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# **“REVOLUTIONIZING CRIME SCENE INVESTIGATIONS”: DRONE FORENSICS**

AYTHORED BY - VANSHITA SRIVASTAVA

## **ABSTRACT**

As the use of unmanned aerial vehicles (“UAVs”) becomes more widespread in civilian settings, it is of the utmost importance to be aware of and address the inherent vulnerabilities that these vehicles possess. It’s important to assess the systematic forensic framework for the purpose of acquiring and assessing evidence from drones. Additionally, the need of keeping data integrity and adopting standard methods.

This research paper investigates drone forensics, which is a dynamic field of digital forensic science that is now in the process of development. The emphasis is placed on the need of standardized methods and collaborative efforts in order to overcome challenges associated with data gathering and administration of drones. This research paper will also reflect upon on the importance of ‘diverse approaches’ and ‘technological advancements’ in order to advance the field of drone forensics.

## **KEYWORDS**

*Drone forensics, UAVs, Data integrity, Standardized protocols, Interdisciplinary approaches*

## **INTRODUCTION**

The Supreme Court of India had stated<sup>1</sup> that the current era is characterized by technological advancements and progress. High-tech advancements are occurring at an accelerated rate. It is imperative to exercise caution when admitting electronic evidence due to the possibility that manipulation has occurred.

Cyber or digital forensics is the forensic science area that studies occurrences and gathers evidence from digital devices. One small component of it is “*drone forensics*.” It is the study of drones for investigative purposes; its main components are the drone that was retrieved from the crime scene and the devices it was linked to. UAVs or drones have become more and more

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<sup>1</sup> *Tukaram S. Dighole v. Manikrao Shivaji Kokate*, (2010) 4 SCC 329

popular for civilian purposes include patrolling, police, search, and rescue, aggrotech and videography, and arresting poachers, mostly because of the widespread digital lifestyle<sup>2</sup>.

Drone that might be in running or functioning states at the scene are an essential instrument. Among their intricate constructions are 'recording devices,' 'wireless RF antennae,' and 'high-resolution cameras<sup>3</sup>.' Depending on the gadget, sensors might be temperature, GPS, or camera. Both directly on the device and on an SD memory card may hold the data gathered.

Drones may be controlled remotely or independently by use of onboard computers. Their connection with the Ground Control System (GCS) is made possible via a network of actuators and sensors that communicate wirelessly. Because of this vulnerability, drones may be targeted by attacks directed against their physical and/or cyber components, the interface between them, the wireless connection, or even a combination of many components.<sup>4</sup> Importance of drone culture in forensic science is also being recognized in india as in August 2021, Kerala came up with India's first '*Drone Forensic Lab & Research centre*<sup>5</sup>.'

## WORKING OF A DRONE

Drone forensics use Wi-Fi signal connection to enable communication between a drone and a controller/mobile phone<sup>6</sup>. Data transmission allows a drone to fly under control, and during the drone's control phase, Wireshark packets locate the network interface cards MAC address when a drone connects to a mobile phone. There is use for this idea in digital and physical forensics<sup>7</sup>. Controlled flight of the drone is made possible via data transmission.<sup>8</sup>

## DRONE FORENSIC FRAMEWORK

This framework explains a systematic process for an investigator collecting evidence. Part of the first stage of the forensic procedure is determining the devices' existence, location, and storage

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<sup>2</sup> Hardam Singh v. State of Punjab, 2019 SCC OnLine P&H 6373

<sup>3</sup> Janice Castelino, *Drones and Future Feasibility of Drones in India*, 4 INT'L J.L. MGMT. & HUMAN. 1062 (2021).

<sup>4</sup> Sihag, et. al., '*Cyber4Drone: A Systematic Review of Cyber Security and Forensics in Next-Generation Drones*,' *Drones* 7, Vol. 7, 430 (2023)

<sup>5</sup> PTI, *Kerala Police comes up with India's first Drone Forensic Lab and Research Centre*, Deccan Herald (2021), <https://www.deccanherald.com/india/kerala-police-comes-up-with-indias-first-drone-forensic-lab-and-research-centre-1019297.html>.

<sup>6</sup> Stephenson, P., & Gilbert, K. (2013). *Investigating Computer-Related Crime* (2nd ed.). Routledge.

