

Modern Technologies in Forensic Research

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Abstract

In recent decades, crime scene investigation has undergone significant transformation due to technological progress, with new digital tools playing an increasingly central role in enhancing the speed and accuracy of forensic investigations. This paper examines the role of modern technologies in the documentation, analysis, and reconstruction of crime scenes, with particular emphasis on the use of drones, 3D technology, and LIDAR scanning. Drones enable rapid and comprehensive image capture from multiple angles, providing an extended perspective over the investigated area, including locations that are difficult to access. 3D technology facilitates detailed virtual reconstruction of the crime scene, contributing to a better understanding of the dynamics of events and to the establishment of spatial relationships between pieces of evidence. The integration of these technologies with advanced data analysis software allows for the correlation of information from multiple sources and the generation of interactive models of event sequences. Through these tools, the investigative process becomes more adaptive, objective, and efficient, strengthening the capacity of judicial authorities to establish the truth.

Keywords: modern technologies, forensic science, crime scene investigation, drones, 3D reconstruction, LIDAR, data analysis, forensic evidence.

JEL Classification: K13, K24

1. Introduction

In recent decades, crime scene investigation has undergone a significant transformation due to technological advances. Modern technologies have become indispensable for achieving faster and more accurate results in criminal investigations. They enable more detailed documentation of the crime scene, a more thorough analysis of evidence and a more accurate reconstruction of events. Below, we will present some of the most relevant technologies used in forensic science, and in particular in crime scene investigation, such as the use of drones, 3D technology and LIDAR scanning, highlighting how these contribute to the efficiency of the investigative process.

Firstly, one of the most significant innovations in crime scene investigation is the use of drones. Drones enable the crime scene to be documented very quickly and comprehensively; this documentation can be achieved by flying them at different angles, something that would be impossible using traditional methods. Drones can be equipped with high-resolution cameras capable of capturing clear images from various heights, providing a wide field of view over the area under investigation; such images are particularly essential for a successful forensic investigation of the crime scene. In this way, drones are capable of conducting video scans of the crime scene, facilitating the

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establishment of the sequence of events that took place at the scene of the crime, in cases of assaults resulting in bodily harm or even murders occurring in open spaces or in public places that are difficult to access.

Another technology that has revolutionised crime scene investigation is 3D technology. 3D crime scene scanners enable a virtual reconstruction of the crime scene, where every detail can be captured with exceptional accuracy. This type of technology not only enables precise documentation of the crime scene, but also offers the possibility of establishing the criminal events of the case under investigation, helping investigators to better understand how the crime unfolded and, by extension, to prove the perpetrator's guilt. 3D technology also enables a more accurate assessment of the actual state of the crime scene and of the evidence found there, such as the exact position of objects within the crime scene and the distances between them – aspects that are essential for establishing the factual situation at the crime scene.

Another advantage of modern technologies is their integration with data analysis software, which can rapidly process the information gathered during the on-site investigation. These programmes are capable of comparing and analysing evidence from multiple sources, providing a clear picture of the relationships between the various elements of the crime scene. For example, by correlating data from a drone with 3D scans of the crime scene, investigators can create interactive routes illustrating the movements of the victim and the offender within the crime scene, thereby establishing the chronological sequence of events during the commission of the offence.

2. The use of drones in crime scene investigation

Any technological equipment that acquires, processes, transmits or stores data leaves records – from a forensic perspective, these are reflections of its activity. Such records constitute forensic evidence. One of the most revolutionary modern technologies in the field of forensic investigation is the use of drones to capture aerial images of the crime scene.³

The use of drones is undertaken at any stage of the criminal proceedings, with the aim of establishing the evidence presented in the case or the accounts developed during the criminal investigation regarding the circumstances of the offence.⁴ In cases where crimes are committed in isolated or rugged terrain that is difficult to access, drones can reach such areas with great ease and capture images of the crime scene before the actual on-site investigation begins. This is essential for securing the crime scene as soon as possible after the offence has been committed, which is crucial for a successful on-site investigation.

