# Evaluation of Multimedia Mobile Guide Applications

Omar Choudary, Benoit Baccot, Romulus Grigoras and Vincent Charvillat
University of Toulouse

**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.

**Index Terms**

Mobile Guide, Mobile Application, Multimedia, User Evaluation, POI

## I. 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]–[6]. 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 and 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 ability of current devices for dealing with rich-media content, we observed that existing mobile guide applications are not fully exploiting these multimedia capabilities. We created two prototype applications to include rich-media features missing from existing commercial applications. The aim of this work is to retrieve the user expectations for mobile guide applications and to analyze the user experience while using our prototypes and the commercial applications. We have focused mainly on the presentation of the Points Of Interest (POI). Other factors such as route planning or directory service have not been considered.

In order to get a clear feedback from the users we 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 chose to use the stadium since it is a very popular venue. On important sport events (e.g. football or rugby), before and after the match there are plenty of attractions and activities around the stadium. Examples 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.

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

Fig. 1. *Stadium Activities Before the Match*

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 data from both implicit and explicit feedback has been extensively analyzed and we have been able to extract interesting results.

Several field studies have been done on mobile guide applications, as it will be seen in the next section. Some of them offer a great amount of information on several aspects of mobile guide applications while others only cover some specific research application. However, most of them are outdated with respect to the current mobile guide applications. To the best of our knowledge there is no research paper evaluating the multimedia features of current mobile guides and more specifically the POI presentation of these applications. Thus, the aim of this work is to present an evaluation of two popular mobile guide applications (*Google Maps* and *Nokia Maps*), based on their multimedia features. We also compare them with our two prototypes in order to determine which features could be added or improved. Based on a user evaluation we are able to determine possible improvements on current mobile guide applications.

The work presented in this article is based on our previous user study [7]. There are many updates in this new work. First of all we have used the last version of `Nokia Maps`[3] and `Google Maps`. Secondly the questionnaire was completely rebuild using more informative items. Thirdly we conducted new user tests directly at the stadium where users could perceive the real usefulness of the tested applications. We present and analyze the different results between the old and the current user evaluation.

## II. Related Work

One of the first prototypes of a mobile guide application was *Cyberguide* [8]. In that work Abowd et al. from Georgia Tech analyzed in depth the mobile guide applications. They presented the main services: cartographer (map component), librarian (information component), navigator (positioning component) and messenger (communications component). Also they identified many important issues related to coupling the position with the communication, the communication medium, the map representation and the cross-platform application development. Many of their ideas from 1997 are still applicable today.

An extensive study on mobile guide applications was done by Ojala et al. within the project `Smart Rotuaari` [9]. 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. [10] made a survey of mobile guide applications until 2004. This survey presented research on map-based mobile guide applications as well as an analysis and comparison of several systems. In their work it is clearly mentioned the issue of how to best represent the information to the user. Also, they discuss the challenges involved in choosing the preferred type of view (2D, 3D, bird-view, pedestrian view, etc...) for each user. They also mention the need for future user studies. In our work we try to

[3]http://www.nokia.com/betalabs/maps

address some of these challenges, by doing a real-user study of current mobile guide applications and by adding some missing features (e.g. lightweight 3D, video) into our prototypes.

In [11] Kray et al. created and evaluated various presentations for a mobile device ranging from spoken instructions to 3D visualizations. They analyzed each type of presentation and they gave some guidelines to help in determining the best presentation for a given situation. Their evaluation was based on 10 users, but they argued this was enough to proof their concept. As one of the conclusions, they mentioned the difficulty of using 3D models but they also argued that 3D models add realism to the application, enabling users to recognize objects from the rendering in the real world. In our `fake 3D` concept [12], used in one of the prototypes, we benefit from the advantages of 3D models while requiring the resources for a simple image.

In 2007 Koutsiouris et al. [13] presented a framework and a business model for 3G location based services. They 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.

Renzel et al. from RWTH Aachen University [14] created a testbed for mobile multimedia community services, based on the communication between a mobile application and their lightweight application server (LAS). They 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.

Current research on mobile guide applications is going towards image recognition and augmented reality. Many research applications use some methods to recognize the image received from the phone's camera and then they augment it with proper information or multimedia content. *PhoneGuide* [15] was one of the first applications to do the image recognition on the phone, although the performance of the application was quite poor. Other applications [16]–[18] use a server to process the image and then the result of the recognition is sent back to the mobile device.

