Building Mobile Context-aware Applications for Leisure and Entertainment

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ABSTRACT
This paper presents a mobile context-aware tourist guide application created with the IVO platform. IVO (Integrated Virtual Operator) enables end-users to quickly build and deploy context-aware applications without the need to write any programming code, and using smartphones as the ubiquitous interaction device. Aiming at exploring the use of the IVO platform to build mobile leisure and entertainment applications, the developed application makes use of most features available in IVO. Using only the tools provided by the platform, IVO Builder and IVO Outlook, users can define temporal and spatial conditions and associate them with workflows of available activities. The paper also presents the user studies performed to evaluate the application's usefulness and usability.

Categories and Subject Descriptors
D.2.2 [**Software Engineering**]: Design Tools and Techniques. D.2.6 [**Programming Environments**]: Interactive environments H.5.2 [**Information Interfaces**]: User Interfaces – *Evaluation/methodology; Prototyping*.

General Terms
Design, Experimentation, Human Factors.

Keywords
Ubiquitous Computing, Context-Awareness, Rapid Application Development, Usability Evaluation, Interaction Design, Mobility.

1. INTRODUCTION
Ubiquitous computing is built on top of the idea that computing moves off the desktop, into the surrounding environment, working in the periphery of our attention [1,2]. Small devices, with robust computing and network capabilities, are seamlessly integrated with the environment. Advances in nanotechnology pave the way to the integration of an increasing set of features to those small devices, thus allowing a greater awareness of the surrounding dynamic world.

Mobile phones are considered the first truly pervasive computers [3]. They're always in reach of their owners, helping them to keep in touch with each other and assisting them in everyday tasks. In this work, smartphones were chosen as ubiquitous interaction devices as they can become the vehicle to the widespread use of our system. Today's devices offer an increasingly large set of possibilities for sensing, communication and user interface, and there is a great market demand for these types of devices [4], making them ideal for the development of ubiquitous systems.

Context-awareness is a central research topic in ubiquitous computing, with applications dynamically adapting to both user's activities as well as changes in the environment [5]. The context can include, among other things, location, activity being performed, time and nearby people or equipments, and it is a particular situation for each user. Context-aware computing is all about sensing those situations to provide adequate information and useful services to the user.

Pioneering work on ubiquitous computing research [1,3,6,7] addresses the topic of context-awareness and has already demonstrated the potential of context-aware applications. Some of the research has focused on developing frameworks, toolkits and infrastructures with the goal to support programmers in building such types of applications, while others have focused on empowering end-users to prototyping their own context-aware applications [5,8,9]. However, they are still lacking in support for end users to create complete applications relying on current smartphones as ubiquitous interaction devices.

To address this problem, we have developed the IVO platform, enabling end-users to build and deploy context-aware applications without the need to write any programming code. The IVO platform is composed by a visual programming application builder available on the WEB, where users can easily define a number of context conditions and workflows of activities, which are later triggered when the user is in the presence of those contexts. The smartphone runtime layer is provided by the second component, an application that provides the necessary support for the execution of such applications.

This paper describes a mobile ubiquitous tourist guide built using the IVO platform. This application runs on Android smartphones and tablets and allows users to explore different points of interest in the area of Belem at Lisbon. Users can be guided by the application to follow a certain path that goes through the main points of interest. Users are also free to walk around at their own will, receiving information regarding their surroundings. During the tours, users can as well engage in entertainment activities, such as quizzes or peddy-paper games. Peddy-paper is a leisure activity often linked to the acquisition of knowledge about a certain topic or place. The players have to follow a route while answering a quiz or completing tasks, corresponding to different

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intermediate points, which can determine the transition to the next part of the route. Additionally, several services are available, automatically or on-demand, such as updating the Facebook status, changing the phone profile or sending an SMS.
The paper also presents the first user studies performed to evaluate the usefulness and usability of the application and it is structured as follows. Related work is discussed in section 2 before a brief description of the IVO platform in section 3. Section 4 describes the application created and section 5 deals with the planning and realization of the user studies, as well as the discussion of results. Finally we draw our conclusions and suggest directions for future work.