Drones are equipped with advanced imaging technologies, which enable them to capture high-quality images of great value to investigators, leading to a professional resolution of the criminal case, even in particularly adverse weather conditions. For example, in the dark, drones equipped with thermal imaging cameras can detect the heat emitted, for instance, by suspects attempting to cross the state border illegally, thereby

³ Jozef Metenĸo, Martin Metenĸo, and Jan Hejda, "Digital Trace in Criminalistics," in *MeĹunarodni nauĸni skup "Dani Arĸibalda Rajsa"*, vol. 1 (Belgrade: Kriminalistiĸko-policijska akademija, 2013), 359–71.

⁴ Cosmin Ionescu, Valentin Zorilă, and Căţălin Vasiliĸă Băncioi, *Criminalistică. Medicină legală: Note de curs* (Craiova: Universitaria, 2016).

helping to locate them at night. This thermal imaging camera technology is used, in particular, for searches in conditions of reduced visibility and can also play a very important role in cases involving missing persons.

Given the occurrence of homicides or serious accidents of various kinds that can take place anywhere in public or private spaces, including in challenging natural environments such as rugged terrain or remote mountainous areas, it is fair to say that drones are the most suitable solution for investigating crime scenes located in such environments. In such locations, drones can cover vast areas and are capable of capturing and transmitting images in real time, enabling investigators to access the relevant information that may be indispensable for the objective resolution of the criminal case under investigation, with great efficiency. Such information is particularly valuable in cases of crimes committed in isolated or hard-to-reach areas, where traditional forensic investigation of the crime scene would be extremely difficult.

Another important aspect of the use of drones in forensic investigations is that they can assist in the surveillance of areas of particular interest over a long period of time. In investigations into drug trafficking or human trafficking offences, drones can be used to track and monitor the movements of suspects or suspicious vehicles across a wide area, gathering valuable information to support the documentation of a complex case. Drones are capable of documenting suspects' routes and capturing images during the transport of drugs or victims of human trafficking or child trafficking, thereby helping to uncover and prove causal links within the crimes under investigation.

In some cases, drones can also be fitted with lighting equipment or high-performance devices, such as gas detectors or chemical detectors. This equipment allows for intervention in hazardous areas, such as during forensic investigations of crimes involving toxic or explosive substances, without endangering the safety of forensic experts. Therefore, the use of drones to investigate these types of crimes eliminates risks of any kind for forensic investigation teams and improves the efficiency of operations.

Drone technology has revolutionised several industries in recent years, with today's drones being equipped with state-of-the-art sensors and cameras, making them invaluable tools for precise measurements and analysis. Using advanced surveying techniques, drones enable the accurate collection and analysis of data, allowing for more efficient and precise work.⁵

In conclusion, we can highlight a number of positive aspects of the use of drones by forensic officers or criminal investigators in the course of criminal investigations. Some of the advantages of using this equipment include: the ability to take photographs and video footage of locations that are difficult to access or inaccessible, such as the roofs and walls of houses, balconies, the roofs and bodies of large lorries or other vehicles, and mountainous or marshy terrain; the ability to take photographs and video footage of the area where the criminal investigation is taking place, without disturbing the original scene and without the risk of damaging or negligently destroying evidence of the offence (including indoors); use for the purpose of photographing and filming the crime scene where the lives and health of members of the operational investigation team may be endangered or where there is an imminent danger to them (for example,

⁵ Paweł Wójcik, "Tehnici avansate de topografie cu dronă pentru construcții: Un ghid," *SkySnap*, accessed August 20, 2025, <https://skysnap.pl/ro/tehnici-avansate-de-topografie-cu-drona-pentru-industria-construc-tiilor/>.

examining the crime scene in the event of an explosion, arson or building collapse, etc.). In such situations, the use of a drone not only enables photographic and video recording but also allows specialists to assess in advance the level of danger to the life and health of the operational investigation team. In this way, factors that may endanger the life and health of a police officer are minimised.⁶

3. LIDAR (Light Detection and Ranging) scanning in crime scene investigation

LIDAR (Light Detection and Ranging) is a scanning technology that uses lasers to create detailed models of the terrain and of the objects being investigated or analysed. LIDAR scanning is a highly effective technology for crime scene investigations, particularly in vast or complex areas such as forests, mountainous regions or other natural environments that are difficult to access. LIDAR can produce high-resolution images that capture even the smallest details of the crime scene.

