

Revolutionizing Justice: How Artificial Intelligence Is Transforming Autopsies And Crime Scene Investigations.

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Abstract

Forensic science is poised to transform, and artificial intelligence (AI) is its driving force. A future where machines support forensic specialists, autopsies become more accurate, and crime scene analysis accelerates, can be imagined. We delved into this by searching through medical databases such as PubMed and Scopus, looking for research on AI in the field of forensics—autopsies, crime scenes, forensic odontology, and so on. The results are exciting: AI, in the form of tools such as machine learning, deep learning, and robotics, is transforming the discipline. It's assisting in identifying dead bodies, interpreting post-mortem X-rays, identifying weapons, estimating time of death, and detecting toxins. Most importantly, it's reducing human error caused by fatigue or pressure. But it's not all smooth sailing—AI's integration must balance innovation with ethical responsibility to maintain trust in forensic practices.

Keywords: Artificial Intelligence; Autopsy; Post-Mortem Interval; Machine Learning; Deep Learning

INTRODUCTION

Artificial intelligence (AI) isn't buzzword nonsense; it's a revolution that's redefining our relationship with technology. Essentially, AI replicates human thought—machines that think, reason, and learn from experience. They can recognize patterns, solve intricate problems, and even make choices (1). In medicine, AI's already reducing costs and enhancing results (1). And now, it's at the doorstep of forensic science, threatening to disrupt the way we investigate deaths and examine crime scenes.

Forensic labor is not a Sunday stroll. Crime scenes are messy puzzles—securing a large area, gathering minute clues, maintaining evidence, and gauging how long a body has lain there. Autopsies are equally challenging: inspecting wounds, establishing causes of death, and gathering samples to send for toxicology or histology. A single misstep can kill a case, with real-world repercussions in courtrooms. Human mistake, fueled by exhaustion or stress, is ever-present. That's where AI comes in, providing solutions to enhance precision and productivity.

AI is diverse—machine learning that identifies patterns in data, deep learning that replicates the brain's neural networks, natural language processing (NLP) that interprets text, and robotics that execute detailed tasks. Forensics makes use of these tools to address issues such as the identification of bodies, crime scene reconstruction, and even estimating the time of death. This article explores how AI is revolutionizing forensic science, particularly in relation to autopsies and crime scenes, and discusses its advantages and disadvantages.

MATERIALS AND METHODS

In order to have a clear vision of AI's place in forensics, we searched PubMed and Scopus, two giant databases for medline research. We employed particular search terms: "artificial intelligence" AND "forensic" AND a variety of related terms such as "autopsy," "crime scene management," "forensic odontology," "post mortem interval," "forensic anthropology," or "forensic sciences." Two authors worked independently to maximize thoroughness, using English-language studies between 2014 and 2024. We began by scanning titles, then delved into full texts for pertinent papers, dismissing anything not within the topic or out with our criteria.

This strategy provided us with a good ground to cover AI applications, from innovative algorithms to robot systems, and see how they're impacting forensic practice in actual environments.

RESULTS

Our search yielded 70 studies, with an increase of AI-centered forensic publications in the past five years. The results reveal AI making a splash in several fields of forensic science.

Autopsies and Forensic Pathology

Autopsies are the foundation of forensic pathology, but they're sophisticated and time-consuming. AI is coming into fill that role by making them more dependable. For example, Tang et al. demonstrated how AI, with natural language processing, can forecast lethal drug overdoses based on autopsy reports only (3). By sorting through scene evidence and medical histories, it identifies patterns that might otherwise be missed by humans. This is a huge deal in situations where the cause of death is not self-evident, such as overdoses that are hidden by other issues.

Lin et al. pushed this even further, combining deep learning with spectrometry to examine lung fluids (4). Their computer program was able to differentiate between causes of death—sudden cardiac event, drowning, poisoning, asphyxia, or brain injury—depending on fluid spectra. This level of specificity is a godsend for pathologists dealing with uncertain cases.

Gunshot injuries are also a hard nut to crack. The randomness of multiple shots can make it difficult to distinguish entry from exit wounds, and thus complicate crime scene reconstruction. Cheng et al. addressed this with a deep neural network model that learned from 2,400 wound images, accurately distinguishing entry wounds 88.19% of the time and exit wounds 87.71% (5). Such accuracy assists in reconstructing the narrative of a shooting with assurance.

AI is also transforming the way we date injuries. Bruises, for instance, evolve in color as hemoglobin decomposes, providing hints at when they occurred. Historically, pathologists eyeball such changes, but AI does it more accurately. By taking bruise colors into account, it delivers more accurate timelines, cutting down on guesswork. This comes in handy particularly in cases of abuse, where timing can be a lifeline or death sentence in a legal case.

