Corona: Audio Augmented Reality in Historic Sites

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Abstract
Augmented reality is very well suited to convey information in the context of historic sites, as it is possible to integrate such systems in an unobtrusive manner. In this paper we present Corona, an audio augmented reality experience deployed in the historic town hall of Aachen/Germany. We describe the auralization process and the technology used and give an outlook on interesting research questions that need to be investigated.

Keywords
audio augmented reality, museum, spatial audio, history, exhibit

ACM Classification Keywords
H5.1. Information interfaces and presentation (e.g., HCI): Multimedia Information Systems — *Artificial, augmented, and virtual realities.*

General Terms
Experimentation, Human Factors

Introduction
Many historic sites have interesting stories to tell about what happened at that place in the past, but these locations are often under monumental protection, which

makes it difficult to install interactive exhibits. Mobile augmented reality however, can be integrated into a museum concept without the need for obtrusive installations as, depending on the required features, it does not need much or no additional systems at all.

Figure 1: The Coronation Hall in the historic town hall of Aachen/Germany

An example for such a historic site is the city hall of Aachen. Built in the 9th century [2], it served Charlemagne and several other emperors as seat for their government, and is still in use as city hall today. Among the most important ceremonies that took place in its 45m×20m Coronation Hall (cf. Figure 1) were the coronation feasts of the 15th and 16th century. However, the only visual remainder of these festivities is a set of coats of arms describing the seating arrangements. The goal of Corona was to bring those coronation feasts back to life for visitors of the city hall.

Corona runs on the next-generation audio guide for the city of Aachen called Aixplorer. This guide is based on an Apple iPhone, which provides enough processing power for spatial audio rendering.

The Corona Audiospace

The virtual auditory layer we designed consists of a virtual audio scene representing a coronation feast from the 16th century. From historic documents we know who attended that feast, what the seating arrangement looked like, and what role the guests played during the ceremony. Virtual characters that are part of the feast present the information by discussing the ceremony and important concerns of that time, such as the Black Death. These characters are distributed throughout the Coronation Hall at their historically handed-down places (cf. Figure 2). However, the virtual audio sources are not connected to a physical item, such as a painting.

Each visitor explores her own, private audio space. As the rendered audio signal is a result of the selected language, the current location and the chosen path

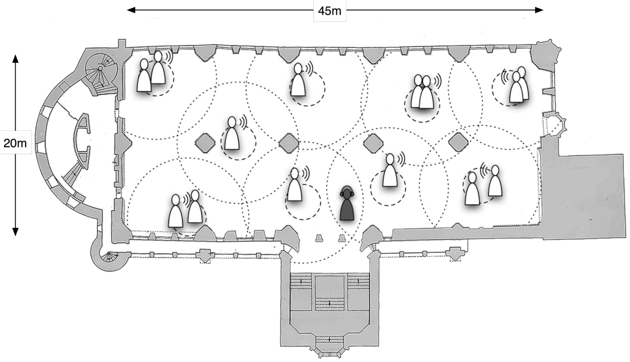

Figure 2: The Corona audio space. Virtual characters discuss different aspects of the feast.

inside the hall, the experience is highly individual. The display of the audio guide shows a map of the hall with the positions of the different sound sources. Although not necessary for navigation, some of our participants mentioned that such a feature would be helpful as additional information, e.g., to not miss a sound source.

System Setup

To create such a virtual audio space we need at least some information about the position of the visitor and her head orientation. We therefore installed a Ubisense[1] Real Time Localization System that tracks the visitors position with ultra-wideband RF-tags integrated in the headphones. Along with these tags we integrated a digital tilt-compensated compass that allows precise measurement of the head orientation.

Audio Rendering Comparison

The gathered information is then handed over to an audio rendering engine. Apples iOS SDK comes with an implementation of OpenAL[2]. The auralization algorithm used by this framework however, represents only a very basic one as it relies on simple stereo panning. We extended the rendering by adding a low-pass filtered sample played back if the virtual sound source is behind you, and a reverberated one used as distance cue (cf. Figure 3). State-of-the-art auralization is based on so called Head Related Transfer Functions [3], i.e., a mathematical function that describes all the factors that lead to spatial hearing (including the shape of the ears, absorption of the head, etc.). We compared these different rendering methods regarding "Navigation-by-Ear"-performance and perceived realism in a small user study. The results showed, that although the HRTF-based rendering was rated as most realistic, some participants reported that the auralization felt unnatural. This is why, in the context of our museum application, we opted for the more robust implementation with the three samples per sound source.

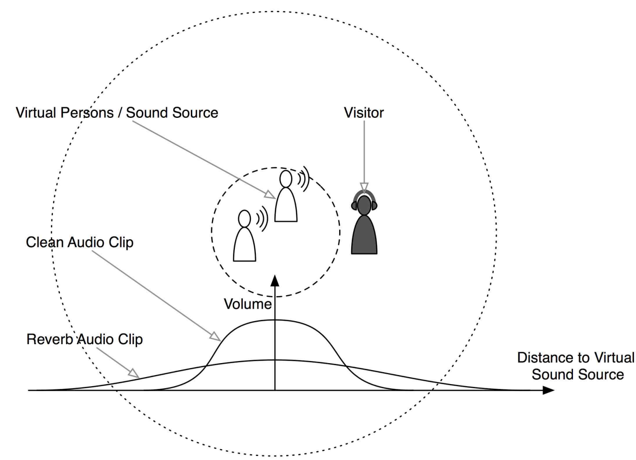

Figure 3: The design of a source area. In the outer circle the voices of the two talking characters become clearer towards the center.

Research Questions

In this section, we present three research questions of very diverse nature. As it is impossible to determine whether a visitor is listening to a specific sound source or not, the content has to be written such that the important information is repeated but without the sample being repetitive. If a sample is too short, the visitor might feel that the content is looped, if on the

[1] www.ubisense.net

[2] www.openal.org

other hand, the sample is too long, some of the information might never be heard.

As stated before, we opted for a robust auralization algorithm. However, we would like to increase realism without loosing this robustness. This is especially interesting, as we have to deal with rather imprecise data from our sensors. The question is, if the overall experience can profit from very realistic audio rendering. On the other hand, it is interesting to find out, how bad the sensor data can be, before the user experience breaks down.

Finally, visitors come to museums with friends, to make the visit a common activity [1]. By requiring our visitors to wear headphones we isolate them from each other. How can we design a group experience in such an augmented reality scenario?

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