Another benefit of using LIDAR technology is its ability to capture detailed images of the relief and topography of the area under forensic investigation, even in environments with low- e visibility, such as dense forests or mountainous areas with rugged terrain. By using a LIDAR scan, a precise digital map of the scanned terrain can be created, capturing even the most subtle variations. Another important aspect is that LIDAR technology can be used to obtain three-dimensional images of the crime scene. This three-dimensional image allows for the spatial reconstruction of the crime scene, providing a much more detailed picture than that obtained through traditional measurement methods.

Furthermore, in the investigation of road traffic accidents, LIDAR technology proves to be an extremely useful tool, as it enables highly accurate measurement of distances and angles of impact between vehicles, thereby facilitating the determination of the details of how the incident occurred. At the same time, LIDAR technology can also be used to determine the speed of the vehicles involved at the moment of impact.

Another significant advantage of using LIDAR is its ability to obtain precise data without compromising the integrity of the crime scene. Although traditional forensic investigation methods involve, in the dynamic phase, the physical handling of objects and evidence, LIDAR allows for the acquisition of clear images of the scene without touching or handling any physical evidence, which is a very important aspect in protecting the crime scene and preventing the contamination of evidence.

LIDAR technology proves to be particularly effective in complex urban environments, where there is a wide variety of structures and obstacles. LIDAR can create a digital model of buildings, roads and other structures, providing an accurate picture of the crime scene. This capability is essential when investigating crimes committed in a dense urban environment, such as thefts or violent crimes committed in public places or within buildings. LIDAR helps to assess the urban environment and identify areas where evidence might be hidden or places where offenders might be hiding. Another aspect of using LIDAR is its integration with other modern investigative technologies, such as drones and 3D cameras. For example, LIDAR data can be

⁶ Constantin Rusnac, "UVS ca tehnologie avansată aplicată în activitatea poliției," *Legea și Viața* (March–April 2021): 60–64, <https://doi.org/10.5281/zenodo.4682816>.

combined with aerial imagery or video footage to create a more detailed view of the crime scene. This combination of technologies can help form an integrated framework to support evidence analysis and help investigators achieve more accurate and efficient results.

LIDAR can also be deployed on aerial, space-based or ground-based platforms. Compared to LIDAR deployed on ground-based platforms, that deployed on aerial platforms can survey and map very large land areas in a very short time, thanks to the advantages offered by high-altitude surveillance and the technical advantages of aerial platforms.⁷ Another positive aspect of using LIDAR is that the data obtained can be stored and archived digitally for future use. This data can be reviewed and analysed as the investigation progresses, providing a quick and efficient way to access essential information.

Furthermore, the data can also be used to create comparison databases when investigating similar crime scenes, thereby facilitating the identification of patterns and the correlation of information obtained from different investigations.

4. 3D technology in crime scene investigation

3D technology is increasingly used in forensic investigations. This technology facilitates the reconstruction of the crime scene, capturing details of the scene and establishing the relationships between objects and evidence discovered at the scene. 3D scans can be carried out quickly and with great precision, and the resulting models can also be used for further analysis of the crime scene. The 3D image can be used to visualise the crime scene from different angles, which helps investigators to better understand the spatial relationships between the various elements of the crime scene and the evidence found there. 3D technology can also be extremely useful in reconstructing the crime scene to test different hypotheses or to simulate the movements of victims and offenders.

The purpose of 3D technology is to reconstruct a crime, with the aim of producing visual aids useful for police investigations or for presentation in court. The purpose of 3D technology is to supplement witness statements and provide a means to help the court better understand the evidence presented. 3D technology can be presented in court either as a simple visual aid or as evidence in its own right, in which case it will have probative value.⁸

Another major benefit of 3D technology is that it allows investigators to explore the crime scene from multiple angles and perspectives, which would not be possible using simple forensic photographs or traditional sketches. 3D models can be rotated, zoomed in on and viewed from different angles, allowing investigators to observe essential details that are not evident from fixed angles. These three-dimensional images allow for a detailed examination of the scene, providing a deep understanding of the spatial relationships between victims, suspects and evidence, which is crucial for

⁷ Pătru Pîrjol, "LIDAR Applications for Earth Observation Missions," *Bulletin of "Carol I" National Defence University*, no. 4 (2020): 7–13.

