Preparing and Guiding Forensic Crime Scene Inspections in Virtual Reality

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ABSTRACT

Computer-based scene reconstruction is a method for answering specific forensic questions in the context of accident or crime scenes. For the resulting 3D reconstruction, the use of virtual reality (VR) technology is a novel presentation form. For the presentation to a prosecutor, the need to put visible content into context awards special significance to the moderator, especially as in a VR presentation the head mounted display (HMD) cuts VR users off from their natural environment. We analyze use cases for the parties involved in the courtroom VR presentation and consider the author, moderator and spectator roles and their corresponding session types for creating, directing and watching the presentation. A prototype system has been implemented to allow for suitable VR interactions for the three roles. An evaluation of the system with 12 participants assuming the role of the spectator yielded positive results with regard to the user experience and utility.

CCS CONCEPTS

• Applied computing → Law, social and behavioral sciences → Law

• Human-centered computing → Interaction design → Empirical studies in interaction design

KEYWORDS

Forensics, Law, Virtual Reality, Multi-User Interaction

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1 Introduction

During a legal trial, it is the task of prosecutors to investigate crimes and press charges based on the available evidence and witness testimonies. In certain cases, the collected information is used to create 3D models of the crime scene to answer specific forensic questions. Schofield describes a case of high public interest in which 3D reconstructions were used as a "briefing tool" at court [7]. In that case, several persons became victims of fatal shootings at a public party event. The cited key advantages of computer-based reconstruction were efficiency, persuasiveness and increases in spectator's comprehension and attention.

The Swiss police generates 3D models from crime scene laser scans since 2004, for analysis and presentation of transient evidence [2]. The 3D crime scene reproduction used for this work was first shown in *The Forensic Holodeck* [3], where it was proposed to explore the virtual scene with virtual reality (VR) equipment. For the purpose of documenting the interaction of users with the virtual scene, audio and video recordings can be deployed [9].

In this study, the presentation requirements are analyzed for a VR application used in a legal proceeding. In the phase of preparing the simulated crime scene, objects and persons need to be annotated with basic textual information, and interesting observation points in the scene have to be defined. During the actual presentation taking place in the court room, the person wearing the head-mounted display (HMD) can then interact with the scene either under the guidance of a moderator, or in a mode of free roaming. The authors recognize the particular need for guiding the focus of non-expert users [4].

The interaction requirements found were used to develop a software prototype with the Unity game engine [10] and the HTC Vive VR hardware [5].

2 Material and methods

We used the case reconstruction of a failed arrest attempt in an internet café in Zurich, Switzerland (Fig. 1). The perpetrator managed to draw a gun during his arrest and fired seven times. For each gunshot, a reconstruction was conducted, based on a laser scan of the scene, traces such as gunshot holes in the wall and surveillance camera footage [3].

2.1 Roles and basic interactions

The users of the proposed system will assume the role of author, moderator and spectator. The author is an authorized expert, who is familiar with the course of events and the body of evidence. His goal is it to produce a useful presentation of the data. He is given a scene model which reflects the forensic knowledge of the case and which should be backed up with a comprehensive audit trail [7]. As fundamental authoring task, we defined the ability to annotate persons or objects with textual information and to choose observation points from which the spectator has a view on the scene.

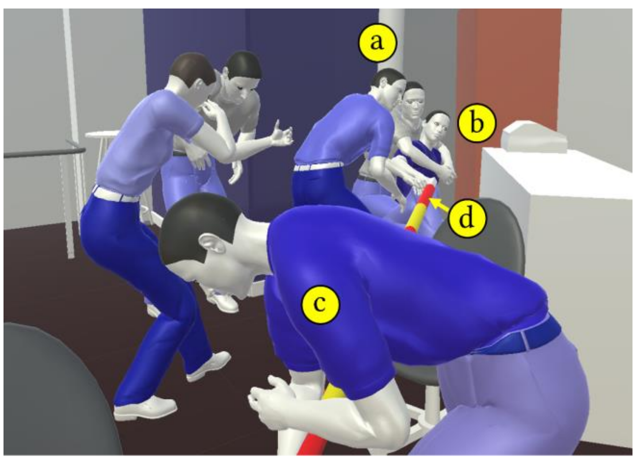

Figure 1: 3D scene model reproducing the shooting event inside the Internet café. Undercover agents (a) try to apprehend the suspect (b), who fires a shot in the direction of another officer (c) stumbling into the line of fire (d).

