After performing the informal user study to enhance the MKiosk prototype and to gather experimental results for further comparisons, we have proceeded with our experiments. In contrast with the preliminary informal study, the user study was carried out in an outdoor environment to enable real-life testing conditions and hence assure realistic tasks. We have recruited a new group of subjects, unpractised with the use of the Wikitude and MKiosk interface and tasks.

6.3.1 Subjects

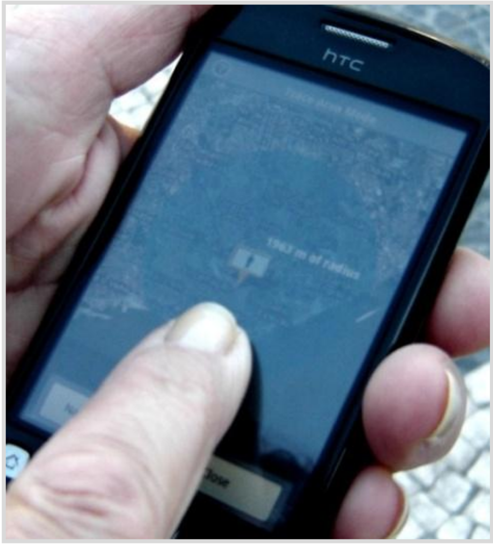
Eight subjects participated in our study, five male and three female. Ages ranged from 23 to 56. All of the participants reported to have already done tourism, to use their mobile phoneeveryday and to handle map-based resources regularly. Among all of the participants, five attended high school and three were not graduated. Moreover, most participants did report to be unfamiliar to touch screen devices. This led us to do further testing sessions with the equipment to avoid the interference of interaction actions in task completion. Regarding mobile applications, such as games or media players, six participants reported to play it in a regular basis. The remaining three answered to use it rarely.

6.3.2 Procedure

The user study was performed in an outdoor environment situated in Square D. Pedro IV, Lisbon. Appendix C illustrates an aerial view over the testing field. Initially, test subjects were introduced to the equipment and participated in a practice trial session to familiarize themselves with touch screen interaction methods. Prior to the full experiment started, they were also instructed to perform certain tasks using Wikitude and MKiosk. The user study was conducted along two stages. Firstly, we carried out a comparative user study. Then, we proceeded with a user study solely focused on MKiosk. Through experiments we used a within-subject experimental design, i.e., each subject carried out same tasks and experimental variables on both interfaces and under similar conditions. In order to avoid potential-learning effects on a particular task, tests were counterbalanced among subjects by alternating tasks order. Hence, four participants started with Wikitude interface and other four participants started with MKiosk interface. During experiments subjects were observed by an examiner that manually registered some of their actions. Moreover, participants were only allowed to explore POIs and UPs within the aforementioned physical area. As stated before, we have designed different tasks for each study. For the comparative user study, subjects performed T1 and T2 tasks (see Table 6.2). Upon concluding the comparative study, each participant was asked to complete a questionnaire regarding their interface preference. The next user study demanded subjects to test MKiosk, as a whole, regarding its main features. To that end, subjects had to perform T3, T4 and T5 tasks. Upon concluding both studies, participants were asked to complete a post-study questionnaire followed up with a non-structured interview. Each experiment took around 60 minutes to complete. To measure completion times, we used a stopwatch rather than system logging, since we wanted to record time regardless of internet connection delays and additional system events. Nevertheless, we used system logging to record the number of iterations between screens, as also the number of taps performed. For the comparative user study, we were not able to count the occurrences of taps performed for Wikitude using a system logging. Instead, the examiner had to carefully observe and count users' taps while performing tasks.



(*a*) A subject aiming the camera to D. Pedro IV monument



(*b*) Use of *trace area mode* over downtown Lisbon

Figure 6.3: Illustrations about outdoor experiments

Recalling exploratory tasks (see Table 6.2), we have decided to start recording completion times, once users found the POI or UP concerned to perform the task. In more detail, to carry out task T3, a user has to seek for an UP in the physical location prior to using our application to insert the concerned UP in MKiosk. Since we do not want to record the elapsed time while users look for the UP in their surroundings, we begin registering the time, once users start using MKiosk perform the task. Figure 6.3 presents different search interactions with MKiosk registered during experiments. In Figure 6.3 (a), we see a participant photographing a monument through the *what is that* feature and in Figure 6.3 (b) a search interaction using *trace area mode*. In the next section, we analyze and discuss the results gathered throughout this study and feature participants' contributions.

6.4 RESULTS

Upon carrying out the user study, we started by interpreting collected outputs, in particular subjects' opinions and quantitative information registered by the examiner and MKiosk. The present section aims to expose the results that sustain the objectives of this thesis. First of all, we discuss collected results concerning the tasks and experimental variables formulated. We next remark some usability constraints and underlined difficulties, followed with suggestions given in the post-study questionnaire and performed interviews.

6.4.1 Comparative User Study

For the comparative user study, we have used two mobile applications, the Wikitude an MKiosk. For this experiment, users performed tasks T1 and T2.

Objective Results

Figure 6.4 summarizes the average completion time subjects took to complete tasks. As we can see, MKiosk reveals a favourable performance compared to Wikitude. For T1, although the advantage over Wikitude, MKiosk subjects expended more time preparing their request. In other words, our application demanded participants to photograph a POI in order to request for related information. On the contrary, Wikitude combined GPS and compass data disregarding photo capture, and thus allowing subjects few iterations. Some have considered also the approach of Wikitude more incisive. Nevertheless, the overall task performance was favourable for MKiosk mostly due to symbol overlapping detected in Wikitude.

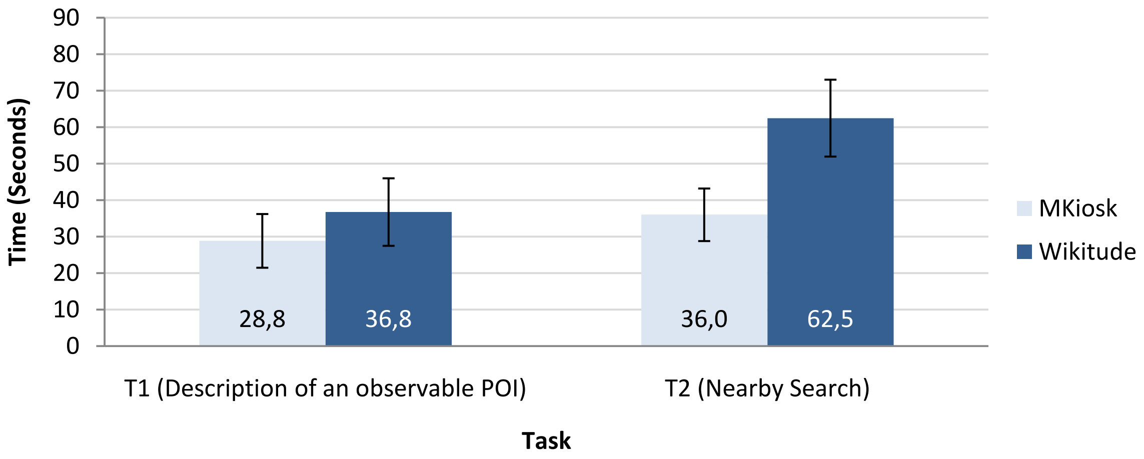


Figure 6.4: Average time to complete comparative tasks

Regarding task T2, our application produced optimistic results. In addition to symbol overlapping issues detected in Wikitude, according to participants and the examiner, search settings represented a major barrier in task completion time for Wikitude. Rather than providing in advance a detailed list containing POIs available in the system, Wikitude forced subjects to write for POIs into a text box, which violates the usability heuristic of recognition rather than recall [Bertini 06]. Reflecting this, we have attempted unsuccessfully to search for theatres in Lisbon using Wikitude.

Figure 6.5 shows completion times in regard to sub-tasks of search-based tasks, as described earlier. These sub-tasks are designated ST1 and ST2 (see Table 6.3).To better understand subjects' progression we measured tasks partially. As illustrated in Figure 6.5, expended average time to set search preferences, prior to the beginning of the search ,was significantly higher in Wikitude. The reason for this was due to search preferences iteration process, as shown in Figure 6.6.

