Evaluation of Multimedia Features in Mobile Guide Applications

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ABSTRACT: *Mobile guide applications are among the most used applications in Today's smartphones. These applications provide position information, map, directory services as well as guidance. Still there are many multimedia features that could be added to these applications. We present a user study on such applications, comparing the commercial Google Maps and Nokia Maps with two prototypes that we have created to expose missing multimedia features in the commercial applications. We have evaluated the applications with real users and we have obtained direct feedback via questionnaires as well as implicit feedback using an observer framework.*

Categories and Subject Descriptors
H.5.1 [Multimedia Information Systems]: C.1.4 [Parallel Architectures]: Mobile processors

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1. Introduction

Nowadays mobile phones have become an indispensable accessory for most people. The increasing demand for more capabilities and features has transformed current devices into small fully functional computers with plenty of sensors. These powerful devices, called smartphones, can provide information such as position [1], [2], orientation, light intensity, surrounding sound, real images and more. Mobile services that use the position information are commonly referred as location based services (LBS) [3]. More generally, if the applications use more context-related information they are referred as context-aware applications [4]. Among all these context-aware applications, very popular are the mobile guide applications which provide a map to explore the environment, the user position, a directory service to find nearby restaurants or other interesting places, and very often a guidance service to find your way from your current position to a given destination. The most popular commercial mobile guide applications are `Google Maps`[1] and `Nokia Maps`[2].

Based on the capabilities of current devices for using rich-media content, we observed that existing mobile guide applications are not fully exploiting these multimedia capabilities. We have created two prototypes which include rich-media features missing from existing commercial applications. Our goal is to determine what are the user expectations from these applications and how they perceived our prototypes. We have focused only on the way in which the points of interest (POI) are presented to the users in these applications. Other factors such as route planning or directory service have not been considered.

In order to get a clear feedback from the users we have made an empirical evaluation with real users comparing Google Maps and Nokia Maps with our two prototypes in the context of the Toulouse stadium. We used this venue as it is a very popular place in our city. On big events, before and after the match there are plenty of attractions and activities around the stadium. Example of such activities are small football contests or rotating cups (see Figure 1). These attractions can be hard to observe and locate, especially due to the large number of people that participate to such events.

During the user evaluation we obtained explicit and implicit feedback. The explicit feedback was obtained from questionnaires completed by the users after each test. To obtain implicit feedback we used a framework that captured all the interactions between the user and the applications. All the results from both implicit and explicit feedback have been extensively analyzed and we have been able to extract interesting results.

The work presented in this article is based on our previous user study [5]. There are many changes done for this new work. First of all we have used the third version of `Nokia Maps`[3]. Secondly the questionnaire was completely rebuild using more informative items. Thirdly we conducted our user tests directly at the stadium where users could perceive the real usefulness of the tested applications.

2. Related Work

One of the first prototypes of a mobile guide application was Cyberguide [6], when Abowd et al. from Georgia Tech analyzed what should do the mobile guide, what was the current and future technology that could be used. Many of their ideas from 1997 are still used today. An extensive study on mobile guide applications was done by Ojala et al. within the project `Smart Rotuaari` [7]. In this project multiple mobile services have been tested, including Bluetooth localization, mobile advertising, mobile multimedia broadcast, Wireless positioning, 3D visualization of the city, service directory and mobile payment. For many of these services an extensive user study has been made. Baus et al. [8] present a survey of mobile guide applications until 2004. This survey presents research map-based mobile guide applications as well as an analysis and comparison of the presented systems.

[1]http://www.google.com/gmm
[2]http://europe.nokia.com/maps
[3]http://www.nokia.com/betalabs/maps

Figure 1. Stadium Activities Before the Match

In 2007 Koutsiouris et al. [9] have presented a framework and a business model for 3G location based services. They have analyzed how multimedia content could greatly improve location based services and help operators in deploying and benefiting from such services, taking in consideration the improved data bandwidth provided by the 3G network. In our previous work [10] , we have shown how images rendered from 3D models can be used as a great user interface for mobile guide applications. This technology, called `fake 3D` is used in one of the presented prototypes. This kind of user interface gives the users the sensation of navigation in a 3D model but it doesn't imply the complexity nor the computational requirements of a real 3D model. Renzel et al. from RWTH Aachen University [11] have created a testbed for mobile multimedia community services, based on the communication between a mobile application and their lightweight application server (LAS). They have also presented a new success model, `MobSOS`, which is used by their system to find out if a mobile multimedia service will be successful. We have used part of their success model in our user study. We did not use their entire system because we needed to compare four different mobile applications on specific features, and not the success of a given application. Also, as it will be presented, we already had a test framework to analyze the interaction between the users and the applications. Recently [5] we have conducted another user study where we compared mobile guide applications. The work on this article is based on this user study, but we have improved the test methodology as well as the tested applications.

