A Mock-up System for the Early Testing of Location Based Services

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ABSTRACT
In this paper we describe a mock-up system for Location Based Services for the use on mobile devices. It allows an early testing of applications, user interfaces, interaction techniques and computer vision algorithms. Since no special hardware and effort is needed to virtually place a user on an arbitrary location, it is a fast and low cost prototyping system. A specialised Wizard-of-Oz testbed is used to incorporate reality and to simulate application logic and localization. We use an User Centered Design approach by allowing the involvement of the user in the application's design process.

Categories and Subject Descriptors
D.2.11 [**Software Engineering**]: Software Architectures; H.5.2 [**User Interfaces**]: Evaluation/methology

1. INTRODUCTION
The processes of software engineering as well as the design of novel applications dealing with the real world is time-consuming and cost-intensive. Applying User Centered Design (UCD) can help developers to early evaluate application approaches, user interfaces and interaction techniques. UCD refers to the involvement of the user and has the goal to understand her needs and to analyse the requirements to perform a task and hence comprises an iterative design process and evaluation [1].

The design process contains constructional design at the one hand and behavioural design on the other hand [2]. Constructional design means the real, clearly structured software development process which is handled by programming experts. The behavioural design process considers the view of the user who interacts with the system using multimodal Human Computer Interaction (HCI) techniques. This process is accomplished by designers, HCI experts and evaluators. The complete UCD development process requires thus an accurate schedule and a sensitive cooperation between both development groups.

Applications interacting with the real world mainly exist in the area of research for demonstration purposes. End users are rarely familiar with these applications and there interaction techniques. Hence, the challenge is the creation of highly intuitive, fast and reliable user interfaces. To test and evaluate these in the run-up, systems, tools and proceedings have to be designed that allow a fast investigation and evaluation of HCI techniques in the field of real world interaction. Our system is based on an existing mock-up system for the early testing of Augmented Reality (AR) applications and thus has the ability to easily provide AR functionality like adding virtual objects to the real world.

Applications on mobile devices that use Location Based Services have to consider the special characteristics of the devices as well as methods for the acquisition of context information. Graphical User Interfaces (GUIs) on mobile devices are often designed according to standard desktop GUIs. They rarely take the small display size and limited input modalities into account. A goal of our system is to develop suitable and highly intuitive GUIs and interaction techniques for mobile devices. Context information is needed for Location Based Services and has to be procured by the device. Therefore several device sensors like GPS, Bluetooth, infrared or other optical sensors can be used. Since it is quite difficult to test this data in a laboratory, we developed a mock-up system that emulates all needed context information in order to place the user on an arbitrary location where she uses Location Based Services.

The motivation for the creation of our system is founded in the development of services for the LOMS (Local Mobile Services) project [3]. Here local, location dependent services are to be developed which are highly context sensitive, use different end device sensors and provide intuitive user interfaces using AR. Further on tools for the fast creation of Location Based Services are to be created that support non computer experts in the creation process. Therefore an early testing of applications and interaction techniques is essential.

This paper is structured as follows: After presenting some related work in section 2, section 3 introduces our mock-up system. We first address the reproduction of reality in our laboratory and afterwards explain the context of Location Based Services and the implemented line of sight detection of the system. At last we address the Wizard-of-Oz approach that we used. Section 4 introduces our ideas of future work and section 5 finally summarises this work.

2. RELATED WORK

Since Wizard-of-Oz simulation allows an early testing of user interfaces and interaction techniques it is a very easy, fast and reliable way to involve users into the development process. Some research is already done in this field and we here present a few examples.

A prototype system for mobile devices and applications is LiLiPUT (Lightweight Lab Equipment for Portable User Testing in Telecommunications) [6]. The system provides an early testing of mobile applications through several observer approaches. The user of a mobile device here wears a hat that is equipped with two cameras recording the user's surrounding and her facial expressions and with a microphone for recording her utterances. Further on a person (the observer) follows the user in order to make notes of her behaviour. The observer also wears a camera that records the user in her surrounding. Several applications providing information depending on the user's location are now tested and afterwards an evaluation is accomplished by analysing the camera and audio recordings as well as the notes of the observer.

The Wizard-of-Oz testbed presented in [11] describes a testing system for a medical robot. It uses information from both X-ray images and the surgeon to calculate a correct position and then physically guides a surgeon in the drilling through a patients hip. Further on it provides a touchscreen with a GUI for displaying additional information and instructions. The sessions with several surgeons showed that Wizard-of-Oz prototyping allows users to be heavily involved in the external design of interactive products. The results from the sessions led to some decisions of the final user interface. For example the decision was made to not differ between double and single clicks on the touchscreen. Further on some inconsistencies in the instruction flow were detected and eliminated. Also some menu functions were completely removed because none of the test surgeons used it.