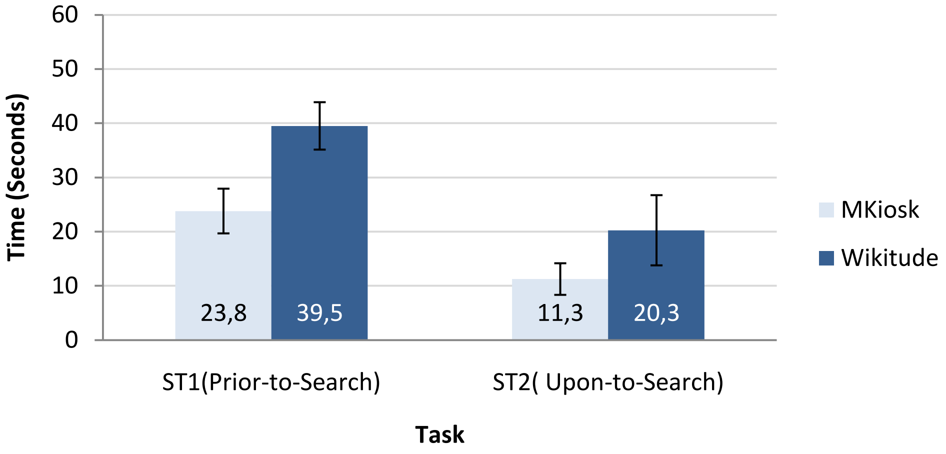
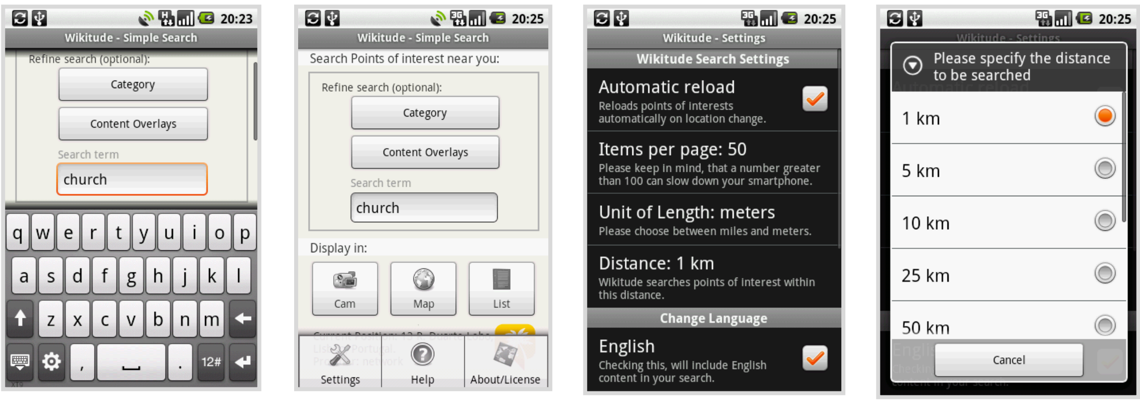


Figure 6.5: Average time to complete sub-tasks for the comparative search-based task

Figure 6.6 shows Wikitude search settings iterations. Additionally, users when returning to screen (*c*), did manifest difficulties on confirming changes due to the lack of saving options.



(*a*) Item to find (*b*) Shortcut Menu (*c*) Settings list (*d*) Distances list

Figure 6.6: Wikitude search setting menu sequence

In Figure 6.5, completion times for actions performed upon the search process, i.e., selecting a delivered symbol and visualizing related contents, evidence again favourable results for MKiosk. Users' and examiner's remarks expressed that the selection of symbols in Wikitude revealed to be a cumbersome process due to symbols overlapping, and to their size and uniformity, Figure 6.7.

According to Fitt's Law, time to move to a target area is the function of the distance to the target and the target size. Thus, the size of the symbol directly affects the difficulty of the task. A smaller symbol will be more difficult to select, and conversely, a larger symbol will be easier to select [Wobbrock 08]. Figure 6.7 shows a great amount of overlapped symbols.

This amount can be reduced setting a closer distance. However, the selection process remains inappropriate for larger ranges.

Figure 6.7: Wikitude live-camera preview

In order to confirm some of Wikitude and MKiosk issues and to analyze task iterations, we also registered the occurrences of touch screen events. Figure 6.8 presents an average on task tap frequency.

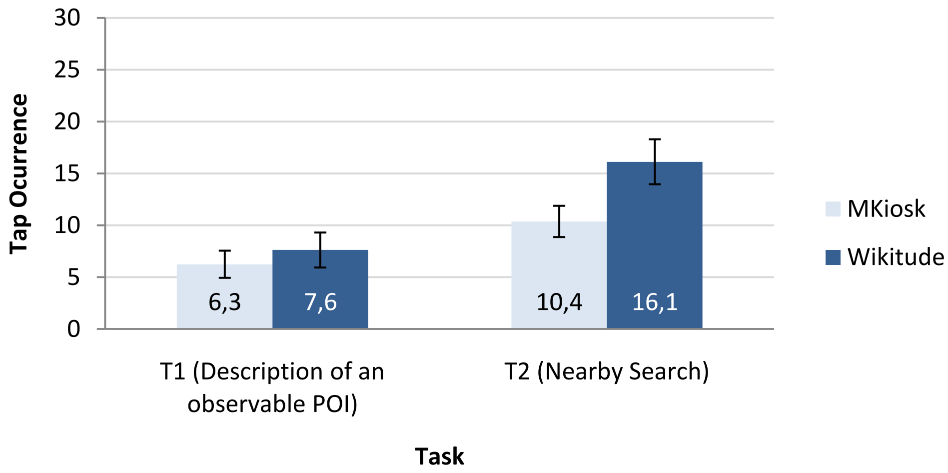


Figure 6.8: Task tap frequency average regarding both comparative tasks

Considering task T1, results were approximately equal. According to participants' comments and to the study examiner, we were able to clarify these values. On the one hand, photo recapture iterations increased the number of taps performed in MKiosk. On the other hand, subjects using Wikitude tapped frequently while attempting to select a symbols overlaid in map or in live-camera preview. Not surprisingly, the Nearby Search task showed significant differences. As previously stated, search setting iterations and failed attempts to select overlapped symbols were again the major causes in Wikitude. Next, we will present participants' preferences on both applications.

Subjective Results

In terms of subjective assessment, qualitative data included a simple questionnaire, administered at the end of each user comparative session, and the examiner notes. The questionnaire posed questions about which interface the participants liked most to date and which interface they liked least to date. The examiner notes contained relevant observations about the session, including task progression and subjects' interaction issues regarding Wikitude and MKiosk. In general, subjects had significantly more bias towards using MKiosk to perform experimental tasks than using Wikitude. Upon collecting answers, we firstly concluded that the majority of participants, six in eight, considered Wikitude's search approach more effective in the sense of avoiding photo capture issues. However, in consideration to usability and interface aspects, participants did reveal higher levels of satisfaction with MKiosk. According to their answers, the overall search process in MKiosk reflected better precision, performance and flexibility than in Wikitude. A varied range of available options, well-defined and appellative symbols, few screen iterations and a user-friendly application, were some of the remarks referred in the post-study. Concerning the filter of POIs, one participant chose Wikitude, arguing that users were able to quickly write something, using on-screen keyboard, and search, if present in the system. Closer examination revealed that this participant used a touch screen mobile phone regularly. On the contrary, other participants did not handle touch screen operations in a regular basis, in particular typing on-screen keyboards. Thus, MKiosk seemed a reasonable choice for them. Nevertheless, some participants have suggested that using an auto-filter would greatly improve this process. Regarding delivered results, icon-based symbols and different colours distinguishing POIs from UPs, assured subjects an effortless selection. From their response, non-referenced symbols in Wikitude led them to a slightly higher cognitive load to distinguish POIs. Another issue was related to search distance setting. Seven participants have chose MKiosk. According to their comments, MKiosk comprised all search options in a single point, thus preventing users to perform several iterations. One subject considered that both process's effort was not significantly different. In the following sections, we discuss results produced with MKiosk user study and compare with registered results in the pilot test.

6.4.2 MKiosk User Study

In contrast with the last study, the present study addresses the results on tasks that we have defined to fully evaluate MKiosk. Furthermore, task results are compared with times gathered during a pilot-test with a trained user. Through the analyses of results, we present quantitative data in terms of task completion times and occurrences of taps.

Objective Results

Figure 6.9 discloses, in general, approximated results in consideration to the three tasks. According to post-study comments and examiner’s notes, participants felt frequently comfortable while performing tasks.