It is not sure how mobile guide applications will look in the future, but it seems clear that users will be able to take images from any place and see information about it, either as a new augmented image or in real-time while using the mobile phone's camera. In Mobile Tourguide System [12], Yow et al. present a solution which uses a database of panoramic images to recognize an image snapped using the mobile phone. After the image is recognized an augmentation with useful information is sent back to the mobile user.

A similar idea which uses panoramic images from a given position is presented by Baldauf et al. in the project `WikiVienna` [13]. In this approach, a server analyzes all the images sent by different users and when there are enough images from a location a reconstruction of a simple 3D model from that point is made. When a mobile user requests a map from that place a panoramic image is rendered from the reconstructed 3D model and sent to the requesting user.

3. System Overview

In order to investigate multimedia features missing from commercial mobile guides applications we created two prototypes which are presented in this section. We compared these applications with the commercial applications Google Maps and Nokia Maps in a user study which is presented in the next section. In order to retrieve the user's opinion on the applications we used questionnaires to obtain direct feedback and an event listener framework which provided implicit feedback based on all the interactions between the users and the applications.

A. Hardware

All the applications have been tested using a `Nokia N95`[4] mobile phone. This smartphone has multiple features, including A-GPS, GPU, dual processor (ARM11), Wi-Fi, 5 Mega-pixel camera, 240x320 screen resolution and the possibility to play MPEG4 video files. The N95 runs on the Symbian OS, version 9.2 and it provides a rich sets of APIs to access most of the phone's features. We have used the native Symbian C++ to develop our prototypes.

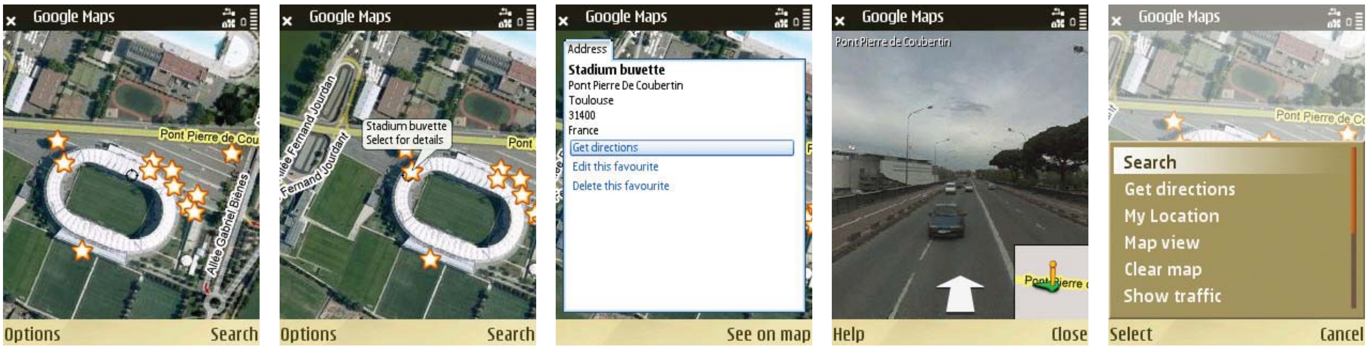
B. Applications

Below we present the four applications used in our tests, starting with the commercial applications and ending with our two prototypes.

1) Google Maps: Since its release in February 2005, Google Maps has been one of the most popular web guiding applications. Besides the web application, Google has created Google Maps for mobile devices. One of the most popular features of the mobile Google Maps is called `My Location` which can give the approximate location of the user by using only the information from the mobile network without any constraint on the GPS capabilities of the phone. The last version of the Google Maps for Symbian (2.03) also offers the Street View feature, allowing users to actually see real images from the places they choose. Nevertheless, this last feature is available only for major cities in a few countries.