Most recent research [19], [20] has provided solutions which recognize and augment the images from phones' cameras in real time. In [21] Morrison et al. present a user evaluation of their mobile augmented reality solution *MapLens*, which is based on [20]. In this evaluation they compare their application with a classic *Google Maps*-like application which provides only a digital map. From their results it seems that the augmented reality application is generally more cumbersome for the individual but cooperative group work benefits from the collective use of the application.

## III. Applications and Test Framework Overview

In order to investigate multimedia features missing from the commercial mobile guides applications we created two prototypes which are presented in this section. We compared these prototypes with the commercial *Google Maps* and *Nokia Maps* applications 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 recorded interactions between the users and the applications.

We start by presenting the hardware and the applications used in our test. Then we describe the test framework (called `Observer Framework`) which is used to record the interaction between the test users and the mobile 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

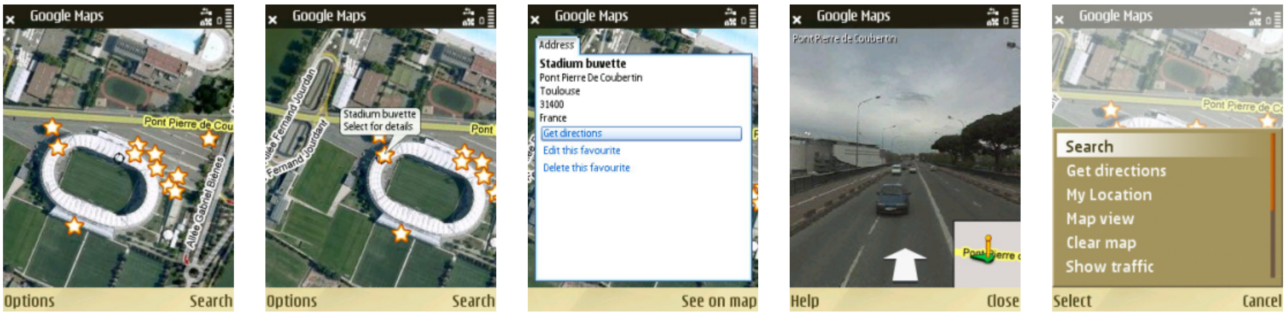
[4]http://www.nokia.fr/les-produits/tous-les-mobiles/nokia-n95-8gb

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.

*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 *Google Maps* for Symbian (2.03) offers the *Street View* feature, allowing users to actually see real images from the places they choose. Unfortunately, this last feature is available only for major cities in a few countries.




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

Fig. 2. *Different snapshots of the Google Maps application*

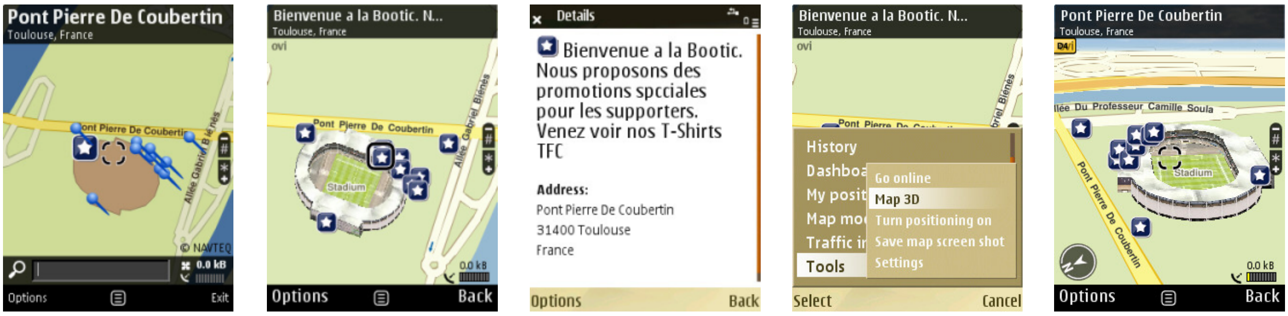
The Google Maps application interface can be seen in Figure 2. The stars represent the points of interest -POI- (the activities around the stadium in our case). The user can move through the map using the navigation keys (up, down, left, right), zoom in and out using the `1` and `3` keys, select a POI 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.

