MKiosk: The Mobile Kiosk for Tourists

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ABSTRACT

Tourism is a highly active and growing sector of the economy. In tandem, the advances in mobile computing have made platforms available for developing mobile GPS services 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. Further, touristic information sometimes cannot be found *in loco* and paper maps. With this in mind, we propose a new approach for the search, insertion and visualisation of tourist information based on the recognition of contents in photographs. We also suggest the search for information based on distances, sites or geographical areas. For the visualisation of detailed descriptions, we provide list, map and gallery views, along with the 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 under real conditions. We concluded that our approach is adequate to tackle existing problems. In addition, we found that 75% of users approved the recognition of photographs containing Points of Interest.

Author Keywords

Mobile Tourism, Content-Based Image Retrieval, Location-Based Services, Point of Interest

1 INTRODUCTION

Recently, the tourism industry has been gaining significant worldwide relevance. Emerging technologies have been also increasingly exploited to support and enable a more enjoyable and creative experience through tourism related activities, and leaflets with detailed information and guidebooks are likely to be superseded by digital resources displayed on mobile devices. 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 HCI mobile approach. The GPS technology is becoming as well widely available for mobile phones. In addition, the emergence of location-based mobile applications is likely to increase due to the availability of mobile development platforms and Google services.

Despite tourism industry evident growth and the development of e-Tourism services, some tourists still remark for a lack of information about Points of Interest (POI) and Utility Points (UP) while sightseeing, mostly due to unreferenced touristic elements on maps and especially *in loco*. Regarding existent mobile solutions, most 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.

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. In order 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 also inputs for distances and the number of results. Moreover, when tapping symbols, users are presented an additional visualization mode consisting of an image gallery jointly with related descriptions. We have also designed a location-based component to support *in loco* insertion of geo-referenced information.

Prior to the development of our approach, we started by first performing a user study to understand user's needs and habits in a tourism context. We also asked them about their expertise when performing mobile phone common tasks. Based on this, we identified a set of implication designs, which we represented on paper prototype design sessions. Upon gathering findings derived from the user study, we designed a prototype regarding users' recommendations. Along the design stage, we improved our prototype through informal testing sessions with a well-defined user group, designated the MKiosk User Group (MUG). Finally, the experimental evaluation with users revealed that they successfully took photographs to

POIs and visualized related descriptions. In addition, results for location-based features, such as searching for POIs or inserting UPs, were favourable using our approach than existent solutions.

Throughout this paper, we present some related work in Section 2, enhancing well-known fields of study: mobile computer vision (MCV) and location-based services (LBS). We also evidence some problems detected in current mobile approaches. Section 3 presents the main results of the user study and the design implications identified. Next, we describe our solution, detailing its underlying modules: the mobile module, the spatial module and the Content-Based Image Retrieval (CBIR) module. In Section 5 we introduce results derived from the experimental evaluation with users. Finally, in Section 6 we conclude the paper and discuss some future work.

2 RELATED WORK

During the research phase, we analysed current solutions according to MCV and LBS applications separately. Thus, through this section we first refer to MCV applications and then to LBS solutions. For the MCV, 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, we describe recent location-based applications, highlighting 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.

Agamemnon [1] 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. Delivered results are displayed in form of a rudimentary list or a sketchy map.

Contrarily to previous solution, the On the Go project [2] considers an CBIR system, handling real-time image capture. The capture process is carried out through real-time camera, performing multiple capture, instead of a single capture. Moreover, On the Go, does not list results according to image similarity rate.

WikEar [3] 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 [4] enables geo-referenced image retrieval. Images are interactively dragged to a search box in order to carry out image-retrieval computations. Memoria allows also map-region queries by recognizing 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, we believe that real-time 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 object and performing one single capture avoids some capture issues. 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, we believe that 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. In the context of LBS applications, we also identified some underlying constraints.

The GeoPix application [5] 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.

Mobilizy [6] 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, though 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.

Differently from general LBS, REXplorer [7] 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 [8] 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.

Finally, Layar [9], introduces a solution based on GPS and compass functionalities like Wikitude. Users may search for information according to their current position, yet only locally. Layar does not support the selection of multiple POIs through search filters.

