Article

The Use of Unmanned Aerial Vehicles (UAV/Drone) in Scene Investigations

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Abstract:The investigation of a crime scene is an interrelated system of procedural actions aimed at the detection, fixation, seizure, and examination of traces of an offense. This investigation may ultimately lead to the prosecution of offenders. As new digital technology emerges, law enforcement and emergency responders must carefully deliberate the introduction of new equipment and software to ensure scientific integrity and legal admissibility of the technology. The usability of drones has increased dramatically over the past two decades, making them an effective tool in various areas of public activity and leading to a significant number of scientific developments. Such technologies have become an everyday and integral part of society due to rapid technological development, computerization, mobility, safety, ease, reliability, affordability and economic benefits. Despite these attractive benefits, drones are characterized by operational limitations due to several critical issues in terms of autonomy of flight, trajectory planning, battery life, flight time, and payload capacity. Thus, the main purpose of this study is to provide practical recommendations for the use of unmanned aerial vehicles (drones) in the investigation of offenses. The provisions and practical recommendations presented in this article are relevant in the context of the use of modern technology for inspecting crime scenes.

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Introduction

The investigation and prosecution of criminal activities often rely on complex networks of highly trained specialists and technology. Ideally, these networks of people and technology facilitate investigative activities and maximize impartiality during trials [1]. Unmanned aerial vehicles (UAVs), with a wide range of capabilities and features, have become available in recent years. UAVs are aircraft without a human pilot on board and are components of unmanned aerial systems (UAS). The UAS includes an aircraft, a ground controller, and a communications system between them. UAV flight can be carried out with varying degrees of autonomy, either under the remote control of a human operator or autonomously by onboard computers [2].

Most scientific and practical research has focused on unmanned remotely piloted aircraft (RPAs) (i.e., multi-copters) because of their simplicity in the control mechanism and high positioning accuracy. Since the year 2000, aviation has experienced a rapid expansion of this type of aircraft, commonly referred to as "drones". UAV refers to the aircraft itself, which is controlled by one or more pilots via communication channels. UAV crews may include a commander, a sensor operator, and a firing equipment operator. UAV crews change during long-term missions, generally every 4 hours. The number of the other types of UAVs (e.g., unmanned unguided or unmanned automatic), is relatively small [3,4]. UAVs can capture real-time video and images and transfer them to a remote server for storage and later use. All files, including video and image files, drone flight coordinates, and other pertinent data, are typically stored on a flash memory installed in the drone and at the drone operator (in the controller with their dedicated interfaces) [5].

Given that UAVs are small-guided aircraft that can be operated remotely, their use was previously limited to military targets and those who maintained an enthusiasm for aircraft. In recent years, however, the public use of drones has greatly expanded from the military to the private sector, industry, and society at large. The increased popularity has been facilitated by the fact that UAVs are now more reasonably priced.

UAVs have also been studied for police force applications (e.g., patrol and police surveillance, search and rescue operations, and poaching detection) [6]. The use of UAVs by law enforcement is anticipated to increase as law enforcement agencies become more familiar with the technology and explore the use of UAVs for both criminal investigations and police

safety. For instance, UAV's can be deployed to assist in navigation, secure communications, and reconnaissance. Drones can also be a cost-effective alternative to helicopters when searching for people in difficult environments without putting their crews at risk.

There are ongoing efforts to expedite the investigation of crime scenes, often through the development of technology to aid in the documentation and recovery of forensic evidence. UAVs are useful for locating and documenting crime scenes because they can quickly cover large distances, access locations under difficult conditions (e.g., poor weather), or survey locations with limited access. Improved crime scene surveying permits better informed operational decisions and resource management. Additionally, UAV's may reduce the material costs and time needed to inspect objects and take samples for analysis.

UAV Application Areas

Crime Scene Inspection

One of the requirements for conducting an inspection of a crime scene is to document the entire area, often including aerial views. Crime scene documentation is typically achieved with a mix of photography and crime scene sketches and diagrams. Scene diagrams are frequently created by manually measuring the location of traces and physical evidence with a tape measure or a laser rangefinder. Unfortunately, this process can be time-consuming and does not always yield the best results. For instance, some locations require a bird's-eye view to provide context and clarity of the entire crime scene. Crime scene documentation must be completed accurately and sometimes in the shortest time possible to reduce the time spent in the scene.

A wide range of UAVs [6] have the appropriate capabilities to aid in the documentation of a crime scene. UAVs can capture video and images in real time and transfer them to a remote server for storage and review by investigators. UAV-assisted forensic mapping can increase the accuracy of the data collected and provide demonstrative evidence in a more professional manner. The compactness, mobility, and high resolution of the real-time video image allows investigators to efficiently explore large areas, locating evidence quickly and shifting resources as needed.