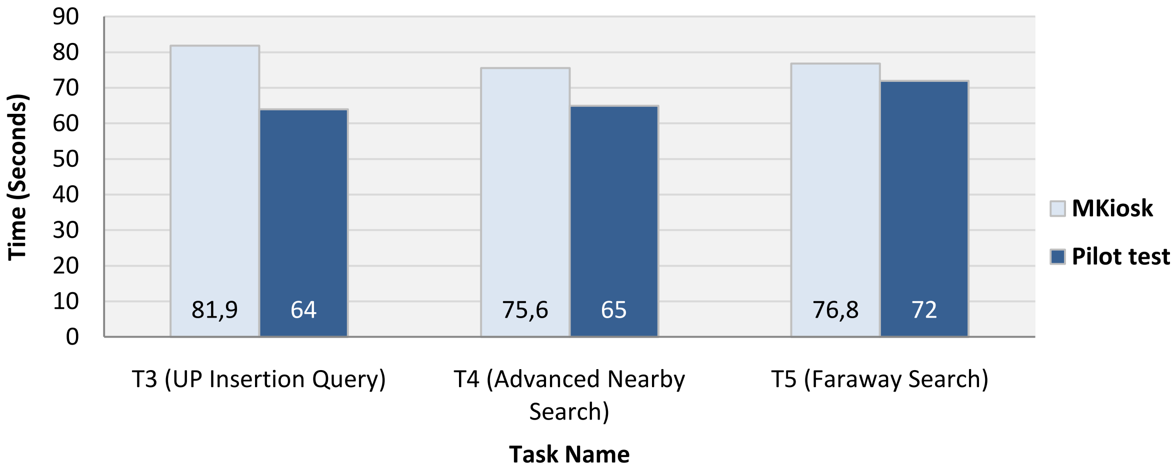
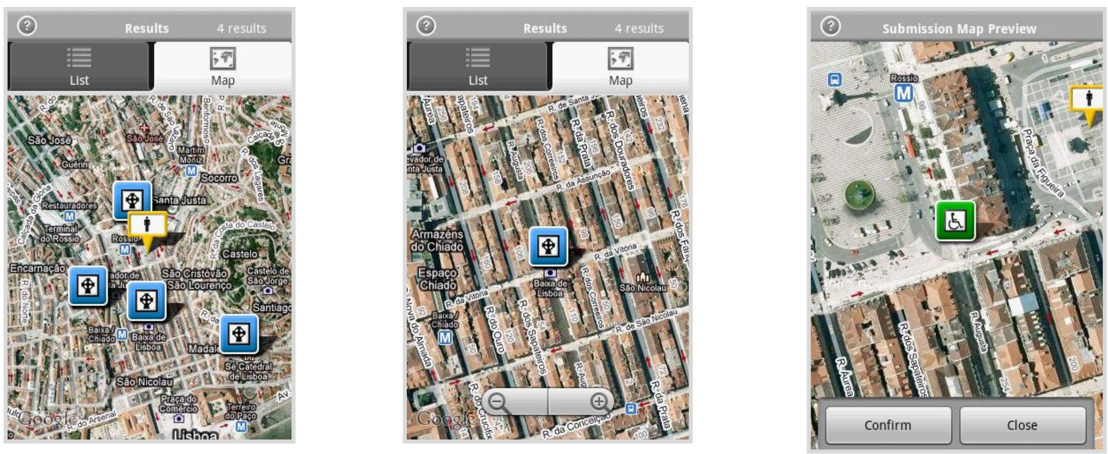


Figure 6.9: Averages on task completion times for MKiosk tasks

Figure 6.9 shows that completion times converged as subjects explored MKiosk. It was most likely that learning effects had influenced results. Confirming our assumption, subjects declared that during experiments easily apprehended operations in MKiosk. During tests some iterations were also frequently repeated.



(*a*) Normal zoom level

(*b*) Approximated zoom level

(*c*) The insertion of an handicap access UP

Figure 6.10: Different Zoom Levels

Subjects did often lean toward zooming operations prior to the selection process. Figure 6.10 depicts in (*a*) four churches as result. Given that markers are sufficiently sparse in space to proceed to their selection, zooming the map would be needless. Yet, most subjects zoomed the map to focus their desired marker as shown in Figure 6.10 (*b*). During interviews they were asked about this behaviour and the generality of responses were related to space awareness. In other words, zooming the map would allow a clearer perception on the physical area of a POI. During the pilot-test, we did not consider this situation, since our tester was entirely focused in concluding the task instead of browsing the map. For task T3, the presented results in Figure 6.9 evidence a significant difference. In addition to the aforementioned reasons, the process of placing an UP element over the map revealed some difficulties. The lack of map navigation and zooming controls led the majority of participants to take longer to conclude this process, Figure 6.10 (*c*). Still, they all concluded task T3 successfully. Results for Task T4 did not represent a significant difference as Figure 6.9 confirms. In this sense, we may infer that subjects were able to search smoothly for POIs in nearby and distant locations. Some subjects did use as well the *trace area mode* to trace a search area over the map, as opposite to selecting a search distance from a list. Considering the results in Figure 6.9 and participants' comments on this mode, we confirmed that the generality was successful while using it.

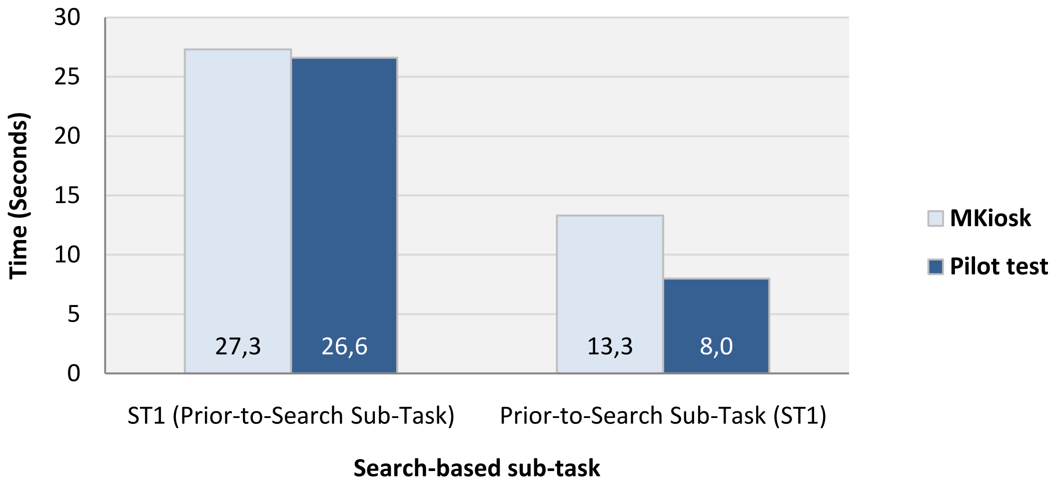


Figure 6.11: Sub-task completion time averages concerning search-based tasks

Figure 6.11 depicts MKiosk sub-task completion times for search-based tasks. For task ST1, we may conclude that the average of completion times is clearly balanced. On the contrary, POI Information Access showed a substantial difference. The main cause for this reaction was mostly due to the additional amount of time to perform zoom iterations, as previously mentioned.

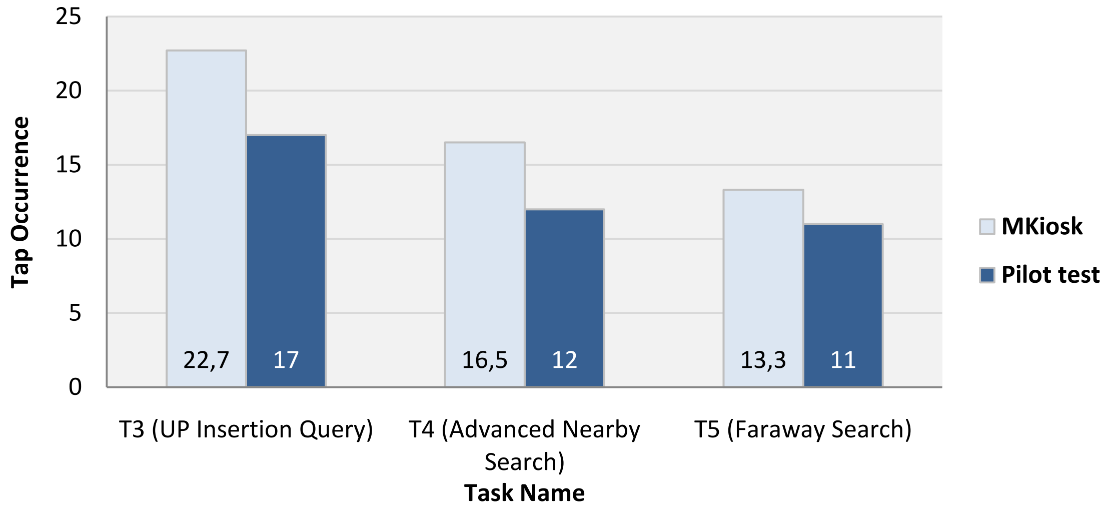
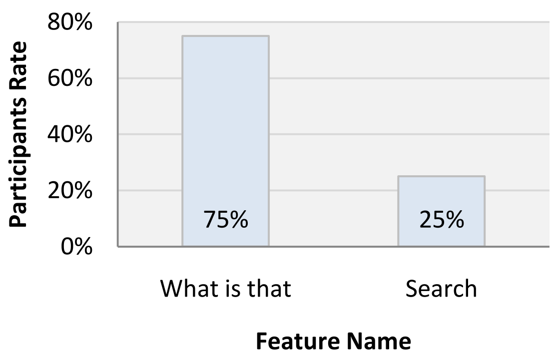


Figure 6.12: Task tap occurrence average for MKiosk tasks

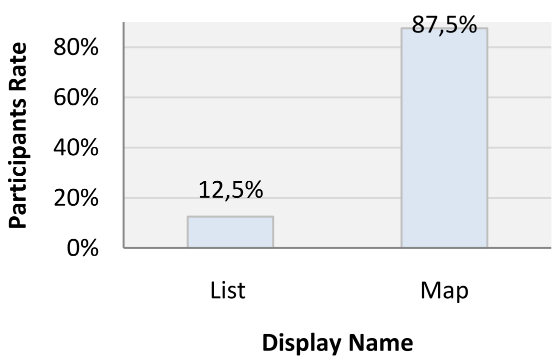
Results in Figure 6.12 reveal that MKiosk taps performed maintained slight differences compared to pilot test results. Confirming these results, we found out that the regular zooming activity previously mentioned was a major factor contributing for a higher occurrence of taps. Furthermore, examiner's notes pointed out that some subjects did not made use of shortcuts menu. This reaction leaded to a higher screen iteration, and thus an increase in taps performed. In the next section, we address participants' subjective results.

