

A Primer on Drones

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ABSTRACT

Drones, also known as unmanned aerial vehicles (UAVs), are unmanned aircrafts. They are small remotely controlled aerial vehicles. They have been crucial to the operations of many enterprises and governmental organizations in recent years, including monitoring the Earth's surface, agriculture, construction, and surveillance. These robot-like aircrafts can assist in the hunt for hurricane survivors as well as deliver groceries to your home and almost everywhere in between. One of their strengths is the many different applications for which they can be used. This paper explores the various applications of drones.

KEYWORDS: *drones, Unmanned aircrafts, unmanned aerial vehicles (UAVs)*

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INTRODUCTION

For decades, drones have been used by the military and government organizations to gather data. Their use in the private and commercial sectors is much more recent. Drones have come in a great diversity of several applications such as military, construction, agriculture, healthcare, search and rescue, parcel delivery, hidden area exploration, power line monitoring, wireless communication, and aerial surveillance. These industries are commonly using drones to improve operations, increase efficiency, and save time and cost on data collection.

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. 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.

Drones, designed with a kite-like mechanical architecture, mainly consist of four basic components: propeller, engine, body, and flight board. As shown in Figure 1, drones come in two main types: fixed-wing and rotary [1]. In the fixed-wing platforms, the wings are fixed to body of the drone. A rotary platform has a rotary wing (i.e., a propeller) that is fixed to a motor. On a rotary platform, the motor spins the rotary wing against the air to create lift. Also called rotor or blade, drone propeller comes in various shapes, sizes, and materials. The drone motor is the main dynamo that makes the propellers spin and provides enough thrust for flight. Motors and propellers are the technology that lifts the drone, allowing it to fly or hover. The battery is regarded as the heart of the drone; it is the most important part in terms of power generation and performance. The drone controller is the tool for

managing and directing the drone. Not all drones have a camera system, but models offer additional options in-flight, such as aerial photography. Drones can operate in Global Navigational Satellite Systems (GNSS) such as GPS [2].

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 [1],

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 [6]. 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.

TYPES OF DRONES

Different drones may travel at different heights and distances. Drones can be classified according to size, from very small to large drones. For a drone to fly, it must have a power source such as batteries or fuel. Their power sources classify drones as battery-powered, gasoline-powered, hydrogen fuel cell, and solar drones. They can also be classified as single rotor (helicopter), multi-rotor (multicopter), fixed wing, and fixed-wing hybrid VTOL according to their physical structures. Multicopters are further divided into models with four engines (quadcopter), six engines (hexacopter), and eight engines (octocopter) according to the number of motors. Thus, we have the following types of drones [2]:

- *Tricopter*: It is a type of drone that can take off and land vertically and has six degrees of freedom on the X–Y–Z axes. Although its cost is lower than other options, it has a disadvantage of not being symmetrical (Figure 2),
- *Quadcopter*: It is the most preferred type of drone. It is simple as well as versatile. It has four propellers and four motors, with a load of up to 5 kg. A higher flight comfort can be achieved with

its four-arm structure being symmetrical. In case of any malfunction, the drone will most likely crash (Figure 3).

- *Hexacopter*: It is a type of drone with six propellers. It is a type of drone that can offer excellent performance even on indoor flights. It can be equipped with various equipment and take off with a load of up to 10 kg, as in other models (Figure 4).
- *Octocopter*: It is a type of drone with eight propellers. It is an advanced type of drone that can take off with a load of 25 kg with its equipment. It is especially preferred for heavily loaded works (Figure 5).
- *Fixed-wing drones*: Unlike rotary wings, they use wings like a regular airplane instead of vertical lift rotors to provide lift (Figure 6). They are much more efficient as they do not use additional power to stay in the air, so they can cover longer distances and scan much larger areas. The main disadvantage of a fixed-wing aircraft is that they cannot fly in one spot. Depending on their size, they need a runway or launcher to get them into the air.

