

Drones in Surveillance

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Abstract:

A drone is an aerial vehicle designed to be used without a human pilot onboard. Drones are being used in a wide variety of applications, from surveilling perimeters to conducting 24/7 surveillance of huge sectors. Drone surveillance is the use of unmanned aerial vehicles (UAVs) to capture still images and video at a high altitude to gather information about specific targets. Surveillance drones have emerged as powerful tools in the realm of aerial monitoring. They have ushered in a new era for private investigators, expanding their capabilities in surveillance investigations beyond traditional means. The integration of drone technology into various sectors has paved the way for innovative solutions to age-old challenges. This paper highlights the applications, benefits, and challenges of drones in surveillance.

Keywords: drones, unmanned aircrafts, unmanned aerial vehicles (UAVs), surveillance, surveillance drones.

INTRODUCTION

Surveillance is the close observation of a person, group of people, activities, infrastructure, building, etc. for the purpose of managing, influencing, directing, or protecting. There are several different methods of surveillance. Methods include GPS tracking, camera observation, and stake-outs. Traditional observational surveillance methods are typically limited by the stationary nature of the camera, which is usually handled manually or fixed upon a structure. Drones provide the ideal solution to the problems and limitations faced by other surveillance methods. Drone surveillance

presents an easier, faster, and cheaper method of data collection. It provides imagery that the human eye is unable to detect.

WHAT IS A DRONE?

The FAA defines drones, also known as unmanned aerial vehicles (UAVs), as any aircraft system without a flight crew onboard. Drones include flying, floating, and other devices, including unmanned aerial vehicles (UAVs), that can fly independently along set routes using an onboard computer or follow commands transmitted remotely by a pilot on the ground. A typical drone is shown in Figure 1 [1]. A drone is usually controlled remotely by a human pilot on the ground, as typically shown in Figure 2 [2]. Drones can range in size from large military drones to smaller drones. Drones, previously used for military purposes, have started to be used for civilian purposes since the 2000s. Since then, drones have continued to be used in intelligence, aerial surveillance, search and rescue, reconnaissance, and offensive missions as part of the military Internet of things (IoT). Today, drones are used for different purposes such as aerial photography, surveillance, agriculture, entertainment, healthcare, transportation, law enforcement, etc.

Commercial drones have come a long way in the last decade. Drones work much like other modes of air transportation, such as helicopters and airplanes. When the engine is turned on, it starts up, and the propellers rotate to enable flight. The motors spin the propellers and the propellers push against the air molecules downward, which pulls the drone upwards. Once the drone is flying, it is able to move forward, back, left, and right by spinning each of the propellers at a different speed. Then, the pilot uses the remote control to direct its flight from the ground [3].

Drone laws exist to ensure a high level of safety in the skies, especially near sensitive areas like airports. They also aim to address privacy concerns that arise when camera drones fly in residential areas. These include the requirement to keep your drone within sight at all times when airborne. In the United States, drones weighing less than 250g are exempt from registration with civil aviation authorities. If your drone exceeds 250g in weight, you will also require a Flyer ID, which requires passing a test [5]. It is necessary to register as an operator, be trained as a pilot, and have civil liability insurance, in addition to complying with various flight regulations, and those of the places where their use is permitted.

Most drones have a limited payload, usually under 11 pounds. Drones are classified according to their size. Here are the different drone types:

- Nano Drone: 80-100 mm
- Micro Drone: 100-150 mm
- Small Drone: 150-250 mm
- Medium Drone: 250-400 mm
- Large Drone: 400+ mm

One of the emerging trends in drone use for factories is the utilization of LiDAR technology. LiDAR stands for Light Detection and Ranging. This technology provides accurate depth information essential for understanding the three-dimensional structure of the environment. LiDAR sensors emit laser beams to measure distances to objects, creating high-resolution 3D maps of the surrounding terrain and objects. The ability to capture detailed data through LiDAR technology has opened up opportunities for better predictive maintenance, reduction in inspection times, and overall cost savings [5].

SURVEILLANCE DRONES

Traditional aerial surveillance with a helicopter achieves the desired result but is also very costly. A surveillance drone is an unmanned aerial vehicle (UAV) equipped with cameras, sensors, and other monitoring devices to gather visual and/or audio information from the environment below. Surveillance drones can be equipped with sophisticated imaging technology that provides the ability to obtain detailed photographs of terrain, people, homes, and even small objects. They can be equipped with different monitoring tools, including high-resolution cameras, thermal sensors, GPS, and sensors to detect motion. They can be remote controlled or fully automated. They keep an eye on operations, individuals, and valued assets from above. Some of these drones are displayed in Figure 3 [6]. Figure 4 shows how a surveillance drone works [7].

