Smart-Islands: Enhancing User Experience for Mediterranean Islands for Tourism Support

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Abstract. In recent years, several mobile devices with excellent performances have become accessible to people at affordable prices. The availability of this type of equipment, especially in the mobile sector, has encouraged research and development of increasingly complex applications ("Apps") that require visualization of large-scale scene. However, large-scale 3D maps typically available through mobile version of so-called "spinning globes" do not allow the use of high definition data, due to their hardware limitations. This kind of lack should not be considered as a limitation, but as an opportunity: there are a lot of possibilities, especially in the tourism domain, where it is not required to construct wide 3D environment. Instead only a little portion of a specific territory using high quality spatial data over high fidelity three dimensional geometry models of the environment is sufficient. A simple example of this domain could be the representation of a Mediterranean island: these islands are generally small, numerous, lacking infrastructure whilst impacted by seasonal tourism, being far from the definition of smart cities. The infrastructure of future cities needs to support vibrant, innovative and entrepreneurial communities such as the community of an island that takes advantage of the digital environment and realize their potential to become "smarter". In this context, this document presents the SMART-ISLANDS framework: a set of mobile and desktop applications for the seasonal tourism support, public sector and administration, private sector and university focused on the contest of the Mediterranean islands, using high fidelity 3D model for the environment representation and geographic information aiming at leveraging the concepts of smart-cities on the island context. After the presentation of the application, a study will be conducted to investigate how the user experience and usability will change if the same application is executed as an applet, using a custom web browser, or on a mobile device as an application, changing the input device (mouse and gestures). Results, obtained by using ISO 9241 guidelines will be analysed, summarized and commented.

Keywords: user experience, human computer interaction, HCI, LBS, mobile devices, common gestures.

1 Introduction

The technological progress has made available to masses electronic devices with compact size and high performances and quality at affordable prices. The possibility

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for each user to be constantly connected to the network, by using 3G/Wi-Fi wireless connections available at more affordable rates, has changed their habits. Tourism and personal entertainment are perhaps the areas that are mostly benefiting from this evolution. It often happens that someone is searching for a given piece of information about a particular activity when it is in a specific place.

1.1 The Problem

The decentralization of this type of information, causes an inevitable loss of time due to four main factors:

- The amount of information on each site;
- The comparison between different opinions and results;
- The difficulty to find trusted information: it often happens that information are copied from another source, especially in forums;
- The difficulty to find all the necessary kind of booking services: transportation to and from the island, by navy or plane; internal transportation: in some islands cars are not allowed; accommodation: hotel, B&B, camping, etc. from a single source;

1.2 Motivations

An island is an "isolated self-contained territory" with a capital and a network of smaller cities and villages. "Mediterranean" islands are small, numerous, lacking infrastructure whilst impacted by seasonal tourism, being far from the definition of smart cities.

1.3 Innovation

The SMART-ISLAND platform will:

- Deliver under one-platform eight independent and existing Web services;
- Expand the Platform to accommodate additional when available island services;
- Provide island citizens & visitors accurate services, data & information through Location Based Services;
- Deliver 3D Internet based visualization system in real time;
- Provide an integrated multi-platform of 3D Smart-Island "Globe";
- Provide a specific integration of existing weather forecast services in a 3D environment, using techniques and methods of intuitive representation and animation;
- Provide complex operation support using an extremely easy to use user interface;

2 The SMART-ISLANDS User Interface Evolution

The final objectives of the SMART-ISLANDS framework, is to offer a number of complex integrated web service in fast and easy way to any kind of user. To reach the final objective, and increase the User Experience [1], many kind of graphical user interfaces have been designed and tested, and in this chapter they will be presented. From the first version of the graphical user interface many changes have been done to create the final GUI, the existing literature offers a set of human computer interaction guidelines for mobile devices [2][3] that has been taken into account to fix errors step by step. Figure 1- left shows the first SMART-ISLANDS graphical user interface prototype: the entire screen was used to display the three dimensional environment, features were offered by clicking on the left and right tab. Although the first prototype was clearly created only to test the implemented functionalities, human-centred design lacks were immediately discovered: in particular, the tabs buttons were too small with respect to the area size and the final result was the obvious difficulty to complete any kind of action without a specific training.

