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PP	Restricted to other programme participants (including the Commission Services)	
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EPOCH Showcase: On Site Experience

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Abstract

Our showcase 'On Site Reconstruction Experience' will present the use of augmented reality (AR) technology and virtual 3D reconstruction techniques to give visitors of the ancient city of Sagalassos new insights into historical times. The showcase addresses the problem of imaging the past. Visitors and researchers of an archaeological site usually need to imagine the original appearance to understand the history of the space. Realistic reconstruction can greatly increase the level of understanding and involvement. With mobile augmented reality technology, we can help visitors to imagine the past in situ, making the experience more attractive and enjoyable.

1. Outline

Our showcase combines AR technology, described in Section 2 with a virtual reconstructed building at the archaeological site of Sagalassos, which is presented in Section 3. The integration of these two parts is given in Section 4. The last section finally concludes the showcase description.

2. AR Technology

Augmented reality is a new form of man-machine-interaction, where digital information is displayed into the field of view of the user. The core component of the AR system is a see through display (Fig. 1), through which the user observes it's surrounding, that is cross-faded with digital information. This technology offers - especially in combination with the mobile computing area - great potential. Equipped with a portable computing entity including a video camera the user moves across streets and places and will be supplied with location-specific information. This idea will be value-adding in e.g. tourism, where places of cultural interest are reconstructed and historical events and scenes can be displayed.

In order to integrate the virtual objects into the user's view; we need to determine user's exact position and direction of view. There are many different tracking technologies available today that offer position and orientation tracking with high precision and low latency. However, none of the available systems is suitable for outdoors usage with sufficient precision as required. Integrating different tracking

technologies into one hybrid system seems to be the most promising approach [SKV*02].



Figure 1: User with AR glasses

A first rough positioning of the user is given by using the GPS and compass system. For exact tracking image-based techniques are used. The only additional hardware that we need in order to perform the vision-based tracking is a tiny off-the-shelf camera attached to the user's HMD. The system can determine the user's viewpoint based solely on the video image.

Another possibility to present reconstructed buildings to tourist would be immobile systems like the AR Telescope [LS04]. The principle of the AR Telescope solves the prob-



Figure 2: *Augmented view from viewpoint number three*

lems of tracking the position of the user by setting up a stationary augmented reality device. The mobility of the user thus is limited due to the fact that the AR Equipment is embedded into a traditional coin-operated binocular. The advantages are that sensors equipped at the binocular provide an exact registration of the telescopes' view direction and that powerful computers and displays can be used offering strong contrasts, without having to pay attention to the mobility of the device itself.

3. The Nymphaeum at Sagalassos

The topic of our showcase is the ancient city of Sagalassos, about 100 km to the north of modern Antalya in Turkey. It was a prosperous city from early Hellenistic times until a ravaging earthquake stuck it in the 7th century. After having been inhabited for more than thousand years, the city was abandoned and disappeared into oblivion. From 1982 onward the Pisidia Survey Project, directed by Prof. S. Mitchell put the region back on the archaeological map. In 1986 Prof Marc Waelkens joined the team at Sagalassos and from 1990 onwards he turned the large scale and highly interdisciplinary excavation into one of the largest archaeological enterprises in the Mediterranean [Van93, Van97].

For our showcase we focus on one particular building in Sagalassos, the nymphaeum (ornamental fountain) at the upper agora (Fig. 3). The nymphaeum was erected during the Roman era of the city, more particular during the reign of emperor Marcus Aurelius (AD 161-180). Excavations on the nymphaeum started in 1994. More than 90% of the building elements have been found, more often in a seriously damaged state. The finds have been documented by a large set



Figure 3: *Normal view at the historical site*

of photos and drawings, used to build a photo-realistic 3D reconstruction, shown in Figure 2.

The techniques we have used to build the 3D model include multiple 3D acquisition techniques. Some reconstructions were build directly from the photographic material based on our 'shape-from-stills' pipeline [VTF*02], where the 3D structure of the photographed object is extracted from a series of sufficiently overlapping pictures. Apart from this passive 3D extraction method, we also used Eyetronics' ShapeCam [Eyecs], mostly for some highly decorated elements, where the geometry could be quite intricate. This structured light device projects a grid onto the object while taking an image, and from the grids deformation in the image, a complete surface patch is reconstructed. The 3D data was further processed with various techniques including texture modeling and synthesis, data clean-up, and visualization. The result is a maximally realistic but also veridical model [VWM*04].