When choosing your ideal drone, budget is the obvious place to start. Then, keep size and weight in mind. Beginner fliers should consider drones with safety features like obstacle avoidance, which help to prevent mid-air collisions.

APPLICATIONS

Being versatile technology, drones are used across a wide range of industries. The following are ten typical applications of drones [2,3-7]:

1. *Agriculture*: The use of drones in agricultural production is becoming more common daily, and it provides convenience for producers to optimize production. In agriculture, drone contributes significantly to providing data to sector stakeholders and increasing producers' productivity by collecting data with regular land observation. Drones are used in spraying, fertilization, and plant damage detection. Drones can map regions and determine crop damage after a storm, discover water drainage issues, determine quantity of yield, find disease or pest, and check up on livestock quickly. By collecting and analyzing data on soil conditions, irrigation, and plant health, drone technology enables farmers to identify issues early and take corrective action. Figure 7 shows how drone is being used in Agriculture [5].

2. *Healthcare:* The use of drones for healthcare purposes is used to transport response equipment to the scene in urban areas. Drones are used to improve emergency response after a disaster or in dangerous situations. Medical samples, medications, and supplies can be transported quickly and efficiently by drones, saving time and potentially saving lives. Delivering a life-saving defibrillator (AED) by drone is 32% faster in urban centers and 93% faster in rural areas where other vehicles cannot reach. Drones are also being used to transport donated organs to transplant recipients. In the same way, it has been demonstrated that it is possible to transport drugs/tissues, and blood products, with drones.
3. *Law Enforcement:* Drones are used for maintaining the law. They help with the surveillance of large crowds and ensure public safety. They assist in monitoring criminal and illegal activities. Law enforcement agencies are finding new and innovative ways to utilize drones in their operations, enhancing public safety and officer efficiency. Drones can also be used for crowd monitoring during large events or protests, enabling law enforcement to identify potential issues and respond accordingly. Drones have been used for domestic police work in Canada and the United States. Many police departments in India have procured drones for law and order and aerial surveillance. Figure 8 shows how police officers are using a drone in their operations [6].
4. *Disaster Management:* Drones have become indispensable tools in search and rescue operations, significantly improving the speed and efficiency with which missing persons can be located. After a natural or man-made disaster, drones can be used to gather information and navigate debris. Its high definition cameras, sensors, and radars give rescue teams access to a higher field of view, saving the need to spend resources on manned helicopters. Due to their small size, drones can provide a close-up view of areas. In situations where time is of the essence, this rapid response capability can mean the difference between life and death. Drones can be used to deliver critical supplies, such as food, water, or medical equipment, to stranded individuals, ensuring their safety and comfort until rescue teams can reach them.
5. *Photography:* Drones provide a detailed view of large areas, spaces, and a particular subject. They have been a benefit to aerial photographers who employ them to get expansive shots. They are most commonly known for capturing stunning aerial photography and videos that are used in marketing or advertising. Professional video shoots are made today using drones in commercials, TV series, and movie sets, successfully capturing specific images. Drones with high-definition cameras serve successfully in aerial image and video shooting at sports events. They provide great convenience in collecting images and information from places that cannot be visited or entered, especially due to security problems. The use of drones can make a significant contribution to innovation and quality in the film industry.
6. *Power Systems:* Drones have proven to be invaluable tools for inspecting and maintaining electric power lines. Power grids sometimes run through areas that are hard to reach and, therefore, drones are the perfect solution to inspect and service these grids. A long range drone equipped cameras and GPS can carry out autonomous cruise along the power grid, and transmit and shoot images in real-time. Drones can safely fly close to transmission lines, towers, and antennas, capturing detailed images and data for analysis. The cost of manual positioning of power line faults is too high, and drone cruises can significantly improve efficiency. Several energy companies, like Southern Company and Duke Energy, are using drones to inspect power lines, power plants, and storm damage. Figure 9 shows an example of how drone is monitoring the power system [6].
7. *Business:* Drones, modern camera technology, GIS, and specialized software have enabled businesses to leverage new kinds of data for stronger insights. When more precise and consistent measurements and data are provided, businesses have the tools to prepare better financial data. From a business point of view, the drone revolution is leading to an in-depth transformation of the main sectors of activity, since they can take on complex tasks and reduce costs.
8. *Manufacturing:* Integrating drones in manufacturing adds a new standard of automation and efficiency. Manufacturing drones use various advanced technologies that increase their technical capabilities. Drones can be used for the additive manufacturing of structures. Artificial intelligence (AI) plays a critical role in drone use for manufacturing development. AI-driven drones autonomously capture, process, and analyze aerial data. AI is the fundamental technology for creating advanced drones. It makes drones in