Upon a brief analyses on some LBS applications, we note that most of solutions do not provide an advanced search component in the sense of performing faraway or traceable search queries for instance. Multiple filter selection is also 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. We believe that providing multiple displays to visualize information may overcome some issues concerning overlapping symbols.

According to previous discussions on MCV and LBS highlighted features and issues, we may infer an adequate mobile solution to tackle the aforementioned problems and to improve some existing features. Differently from general MCV applications, we aim to integrate an image-retrieval system with a geographical-based system in order to increase the performance of the recognition process concerning POIs within worldwide locations. We also aim to perform map-region based search queries over digital maps. Our approach enables map regions recognition 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. Additionally, we introduce the utility point (UP) concept which refer to geo-referenced elements regardless of descriptions, namely, WC or phone booths. We are considering to exploit the UP concept particularly for the insertion of geo-referenced elements into our system.

3 USER STUDY

In order to better understand user's profile in concern to tourism and mobile phone related activities, we carried out the user profile study during one month sensitively. It consisted of three distinct stages: administering an online survey addressing users' habits and demands concerning tourism and mobile features; 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 for paper prototypes sessions. The online survey was broadcasted to 200 respondents, though only 165 answered the survey entirely. Upon collecting and consolidating online findings, we carried out contextual inquiries, involving 8 potential users, with the purpose to capture information in a semi-structured interview which covered the entire online survey. Interviewed users were given additional attention across the system and experimental design phase. We refer to this users as to the MKiosk User Group (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.

Upon concluding the online survey stage and collecting related results, we verified that the generality of respondents does tourism or has already done it. Additional results, evidenced that respondents travel between once to five times per year. From this study we also concluded which elements do tourists prefer to photograph.

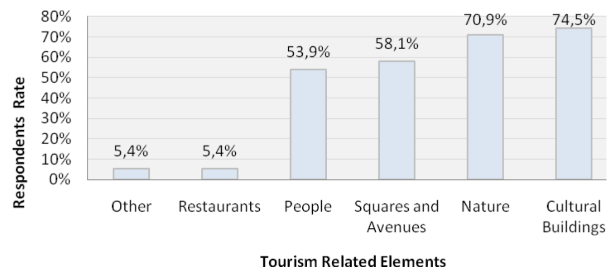


Figure 1. Respondents' most photographed elements while sightseeing

Answers in Figure 1 expresses that 74.5% prefers taking photographs to cultural buildings, 70.9% for nature elements, 58.1% and 53.9% for squares and people accordingly. Figure 2 depicts that 68.4% of responses concerns users willing to use tour guides while travelling.

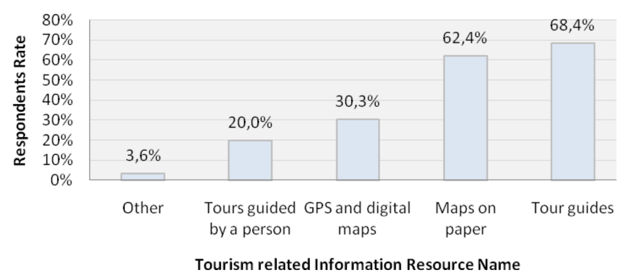


Figure 2. Preferred resources to get information about POIs

Also, 62.4% chose for maps on paper to find POIs. The remainder answers shows that 30.3% prefers using digital maps and 20.0% for tours guided by someone. This study provided answers as well in regard to the mobile technology in present day users' mobile phones. We also found out that most users have with themselves camera enabled mobile phone. In contrast, 22.4% state to use mobile phones with GPS functionality. Furthermore, we asked respondents on different camera devices to take photographs. Figure 3 reveals that the majority (91.5%) prefers taking photographs while touring using digital camera devices.

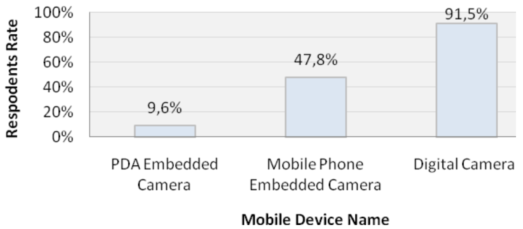


Figure 3. Respondents' preferred means to take photographs

Nevertheless, results for mobile devices are significant, in particular for the mobile phone (47.8%). In addition to tourism and mobile practices, we addressed the arrangement of POI information in a mobile phone screen. Thus, we asked users about the displacement of different types of information concerning an observable museum.