The moderator guides the spectator through the actual presentation, similar to a 2D presentation, and explains the specific forensic issue treated in the scene. During the course of the presentation, the moderator invites the spectator to different observation positions. The moderator takes part at a separate conventional desktop display, which mirrors the HMD view of the spectator (Fig. 2). The moderator can alter the scene in real-time (i.e. hiding or highlighting assets) and talks to the spectator to explain findings and answer questions.

The spectator (who might not be technologically adept) is to be guided through the scene and is thereby introduced to the reconstruction. During the presentation, the spectator is the only person who views the scene by means of the VR headset. The spectator does not need to use any kind of controller at this time. The only interaction is enabled through a VR-specific “3D mouse pointer” or *gaze pointer*, which becomes visible when the center of sight touches a person or object annotated by the presentation author (Fig. 3). The gaze pointer follows the HMD and therefore the head movement of the spectator. During guided moderation, the spectator interaction is limited to looking around, possibly moving the gaze pointer by looking at one or the other object or person.

After the moderated session is over, a free roaming session can commence in which the spectator is given a VR hand controller, which allows for choosing one of the predefined or arbitrary other observation positions as well as free walking. Table 1 summarizes the interaction options for the different roles.

For the role of the moderator, the interaction with the system takes place only through keyboard and mouse. For the role of the spectator, it takes place first only through head-movement and later by using a button on the VR hand controller.

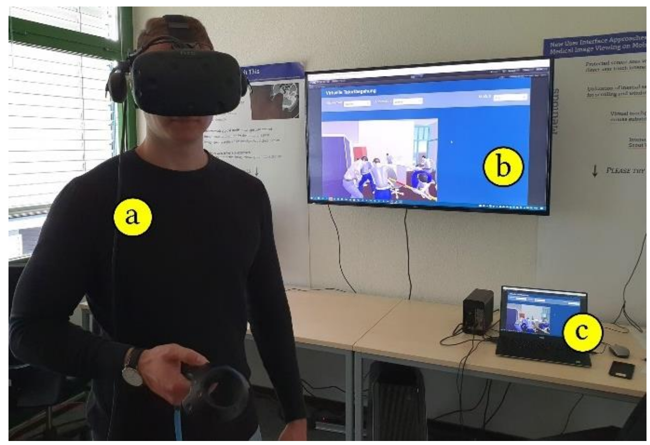

Figure 2: The spectator (a) explores the scene with the HMD. Attending audience may follow the spectator’s view on a large monitor (b) or projection. The moderator’s workplace (c) is the computer running the VR application.

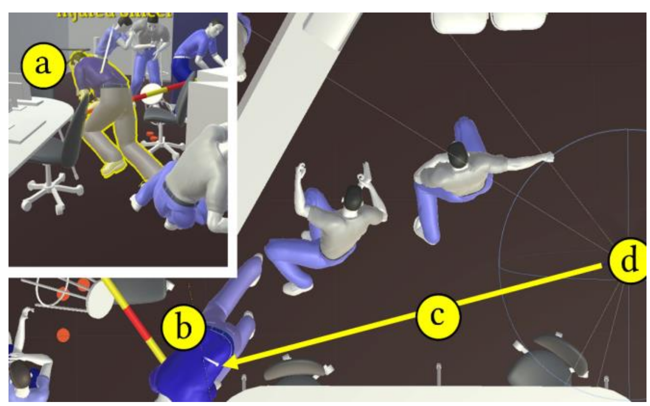

Figure 3: Gaze pointer mechanics. Upper left inset (a): the user’s gaze rests on the person marked as “injured officer”. Overhead scene map: the same person (b) with an arrow (c) indicating the viewing direction at the user’s position (d).

