USE OF AUGMENTED REALITY FOR CRIME SCENE INVESTIGATION

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Abstract *Considering the technological advancements, this paper explores how the use of Augmented Reality provides a promising approach for crime scene investigation. At the scene of crimes, it is important for the evidence to be identified, collected, and kept a record of safely and without contamination. Modern-day investigation methods are being constantly improvised by use of new technologies to aid the analysis and presentation of the crime scene. One such technology is the use of Augmented Reality (AR). The crime scene contains a narrative which seems hidden initially. The use of AR broadens and enhances the perspective by either providing a walkthrough of the scene using HMDs or smart lenses, etc. for expert inputs or by recording and storing it so that the scene can be reconstructed virtually thus helping depict the course of events that were linked to the crime.*

Keywords*—Augmented Reality, Crime Scene, Investigation, Head mounted devices.*

I. INTRODUCTION

Augmented Reality (AR) is a live simulation of reality where indirect or direct views of physical objects at an area in the real-world environment are augmented using computer-generated superimposed images to obtain a view, thus broadening the perception of reality.

Crimes require a plot and a place. A place may be a room, garden, building, lake-
anything that inhibits some kind of authenticity and is situated right here, unmediated, as it can be perceived and experienced. A **crime scene** is a place which happens to be in a specific state at an instant of time when criminal activity is taking place. It has been encoded by marks and traces which can be analyzed, hence revealing the train of events leading to the crime. This place carries a plot which is scattered and covered up and must be assembled and analyzed. Important pieces of evidence such as hair, nails which contain DNA, traces of blood, gunshot residue, etc. can all be analyzed and interpreted.

The first officer to arrive on the scene has a very vital role as all the evidence, at that point is uncontaminated and uncompromised. Also, there could be a suspect hiding or dangerous, toxic chemicals could be present. Under such stressful circumstances, it is easy for what might turn out to become a vital piece of evidence to be 'polluted' by being accidentally knocked over or mishandled. So, the first person should be the most qualified to explore and observe the scene with precision. This is not always necessarily possible due to time, cost, and geographical constraints. The first officer on the scene is provided with prototypes using which they can view the AR version and explore the crime scene using devices and it can be recorded and sent over at different locations hundreds of kilometers away to people with finest minds in crime scene investigation such as forensic scientists, specialists, and experts who can guide the officers on site and actively contribute in analyzing the scene. This system also keeps the number of people at crime scenes minimum so the risk of contamination decreases and also helps uncover clues without physically touching anything. The recordings from the system could also potentially be used in court. The unrealized potential of augmented reality lies in the ability to recreate a crime scene for a jury.

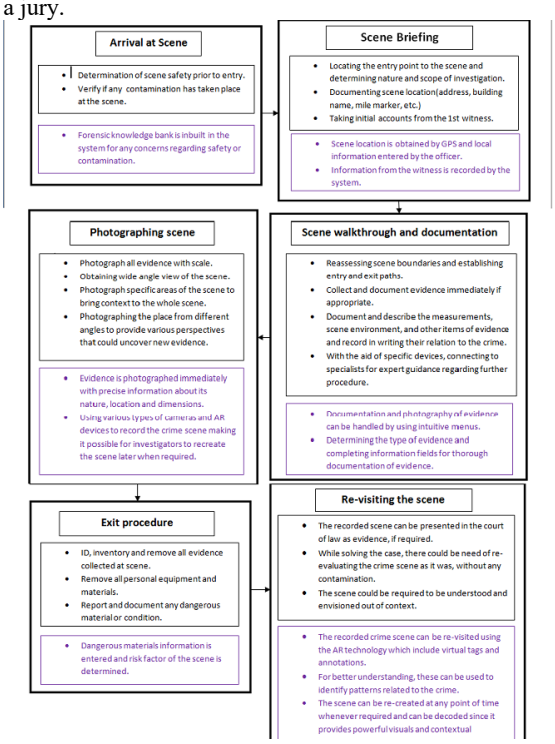

Fig. 1. Methodology diagram for the flow of events during investigation and use of AR correspondingly

II. CASE SOLVING METHODOLOGY

The purpose of examining a crime scene is to formulate a hypothesis based on all the available evidence understanding the most likely course of events that have resulted in the observed circumstances. Within the domain of CSI, there are four main parameters used to construct a narrative for a case:

- *The environment:* It provides a particular perception for examination.
- *Objects within the environment*: These require certain interpretation as evidence.
- *Methods that govern the investigative process:* The way in which the process is carried out.
- *Construction of narratives during the course of investigation*: Primarily includes formation of hypothesis and explanatory models of the incident.
- Considering these parameters, the investigator builds a case that can be presented. Therefore, their role is to retrieve important information via the evidence collected and interpret the crime.

III. AR SYSTEM DEVELOPMENT

Since the fidelity of the real-world view is limited by the world capture device, a video-based method dramatically degrades the fidelity of the real environment. This environment can be controlled and the users viewing perspective can be focused more easily. Equally resolved virtual data can be augmented and easily matched to the resolution of the real environment as it is captured. This creates a more compelling and plausible mixed reality experience because the merging of mediums is indistinguishable.