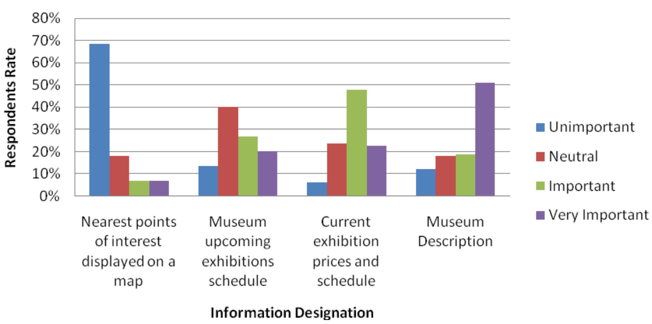
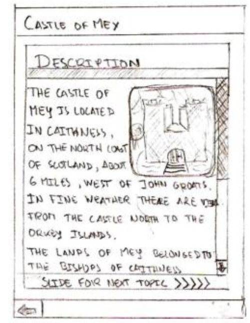


Figure 4. An overall view on respondents' considerations to museum related information arrangement on the mobile phone screen

Figure 4 shows that a description about what is being seen is definitely the primal choice, along with prices and schedules, and upcoming exhibitions. During paper prototype sessions, we designed some screens according to users' needs and recommendations given throughout online surveys, contextual inquiries and informal interviews. Figure 5 illustrates to paper prototypes created through design sessions. In Figure 5 (*a*) it is represented a list showing existent POIs in user's surroundings. On the contrary, Figure 5 (*b*) shows an illustration referring to a POI description displayed in response to a user's request.

(*a*) A list containing POIs



(*b*) A description and an illustration of a POI

Figure 5. Paper prototypes designed according to findings

Upon perceiving the needs and habits of present day tourists, we proceeded with the design of our solution.

4 PROPOSED SOLUTION

With this solution we wanted to give users the ability to search, insert and visualize geo-referenced contents while touring. To that end, we first performed a user profile study. We tried to find out user's requirements concerning habits in tourism activities, with digital resources and the visualization of information in mobile phone screens. Based on its results, we designed our solution. The framework we propose involves three different components: the geographical component, the image-retrieval component and the mobile component. We named the geographical component as GeoFinder. 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 we can see in Figure 6, the interconnected modules of our solution jointly follow a client-server architecture.

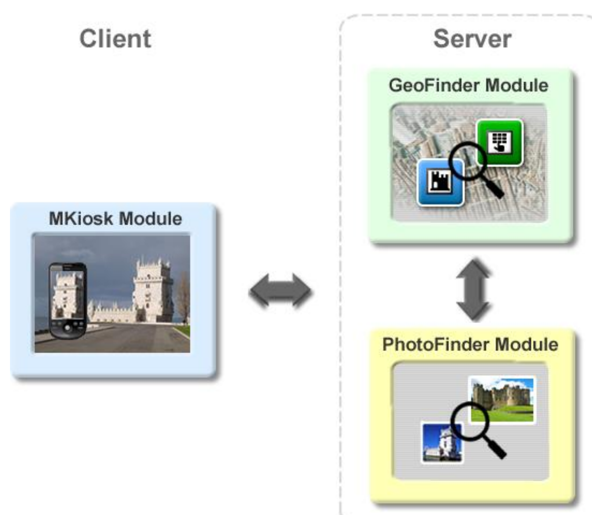


Figure 6. A modular overview of our solution

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.

MKiosk Module

The current section exposes an overview of the solution we have determined for MKiosk. Due to mobile technology advancements, we were able to achieve some creative interaction features engaged in touch screen based devices. Thus, a careful and thoughtful interface design was indispensable. We therefore decided to carry out the overall interface design process followed with the MUG intervention. The MKiosk component deals with linking users and the basis of our work. In this sense, it is crucial designing appropriated interfaces to succeed objectives determined.

Our solution allows users to take photographs to observable POIs and to visualize related descriptions. On capture and visualization purposes, we consider some additional features, like for instance enabling photo recapture and displaying similar results through a list component, Figure 7 (a). In addition to the list display, we also provide a map display to organize and present results within a different approach Figure 7 (b).