The Google Maps application interface can be seen in the Figure 2. The stars represent the points of interest -POI-(the activities around the stadium in our case). The user can move through the map using the navigation keys (up, down, left, right), zoom in

[4]http://www.nokia.fr/les-produits/tous-les-mobiles/nokia-n95-8gb



(top view) (target on POI) (POI selected) (Street View) (Options Menu)

Figure 2. Different snapshots of the Google Maps application

and out using the 1 and 3 keys, select a POI using the middle key in order to see more information about it, see a list of the POI, center the map on the selected POI and switch between a simple 2D map or a satellite view. The position of the user (if available) is marked in the interface by a small blue dot. It is also possible to use the Street View feature to see images from the *Point Pierre de Coubertin* which is close to the stadium.

2) *Nokia Maps:* Nokia Maps is developed by Nokia and it is one of the most popular mobile guide applications[5]. Its success is mainly due to the fact that it is targeted only to mobile phones and its features and user interface have been thought especially for these devices. This application is only available for Nokia phones, running the Symbian OS and using the S60 or S40 user interface. The stable version (2.0) only has 2D and satellite images, but the 3rd version which is already available for many devices running Symbian 9.2 or later allows a 3D navigation of the maps, including 3D landmarks. This last version includes a coarse 3D model of the Toulouse stadium, the venue used for our tests.

In the Figure 3 we can see the user interface of Nokia Maps for both versions 2.0 (left) and 3.0 (others). The blue balloon-like icons represent our POI. The navigation through the map and selection of POI is done in a similar manner as in the Google Maps application. The main differences are in the map and POI interface, the way to display the information of the POI and the options of the application. The position of the user is presented by the rounded dashed rectangle. When the user is navigating through the map and the rectangle position is close to a POI its border line transforms to a continuous line.

[5]http://www.abiresearch.com

For the tests presented in this article we have used the latest version of Nokia Maps. This has influenced strongly the results of the tests compared with the results obtained in the precedent work where we have used the previous version of the application.

3) Prototype 1 -Fake 3D: Our first prototype uses a `fake 3D` model based on images rendered from a 3D model of the stadium. One of the main differences of this approach when comparing it to the 3D landmarks from Nokia Maps is that we use a fine and high quality model of the stadium. The application allows the user to navigate around the stadium using simple images and it gives the sensation of a realistic navigation in the stadium.

The interface of the application can be seen in Figure 4. The application presents a perspective view of the stadium around which the user can move using the left and right keys. On top of the image we have overlaid numbered icons representing the points of interest. When the user presses the key corresponding with the number on the icon a new image is presented to the user, containing a visual representation of the POI as well as a text containing more information regarding the activity or place. Using the * and # keys of the phone the user can zoom in and out in the images in order to see better where each activity is located.

4) Prototype 2 -Video Sequences: In the second prototype we use video sequences recorded from the stadium to show exactly what interesting activities or places exist around the stadium just before the actual game. A key difference from our previous work [5] is that we have added audio comments to our video sequences. This has improved considerably the usefulness of this prototype and the results have changed unexpectedly.

(Nokia Maps 2.0) (target on POI) (POI selected) (Options Menu) (3D Navigation)

Figure 3. Different snapshots of the Nokia Maps application

(perspective view) (perspective view) (zoom in) (POI selected)

Figure 4. Different snapshots of the fake 3D prototype

(top view) (zoom in) (POI selected)

Figure 5. Different snapshots of the video prototype

As it can be seen in Figure 5 we have used a top view of the stadium taken from Google Earth[6] to display the stadium area to the user. On top of this image we have added overlay icons representing the interesting activities and places. The user can zoom in or out and move around the top image to locate the position of the icons. When she presses the key corresponding to the icon a video sequence is played in the application, showing the real activity. The user has the possibility to adapt the volume using the volume keys of the device and she can stop playing the video using the middle key.

The points of interest (POI) used in the four applications represent different activities that exist around the stadium with the occasion of a game (see Figure 1). The same POIs are used in all the four applications, even if they are represented in different ways: default markers on Nokia Maps and Google Maps, numbered icons in our prototypes.

C. Observer Framework

Based on our existing work [14] we have created a new framework that is able to capture and analyze all the events produced by the user when she is navigating in one of our web-pages. We have used the same framework in order to analyze all the interactions between the user and the mobile applications. Normally the user tracking service works only with HTML pages : our platform includes a proxy that modifies the HTML page returned to the user in order to add some JavaScript listeners intended for tracking user interactions (mouse-click, mouse-move, key-input, etc...). In order to make our mobile applications work with the platform, we have created a bridge (`Bridge`) which listens to HTTP requests from the mobile application and then forwards them to the actual service (`Observer` and `Database`, see Figure 6).