The most significant application of technologies falls into two broad categories: development of systems to present valid information and implementation of system tools to assist in the crime scene inspection. There are numerous devices which can be used for evidence retrieval. Cameras, along with trackers, distance calculators, ultrasonic transmitters which store the coordinates along with photographs of the scene before evidence collection takes place so that a 3D model can be reconstructed. Augmented Reality aims to enhance a user's perception of and interaction with the real world. Typically, this is achieved the use of a head mounted display which provides a medium to augment virtual data to and register it accurately from the user's point of view. However, handheld mobile displays are also utilized which are compact and easy to use.

The usability of the AR system regarding the information exchange needs to consider several aspects such as hardware ergonomics, network communication, technological aspects, situational awareness, remote guidance, etc. The exchange of information is bi-directional, i.e. the remote user can directly visualize the video stream from the camera of the AR device. In turn, the remote user can make annotations which are visible in the **HMD** view of the officer on scene.

To obtain the complete view of the user, every axis of freedom in real space can be tracked by using a combination of technologies. Tracking the various degrees of freedom facilitated by movement on foot, head rotation, and eye movement requires that various technologies be employed: First, Magnetic, optical, and ultrasonic devices to obtain positional data. Second, Accelerometers and gyroscopes for head tracking. Third, Corneal reflection to track the x-y position of eye gaze every 1/60th second. To obtain the complete view of the user, every axis of freedom in real space can be tracked by using a combination of technologies. Few devices that can be used are:

- LIDAR (Light Detection and Ranging)
- Stereo Camera
- Ultrasonic transmitters
- Magnetic trackers

IV. AR TECHNOLOGIES

1.HoloLens

One of Microsoft's Partner agencies, Black Marble, has been working on an award-winning application-tuServ, has allowed the users to explore the crime scene, placing virtual markers and collecting evidence without disturbing and compromising integrity of the evidence. It can even work long after a crime scene has been cleaned. By the utilization of this application, investigators can return virtually to the scene of the crime, referring to the virtual markers that had been placed, in addition to the proof already accumulated officially. Everything is placed where it was, enabling them to comprehend the crime scene as though it hadn't been tidied up. Video proof can also be obtained, with the cops able to playback and reconstruct the footage.

It uses the Microsoft HoloLens to aid officers by real time mapping of the scene surroundings and then building a digital recreation using 3D objects, virtual markers, as well as other multimedia such as video and audio—all while eliminating any risk of the physical evidence at the scene being contaminated or altered.

The team noticed that when the device first boots up, the HoloLens maps out the room around. Using this mapping process, details can be recorded and then be integrated during the investigation. Once the crime scene has been mustered and mapped out, it can later be conveyed to other officers or investigators easily, without having to go in person and allows you to recreate the scene in any location in full detail, at will. The officers could record and livestream crime scene with the evidence, then the cases files can be shared remotely so that others on the case can access it right away, creating a more efficient, beneficial, productive, and collaborative workflow among law officers and investigators. This helps with time, which is of great urgency for some investigations, as well it is cost effective. This also means that the AR crime scene which was recorded and mapped-out could be used as proof when the case goes to trial.

2.Google glass

It is a compact, head-mounted framework that superimposes graphics and information over the user's field of view. The wearable gadget consists of a small computer screen can take photos, record videos, and play sound. The screen is mounted in the corner of an eyeglass frame and these innovative glasses, which consolidate an automated interface into the user's field of vision, could enable the officers to quickly observe the essential data

3.Smart lenses

The lenses are equipped with inbuilt sensors and a camera that can be regulated by simply blinking. Data is sent to a smartphone through embedded antennas, where the information is handled. Just like the devices described above, these lenses also can help record and deliver information about a crime scene.

In September 2014, a patent by Samsung was filed and granted in South Korea for smart contact lenses. It contains a display that projects images directly into user's eyes. Along with built-in cameras, it also contains embedded antennas and is fitted with several sensors that will let the users control display by detecting eye movement and blinking.

V. POSSIBLE CHALLENGES FACED

Enabling the AR technology has made significant progress. For online AR annotations to work, there are a few technical issues that need to be considered: Perceptual and Positioning issues. Perceptual issues include inaccurate depth perception and ordering, object matching, blurred visibility due to displays, etc. There is a possibility of instances when the user fails to match the overlaid information with the real world. When considered for professional domains, this is a serious risk when user acceptance is considered. Also, another factor that influences perceptual issues is whether hand-held or **head-mounted device (HMD)** is used. While the HMD leaves the user's hands free for other tasks, it can cause motion sickness or visual discomfort as the field of view gets restricted. The user's view of the world is constrained to a limited field of view and prohibited by a fixed degree of freedom that only allows for movement of the head and body while ignoring movements of the eye. Forcing the user to see the world through cameras disassociates the user's autonomy with the real-world.

AR annotation systems rely on GPS for positional or orientational information as far as the location is concerned. But this information does not include indoors so that remains a challenge. This issue can be solved by a proposed vision-based positioning system wherein a preconstructed image set is used.

The drawback of the AR technology is mainly the immobility of the system and its user.

The AR systems do not have capabilities for the local user to interact with the AR content. In future we could enable the interaction with the AR content for the local user via free-hand gestures (using a depth sensing camera).

VI. CONCLUSION

The usability of AR-based technology was explored to support information exchange in terms with the objective of reducing the incidental critical human mistakes in analyzing and decoding crime scenes. The use of AR simply assists the user to gather and store data, modify it by using annotations or virtual tags and refer it later when required. It also reduces error-prone activities on the scene of investigation.

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