Subjective Results

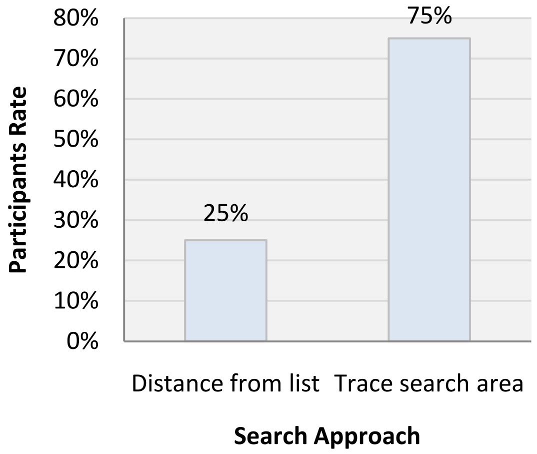
To better understand the strengths and weakness of MKiosk, we did a final post-experiment based on a questionnaire followed up by a non-structered interview. Under mentioned figures introduce some of the answers sustaining the objectives of this thesis. Through the next paragraphs we first exhibit participants' subjective results, and then we discuss and remark the findings derived from the present study. Generally, post-study responses evidenced that tasks and underlying operations were successfully performed.



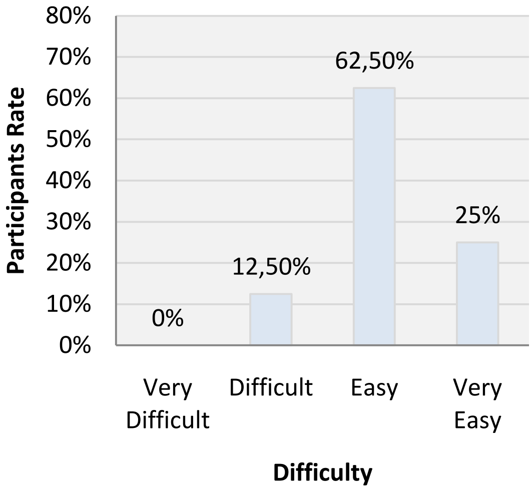
(*a*) Preferred method to get the information on an observable POI



(*b*) Preferred information display views



(*c*) Preferable method to search POIs and UPs considering wide distances



(*d*) Difficulty to perform the UP Insertion task

Figure 6.13: Subjective answers resulted from the user study

Participants were also asked about if they would use MKiosk again, and they all answered affirmatively. Figure 6.13 encompasses answers that confirm some of the quantitative results analysed in previous section. Aiming to achieve the objectives established in Chapter 2, we have confirmed from Figure 6.13 (*a*) that the majority of subjects were willing to photograph POIs to receive related descriptions. During interviews we also attempted to clarify answers considering both approaches, the *what is that* and the *search* feature. Subjects for *what is that* feature, commented that this process did not demand people to know in advance for the name of a determined POI. Steps performed along the overall process were also reduced, thus allowing information to be immediately displayed. In contrast, those who did chose the *search* feature reported that task learning effects led them to manually search for information comparably faster than photographing POIs, even though the *search* feature imposed a longer iterative process. About the results on information display views in Figure 6.13 (*b*), the generality of participants answered that visualizing the displayed results over a map would significantly help people aiming to their desired POIs, rather than accessing a list. On the other hand, one participant preferred accessing information through a list. According to his opinion, POIs presented over a list would never overlap even considering substantial amounts of information for the same area. Furthermore, people could be presented additional information on distance, category and assigned ratings. Still, according to results presented in Figure 6.13 (b), we realized that the spatial component did have a significant priority compared to the list approach. Concerning location-based features, in particular setting wide search areas, Figure 6.13 (*c*) shows an evident difference in results. Those who chose for defining distances through the list option reported that compared with *trace area mode* was more accessible, although disregarded accurate values. Subjects for the *trace area mode* did comment that selecting a great distance through distance list did not benefit space awareness. For instance, during experiments, some participants have set search distances of five kilometres using list option. In fact, they were unaware that a significant search area covered Tagus river. Thence, tracing a search area over the map would give people a reliable precision and avoid searching undesirable areas. Nevertheless, those for *trace area mode* commented that to define reduced distances, accessing the list approach would be preferable for being an efficient method. In Figure 6.13 (*d*) are shown the results, according to different levels of difficulty, to perform task T3. In general, participants commented that they carried out this task quite smoothly. However, some remarked the lack of zooming controls during UPs placement process.

Questionnaire Question	Very Easy	Easy	Difficult	Very difficult
In general, performing tasks in MKiosk was	62.5%	37.5%	0%	0%
Get information about a POI is	75%	25%	0%	0%
Insert an UP is	62.5%	37.5%	0%	0%
Perform a Nearby Search is	50%	50%	0%	0%
Performing a Faraway Search is	37.5%	62.5%	0%	0%

Table 6.5: Answers given by participants concerning some features of MKiosk

In consideration to remainder features, in particular POI and UP filter selection, POI related pictures preview, POI additional information and shortcut menu access, and faraway location setting, subjects' responses and additional comments expressed optimistic results. Table 6.5 presents an overview to some answers given through the post-study questionnaire. These findings confirm the objective results gathered while performing some tasks. Indeed, users did easily performed some tasks.

Questionnaire Question	Totally Agree	Agree	Disagree	Totally Disagree
The arrangement of POIs in list display is appropriated	37.5%	62.5%	0%	0%
The arrangement of POIs in map display is appropriated	25%	62.5%	12.5%	0%
Symbols used for POIs and UPs are perceptible	37.5%	62.5%	0%	0%
Tracing a search area was easy	37.5%	62.5%	0%	0%

Table 6.6: Another set of participants' answers extracted from questionnaire results

Table 6.6 presents results concerning the arrangement of symbols through list and map displays, as well as on whether symbols were easy to been recognized. In addition, most of users approved tracing map regions over the map. One user did disagree with the arrangement of POIs over the map display. Upon presenting and discussing the subjective findings resulted from this study, we next underline participants' comments regarding usability and interface constraints.

6.4.3 USABILITY ISSUES

Throughout interviews we were also aware of usability and interface issues found in MKiosk. In respect to usability constraints, subjects pointed out the lack of controls in the *Results* screen, in particular cancellable or back buttons. Indeed, our application did evidence some incoherence in that sense. Additionally, we were advised to add overlay buttons in the map to enable different real-time map views (e.g. satellite or street view).

As previously referred, zooming controls should be accessible when attempting to place UPs over the map. The main reason was that people would wish to place UPs in areas regardless of their current position. Taking in consideration interface issues, we were recommended to enlarge main controls at the bottom of the screen. Moreover, the large amounts of information produced along the *Additional Information* screen, leaded users to some unawareness on remaining information underlying the bottom of the screen. According to the generality of suggestions, using tabs as we did for *Results* screen, could significantly improve the display of additional information and avoid touch screen scrolling. Additionally, subjects pointed out the lack of status information prior to tracing a search area. Once they were presented a map, there was no reference on scale aspects. For example, it would be difficult for someone willing to trace a one kilometre radius of search area to perform it without a reference over the current map scale.

6.5 SUMMARY

In this chapter we described the study undertaken to assess MKiosk, and interpreted the results gathered throughout experiments. We began by explaining the aims of this study and the reasons that led us to pick Wikitude as the comparative application. Additionally, we mentioned the tasks and experimental variables formulated to perform the overall study. The following sections addressed studies carried out and findings. We started by explaining how the informal user study was conducted, along with a full description on the user study, concerning a comparative study and a focusing on MKiosk experiments. Upon describing the experimental design procedures and performed steps, we have discussed objective and subjective results collected along the study. We realized that the results were significantly optimistic in terms of task completion times. Also, subjects have done well with MKiosk main features and additional operations, in particular, demanding for POIs descriptions using both search approaches, the *what is that* and the *search* feature. Participants' opinions regarding the *trace area mode* were also favourable. Concerning the visualization of POIs, we were able to find out the most appropriated view according to participants' recommendations. Regarding the UP Insertion process, subjects did successfully perform related iterations, though the emergence of some inconveniences. We finally described and mentioned subjects' remarks in regard to usability and interface prospective improvements. In the next chapter we summarize the present thesis, referring to their underlying chapters. We introduce as well the conclusions derived from studies performed and related contributions.