manufacturing more accessible. One of the most prominent applications of drones in manufacturing is inventory and production line management. There are several tasks that drones can automate in warehouses and production lines. Figure 10 shows the use of drone in manufacturing [7].

9. *Military*: The first known use of drones was for military purposes. Thus, military is the oldest, most well-known, and most contentious application of drones. Drone is used for different purposes ranging from military, espionage, radar system, area detection, and observation to transporting food, weapons, and ammunition. In the early 1940s, the British and American forces began utilizing extremely crude kinds of drones to spy on the Axis powers. MQ-9 Reaper is one of the drones used for military purposes today. It has a length of 36 feet and is equipped with a 1852 km flight system at an altitude of 50,000 feet. It is outfitted with a variety of missiles and intelligence gathering systems. Islamic State of Iraq and the Levant have used drones to drop explosives, primarily using quadcopters.
10. *Space*: Drones have already conquered the earth's surface and are now heading into space. NASA and the United States Air Force have been testing drones designed for space flight. The Air Force's ultra-secretive X-37B UAV has been quietly circling the Earth for the past two years, setting a record for the longest unmanned aircraft flight (781 days and counting). Although the Air Force has been ambiguous, it has stated that "the primary objectives of the X-37B are twofold: reusable spacecraft technologies for America's future in space and operating experiments that can be returned to, and examined on Earth." Some of these applications are displayed in Figure 11 [4].

BENEFITS

Drones are used by a broad range of military forces, from Argentina to the US. They make it possible to collect data and access information in a variety of ways while saving time and minimizing costs. The commercial use of drones is transforming various industries and providing significant benefits, from increased efficiency and cost savings to improved safety and reduced environmental impact. Reducing costs and expenditures while improving the efficiency of technological solutions is essential for large-scale industries. Industries such as mining, ports, gas, and large plants involve processes and applications where human power may be at risk or impossible to use. Other benefits of drones include the following [8]:

- Cheap and cost effective

- High spatial resolution
- High accuracy
- Easier to deploy
- No hindrances from clouds
- A great tool for surveillance

CHALLENGES

Although drones have many benefits, there are some challenges to their widespread use. Such challenges include obstacle detection, battery life, and hacking. Other challenges include the following [2].

- *Power Source*: One of the biggest problems with drone is the power requirement. Due to the limited flight times, developing drones capable of long flights with smaller and more powerful batteries remain the priority to solve this problem.
- *Security*: The greatest challenges of drones is security. All human-operated aircrafts inherently pose a risk of falling. Working on limited battery power, having fast spinning propellers, and the potential to fall from heights greatly threaten living things, structures, and the environment. The importance of safe use is increasing, especially with using drones in daily life. Law enforcement should be put in place to limit drones' interference with the privacy of others.
- *Hacking*: Drones are becoming a bigger target for cyberattacks as their use increases and their number increases. Hackers can intercept the transmitted data to take control of the drone. Extra measures should be developed to protect drones and the information they store.
- *Regulation*: The deployment of drones in manufacturing settings is gaining momentum. Adhering to local and federal regulations is becoming a pivotal concern for drone manufacturers. Responsible operations must comply with safety, security, and privacy regulations. It might be challenging, as legal issues are consistent and precise regulation can be complicated. European law, for example, regulates the activity of drones and a map by country of the areas where a drone can fly.

