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Historical Oslo on a handheld device – a mobile augmented reality application

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Abstract

Mobile augmented reality (AR) applications can provide just-in-time information based on the user's preferences and context and thus improve the tourist experience. Due to various problems, the potential of this technology has yet to be fully exploited. In this paper, we present the design, implementation and evaluation of a mobile AR application for historical Oslo that aims to bring history to life by providing historical pictures of a location, depending on the direction in which the camera is pointing. This application can run offline and is designed as a generic framework where a similar application for a new city can be created by simply replacing the city-specific database.

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Keywords: Augmented reality; location awareness; tourism; history

1. Introduction

Augmented Reality (AR) is an environment that includes both virtual reality and real-world elements. It allows the user to see the real world, with virtual objects superimposed upon or composited with the real world[1]. The virtual objects are computer-generated data, such as text, video, graphics, and GPS data. The real-world view is usually

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captured by the camera of a computer, mobile phone or other device. The superimposition of the computer-generated data on the view captured by the camera in AR enhances a user's perception of and interaction with the real world[2].

AR applications have been explored and used in several different fields, including medical visualisation, maintenance and repair, annotation, entertainment and education[3]. They have also been explored in tourism to enhance tourists' experiences[4,5]. AR applications provide not only practical information, such as facts about accommodation, attractions, museums and monuments, but also customised information based on the user's preferences and context. With the increasing popularity of smartphones, mobile location-based AR applications have started to play an important role in the tourism industry. These applications help tourists to access context-aware information on locations or tourist attractions that can enhance their knowledge about the area. Mobile location-based AR applications allow users to explore the world by adding new layers of location-based information to their reality and to create lists of their favourite point of interests (POIs) using this information[5]. This is thought to provide a more interactive and dynamic experience. However, various difficulties, such as the need for an Internet connection, hinder the full exploitation of the potential of this technology. Although most mobile location-based AR applications for tourists require Internet connectivity, not all cities are fully covered by a Wi-Fi network. Moreover, data roaming charges can be considerable. Offline applications are a viable solution to these problems. In this paper, we present an offline mobile location-based AR application for historical Oslo on Android phones. It aims to bring history to life by providing historical images based on the current location and the direction the user is facing. It is designed for people who are interested in the city's cultural heritage and history.

The rest of the paper is organised as follows. After a discussion of related research and applications in Section 2, the design and implementation of the historical Oslo application is presented in Section 3, followed by an evaluation in Section 4. The conclusion and future work are discussed in Section 5.

2. Related research and applications

Mobile AR applications have been developed for the travel industry to support tourists. Many of these applications, such as Yelp, mTrip, Etpis and Wikitude, provide location-based practical information for tourists. Some of these provide useful information, such as on WiFi spots, ATMs, car parks, transportation, local news and weather. Other applications describe tourist attractions, restaurants and monuments or provide user-generated content, such as photos, videos and comments related to a specific location. AR applications for tourism can be divided into three categories: AR browsers that enable service and content providers to publish thematic content (e.g. Layer, Wikitude), dedicated AR applications (Augmented Reality UK, London AR Guide) and AR view-enabled applications (e.g. mTrip, Etips, Yelp)[4]. The application presented in this paper belongs to the last category.

Frameworks and toolkits have been developed for easy implementation of AR applications. Kounavis et al. examined seven such frameworks and toolkits (DroidAR, Layar, IN2AR, FLARManager, PanicAR, SudaRA and FLARToolKit) and discussed their functions and Operating System (OS) availability[5]. In addition, based on a state-of-the-art analysis of four existing mobile AR applications (Urban Sleuth, Tuscany+, Basel AR tourist Guide and StreetMuseum), they proposed an archetypal framework for the development of mobile AR applications, focusing on the analysis of the design processes. Their framework included four steps: the representation of the situation, the design of the mental model, the laying out of the activity model and the design of the class diagram, which represents the class structure of the system.

Some applications similar to that described herein have employed AR reality to present location-based historical information[6]. For example, tourists can have an AR view of the historical city of Seville in Spain using earphones and glasses. These glasses are a lighter version of the earlier head-mounted display. An Urban AR application developed by the Netherlands Architecture Institute allows mobile phone users to see what was in a location in the past and what is planned in the future. The Then and Now application for Paris, France allows visitors to see historical images from 100 years ago layered onto physical surroundings. In contrast to these applications, the application presented in this paper is designed as a generic framework, and historical Oslo is used an example to demonstrate its functionality. The application can be applied to another city by simply replacing the database content. The replacement can be done relatively quickly and easily.