*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 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.

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

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




(Nokia Maps 2.0) (Nokia Maps 3.0) (POI selected) (Options Menu) (3D Navigation)

Fig. 3. *Different snapshots of the Nokia Maps application*

*3) Prototype 1 - Fake 3D:* Our first prototype uses `fake 3D` images [12] 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 provides a realistic navigation around the stadium using simple images.


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

Fig. 4. *Different snapshots of the fake 3D prototype*

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 to an 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.

The 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 applications, but they are represented in different ways: default markers on Nokia Maps and Google Maps, numbered icons in our prototypes.

In order to place our activities (POI) on the four applications we have used *Google Earth*[6] to match them against our video recordings. We had a real video recording of each POI and we had to manually choose a map position for each of the activities. After having the position for each of the activities, we created a **KML**[7] file containing the position and the description of each POI. Then we converted this file to the **LMX** format required by the Nokia POI manager. In this way we automatically had the POI information available on both *Google Maps* and *Nokia Maps* as they both use the same landmark database. For the prototypes the work was more cumbersome. The prototype applications use configuration files, each file

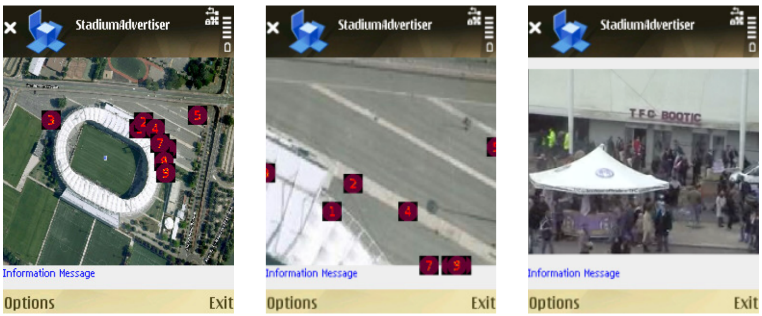
[6]http://earth.google.com/
[7]http://code.google.com/apis/kml/documentation

corresponding to one view (image). These files contain the number of visible POI, their ID and their position on the image. The position of each POI was specified based on the visual correlation between the *fake 3D* image and the recorded video. An alternative to this would be to automatically compute the position using the approach in [12], but this would have required more time since the process is more complex. As for the POI description, we had a static array of strings loaded in the application. Each string corresponds to a POI and matches the IDs from the configuration file.

As it will be seen in Section III-C, our software detects the key events from the tested applications and send this information to a server in order to record the implicit feedback from test users. The key capture is implemented only in the prototype applications, which run in the background when *Google Maps* or *Nokia Maps* are being tested. We explicitly instruct any of our prototypes to start capturing events from a given application (*Google Maps* or *Nokia Maps*). This explicit instruction also serves to identify the current application being tested. In order to capture the key events we have used a feature of the Symbian OS which allows any application running in the background to capture any key events as long as it has the proper capability rights. These capability rights are required on the Symbian OS in order to block unwanted functionality (e.g. calling international numbers) from untrusted applications. Each detected key (we do not capture all the phone keys, as some of them are not used in our applications) is sent to our server using a HTTP request with several parameters.

All the images used in the prototype applications are 512x353 pixels, with an average size of 200KB. This resolution has been chosen as a best compromise between the memory and latency required to load the images and the quality of the image while zooming. The average load time is below 1 second. The total amount of disk space needed by the application is around 50 KB for the application itself and 4 MB for the multimedia content which is stored in the flash memory or a removable micro-SD card. The video used in the second prototype require an additional space of 5 MB. We have optimized the loading process of our multimedia content, by using sequential asynchronous callbacks, in order to minimize the amount of memory needed while keeping a good loading time. Thus we have improved the scalability of our prototypes.

*4) Prototype 2 - Video Sequences:* In the second prototype we use video sequences recorded from the stadium to show explicitly the interesting activities or places which exist around the stadium just before the actual game. A key difference from our previous work [7] is that we have added audio comments to our video sequences. This has improved the usefulness of this prototype and the results have changed considerably.




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

Fig. 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* to display the stadium area. 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 this image to locate the position of the icons. When the user presses the key corresponding to an icon, a video sequence is played, showing the real activity. The user has the possibility to adapt the volume using the volume keys and she can stop playing the video at any time using the middle key.