<sup>7</sup> G.M. Jones & S.G. Winstler, '*Forensics Analysis on Smart Phones Using Mobile Forensics Tools*,' *International Journal of Computational Intelligence Research* 8(13), 1859-1869 (2017)

<sup>8</sup> J. Kävrestad, '*Fundamentals of Digital Forensics Theory Methods and Real Life Applications*,' Springer International Publishing AG (2018).

as well as their identification and tagging.

An alternative method to prevent tampering with digital evidence is to restrict access to the collected devices. Memory cards and hard drives are separated and forensically inspected in order to protect and prevent data tampering of the original media. And last, a significant area of research and development that requires a comprehensive approach to gather data from various digital devices is drone forensics<sup>9</sup>.

The collection stage is followed by the examination of the raw data from devices. At this point, memory cards, GSC, mobile devices, and drones have to be located and data collected. Event logs are a chronologically arranged compilation of recorded events, while flight logs include a plethora of information in several formats, including the location, speed, flight duration, gimbal angle, and camera shooting time<sup>10</sup>.

The analysis stage involves comparing the examined data to extract information—such as controller commands, GPS coordinates, sensor metadata, and hardware failures. Useful Exchangeable Image Format (EXIF) data is included in media files, such as photos and videos, and may be obtained using tools like Exiftool<sup>11</sup>. Examiners also decide whether the material they have collected is relevant to the ongoing case and, if necessary, they may rewrite some of it.

At the reporting phase, the information gathered is compiled and transformed into evidence, which is subsequently delivered as a report. This article should include a detailed account of the research techniques followed as well as comprehensive details on the examined evidence, interpretation, and crediting. The two important considerations when writing the such report are: **(1.)** verifying the facts first; and **(2)** that the activities are ‘clear’, ‘simple’, and ‘repeatable’.

Along with this, ‘Route maps’ and ‘log visualizations’ must also be included in drone forensics documentation. Route charts are graphical depictions of GPS and flight data shown on ‘2D or 3D maps’ created using applications like ‘WebFlightPath’, ‘GPS Visualizer’, and ‘GeoPlayer’.

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<sup>9</sup> Da-Yu Kao et al., *Drone Forensic Investigation: DJI Spark Drone as A Case Study*, *Procedia Computer Science*, Vol. 159, 1890-1899 (2019)

<sup>10</sup> You, Il Sun, et al., ‘*Method for verifying drone included in industrial internet of things system, by using petri-net modeling*’ U.S. Patent No. 11,914,720. (2024), [US11914720B2 - Method for verifying drone included in industrial internet of things system, by using petri-net modeling - Google Patents](#)

<sup>11</sup> Andrew M. Lemieux, *Geotagged Photos: A Useful Tool for Criminological Research?* 4 *CRIME SCI.* 1 (2015).

## EFFICIENCY OF FORENSIC DRONES

GPS enables drones to self-localize and navigate; therefore, flight path data for off-site criminal scenes can be admissible in court. Their enhanced precision and rapidity of detection surpasses those of on-foot field teams, rendering them more effective when operating in areas exceeding '1,500 square meters'. Light Detection and Ranging (LiDAR) technology and drones that calculate distances with lasers and generate accurate maps could be utilized to reconstruct the crime scene in three dimensions ('3D').

Drone photogrammetry enables 'higher-resolution images' of the crime scene, which provide accurate topographical data and distance measurements between individuals, which are considered evidence. In order to record postmortem remains, the forensic pathology division makes use of portable scanners that incorporate digital cameras and stereophotogrammetry. In order to locate forensic evidence, one must be cognizant of time-sensitive hues and minute external interferences. Their integration with analysis of textures at a high resolution could potentially yield these tints.

### LITERATURE REVIEW

According to the present literature on Drones forensic, *Firstly*, this type of forensic science has become far more necessary at crime scenes in present time as it supplements important information about possible suspects due to its vast reach, however, drone surveillance provides a pattern analysis of who was where and when, without distinguishing between different zones<sup>12</sup>. It applies the "*Locard Exchange Principle*<sup>13</sup>," which says material is transmitted reciprocally when two items come into touch. Therefore, its difficult to filter out places, the ones that has to be surveyed and the others that need not be surveyed<sup>14</sup>. Moreover, challenges such as legal issues, ethical procurement and partnerships in a UAV industry, privacy issues, and community engagement needs to be addressed for it to become a viable source of information. Drone surveillance gives rise to a new information environment, new risks, new obligations and new informationist conceptions of peace and peacekeeping<sup>15</sup>. *Secondly*, drones, which have the ability

<sup>12</sup> Adam Smith, *Drones as Techno-Legal Assemblages*, 4 LAW, TECH. & HUM. 152 (2022).

