Our Heritage

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Drone Forensics

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ABSTRACT

Powerful information acquisition and processing capabilities, coupled with intelligent surveillance and reconnaissance features, have contributed to increased popularity of Unmanned Aerial Vehicles (UAVs), also known as drones. In addition to the numerous beneficial uses, UAVs have been misused to launch illegal and sometimes criminal activities that pose direct threats to individuals, organizations, public safety and national security. Despite its increased importance, "drone forensics" remains a relatively unexplored research topic. There are regular news stories, both positive and negative, about the use of drones, and the opportunities, risks and threats they can pose to leading industries as well as the general public. Changes in public perception, increases in manufacturers and available models, falling commoditized pricing and rapidly advancing technology have all served to put drone devices in possession of many people around the globe. Use the drone as a menace to disrupt daily life such as flying a drone above or near an airport. As UAV technology continues to develop and prices continue to diminish, adoption will increase and present new challenges for first responders, through to digital investigation subject matter experts, across the law enforcement community. This paper presents new insights into drone forensics in terms of accessing the digital containers of an intercepted drone and retrieving all the information that can help digital forensic investigators.

KEYWORDS: Drone Forensics, Forensic Investigation, UAV, Smart Devices.

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1. INTRODUCTION

Drones in this modern world are very popular; from recreational use by children, through to adoption by experienced criminals for the distribution of illegal items. Whether you are interested in using the technology or not, it is impossible to escape the continual presence of drones in our everyday lives - either as a recreational pastime in the park, in mainstream media, footage on social media platforms, or television and in films. There are regular news stories, both positive and negative, about the use of drones, and the opportunities, risks and threats they can pose to leading industries as well as the general public. Changes in public perception, increases in manufacturers and available models, falling commoditized pricing and rapidly advancing technology have all served to put drone devices in possession of many people around the globe. Whilst commonly and regularly referred to by the public and mainstream media as 'drones', many law enforcement agencies around the globe use differing terms – i.e. unmanned aerial vehicle (UAV), unmanned aerial system (UAS), small unmanned aerial system (sUAS) and remotely piloted aircraft system (RPAS). This paper will use the terms drone and UAV interchangeably. Drones come in many shapes and sizes and can be used for a variety of operations, ranging from aerial photography and videos to transporting goods from one place to another. Drones have been increasing in availability and used by the public over the last few years. This, in turn, has led to utilization by criminals to aid in illicit acts such as the invasion of privacy, drug smuggling, terrorist operations, and the disruption of critical infrastructure. Common examples include Transport contraband into prohibited areas such as prisons. Fly in restricted areas to take photographs or videos for personal use or to gather intelligence. Drones are used as a menace to disrupt daily life such as flying a drone above or near an airport. As UAV technology continues to develop and prices continue to diminish, adoption will increase and present new challenges for first responders, through to digital investigation subject matter experts, across the law enforcement community.

2. CATEGORIES OF UAVS

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UAVs can be effectively summarized into three categories:

a) Recreational UAVs: Recreational UAVs are designed for use by amateur enthusiasts, hobbyists and children, and tend to be low in price. Recreational UAVs start at the lower end of the specification spectrum and can be purchased for less than Rs 1500. They are generally intended to be used outdoors and possess a very limited battery life. UAVs are often classified as recreational when weighing less than 250 grams. There are now thousands of recreational UAVs available in the marketplace from a range of technology stockiest and toy stores, as well as endless online shops.

b) Commercial UAVs: Commercial UAVs are designed to be used in commercial practices. These UAV devices usually carry a payload depicting their usage purposes - such as a camera, used for professional photography, industrial inspection, or land survey. Like their recreational counterparts, commercial UAVs are not governed by device capability but by the intention of the user, thus even the cheapest device could be classified as commercial if an operator was to deploy the UAV with a commercial intention.

c) Bespoke UAVs: Bespoke UAVs are engineered by the owner using parts that are purchased individually and then put together, rather than purchased as a complete off-the-shelf system. Whilst recreational and commercial UAVs offer great functionality in an 'off-the-shelf' combination of UAV and controlling software, the market for bespoke UAVs has expanded at a rapid rate in recent years as a wider selection of parts have become available and commoditized, driving down costs. Bespoke UAVs enable a user or trader to purchase disparate parts of a UAV from different sources, and then build and configure the device according to their requirements or available budget. These systems are only limited in capability by the capacity of available components and the knowledge and skill of the people building them, which are both increasing exponentially.