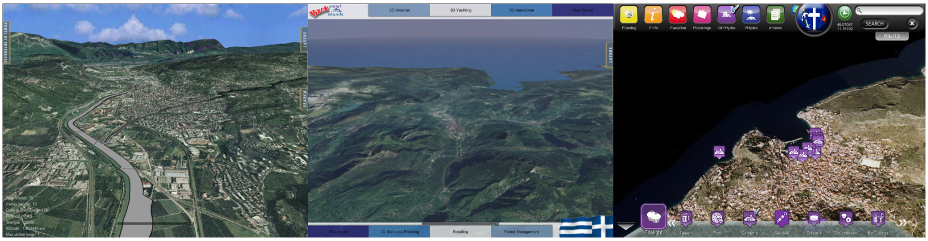

Fig. 1. SMARTS-ISLANDS user interface history

Figure 1 - centre shows the first official framework interface prototype. The picking button problem identified in the first testing prototype was solved by placing always-visible bigger buttons on the top and on the bottom of the screen. During internal testing phase, a well know problem [3] was encountered: there was problem in both physical, the specular colour of the upper and lower option bar was disorienting the tester that did not have the opportunity to associate a specific option of the framework with a specific colour, and perceptual distinctiveness: it is not possible to identify the associated functionality by looking at these icons without reading the explanation text inside the button itself. Based on the analysis conducted for first and second version of the interface, Figure 1 – right, shows the final, ready for testing, SMART-ISLANDS graphical user interface.

3 Experimental Evaluation

The whole set of graphical user interface designed to improve the usability of the SMART-ISLANDS framework, has been designed to allow the final users to use a set of complex Web Services in an easy and fast way. The experimental evaluation focuses its attention on the evaluation of the final GUI. This process was subdivided in three main steps:

- Internal Evaluation;
- External Evaluation conducted by questionnaires on volunteers;
- Data Analysis;

3.1 Usability Tests

The test's main goal has been to assess the performances of the interfaces as well as their level of usability considering the developed interaction paradigms. In order to provide the widest possible range of representative parameters, a user details form together with two questionnaires have been defined. The user details form has been intended to collect anonymous data about the user evaluating the application, like its gender, age range, experience with the software and profile, plus the version he has tested, a fundamental parameter for a platform like SMART-ISLANDS were the same service should be available to the widest possible range of users. The first of the two questionnaires were aimed at the assessment of several application heuristics, namely:

- Overall System and Ergonomics;
- Testing Scenario;
- Overall use of the interface;
- Data access;
- Expectations for implementation in final SMART-ISLANDS clients;

Each of these categories included a number of different questions to which each user was asked to answer through a scale from 1 to 5. A score of one means complete disappointment while a score five means satisfaction. Together with the score the user was asked to provide a severity ranking (as low-med-high) measuring the importance of the stated question.

The first category, overall system ergonomics aimed at assessing how comfortable the use of the Smart-Hydra system was in the chosen scenario. This included verification of:

- Graphics quality of the 3D model;
- Usefulness of the booking and multimedia features;
- Intuitiveness of the interface;

The second category, testing scenario, has been planned to verify the satisfaction of the main use case scenario. That is if the choice is representative of ordinary use conditions, tasks and activities. The third category, overall use of the interface, aimed at assessing the quality of the information provided by the visual interface, such as readability, ease of understanding, colour consistency etc. The fourth category, data access, had the goal of evaluate if the information stored internally and remotely was easy to retrieve through the use of categories and application search features. Finally, the fifth category, expectations for implementation in final SMART-ISLANDS clients, was tailored to the collection of user expectations about additional features to eventually be introduced in further releases of the software. The second test, which has been carried over the guidelines defined by the International Standard ISO 9241, aimed at understanding whether the interface developed could be considered suitable to the chosen application scenario or not. Here the assessment has been done on the basis of the following categories:

- Suitability for the task;
- Self-descriptiveness;
- Controllability;
- Conformity with user expectations;
- Error tolerance;
- Suitability for individualisation;
- Suitability for learning;

Each of these categories, as well as those within the first test, included a number of different sentences to which the user was asked to answer through a scale from 1 to 5. A further option was provided in case the user had no specific opinion. Likewise the user was asked to assess the importance of each sentence in a scale from 1 to 5. Also in this case a further option was provided in case the user had no specific opinion. Following each sentence the user has been free to provide a concrete example where he/she does not agree with the statement. The first group of statements, aimed at assessing the suitability for the task, have explored:

- The system's appropriateness when it comes to its functionalities;
- The correctness of the components of the interface to suit the operational tasks;
- The number of operations required to perform a task;
- The suitability of the output produced by the system;
- The ease of use;

The second group of sentences aimed at assessing the self-descriptiveness of the system in terms of how self-explanatory the interface and the metaphor adopted were. This includes also how easy for the user was to understand the set of functionalities available at each given time as well as to understand the function currently being used.