<sup>13</sup> Claude Roux, et al., '*The End of the (Forensic Science) World as We Know It? The Example of Trace Evidence*, Philosophical Transactions: Biological Sciences, vol. 370(1674), 2 (2015), JSTOR, <http://www.jstor.org/stable/24505153>

<sup>14</sup> Jutta Weber, '*Keep Adding. On Kill Lists, Drone Warfare, and the Politics of Databases*,' Environment and Planning D: Society and Space 34, 1 107-125 (2016)

<sup>15</sup> Lisa Portmess & Bassam Romaya, '*Digital Peacekeepers, Drone Surveillance and Information Fusion: A Philosophical Analysis of New Peacekeeping*,' *Theoria: A Journal of Social and Political Theory*, vol. 62(145), 15-

to continuously monitor individuals at a close and personal level, are largely a subject of controversy due to concerns around 'privacy and civil rights' because although drones may seem to enhance flight safety, they are fundamentally aerial devices equipped with cameras and sensors. However, in US, the public's widespread acceptance of surveillance cameras in public areas seems to also apply to drones, as shown by the use of shop security camera footage by law enforcement to identify the perpetrator of the Boston Marathon bombing in 2013<sup>16</sup>. *Lastly*, three things come into play in digital forensic investigations: **(1.)** 'Standards', **(2.)** 'Program Accreditation,' and **(3.)** 'Practitioner Certification'<sup>17</sup>. A set standard is the main obstacle in forensic drones as there is no set regulation or act binding it<sup>18</sup>.

## CRITICAL ANALYSIS

### Viability/Reliability of the Data Collected From Drones

The most common problem, when it comes to forensic science is faulty convictions<sup>19</sup>, and therefore, to be administered as forensic evidence, the information collected from drones should be both, viable and reliable. A digital forensic study was carried<sup>20</sup> which revealed that there is no way to get information on the process of proving ownership of a drone in situations when the drone was abandoned without the controller. Since anybody may be the owner of such information and use it to shape the thoughts of law enforcement officials, it is a difficult scenario. When the owner is absent, what credibility will the evidence have?

When a picture is presented as evidence, the environment in which the image was taken and the degree to which it matches the original recording are both called into question. Typically, the individual who took the snapshot is the one who delivers testimony on the date, time, and place of the photograph. There is a possibility that the unmodified status of the image will also need the testimony of experts. On the other hand, the fact that digital images may be altered with relative simplicity has discouraged their usage in situations where a photograph is likely to be used as evidence. It is possible to decode a digital image that has been subjected to the auto-

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16 (2015), <http://www.jstor.org/stable/24719928>.

<sup>16</sup> Timothy M. Ravich, *Courts in the Drone Age*, 42 N. KY. L. REV. 164 (2015).

<sup>17</sup> P. R. Stephenson, *Digital Forensic Science: An Oxymoron*, 6 LEGAL ISSUES J. 95 (2018).

<sup>18</sup> H. Bouafif et. al., 'Drone forensics: Challenges and new insights,' In Proceedings of the 2018 9<sup>th</sup> IFIP International Conference on New Technologies, Mobility and Security (NTMS), Paris, France, 26–28 February 2018; IEEE:Piscataway, NJ, USA. 1–6. (2018)

<sup>19</sup> Jennifer Mnookin, *Excerpt from Transcript of Proceedings: Experts and Forensic Evidence*, 37 SW. U. L. REV. 1009 (2008); Brandon L. Garrett & Peter J. Neufeld, "Invalid forensic science testimony and wrongful convictions" Virginia Law Review 1-97, (2009)

<sup>20</sup> Graeme Horsman, Unmanned aerial vehicles: A preliminary analysis of forensic challenges, Digital Investigation, Vol. 16, 1-11 (2016)

notary encode procedure in order to demonstrate the context of the shot and provide evidence that it has not been changed. In addition, images that have been transformed via the process of derived from the original may be shown alongside the original photograph, which guarantees the authenticity of the photograph<sup>21</sup>.