Session type	Author	Moderator	Spectator
Creating, editing	adds annotations, defines observation points		
Moderation		navigates spectator, explains forensic question	interacts through HMD and gaze pointer
Free roaming		supports spectator, answers questions	interacts through HMD and gaze pointer, self-navigates by "teleporting"

Table 1: Interactions for session types and user roles.

2.2 Observation points

The observation points are intended to let the moderator structure the presentation for the spectator. Each point can be a significant location or witness position in the crime scene (Fig. 4). The moderator has the freedom to choose the location and order of the observation points for an optimal narrative flow.

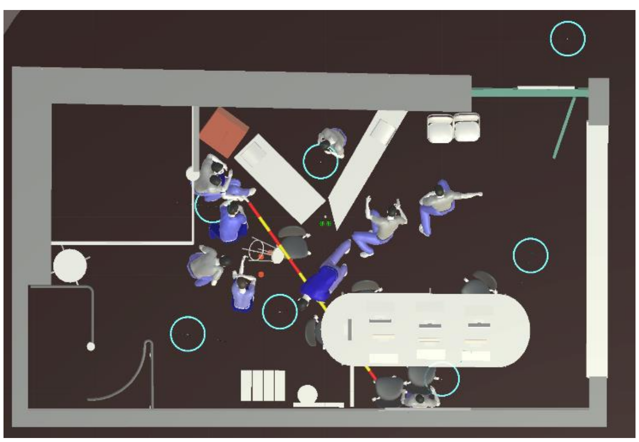

Figure 4: Overview map of the Internet café scene. The presentation author defines observation positions that are of interest for the court presentation (marked with circles).

For VR systems, the virtual scene is superimposed onto the physical space of the user. The spectator's natural mobility (e.g. by walking) is therefore limited to the designated area tracked by the VR system (depending on hardware capabilities, the maximum is near 23 m² for the standard HTC Vive), but more often it is constrained by the physical space situation.

For the spectator wanting to go to locations outside the tracked area, a special method has to be used. One game-like approach could be to make the user float to another position, but this can lead to cyber sickness in VR. We chose the VR technique of "teleporting" [1], with which a user can point to a specific ground location in the virtual scene, and gets re-positioned there in an instant.

We applied two changes to the typical teleporting process: For the guided presentation, the teleporting is initiated not by the user (the spectator), but by the moderator, initially only after a short explanation and always with prior notice that the observation point is about to change. Second, the spectator's current viewing direction is not kept, as this might be confusing to the spectator. Instead, it is changed to a viewing direction that is defined by the author together with the observation position.

2.3 Annotations

For descriptive purposes, any person or object can be annotated with a short text. The concurrent display of annotations can however impair readability significantly (Fig. 5, left). The problem needs special attention in VR since the spectator's gaze is moving frequently. The readability of multiple text labels for arbitrary arranged 3D objects is not easily ascertained, as it is already a non-trivial problem in two dimensions [6]. To address this problem, only a single annotation is shown when the spectator's gaze pointer touches the annotated person or object (Fig. 5, right).