(*a*) Results over list (*b*) Results over map

Figure 7. Different visualization modes

Regarding the location-based features, we provide map-based interfaces allowing users to handle symbols directly over the map. Figure 8 presents a POI and an UP symbol.

(a) A representation of a castle POI (b) A fast-food UP element

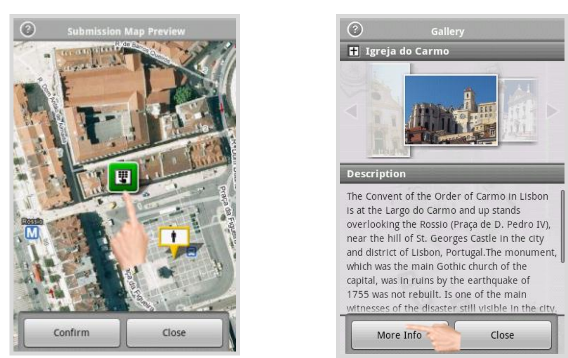
Figure 8. POI and UP symbols

POIs and UPs symbols are assigned distinct themes, i.e., symbols are distinguished by different colours and icons, as Figure 8 depicts. With regard to location-based queries settings, we enable users to select distances through a list containing values by default, to input well-defined localities and to trace geographical areas. The process of inputting localities is based on a text input search box which requests locations from the Google Maps service.

(*a*) Faraway location (*b*) Tracing map region

Figure 9. Different search-based Inputs

Concerning the UP insertion query, MKiosk allows the selection of an UP through a list containing the UPs available in our system. We also provide an interactive map display to enable the placement of an UP by pressing directly over a specific map region Figure 10 (a). The visualization of the information delivered to the end-user upon performing a query, is displayed in different views. Our solution supports a flexible visualization of results through map and list displays. We enable as well an additional view to present results over a gallery Figure 10 (b). Still in concern with the visualization purposes, MKiosk introduces a particular screen regarding POI or UP additional information. The contents of this screen are dynamically generated according to the additional information assigned for each element.



(*a*) Placing UP over map (*b*) The Gallery view

Figure 10. Interactive Map for UP and Gallery view

GeoFinder Module

The GeoFinder component was designed to handle location-based queries requested by MKiosk. These queries are based on a distance and a number of results. Additionally, we consider POIs and UPs category inputs as well as their geographical coordinates. We therefore allow distance-based queries which return geo-references within a well-defined range. The GeoFinder component represents also an important contribution to improve the performance of CBIR systems. In addition to the queries, GeoFinder holds POIs and UPs related information, with particular focus on the geographical data. Figure 11 depicts an overall representation of our database structure concerning POIs.

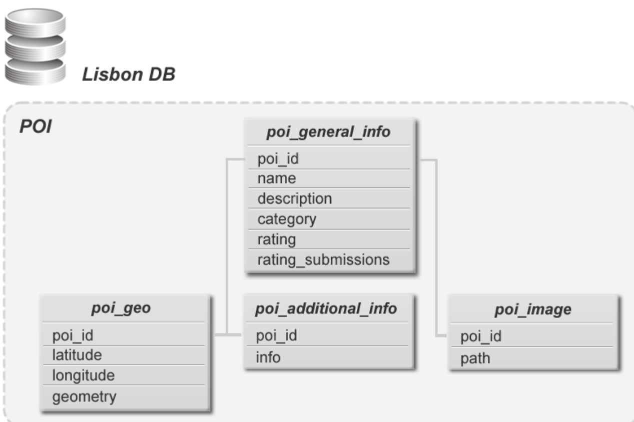


Figure 11. An overview of POI database structure

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 we believe that maintenance and update tasks will be easier.

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. In Figure 11 we depicted and described the database structure for POIs in the GeoFinder module. Figure 12 depicts the database framework we designed to support our solution. According to the illustration, PhotoFinder and GeoFinder follow an identical structure concerning the localities.