7 CONCLUSIONS AND FUTURE WORK

In this chapter we introduce and discuss the final conclusions and contributions derived from our work, enhancing the design issues arose from the experimental design and suggesting additional features for future work.

7.1 THESIS SUMMARY

For this thesis, we proposed a new approach to search, insert and visualize geo-referenced information. In chapter 2, we first described the research performed concerning the related work on mobile computer vision and location-based services. Through this study, we have realized that current mobile applications, in concern to the aforementioned fields, were lacking in location-based features and flexible visualization modes. In addition, image retrieval methods did not regard geo-referenced elements. According to these considerations, we identified some underlying constraints: difficulties on searching POIs and UPs and on retrieving related information properly; unfeasibility on defining search queries based on well-defined locations and map regions; rudimentary interface screens considering mostly text-based information; adversities on selecting and accessing overlapped symbols. At the end of the related work chapter, we were able to determine a well-defined set of objectives and expected contributions, supporting our solution.

In chapter 3, we presented the studies performed for the user profile study. In order to better understand user’s profile concerning tourism and mobile phone related activities we broadcasted online surveys and carried out contextual inquiries with a restricted user group designated MKiosk User Group. Additionally, we analysed and discussed results gathered through both studies. Online survey responses evidenced that present day users are willing to resort to digital touristic and map-based contents. Initially the photograph recognition approach revealed to be seemingly devalued according to the generality of online responses. Further research and testing sessions confirmed that users were in favour for capturing a photograph, by means of a mobile phone, and acquire related descriptions. Regarding users’ recommendations on features and different types of geo-referenced information, we were remarked a range of valuable solutions: collecting and displaying comments submitted by other users; zooming the map to extract a desirable area as an image; a note book to register events occurred while touring; indicating POIs ratings and of transport stations, e.g., bus, metropolitan; multiple route generation from current location to desired destination; toilets and ATM services. In addition to suggestions on features and types of information, we carried out paper prototype sessions regarding users’ opinions on the interface design. Upon performing the research for our work, we proceeded with the implementation of our solution.

In chapter 4, we fully described the solution designed in terms of the mobile and the spatial component, and technical considerations. Prior to explaining in detail both components involved, we presented an illustration encompassing the main modules of our solution and their correlations. Next to this representation, we have carefully described the mobile supported features, such as geo-referenced image retrieval, multiple filter components, search-based features, multiple visualization modes and on-field insertion of UPs. In concern to the geographical component, we referred to its database framework, enhancing related table contents. Upon describing the concepts introduced in the spatial database, a query representation was outlined according to relevant pieces of code. Additionally, we described variables and functions supporting search and insertion queries.

In contrast with previous chapters, chapter 5 explained the solution design in terms of stages of implementation. We therefore introduced an illustration with regard to the system implementation process. Implementation stages were individually described, focusing on steps performed to accomplish the solution design. In addition to the system implementation stages, we mentioned technology issues encountered through the development process. The mobile development platform, the spatial database and modules integration, represented some topics related to the technology section.

Finally, in chapter 6 we have described experiments undertaken in order to assess the solution designed, and discussed results associated. Prior to the formal user study, we carried out an informal user study with the users and the MKiosk User Group. Through this study we aimed to enhance our prototype regarding usability and interface issues. Once improved, a restricted group of users, unaware of tasks and our prototype, performed experiments in a real life scenario. Through the full user study, we also performed a comparative study involving the Wikitude application. Upon experiments completion, we realized that gathered results were in accordance with our expectations. Task completion time, sub-tasks completion time concerning search-based tasks, and the occurrence of taps along tasks, revealed favourable results for our solution. Regarding subjective results, we were also confronted with results that sustained the objectives proposed for this thesis, and remarked to improve some location-based features.

7.2 Final Conclusions and Contributions

The results collected through user experiments were outlined in chapter 6, allowing us to formulate clear conclusions. According to objective and subjects findings, we found out that our features were successfully used by the generality of users while performing the experimental tasks. Considering the geo-referenced image retrieval feature, gathered results indicate that most of the users successfully accessed information by pointing the camera to a determined POI. In addition to the recognition process, the search component produced favourable results, in spite of some remarked constraints in post-study interviews. Users did also successfully search for nearby references, as well as for faraway locations. Moreover, map-region based search queries produced satisfactory results. Nevertheless some users pointed out the lack of additional information on current map scale, prior to the search area tracing process. In concern to the UP insertion feature, we realized that users were willing to insert geo-referenced information using our solution. We were advertised as well to employ additional methods in order to assure higher levels of credibility on uploaded UPs. Overall, our primary contribution refers to a solution which provides well-defined features to search, insert and display geo-referenced information relating POIs and UPs. We next line up the following achieved contributions according to the problem identified and objectives determined:

- Geo-Referenced Image-Retrieval Mobile Platform – Integration of a spatial module with a CBIR module functioning as a black box. Definition of appropriated methods to retrieve closest geo-referenced POIs which may improve image-retrieval computations. Also, the spatial database framework was properly designed according to different locations;

- UP On-Field Insertion – Enables the upload of geo-referenced elements, directly from UPs physical location. This process displays a list component containing the available UPs in the system, and an interactive map view so one can places concerned UPs in particular geographical positions;

- Nearby Search Query– Enables searching for POIs and UPs within a range of closer distances given by default. The search process is carried out according to user's current geographical position. In addition to distance setting, defining the visualization mode, e.g., list or map view, and the number of desired results is allowed as well;

- Faraway Search Query – Differently from Nearby Search, performs search queries regardless of user's current position, thus providing a flexible search component, either for nearby locations or well-defined locations;

- Map-Region based Search Query – In contrast to distance-based search queries, this feature allows searching for geo-referenced elements according to a well-defined area traced over the map. This method complements previous Search features in the sense of providing information for unreferenced locations, and an accurate traceable control to outline map regions;
- Multiple Visualization Mode – In order to avoid overlapping symbols, list and map views are displayed according to distinct tabs. The list mode organizes delivered results by distances, followed with additional information, e.g., distance from user, symbol category or rating, and also illustrative elements. Map view displays elements presenting their corresponding symbols. Additionally, zoom controls were enabled in order to disperse overlapped elements. Gallery mode consists in an additional contribution to allow the visualization of interactive images supported with related descriptions;
- Multiple Filter Selection – Introduction of distinct filter components containing well-defined POI and UP elements according to different colours and symbols. The filter was designed to enable multiple item selection, in particular to cross POI elements with UP elements through the search process.

According to post-study questionnaires and interviews, we concluded that the generality of processes was smoothly performed. Acquiring information for a POI, inserting an UP, tapping over delivered results in map and list view, or setting distances and locations, were examples of actions successfully performed by most users.

7.3 Future Work

The studies performed, either during the user profile study or the experimental design, allowed us to identify some aspects that encourage future development in the mobile computer vision field and location-based services. We therefore defined the future work according to different considerations: usability and interface improvements; additional features and recent technologies. Regarding usability and interface aspects, we firstly refer to the traceable area process. Users complained about the lack of information on map-based zoom level and scale aspects. Due to the irreversible process when tracing a search area, it is relevant displaying the largest radius admitted for a traceable area prior to the tracing process. Primary controls and related labels should also be resized due to touch-screen interaction constraints with elements of small dimensions. We designed an adequate solution to freely explore geographical regions. Nevertheless, users, in particular tourists, do not have in mind normally location names or even map regions where they may certainly discover interesting POIs. Thus, in order to complement our solution, it would be reasonable designing an approachable method to give users beforehand information on most visited POIs, well-known location names and tourism related regions according to their surroundings.

Figure 7.1: Prior to trace a search area, user is given real-time information on regions containing touristic references.

Displaying map regions with circular overlays according to different levels of POIs and UPs density, could be an achievable approach to give users in advance an idea of map regions with touristic references. Figure 7.1 illustrates this solution. In concern to the additional features suggested, we noticed that the generation of well-defined routes, regarding a starting point and an ending point as references, was frequently suggested by users through the studies performed. Again, our solution lacks of informative elements when walking in the outdoors. Through experiments, users remarked that all, although the image retrieval process delivered adequate results, using an approach based on GPS and an embedded compass would likely made the information acquisition comparably faster to image retrieval techniques which may be time-costly. An additional interesting feature to support the UP insertion process, would consist in photographing the UP element at the physical location upon placing it over the map, Figure 7.2.