The video sequences have been recorded using an amateur JVC video-camera. We processed these sequences and we kept only one processed sequence for each POI shown in the application. These sequences are in average 10 seconds long with a size of 500 KB. We added audio comments to explain clearly the activity in the presented video. We needed to convert the video to the **3GPP** format, which is among those supported by the Symbian OS.

### *C. Observer Framework*

Based on our existing work [22], we have created a framework that is able to capture and analyze all the input (mouse, keyboard) events produced by the user when she is navigating in one of our web-pages. We have used this framework in order to analyze the interactions between the user and the mobile applications. Normally the original 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 compatible 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 (`Event Collector` and `Database`, Figure 6).

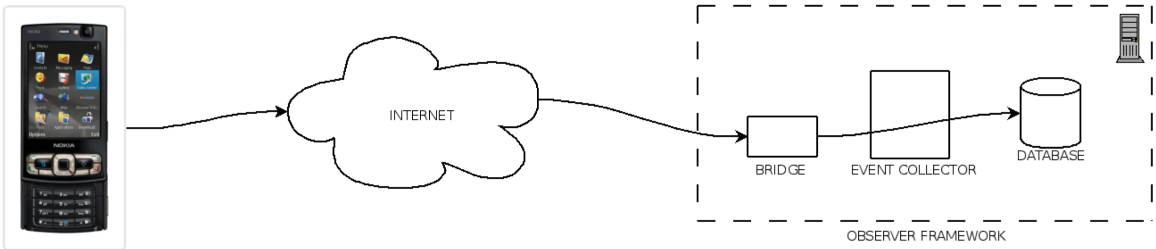



Fig. 6. *Observer Framework Overview*

The parameters received via the HTTP requests from the mobile applications are: `CODE_EVENT`, `INFO_CODE`, `ID_APP` and `SESSION_ID`:

- `CODE_EVENT` represents the type of action: key event, view changed, movement key, start session, end session, zoom in, zoom out, POI selected, POI closed, video play or video finished. However, some of these values were available only on the prototype applications, such as POI selected and POI closed, because we could detect them. On *Nokia Maps* and *Google Maps* we could only detect when the user pushed the phone keys. For this reason, based on initial experiments, we assumed several events. For example, when testing *Google Maps*, if the user pressed the middle button we considered she has selected a POI and when she first touched another key we assumed the POI was closed,
- `INFO_CODE` gives information about the key which was pressed in case of a key event, the application in case of a new test session, the view ID in case of a view change, the POI selected or the video which is being played,
- `ID_APP` provides the ID of the application which is being tested,
- `SESSION_ID` uniquely identifies each test user so that we can analyze all the events for each user.

Other parameters such as `TIME` and `EVENT_ID` where added automatically by the server.

After having recorded all the events from the field test we used the *Observer* framework to analyze them. For this scope we used an interface which allowed us to enter queries of interest. We tried to extract meaningful results, which together with the questionnaire results, could show better the characteristics of each application. For some results like the `zoom interactions on each application` we only had to count the number of zoom events for each user, while for other results like the `number of` events per visited activities we used more complex formulas. Some results were computed automatically using the framework while for others we created specialized scripts.

## IV. User Evaluation

In order to compare the presented applications we made a field study with real test users at the Toulouse stadium, on the occasion of a big rugby derby, Stade Toulousain vs Stade Français.

The test was done in a real before-the-match context. We encountered several problems related to the noisy environment, light condition and people agglomeration (See Figure 7). However these problems helped in the realism of our study and results.

Fig. 7. *Tests at the Toulouse stadium*

It was a challenging task to convince people to stop and make our tests since most people were eager to get inside the stadium as soon as possible. We quickly realized that it would be more easy to find test users among young people which were not standing near the entrance. Finally we were able to test the applications on 21 users by using two phones simultaneously.

The test protocol was the following:

- brief the user with an overview of the test and present the applications,
- start a new test user session; the new session ID was also written on the questionnaire in order to match the results from the questionnaire with the *Observer* data,
- test the first application,
- complete the questionnaire for the first application,
- test the second application,
- complete the questionnaire for the second application,
- complete the general information questionnaire,
- reward the user.

From our previous experience [7] we observed that testing all the four applications sequentially is not efficient as users did not remember well the details of each application. In this new field study each test user has tested only 2 applications For each test we have randomly chosen one commercial application and one prototype.