⁸ Rachael M. Carew, James French, and Ruth M. Morgan, "3D Forensic Science: A New Field Integrating 3D Imaging and 3D Printing in Crime Reconstruction," *Forensic Science International: Synergy* 3 (2021): 100205, <https://doi.org/10.1016/j.fsisyn.2021.100205>.

reconstructing events.

In practice, the use of 3D reconstructions in the analysis or interpretation of evidence by a forensic expert has been fairly limited. Interpretations derived from 3D reconstructions of evidence are not always supported by databases or solid evidence, and experts are advised to rely on the analysis of original materials or more established techniques, such as medical imaging, microscopy or histology.⁹

A significant contribution of 3D technology to forensic work lies in the analysis of traces and evidence discovered at the crime scene. For example, where bloodstains or fingerprints are identified, three-dimensional models can provide a clear picture of their direction and distribution, assisting investigators in reconstructing the sequence of events and establishing a timeline of the crime.

At the same time, 3D technology facilitates the creation of simulations that help clarify the circumstances surrounding the movements of victims or suspects. In cases of extreme violence or multiple homicides, three-dimensional models can be used to analyse the perpetrator's movements at the crime scene and to test hypotheses regarding the sequence of events. In this way, investigators can obtain additional information that might not be apparent through traditional investigative methods. 3D technology can also be used to create a digital reconstruction of a crime scene for use in the case. Three-dimensional models can be presented in an interactive format, allowing investigators to visualise the crime scene and more easily understand its complexity. These digital reconstructions are clearer and more informative than traditional presentations of evidence, making them even more useful, particularly in complex cases. For example, where shoe or tire marks are usually cast in plaster — a time-consuming procedure that damages the mark — the use of 3D scanning can help overcome these challenges and preserve the marks.¹⁰

5. Augmented and virtual reality in crime scene analysis

Augmented reality (AR) and virtual reality (VR) are emerging technologies that are finding increasing application in forensic investigation. These technologies allow investigators to interact with a virtual representation of the crime scene, enabling them to analyse the scene from various angles, simulate the movements of offenders and victims, and test different hypotheses. In augmented reality, digital information, such as bloodstains, fingerprints or the positions of objects, can be superimposed onto the real-world image of the crime scene, providing a more detailed understanding of the events.¹¹

One area of application for AR in forensic investigation is the analysis of interactions between victims and offenders. For example, by using AR, investigators can visualise the movement trajectories of victims and assailants during the commission of the crime. This allows investigators to analyse the possible routes taken by offenders to leave the crime scene and to establish the link between the various actions that took place. This type of simulation can help reconstruct a more realistic scenario and provide

⁹ Carew, French, and Morgan, "3D Forensic Science," 100205.

¹⁰ Madeleine P., "How Can 3D Technologies Help Solve Crimes?," *3Dnatives*, October 10, 2024, <https://www.3dnatives.com/en/how-can-3d-technologies-help-solve-crimes-forensic-101020244/>.

¹¹ Constantin Drăghici and Adrian Iacob, *Tratat de tehnică criminalistică*, 2nd rev. and enl. ed. (Craiova: Sitech, 2009).

additional information.

Virtual reality (VR) represents a significant innovation in crime scene investigation, offering the ability to digitally reconstruct the crime scene and allowing investigators to explore it interactively. Using VR technology, investigators can analyse significant details from multiple angles, reconstruct the sequence of events and test different scenarios without altering the actual crime scene. Augmented reality (AR) and virtual reality (VR) also have implications for legal research, the professional training of magistrates and access to justice. The importance of crime scene investigation and reconstruction in forensic science is emphasised, highlighting their role in preserving evidence, identifying and establishing the cause and manner of death. AR and VR technologies have the potential to improve forensic practices and the judicial system, providing new tools and capabilities for investigators, legal professionals and the general public.¹²

When it comes to presenting evidence in court, VR and AR offer an opportunity to create compelling visual evidence. The use of these technologies can transform the way evidence is presented, allowing for a much clearer presentation of the circumstances in which the crime was committed.