In addition to facilitating mapping and expediting exploration of a crime scene, UAVs can minimize introduction of

foreign traces (contamination) of the scene itself by permitting virtual inspection of the scene prior to the arrival of ground personnel and equipment. Installation of various sensors and devices on the UAV, including thermal (infrared) video cameras, permit documentation of evidence that cannot be readily seen with visible light under normal conditions. For instance, terrain investigation using thermal video cameras can make it easier for investigators and forensic specialists to find certain items at the scene or people in a large area or in an inaccessible area, regardless of visibility conditions and time of day.

Integrating drones into forensic mapping helps collect data more efficiently and safely, reducing costs and saving time. Presenting three-dimensional (3D) images in the courtroom during the trial could allow for a more accurate picture of the scene itself and a visual presentation of the physical evidence recorded at the scene. These steps will be able to bring forensics to a new technological level [7].

It is worth noting, however, that traditional mapping cameras are very complex and expensive. Additionally, these cameras are bulky and heavy, making them difficult to integrate into standard drone platforms. The two most limiting factors for any type of UAV sensor equipment are maximum takeoff weight (MTOW) and size. Therefore, large-format mapping cameras are generally not deployed on UAVs. Given crime scenes are typically limited in terms of mapping area size, compact cameras with smaller image formats are often adequate. If the UAV has a MTOW of about 25 kg, a 150 MPix camera is currently the best that can be integrated into the platform. For a standard UAV (takeoff weight <5 kg), image formats currently range from 20 to 60 MPix. In addition, since the UAV operates closer to the ground and aims at a Ground Survey Distance (GSD) of only a few centimeters, cameras placed on fixed-wing aircraft must have a fast shutter to avoid motion blur due to lack of forward vision (motion compensation). In contrast to such standard cameras, special drone mapping systems which combine large formats and good quality with high compactness and less weight are also on the market [8].

Identification and Fixation of Forensic Evidence

The main task of a detailed inspection of a crime scene is to locate, document, and collect evidence that may be relevant to the event under investigation using the entire arsenal of technical and forensic means, methods, and techniques [9]. For

example, a shoe print or tire track found at the scene of a criminal offense could be be photographed and sent directly to the forensic laboratory using a drone. Also, UAVs could be useful when it is difficult to obtain forensic evidence for practical reasons. For instance, high-quality digital photographs from a crash scene could be quickly captured while the vehicles and debris are still at the scene. The rapid documentation could permit quick assessment of the accident scene and release of the scene and reducing the period of road closures, avoiding traffic congestion [10].

Forensic Anthropology

One promising area of drone use could be forensic anthropology. Currently, the use of drones to search for human remains is still in the early stages of development. The U.S. Department of Justice has awarded a grant to the Forensic Anthropology Center at Texas State University (FACTS) to study the possibility of using modified drones as tools for detecting and identifying human remains. The goal of the project is to create standardized procedures for using drones to search for human remains so that police units have a quick and relatively easy-to-use solution in such situations [11]. Using laser scanners mounted on UAVs, it is possible to effectively record the scene and combine the data to create a complete picture of the scene in three dimensions (3D), which can be used and analyzed at any time. In investigative practice, sensors that can be attached to drones to search for human remains can include (but are not limited to):

- Near-Infrared (NIR) imaging. Insect and microbial activities on a decomposing body cause the release of nutrients. As these nutrients mix with the surrounding soil, a cadaver decomposition "island" (CDI) forms under the body. Preliminary research findings indicate that CDIs are detectable in the NIR spectrum and that drones equipped with NIR sensors can help find human remains by searching for the spectral signature of the CDI [12].
- Infrared imaging. Decomposing bodies also release a significant amount of nitrogen into the surrounding soil. This nitrogen is absorbed by the nearby vegetation. Plants that have absorbed the excess nitrogen reflect infrared light differently than those plants exposed to the normal soil levels (away from the body). Such changes allow a drone equipped with an infrared sensor to locate the human body [13].
- Hyperspectral/multispectral imaging. Database have been created that store spectral data for materials related to human activity, including things like clothing and skin tones. The

spectral data collected by a drone can be cross-referenced to a database to locate missing persons or human remains [13].

In general, UAV surveys also help identify recent disturbances and ground shifts and even identify some burials. This will be very useful in cases such as the discovery of mass graves. Aerial photography allows the researcher to look at the scene from a different perspective and is often more useful than conventional ground surveys [10].

Fire Investigation

UAVs can be used to detect and track fires in open areas in real-time, permitting the allocation of resources to contain the fire and prevent structural damage. Drones can be used to provide aerial documentation of damage to vegetation, buildings, and infrastructure. Fire investigation (origin and cause investigation) and debris field analysis can also be facilitated by the use of drones, especially if the relevant areas are impossible to reach from the ground [14].