Post-mortem radiology, or Virtopsy, is another field where AI excels. Interpretation of X-rays or CT scans post-mortem involves skill, and human bias can intrude. AI assists by viewing images with a cold, objective gaze. Zirn et al. employed convolutional neural networks (CNNs) and DenseNet to investigate 81 cases of brain hemorrhage vs. healthy controls, correctly diagnosing the cause of death (8). Other studies have applied similar methods to detect heart issues, bone fractures, and even hypothermia, showing AI's versatility (6-7).

Drowning deaths are notoriously difficult. Autopsy results can be ambiguous, and diatom testing—searching for microscopic algae in the lungs—isn't always an option because of expense. AI intervenes by interpreting CT scans and comparing drowning deaths with controls, although sensitivity and specificity still require improvement (9-10). This may open up drowning diagnoses, particularly for underfunded laboratories.

In forensic anthropology, bones are examined by AI to estimate age, gender, or height. Machine learning algorithms process data from skulls or collarbones, providing information for identification (11-12). Forensic odontology applies the same methods to reconstructing profiles from teeth to help identify remains or evaluate injuries.

Robotics is another arena. Virtobot, for instance, does "post-mortem biopsies" with accuracy, saving pathologists money and risk. Robotic instruments secure samples cleanly, which is essential for toxicology or histology.

Another AI success: estimating the post-mortem interval (PMI)—how long the person has been dead. Using changes in body fluids, such as potassium or sodium content in the vitreous humor, AI constructs predictive models. One study applied neural networks to 61 cases and improved upon standard methods (13-16). Others investigated gut bacteria in human and mouse cadavers to differentiate early (0-7 days) from delayed (9-30 days) PMIs. Even forensic entomology is not immune, with AI calculating the age of the flies to limit the time of death.

Crime Scene Analysis

Crime scenes are where investigations start, and AI making them more accessible. Standout use is the ability to differentiate between human and animal blood. With the use of close to 2,000 digitized human, chicken, bovine, and goat blood cell images, AI was able to learn through deep learning with near-perfect results (17). This is important when blood evidence might belong to a pet or wildlife so that investigators do not waste time following false leads.

Microbiomes—bacterial signatures on evidence—are yet another AI playground. When combining next-generation sequencing with machine learning, AI can tell who deposited a trace, what type of trace (saliva, blood, etc.), and how long it has been present. Another layer of accuracy to add to scene analysis. Bloodstain pattern analysis (BPA) is also being AI-boosted. By analyzing stains, AI is able to infer the weapon—gun, blunt instrument, or knife—and the amount of force that was used. Convolutional neural networks also sharpen blurry evidence, such as shoe prints, and match them across scenes. Maybe most amazingly, AI is able to recreate entire crime scenes in 3D, saving them to review later using augmented reality (17-18). This allows investigators to "walk" the scene long after it's been cleared, noting details they may have otherwise overlooked.

DISCUSSION

AI's takeover of forensics is unstoppable, touching everything from pathology to entomology. Its strengths are clear: it classifies data, spots differences, and nails diagnoses with speed and precision. Machine learning, for instance, can analyze autopsy reports to pinpoint causes of death, even in murky cases (13-18). It's like having a tireless assistant who never misses a detail.

One of the greatest victories for AI is to notice what humans can't. Whether it's faint patterns in bloodstains or abnormalities on X-rays, AI picks up cues that might fall through the cracks. Huge in forensics, where experience, pressure, and time constraints can result in errors. Predictive models are another gem, doing routine tasks such as fingerprint matching or PMI calculation, saving time and improving accuracy.

Use blood spatter analysis: AI can trace out the angle and velocity of a blow, providing investigators with a better understanding of what happened. In fingerprint examination, it matches latent prints against databases in mere seconds, accelerating the identification of suspects. These technologies don't only solve cases quicker— they make results more predictable.

But AI is not flawless. It requires continuous monitoring to keep its learning on course. Biases in training datasets can result in biased outcomes, and there is a genuine possibility of abuse if systems end up in malicious hands. Ethical responsibility is not negotiable. AI's choices need to be clear and just, lest we corrupt the system and lose public trust.

The human touch in forensics is important as well. Pathologists use intuition and background that computers can't. AI must be a complement, not a substitute, to augment human judgment without displacing it. Finding this balance is most important to establish AI as a reliable tool for the practice.

CONCLUSION

Forensic science has ever been about accuracy and truth based on decades of painstaking work. AI doesn't supplant that—it turbocharges it. From more acute autopsies to more intelligent crime scene analysis, AI is accelerating forensic specialists to work quicker and more accurately. It's identifying patterns, lowering blunders, and revealing new avenues to solve cases.

But with all power comes great responsibility. As we integrate AI into forensics, we need to keep its boundaries in check—bias, misuse, and overdependence. By using it judiciously, we can make sure that AI becomes a reliable partner, augmenting justice without undermining integrity. The future of forensics is bright, and AI is paving the way.

Conflict of Interest: None

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