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Use of photogrammetry in criminology

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Abstract

Criminology is a scientific discipline which explains the commission of crime, studies criminal conduct and its origins, and deals with preventing and combating crime. It is widely considered as a field of observation that can play a vital role in promoting a more peaceful society. By identifying a sustainable strategy for a harmonious societal response to crime, criminology can serve as a catalyst for societal transformation. The primary objective of criminology is to guarantee that the evidence found at crime scenes is gathered and documented without incurring any damage or loss. In the traditional approach, police officers and forensic experts take various measurements and photographs of the crime scene. This method consumes a considerable amount of time to resolve the case, and the reconstruction of crime scene drawings is carried out manually. This approach presents various limitations, including time constraints, imprecision, and the restricted view of findings in just two dimensions (2D). However, these drawbacks can be addressed with the implementation of photogrammetry, a scientific method for observing and quantifying objects in 2D or 3D by analyzing photographic data with specific metrics for documentation and interpretation.

1. Introduction

Thorough and accurate documentation of an authentic pre-autopsy situation, perishable findings and the subsequent step of an autopsy enables preservation of forensic evidence and allows other experts to review original results, prevent misdiagnoses and uphold high standards of quality control (Yakar et al., 2013; Polat et al., 2020). Where physical evidence is concerned, this affords a three-dimensional portrayal where all elements are equally represented, without any being overlooked or skewed (Yakar et al 2015b). Three-dimensional surface data is utilized to measure body dimensions and make comparisons across different types of forensic evidence, such as in the analysis of weapons and the examination of how injuries were inflicted by the tool that caused them (Tülüce, 2010). The use of spatial photogrammetry, through photographs taken at the crime scene, enables easy creation of a measurement sketch of the area (Sarıtaş, 2015; Ulvi et al., 2019; Kanun et al., 2021). Photographs taken at the crime scene have the potential to accelerate the interpretation of events, and rectify any mistakes in the measurement sketch. These pictures can also supplement missing or incomplete information.

In the field of criminology, photogrammetric science is employed to resolve and authenticate incidents swiftly and without any loss of physical evidence. Photogrammetry offers swift access to accurate model information at a low cost, while allowing for quick data transfer and computer-based work. It provides a reliable means for criminology to achieve its goals and foster trust among individuals who seek justice (Edelman & Aalders, 2018; Villa & Jacobsen, 2019; Kaya & Yiğit, 2020).

Terrestrial photogrammetry proves a useful forensic documentation tool for homicide cases. Photogrammetry provides more accurate measurements of injuries compared to traditional photography. While traditional methods are still useful for pure documentation purposes, they are outdated and less effective when precise measurements or forensic reconstruction is required (Abate et al., 2017; Sacco & Ricci, 2022). Forensic sciences have already integrated terrestrial photogrammetry in several ways, most notably in crime scene and traffic site documentation. With the use of emerging technologies, it is feasible to determine the height of individuals involved in criminal activities or reconstruct the trajectory of shots fired from a firearm (Ulvi & Yakar, 2010; Ospina-Bohórquez et al., 2023).

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Terrestrial photogrammetry is a leading method for producing high-quality 3D models (Yakar et al., 2015b; Gonzalez-Aguilera & Gomez-Lahoz, 2019). The archives resulting from 3D documentation studies are more effective documentation tools, both metrically and visually, than digital and classical alternatives (Şasi and Yakar, 2017). In forensic medicine, 3D recording will aid communication among judges, prosecutors, lawyers, and police officers. After the post-mortem, only the autopsy report and 2D images remain once the body is buried. As the report may contain subjective evaluations, 2D images cannot capture sufficient detail regarding angles, depth, and colour. Consequently, 3D recording enables the immortalization of corpses. Employing photogrammetry software, today's mobile device cameras enable cost-effective use of photographs. The research study intends to evaluate whether the initial investment in 3D photogrammetric documentation technology can lead to cost savings for law enforcement agencies by improving efficiency. For this purpose, a cost-benefit analysis was carried out by the research team for the photogrammetry method.

2. Method

Today, three-dimensional (3D) documentation can be achieved using various instruments (Karataş et al. 2022). For human body scanning, lasers, terrestrial photogrammetry, and video imaging are available (Polat et al., 2020).

Laser surface scanners operate by projecting laser beams progressively over the scanned surface and registering their reflection on a light sensor (Karataş and Alptekin, 2022). In general, the scanned object should remain static for an extended period to avoid movement during the scanning process (Yakar and Doğan, 2019). Photogrammetry can be applied within the forensic environment to scan environments such as crime scenes, skeletal remains, corpses, and weapons (e.g., knives, shotguns). However, it is not considered as a preferred method for living persons. In this scenario, a terrestrial photogrammetry technique was employed. To evaluate the quality of the data collected via close-range photogrammetry method, a reference 3D model of a simulated crime scene was photographed from various locations using a camera. Artificial targets were utilized with target marks visible between consecutive photographs to ensure automation and precision in the alignment process. It is important to note that subjective evaluations are excluded unless specifically marked as such. Artificial targets were utilized with target marks visible between consecutive photographs to ensure automation and precision in the alignment process. Artificial targets were utilized with target marks visible between consecutive photographs to ensure automation and precision in the alignment process.