2. RELATED WORK

Several systems have been developed to provide programmers with the infrastructure that enables them to create context-aware applications [6,10,11], but they do not provide any support for end-users.

Regarding the development of authoring tools that enable the rapid authoring of context aware applications by domain specialists, we can point the example of UbiCicero [12], an evolution of previous work described in [13] and [14]. It is a multi-device, location-aware guide, supporting museum visits, which also provides the possibility of enriching the user experience through individual or collaborative games. Museum curators, the real users of the authoring tool, can easily customize the contents for their museum guides through an authoring environment. IVO allows a wider use, with the possibility of building applications in several areas. IVO also provides indoor use, through IVO Codes activities (QR-codes) and the support for NFC (Near Field Communications) which is planned to have in a near future.

Tools such as “a CAPella” [5], Topiary [9] and iCAP [8] are aimed to end-users prototyping. “a CAPella” is a context-aware prototyping environment that gives the end-user the ability to program by demonstration. Its main components are: a recording system, an event detection engine, a user interface and a machine learning system. Topiary builds storyboards from scenarios that represent local contexts. These scenarios are "demonstrated" by the end-user and the constructed storyboards describe interaction sequences that can run on mobile devices. iCAP allows end-users to visually design context-aware applications, including those based on if-then rules, temporal and spatial relationships and environment personalization. It offers an interface to describe a context and associate an action with it. Unlike iCAP, IVO’s user interface is web-based which facilitates its use globally. IVO also uses widely available smartphones as the ubiquitous interaction device, therefore allowing for a widespread use of the applications created by the end-users.

In the field of mobile guides, projects like Cyberguide [15], GUIDE [16] and C-MAP [17], aim to provide information according to user's current location, but they do not support end-users to create their own applications as opposed to IVO.

Tasker [18] and Locale [19] are standalone applications for the Android platform, which seek to automate tasks based on context information. With these applications, a user define contexts based on combinations of running application, data, time, location, device state and events, to automate a set of actions that alter the mobile device settings such as entering airplane mode, muting the sound, or executing predefined application actions like sending an SMS. Unlike our approach, this programming of behavior is performed in the mobile device itself.

In our proposed platform, we allow the creation of richer and more complete applications. The IVO platform enables an easy definition, both of contextual information associated with each situation, and the activities to be performed following workflow logic. Since we adopted a separation between the builder, which is web-based, and the player, applications created by users are easily shared and its web-based interface is a good step towards its global use. Not only everyone can create applications but also everyone can use them, as IVO also uses widely available smartphones as the ubiquitous interaction device.

Furthermore, the location and temporal contexts of IVO are also richer than the ones allowed in [18] and [19].

The IVO platform allows the creation of fully functional applications with a wide range of uses including entertainment and leisure applications that can be created by the users themselves or distributed to third parties. In this paper we demonstrate its use for the creation of a mobile ubiquitous tourist guide, testing the usefulness and usability of this leisure application that also includes context aware quizzes.

3. THE IVO PLATFORM

IVO (Integrated Virtual Operator) enables non-programmers to create and run context-aware mobile applications. The developed platform follows an event-driven workflow model in order to support the dynamic nature of context-aware applications. The workflows are created by combining the available activities which can be performed by an application. An IVO application is therefore described as a set of workflows that are triggered when a certain context is checked.

IVO provides two composite tools, IVO Builder and IVO Outlook, which allow the creation and deployment of context-aware mobile applications by end-users without the need to write any programming code. These two tools, successfully tested for their usability in [20], enable end-users to set contexts that are used to define conditions for starting the workflows.

The IVO Client (running on Android smartphones and Tablets) loads the developed applications and a Workflow Engine is provided to enable the coordination of the flow of activities as a workflow process.