[6]http://earth.google.com/

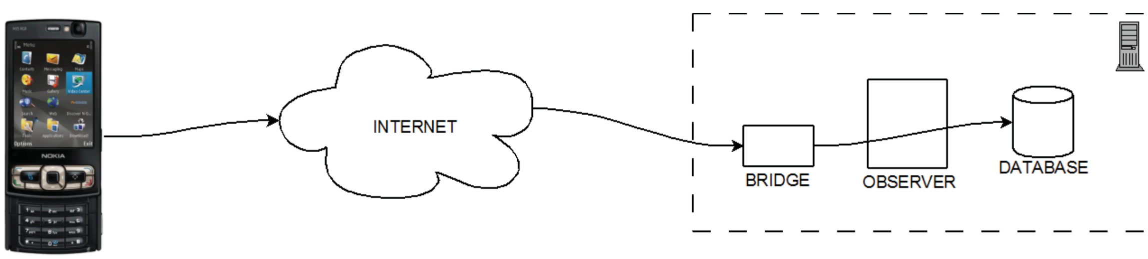


Figure 6. Observer Framework Overview

Figure 7. Tests at the Toulouse stadium

In order to analyze the interaction (key events), in our case, between the user and the mobile applications we have created an intercepting application that was running in the background in the mobile phone. The Symbian OS 9.2 allows an application that runs in the background to capture any key event as long as it has the proper capability rights. After a key event was captured we sent a HTTP request to our observer service via the `Bridge` in order to log the event.

After having recorded all the events from the test we used the observer framework to analyze them. Some results were computed automatically by the framework while for others we created specialized scripts in order to retrieve information particularly interesting for this user study.

4. User Evaluation

In order to compare the presented applications we made a user study with real people at the Toulouse stadium, on the occasion of a big rugby derby `Stade Toulousain` vs `Stade Français` (See Figure 7).

Convincing people to make our tests while they are waiting to enter the stadium for such a great match is a challenging task. For this reason we gave each test user a bottle of juice as a reward. Generally it was easier to find test users among young people which were not standing near the entrance.

The test protocol was the following

- brief the user with an overview of the test, explain why we are doing it and present the applications
- start a new test session for this user; the new session ID was also written on the questionnaire in order to match the results from the questionnaire with the logged data
- test first application
- complete the questionnaire for first application
- test second application
- complete the questionnaire for second application
- complete the general information questionnaire
- reward the user

From our previous experience [5] we observed that testing all the four applications one after the other was not a good method as users lost their interest after the first applications tested. In this user study we have tested only 2 applications per user. For each test we have randomly chosen one commercial application and one prototype.

Another improvement in this study was providing the test users with a clear task. Instead of simply using the application for a given amount of time, in this tests we have asked the users to find 4 activities among the set of 9 on each tested application. This method allowed us to analyze how easy was to find the activities using each of the applications.

We had a total of 21 users. 15 were between 18-30 years, 5 were between 31-50 years and 1 was older than 55 years. Among them 13 were men and 8 women.

The questionnaire was divided in three parts. One part for the first application, another part for the second application and the last part was used to get general information about the user. The questionnaires for each application had the same items. While creating the questionnaire we greatly benefited from the `MobSOS` success model [11]. For all the items in the application's questionnaire the answer could be in the form of a value between `1` (very bad) and `5` (very good). These items were divided in three categories: `System Quality`, `Information Quality` and `User Impact`.

5. Results

From the user evaluation we obtained two results, direct feedback from the questionnaires and implicit feedback by analyzing the events recorded using the observer framework.

A. Questionnaires

The items used in the questionnaires as well as the applications with the best score can be seen in Table I. The complete statistics for the most important results are presented in Figure 8.

In the charts (a) and (b) we show the average value of the response from the test users. In chart (c) we show the percentage, in average, of the remembered activities when each of the presented applications was tested first. An interesting but expected result is that people remember more activities while watching a video. In charts (d), (e) and (f) we show the percentage (100% is 1) of users which have voted each application as the preferred, most visually appealing and most easy to use, respectively. We must remember that we have tested the applications two by two which means that the maximum percentage when summing the four applications is actually 200%.