3. Design and implementation

User-centred design methodology was adopted for the design and development[7]. The process included two major iterations, and formative evaluations were conducted as the last step in each iteration. Potential users were involved in the whole process, and they tested both low-fidelity prototypes and high-fidelity ones. Their requirements and feedback were then used to improve the system.

The historical Oslo application includes two main views: a map view and an AR view. In the map view, the users can orient themselves on the map, browse points of interests and save the locations. In the AR view, they can point the camera of their mobile device in a particular direction (e.g. at a building). Based on the location and the direction, the users get a corresponding picture from the database showing how the area as it looked at a specific point of time in history. In this view, the users can also read related historical information about the particular location.

3.1. Scenario

When a user stands in front of Pilestredet Park 7 (Fig. 1a) and points the camera at the building, the AR view will show a historical picture of the building from 1930 (Fig. 1b). By clicking on an information button, the user can access the following information about the current use of the building and its history:

This building currently hosts Domus & Medicus, which is a health and research centre. Domus & Medicus was officially opened by Oslo's Mayor Per Ditlev-Simonsen on August 3, 2006. The building is the former Women's Clinic at the National Hospital, which has a central place in Norwegian medicine. Many people have a relationship with the building, with 174,369 births taking place here from its opening in 1914 until 2000. Professor of Obstetrics and Gynecology Kristian Brandt (1859–1932) played a crucial role in the establishment of the building, and he also participated actively in its design. The building was officially reopened on August 31, 2006 and is today a modern health and research centre. Among other businesses and institutions, it hosts the National Museum of Medicine.

Fig. 1. (a) view of Pilestredet Park 7; (b) historical image from 1930.

The user can go to the map view from the AR view, and a pin will show the location on the map. The user can then save this location for later review.

3.2. Implementation

The application is implemented with an SQLite database in the backend that includes the GPS coordinates of locations (latitude and longitude), compass direction, historical pictures and additional information. In the front end, there is an interface with icons for the AR view, map view and other functions. Figure 2 shows an early prototype of the AR view (a) and map view (b).

When a user enters the AR view, the latitude and longitude are automatically gathered. For Pilestredet Park 7, the coordinates are (59.92153, 10.738644). A compass function identifies which direction the user/camera is facing (149 degrees from North). A query with the information gathered is then sent to the database to retrieve the picture and additional information. The query returns the relevant picture (Fig. 1b) and historical information.

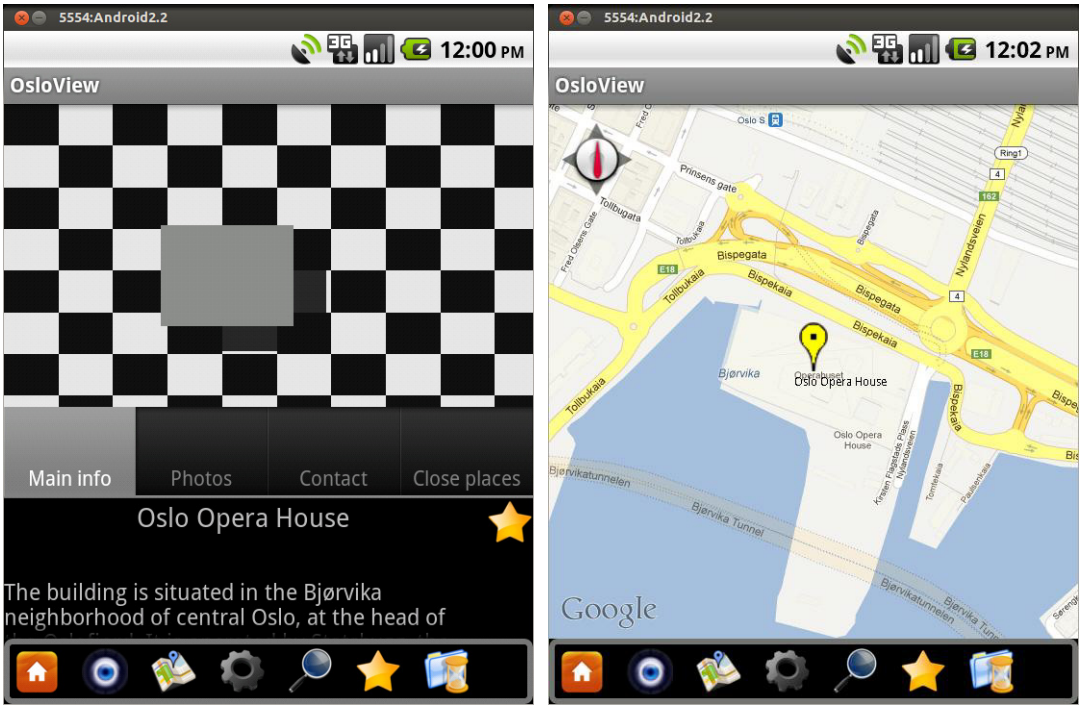

Fig. 2. (a) user interface augmented reality view; (b) map view.