(a) Placement an UP (b) Captured Photograph to the McDonalds (flickr[10])

Figure 7.2: UP insertion process supported with a photograph

[10] Flickr images: http://www.flickr.com/

Thus, by means of Google's recent panoramic technology designated Google Maps Street View[11], we would be able to extract and compare nearby building facade images with the captured on the street. This would probably ensure more credibility over users' on-field contributions.

Figure 7.3: Image extracted from McDonalds in Rossio using Google Maps Street View

Lastly, we refer to a feature based on a detailed POI and UP filtering process. In other words, rather than querying for a typical restaurant, it would be favourable querying for restaurants according to additional parameters, like for instance the most accessible in terms of price. Another example would consist in refining the search process to retrieve nearby hotels rated as a three star hotel.

[11] Google Maps Street View: http://maps.google.com/help/maps/streetview/

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A User Profile Study Online Survey

MKiosk

Constant Contact Survey Results

Survey Name: MKiosk

Response Status: Completed

Filter: None

Apr 12, 2009 7:51:02 PM

TextBlock:

Este questionário é composto por 25 perguntas e encontra-se dividido em 4 secções.

TextBlock:

I - Dados pessoais

* Qual é o seu sexo?

Answer	0% — 100%	Number of Response(s)	Response Ratio
Feminino		69	41.8 %
Masculino		96	58.1 %
No Response(s)		0	0.0 %
	Totals	165	100%

* Em que faixa etária se encontra ?

Answer	0% — 100%	Number of Response(s)	Response Ratio
15-22		24	14.5 %
23-30		62	37.5 %
31-45		39	23.6 %
46-60		33	20.0 %
Mais de 60		7	4.2 %
No Response(s)		0	0.0 %
	Totals	165	100%

Com que frequência o faz por ano?

Answer	0% 100%	Number of Response(s)	Response Ratio
1 a 5 vezes por ano		137	83.0 %
6 a 10 vezes por ano		11	6.6 %
Mais de 10 vezes por ano		0	0.0 %
Other		1	<1 %
No Response(s)		16	9.6 %
	Totals	165	100%

Em que circunstâncias faz turismo ?
Seleccione uma ou mais opções.

Answer	0% 100%	Number of Response(s)	Response Ratio
Com a familia		121	73.3 %
Em trabalho		19	11.5 %
Com amigos		89	53.9 %
Sozinho		18	10.9 %
Other		4	2.4 %
	Totals	165	100%

* Quais as suas habilitações literárias ?

Answer	0% 100%	Number of Response(s)	Response Ratio
Frequenta Ensino Básico		0	0.0 %
9º ano concluído		6	3.6 %
Frequenta Ensino Secundário		2	1.2 %
12º ano concluído		22	13.3 %
Frequenta Ensino Superior		47	28.4 %
Bacharelato		7	4.2 %
Licenciatura		55	33.3 %
Mestrado		15	9.0 %
Doutoramento		7	4.2 %
Other		4	2.4 %
No Response(s)		0	0.0 %
	Totals	165	100%

TextBlock:

II - As questões que se seguem estão relacionadas com as práticas e necessidades das pessoas que fazem turismo. No contexto do nosso projecto, por turismo entende-se a visita a locais turisticamente reconhecidos e com alguma densidade de monumentos e outros pontos de interesse.

* Costuma fazer turismo?

Answer	0% 100%	Number of Response(s)	Response Ratio
Sim		147	89.0 %
Não - Passe à secção seguinte		18	10.9 %
No Response(s)		0	0.0 %
	Totals	165	100%

Numa visita a uma cidade desconhecida, já lhe aconteceu não ter à mão a informação sobre o que estava a ver ? (ex. um monumento, uma praça)

Answer	0% 100%	Number of Response(s)	Response Ratio
Sim		121	73.3 %
Não		29	17.5 %
No Response(s)		15	9.0 %
	Totals	165	100%

O que tem por hábito fotografar ?
Seleccione uma ou mais opções.

Answer	0% 100%	Number of Response(s)	Response Ratio
Natureza		117	70.9 %
Pessoas		89	53.9 %
Edificios culturais (ex. monumentos, igrejas, museus, castelos e outros edificios)		123	74.5 %
Restaurantes		9	5.4 %
Praças e ruas		96	58.1 %
Other		9	5.4 %
	Totals	165	100%

Seguem-se alguns elementos que podem ser encontrados enquanto visita uma cidade.
Classifique-os de acordo com a sua ordem de importância.
1 - Nenhuma importância
5 - Muita importância
1 = 1, 2 = 2, 3 = 3, 4 = 4, 5 = 5

Answer	1 2 3 4 5	Number of Response(s)	Rating Score*
Alojamentos (ex. hoteis, pensões)		150	3.9
Locais de diversão (ex. discotecas, parques)		150	3.2
Restaurantes		148	3.6
Edificios culturais		150	4.1
Hospitais		148	2.9
Transportes (ex. metro, aluguer de automóveis)		149	3.9
Postos de turismo		149	3.5
Zonas comerciais		150	3.0

*The Rating Score is the weighted average calculated by dividing the sum of all weighted ratings by the number of total responses.

Qual o método mais utilizado para definir os pontos de interesse a visitar nas suas viagens ?

Answer	0% 100%	Number of Response(s)	Response Ratio
Antes de viajar, faz um plano com todos os pontos de interesse a visitar		43	26.0 %
Antes de viajar, faz um plano com alguns pontos de interesse a visitar e depois procura os restantes no destino		73	44.2 %
No destino, procura os pontos de interesse a visitar e faz um plano		18	10.9 %
Não faz qualquer plano		13	7.8 %
Other		3	1.8 %
No Response(s)		15	9.0 %
	Totals	165	100%

A que instrumentos de orientação costuma recorrer ?
Seleccione uma ou mais opções.

Answer	0% 100%	Number of Response(s)	Response Ratio
Guias turísticos (ex. livros com roteiros)		113	68.4 %
GPS e mapas digitais (ex. google maps no telemóvel)		50	30.3 %
Mapas em papel		103	62.4 %
Visitas guiadas por uma pessoa		33	20.0 %
Other		6	3.6 %
	Totals	165	100%

TextBlock:

III - Nesta secção será questionado(a) acerca dos seus conhecimentos na utilização de dispositivos móveis (ex. telemóvel, PDA) e de que maneira os utiliza no contexto turístico.

* Possui um telemóvel ?

Answer	0% 100%	Number of Response(s)	Response Ratio
Sim		165	100.0 %
Não - Passe à secção seguinte e termine o questionário sem responder a qualquer outra questão.		0	0.0 %
No Response(s)		0	0.0 %
	Totals	165	100%

Diga-nos se o seu telemóvel possui as seguintes funcionalidades :
Seleccione uma ou mais opções.

Answer	0% 100%	Number of Response(s)	Response Ratio
Câmera Fotográfica		148	89.6 %
Sistema GPS		37	22.4 %
	Totals	165	100%

Das funcionalidades que se seguem, quais sabe executar ?
Seleccione uma ou mais opções.

Answer	0% 100%	Number of Response(s)	Response Ratio
Agendar uma reunião		140	84.8 %
Compor uma SMS (Mensagem escrita)		162	98.1 %
Compor uma MMS (Mensagem multimédia)		128	77.5 %
Ouvir uma música		136	82.4 %
Visualizar uma imagem		151	91.5 %
Tirar uma fotografia		152	92.1 %
	Totals	165	100%

Costuma levar consigo o seu telemóvel quando vai de viagem para o estrangeiro ?

Answer	0% 100%	Number of Response(s)	Response Ratio
Sim		153	92.7 %
Não		9	5.4 %
No Response(s)		3	1.8 %
	Totals	165	100%

Que tipo de dispositivos utiliza para tirar fotografias ?
Seleccione uma ou mais opções.

Answer	0% 100%	Number of Response(s)	Response Ratio
PDA		16	9.6 %
Máquina fotográfica convencional		151	91.5 %
Telemóvel		79	47.8 %
Other		5	3.0 %
	Totals	165	100%

Já alguma vez recorreu à câmera fotográfica de um telemóvel para fotografar algum ponto de interesse (ex. monumento, praça, etc.) ?

Answer	0% 100%	Number of Response(s)	Response Ratio
Sim		130	78.7 %
Não		34	20.6 %
No Response(s)		1	<1 %
	Totals	165	100%

Se respondeu que não à questão anterior, porque razão nunca o fez ?

33 Response(s)

Alguma vez consultou um mapa digital num dispositivo móvel (ex. telemóvel, PDA, GPS) ?

Answer	0% 100%	Number of Response(s)	Response Ratio
Sim		84	50.9 %
Não		81	49.0 %
No Response(s)		0	0.0 %
	Totals	165	100%

TextBlock:

IV - Imagine-se agora a fazer turismo numa cidade que lhe é desconhecida, e que consigo leva um telemóvel com uma aplicação para lhe fornecer informação turística.

* Encontra-se diante de um museu e pretende obter a informação acerca do mesmo. Qual dos seguintes métodos considera mais prático para obtê-la ?