We had 8 users testing the second prototype which used video sequences. From these, 4 used the audio comments and 4 did not. Based on the questionnaire results, all the users using audio comments voted the `video` prototype as the preferred application while from the users that did not use the audio comments only 2 of them voted the `video` prototype as the preferred application. Based on this result and also comparing current results with our last user study we can certainly confirm that video sequences with audio comments is one of the best multimedia contents for mobile guide applications, even if these videos are not of professional quality.

Feature	Application with best score
Intuitiveness	Fake 3D
Responsiveness	Video Sequences
Multimedia Support	Video Sequences
Usefulness in Stadium Context	Nokia Maps
General Usefulness	Nokia Maps
Understandability	Fake 3D
Completeness	Fake 3D
Overall Presentation	Video Sequences
POI Presentation	Fake 3D
Overall Satisfaction	Fake 3D
Information Satisfaction	Fake 3D
Privacy Support	Google Maps
Preferred Application	Fake 3D
Most Visually Appealing	Fake 3D
Most Easy to Use	Fake 3D
Remembered Activities	Video Sequences

Table 1. Questionnaire Results

A clear difference from the previous work is that in these results Google Maps has been overpassed in most of the items. This is mainly caused by the last version of Nokia Maps used as well as the improvements in our second prototype in which we have added audio comments to the video sequences. Another important factor for the different results is the way in which we have tested the applications. In the previous user study we have always started the test with Google Maps followed by Nokia Maps and users lost all their interest when they reached to our prototypes. For this new user study we have mixed the applications, testing only two by two, always comparing a commercial application with a prototype.

B. Observer Logged Data

Using the observer framework we were able to capture over 5000 user events during the user test. We have analyzed this data and we show the most interesting results in Figure 9.

From chart (a) we can observe that the time needed to complete the task in all the applications is comparable. In charts (b) and (c) Nokia Maps is the application with the highest level of activity. This was probably caused by the way in which the POI were selected. Without zooming in it was hard to select activities which where closely positioned. We can also observe that the `video` prototype required the least interaction which could be intuitively translated as being one of the most easy to use applications, fact proven also in Figure 8f. The great amount of time needed in the `video` prototype to visit each POI in chart (d) can be explained by the length of the video sequences of about 5 seconds, compared with a simple image or text which could take about 2 seconds to be viewed by an user. From chart (f) we can observe that users have zoomed in and out more in the `fake 3D` prototype than in the other applications, probably due to the nice content and the desire of exploration.

C. Analysis of Results

After analyzing the results, both in terms of explicit and implicit feedback we can comment the impact of the features in each application.

Google Maps scored close to the other applications in most of the analyzed features but it was not the best application in none of our items. The only exception was the `Privacy Support`, where we cannot determine why users preferred this application, as none of them were asking for user information. `Google Maps` has obtained a low score especially on the POI presentation. The presentation of the POI was simply a text as well as on `Nokia Maps` but surprisingly the latter has obtained a better score, probably because of the influence of the nice 3D stadium landmark. We should note that in our tests the users did not use the `Street View` feature of this application which could have possibly increased its score for a few items. We did not use that feature first of all because our activities were not visible in the images from `Street View` and secondly because it was complicated for the unexperienced user to navigate inside the menus and switch between different views of the application. These results for `Google Maps` were very surprising as it was one of the preferred applications in our last user study. The changes introduced for `Nokia Maps` and the `video` prototype have influenced significantly their ranking.

Nokia Maps has obtained good results in most of the tested features. As it can be seen in Table I it was the best application in terms of `General Usefuleness`. The main drawbacks of the application were in its usability, as it can be seen in Figure 8f. This is probably caused by the way the application handles the POI selection. For the experienced users the interaction is good, as the view dynamically adapts to the closest POI and it zooms in or out automatically but for new users these features can present an impediment at the moment of choosing between `Nokia Maps` and `Google Maps`. A very important feature of this application has been the 3D model for the Toulouse stadium. Comparing the results from the current tests with our previous user study it is clear that `Nokia Maps` has obtained a very good score thanks to this feature. This kind of multimedia content is very intuitive and appealing for users.