Furthermore, in light of the fact that any drone is capable of being attacked, it is vital to carry out audits and forensic investigations of the devices' internal operations.

As per *Ram Singh v. Col. Ram Singh*,<sup>22</sup> the electronic evidence must be “preserved properly.” In accordance with some findings<sup>23</sup>, drones are susceptible to three distinct types of assaults: attacks on their integrity, attacks on their secrecy, and attacks on their ability to access information without authorization. Integrity attacks may be made feasible by modifying current data or creating new data on the drone storage, while confidentiality attacks include unauthorized access to information by compromising or intercepting data transferred between the drone and its controller. Additionally, confidentiality attacks can be carried out by compromising or intercepting data. This makes the information of drones unreliable.

### ISSUE OF PRIVACY

The issue at hand is not whether the heightened use of drones by law enforcement is infringing upon our right to privacy. From a commercial standpoint, the use of drones in the private industry is becoming widespread. The issue at hand is the misuse of law enforcement powers, wherein the government gathers video and images via drone surveillance under the pretence of a lawful objective, but then employs this data for malicious or unauthorized intentions.

The expansion of objectives and the portrayal of drones as aggressive robots in military operations further complicate the acceptance of unmanned and optionally-piloted aircraft technology by some politicians and public, who may see it differently from other machines that provide aural and visual proof<sup>24</sup>. Drones have ‘potential’ to improve legal process significantly by boosting the quality of evidence that may be submitted to a court. For instance, drones that capture footage of a damaged property will provide compelling evidence in any legal proceeding.

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<sup>21</sup> Cyber Forensics and Admissibility of Digital Evidence, (2012) PL January S-23

<sup>22</sup> *Ram Singh v. Col. Ram Singh*, AIR 1986 SC 3

<sup>23</sup> A.Y. Javaid et. al., ‘Cyber security threat analysis and modelling of an unmanned aerial vehicle system,’ In Proceedings of the 2012 IEEE Conference on Technologies for Homeland Security (HST), Waltham, MA, USA, 13–15 585–590 (2012).

<sup>24</sup> Timothy M. Ravich, *Courts in the Drone Age*, 42 N. KY. L. REV. 161 (2015).

Instead of completely prohibiting UAVs or requiring a probable cause warrant and/or involvement of national security or terrorism for any drone use, integrating dependable drone technology into current procedural and evidentiary regulations would support the goal of the fact-finder. Integrating drones into legal procedures is challenging due to the fact that conventional tort principles, such as trespass, might apply to UAV activities.<sup>25</sup>

The case of *Guille v. Swan*<sup>26</sup> was a significant legal precedent in New York City, involving a property owner who filed a lawsuit against an air balloonist for the act of trespassing. Subsequently, legislation specifically tailored to the aviation industry have been established, nevertheless, issues over privacy and the Fourth Amendment persist. The growing use of drones in criminal activities poses difficulties for forensic digital investigations, since there is a lack of set protocols or norms. Drones provide distinct challenges in terms of data acquisition and storage, requiring digital investigators to possess comprehensive expertise. Primary concerns include the gathering of data, retrieval of information, and validation of drone possession.

Though the law has not yet specified what reasonable privacy expectations, if any, attach to unmanned aircraft operations, cases of *Ciraolo*<sup>27</sup> and *Riley*<sup>28</sup> seem to permit UAV flights for analogous law enforcement reasons. References to the “naked eye,” made by Riley and Ciraolo, also pertain to manned aircraft and, almost by definition, do not apply to surveillance systems that operate outside of the operators’ line of sight. More recent decisions by the country’s highest court have also expanded Fourth Amendment protections to sense-enhancing technology, which may have a big effect on drone operations. The Supreme Court barred searches in the physical trespass case *Kyllo v. United States*<sup>29</sup> utilizing precisely the kind of technology that may be used on a drone, including radio transmitters, receivers, high-definition digital video cameras, navigation, and global location tracking systems.