Answer	0% 100%	Number of Response(s)	Response Ratio
A partir do telemóvel, procurar o museu numa lista de pontos de interesse próximos e consultar a informação		61	36.9 %
Tirar uma fotografia ao museu com o telemóvel e consultar a informação associada à fotografia		92	55.7 %
Procurar por uma fonte de informação (ex. roteiro de museus, pessoa, placa descritiva)		146	88.4 %
Other		0	0.0 %
No Response(s)		0	0.0 %
	Totals	165	100%

* Ainda para o mesmo museu, qual a ordem que escolheria para a apresentação da informação no visor do seu telemóvel ?

1 = Primeira informação a aparecer ; 4 = Última informação a aparecer

Answer	1 2 3 4	Number of Response(s)	Ranking Score*
Calendário de exposições		165	2.5
Preços e horários da exposição actual		165	2.1
Descrição do museu		165	1.9
Pontos próximos de interesse apresentados num mapa		165	3.5

*The Ranking Score is the weighted average calculated by dividing the sum of all weighted rankings by the number of total responses.

Qual dos seguintes modos de visualização seleccionaria para consultar o mapa ?

Answer	0% 100%	Number of Response(s)	Response Ratio
Apresentação de um mapa real (Satélite)		88	53.3 %

Apresentação de um mapa normal 		73	44.2 %
Other		4	2.4 %
No Response(s)		0	0.0 %
	Totals	165	100%

Das seguintes informações, qual considera a mais importante para aparecer num mapa ?

Answer	0% 100%	Number of Response(s)	Response Ratio
Identificação das ruas 		82	49.6 %
Identificação de pontos de interesse 		62	37.5 %
Other		20	12.1 %
No Response(s)		1	<1 %
	Totals	165	100%

B USER PROFILE STUDY PAPER PROTOTYPES

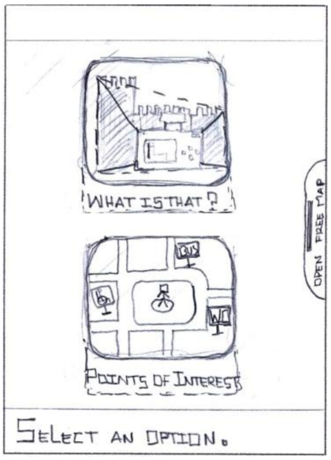

Figure B.1: Home Menu Screen

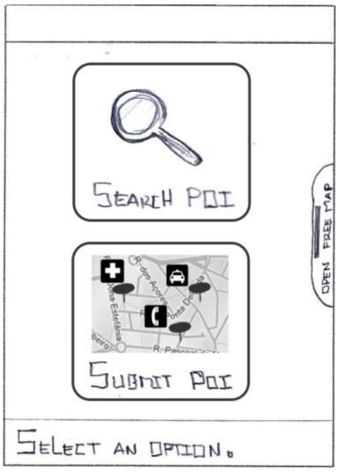

Figure B.2: POI Menu Screen

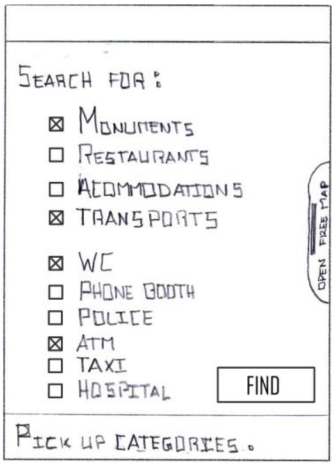

Figure B.3: POI Filter Screen

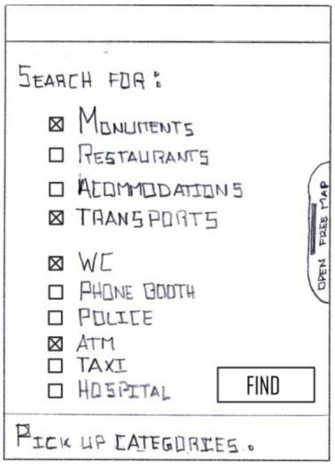

Figure B.4: UP Filter Screen

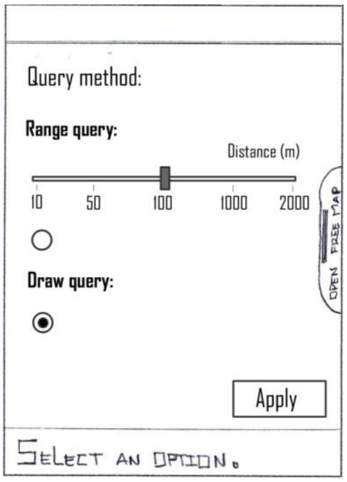

Figure B.5: Distance Preferences Screen

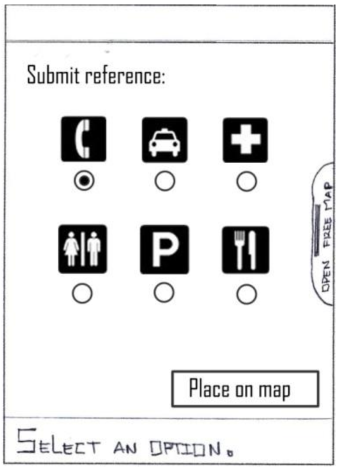

Figure B.6: UP Insertion screen

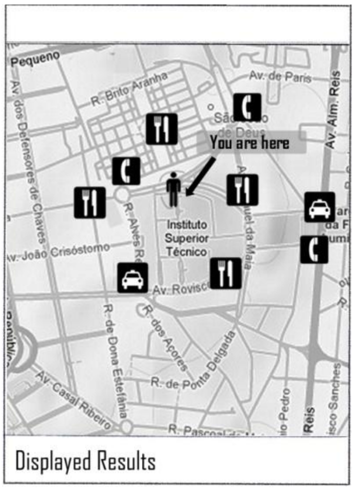

Figure B.7: Nearby Search Result Screen

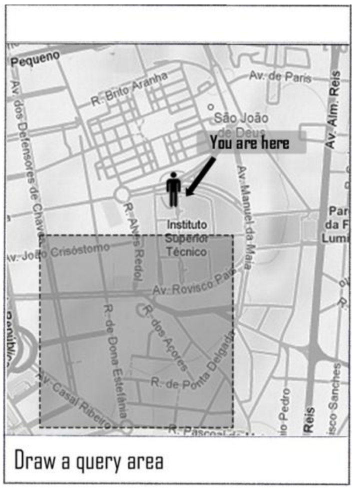

Figure B.8: Tracing Map Region Screen

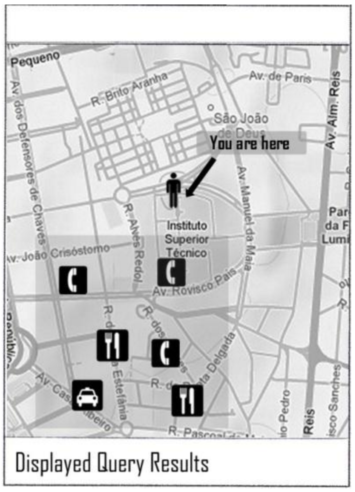

Figure B.9: Map-region based Search Result Screen

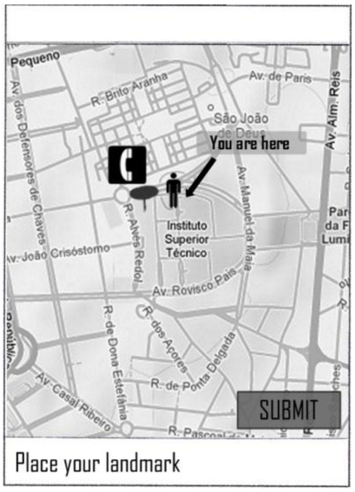

Figure B.10: UP Placement Screen

C EXPERIMENTAL PROTOCOL

Guião Para Avaliação Experimental

Com esta avaliação experimental pretendemos testar a nossa aplicação desenvolvida no âmbito de uma dissertação de mestrado. No sentido de orientar pessoas em locais desconhecidos, estamos interessados em observar o seu comportamento recorrendo a aplicações num telemóvel com ecrã táctil, e em registar a sua opinião. Para tal, pedimos a execução de várias tarefas e o preenchimento de um questionário. A primeira fase terá por objectivo um estudo comparativo entre as aplicações Wikitude e MKiosk, seguido de várias questões sobre o mesmo. A segunda fase consistirá no teste da nossa aplicação. O registo da sua opinião, relativamente a este último teste, acontecerá numa terceira e última fase.

O guião apresenta um conjunto de tarefas distintas para o estudo comparativo e o teste à nossa aplicação. Existem dois tipos de tarefas: tarefas pouco informativas que obrigam o utilizador a explorar o que existe à sua volta e as próprias funcionalidades da aplicação; tarefas claras e informativas onde todos os procedimentos são descritos *a priori*. Todas as tarefas serão realizadas na Praça de D. Pedro IV, como indica a figura da última página.
Antes de iniciar, terá ao seu dispor um tempo de treino e de adaptação às duas aplicações e às tarefas sugeridas. Quaisquer dúvidas serão esclarecidas nesta fase.