Another improvement in this study was providing a clear task to the test users. We have asked the users to find 4 activities among the set of 9 on each tested application. This method allowed us to better analyze each application.

TABLE I
QUESTIONNAIRE RESULTS

| Feature | Application with best score |
|---|---|
| How intuitive was the application? | Fake 3D |
| How well reacted the application to user input? | Video Sequences |
| Multimedia support | Video Sequences |
| Usefulness in stadium context | Nokia Maps |
| General usefulness | Nokia Maps |
| Amount of information | Fake 3D |
| Overall presentation | Video Sequences |
| POI presentation | Fake 3D |
| Overall satisfaction | Fake 3D |
| Information quality | Fake 3D |
| User privacy support | Google Maps |
| Remembered Activities | Video Sequences |
| Preferred application | Fake 3D |
| Most visually appealing | Fake 3D |
| Most easy to use and interact | Fake 3D |

From the 21 test 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. The first two parts concerned each of the tested applications (`Application Questionnaire`), while the last part was used to obtain general information about the user (`General Questionnaire`). While creating the questionnaire we greatly benefited from the `MobSOS` success model [14]. The items in the `Application Questionnaire` where the same for all the tested applications and they were divided in three categories: `System Quality`, `Information Quality` and `User Impact`. We used a `LIKERT` scale from 1 (very bad) and 5 (very good) to score each item. In the `General Questionnaire` the users had to choose among the tested applications for each item: `Preferred Application`, `Most Visually Appealing` and `Most Easy to Use and Interact`

## V. 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*

We have changed completely the items in the questionnaires compared to our previous work, using as a reference the `MobSOS` success model. The `MobSOS` is based on the `Delone and McLean` (D & M) success model which is highly accepted among researchers. The `MobSOS` model has been especially adapted for mobile community information systems (MCIS) which makes it the best choice for our user evaluation.

The features analyzed through the questionnaires as well as the applications with the best score on each of these features can be seen in Table I. The items above the double line are part of the application questionnaire while those below the double line are part of the general questionnaire.

The complete statistics for the most important results are presented in Figure 8.

In charts (a) and (b) we show the average value based on user response. In chart (c) we show the average percentage of remembered activities when each application was tested first. An interesting but