The third group's goal was to verify the level of controllability of the application in terms of:

- Navigation of the scene.
- Capability to switch between different functions.
- Capability to interrupt the current procedure.
- Consistency of use of conventions.

The fourth category dealt with the interface's conformity with the user expectations. This included how the interface fitted with the mental process the user would expect to follow during the use of the system. Further this included assessment of the interface's level of predictability. This category therefore also explored features related with the level of familiarity of the interface when compared with the software packages used during standard workflow. The error tolerance section assessed how easy was for the user to recover from accidentally inferred commands or from mistakes and errors produced by the system. This was particularly important since this measured failure to recover smoothly from potentially wrong states or which could be cause of loss of data. Most importantly this included safety features to prevent the user from inferring potentially unintended commands as well as the capability to recover original state prior to the wrong actions. Failure to provide this could bring to lower efficiency, frustration and ultimately loss in user's confidence towards the system. This section also assessed the stability of the system in terms of errors or ultimately system crashes occurred during its use. The sixth section's goal was to assess the system's suitability for individualisation. This is the extent to which the software can adapt to the users' personal preferences both in terms of appearance and granularity of the information available to the user.

Last but not least we planned to assess the level of suitability for learning of the SMART-ISLANDS system. This meant to assess the time the user takes to learn how to use the system, its functions and the amount of information provided by the interface in terms of user hints.

This document focuses its attention on the "Overall use of the interface" and "Controllability" test results.

3.2 The Testing Phase

This section provides an aggregated analysis of the survey results performed both online and on the Hydra Island as an evaluation of the Smart-Hydra product done right after an accurate usage test without any hint from the operator. Overall, around 60 questionnaires have been completed at the time of writing, referring mainly to the iPad platform (60%), followed by the web (31.67%) and the Android one (8.33%).

The majority of testers have been male (86.11%) with an age between 18 and 45 years old. This range covers around 75% of our testers with a small amount of people with more than 55 years and around 20% of people, which did not want to communicate their age. The missing 45-54 years old range, as well as the low amount of elderly users is a lack, which is in contrast with our main use case where two retired people were planning their vacation on the Hydra Island.

3.3 Analysis

This section shows a part of the questionnaires results from all the volunteers involved in the test. Recommendations have been derived from the results obtained after processing all the data from the various questionnaires collected, in particular analysing two types of charts for each main survey category based on:

- An averaged numerical result of the response to the questionnaire. The numerical result expresses the joint opinion of the partners in terms of degree of acceptance with the statement made. The variance, plotted as black segments over the charts, then measures the variability, or diversity, of the opinion of the partners.

- A second chart measures the degree of importance, by the various users testing the system, given to the argument set in the statement. A high value expresses high importance, while low value indicates low importance of the analysed subject.

3.4 Overall Use of the Interface

In this set of questions, despite some different opinions on specific aspects it is important to highlight the fact that the interface is perceived as consistent across different functions and that the reactivity of the system is considered as good with a high importance value.

- C1: Feedback time is adequate;
- C2: Processing time is adequate;
- C3: I have experienced no time delay during the working session;
- C4: There is some form of system feedback for every action;
- C5: The interface is user-friendly;
- C6: The system features a consistent icon design scheme and stylistic treatment;
- C7: The colour schemas of the interface are properly chosen;
- C8: The current status of the system is clearly indicated at all times;
- C9: The interface is consistent during the different functions;
- C10: Excessive detail in interface design has been avoided;
- C11: The results are displayed clearly and understandably;
- C12: The results displayed contain all important information;
- C13: The bubble view interface is easy to understand;
- C14: Excessive detail in interface design has been avoided.