Unlike some nocturnal animals, such as owls and cats, which see well in the dark, humans need light to distinguish their surroundings, making it almost impossible to discern anything in the dark or at night. Some night surveillance drones have great features or specs to capture nighttime video perfectly. Surveillance drones designed for night operations come with a set of specifications that enable them to function effectively in low-light and challenging conditions. Night vision cameras can be equipped with drones for filming and recording at night. A surveillance drone designed for night operations is typically shown in Figure 5 [8]. The primary use of night vision drones is photography. This might include wedding photography, where weddings or receptions and celebrations continue long after dark.

Surveillance drones are of great use in today's life. These drones have rapidly become indispensable tools in a wide range of applications. Their versatility, maneuverability, and ability to capture high-quality imagery from above have opened the door to numerous possibilities across various sectors.

APPLICATIONS

Recently, surveillance drone technology has been used in different fields, such as military, agriculture, law enforcement, border patrol, etc. Common applications of surveillance drones include the following [9]:

- *Surveying:* Surveillance drones capture high-quality aerial images which provide valuable information about the topography, land features, and vegetation cover. Moreover, drones can cover large areas quickly and efficiently. Thus, they enable rapid data collection compared to ground-based surveys.
- *Agriculture:* Surveillance drones have potential benefits in the agriculture sector. They can assist farmers by providing them with accurate and timely data about soil variability, moisture levels, and nutrient distribution. For example, drones equipped with high-resolution cameras can capture detailed imagery of crop fields. This imagery can be used to monitor crop health, identify areas of stress or disease, and assess overall crop condition.
- *Emergency Response:* In the aftermath of a natural disaster or conflict, drones can be used to provide vital aid and support. Drones can be deployed quickly to assess the situation in emergency scenarios such as natural disasters, accidents, or hazardous incidents. They can be launched within minutes and provide immediate aerial reconnaissance to emergency responders on the ground. Drones can capture high-resolution aerial imagery of disaster-affected areas.
- *Mining:* Drones equipped with specialized sensors, such as LiDAR and multispectral cameras, can conduct aerial surveys of prospective mining sites. Drones play a crucial role in environmental monitoring and compliance for mining operations. They can assess vegetation cover, monitor water quality, and detect changes in land use to ensure compliance with environmental regulations.

- *Aviation:* Drones can be used for perimeter security patrols around airports and aviation facilities. They can monitor fences, gates, and other access points, providing real-time surveillance to detect intruders or suspicious activity and enhance overall security measures. Drones equipped with high-resolution cameras and sensors can conduct inspections of airport runways, taxiways, and other infrastructure.
- *Law Enforcement:* Security drones equipped with live video cameras, infrared cameras, thermal sensors, and LiDAR are used in large quantity by law enforcement agents. Drones can serve to augment human guards by patrolling the worksites and capturing aerial footage of the assets, securing perimeters and preventing break-ins. They can be used for crime scene investigations, monitoring crowds, and border security. Law enforcement must obtain special permission to use drones for surveillance. Privacy law has not kept up with the rapid pace of drone technology, and police may believe they can use drones to spy on citizens with no warrant or legal process whatsoever. There are no systems currently available to law enforcement that can conduct fully autonomous operations. To counter the threat of surveillance, privacy advocates have focused solely on requiring warrants before the use of drones by law enforcement. A police drone is shown in Figure 6 [2].
- *Military:* Military surveillance drones serve a dual purpose. They can provide real-time intelligence on enemy movements and geographic information, which is critical in border surveillance and conflict zones. They also excel in the identification and tracking of potential threats, aiding precision strikes and reducing unintended harm. These capabilities enhance military strategies and safety in the field.
- *Security:* The use of drones in the security industry has been widely debated over the past years. Drones can provide a lot of possibilities as a physical security technology tool. Drones can be used for indoor surveillance in large facilities like warehouses and shopping malls. They can also be used for outdoor security and surveillance missions, such as highway inspection, border patrol, and perimeter security. Drone security patrols have the ability to monitor vast areas and provide high-quality images and video footage in real time, which could also mean that fewer on-site security officers are needed to protect a site or property. While securing parking lots, drones can compare license plates against those on the hot sheet, in this way helping security staff spot stolen cars or identify unauthorized vehicles.
- *Mapping:* Drones can be used to create accurate maps for strategic purposes, such as mapping dangerous roads. A mapping drone helps visualize and georeference any foreign environment that is expected to be the action ground of defense and security missions. You can scan large regions and create digital surface models and 3D maps for further strategic planning, logistics, and other military intelligence tasks.
- *Maritime Surveillance:* Drones operating in the air and at sea can enhance nations' ability to patrol and control their coastal waters. For example, Africa's coastal nations are responsible for more than 13 million square kilometers of maritime territory. Countries are embracing drones to strengthen their ability to patrol and control their coastal waters because they allow for surveillance and documentation of piracy, illegal fishing, and other activities with minimal human resources.
- *Crowd Monitoring:* In scenarios such as public events or protests, drones can provide aerial views of crowds, assisting security personnel in identifying potential threats or disturbances. Law enforcement agencies can employ drones for surveillance during operations, tracking suspects, or managing emergency situations effectively. Surveillance drones can play a role in monitoring for human rights abuses.