[7] introduces Topiary, a framework for Wizard-of-Oz testing of Location Enhanced Applications which provides maps, scenarios and storyboards for the easy creation of Wizard-of-Oz test situations. During a test, a wizard follows the user and permanently updates the environment of her, e.g. the positions of persons and things. The end user's user interface is automatically updated by Topiary if things change or the user interacts with it. The behaviour of the user interface is defined in the Topiary storyboard.

In [8] a system for Reality Reproduction is presented which provides immersive video and surround sound. The aim is to let the user fully immerse into a virtual world and to test user interfaces and applications that deal with contextual information.

Mobile, CV based Line of Sight detection and information overlay is presented in [9]. Here a camera equipped PDA with GPS receiver is used to analyse images taken by the user. These are uploaded to a server machine that analyses which buildings are currently in the user's field of view. Additional information about a single building is than presented on the PDA.

3. MOCK-UP SYSTEM

This section describes the framework of our mock-up system, early testing procedures and the application currently running on the system.

3.1 REALITY REPRODUCTION

Since Location Based Services depend on the position the user currently remains it is difficult to test these kind of applications in a laboratory during the development process. Therefore our system is capable to simulate the reality of an arbitrary place. For raw position tracking GPS is used directly on the mobile device. Since there is no possibility to receive real GPS data in our laboratory we developed a GPS emulator. The emulator sends GPS NMEA strings via Bluetooth to the mobile device and thus acts like a GPS mouse. This enables us to virtually place the user on an arbitrary place by just changing the transmitted GPS data. We use a laptop pc as emulator which provides an application to easily change the GPS coordinates (see section 3.4). Since GPS only provides raw accuracy and does not address the direction the user is currently looking at, we further use Computer Vision (CV) based line of sight detection. We called this part of our system Reality Reproduction since GPS data and image data is created artificially for simulating an arbitrary place on earth.

Meanwhile there are only a few – and if, inaccurate – possibilities to get the actual heading or direction of a mobile device. Most of them use the incremental change of positions to compute an approximate heading but this method can only be used when the mobile device is moving around. In the case of a human carrying the device, the calculated heading is even less accurate. Particularly, these devices have only the information about past movements and the accuracy of e.g. GPS is not good enough to track rotation while the device is not moving. Assumed the mobile device is carried by someone who is stopping every now and then to look around, the device would not recognise the corresponding rotations. Of course, it is possible to track the user's rotations with an additional sensor, e.g. like in [10], where an external digital compass was used. In that approach, the data from the external orientation sensor was used to show the corresponding section of a panoramic image, which is located on a server and has been enriched with additional information before. The mobile device is connected via a wireless network to a server system, which holds the image database. The main disadvantage of this approach is its need for an external sensor to gather the orientational information. Furthermore, an additional sensor would be necessary to gather position information inside the museum;

since neither the digital compass nor a GPS system would provide the necessary information, thus another sensor has to be found. The intent of the approach described here, is to use sensors already available in the mobile device instead of attaching external ones. Currently, a trend is integrating as much functionality as possible in continuously shrinking hand-held devices. So today, you will not have a pure mobile phone, but rather a small PDA integrating Bluetooth, wireless LAN, UMTS and even a GPS receiver. Thus, all necessary sensors for an outside-the-house navigation are existent, but still it is hard to guess the actual heading of the mobile device while it is not moving. Almost all of these multi-functional hand-held devices integrates cameras with at least VGA resolution. So, it stands to reason using the integrated camera to get the actual heading.

Our approach uses prepared panoramic images for Reality Reproduction. Such an image is displayed on a huge screen using a projector. The panoramic image must accord to the GPS coordinates received from the GPS emulator. The user now records parts of the panoramic image by pointing the embedded camera of her device towards the screen. Using CV algorithms the direction of the user can be analysed. Figure 1 shows a model of the recording of an image part from a projected panoramic image.