Forensic (often digital) photography has been the traditional method of carrying out homicides by forensic pathologists or police personnel until recently. Forensic photographs may capture the entire body, smaller anatomical regions, or specific organs (Tülüce, 2010; Sarıtaş, 2015). When photographs are taken from various angles or poses, their size or shape may be altered due to optical distortions (Kanun et al. 2021). As each individual possesses distinctive anatomical structures, such differences often result in distortions between photographs. This makes it challenging to comprehend forensic photography, hence it is imperative to furnish a reference for the object of interest's size and location on the body. It is crucial to commence forensic documentation with a scale-less overview photo of the item in focus, followed by more comprehensive shots from varying perspectives with a scale included. The caliber of the evidence can be heavily impacted by common faults in the technical quality of the pictures. To obtain optimal photographic quality, various aspects must be considered, including white balance, exposure, verticality, and especially the sharpness of the intended area. Technical errors in these categories can be minimized by ensuring forensic and specialized police officers receive the appropriate training (Edelman et al., 2018; Villa and Jacobsen, 2019). Viewing a three-dimensional (3D) object on a two-dimensional (2D) photograph always incurs some form of information loss or deformation of the object of interest (Abate et al., 2017; Sacco and Ricci, 2022). This effect becomes more pronounced in areas of high curvature, such as the arms, neck, or hands. It is therefore essential to meticulously photograph these regions when examining forensic images. The visualization of 2D information in forensic photography can be improved by implementing photogrammetry techniques.

Additionally, the application of photogrammetric models to map surface injuries to specific instruments has proven to be an effective technique for reconstructing patterned wounds. It should be emphasised that photogrammetry alone does not provide information regarding subcutaneous medical conditions. The documentation process has a significant impact on the ability to address forensic inquiries. There are several variables that affect the quality of the documentation when photogrammetric methods are involved in measuring the human body. The slightest body movement, such as breathing, may cause problems when attempting to recreate a 3D model.

Here is the workflow employed in this study:
- Location selection (Open space, Closed space)
- Survey (Planning)
- Lifeless Mannequin supply
- Creation of the crime scene
- Photographing the scene of the incident
- Transferring the photographs to the programme
- Creating a three-dimensional model
- Measurement on the model
- Model analysis.

3. Results

Firstly, photographs were taken of the area where the crime scene was staged. A total of 55 photographs were collected for this purpose. These photographs were then 3D modelled using the SfM algorithm. The photogrammetric process was carried out using Context Capture software and took approximately 8 minutes. Data processing took a total of 28 minutes. Consistent citation and footnote style have been followed, with quotes clearly marked, filler words avoided and a logical structure maintained. The figures showcasing the 3D model generated are presented in Figures 1-2 and 3, respectively.

Figure 1. Top view of the 3D model of the crime scene.

Figure 2. Front view of the 3D model of the crime scene.

Figure 3. Bottom view of the 3D model of the crime scene.

Analyses were conducted on the acquired models. For instance, measurements were taken as illustrated in Figures 4 and 5.

Figure 4. The length of the knife at the staged crime scene. The unit is set in cm.

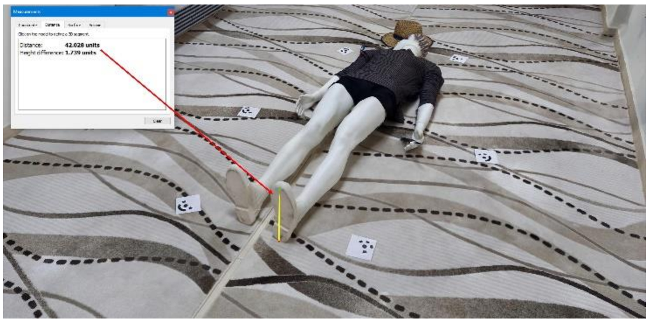

Figure 5. The length of the victim's foot in the staged crime scene. The unit is set in cm.

As demonstrated by the analyses, highly accurate measurements can be obtained from the model, without compromising the integrity of the crime scene.

The study indicates that precise analyses can be conducted on-site at crime scenes and subsequently in digital media. Moreover, institutions may benefit from long-term cost savings. For instance, the photogrammetric software incurs an annual cost of $3500. The remuneration for crime scene investigators is variable. Crime scene police officers and scene experts receive $1000. The classical method offers a pay range of $2000-$4000, depending on the investigator's acumen. Photogrammetric method entails an average salary of $1000 due to less technical skill and sensitivity requirements, unlike crime scene investigation. If the photogrammetry expert is required for future studies, their salary could be adjusted accordingly. The specified prices are solely evaluated for crime scene investigation and modelling purposes.

4. Conclusion

This paper reports on a study analyzing the performance of a handheld camera for crime scene documentation, reconstruction and analysis using photogrammetry. The authors conducted a three-dimensional analysis of a simulated crime scene using data acquired from the sensor. Measurements were extracted from images and 3D point clouds, while point cloud models were generated by applying SfM to 55 multiple images captured from the handheld camera. This study demonstrates that 3D model technology has greatly benefited criminology, particularly in conducting crime scene analyses. Despite this, the use of this technology remains limited in most countries. The primary advantage of 3D modelling is that it improves visualization, interpretation and comprehension. Moreover, the 3D model is a humane approach that prevents damage to the real evidence as it is reconstructed without touching it. Scanned images of the original evidence can be magnified for analysis, printed, and used as explanatory evidence in court. Preliminary study results have demonstrated that this technology provides precise outcomes. Further research, adoption of advanced 3D data collection methods, and sensitization of criminology practitioners have all contributed to the technology's usefulness.

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