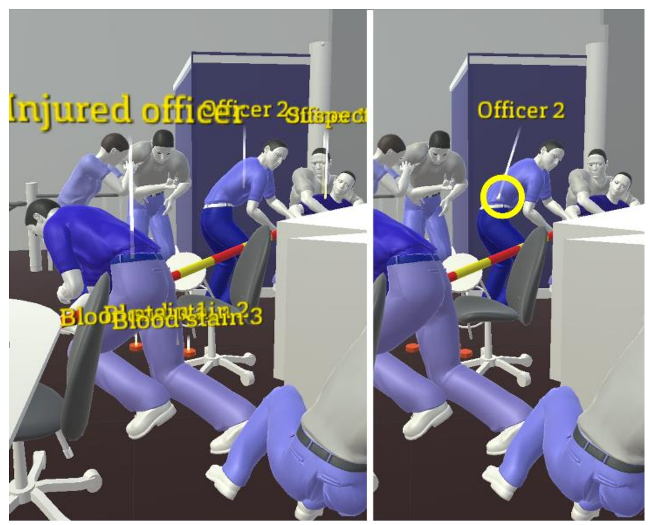

Figure 5: Left: A naive mechanism for display of annotations results in unreadable overlapping texts. Right: a single gaze pointer-activated annotation. The connecting line between the person and the annotation text starts at the spectator's current center of sight (highlighted by the circle).

Another problem lies in the display being blurry at the margins due to the lens construction in the HMD, which reduces available display area for text. The use of longer text messages in the simulation for communicating complex facts to the spectator has therefore been discarded. That approach would be too inefficient compared to verbal communication by the moderator.

2.4 Evaluation

To evaluate the prototype, 12 students assumed the role of the spectator in individual sessions with the moderator. No user had experience with crime scene reconstructions, 7 users reported prior experience with VR. One of the developers took the role of the moderator, who guided each participant through the predefined observation points, from outside the Internet café to a position next to the shooter. Each user was asked to form an opinion about the line of fire and bloodstains on the floor. After the moderator-guided part, users were given a Vive hand controller, to let them teleport around the scene on their own.

Feedback on user experience was gathered through the user experience questionnaire (UEQ) [8].

In a separate feedback form, the users assessed the system with regard to its usefulness for presenting crime scene reconstruction and with regard to its applicability for information propagation in a courtroom.

3 Results

The six UEQ scales, which range from -3 to +3, are considered giving "positive results" starting with 0.8 in the UEQ evaluation scheme. The UEQ results showed 1.9 for *attractiveness*, 2.0 for *perspicuity*, 1.3 for *efficiency*, 1.5 for *dependability*, 2.3 for *stimulation*, and 2.1 for *novelty*. *Efficiency* was rated lowest (1.3), but was still above average in the *UEQ benchmark*, which compares UEQ results with 246 other product studies (Fig. 6).

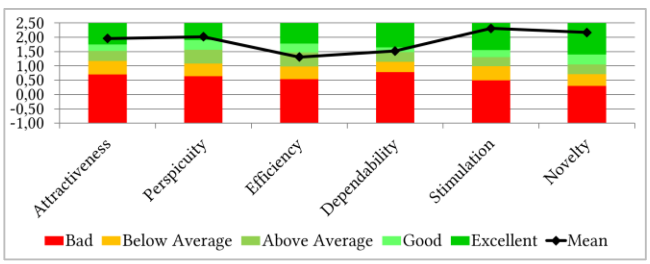

Figure 6: UEQ benchmark results for the spectator's role

The usefulness for presenting crime scene reconstruction and the applicability for information propagation in a courtroom were both assessed with a mean value of 4.75 (on a 5-point Likert scale).

In the additional written comments, one person mentioned dizziness and two persons mentioned visual problems related to the HMD usage. Three persons requested more textual annotations. Seven persons explicitly praised the usefulness of the presented approach for gathering information about the crime scene.

4 Discussion

We have shown the basic procedure and interaction elements for the VR-based presentation of 3D crime scene reconstruction. The evaluation participants rated the VR prototype very positively. If the required expenses for visiting physical crime scenes had been detailed to participants, the efficiency rating in the UEQ might have been better.

During the conversation between the moderator and the spectator, a virtual laser pointer would have been helpful. This feature should be implemented in the desktop interface of the moderator, as the view of the spectator is mirrored there and the moderator could selects objects in the field of view. Further observations during the evaluation reinforced the need of proper annotation and proper verbal moderating, as scene details not annotated or mentioned during moderation were in danger of not obtaining user attention at all.

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