The **fake 3D** prototype has been voted as the preferred, most visually appealing and most easy to use application. These results are consistent with the previous results and confirm that our fake 3D user interface is one of the best choices to display important buildings or any other kind of environment in mobile guide applications. An important feature used in this application was the use of descriptive images to display the different activities (See Figure 4). It should not be hard to use

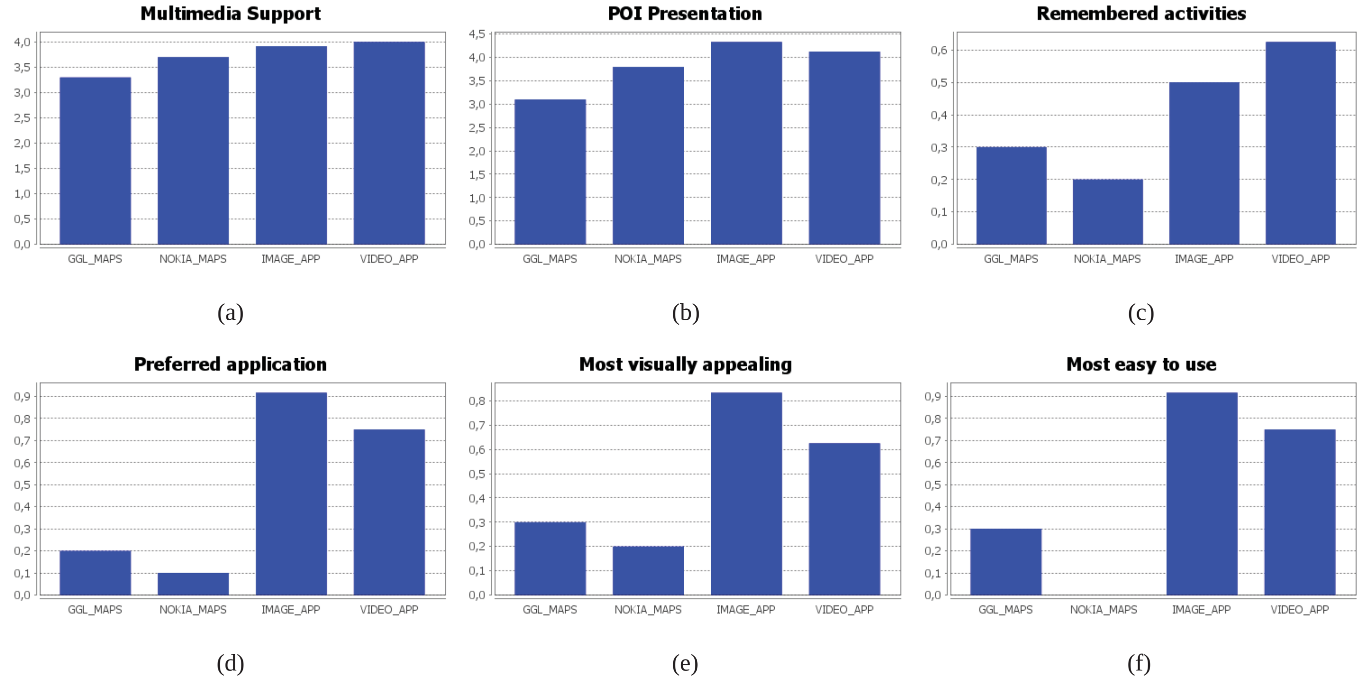


Figure 8. Questionnaire Statistics

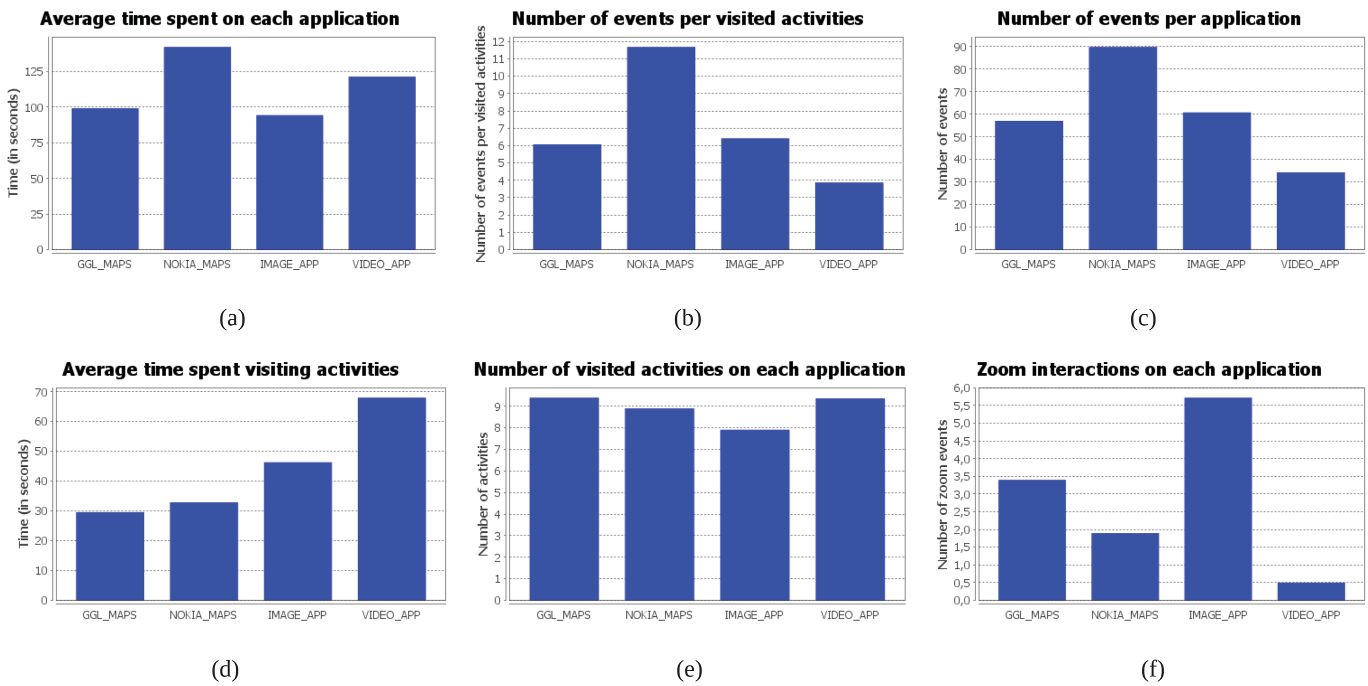


Figure 9. Log Statistics

some descriptive images for the common POI in commercial applications, for e.g. an image with a sandwich and a coke for a snack-bar. This would increase the understandability and usability of the application. There are no such simple images in `Nokia Maps` or `Google Maps`. It is also true that showing a POI for all the small activities like in our tests would possibly decrease significantly the usability of the application.

The **video** prototype has shown the most surprising results. In our last user study, in which we did not add audio comments, it was ranked among the last. It is clear from current results that video sequences showing real images from a place together with audio comments is a great combination of multimedia content to be used in mobile guide applications. As it can be seen in figure 8c this type of content helps users to remember and implicitly understand the POI much better than the other types of content. This content can be used to show and describe routes in mobile guide applications. It can also be used in a `Youtube` fashion, in which users can share their videos with audio comments.

Based on the presented results we can conclude the following:

- 3D-like content is the best to represent the environment, either using 3D landmarks as in `Nokia Maps` or 3D images as in the `fake 3D` prototype or in the `WikiVienna` project. Real images like in the `Street View` feature of `Google Maps` also represent a good content but this feature should be made easier to use.