6. Fingerprinting and DNA techniques

Fingerprinting and DNA analysis are two of the most important and reliable techniques used in forensic science to identify evidence and suspects. These techniques have revolutionised the way evidence is collected and analysed, helping to solve cases that would otherwise have remained unsolved. In addition to traditional methods, modern technology has significantly improved the fingerprint collection process. Today, fingerprint scanners and facial recognition software enable rapid and accurate identification of individuals, helping to reduce the time required to resolve criminal cases.

DNA analysis technology has seen significant development in recent decades, making it possible to obtain genetic profiles even from extremely small amounts of biological material. Methods such as PCR (*Polymerase Chain Reaction*) and STR (*Short Tandem Repeat*) make it possible to amplify DNA fragments, so that even minimal traces can provide conclusive results. The relevance of these techniques lies not only in identifying suspects, but also in ruling out certain individuals from the circle of suspects. A major advantage of DNA analysis is its ability to provide additional information regarding how the crime was committed. If a suspect denies involvement in a crime, evidence such as fingerprints or DNA can be used to prove with certainty their presence at the crime scene.

Although fingerprinting and DNA analysis are among the most reliable methods of forensic investigation, in certain cases this evidence is damaged. In such situations, this makes the investigators' work very difficult.

The results of DNA analysis can establish both a person's guilt and innocence; however, errors may arise as early as the stage of collecting biological samples from the

¹² P. R. Harshith and P. N. Ramakrishnan, "Exploring the Potential of Augmented Reality for Forensic Crime Scene Reconstruction: A Review," *International Journal of Trendy Research in Engineering and Technology* 7, no. 3 (2023): 28–34, <https://doi.org/10.54473/IJTRET.2023.7305>.

crime scene if procedural rules governing their collection have not been followed. Therefore, the results of DNA analysis can constitute conclusive evidence in a criminal case only if the biological material has not been contaminated.

Bibliography

1. 3DMakerPro. "The Role of LiDAR Spatial Scanners in Forensic Science." April 16, 2025. <https://store.3dmakerpro.com/blogs/3d-scanner/lidar-spatial-scanners-in-forensic-science>.
2. Carew, Rachael M., James French, and Ruth M. Morgan. "3D Forensic Science: A New Field Integrating 3D Imaging and 3D Printing in Crime Reconstruction." *Forensic Science International: Synergy* 3 (2021): 100205. <https://doi.org/10.1016/j.fsisyn.2021.100205>.
3. Drăghici, Constantin, and Adrian Iacob. *Tratat de tehnică criminalistică*. 2nd rev. and enl. ed. Craiova: Sitech, 2009.
4. Harshith, P. R., and P. N. Ramakrishnan. "Exploring the Potential of Augmented Reality for Forensic Crime Scene Reconstruction: A Review." *International Journal of Trendy Research in Engineering and Technology* 7, no. 3 (2023): 28–34. <https://doi.org/10.54473/IJTRET.2023.7305>.
5. Ionescu, Cosmin, Valentin Zorilă, and Cătălin Vasiliică Băncioi. *Criminalistică. Medicină legală: Note de curs*. Craiova: Universitaria, 2016.
6. Madeleine P. "How Can 3D Technologies Help Solve Crimes?" *3Dnatives*. October 10, 2024. <https://www.3dnatives.com/en/how-can-3d-technologies-help-solve-crimes-forensic-101020244/>.
7. Meteňko, Jozef, Martin Meteňko, and Jan Hejda. "Digital Trace in Criminalistics." In *Međunarodni naučni skup "Dani Arčibalda Rajsca"*, vol. 1, 359–371. Belgrade: Kriminalističko-policijska akademija, 2013.
8. Pirjol, Pătru. "LIDAR Applications for Earth Observation Missions." *Bulletin of "Carol I" National Defence University*, no. 4 (2020): 7–13.
9. Rusnac, Constantin. "UVS ca tehnologie avansată aplicată în activitatea poliției." *Legea și Viața* (March–April 2021): 60–64. <https://doi.org/10.5281/zenodo.4682816>.
10. Wójcik, Paweł. "Tehnici avansate de topografie cu dronă pentru construcții: Un ghid." *SkySnap*. Accessed August 20, 2025. <https://skysnap.pl/ro/tehnici-avansate-de-topografie-cu-drona-pentru-industria-construcțiilor/>.