CONCLUSION

Drone technology is one of the advanced innovations in the realm of technology. As drone technology advances, engineers are pushing its boundaries to explore unconventional applications for drones. As the technology and equipment become more accessible, drones will be more active part of commercial and industrial operations. Being inexpensive and accessible, drone will be put to several novel uses around the world. Complementary technologies such as augmented reality and computer

vision are likely to drive drone market growth and improve drone communication and intelligence. For more information about drones, the reader should consult the books in [9-13].

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Figure 1 Fixed-wing and rotary types of drones [1].



Figure 2 Tricopter [2].



Figure 3 Quadcopter [2].



Figure 4 Hexacopter [2].



Figure 5 Octocopter [2].



Figure 6 Fixed-wing drone [2].

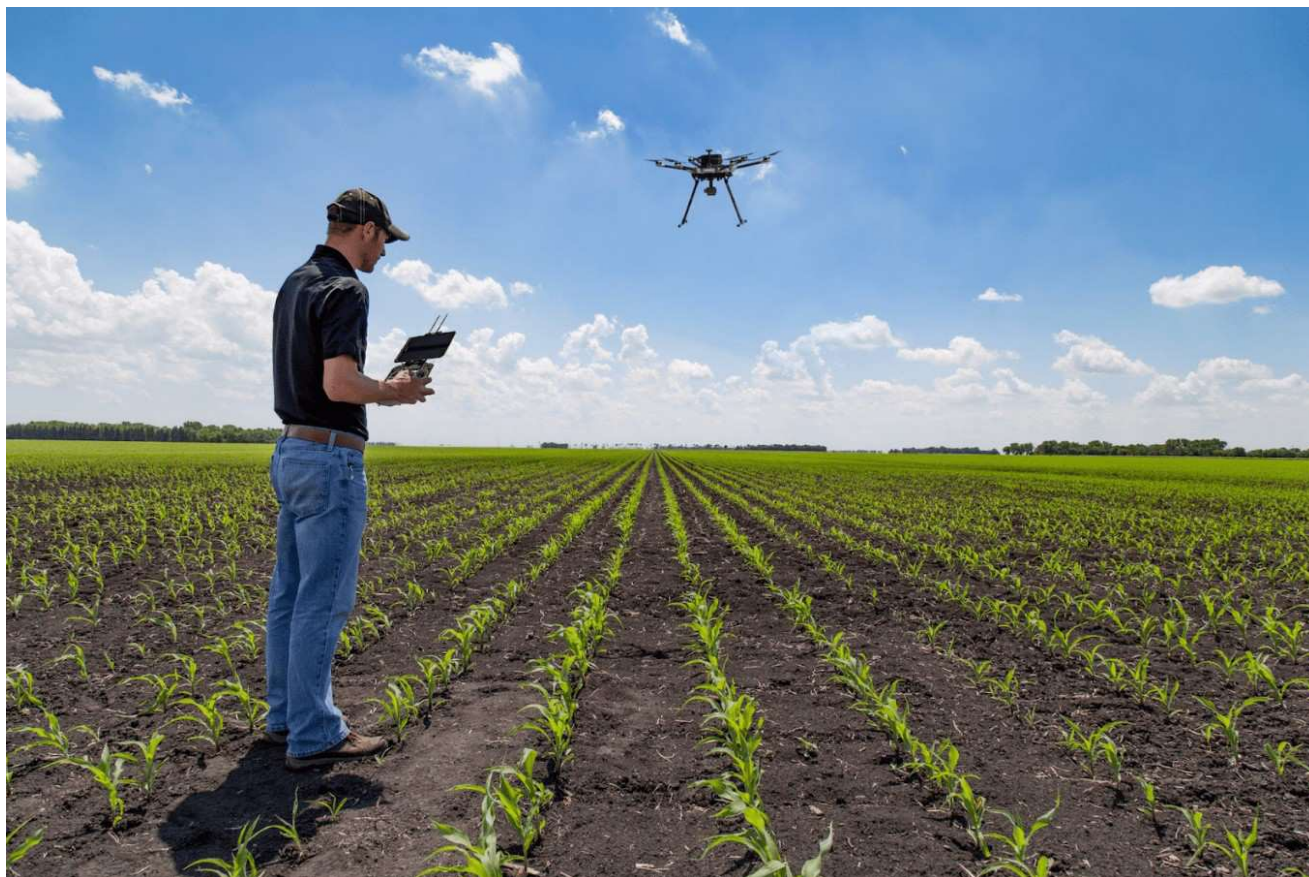


Figure 7 Drone is used in Agriculture [5].