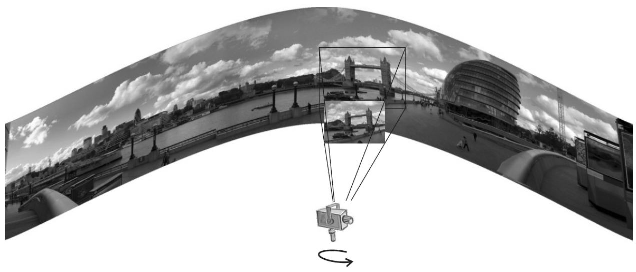

Figure 1: Panorama of London: Camera records an image part

3.2 LOCATION BASED SERVICES

The scenario described in this paper is to be implemented within the scope of the LOMS project [3]. Recorded image parts of a real surrounding are to be transmitted to a remote LOMS service and analysed there. The service afterwards responds with corresponding information about visible points of interest. The localization happens as previously described in a two-stage way via GPS and line of sight detection using CV. The GPS data is also transmitted to the LOMS service.

The main advantage of this system is, that besides complete applications also different interaction techniques, user interfaces and CV algorithms can be tested and evaluated. Further on AR functionalities for a rich superpositioning of the camera image can be applied. The use of remote services allows a faster analysis and enhancement of a recorded camera image since processors of mobile devices are rarely able to do such complex computations.

3.3 LINE OF SIGHT DETECTION

In most cases a heading information is needed to identify objects of relevance, e.g. interesting buildings, while looking around. Hence it would be sufficient to get the information on user's request with a small delay. The user points her camera-and-GPS-equipped hand-held to a direction and initiates a request. Such a request consists of the image taken and the global position information obtained by the GPS receiver, both sent to a mobile service server holding the panorama picture database. The server then analyses the received image and extracts distinctive image features (e.g. SIFT points, see [5]) to match them afterwards against the database. The typically huge search space in the database is reduced thanks to the knowledge about the global position. As can be seen in [4], objects and their spatial orientation can be detected with this kind of image features. Using an image based line of sight detection also offers the possibility to enrich the recorded image later with additional information (e.g. using Augmented Reality which needs a high accuracy and addresses lens distortion). The extracted and the stored keypoints are matched against each other. A weighted sum of all positive matches is built up; and with its help the centre of the matched coordinates can be found. The found coordinate in the panoramic image can be interpreted as a heading or line of sight. With all these information together (global position, heading, up-to-date camera image), an augmented image can be sent back, where e.g. interesting points of view are marked. Along the way, additional information about the user's location or about the near by interesting locations can be sent to the user's hand-held.

3.4 WIZARD-OF-OZ SIMULATION

To allow an early testing of applications and interaction techniques it would be cumbersome and time-consuming to develop a complete application in each case. Hence we created a mock-up system which is based on Wizard-of-Oz simulation. Wizard-of-Oz simulation replaces the application logic by a human wizard. The wizard always provides a current GUI for the user and analyses her actions. If the user interacts with the GUI the wizard thus provides a new look of it containing changes caused by the action. Afterwards an evaluation of the application and interaction technique can be accomplished through user interviews.

Hence in our system the human wizard firstly cares about sending GPS coordinates that fit to the displayed panoramic image. The GPS emulator application provides a GUI that allows the easy change of GPS coordinates. It therefore provides a clickable map. If a position on the map is selected the corresponding GPS coordinates are calculated and henceforth continuously sent to the mobile device. Figure 2 shows the emulator application which here uses a map of a virtual theme park which can easily be replaced by e.g. a real city map. The user now applies the camera of her device to record image parts from the panoramic image. Once she made a decision of her line of sight she requests additional information about it by pressing a button on the GUI. The recorded image is now transmitted to a server machine which analyses the line of sight. If the user is looking towards a special point of interest, the wizard sends a new GUI to the user containing information about e.g. buildings or mountains she is currently looking at.

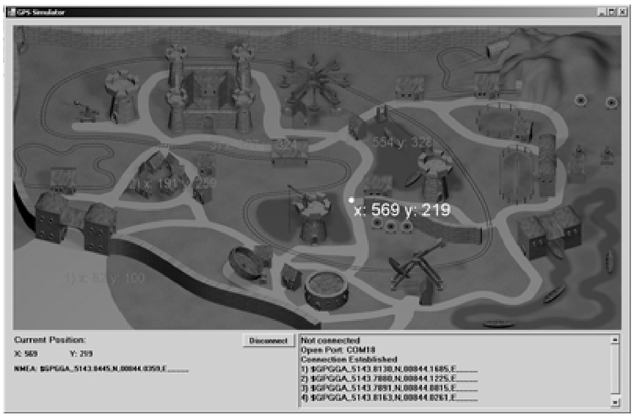

Figure 2: GPS emulator with virtual map

3.5 APPLICATION

Our application currently uses a panoramic image and GPS data of the city of London. The wizard initially provides the projection of the panoramic image and virtually positions the user into the city of London by using the GPS emulator. The GPS emulator from now on acts as a GPS mouse and continuously sends the GPS NMEA string via Bluetooth to the mobile device. The user now records an image part of the panoramic image with her camera equipped device and sends it to the server machine using WLAN. The server then computes the line of sight and displays the result to the wizard. The wizard decides which image is to be sent back and thus provides a superimposed image to the user that contains additional information about a building the user is currently looking at. After receiving the result image the mobile device displays it to the user. Figure 3 provides a scheme of the process containing concerned hardware and the data flow.