4. APPLICATION DESCRIPTION

Using IVO Builder, we built a mobile tourist guide application for the area of Belem in Lisbon. Belem neighbourhood stand by the river and holds several of the most interesting historical spots in Lisbon, including. Jeronymous Monastery, Belem tower, several museums and beautiful gardens. Our goal is to explore the use of IVO for the creation of leisure and entertainment mobile applications.

The application consists of 16 points of interest, being the user guided by five of these points. All 16 points have contextualized information that are shown and spoken to the visitor when he enters the space surrounding each point of interest.

The five selected points of interest have more detailed information with audios, videos and quizzes in order to improve the visitor experience. After visiting each of these points, the next point is indicated through spoken text and the Navigator is launched to guide visitors. The visitor can then decide to take the instructions to the next point or go to any of the other points of interest or even relax in one of the beautiful gardens or cafes in the area before continuing the tour. During the tours, users can as well engage in entertainment activities, such as quizzes. Additionally, several services are automatically available, such as updating the Facebook status, changing the phone profile or sending an SMS.

The main features of the application are described next.

Event-driven Workflow Model. IVO use an event-driven workflow model to enable the dynamic execution of actions that should be performed by the application when a user enters or exits an area of interest. IVO Builder includes features that allow users to create spatial contexts and define the actions that should be performed by the application when those contexts are achieved. As an example, in Figure 1, we show the workflows created with IVO Builder that will be executed in the IVO Client when the user enters and exits one of the points of interest of the tour: the Jeronymous Monastery.

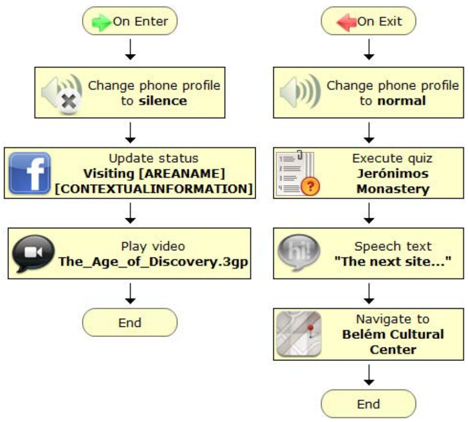

Figure 1. Enter and exit workflows of one of the spots of the test scenario.

When the user enters this spot, the sound of the phone is placed in silent mode; a message is placed in the visitor's Facebook wall; and a video about the site is played on the mobile device. Upon exiting, the sound of the phone is placed back to the normal mode, and a quiz is executed. After completing the quiz, new spoken instructions are given to notify the visitor about the next point of interest to visit and the Navigator is launched to guide the user to that point.

Context-aware Information. The visitors can use IVO to retrieve information about the points of interest. This information is retrieved based on visitors' current location and also through the "Search" feature. It includes all the data defined in the IVO Builder plus contextual information gathered from Twitter (what others are saying nearby), from Panoramio (what can be viewed nearby) and from the weather forecast for that local. Figure 2 illustrates the contextual information of the first point of interest of the tour, which was extended with audio (e.g. background music) and video. Descriptions are vocally reproduced by means of a TTS (Text-To-Speech) engine. We use SVOX engine for the Portuguese voices and the free TTS engine available on Android, for the English voices. These extensions were implemented in IVO Builder through the inclusion of their activities in the workflow that run when visitors are nearby the point of interest.

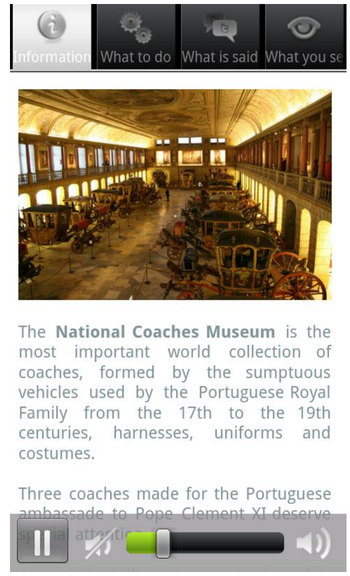

Figure 2. Contextual information for the first point.