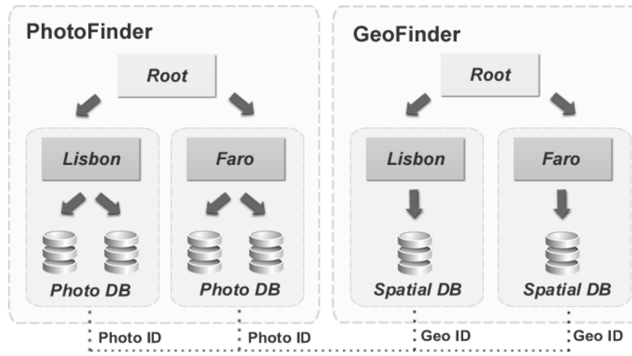
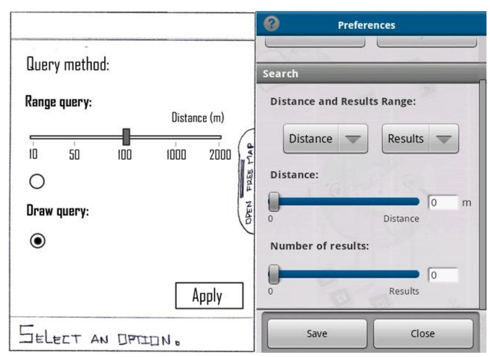


Figure 12. An overview of POI database structure

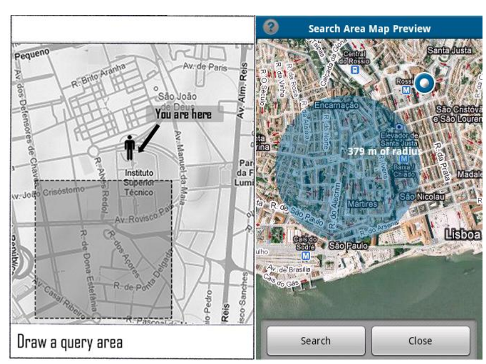
Their databases, however, are defined for different purposes: databases for PhotoFinder hold information on POIs image data; on the other hand, databases for GeoFinder hold spatial data for the same POIs. In order to associate both image and spatial data for a specific POI, we establish an ID relation for each POI in PhotoFinder and GeoFinder databases, as Figure 12 shows.

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, Figure 13. We were able to test our design ideas and especially user's design ideas.



(*a*) Distance Settings design



(*b*) Search map region design

Figure 13. Paper prototypes and prototype design

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 13 shows two different illustrations designed along the user profile study and the system design accordingly.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 13 (*a*) and (*b*), are screens from the first iteration of the prototype design.

5 USER EVALUATION

The main goal of the study performed consisted in evaluating our proposal for MKiosk and answer to the objectives formulated in the Section 1. The solution we designed enables taking photographs to POIs and recognizing their contents, as also searching for POIs and UPs, locally or remotely. During experiments we have attempted to find out users' behaviours while interacting with MKiosk in a real life scenario. With this study we collected relevant results concerning user's willingness to photograph POIs and visualize related information. We gathered results as well on the execution of location-based features, in particular tracing geographical areas. In addition, aiming to investigate our assumption that users would successfully insert UPs into the system, we managed to meet all real-life conditions to ensure realistic results.

Procedure

The user study was performed in an outdoor environment situated in Square D. Pedro IV, Lisbon. 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. We first conducted a comparative user study. Upon concluding the comparative assessment, 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. After both studies completion, participants were asked to complete a post-study questionnaire followed up with a non-structured interview. Each experiment took around 60 minutes to complete.

Participants

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 phone everyday 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.

Tasks

Our experiment was designed considering distinct studies. We have assigned each study different tasks due to some Wikitude constraints compared to our solution.

Table 1. Tasks used for the experiments

Comparative User Study	
Task	**Description**
T1	Present a description about an observable POI;
T2	Obtain an address for a restaurant within 1000 meters of distance;
User Study	
Task	**Description**
T3	Verify the existence of an UP in MKiosk. If not present, add to MKiosk;
T4	Search the nearest 10 churches and museums. Preview a picture of a given result;
T5	Search, in Sintra, for palace's tour prices.

Table 1 presents the five tasks defined for the user evaluation. In this sense, the comparative user study was based on two tasks. In contrast, the MKiosk user study addressed three tasks. To estimate step-by-step completion times we have disjoined the search tasks into two parts.

Table 2. Sub-tasks for search-based tasks

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

Thus, Table 2 presents two different sub-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.

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 3 shows their meaning in more detail.