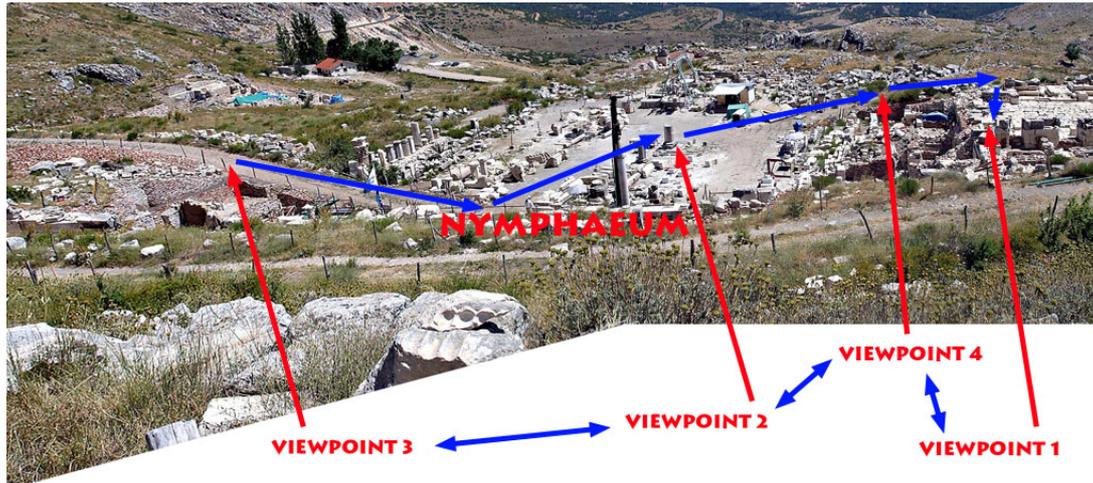


Figure 4: Selected viewpoints seen from the back of the nymphaeum

4. The Showcase Setup

In collaboration with the archaeological team, multiple viewpoints in front of the nymphaeum have been selected to calibrate the AR system (Fig. 4). While the visitor is standing on a selected viewpoint, the pre-rendered 3D model is superimposed on the user's real view to generate the on site experience. The system tracks the visitor's head motion and the image is continuously adjusted to the actual field of view.

Our showcase will present this technology to the visitors of the VAST conference. The setup of the presentation will consist of:

- The Augmented Reality System for Cultural Heritage Presentation including the semi-transparent display, the video camera and the graphic computer
- Posters with photographs of the landscape and the ruins of Sagalassos
- A display to present the resulting augmented images to the visitors

Visitors will be able to test the Augmented Reality system in a demonstrative scenario and to use the system to see different parts of the reconstructed site as if they were standing in Sagalassos.

5. Conclusion

In this showcase description, we have presented an augmented reality system capable of superimposing the 3D reconstructed nymphaeum in Sagalassos on a head mounted display in situ as a case in point. Using the video-see-through HMD, the visitor was able to see ancient buildings or even animated historical stories as a virtual reconstruction on top of the real surrounding. Thus it was presented how this place could have looked like in ancient times to achieve a better understanding of the past.

6. Acknowledgments

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ON SITE RECONSTRUCTION EXPERIENCE

Imaging the Past Visitors of an archaeological site usually need to imagine its past appearance to understand its history of the space and the difficulty of this task limits the enjoyment of their experience. This Showcase presents an AR (Augmented Reality) system where visitors see virtual reconstructions of ancient monuments superimposed on the scene through AR glasses. This gives visitors and researchers a feeling for the original appearance of a site, and this experience is provided *in situ*.

The mobile unit is based on a Head Mounted Display, a camera and a laptop. Its optical tracking algorithm is capable of identifying the visitor's position among several pre-selected viewpoints.

This allows for the integration of real and virtual scene elements on the head-mounted display and facilitates the comprehension of the visited site.

Sagalassos The system has been applied to the *nymphaeum* (ornamental fountain) at the upper agora of the ancient city of Sagalassos, about 100 km to the north of modern Antalya in Turkey. Sagalassos was a prosperous city from early Hellenistic times until it was struck by a devastating earthquake in the 7th century.

Since 1994, more than 90% of the building elements have been found during excavations, more



User wearing the mobile unit

often than not in a seriously damaged state. The finds have been documented by a large set of photos and drawings, used to build a photo-realistic 3D reconstruction.