BENEFITS

Drones make aerial surveillance easy for anyone to do. They allow the real-time monitoring of entire urban populations. Other benefits include [10]:

- *Autonomy*: This is the key benefit that drones integrated with AI can bring to physical security. Human operators involved in drone surveillance are prone to fatigue and errors, can lose concentration, and miss threats. Autonomous drone security systems can be programmed to operate reliably and continuously and can be rapidly deployed across large areas.
- *Monitoring Hazardous Areas*: Drones can do tedious and repetitive tasks of monitoring large areas very efficiently and rapidly, inspecting hard-to-reach locations and gathering data necessary to assess potentially dangerous situations. Due to the ability to cover vast areas regardless of terrain, drones can get closer to hazards, such as high voltage areas, without putting humans at risk of harm and enabling better-informed decisions during adverse incidents.
- *Cost Saving*: While the initial investment in drone technology will be expensive, the long-term benefits far outweigh the initial cost in terms of return on investment. The cost of a security drone is only 20% of the cost of helicopter patrol and 40% of the cost of foot patrol. Drones greatly reduce the cost of aerial surveillance. They are far cheaper to use for aerial surveillance than traditional crewed aircrafts. A drone does not require an expensive certified pilot to operate. Drones can help save cost especially when it comes to large industrial facilities, like oil and gas sites, solar farms, storerooms or securing pipelines where proper video surveillance is critical to reducing risks of damage, leaks and protecting against theft of equipment and raw materials. However, buying, installing and maintaining cameras in remote areas is expensive. With drones, carrying out inspections is cheaper.
- *Speed*: Drones are much faster than a patrol vehicle or a security officer, which allows them to reach the scene of the incident several times quicker and give the opportunity to provide a rapid remedial response.
- *Efficiency*: The number of drones is constantly increasing every year worldwide, as they have already proven their efficiency when deployed to patrol perimeters, inspect pipelines, deliver medical supplies, and gather data.
- *Rapid Response*: Emergencies require immediate action because every minute can be a difference between life and death. With security drones, the process is much more effective. A drone for surveillance can perform perimeter patrols 30 times faster than a manned patrol.
- *Improved Visual Capacities*: Surveillance drones can fly from a high altitude that allows offering a wide aerial viewpoint without blind spots. With high-quality sensors and HD cameras, drones can detect anomalies or events in low light conditions and from meters away.
- *Safe Missions*: By using remotely controlled drones, you can help reduce the risk to security staff as pilots will be a safe distance away. In the event of a suspect apprehension or disaster outbreak, it is best to send a drone to see the situation first and investigate potential risks before humans get inside.
- *Drone as First Responders (DFR)*: The air robots provide an additional set of eyes that can help first responders quickly assess and respond to situations while providing valuable situational awareness. The main goal is to provide immediate assistance and support to those in need, stabilize the situation, provide medical attention and transport, and ensure the safety of everyone involved until more advanced medical or emergency services arrive.
- *Autonomous Deployments*: Autonomous operation of drones can be utilized for 24/7 deployments. An autonomous drone requires no pilot training for security guards and no

preexisting flying skills. The drone is deployable in less than 30 seconds and everything from takeoff and landing to path-planning is handled automatically.

