Virtual Crime Scene Investigation and Evidence Protection

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Abstract— This paper presents the recreation of crime scenes through Virtual Reality for crime investigation and evidence storage. 3D image capturing and processing techniques are used to render fully-immersive Virtual Reality environment for investigators to work with. Cloud database and Blockchain technology for evidence storage are explained. The different levels of views on such virtual crime scenes and evidence storage are also expounded.

Keywords — *Crime Scene Investigation; Virtual Reality; Virtual Crime Scene Regeneration; Virtual Evidence Storage; Blockchain; Cloud Database.*

1. Introduction

Virtual Reality has started to gradually influence various fields such as entertainment, education, architecture, engineering, research, tourism, etc. Virtual Reality not only renders a synthetic environment as a result of either graphical designing or the data collected from external factors but also allows the user to manipulate and interact with that environment. Pan et al. [1] states that the key reason to use VR is to maximize experimental control of a complex social situation and provides with good control of any interactive situation. Wang et al. [2] conducted a comprehensive review on VR-related studies in CEET. The review explained the domain-specific development trends of Virtual Reality in CEET. Portman et al. [3] stated that improved graphics, design and object modelling using modelling technologies are the core benefits of using VR. . Matsangidou et al. [4] conducted a study to examine how VR can influence perception of task difficulty and concluded that reducing the virtual weight presented through VR applications will increase the training session duration and decrease muscle pain. In the past few years, VR has extended its application to training the law enforcers in handling the crime scene. Its uses can be extended further by rendering a virtual crime scene, an exact replication of a real crime scene, for the crime scene investigators to work with. Kavanagh et al [5] conducted a comparative study, addressing various issues in VR including cost and user experience and proposed several novel techniques to address these problems.

Crime scene preservation is an essential part of investigations. It has a high possibility of contamination, evidence obstruction and such. These factors hinder the investigation to a great extent. Also, crime investigators prefer to have access to the crime scenes all time. This can be achieved by utilizing fully-immersive Virtual Reality technique. The other aspect of using Virtual Reality is that the evidences obtained from a crime scene can be secured effectively. Evidence obstruction is a serious cause that affects the judgment on a case. Proper utilization of Virtual Reality can prevent destruction of evidence done either deliberately or accidently. Nevertheless, the effectiveness of the synthetic environment depends immensely on how the VR resources are utilized. For the concept of immersive to be beneficial in this situation, the scenes must be created by focusing on obtaining the expected results [6]. While developing an artificial crime scene, a few questions have to be answered:

- What are the challenges in criminal investigations?
- How the Virtual Environment will meet the challenges?
- How reliable and effective the Virtual Environment can be in recreating the crime scene and the evidences?

Another emerging technology that is revolutionizing the digital world is blockchain. Park et al. [7] described the blockchain technology and various issues surrounding the technology.

2. Crime Scene Replication

Replication of the real crime scene is the first and most significant step in crime scene investigation. Exact replication of the crime scenes before they are polluted by human intervention and other factors plays a major part in the investigation. 360° images of the crime scene are captured before the forensics probe into the crime scene. Alternatively, a 360° video is produced by filming 360° of the crime scene. These images are stitched into a single 3D image using specialized video editing methods. Also, the data obtained from CCTV, if present in the scene, and terrestrial laser scanners are used to enhance the authenticity of the artificial crime scene. The resulting data is rendered into VR software to recreate the crime scene.

The capability of VR lies in turning (architectural) data into information suitable for investigation, hypothesis and conclusions [8]. A static crime scene is produced using the images where the crime investigators can analyze the crime scene in depth. Following information are obtained from the virtual crime scene:

- Biological evidence such as tissues, hair, etc.
- Study of the bloodstain pattern such as the angle of the blood splatter on the surface, impact splatter, satellite splatter and such.
- Ascertain if the body has been relocated after death.
- Determine if the crime has been deliberately committed or an accident.
- Evidences of tool or tool mark used in the crime.

The other reason for reconstructing a crime scene is that the crime investigators are provided with a benefit of analyzing the crime scene at their own pace and accessing it whenever they want. Bornik et al. [9] proposed a novel computer-aided forensic toolbox to support documentation and illustration of forensic cases using heterogeneous data. With fully-immersive Virtual Reality and multimodal CAD imaging techniques, a virtual scenario of how the crime happened can be produced. Suppose a murder obscured as suicide by falling from a building. This method is applied to produce a virtual animation of the suicide taking place. The data collected from the real crime scene and the virtual reproduction of the event is compared. If any discrepancy between the data is noticed, the alleged suicide can be resolved as a murder.

