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Integrated multimodal documentation of homicide crime scenes: operational experience in criminal and medicolegal investigation with the availability of immersive content through QR code

Abstract

Crime scene documentation constitutes one of the fundamental stages of criminal investigation, directly influencing the quality of event reconstruction and the technical evidence produced. Technological advances have enabled the incorporation of innovative tools capable of significantly expanding the documentary capacity of forensic investigations. This study aimed to describe and evaluate the operational experience of the integrated use of a drone, a 360° panoramic camera, smart glasses, and complementary audiovisual records in the documentation of homicide scenes. A descriptive observational study was conducted based on the prospective analysis of 28 homicide scenes examined by the Homicide Division of the Capital of the Civil Police of the State of Rio de Janeiro between March 2025 and June 2026. A proprietary multimodal documentation protocol was developed using a DJI Mini 2® drone, Insta360 X3® camera, Ray-Ban Meta® smart glasses, and a mobile phone. The records obtained were integrated into a single audiovisual product and made available through a QR Code incorporated into the forensic report. Twenty-eight homicide scenes were documented, including 25 outdoor environments, 2 residences, and 1 motor vehicle interior. The drone was employed in 23 cases and contributed to identifying the probable origin of firearm shots in two investigations. No operational failures were observed. The methodology improved spatial understanding of evidence, enhanced scene preservation, and increased accessibility of forensic information for investigators, prosecutors, judges, and technical assistants. Integrated multimodal documentation proved to be a feasible, safe, and promising approach for criminal and medicolegal investigations.

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Introduction

Proper crime scene documentation constitutes one of the fundamental pillars of modern Criminalistics. Historically, homicide scene documentation has relied on photographs, sketches, and written descriptions. Although indispensable, these methods have limitations regarding spatial perception and immersive reconstruction of the environment.

Recent studies have demonstrated the growing role of digital technologies, immersive visualization systems, artificial intelligence, and advanced imaging platforms in enhancing crime scene investigation and forensic decision-making.[1–3] Drones, panoramic imaging systems, wearable devices, and digital dissemination tools have expanded the possibilities of forensic documentation.

Despite these advances, few operational studies have described the integration of multiple technologies into a single standardized protocol for homicide scene investigation. This study presents the operational experience of the Homicide Division of the Capital of Rio de Janeiro through an integrated multimodal documentation model.

Objectives

General objective: To describe and evaluate the application of an integrated multimodal documentation protocol in homicide scenes.

Specific objectives:

I. Evaluate the use of the DJI Mini 2 drone.

II. Evaluate the use of the Insta360 X3 panoramic camera. • Evaluate the use of Ray-Ban Meta smart glasses.

III. Integrate multiple image sources into a single audiovisual platform. • Expand access to forensic information through QR Codes incorporated into forensic reports.

Materials and methods

Descriptive observational study conducted between March 2025 and June 2026. All homicide scenes examined by the researchers during the study period were included.

The protocol consisted of four stages:

Aerial recording: DJI Mini 2 drone used to document the general scenario, access routes, evidence distribution, victim positioning, and examiner positioning.

Panoramic recording: Insta360 X3 camera used in indoor and outdoor environments.

Operational recording: Ray-Ban Meta smart glasses and mobile phone used to document the examiner's perspective and specific forensic details.

Integration of records: All audiovisual material was edited and synchronized into a single technical video linked to the forensic report through a QR Code.

Results

Twenty-eight homicide scenes were documented: 25 outdoor environments (89.3%), 2 residences (7.1%), and 1 vehicle interior (3.6%).

The drone was employed in 23 cases (82.1%). Non-use occurred in indoor environments and in areas with dense vegetation. Additional operational difficulties involved overhead wiring in urban communities.

In two cases, aerial documentation contributed directly to identifying the probable origin of firearm shots. No operational failures were observed. All cases underwent multimodal integration and were made available through QR Codes incorporated into forensic reports.

Discussion

The main innovative aspect of the proposed methodology does not lie in the isolated use of the equipment employed, but rather in the integration of all information sources into a single documentary system.

This approach is consistent with current international trends that seek to integrate multiple digital sources into immersive forensic environments capable of improving scene reconstruction, evidence interpretation, and communication among stakeholders in the criminal justice system.[4,5]

The drone provides a global perspective of the scene, the panoramic camera preserves spatial perception, and the smart glasses document the operational perspective of the examiner. When combined into a single audiovisual product, these records produce a virtual reconstruction significantly closer to the original forensic experience.

The availability of records through QR Codes democratizes access to forensic information. Investigators, prosecutors, judges, technical assistants, and attorneys gain access to a broader understanding of the evidence. Similar benefits have been reported in recent studies evaluating immersive forensic visualization and digital evidence presentation, particularly regarding improved understanding of complex forensic scenarios by judicial stakeholders.[5]

This increase in transparency strengthens due process, improves interpretation of forensic findings, and reduces informational losses inherent to conventional documentation methods.

Presentation of photographs

Next, we will present some photographs (Figure 1,2) that demonstrate the usefulness of the technologies presented here:

Figure 1 In the photograph provided alongside, taken from the drone (aerial view), we can identify, in a wider view, surrounded by white chalk, the location where ammunition casings were found, allowing the dynamics of the event to be better understood.

Figure 2 In the photograph provided alongside, we demonstrate the use of smart glasses, which allow not only filming but also taking photographs, allowing both hands of the forensic expert to be free to handle the body.

In the case presented, the expert's left hand is identified mobilizing the craniofacial region of the cadaver, allowing examination of a wound located in the left cervical region, resulting from penetration by a firearm projectile (circled in blue).

The right hand abducts the cadaver's left upper limb to allow better visualization of the wound (Figure 3).

Figure 3 In the photographs provided, we demonstrate the importance of using the Insta 360° camera to record, with rich detail, as much information as possible regarding the homicide scene, allowing those responsible for the investigation to "return" to the scene as many times as necessary, seeking to resolve any doubts that may exist.

Limitations

The principal limitations identified were dense vegetation, overhead wiring, and the need for post-processing and editing of audiovisual records, and operational restrictions inherent to drone flights in complex urban environments. None of these limitations prevented application of the protocol.[6–12]

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Conclusion

Integrated multimodal documentation proved to be a feasible, safe, and operationally applicable tool for criminal and medicolegal investigations.

Three innovative contributions deserve special emphasis:

I. Systematic integration of drone imagery, 360° panoramic recording, smart-glasses documentation, and conventional mobile imaging into a single multimodal forensic protocol.

II. Transformation of multiple documentation sources into a unified audiovisual product capable of reproducing the expert's observational experience during scene examination.

III. Incorporation of QR Codes directly into forensic reports, providing immersive access to forensic content for investigators, prosecutors, judges, attorneys, and technical assistants.

The results are promising and support the expansion of this methodology through larger studies and comparative evaluations against traditional forensic documentation systems.

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None.

Conflicts of interest

The author declares that there is no conflict of interest.

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