Table 3. Experimental variables for experiments

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

As we see in Table 3, variables are arranged according to variable type. The *Mobile Application* variable differs between two different levels, Wikitude and MKiosk. Regarding dependent variables, we first have *Task Completion Time* variable which consists in the time elapsed to perform the overall task. In contrast, the *Number of taps performed* variable counts the occurrences of tap events and steps performed while executing tasks.

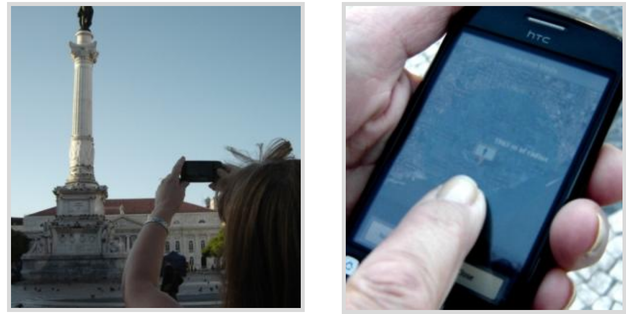
Equipment

The study was carried out with a mobile phone recently brought to the mobile phone market, Figure 14. The HTC Magic, an android-powered mobile phone, provides a touch screen display and enables Google Maps based mobile applications. It also incorporates camera, GPS and compass functionalities.

Figure 14. The HTC Magic mobile phone

Results

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. We then performed the user study under a real life scenario. Figure 14 presents different search interactions with MKiosk registered during experiments.



(*a*) Participant taking photograph to a POI

(*b*) Tracing a map region to search POIs

Figure 15. Illustrations of outdoors experiments

In Figure 15 (a), we see a participant photographing a monument through the POI recognizer feature and in Figure 15 (b) a search interaction using *trace area mode*. We next analyze and discuss the results gathered throughout this study and present participants' contributions. We begin by the comparative user study

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.

Execution Time

Overall, results show that our solution is faster than Wikitude. Figure 16 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. Nevertheless, the overall task performance was favourable for MKiosk mostly due to symbol overlapping detected in Wikitude.

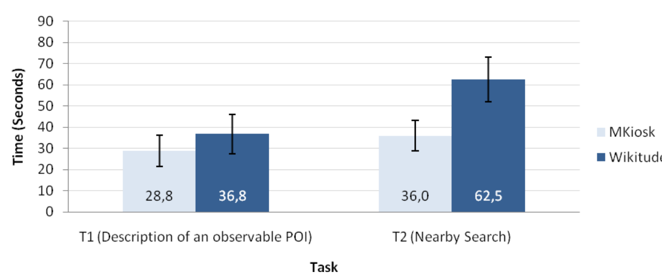


Figure 16. Average time to complete comparative tasks

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. Figure 17 shows completion times in regard to sub-tasks of search-based tasks.

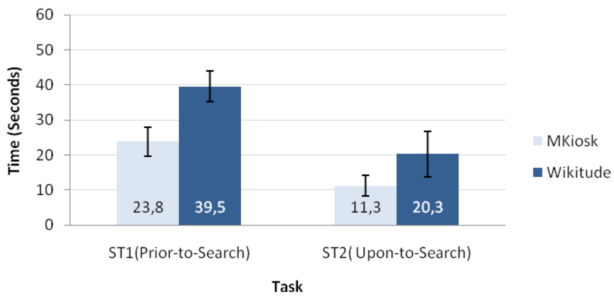


Figure 17. Average time to complete sub-tasks

These sub-tasks are designated ST1 and ST2, see Table 2.To better understand subjects' progression we measured tasks partially. As illustrated in Figure 17, 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. 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. According to users and examiner's remarks, the selection of symbols in Wikitude, Figure 18, revealed to be a cumbersome process due to symbols overlapping, and to their size and uniformity.

Figure 18. Symbol overlap for large distances in Wikitude

Taps Performed

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 19.