3. Virtual Evidence Storage

The idea is not only to render a virtual crime scene to work with but also to store the evidences related to the crime that, in real world, have the possibility to be eradicated. Evidences pertinent to the case are damaged when more people interact with the crime scene and other factors especially when the crime takes place in an open area. In some cases, the evidences are missed out when the crime scene is not properly handled. There exists another possibility which is evidence manipulation. The major reason for many cases being ruled out is insufficient evidence. Furthermore, Li et al. [10] addressed key privacy issues and proposed a concrete blockchain framework that includes evidence collection and court data.

This can be averted by utilizing VR effectively. The virtual crime scene should be constructed in such a way that the objects present in it cannot be manipulated. Though the investigators are enabled to analyze the virtual crime scene, they will not be able to manipulate the objects present in the false environment. This prevents the evidences from being destroyed.

4. Virtual Reality Components in Crime Investigation

The recent development in VR field allows the programmers to manifest a virtual world which looks like the real world. Unreal 4 engine is a popular one among VR developers to replicate the real world. The crime

investigators do not necessarily have to be at the same place to access the virtual crime scene rather they can access it even when they are at different locations. After constructing the virtual crime scene, the users are supplied with required equipment such as Head Mount Display (HMD), touch controllers, sensors and headphones that enable them to interactive with the virtual environment.

5. Evidence Storage And Security

Managing security in a distributed environment refers to data management, system integrity and cyberspace security [11]. Once the data is provided into VR, the data is stored into Cloud database to which only the investigators in charge of the case and higher officials are provided with the privilege to access the data. However the permission to manipulate the data is limited to only updating the data received from the investigation into the Cloud database. However, "Zero risk" is difficult to attain as the data security depends on the Cloud outsources and operators. Moreover, Cloud has been attracting the attention of attackers since it is a centralized data mine [12].

Although, the Cloud database comes with its own data protection services to prevent the data from being hacked, Blockchain technology is collaborated with Cloud database to deter evidence manipulation. Zheng et al. [13] developed a blockchain technology called NutBaaS that helps the developers to explore on appropriate deployment of blockchain rather than bothering about maintenance and management of system. Consortium Blockchain is a digital, append-only ledger that allows only the authorized people to access it in order to append the data into the database and not in other operations [14]. The emerging service in Cloud, Blockchain-as-a-Service (BaaS) is utilized for this purpose. The public key to the data is provided to the relevant investigators and the Blockchain contains the private key. This way the data relevant to the case is prevented from manipulation or obstruction.

6. Experiment and Analysis

A single 3D image was developed from the images obtained from a mock crime scene. The positions of the objects were adjusted based on the facts collected from terrestrial scanner and CCTV, and the image was fed into Unreal. First, a static crime scene was developed and stored that can be accessed later for analysis. Then, a 3D animated video was produced using CAD technique that provides virtual interaction between the injuries and weapons. The video described the impact of the bullet on the body, the pattern of bloodstain and the position of the body after fall. The video was edited accordingly such that the final result of the bloodstain and body position matched that of the actual crime scene. This helped in understanding the direction of the bullet and the position of the offender.

The virtual reality scenes were stored in cloud with Blockchain service and the privileges were assigned. As the case progress, the data related to the case could be stored, retrieved and edited from cloud. Once the case is closed, the data stored in cloud could be moved to other forms of data storage such as magnetic tapes due to large file size of the VR scenes. These techniques are used to deploy only the virtual background whereas the high level of immersion is the anticipated result of the virtual scenario [15]. The participant could take any roles within the virtual environment. She could enact the roles of offender, witness or judge to obtain the expected goal. These roles have different utilization for the virtual scenario.

A witness could aid in constructing the virtual scenario. This may improve the reliability of the virtual scenario. Role of offender provides a number of significant information that could contribute to the investigation as discussed before. The view of the judgement commission helps in determining the acceptance of VR as evidence. Although the virtual environments are developed with the goal of providing an accessible real-like crime scene to the crime investigators, it plays a vital role in courtrooms. All the data gathered must be evaluated before presented as evidence to ensure data integrity. Judge or commission could use the animated video or the VR scenario to get a precise overview.

7. Conclusion

The article proposed an extended application of Virtual Reality to aid the law enforcers with crime investigations. An effective method of evidence storage and protection is discussed. Finally, the concepts of Cloud database and Blockchain technology are exploited for evidence preservation. However, when presenting virtual crime scenario as evidence, the perspective of the judge or the commission must be considered. There may arise a disagreement in accepting VR as potential evidence. A difference in perception of the evidence may occur as they are recreations of the real crime scenes and not the original ones. In rendering the virtual scenario, mistakes may happen in placement of objects and such that can misdirect the investigation. Hence the originality of the virtual scenario relies greatly on the creator. But, when properly utilized, VR can contribute immensely in the investigation process. Consequently, the difference between the original evidence and the VR generated scenario must be specified during prosecution of the case.

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