Another way to obtain contextualized information is through the use of the Augmented Reality browser, which enables users to visualise augmented information about their surroundings overlaid on images captured with the smartphone's camera. It can use several sources of information including geo-referenced articles of Wikipedia, existing areas of Wikimapia and the areas of interest created with IVO Builder. Figure 3 illustrates the view of reality augmented with overlaid contextual information including two IVO spots.

Figure 3. Example of the Augmented Reality browser with IVO spots marked.

User Preferences. The user preferences let visitors define which actions (i.e. the activities used in workflows) can be performed automatically by the different workflows, whenever the start condition holds (entry or exit of an area). When the application is loaded, the visitor is asked to define which actions he or she wants to see automated, as shown in Figure 4. This screen lists all workflow activities used by the application, allowing the visitor to enable or disable each one. For example, a visitor may not want posts inserted on Facebook or any audio played because it can be distractive when crossing roads or just because he or she doesn't have a headphone.

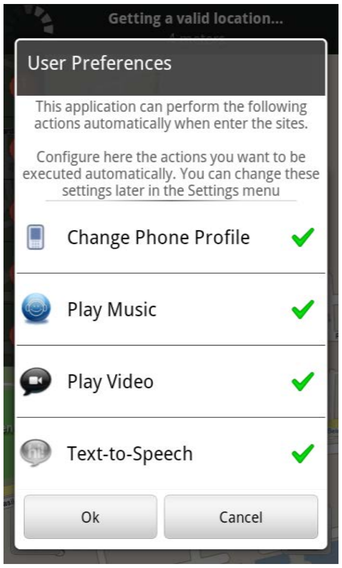

Figure 4. Obtaining visitors' preferences.

Navigation. Visitors can use the map to orient themselves or can use the Google Navigation application to get directions between the current location and one point of interest.

The IVO map service (Figure 5a) consists of a map on which layers with the areas of interest of IVO (marked on the map in green), geo-referenced articles of Wikipedia and defined areas of Wikimapia, can be added.

The Google Navigation (Figure 5b), can be launched automatically by the workflows that use "Navigate to Activities", or can be launched manually by the visitor when he or she clicks on the navigate buttons available in the context information screens. In any case, the destination point is automatically introduced.

Figure 5. a) The main screen of IVO with points of interest marked on the map; b) The Navigation with directions from one point to another.

Quizzes. Quizzes can provide an interesting and amusing way to enrich visitors' experience. They are related to the real visit, and are essentially aimed at stimulating more active participation from users. In this application we have four different quizzes corresponding to four of the five tour points of interest. They have been configured to end at any time if the user wishes and to provide feedback after each answer (see Figure 6).

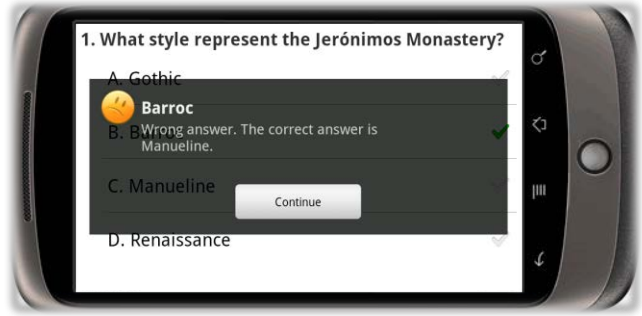

Figure 6. Feedback to an answer of a Quiz.

Context Adaptation. IVO allows the adaptation to context to enable a degree of personalisation in the user interface and experience. We enable the authors of the IVO applications to use *Context Variables* that control the display of the information or the messages generated by IVO for Facebook, Twitter, SMS or e-mail.

The *Context Variables* represent the current state of the environment including the values of sensors such as current location, lightness, battery level, date/time, free memory, and smartphone user ID or current context information. Figure 7, illustrates the screen of IVO Builder that allows editing a workflow Facebook activity, showing *Contextual Variables* `[AREANAME]` and `[CONTEXTUALINFORMATION]` inserted on the message. Figure 8 illustrates the result of such Facebook messages on the user's wall.