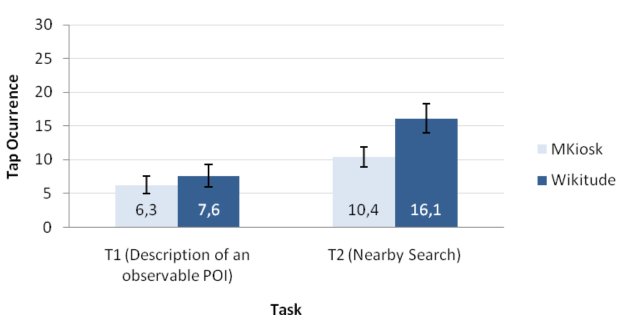


Figure 19. Task tap frequency average

Considering task T1, results were approximately equal. 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.

User Satisfaction

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. 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.

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.

Execution Time

Figure 20 discloses, in general, approximated results in consideration to the three tasks, see Table 1. According to post-study comments and examiner's notes, participants felt frequently comfortable while performing tasks. Figure 20 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.

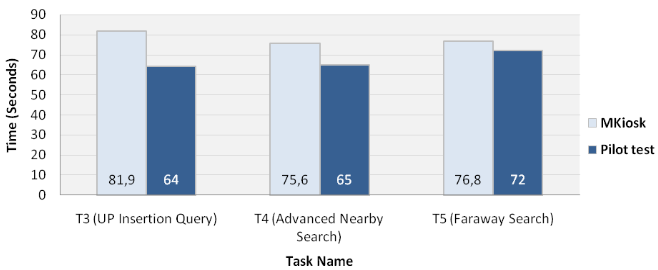


Figure 20. Averages on task completion times for MKiosk tasks

During tests some iterations were also frequently repeated. For task T3, the presented results in Figure 20 evidence a significant difference. 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. Still, they all concluded task T3 successfully. Results for Task T4 did not represent a significant difference as Figure 20 confirms. In this sense, we believed 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. Figure 21 depicts MKiosk sub-task completion times for search-based tasks.

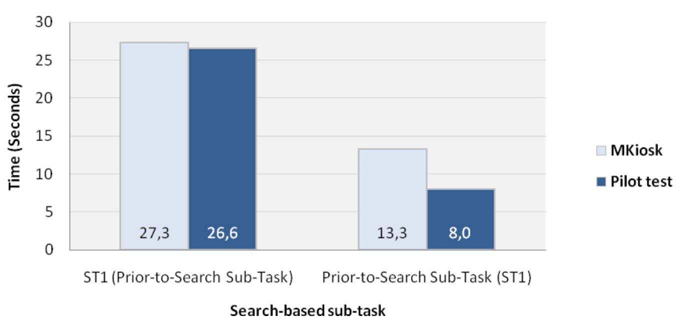


Figure 21. Sub-task completion time averages concerning search-based tasks

For task ST1, we may conclude that the average of completion times is clearly balanced. On the contrary, ST2 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.

Taps Performed

Results in Figure 22 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.

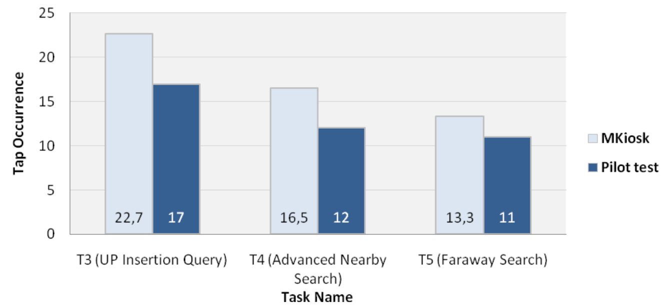


Figure 22. Task tap occurrence average for MKiosk tasks

This reaction leaded to a higher screen iteration, and thus an increase in taps performed. In the next section, we address participants' subjective results.

User Satisfaction

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. Generally, post-study responses evidenced that tasks and underlying operations were successfully performed. Participants were also asked about if they would use MKiosk again, and they all answered affirmatively. We have confirmed 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 Image Recognition feature and the Search feature. Subjects for the first 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. About the results on information display views, 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 because 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. Concerning location-based features, in particular setting wide search areas, we concluded that most of participants chose for defining distances through the *trace area mode* due to a better space awareness.

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). Taking in consideration interface issues, we were recommended to enlarge main controls at the bottom of the screen. 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.

6 CONCLUSIONS AND FUTURE WORK

In this paper we proposed a new approach to search, insert and visualize geo-referenced information. The results collected through user experiments were outlined in Section 5, 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 easily 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. 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.

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.

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