4. Usability evaluation

Two formative evaluations were conducted to investigate the usability of the system and gather feedback for further improvements. First, a heuristic evaluation was carried out with five experts based on the 10 heuristics of Nielson[8]. A hallway test was then carried out with five participants who were in Oslo only for a short time and thus could be considered potential users. A think-aloud protocol was followed during the hallway test. In both evaluations, the participants were given a number of tasks to enable them to explore the systems. The tasks for the heuristic evaluation were as follows:

1. You want to visit Oslo Cathedral but you are new to the city and have no idea of its location. Can you find it using the application?
2. You are standing in front of an interesting looking building but you do not know anything about it. Can you find information about the building using the application?
3. You are very interested in the building and want to mark in on the map for later review. Can you do this?
4. You want to know where exactly you are standing at this minute. How do you find it out on the map?
5. You want to download a new city. How would you do it?
6. You want to visit a place that someone recommended. Although you know it is close to the opera, you do not know its exact location. How would you find out using the application?
7. You were at your university and marked it as a favourite. Can you find the information about the place again?

In the heuristic evaluation, notes taken by the participants were organized into 10 heuristics. Usability problems discovered in this evaluation were categorised using a 5-grade 'Severity Ratings' scale[9]. After the hallway test, the participants completed an additional questionnaire, which included 14 questions/statements about the system. These were answered on a 5-point Likert scale, with 0 denoting strongly disagree and 5 denoting strongly agree. The statements were as follows:

1. In relation to other software I have used, I found the application to be very difficult to use/difficult to use/average/easy to use/very easy to use.
2. The menu items were well organized.
3. I immediately understood the function of each menu item.
4. All the functions I expected to find in the menus were present.
5. I immediately understood the function of each button.
6. The buttons were well organised and easy to find.
7. All the functions I expected to find on a tourist application were present.
8. The different functions were easy to find.
9. I found navigating around the application to be very difficult/difficult/average/easy/very easy.
10. How easy did you find it to understand the contents of the application?
11. Did you find the application simple?
12. The information in the tourist guide was useful.
13. Would you suggest this application to other people? (from definitely not to absolutely).
14. My overall impression of the application is very negative/negative/neutral/positive/very positive.

4.1. Results

Some of results from the heuristic evaluation are shown in Table 1. For each task, the table includes the actions taken by each evaluator during the task, the comments and suggestions made by each evaluator (E1 to E5), the heuristics violated and the severity level. Figure 3 shows the results from the hallway test. The five participants in the evaluation are represented as A–E.

Table 1. Results of the heuristic evaluation

Task	Evaluator	Path	Comments/suggestions	Heuristics violated	Severity
1	**E2**	Clicked Search button, typed 'Oslo cathedral', selected Other, clicked Search	It would be nice to have a link from the search results taking the user straight to the item searched on the map.	Match between system and real world	1
	E3	Clicked Search button, typed 'Oslo cathedral', selected Other, clicked Search	It's easy, and I found all the information straight away.	Match between system and real world	0
2	**E2**	Clicked on AR button, pointed the camera towards the target	I wasn't sure whether the application was working because it doesn't display the information right away, but the rest is ok.	Visibility of system status, recognition rather than recall	1
	E4	Clicked on AR button, pointed the camera towards the target	I liked the eye for the augmented reality tool.	Match between system and real world, aesthetics	0
	E5	Click on Map button, clicked on marker, clicked on AR button and pointed the camera	The icon is unclear. I thought of going to the map first.	Match between system and real world, aesthetics	1
3	**E1**	Clicked on Map button, found the place, clicked on the marker, clicked on the star icon	Requires familiarity with the icons. A description of the icons when they are pressed, such as in all office programs, would be useful.	Recognition rather than recall	2
	E3	Clicked on Add to Favourites button	It is not complicated, but the message that is displayed should be bigger. It is barely noticeable.	Visibility of system status, error prevention, minimalist design	1