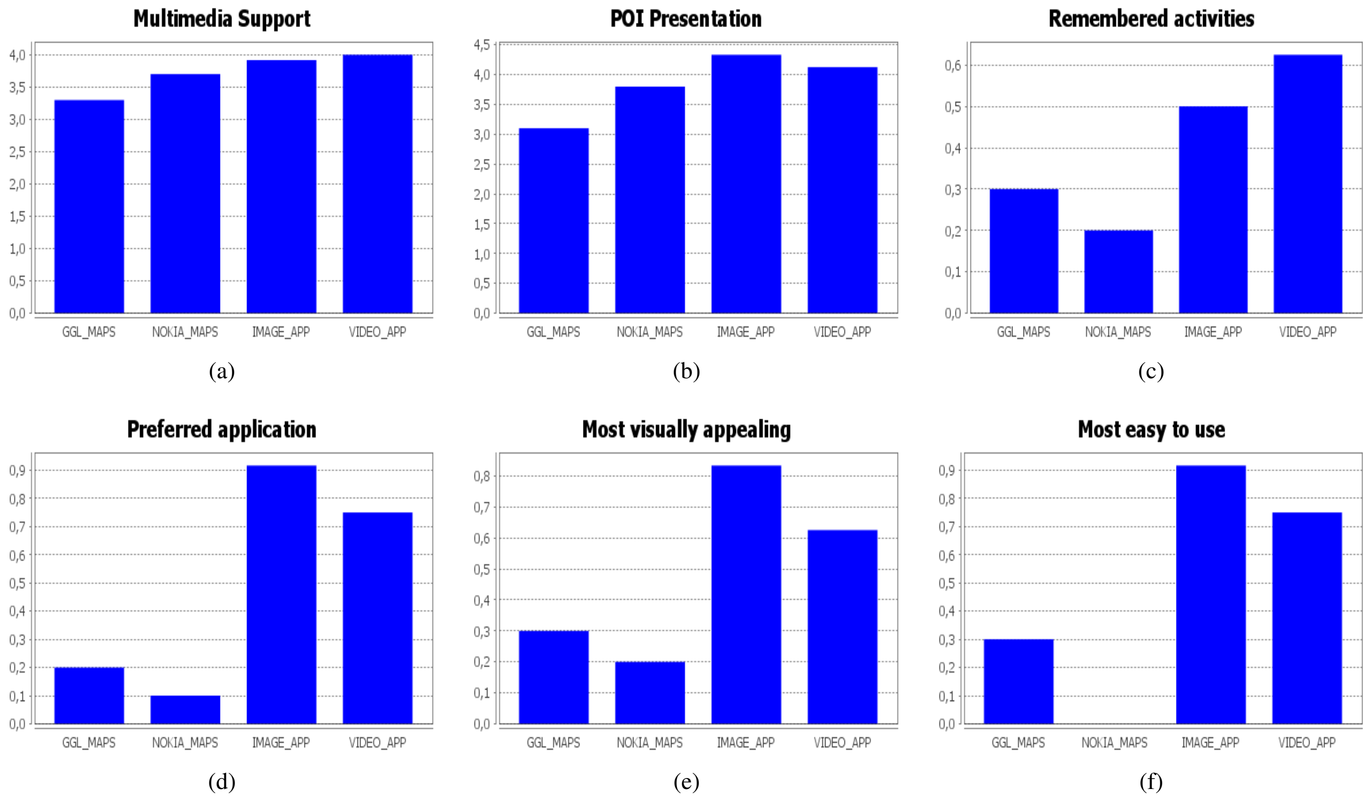



Fig. 8. *Questionnaire Statistics*

expected result is that people remember more activities while watching a video. In charts (d), (e) and (f) we show the perce ntage (1.0 corresponds to 100%) of users selecting each application. 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. 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 voted the `video` prototype as the preferred application. Based on these results and also comparing them to our last user study, where the `video` prototype was only preferred by one user, we can confidently affirm that video sequences with audio comments represent a good multimedia content for mobile guide applications. We can also observe that we don't need professional quality for the video sequences as long as they have fair audio comments.

A clear difference from the previous work is that in these results *Google Maps* has been overpassed in most of the features. This is mainly caused by the use of the last version of *Nokia Maps* as well as the improvements in our second prototype. Another important factor contributing to the different results is the test methodology. In the previous field study we have always started the tests with *Google Maps* followed by *Nokia Maps* and users lost all their interest when they reached to our prototypes. In this new field 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 field 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

