# TREES AS TIME CAPSULES: EXTENDING AIRBORNE MUSEUM HARTENSTEIN TO THE FOREST

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**Abstract**

Battlefield museum "Airborne Museum Hartenstein" is housed in a villa which served as the headquarters of the Allied Forces during World War II. Since heavy fighting took place in the surrounding forest, many of its trees have bullets hidden inside them. We propose an augmented reality (AR) application which superimposes X-rays of the trees upon their trunk, revealing their hidden content. Our approach suggests that augmented reality, when deployed as a means to visualize what is inaccessible to human vision, can be relevant to cultural heritage applications. We present a working prototype of our application and conclude with reflection and future possibilities.

keywords: augmented reality, cultural heritage, museum, X-ray, bullet, tree, World War II, Battle of Arnhem

## Introduction

"Airborne Museum Hartenstein" [1] (Fig.1), located in the Dutch village Oosterbeek, is a battlefield museum about the Battle of Arnhem which took place during World War II. Housed in a monumental nineteenth-century villa, it exhibits the world's largest collection of militaria from the famous battle. The villa served as the headquarters of the British Airborne Division in September 1944, and heavy fighting took place in the forest surrounding the museum.

The AR Lab, a cooperative effort between the Royal Academy of Art in The Hague, Delft University of Technology and Leiden University, was invited by the museum to realize a projection mapping on the villa's exterior. However, during our first brainstorm session with the museum director, we made a serendipitous discovery which changed the course of the project considerably. The director explained that foresters have difficulties cutting down trees in the area around the museum; the trees contain many metal fragments such as bullets and grenade shrapnel, traces of the heavy fighting which took place during the war. The trees were still young when the bullets hit them and, over the course of roughly 70 years, the trunks have completely encapsulated the fragments. When you know what to look for, you can see scars where bullets and other metal fragments pierced a tree in its younger years (Fig.2).

We find it fascinating that these trees have taken on the role of time capsules. The museum itself houses the world's largest collection of militaria from the Battle of Arnhem, but few visitors are aware of the physical remains of the battle in the now peaceful forest just outside the museum. By disclosing the hidden content inside the trees we aim to extend the museum narrative to its surrounding space. We propose an augmented reality application which runs on smartphones and tablets. By pointing the device's camera towards pre-selected trees, its screen will show an X-ray of the tree superimposed on the real tree, giving the illusion that you can look inside it.

**Fig. 1. The villa in which Airborne Museum Hartenstein is housed. (Image from Wikimedia Commons.)**

**Fig. 2. Scar caused by a bullet which once pierced the tree. (Photo © Wim van Eck.)**

This article describes the current implementation of our application which we presented at ISEA2013. Section 2 considers museological aspects of battlefields while section 3 describes various outdoor augmented reality systems in the cultural heritage sector. Our prototype is described in section 4. The article concludes with a reflection on our prototype and future possibilities.

## Context

Military history events such as battles are often commemorated and interpreted outdoors. Battlefield sites, military cemeteries and memorial monuments are outdoor places for experiencing history, constructing national identities and paying respect to the dead. They are also popular tourist destinations visited by people with diverse interests and motivations [2, 3]. Despite the forceful nature of war, the outdoor traces of conflict are often minute: Brandt has commented on the challenge faced by military museums who wish to incorporate the little that is left after destruction into their narratives [4], while Newman reminds us that battlefields are severely subject to landscape changes [5].

Typically, battlefield sites and military museums are located near or at the original site of events. They are places to experience history where it happened. A wide range of museums are site museums, i.e., museums located at the original site of their subject. Still, what constitutes a site and establishing where

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a site begins and ends is a discussion in itself [6]. Regarding battlefields, Carman makes a distinction between a battlefield as a preserved and marked site and a battlefield as a (part of the) landscape [7]. The forest surrounding the Airborne museum is officially a public terrain. While not a clearly marked site, the area is often perceived as part of the museum and used for activities organized by the institute. Yet, it is likely that a stroll in the forest may differ from a visit to a marked battlefield site and may be free from preconceptions about correct visitor behavior. It may also be motivated by emotional motives, for example, a need for relaxation or a desire to enjoy nature. Therefore, we suggest that a technological intervention into this space should be non-intrusive and should allow for an appreciation of nature as much as an appreciation of history.

Interestingly, trees and garden facilities are often utilized as means to commemorate military history events. An overview of the use of trees as means to memorialisation, for example at locations such as war cemeteries or war monuments, is provided by Cloke and Pawson [8]. The authors comment on our desire to use a living and unruly organism as the carrier of a fixed memory. Simply put, nature can and will take over, resulting in landscapes other than the ones originally designed. Furthermore, trees and outdoor spaces afford new meanings, memories and usages to emerge.

## Related Work

This section discusses a number of outdoor augmented reality applications from the cultural heritage sector. Our overview is not an exhaustive survey but an attempt to highlight trends in the use of augmented reality for experiencing heritage outdoors. Focus is on the augmented reality end of the virtuality continuum [9] (virtual reality systems are not relevant to our discussion). Audio augmentation, while potentially powerful, is outside of the scope of this article.