- Videos with audio comments and descriptive images are the best solution to show the points of interest. For noisy environments subtitles should be added to the videos to replace the audio comments which may be impossible to hear.
- A more simple selection of POI is preferred. An example is shown in our prototypes, where a POI was selected by pressing one of the numbers in the phone keyboard. Touch-screen phones will probably make this interaction even easier.
- Mobile guides should adapt their user interface (e.g. zoom level, POI selection) to the dynamic interactions of the users as in `Nokia Maps`

6. Conclusion and Future Work

In this article we have analyzed multiple features of mobile guide applications, comparing `Nokia Maps` and `Google Maps` with two prototypes created in our lab, focusing on the multimedia content. We have made a user study with real users, obtaining implicit and explicit feedback. For the explicit feedback we have used questionnaires inspired from the `MobSOS` success model. To retrieve the implicit feedback we have used an observer framework that was able to log and analyze all the interactions between the test users and the mobile applications. We have presented and analyzed the results. We have also compared these results with those obtained in a previous user study in which we have used the older version of `Nokia Maps` as well as a worse version of the `video` prototype. The results presented in this article could be used as a guideline for the multimedia content in current and future mobile guide applications. In the near future we want to continue the research on user interfaces and new ways of visualizing

the environment in mobile guide applications. More precisely we want to focus on the use of augmented reality on mobile devices and the recognition of the environment.

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