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<sup>25</sup> K. Iqbal et. al., ‘Drone forensics: A case study of digital forensic investigations conducted on common drone models’, Int. J. Digit. Crime Forensics (IJDCF) 13, 1–25 (2021) (PDF) *Drone Forensics: An Innovative Approach to the Forensic Investigation of Drone Accidents Based on Digital Twin Technology*. Available from:

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<sup>26</sup> *Guille v. Swan*, 19 Johns. 381 (N.Y. Sup. Ct. 1822).

<sup>27</sup> *California v. Ciraolo*, 476 U.S. 207 (1986).

<sup>28</sup> *Florida v. Riley*, 488 U.S. 445, 448 (1989).

<sup>29</sup> *Kyllo v. United States*, 533 U.S. 27 (2001).

## **STANDARDIZED PROCEDURES FOR DATA COLLECTION FROM DRONES**

*Firstly*, in criminal investigations, judges are required to pay more attention to digital evidences. In order to enhance the minimum criteria for such evidence, one approach to do so is to take into consideration whether or not the software that generates it has been verified at some point in time<sup>30</sup>.

*Secondly*, DroneGun can cause drones to return to their place of origin, law enforcement can monitor drones in operational states using devices like DroneShield. Obtaining drone images, reassembling flight data to show flight routes, and connecting a drone to a suspicious C&C device should be the primary goals of this technical investigation with digital interference<sup>31</sup>.

*Thirdly*, Law enforcement officials can also ascertain that if the drone-shot images violate privacy or were taken in sensitive locations, they can be removed and recovered as per the need of evidence and the legal proceedings.<sup>32</sup> For instance, in 2014, the Singaporean government addressed the increasing issue of recreational drone usage, especially that which was capable of digital pictures and proposed giving police more authority to manage drones from “rogue” operators and provide them weapons to destroy them<sup>33</sup>

### **CONCLUSION**

The major issue in performing drone forensics is that obtaining clean picture files from aerial cameras and flight data from microcontrollers calls for certain protocols and permissions<sup>34</sup> that are often out of the purview of law enforcement. Extracting consistent data across several UAV models is made more challenging by the absence of standardized software, hardware, and firmware. Flight data is transient, as shown by the need on volatile memory, and encryption of flight data adds even another level of complication.

Another issue is that, drone forensics has ‘gaps’ in knowledge and approaches since most research

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<sup>30</sup> *Daubert v. Merrell Dow Pharmaceuticals Inc.*, 43 F 3d 1311 (9th Cir 1995)

<sup>31</sup> Matyszozyk, C. (2016, October 26). Judge rules man had right to shoot down drone over his house. Retrieved April 22, 2017, from CNET: 2017. <https://www.cnet.com/news/judge-rules-man-had-right-to-shutdown-drone-over-his-house4>

<sup>32</sup> Al-Room Khalifa et. al, ‘*Drone Forensics : A Case Study of Digital Forensic Investigations Conducted on Common Drone Models*’, International Journal of Digital Crime and Forensics, 13(1), (2021).

<sup>33</sup> *The Regulatory Framework for Aerial Imaging by Recreational Users of “Drones” in Singapore*, (2017) 29 SAclJ 126

<sup>34</sup> Evangelos Mantas & Constantinos Patsakis, ‘*Who watches the new watchmen? The challenges for drone digital forensics investigations*,’ Array, Vol. 14 (2022), 100135, ISSN 2590-0056,

focuses on commercial drones with proprietary software<sup>35</sup>. Overcoming these obstacles will necessitate creative ideas along with ‘multidisciplinary’ teamwork. Moreover, Special user permission via the wireless controller is often necessary to access flight data via onboard aircraft microcontrollers; security agencies and forensic investigators are unlikely to have this access of these. The absence of a remote controller further complicates forensic investigation, since most flight data obtained from the flight microchip is encrypted.

Furthermore, UAVs mostly depend on volatile memory, hence if the battery dies, the flight data stored there will be lost. A substitute like a backup memory is needed to overcome this issue and to make drones more reliable as evidences for forensics.

Precisely, the wide variety of digital components and the lack of technical know-how found in UAVs makes digital forensics quite difficult to perform and development in the field is needed, understanding the demand of today’s “technologically advanced” time.

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<sup>35</sup> *Supra* note 1

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