Archeoguide: System Architecture of a Mobile Outdoor Augmented Reality System

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Abstract
We present the system architecture of a mobile outdoor augmented reality system for the Archeoguide project. We begin with a short introduction to the project. Then we present the hardware we chose for the mobile system and we describe the system architecture we designed for the software implementation. We conclude this paper with the first results obtained from experiments we made during our trials at ancient Olympia in Greece.

Keywords
Mobile augmented reality, wearable computers, cultural heritage.

INTRODUCTION
The Archeoguide project aims to present information to visitors of historical sites in a completely novel way. At many historical sites, there are just a few remains, and the visitor only sees ruins or baseplates. Frequently, certain efforts are presented for the reconstruction of these devastated buildings. These plans face strong opposition from archaeologists, which prefer to conserve the current state for future generations. The Archeoguide project is a solution for this discrepancy. Instead of rebuilding real ruins, we present virtual reconstructions to the visitors. The historical site remains untouched. For more information see [1], [2], and [3].

HARDWARE
During the assembly of our mobile device we had to compromise between performance, battery running time and weight/wearability. We made the decision to favour performance over running time and weight, because running time and weight will be automatically improved by the technical advancement of hardware. So instead of using special wearable computers like the Xybernaut or the Via PC that do not provide sufficient performance, our system is based on a highend laptop (800MHz Pentium III CPU, 256 MB RAM, nVidia GeForce2Go GPU). Equipped with two batteries, the system runs about two hours, which was our minimum running time. For the head mounted display we are using the nVision VB-30. We started out first tests with a Sony Glasstron, but soon it became obvious that these devices are much too uncomfortable to wear for a prolonged period of time. The video camera we use is an ordinary USB web cam. Of course such kind of camera is not perfect for image processing, but it is cheap and simple to connect to the mobile device. For rough position and orientation estimation, we use a differential GPS receiver and an electronic compass. For more information see [4].

SOFTWARE ARCHITECTURE
The archeoguide system is composed of three major components: The controller, the video tracker, and the renderer.

Controller
The Controller is responsible to collect the data required to identify the position-orientation of the user in the site, and according to that perform a sequence of actions. For the Controller the entire site is modeled as collection of viewpoints. Every viewpoint is uniquely identified by its longitude, latitude and heading of the user. For each viewpoint we have a set of reference images for the video tracking and an associated set of overlay images for the rendering component. Moreover, every viewpoint contains a collection of images, videos, sounds and VRML objects. The controller is responsible not only to organize the audio-visual material to be presented in a proper manner, but also to communicate with the renderer component in order to dictate the overlay image that has to be rendered by our rendering engine. A collection of photos has been created for every viewpoint in the archeological site. These photos vary at both the time of the year that have been taken as well as on the time of the day. Based on these reference images, different overlay images have been created with the appropriate variations on the lighting conditions.

Video Tracking
The purpose of the video tracking component is to integrate the augmentations seamlessly into the video image. At the moment we exclusively do 2D augmentations, i.e. we overlay the video images with 2D images of the temples. We are using a tracking technique based on reference images because we were not allowed to put any special markers onto the historical site. The controller component provides the tracking component with the current viewpoint as described in the previous section. For each viewpoint there is a set of reference images we took when we prepared the system. The tracking component compares the current video image with the set of reference images and decides which reference image best matches the video image. Then it calculates the transformation that is necessary to fit the reference image to the video image. For each reference

image we know the exact position of the overlay image. So by performing the same transformation we calculated for the reference image on the overlay image, we are able to exactly position the overlay image on the video image. For more information see [5] and [6].

Rendering

The rendering component is responsible for the presentation of all information to the user. Its main task of course is to render the augmentations, but it also plays audio information and displays further material like images, videos, and 3D models of objects found on the site. Last but not least it provides the user interface.

For the rendering of the augmentations the rendering components gets: (1) Information about the current viewpoint from the controller component. Based on this information it loads the set of overlay images for this viewpoint from the database. (2) The current video image from the video tracking component. This video image gets drawn in the background. (3) The current image transformation from the video tracking component.

We extended the simple overlay technique by some interesting features: (1) The user of the system is able to smoothly change the transparency of the overlay image. This way he is able to fade in and out between real image and augmentations. (2) By using more than one overlay image we can "mark" different parts of temples. While the user watches the augmentations, an audio track plays that provides information about the temple. The controller switches between the different overlay images synchronously with the audio information to demonstrate to which parts of the temple the audio information refers to. (3) Obviously, we are not limited to still images. The overlay technique works with videos as well. We use this feature at several viewpoints in the old stadium at Olympia were the user can watch virtual athletes performing ancient sport events.

USER INTERFACE

Most AR systems use special input devices or speech and gesture recognition. We soon had to realize that such sophisticated interaction techniques are not suitable for our system. It is not realistic to run a speech or gesture recognition system besides the video tracking and the rendering system on our limited hardware platform. Furthermore, a gesture recognition system obviously interferes with the video tracking. So we made the decision to drop these sophisticated interaction techniques in favour of more traditional techniques that actually work reliable.

The most user-friendly interface is a system that does not need much interventions by the user. In our system, the user itself is the user interface. That means that he controls the system predominantly by his position on the site and his viewing direction. Nevertheless, now and then the user needs to interact with the system. The average user of the Archeoguide system is not a computer expert. Therefore, we had to develop an interface that can be handled both by teenagers and seniors without any tedious training. A kind of interface that most people already know from their television sets and VCRs are so-called on-screen-displays, so we chose to implement user interface elements like menus and sliders. The user can control these user interface elements by using the buttons available on the VB-30 HMD.

RESULTS

Since May 2001 there is a working prototype of the Archeoguide system. We made numerous tests on the ancient Olympia site at different weather & lighting conditions and different seasons. We also made some tests with visitors of the site not related to the project team. Our first experience is that the augmentations give an added value to the visitor of a historical site. Nevertheless, we had to face some problems, especially concerning the hardware of our system: (1) The complete system is still much too uncomfortable to wear. It is too big and weighty. Furthermore, the complete hardware is way too fragile for rough outdoor conditions. And in the end it is too expensive to use it commercially on a historical site. (2) The display technology is not appropriate for outdoor applications. Brightness and contrast of the nVision VB-30 (and also of the similar Sony Glasstron) are much to low. In direct sunlight its hard to see the augmentations. (3) Also the camera is not suitable for outdoor applications. Especially the autogain is overloaded with the great contrasts we encounter outdoors on sunny days. (4) The user is too limited. At the moment, the visitor of the site gets augmentations only at selected points on the site.

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