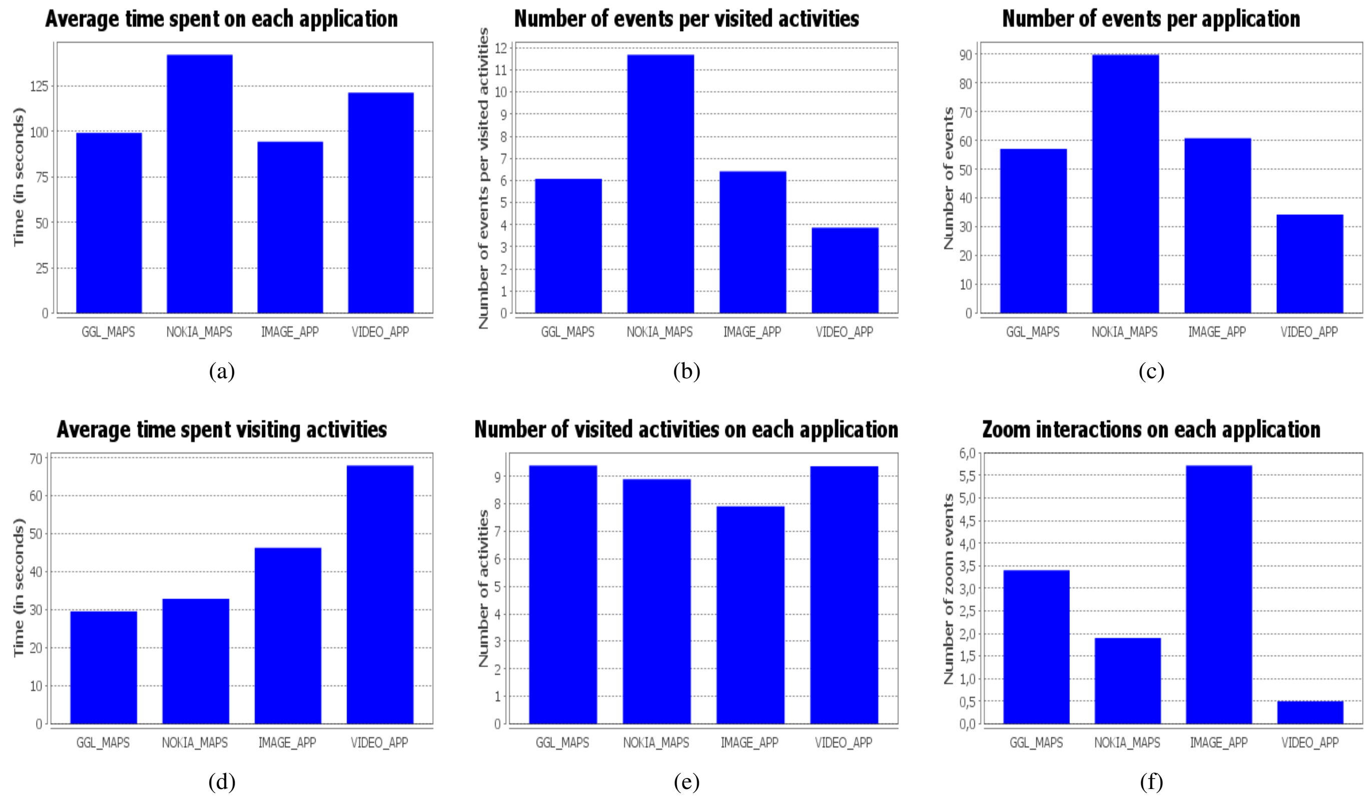



Fig. 9. *Log Statistics*

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 10 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. Nevertheless, users might consider their privacy invaded where we might see expected functionality. *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 nice 3D stadium landmark influence. 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 field 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 work it is clear that *Nokia Maps* has obtained a very good score thanks to this feature. This kind of multimedia content is very appealing for users. Unfortunately we have not found documentation to create our own 3D landmarks in the last version of *Nokia Maps*.

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 landmarks or other kind of environmental buildings 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 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*. We tried to place each POI on a different Nokia landmark category but even then we got the standard POI stars on both *Nokia Maps* and *Google Maps*. However, we must also take into consideration that placing images or icons for any kind of POI would probably decrease the usability of the application.

The **video** prototype has shown the most surprising results. In our last field 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 location together with audio comments represent 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 paths in mobile guide applications. It can also be used in a *Youtube* fashion, in which users can share their video 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. 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,
- Video with audio comments and descriptive images are among the best solutions to show the points of interest. For noisy environments subtitles should be added to the video 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*.

## VI. 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 field study with real test 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 field study in which we have used an 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.

## REFERENCES


[1] N. Deblauwe and P. Ruppel, "Combining gps and gsm cell-id positioning for proactive location-based services," *Mobile and Ubiquitous Systems: Networking & Services, 2007. MobiQuitous 2007. Fourth Annual International Conference on*, pp. 1–7, Aug. 2007.

[2] Y. Chen and H. Kobayashi, "Signal strength based indoor geolocation," *Communications, 2002. ICC 2002. IEEE International Conference on*, vol. 1, pp. 436–439, 2002.

[3] P. Bellavista, A. Kupper, and S. Helal, "Location-based services: Back to the future," *Pervasive Computing, IEEE*, vol. 7, no. 2, pp. 85–89, April-June 2008.

[4] Y. Mowafi and D. Zhang, "A user-centered approach to context-awareness in mobile computing," *Mobile and Ubiquitous Systems: Networking & Services, 2007. MobiQuitous 2007. Fourth Annual International Conference on*, pp. 1–3, Aug. 2007.

[5] Y. Oh, A. Schmidt, and W. Woo, "Designing, developing, and evaluating context-aware systems," *Multimedia and Ubiquitous Engineering, 2007. MUE '07. International Conference on*, pp. 1158–1163, April 2007.

[6] M. Baldauf, S. Dustdar, and F. Rosenberg, "A survey on context-aware systems," *Int. J. Ad Hoc Ubiquitous Comput.*, vol. 2, no. 4, pp. 263–277, 2007.