3. UAV COMPONENTS

Any UAV will consist of the following two types of components:

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a) Physical Components: The physical components of any UAV which make up the body and flight mechanisms can be broken down into the following categories:

- **Drone Body:** The core fuselage of the UAV used to house all other components.
- **Flight Controller:** Used to control flight. This device will stabilize the UAV and generally accept navigation input from a radio control device. In more sophisticated systems the flight controller can both be controlled remotely in real-time and be pre-programmed for autonomous flight.
- **Motors, Rotors/Propellers/Wings, and Speed Controllers:** These parts combined provide the lift and propulsion for the UAV. Different designs exist, for example, specializing in increased speed or flight duration.
- **Protective Casing:** This protection securely encases the motors and propellers (the most vulnerable component of any UAV) to prevent collision and loss of control and subsequent damage to the system.
- **GPS Receiver:** Not essential in all UAVs, but common in the leading solutions. This component is used to effectively manage UAV position, return to home functionally, and autonomous flight routes.
- **Radio Receiver (RX):** Used to receive control input signals received from the ground-based transmitter.
- **Transmitter (TX):** Transmits manual input from the operator on the ground to the UAV.
- **LED Lights:** Some UAVs come equipped with LED lights (usually green and red) which can be used to aid the pilot of the orientation of the drone, and help other airspace users to identify the drone.

b) Software components: All UAVs include an application or software that is used to control the system when it is operational. While each recreational or commercially intended UAV will tend to come with its own configured software or control solution, for bespoke UAVs the responsibility is on the person constructing the device to build or integrate a component which

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works effectively. In support of this model, there are now much open-source flight control and ground control applications available online that can be freely downloaded and easily modified to perform any number of tasks. No matter which system is used or how the software components are configured, UAV software solutions can be classified into two core categories:

- **Flight Management Software:** This software is uploaded to the flight controller within the UAV at one end, and also within the remote control of the user at the other end. When operational, it is used to control the UAV during takeoff, flight, and landing. Typical functions which are controlled by the flight management software solution include UAV flight, device stabilization, and manual navigation input.
- **Ground Control Software:** This software is used to control pre-determined navigation and effectively plan flight schedules, and is best used by a pilot when the UAV is grounded in planning and preparation for flight. Ground control software additionally facilitates enhanced live monitoring to remote users other than the pilot when the UAV is in flight - either directly to their computers or smart devices such as tablets or mobile phones. Whilst offering significant innovation and supporting technical development of skills, consideration should be given to the fact that bespoke UAVs may potentially propose increased risks and more dangerous use, as they are likely to be configured with convenience and cost, rather than safety, in mind. This may result in them lacking core safety features and functionality that are built into many of the leading commercials off the shelf (COTS) systems, such as restricted area control, obstacle avoidance, and fail-safe management. These features lessen the risk to persons and property in the event of a pilot error or a system failure. Whilst some of these proposed categorizations of UAVs can become blurred, for example – in cases where wealthy recreational users purchase higher-end UAVs that are intended for commercial purposes, this categorization approach is recommended when defining UAVs and considering their respective capabilities.

4. DRONE PAYLOADS

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There are many payloads available at different price points that can be carried by commercial UAVs. These typically fall into one of the following categories.

a) Camera and Video Payloads: Whilst most UAVs are designed to carry some sort of camera, commercial UAVs will carry far more sophisticated imaging devices with enhanced features that could include: first-person view (FPV), 4K video, optical zoom for commercial inspection applications, and GPS tagging for 3D mapping. More sophisticated camera systems may have camera gimbals which hold the camera in a level and stabilised position, eliminating any flight movement to produce a superior stabilized image and video output.

b) Thermal, Infrared (IR), and Forward-looking Infrared (FLIR) Payloads: Traditionally reserved for higher-end systems, thermal imaging can be employed in a variety of user cases, including agricultural surveying, health and safety, law enforcement, and digital search and rescue applications. Infrared payloads can be particularly useful for the effective operation of UAVs during dark or night time flying conditions. FLIR uses a thermographic camera that senses the slightest of variances in infrared radiation. FLIR can see different frequency ranges, and hence can detect chemical compounds using light detection and ranging (LiDAR) to capture the exact location and distance between objects.