Monitoring of Road Traffic

There is some interest in integrating UAVs with traffic monitoring systems (TMS), which can provide complete automation of the transport industry [15]. UAVs have become a new tool for collecting traffic data. Compared to traditional monitoring systems (surveillance cameras, ultrasonic sensors, and analyzers), low-cost UAVs can check large sections of road [16]. Patrol police can use drones to obtain a clear picture of traffic accidents or to perform large-scale road safety activities. Examples include:

- countering illegal actions on the roads, including car thefts
- recognizing vehicles
- pursuing hijackers and armed criminals
- minimizing traffic jams

Similarly, UAVs can also be used to prevent accidents and vehicle damage by monitoring road (pavement) conditions. For instance, drones can be deployed to assess roadways for cracks, breaks, and potholes. Currently, road inspections and monitoring are performed on the ground using vehicles and would benefit from increased automation. Combining road inspection technology with UAVs could speedup repair. Such aircraft can photograph road cracks and use target detection algorithms to determine their appearance and potential for causing damage.

Ecological Safety of the Forest

Existing technologies such as GPS and image sensors help UAVs perform specific tasks such as detailed inspections and site monitoring. UAVs can assess any changes in temperature and ecological composition, thus helping in the investigation of illegal logging or illegal transportation, storage, and sale of timber [17]. High-resolution cameras mounted on UAVs can provide useful data on the extent of logging areas, the presence of hidden sawmills, silvicultural facilities, and transport vehicles. Because of the ease of data collection and mobility of UAVs, the appropriate optical equipment can help characterize and study forest landscapes. For instance, the appropriate optical sensors on UAVs can obtain geometric properties of the forest, such as vegetation cover, diameter, and length of the trees [18]. UAVs can also be used for remote sensing, which is a reliable and effective way to observe forests, different from the way it has been done in the past.

Misuse of Civilian Drones

While UAV technology can provide significant benefits to the investigation of crimes, drones can also become a tool of a criminal. Given the main use of drones is to shoot videos, the most common criminal offense is the illegal recording of videos with unauthorized content (e.g., using drones to spy on neighbors or breaking into protected areas) [19]. Therefore, investigators must understand the UAV technology in order to collect, verify, evaluate, and analyze evidence. The primary evidence collected will be images or videos taken by the drone. If the controller did not capture the footage but rather viewed the content in real-time, investigators can analyze the flight logs and verify if the drone was flying around a specific area. Since the flight logs contain flight maps, the dispatcher cannot deny that the drone flew in a certain area [2].

Discussion

UAVs are a promising tool for the investigation of crime scenes. Incorporating their use in forensic investigations and the practical activities of police and fire units on a permanent basis should be considered by law enforcement agencies and fire departments. In financial terms, a civilian UAV is not very expensive. The basic UAV model currently costs approximately $1,000- $2,000 dollars (e.g., Mavic 2 Pro & Mavic 2 Zoom). A more sophisticated device, however, would cost approximately

$4,000 to $7,000 (e.g., DJI Mavic 3 Thermal). The equipment itself is not a great financial burden for an agency performing the crime scene inspection and other investigative (search) activities. While the technical details and features of a particular model or device are readily available online and can be assessed for fit-for-purpose before it is purchased, the image quality is one of the most important aspects to consider.

In addition to purchasing the equipment, operators will need to be trained. Training would include both the functionality of the equipment and laws regarding the use of drones. Operators may be required to obtain pilot certification depending on country of use. Without proper standards for both the equipment and operators, the effectiveness of the application in a crime investigation could be compromised.

Conclusions

As technology continues to progress, new tools emerge that can be exploited to support public works, law enforcement, and emergency services. Given the public funding associated with each, finding cost effective methods to support their missions is always at the forefront of budget deliberations. Unmanned aerial vehicles offer a new frontier, particularly in criminal investigations.

The integration of drones into police departments and forensic units has the potential to advance the technical and practical capabilities of these fields to a new level. A crime scene can be viewed real-time by investigators and forensic scientists to document forensic evidence and direct ground personnel to important locations within the scene to preserve evidence. The captured drone data, video, and crime scene images serve as a permanent record of the scene that can be analyzed by specialists for additional forensic information, provide a detailed map of a territory or scene, and can be used as demonstrative evidence during trials. UAVs can provide critical access to hard-to-reach areas, especially in war zones, and obtain evidence or samples from these otherwise inaccessible regions.

The real time, high resolution video images provided by the compact and mobile UAV facilitate the search and analysis of large territories in a short period while minimizing the "pollution" of the scene with foreign traces. Installation of various sensors and devices, including thermal (infrared) video cameras on UAVs will allow operators and investigators to monitor activ-

ities with the help of thermal radiation reflected by objects or people, regardless of visibility conditions and time of day.

Ultimately, the implementation of unmanned aerial vehicles should be evaluated on an institutional basis. The evaluation of the technology should include the projected application of the technology, the desired features and cost, legal considerations, and training of the operators.

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