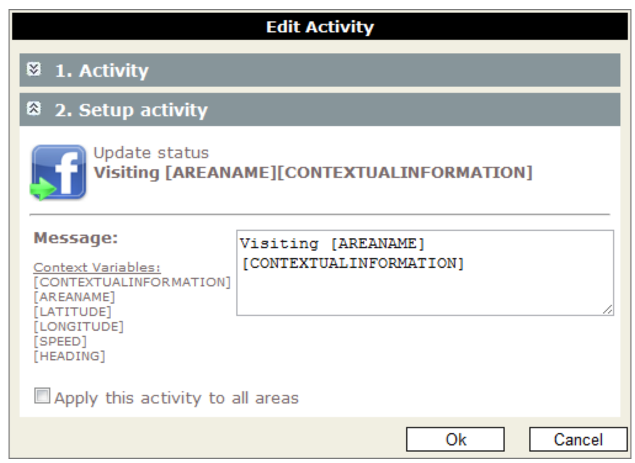

Figure 7. Edit Activity window on IVO Builder showing the use of Contextual Variables.

Social Network Integration. IVO can provide integration with Facebook and Twitter, enabling automatic posts with contextual information. The application just described, posts a message on Facebook wall, informing the user's friends that he or she is visiting that spot, whenever the visitor enters a certain area. Figure 8 illustrates a Facebook user's wall with these automatic posts.

Figure 8. Messages on Facebook published automatically by IVO.

5. EVALUATION

The application was tested by a group of seven volunteers (four male and three female). The volunteers in this experiment have different backgrounds and their ages range from 24 to 37 years old with a mean age of 29.6.

The test sessions were conducted by a researcher, who played the roles of facilitator and observer. Before starting to use the application, users were informed about the objectives of the test, and were provided with an Android device with the application installed. We used Android smartphones and also one Samsung GALAXY Tab with a 7.0-inch display.

After the briefing, the facilitator took each participant to the starting point, and from there on they had to follow the instructions provided by the application. The facilitator accompanied users along the whole route, observing their actions and taking notes. The users were encouraged to "think aloud" and tell what was going through their minds while using the application. After using the application, participants were asked to fill in a questionnaire.

5.1 Questionnaire

After performing the usability tests, users were asked to answer a questionnaire, which captured personal data and experimental feedback, as well as the users' suggestions and comments. Personal data included the participant's age, gender, education level, familiarity with new technologies and frequency of use of Internet, computer, mobile phone, and game console. Experimental feedback was evaluated through five different sections of the questionnaire.

Five statements regarding the usefulness of the application composed the first one (Table 1). Users indicated their level of agreement with each statement by circling a value on a 5-point Likert-type scale, with a response of 1 (one) meaning "strongly disagree" and a response of 5 (five) meaning "strongly agree".

The second section includes three statements regarding the application ease of learning criteria. The third section includes six statements concerning the application ease of use criteria and one question on how easy it was to perform the proposed tasks (Table 1).

To classify the second section and the first six questions of the third section, users followed the same procedure used for the first section, as described above. To answer the last question of the third section, a scale from 1 (one) meaning "very difficult" to 5 (five) meaning "very easy" was used.

Table 1. Statements that composed the experimental feedback part of the questionnaire.

Statement	
Usefulness	
Q1	The tested application is useful
Q2	The tested application gives me more control over the activities that I have to do
Q3	The tested application facilitated the realization of the visit
Q4	The application saves time in making the visit
Q5	The information provided by the application is useful
Ease of learning	
Q6	It is easy to learn how to use the application
Q7	I quickly became able to use the application
Q8	I easily remember how to use the application
Ease of use	
Q9	It is easy to use
Q10	I can use it without written instructions
Q11	I don't notice any inconsistencies as I use the interface
Q12	It was easy to recover from an unexpected situation
Q13	It reacted quickly to user actions
Q14	The application has a friendly interface
Q15	How easy it was to:
	a) Map navigation (move, zoom)
	b) Search for an area of interest
	c) Get information about an area of interest
	d) View of reality (Augmented Reality)
	e) Execute a quiz
	f) Play audio
	g) Play video

In the fourth section users were asked to indicate three workflow activities they considered most useful. An open question allowed users to suggest other possible activities they consider useful and that should be made available.