c) Delivery Payloads: The use of UAVs to provide timely and efficient deliveries has become an ever-increasing area of investment in recent years. While commercial and retail deliveries provide one opportunity for mainstream adoption, radio deployment and delivery technology could also significantly enhance other sectors, such as healthcare, with UAVs able to transport time-critical services including defibrillators on demand. However, the use of UAVs for delivery also offers opportunities to criminals, providing them with innovative solutions for transporting drugs, weapons, and other items. This tactic has been encountered in prisons internationally.

d) Weapon Payloads: UAVs possess the ability to transport weapons for distribution, or to conduct attacks using the UAV itself. This is now seen regularly in military user cases where devices are chosen as the attack method due to the increased precision and reduced risk of loss of life posed in comparison to traditional human-led combat methods. To equate the risk in an operational user case, a medium specification UAV can carry a payload of 3kg for 16 minutes at

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16 meters/second. This could equate to an autonomous vehicle that can effectively carry and deploy 3kg of explosives to a range of 16 kilometres.

e) Communications Payloads: Communications payloads are not yet commonly used, but may become more common with the introduction of 5G networks. UAVs can carry communications payloads that might be used to monitor, interrupt or mimic legitimate private wireless communications – for example, through spoofing cell towers or wireless access points.

5. UNDERSTANDING DRONES & OTHER ASSOCIATED EVIDENCE SOURCES

Drones, unlike many other electronic devices, require supporting devices for appropriate operational capability. These associated devices could include the following components:

a) Remote Controller: These are used to control the drone remotely.

b) Mobile/Tablet Device: These devices are used to view the camera/video feed from the drone. Drone Remote Controllers with Phones/Tablets Attached

c) First Person View (FPV) Goggles: FPV goggles are used to view the camera/video feed of the drone, and may also control the drone by head movements or associated controls. First Person View (FPV) Goggles

d) Memory Cards: Removable media may be utilized to hold pictures and videos taken using the drone. They may also contain flight path data, as well as geotagging of photographs by using exchangeable image file (EXIF) data within the photographs.

e) Cloud Storage: The drone may utilize the associated mobile handset to store photographs or video in cloud storage services such as iCloud or Google Photos.

f) Wet Evidence: Like any other piece of physical evidence, a drone and its associated devices may hold wet evidence such as fingerprints, DNA etc. Figure 10: Fingerprint

6. DRONE DATA

Like all other digital solutions and devices, the use of a UAV will inevitably result in a digital footprint with the creation and storage of data - whether intended by the user as part of the core service capability or as a by-product of the use of the UAV, such as historical usage logs.

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Types of Data There are various types of data which assist the investigation of drone incidents. These include:

a) Audio-Visual Content: In most cases, the primary and largest source of data stored by either recreational or commercial UAVs will consist of digital imagery or video footage. Most operators now strive to record the highest quality of footage possible to give them a unique selling point and business advantage over their competitors, which can result in significant volumes of data and required storage capacity, even in short bursts of filming or capturing imagery.

b) Flight Schedules: Where the UAV control system offers the capability to plan advanced flight schedules and offers a degree of autonomy to the user, this data is regularly retained and can be revisited by the user to review previous activity, repeat an existing flight schedule, or amend previous flight schedules. Often, data that is captured during flight and retrospectively downloaded into a control system or flight schedule review platform will also be intentionally retained by the user for an audit and review of usage overlaid with mapping, so users can track the UAV‘s activity and progress. Data and information that need to be extracted from a drone/remote controller depend on the type of case.

- Pictures and Videos
- Drone flight logs
    - GPS position
    - Time and date
    - Data parameters (i.e. rotor speed, altitude, and direction)
    - Drone telematics
    - Diagnostic error codes
    - Associated media logs
- Applications/Software
- User Activity
    - Drone power on and shutdown times
    - Drone settings

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- Device usage
- User logins/accounts
- Wi-Fi/device connections
- Telematic Logs

- Unallocated
- Cloud and Remote Storage

7. CONCLUSION

UAVs will play increasingly important role in future digital (forensic) investigations, as such devices become more sophisticated and their usage becomes more common in our society. Thus, use of UAVs could greatly enhance the efficacy of crime scene investigation. It also helps to gain access to inaccessible area and also to retrieve evidence/samples from such areas. UAV could serve as a bridge between the investigators in the lab and the crime scene.

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