[7] O. Choudary, B. Baccot, R. Grigoras, and V. Charvillat, "A user study on rich media mobile guide applications," *9th Workshop on Multimedia Metadata (WMM'09)*, vol. 441, 2009. [Online]. Available: http://ceur-ws.org/Vol-441/p06.pdf

[8] G. D. Abowd, C. G. Atkeson, J. Hong, S. Long, R. Kooper, and M. Pinkerton, "Cyberguide: a mobile context-aware tour guide," *Wirel. Netw.*, vol. 3, no. 5, pp. 421–433, 1997.

[9] T. Ojala, J. Korhonen, M. Aittola, M. Ollila, T. Koivumki, J. Thtinen, and H. Karjaluoto, "Smartrotuaari - context-aware mobile multimedia services," in *Proc. 2nd International Conference on Mobile and Ubiquitous Multimedia, Norrkping, Sweden, 9 - 18*, 2003.

[10] K. C. Jrg Baus and C. Kray, *Map-based Mobile Services*. Springer Berlin Heidelberg, 2005, ch. A Survey of Map-based Mobile Guides, pp. 193–209.

[11] C. Kray, C. Elting, K. Laakso, and V. Coors, "Presenting route instructions on mobile devices," in *IUI '03: Proceedings of the 8th international conference on Intelligent user interfaces*. New York, NY, USA: ACM, 2003, pp. 117–124.

[12] O. Choudary, V. Charvillat, and R. Grigoras, "Mobile guide applications using representative visualizations," in *MM '08: Proceeding of the 16th ACM international conference on Multimedia*. New York, NY, USA: ACM, 2008, pp. 901–904.

[13] V. Koutsiouris, C. Polychronopoulos, and A. Vrechopoulos, "Developing 3g location based services: The case of an innovative entertainment guide application," *Management of Mobile Business, 2007. ICMB 2007. International Conference on the*, pp. 1–1, July 2007.

[14] D. Renzel, R. Klamma, and M. Spaniol, "Mobsos - a testbed for mobile multimedia community services," *Image Analysis for Multimedia Interactive Services, 2008. WIAMIS '08. Ninth International Workshop on*, pp. 139–142, May 2008.

[15] E. Bruns, B. Brombach, and O. Bimber, "Mobile phone-enabled museum guidance with adaptive classification," *Computer Graphics and Applications, IEEE*, vol. 28, no. 4, pp. 98–102, July-Aug. 2008.

[16] J.-H. Lim, Y. Li, Y. You, and J.-P. Chevallet, "Scene recognition with camera phones for tourist information access," *Multimedia and Expo, 2007 IEEE International Conference on*, pp. 100–103, July 2007.

[17] M. Baldauf, P. Frhlich, and P. Musialski, "A lightweight 3d visualization approach for mobile city exploration," *First International Workshop on Trends in Pervasive and Ubiquitous Geotechnology and Geoinformation*, vol. Workshop, 2008.

[18] K.-C. Yow and J. Lee, "Mobile tourguide system," *Singaporean-French IPAL Symposium*, 2009.

[19] G. Takacs, V. Chandrasekhar, N. Gelfand, Y. Xiong, W.-C. Chen, T. Bismpigiannis, R. Grzeszczuk, K. Pulli, and B. Girod, "Outdoors augmented reality on mobile phone using loxel-based visual feature organization," in *MIR '08: Proceeding of the 1st ACM international conference on Multimedia information retrieval*. New York, NY, USA: ACM, 2008, pp. 427–434.

[20] D. Wagner, G. Reitmayr, A. Mulloni, T. Drummond, and D. Schmalstieg, "Pose tracking from natural features on mobile phones," in *Proc. ISMAR 2008*, Cambridge, UK, Sept. 15–18 2008.

[21] A. Morrison, A. Oulasvirta, P. Peltonen, S. Lemmela, G. Jacucci, G. Reitmayr, J. Näsänen, and A. Juustila, "Like bees around the hive: a comparative study of a mobile augmented reality map," in *CHI '09: Proceedings of the 27th international conference on Human factors in computing systems*. New York, NY, USA: ACM, 2009, pp. 1889–1898.

[22] B. Baccot, V. Charvillat, R. Grigoras, and C. Plesca, "Visual attention metadata from pictures browsing," *Image Analysis for Multimedia Interactive Services, 2008. WIAMIS '08. Ninth International Workshop on*, pp. 122–125, May 2008.