CHALLENGES

Drone use has led to the rise of many security, safety and privacy issues. Drones' characteristics, namely small size, low cost and ease of use, made them a preferred choice for criminals. Another obvious obstacle for driving the broad adoption of drones is hardware (battery life, sensors, cameras and receivers' quality, flight stability, etc.). Drones can malfunction and crash into a nearby house or a group of people, causing property damage and human injuries. The battery is one of the critical components of a drone. The law around conducting aerial surveillance very much remains in a gray area. Other challenges facing surveillance drones include the following:

- *Privacy:* Drones can raise privacy and civil liberties concerns. Surveillance from the skies threatens to end privacy in public. Drones may also not be used for surveillance in violation of another party's reasonable expectation of privacy. People's privacy is at high risk of being exposed by unwanted interference. Drones can record their movement and capture images without their knowledge or permission. Drones and other aerial surveillance technologies may enable targeted surveillance that protects privacy, while still allowing for the collection of evidence.
- *Regulation:* The integration of drones into the National Airspace requires new regulation to protect people's privacy against aerial surveillance. The Federal Aviation Administration (FAA) has yet to provide information on how these drones will be used. Maintaining compliance with FAA requirements and regulations have been a challenge for security agencies. Previously, such unmanned aircraft were generally not allowed to fly over people, fly at night, or be out of the line of sight of the operator without an FAA waiver. Now, these drones can operate at concerts, sporting events, and for security purposes, although with certain constraints.
- *Legislation:* Drones require new legislation from governments and budgets to pay for equipment and trained personnel. Many critics of drones raise the legitimate concern that the government's collection of aerial imagery and video will enable pervasive surveillance that allows the government to know what all citizens are doing at all points in time. Some jurisdictions have enacted limitations on how information gathered from drones may be used. Legislators should follow a property rights approach to aerial surveillance. The most effective solution is to adopt a property rights approach that does not disrupt the status quo. Legislators should adopt policies that address collection and retention of information in a way that focuses on the information that is collected, how it is stored, and how it is accessed. They should focus on controlling the duration of surveillance. Legislators should craft simple duration based surveillance legislation that addresses the potential for persistent surveillance. Crafting legislation that places aggregate limits on how long law enforcement may surveil specific persons or places can protect against the possibility of persistent surveillance. Surveillance of longer than 48 hours is permissible only when accompanied by a warrant and probable cause. Legislators should adopt transparency and accountability measures. To hold law enforcement accountable, legislators should mandate that the use of all aerial surveillance devices (manned or unmanned) be published on a regular basis (perhaps quarterly) on the website of the agency operating the system.

CONCLUSION

Drone surveillance refers to the act of keeping a visual track of an individual, a group, objects, or a situation for the purpose of thwarting any kind of threat. It can survey objects that may be out of reach and can get a first-person view that photographers do not usually get. It provides real-time insight into security and emergency situations for better control, accurate intelligence gathering, comprehensive situational awareness, and more informed decision making. While the idea of

deploying a personal drone for surveillance might be enticing, it is imperative to acknowledge the potential legal and ethical pitfalls. Engaging a licensed private investigator offers a multitude of benefits, with their expertise in privacy laws standing out as a key advantage.

While drones may be a great asset to your enterprise, there are still a lot of uncharted waters out there. Drones also are at risk of electronic jamming, hacking, and other countermeasures. Professional drones used for surveillance and security have the capability to disrupt a wide range of industries. The cost of drones is low enough that human rights organizations and even private citizens can buy them. More information about drones in surveillance can be found in the books in [11-18].

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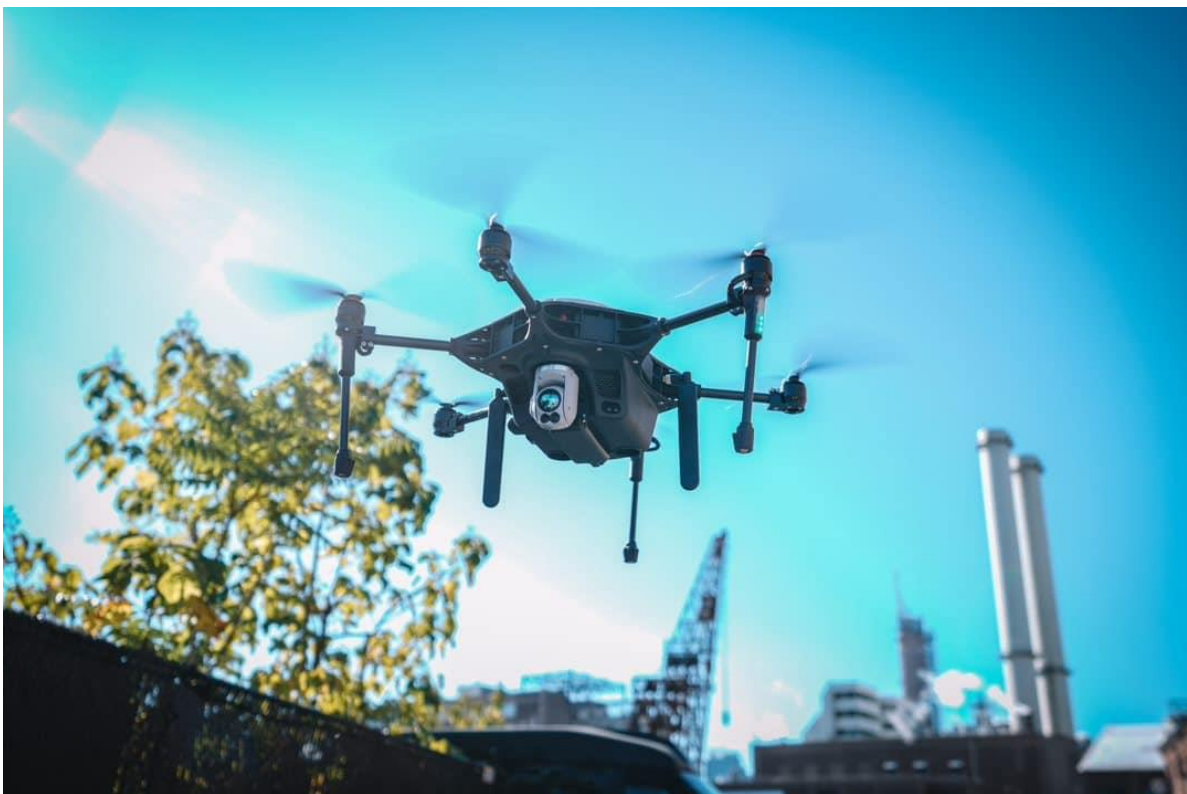