While the visitor is standing on a selected viewpoint, the pre-rendered 3D model is superimposed on the user's real view to generate the on-site experience. The system tracks the visitor's head motion and the image is continuously adjusted to the actual field of view.

Technical details In this showcase ARCHEOGUIDE AR tools, developed by Fraunhofer IGD, combine with 3D modeling methods developed in MURALE by ETH and the University of Leuven, Belgium.

It uses a Fourier-based approach for markerless tracking, which is robust to changing lighting conditions, handles up to 60% of occlusion and works in real-time.

It also caters for head orientation.

ARCHEOGUIDE and MURALE are EU-FP5 funded projects.



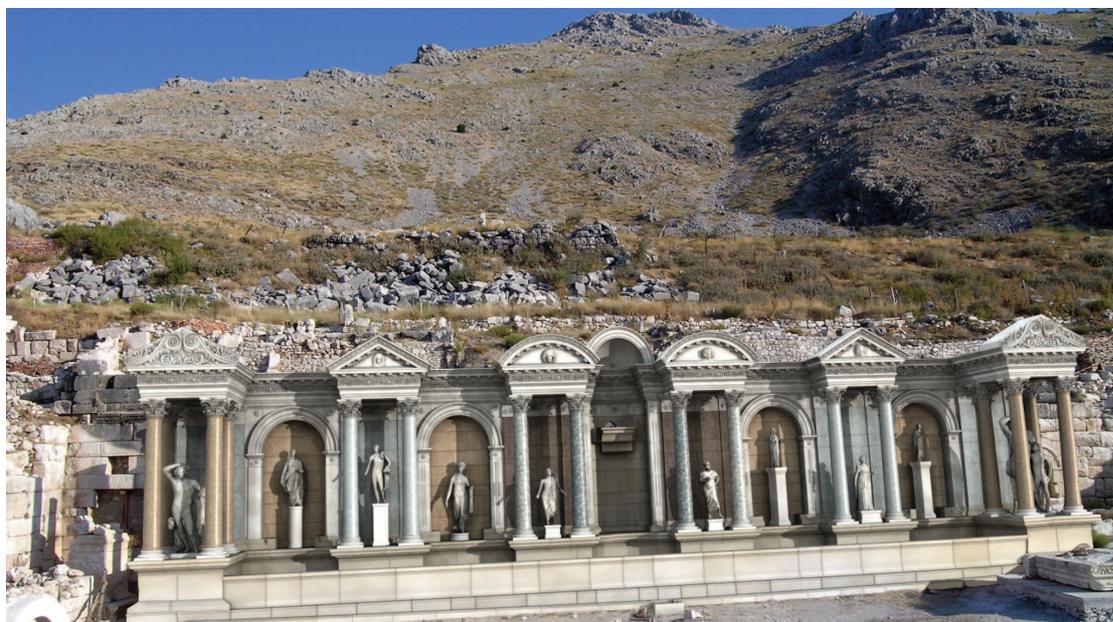
Nymphaeum in its current state

Partners The institutions collaborating on the realization of the showcase *On Site Reconstruction Experience*, to be tested at Sagalassos, Turkey, and Olympia, Greece, are:

- ▶ ETH Zürich, Computer Vision Laboratory, Switzerland
- ▶ Fraunhofer Institut, Darmstadt, Germany



Virtual reconstruction of the nymphaeum



Augmented view of the nymphaeum

Interested?

Are you interested in this showcase? Do you think that this approach can help you in creating effective Cultural Heritage presentation projects or can be integrated in new research projects? Please contact Prof. Luc Van Gool (vangool@vision.ee.ethz.ch) of ETH Zürich at +41 1 6326578 or Dr. Didier Stricker (Didier.Stricker@igd.fhg.de) of Fraunhofer IGD Darmstadt at +49 6151 155188.

EPOCH is a Network of Excellence on Intelligent Cultural Heritage within the IST (Information Society Technologies) section of the Sixth Framework Programme of the European Commission. EPOCH showcases demonstrate innovative solutions and technological integration for target application areas in the Cultural Heritage domain. As they are created with real world content, they stimulate creative thinking about the use of the technologies in Cultural Heritage, and are used to validate new technological approaches with key stakeholders in the Cultural Heritage domain. For more details, visit the project web site:

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