Muito obrigado pela colaboração.

Tarefas a realizar para o estudo comparativo

Tarefa 1. Apresente a descrição sobre um ponto de interesse que se encontre à sua vista.

Tarefa 2. Obtenha a morada de um restaurante típico localizado a menos de 1000 metros distância.

Tarefas a realizar para a nossa aplicação

Tarefa 1. Com base no local onde se encontra, verifique se existe algum ponto útil em falta na nossa aplicação. Em caso afirmativo, adicione-o recorrendo à mesma.

Tarefa 2. Procure pelas 10 igrejas e museus (em conjunto) mais próximos na zona da baixa de Lisboa, usando o modo para traçar uma área de pesquisa. Apresente uma fotografia de um dos pontos de interesse dados como resultado.

Tarefa 3. Procure, em Sintra, pelos preços de visita a um dos seus palácios. Atribua uma classificação ao ponto de interesse seleccionado.

Muito obrigado pela atenção e pelo tempo que nos disponibilizou.

Área dedicada à realização da Avaliação Experimental

Figure C.1: An aerial view from the testing field

D POST-STUDY QUESTIONNAIRE

Dados Pessoais

1. Qual a sua idade?	☐< 18 anos ☐18 a 30 anos ☐30 a 50 anos ☐> 50 anos
2. Sexo?	☐Masculino ☐Feminino
3. Habilitações Literárias?	☐Ensino Básico (9º) ☐Ensino Secundário (12º) ☐Licenciatura ☐Mestrado ou Superior ☐Outro
4. Área Profissional?	☐Engenharia ☐Artes e Design ☐Turismo ☐Outro

Competências

1. Costuma fazer ou já alguma vez fez turismo?	☐Sim ☐Não
2. Se sim, a que meios de orientação prefere recorrer?	☐Mapa em papel ☐Mapa digital/GPS ☐Outro:
3.Utiliza um telemóvel com que regularidade?	☐Todos os dias ☐Às vezes, apenas quando necessito ☐Raramente ou nunca
4.Costuma usar algumas das aplicações *media* (vídeos, jogos) que se encontram no seu telemóvel?	☐Frequentemente ☐Às vezes ☐Raramente ou nunca
5.Já alguma vez tinha manuseado um telemóvel a partir de um visor *"touch screen"*?	☐Sim ☐Não
6. Tem por hábito usar GPS ou visualizar mapas (ex: Google Maps)?	☐Frequentemente ☐Às vezes ☐Raramente ou nunca

Estudo Comparativo entre Wikitude e MKiosk

1. Considerando as duas aplicações utilizadas, qual achou mais simples relativamente ao processo de procura de informação?

☐Wikitude
☐MKiosk

Porquê ?

2. Em relação à filtragem de pontos de interesse, qual achou mais acessível?

☐Wikitude
☐MKiosk

Porquê ?

3. A definição de uma distância para a procura foi mais fácil em que aplicação ?

☐Wikitude
☐MKiosk

Porquê ?

4. A apresentação e selecção da informação, incluindo os símbolos utilizados (ex: monumentos, restaurantes, alojamentos…) pareceu-lhe mais perceptível em que aplicação ?

☐Wikitude
☐MKiosk

Porquê ?

Realização das tarefas no MKiosk

Opinião

1. A realização das tarefas no MKiosk, no geral, foi:

☐Muito difícil
☐Difícil
☐Fácil
☐Muito fácil

2. Obter informação de um ponto de interesse foi:

☐Muito difícil
☐Difícil
☐Fácil
☐Muito fácil

3. Adicionar um ponto útil *“Utility point”* foi:

☐Muito difícil
☐Difícil
☐Fácil
☐Muito fácil

4. Efectuar uma pesquisa local *“Nearby”* foi:

☐Muito difícil
☐Difícil
☐Fácil
☐Muito fácil

5. Efectuar uma pesquisa numa localidade *“Faraway”* foi:

☐Muito difícil
☐Difícil
☐Fácil
☐Muito fácil

6. Atribuir uma classificação a um ponto de interesse foi:

☐Muito difícil
☐Difícil

□Fácil
□Muito fácil

7. Qual o método que preferiu para a obtenção de um ponto interesse que estivesse à sua vista?

□Câmara fotográfica *“What is that”*
□Procura local no mapa *“Search”*

Porquê?

8. Qual o método que achou mais prático para a definição de uma distância durante as tarefas de pesquisa?

□Traçar uma área sobre o mapa
□Aceder a uma lista com distâncias predefinidas

Porquê?

9. Qual o modo de visualização de resultados por que optou?

□Lista
□Mapa

Porquê?

10. Ainda relativamente ao modo de visualização, qual a vista do mapa que preferiu?

□Vista de Satellite
□Vista de Ruas

Porquê?

11. A forma de como os pontos de interesse são apresentados na lista de resultados é o mais indicado?

□Discordo totalmente
□Discordo
□Concordo

☐Concordo plenamente

12. A forma de como os pontos de interesse são apresentados no mapa de resultados é o mais indicado?

☐Discordo totalmente
☐Discordo
☐Concordo
☐Concordo plenamente

13. Os símbolos usados para os pontos de interesse apresentados no mapa são de fácil compreensão?

☐Discordo totalmente
☐Discordo
☐Concordo
☐Concordo plenamente

14. A disposição dos símbolos sobre o mapa é perceptível?

☐Discordo totalmente
☐Discordo
☐Concordo
☐Concordo plenamente

15. Traçar uma área sobre o mapa, para efeitos de pesquisa, foi fácil?

☐Discordo totalmente
☐Discordo
☐Concordo
☐Concordo plenamente

16. O menu de atalho foi útil para a realização das tarefas?

☐Discordo totalmente
☐Discordo
☐Concordo
☐Concordo plenamente

17. A opção de ajuda foi indispensável para a realização das tarefas?

☐Discordo totalmente
☐Discordo

□Concordo
□Concordo plenamente

18. Se tivesse que escolher entre o Mkiosk e outros métodos (ex: mapas em papel, GPS ou guias turísticos) para orientação em locais desconhecidos, por qual optaria?

□MKiosk
□Outros: ____

Se respondeu outros, refira porquê?

Satisfação

1. Utilizaria o MKiosk novamente?

□Sim
□Não

2. Se respondeu SIM, assinale as opções que melhor expressam a sua opinião:

□É fácil encontrar um ponto interesse
□É uma aplicação flexível
□É uma experiência divertida
□Tem aspecto e opções simples
□O modo de interacção é acessível
□Consegui encontrar tudo o que queria
□Outras: ____

3. Se respondeu NÃO, assinale as opções que melhor expressam a sua opinião:

□Não gosto de aplicações digitais
□A aplicação é de difícil utilização
□A aplicação é pouco flexível
□Não consegui encontrar o que pretendia
□A disposição da informação é confusa
□Até utilizava, mas prefiro outros métodos de pesquisa
□Outras: ____

4. Em quais das seguintes tarefas sentiu mais dificuldades:

□Obter informação de um ponto de interesse/útil
□Atribuir uma classificação a um ponto de interesse
□Adicionar um ponto útil

□Efectuar uma pesquisa local *“nearby”*
□Efectuar uma pesquisa numa localidade *“faraway”*
□Traçar uma área no mapa
□Seleccionar as preferências para a pesquisa
□Aceder à opção de ajuda
□Visualizar uma imagem referente a um ponto de interesse
□Consultar informação adicional referente a um ponto de interesse
□Outra: ____

5.Classifique, de acordo com a escala sugerida, as seguintes questões. Se não tiver opinião formada, não preencha a linha correspondente.

Questão	**Concordo plenamente**	**Concordo**	**Discordo**	**Discordo plenamente**
O MKiosk apresenta ao utilizador os pontos de interesse/útil mais relevantes				
A forma como a informação se encontra disposta facilita a utilização do MKiosk				
A pesquisa através do reconhecimento fotográfico é mais prático que a pesquisa local				
É mais fácil definir uma distância de pesquisa traçando uma área sobre o mapa em vez de aceder a uma lista de distâncias				
Os símbolos apresentados no mapa ajudaram, por si só, no reconhecimento dos pontos de interesse/úteis				
As preferências, incluindo a selecção de distâncias, resultados e filtragem de pontos, é acessível				
As ilustrações dos botões nos menus contribuíram para uma fácil compreensão das tarefas				

6. O que gostou no MKiosk?

7. O que não gostou no MKiosk?

8. Teve algumas dificuldades adicionais na utilização do MKiosk que gostaria de acrescentar?

9. Tem alguma sugestão que pudesse melhorar o MKiosk?

Muito obrigado pela atenção e pelo tempo que nos disponibilizou.