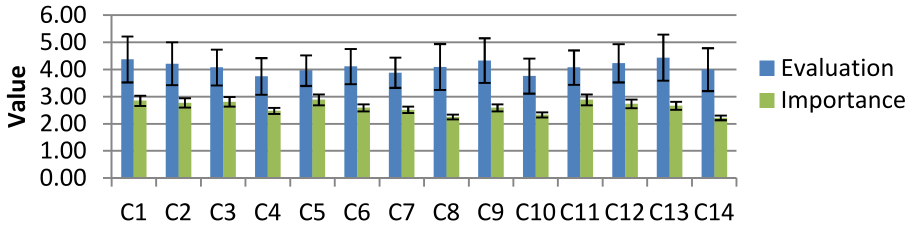

Fig. 2. Overall use of the interface

3.5 Controllability

Figure 3 shows that the design of the system allows a logic and sequential execution of tasks so the user experiences a good sense of control over the system. However, is recommended a greater emphasis on the user's ability to quickly access some tasks or interrupt their execution at any time. The use of things like accelerator to speed up some application tasks is not easily applicable, but careful selection of most frequent activities could suggest which functionalities need to be highlighted.

- Cl.1: The possibilities for navigating within the software are adequate;
- Cl.2: The software makes it easy to switch between different menu functions;
- Cl.3: The software lets me return directly to the main state from any other state;
- Cl.4: I can interrupt any action at any time;
- Cl.5: It is easy to evoke those system procedures that are necessary for my work;
- Cl.6: It's easy for me to move back and forth between different tasks;
- Cl.7: The software allows me to interrupt functions at any point even if it is waiting for me to make an entry;
- Cl.8: The navigation facilities supports optimal usage of the system functionality;
- Cl.9: To perform my tasks the software requires to perform a sequence of steps;
- Cl.10: Selecting menu items I can speed things up by directly entering a letter;
- Cl.11: It is always possible to abort a running procedure manually.

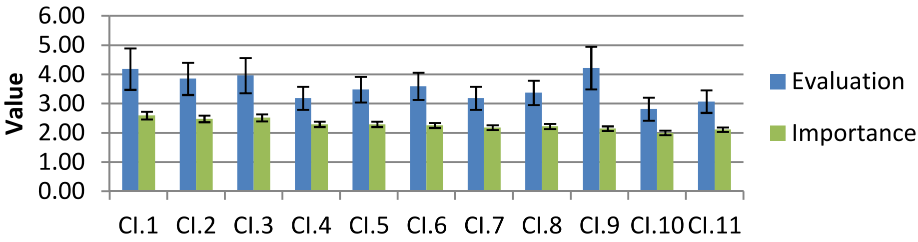

Fig. 3. Overall system controllability

3.6 Portability Test

The questionnaires analysed in the previous section comprehend a variety of different platforms and devices, namely the iPad 2 and 3 for the iOS operative system, Samsung Galaxy Tab 7 and Galaxy Tab 10.1 for the Android OS and Internet Explorer, Firefox, Safari and Chrome for the web platform. The prototype has been tested using each one of them without any difference but it is important to note that the final user experience could have been different even with the same deployment of the app because of the different interaction paradigms between the platforms especially with features depending on external components.