Potential applications of augmented reality for cultural heritage are found in early writings about the field. For example, Azuma, in his influential and widely cited survey of augmented reality in 1997, envisioned augmented reality applications that bring archaeological sites and battlegrounds back to life with reconstructions of what it was like. Interestingly, Azuma's vision explicitly drew upon the tradition of living museums, i.e. open-air museums with enacted displays: “A tourist equipped with an outdoor AR system could see a computer-generated version of Living History” [10].

The majority of outdoor augmented reality systems for cultural heritage offer visual reconstructions of the past on location. Visual material is overlaid/superimposed upon ruins, remains or contemporary versions of buildings in an attempt to visualize what once was there. For example, “Archeoguide”, an on-site augmented reality tour guide for the Olympia archaeological site in Greece, delivers 3D reconstructions of monuments that are now in ruins [11]. 3D reconstructions of what is long gone or replaced are provided in the following systems: the MARS system [12], a pioneering system of mobile outdoor augmented reality for the Columbia University campus, USA; the Ename system [13], a kiosk-based system augmenting the foundations of the Benedictine abbey church, Belgium; the Augurscope system [14], a tripod-mounted mobile mixed reality system for the destroyed medieval castle of Nottingham, UK; and situated simulations of Parthenon, Greece and the Temple of Divus Iulius, Italy [15]. In addition to 3D reconstructions, Papagiannakis et al. introduce virtual characters and narrative elements to revive the ancient site of Pompeii, Italy [16]. Note that the above-mentioned projects use a variety of displays from head-mounted displays, to custom hardware, to smartphones.

While many augmented reality systems strive for reconstructions by means of detailed 3D models, a number of projects opt for reconstructions based on 2D imagery. For example, the “Cultural Heritage Layers” system [17] delivers earlier views of buildings on location based on historic media such as drawings, paintings and archival photographs. The approach is proposed as a means to both reduce computational requirements in the client and deal with a lack of (high quality) 3D content. The system was used to deliver earlier architectural views of the Reichstag building, Berlin, Germany and the Reggia Venaria Reale palace, Turin, Italy. The strategy of superimposing 2D archival material on the 3D environment is employed by several smartphone applications for use in urban outdoor environments such as the “London Street Museum” app by the Museum of London, UK [18].

One of the most powerful attributes of augmented reality is its capacity to visualise what is invisible, to make visible what has gone or been replaced. Yet, many aspects of the technology seem to be neglected in the domain of cultural heritage despite their widespread use in other application domains. Consider, as an illustration, several medical augmented reality systems [19]: such systems employ augmented reality to visualize what is inaccessible to human vision rather than what is no longer there. Expanding human vision is core to medical imaging technologies, from X-rays to MRI imaging, and several medical augmented reality systems superimpose views from multiple imaging modalities. The relevance of augmented reality applications that exploit multi-spectral imaging views to cultural heritage applications is nicely exemplified in the “Augmented Painting” project [20]. This project uses augmented reality to visualize “The Bedroom” painting by Vincent van Gogh in different imaging modalities such as X-ray and infrared imaging. Given the particularities of our project,

**Fig. 3. Scanning our tree trunk with a portable X-ray scanner. (Photo © Wim van Eck.)**

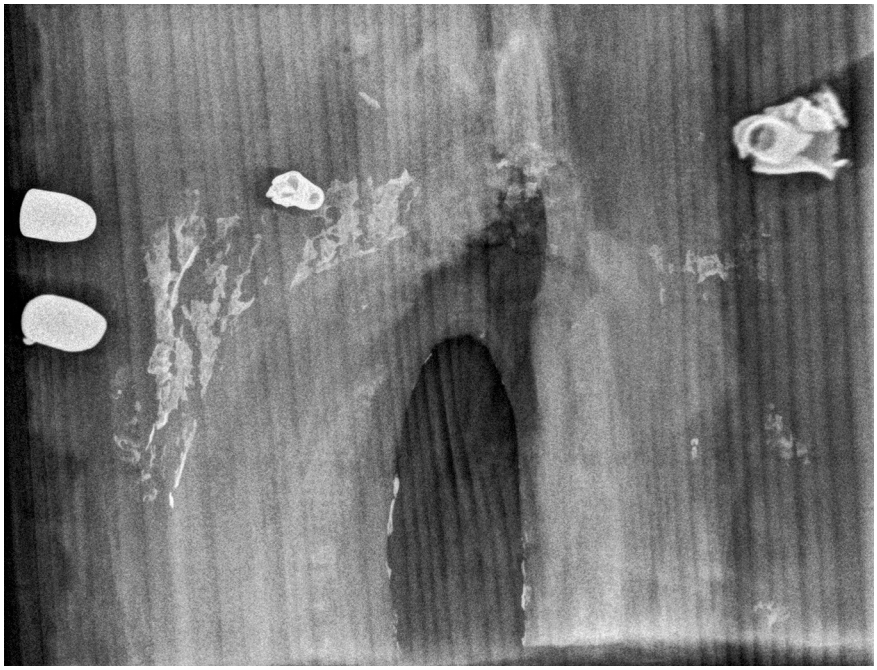

**Fig. 4. Actual X-ray of the tree trunk. (© Wim van Eck.)**

it is clear that the visualisation of the inaccessible, that is, what is hidden from human vision, is an appropriate direction in which to go.