The fifth section included one question based on the Microsoft "Product Reaction Cards". This aimed at capturing the user's feelings when using the system, since it facilitates the measuring of intangible aspects of the user's experience [21]. Users were asked to choose the words that best described their experience while using the system from a list of 24 words, consisting of about 60% of words considered positive and 40% considered negative. Users could choose how many words they wanted.

Finally, the questionnaire also included an open question in order to gather comments and recommendations regarding future developments of additional features and to obtain a more general evaluation of the system.

5.2 Results and Discussion

The users' answers to the questions presented in Table 1 were analyzed and the results are shown and discussed below. We examined the average scores of the users' responses to see if there were general trends in their opinions (strong feelings one way or the other showing up as mean scores closer to 1 or 5). We used the standard deviation of the mean score to determine how broad the consensus about the issue was. Figure 9 summarizes the results for the questions presented in Table 1.

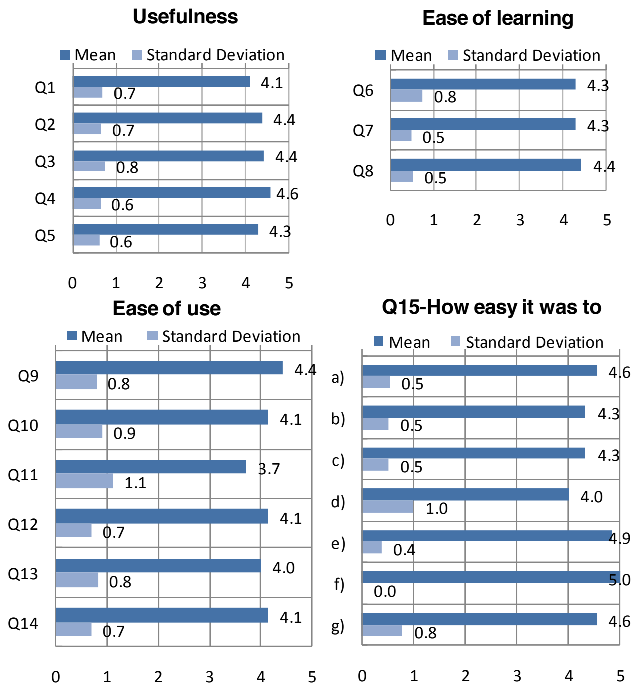

Figure 9. Evaluation results for the questions presented in Table 1.

Most participants classify the questions concerning the usefulness and ease of learning of the application with high scores.

Overall, the results regarding the application "ease of use" (Q9-Q15) were very positive. The majority of the participants stated that the application is easy to use (statement 9), they can use it without written instruction (statement 10), that it was easy to recover from an unexpected situation (statement 12), and that the application is user friendly (statement 14). Although positive, the participants' opinion concerning the inconsistencies found in the interface (statement 11) shows the lowest score and also the lowest consensus. We believe this may be related to the fact that some users were unfamiliar with the Android interface, making it difficult to immediately adapt to the system.

Question 15, assessed how easy users found each of the seven tasks described in Table 1. According to the results displayed in Figure 9, the interactions were generally deemed easy to perform. The view of reality (statement 15d), although positive, was the question with lowest score. As described before, most users didn't realize they had to use the menu button, so they spent some time and effort trying to figure out how to access the augment reality view.

Regarding the fourth section of the questionnaire, the activities considered most useful were "play audio", "post message on twitter", "post message on Facebook", "execute a quiz", "navigate to" and "take a photo" (2 users). We believe that users tend to refer those used in the test as the most useful.