4. FUTURE WORK

Our system currently uses GPS data and a panoramic image of the city of London. We are going to create datasets for additional locations especially to test the line of sight detection with different CV algorithms on different panoramic images. We are also planning to use more special displays for the panoramic images e.g. an L-Shape or CAVE for a better surrounding of the user. The Reality Reproduction could be extended using further stimuli (e.g. noise) for a better immersion of the user. Besides CV algorithms we will also test different user interfaces and interaction technologies on mobile devices. Several scenarios will be created and user questionnaires will be accomplished in order to develop highly intuitive user interfaces for our application. This is then going to be implemented into the LOMS framework where different transmission technologies for service access may be used. Also user tests in the real world are imaginable to compare results with that from the laboratory tests.

5. CONCLUSION

In this paper we presented a mock-up system for Location Based Services. Inside our laboratory we are able to reproduce reality and to virtually place a user on an arbitrary place. Therefore a panoramic image is displayed on a huge screen and a GPS emulator is used to send GPS coordinates

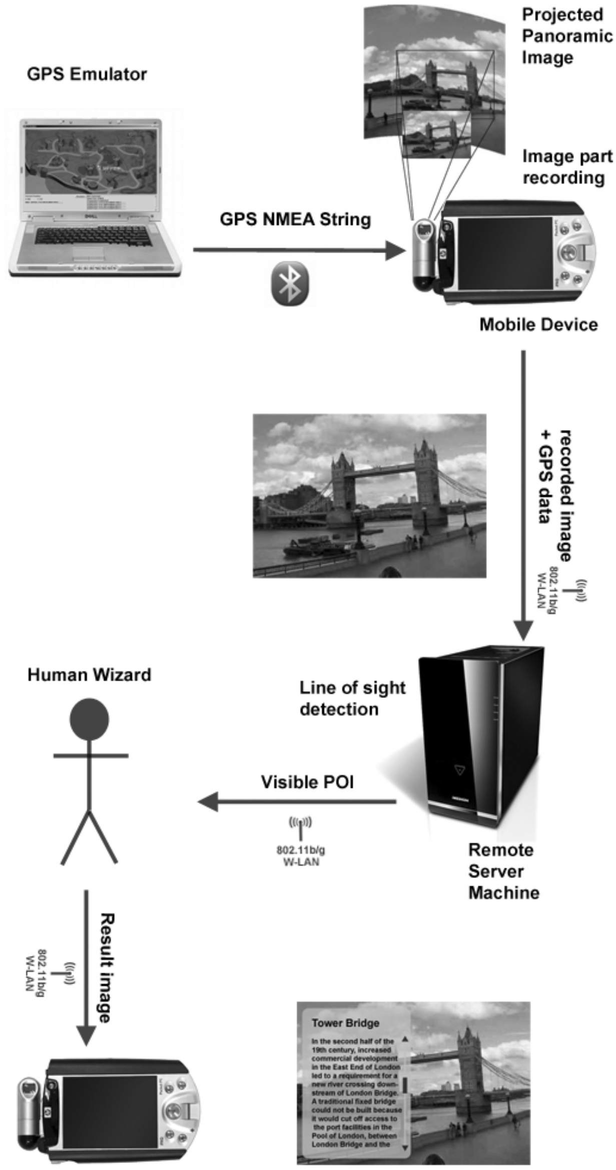

Figure 3: Application scheme

according to the panoramic image to the mobile device. Using CV algorithms and a client / server approach, image parts from the panoramic images recorded by the mobile device are sent to the server which analyses the line of sight of the user. Using Wizard-Of-Oz simulation a human wizard always knows, what the user is currently doing and where she is looking at. The wizard hence changes the GUI of the mobile device manually and can so provide additional information about buildings or landmarks the user is currently looking at. This Wizard-of-Oz simulation allows a fast and cost-efficient testing of the application, user interface, interaction technique and CV algorithm.

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