Figure 1 A typical drone [1].



Figure 2 A drone is usually controlled by operators on the ground [2].



Figure 3 Some surveillance drones [6].

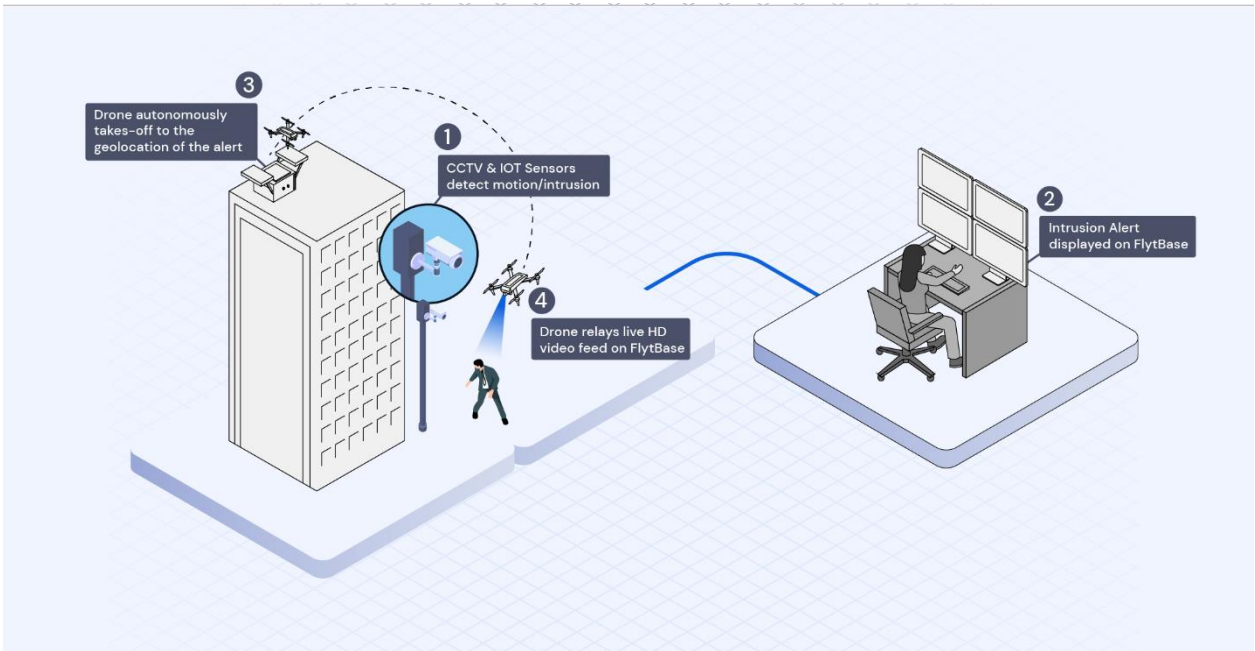


Figure 4 How a surveillance drone works [7].



Figure 5 A surveillance drone designed for night operations [8].



Figure 6 A police drone [2].