From the analysis of the fifth part of the questionnaire (Figure 10), we concluded that participants held positive feelings (98% of the total words selected) when classifying their experience using the system. The most selected word was "pleasant" (60%) followed by the word "stimulating" and "useful" (50%). 40% of the participants considered the system "simple" and "immersive". Only one user reported negative feelings and the word used was "confused".

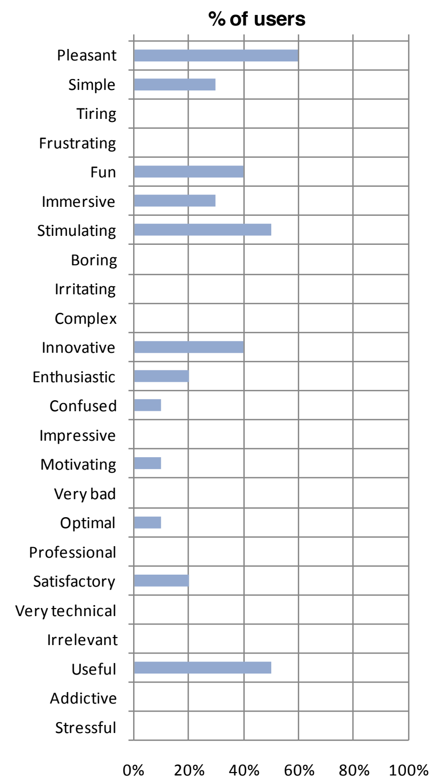

Figure 10. Results for the emotional involvement.

The open question of the questionnaire, gave us some useful comments and suggestions that we will take into account to improve IVO. For example, users stated that will be nice to have quizzes and other games in a cooperation environment, in order to provide an interesting and amusing way to enrich user interaction and promote their collaboration. Other users stated that the interface must provide a easy way to remember the next point to visit and the already visited, as also a filter to "what others are saying nearby" feature in order to get more relevant messages from Twitter.

According to the user studies (users' feedback and observations), our mobile context-aware tourist guide application built using the IVO platform is useful and usable. IVO platform seems to be suitable for the development of this kind of leisure and entertainment applications. As it is detailed in [20], IVO Builder supports the rapid development of context-aware applications by end-users with no programming skills. The prototype application presented in this paper took 2 days to create, including design and implementation, by an experienced user. According to former evaluation of IVO platform [20], we estimate that, for a novice user, it would take about twice as much time. Further tests will be performed in order to accurately measure it.

This way, tourists will be able to collect information from different sources, such as Wikipedia and Wikimapia, and create their own context-aware travel guides whenever they go abroad on leisure or business travels. Once created these applications can be used by anyone with an Android smartphone, so users can share their applications with friends. Entertainment applications, such as peddy-paper games, can also be easily implemented using IVO platform. Moreover, our application prototype can easily be converted in a peddy-paper application.

6. CONCLUSIONS AND FUTURE WORK

This paper explores the use of IVO for the creation of leisure and entertainment mobile applications.

We built a mobile ubiquitous tourist guide using the IVO platform. The application developed runs on Android smartphones and tablets and allows users to explore different points of interest in the area of Belem at Lisbon.

This application was evaluated by a set of end users. IVO platform seems to be suitable for the development of this kind of leisure and entertainment applications, since the evaluation results were very positive, as users expressed very encouraging feelings.

We have found the devices to have a battery life between two and three hours with a normal use of the application (audio, video, GPS and data network). We will investigate some coding aspects that can be improved to extend battery life.

We have plans to test IVO indoor using IVO Codes (QR-codes already implemented in the system) and NFC (Near Field Communication) taking advantage of new smartphone's on the market that already have NFC readers.

IVO is now starting to be used in a project to assist blind people in urban spaces orientation, and in another project in the area of Persuasive Computing, aiming at enhancing people's behaviour towards the environment.

We will also develop IVO clients for other mobile platforms, such as the iPhone and Windows Mobile.

7. ACKNOWLEDGMENTS

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