	E4	Went to Information View, clicked on Add to Favourites button	I did not know where to start in this task, so I selected the Map button and then Information view.	Match between system and real world	1
	E5	Clicked on 'Add to Favourites' button	From the augmented reality view, it is quite easy, but perhaps the icon should be a bit bigger.	Match between system and real world, aesthetics, visibility of system status	1
4	**E1**	Clicked on Map button	Went to the map but struggled to find the locator on the map. Suggest having a 'Where am I' button.	Match between system and real world, aesthetics	1
	E4	Clicked on Map button	It would be much more useful to have an alternative to GPS points to specify locations.	Match between system and real world, aesthetics	2
5	**E2**	Clicked on Settings button, selected a city and downloaded the data	The download button could be in another colour because the current colour makes it appear that download has already been selected.	Aesthetic	1
	E4	Went through every button until clicking Settings, then selected a city and downloaded the data	I would never have thought of looking in Settings to find the 'new cities' option.	Match between system and real world, recognition rather than recall, aesthetics	3
6	**E1**	Clicked on Search button, typed 'Opera', clicked on search, found opera result, hit Nearby Places button	Easy, no suggestions	Match between system and real world	0
7	**E1**	Went to recently visited and found the info from there	It seems pretty logical.	Match between system and real world	1
	E5	Clicked on the star icon, scroll and found the information about the place	No suggestions	Recognition rather than recall	0

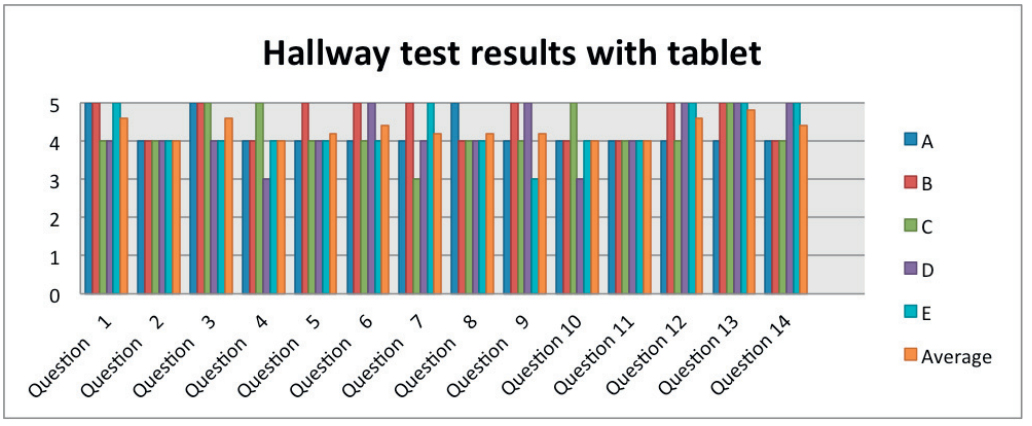

Fig. 3. Results of the questionnaire in the hallway test.

4.2. Summary of results and discussion

Overall, in both evaluations, users felt the application was easy to use and that it has the potential to enhance the experience of tourists and people who are new to the city. The users greatly appreciated the opportunity to obtain historical pictures and information on the screen while they were pointing the camera towards a building. They were also enthusiastic about the possibility of keeping a record of the places that they had recently visited.

According to the heuristic evaluation, the most common problems were the match between the system and the real world and recognition rather than recall. Some icons did not follow real-world conventions, and this caused some confusion among the users. In normal desktop applications, a mouse-over function is usually helpful for users to determine the meaning of an icon. However, it is difficult to provide such function in mobile applications. For the

application to be successful, it is essential that the icons are meaningful to the user and that users do not need to remember their functions.

During the evaluations, the users found the AR button quite confusing. In the AR view, when the application is computing the GPS coordinates, the user does not know whether the application is working or whether it has found the location. One solution would be to add an icon to indicate that the application is searching for the information in the database and to show a message on the screen when no historical information has been found. This type of feedback information would help to reduce confusion and enhance the usability of the system.

5. Conclusion and future work

This paper presented the design and evaluation of a mobile AR application for tourists and others interested in history, using historical Oslo as an example. User-centred design methodology was adopted in the development of the application. The application was designed as a generic framework. To implement a similar application for a new city, the database, which contains the GPS locations, camera directions and the corresponding historical information, simply has to be replaced.

Two usability evaluations were conducted to receive feedback for further improvement. The results showed a general positive attitude among users. They were particularly enthusiastic about the possibility of viewing historical pictures and information when pointing the camera towards a building. Feedback and suggestions for improvements were gathered during the evaluations. These have been prioritised, and some of the suggestions have been implemented.

To further develop the application, we plan on performing an additional thorough evaluation, focusing on location-based AR and the effects of the application on history learning. Future directions of this research include providing adaptive recommendations of historical information and linking relevant Wikipedia articles to the POIs based on the interests and context of the users. User modelling and adaptive information filtering will form essential components of this future work.

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