## Current Implementation of the Application

The main goal of our application is to make the museum visitor or passer-by aware of the physical remains of the battle outside the museum. Because of the travelling distance between our institute and the museum, we chose to first develop a prototype at our lab using an ordinary piece of tree trunk. Obtaining a tree trunk was easy but obtaining a tree trunk with bullets inside was somewhat of a challenge. Since no trees around the museum were scheduled to be cut down, we had to find an alternative way to put bullets in our tree trunk. Members of "Defensie Schietvereniging", a rifle club for employees of the Dutch Ministry of Defence, were willing to help us. They arranged genuine World War II weaponry from their depot (a Lee Enfield .303 rifle, M1 .30 carbine and Browning Hi-Power .9mm handgun) and fired multiple rounds at our tree trunk with genuine ammunition.

Scanning the bullets inside the tree trunk is another key element for the realization of our application. There are many stationary X-ray scanners on the market but only portable scanners are of use to us since eventually scanning should take place on location. While searching for a portable X-ray scanner, we came in contact with "Mijn Paardenarts", a Dutch veterinarian who utilizes a portable X-ray scanner to examine horses on location. Fortunately, they were keen on helping us and at our institute we X-rayed our tree trunk from multiple angles (Fig.3). We merely expected the scans to display the bullets as white blobs on a black background but the quality of the scans was much better than expected. The bullets are easily identifiable and the structure of the tree itself is displayed with much detail so that even the tree-rings are clearly recognizable (Fig.4).

With all necessary parts available we commenced building the augmented reality application itself. We chose augaugmented reality software Vuforia [21] for development since it had proved its stability and ease of use during our previous projects and smoothly runs on mobile devices. To position a virtual layer upon a physical object, the augmented reality software must be able to derive real world coordinates. Technically, it is possible to use the scars on the trees as augmented reality markers since they have unique shapes and are positioned at the location of the bullets. Nevertheless, a sign on the trees is needed to inform the public about the project. Using this sign as an augmented reality marker offers better tracking quality since it can be designed with the requirements of the software in mind.

We do not wish to merely overlay the X-rays on the physical tree but aim to give the impression that you can look inside the tree itself. To realize this illusion we created a 3D scan of the tree trunk using the freely available software 123D Catch [22]. Using this geometry we created an occlusion layer, giving the impression that there is a real hole in the physical tree through which you can see the virtual content (Fig.5).

## Discussion and Conclusion

We presented our application at the ISEA2013 Symposium on Electronic Art where we received feedback on the project. Among other comments, we were asked if we could create a full 3D reconstruction of the bullets since we had already made X-rays from multiple angles. Although we had considered this option during our design process, we chose to

**Fig. 5. Our prototype in action. (© Wim van Eck.)**

keep the visuals as pure as possible as the X-rays turned out to be particularly detailed and aesthetically pleasing. Another question challenged the usage of augmented reality for this project. Indeed, we could adopt a low-tech solution and simply attach a print-out of the X-ray onto the tree. However, attaching a print-out on the location of the actual bullets would occlude the scars caused by the bullets which once pierced the tree, hiding an important aspect of the story. Augmented reality also allows an individual to experience the sensation of truly looking at the inside of the tree to discover its content. Another possibility would be to project the X-rays upon the trees, though this would only be an option after sunset when there is less natural light. By that time, the museum would be closed with few people left in its surroundings, so this option would be applicable for special evening events only.

The trees around the museum are currently under the supervision of the local town counsel, not of the museum. Trees are chopped when deemed necessary and there is no agreed conservation policy. A question to consider is whether these trees have a historic value and if they should be treated as museological objects. Or are they war memorabilia such as the "bullet in wood" items, bullets encased in pieces of tree trunk, branches or even fence posts auctioned on Ebay? Similar questions apply to the site itself: Should the forest area be actively managed as a battlefield site? Independently from the terrain's status as a battlefield site, controlling the natural development of the terrain would be a challenge. Our project can be deployed even in informal settings such as a public and unmanaged forest. At the same time, by revealing the traces of war trapped inside the trees, the project makes questions of preservation and management more relevant.

Our prototype demonstrates that it is technically possible to realize this project on the museum's location. The Airborne Museum Hartenstein showed great enthusiasm and is willing to aid us our in our endeavour to realize the final application. As hidden traces of fighting may be waiting to be discovered in other types of objects, in buildings for example, we are confident that our approach can be of relevance to other locations as well.

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