AUGMENTED REALITY

JEAN-PHILIPPE FARRUGIA and FRÉDÉRIC MERIENNE

COSCH Case Study that has employed this technology: Germolles

Definition

Augmented Reality (AR) is a group of imaging techniques designed to blend virtual and real elements in a coherent scene. Usually, an Augmented Reality application allows a user to navigate in a real environment with an augmented visualization of synthetic elements. This technology has numerous applications, from digital entertainment and video games to specialized professional training and simulation. At the time of writing, AR applications are mainly implemented on smartphones or tablets, which offer an ideal combination of hardware (sensors, cameras, graphics processor, and powerful processing units) for this task.

Description

From a practical point of view, augmenting reality means synchronizing and fusing heterogeneous representations of both actual and virtual scenes. Depending on the targeted application, this fusion needs to be precise and/or complete. For instance, specific applications may require the virtual elements to be positioned very precisely. Other applications may need to be visually convincing, with realistic shading, occlusion, and shadows.

Augmented Reality covers many different software and hardware technologies and is therefore difficult. Its challenges may be presented through three important principles: co-localization, co-occlusion, and co-lighting.

Co-localization means aligning the real scene with the virtual scene: the camera of the virtual scene is placed at the same coordinate location as the physical camera (fig. 13.1). This process is generally achieved through a combination of computer vision techniques with specialized sensors: accelerometers, GPS, gyroscopes, depth cameras, etc. It may also be facilitated by placing custom markers

Figure 13.1. Augmented Reality with co-localization and co-lighting (no co-occlusion). © Jean-Philippe Farrugia and Frédéric Merienne, 2015.

Figure 13.2. Augmented Reality with co-localization, co-occlusion, and co-lighting. © Jean-Philippe Farrugia and Frédéric Merienne, 2015.

throughout the environment. These markers look like two-dimensional barcodes and present high contrast to enable easy detection. By comparing their projection onto the camera image plane with a reference picture, it is possible through basic linear algebra to retrieve the position of the user. Marker-based co-localization is usually more robust than marker-less and sensor-based techniques, but it is also more intrusive.

Co-occlusion means taking into account the geometry of the real world when rendering virtual elements. Specifically, virtual and real elements should occlude each other, depending on their respective shapes and locations in the environment. Since the shapes of the virtual elements are known, the significant challenge is to acquire the geometry of the real elements. This is generally done with dedicated scanners or depth cameras, offline (in advance, ahead of usage) or in real time if the device has the necessary hardware.

Co-lighting means computing light interactions between real and synthetic elements. For instance, a virtual object lying on a real desk should project a shadow onto the desk. Similarly, synthetic objects should be illuminated or shaded by the real lights of the environment. Achieving co-lighting is difficult since it requires two simultaneous tasks: dynamically capturing ambient lighting and rendering virtual objects with this potentially highly complex data. To date, only *ad hoc* real-time solutions provide a viable way of meeting this challenge.

Significant Applications

Augmented Reality has been used for several purposes in the cultural heritage domain: for archaeologists, as an assessment tool; for tourists, for a better understanding of a site; and for museum stakeholders, for planning and education (fig. 13.3). Early projects in the 1990s explored the added value of AR for cultural heritage. Some of them, funded by the European Union, were focused on European archaeological sites. For instance, in the Archeoguide project (Vlahakis et al. 2002) a mobile AR system was developed. The project focused on issues of localization (tracking), mobility (portable system), and narration (using an avatar in a virtual scene). The system provided onsite help and AR reconstructions of ancient ruins, based on the user's position and orientation within the cultural site, as well as real-time image rendering. It incorporated a multimedia database of cultural material for online access to cultural data, virtual visits, and restoration information.

As a proof of concept, an application was developed for the ancient archaeological site at Olympia in Athens, Greece. The Gunzo project (Durand et al. 2014), funded by the European Regional Development Fund and the authorities of Burgundy, France, developed an on-site AR system, allowing virtual re-creation of the Cluny III abbey (1088–1109) demolished in the early nineteenth century. Using on-site visualization devices, visitors may switch between a view of the present architectural remains of the monument, and the view into the medieval abbey church's nave or choir, recreated with consistent materials and lighting. Because a real-time computation of lighting was not possible, the device was placed in a specific area and the rendering was carried out offline.

Figure 13.3. Studying a museum object through AR. The UK V-Must School at the University College London Petrie Museum. Photo: Martin Blazeby, 2013. Reproduced by permission.

More recently and thanks to the fast development of smart mobile devices, many companies, including Humarker, Marte5, and Paztec, have emerged. New applications for cultural heritage, such as LecceAR, have been developed.

Literature

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