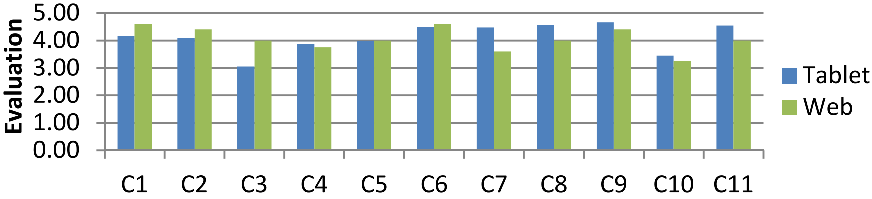

Fig. 4. Use of the interface Tablet versus Web

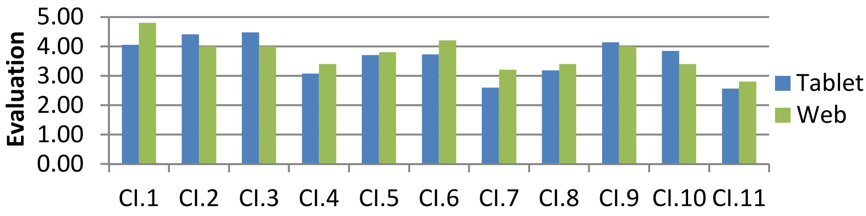

Fig. 5. System controllability Tablet versus Web

4 Experimental Results

The results of the questionnaires, offered very interesting data, especially in the areas where the variance between the results is very high. In particular, it showed a very high variance in the results of the questionnaire on the application controllability (CI.1). The term controllability refers to all those tasks necessary to use the framework, in particular the use of the mouse on web application and use of common gestures for mobile devices that are equipped with a multi touch touchscreen display. Crossing the data obtained was a clear discrepancy between the assessments made on mobile devices and web, as shown in Figure 5. Further analysing the data obtained, in particular observing the data relating to the ages of those who have carried out the testing, were obtained the following results, shown in Figure 6.

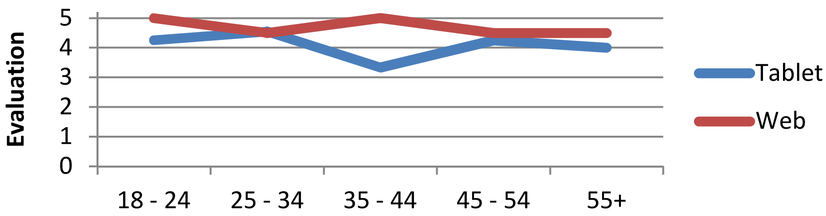

Fig. 6. System controllability age range comparison

Figure 6 shows clearly how the general usability of the SMART-ISLANDS framework increases using the Web version: the only difference between the Web and Tablet versions is the input device that is used: for the Web application the navigation is ensured by the use of mouse as input device, whose usage is well known by years while in the tablet version the navigation is allowed by the use of common gestures for actions like pan, zoom, rotation and touch on buttons to enable/disable features and functionalities. Chapter 3.2 shows how the 75% of the age of the people involved in the testing phase was between 18 and 44 years: this subset of testers will be called the "significant group of testers" (SGT). Analysing the data reached by SGT it is possible to see how the controllability of the framework remains almost constant for the web version, with very high levels of evaluation, while showing an irregular trend for the mobile version. A numbers of researches has been conducted by private statistic institute regarding the smartphone and tablet ownership by age. In particular, Nielsen and Pew Internet published results based on this research for years 2010-2013 [5][6][7][8]. Combining the data reported with the results obtained in Figure 4, it is possible to see how the controllability of the framework for mobile devices goes in pairs with the data reached by the two investigations: 25-34 is age range that has obtained better feedback by SMART-ISLANDS navigation module, 18-24 the second and 35-44 the last one of the SGT.

5 Conclusions and Future Work

Combining the data reached by Nielsen and Pew with the information obtained by the questionnaires, emerges the difficulty of use of this kind of software by the users that probably are not smartphones or tablets owners, in particular, the use of the common gestures used until now for navigation in a three dimensional environment, compared to the same mouse-based version. The youth of the market for mobile devices, compared to the decades of personal computer, emerges in situations like this one: some of the common gestures used for navigation of three-dimensional environments are not so intuitive, testing of alternative solutions is required. Fig. 2 shows how the results obtained in C1, C2 and C3 have a very high variance and are related with the general performance of the SMART-ISLANDS framework. Fig. 4 splits the problem in Tablet and Web version, at the same way as the analysis conducted before: it is possible to see how the overall processing time takes advantages by the Web version. This kind of result is due to the performance difference between a desktop computer and notebook compared to last generation smartphones or tablets, but it is interesting to see how this difference was confirmed by the questionnaire. The last performed analysis regarded the question C4 “the interface is user friendly”. Figure 5 shows how there are not particular differences between the mobile and Web version of the framework. Analysing these data it is possible to conclude that the graphical user interface designed to be used on mobile devices can be adopted without any difficulty by the end user also on conventional personal computers. Future works are related to a more accurate investigation, using questionnaires and interviews, focused on the use of the common gestures to navigate the 3D environment using mobile touchable devices, like smartphones or tablets. The future questionnaires that will be conducted will be focused mainly on the kind of gestures that are used to perform each action, individuate the most intuitive from the other ones. Finally, propose a new set of gestures and evaluate them, using a new set of testers that have any kind of experience with the SMART-ISLANDS framework.

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