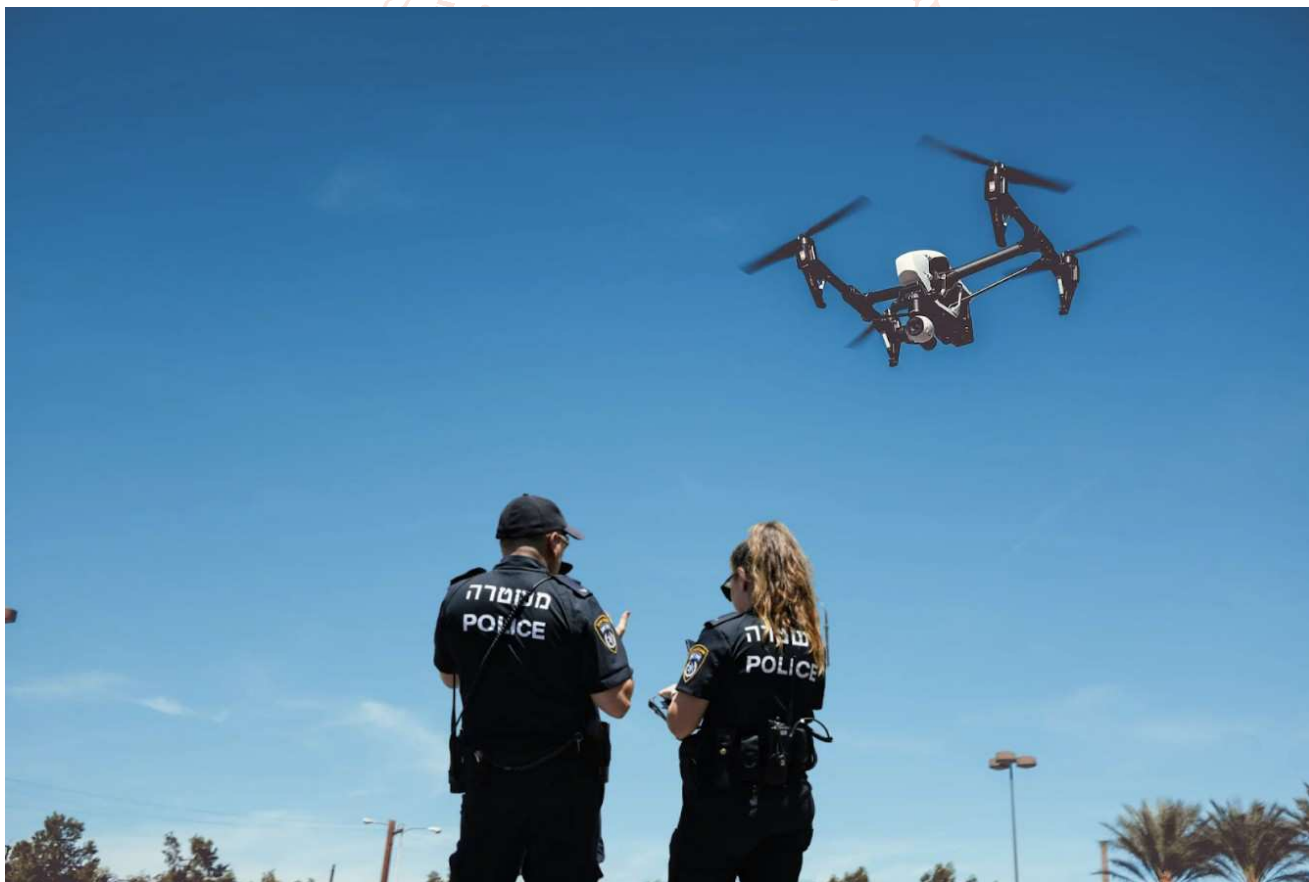
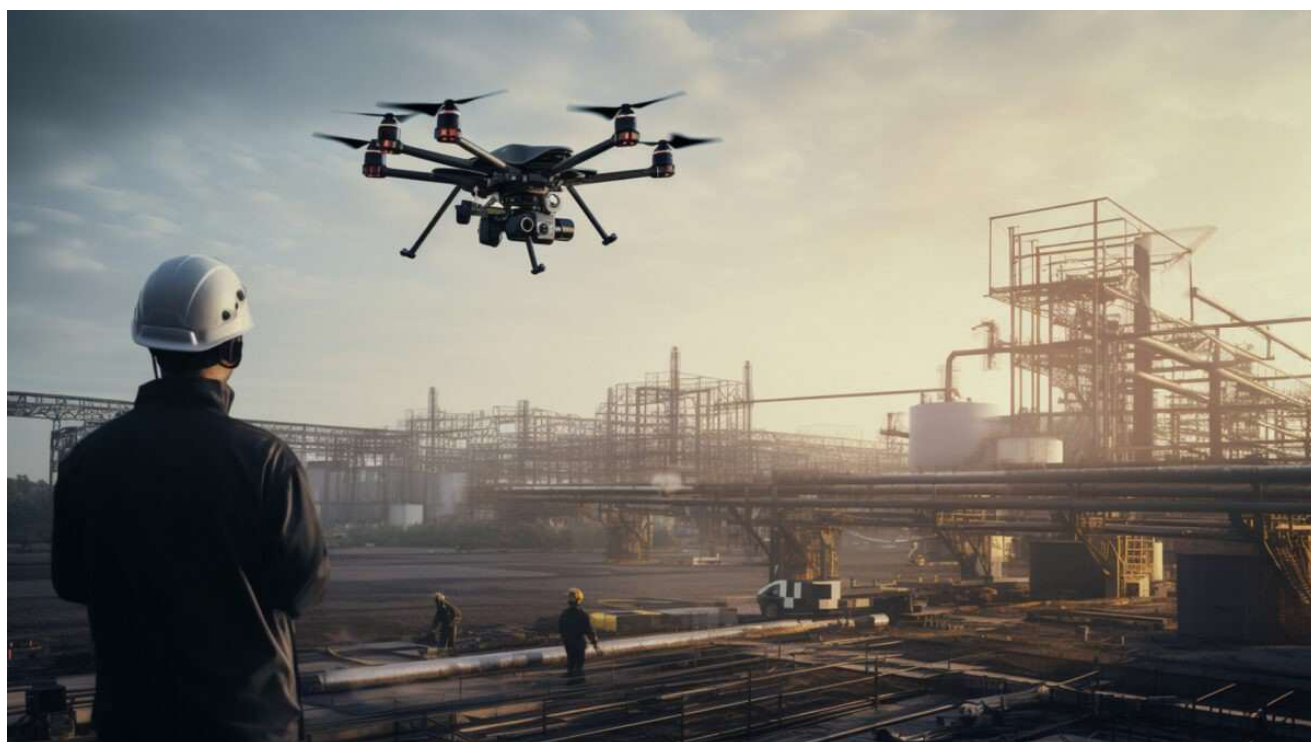


Figure 8 Police officers are using a drone in their operations [5].



Figure 9 Drone is monitoring the power system [6].



Figures 10 Use of drone in manufacturing [7].



Figure 11 Some of the applications of drones [4].

