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THE EMERGING USES OF UNMANNED AERIAL VEHICLES (UAVs) IN MODERN SOCIETY

USOS EMERGENTES DE VEHÍCULOS AÉREOS NO TRIPULADOS (VANTs) EN LA SOCIEDAD MODERNA

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Abstract

Unmanned aerial vehicles, commonly known as drones, are becoming increasingly popular in today's society on both hobby and commercial levels. One million drones are built every year across the globe. In the United States alone, 5,168 businesses have already been granted permission to make use of UAVs, mainly in the agriculture and aerial videography/photography sectors. However, the principal use of drones today is still hobby and recreation. In this paper, I focus on the exciting applications of UAVs, which are emerging today or will be available in near future. These include: package delivery, emergency response and medical uses, meteorology, education, inspections, and even wildlife conservation. I cover drones of all sizes, starting from micro- and mini-UAVs and ending with optionally piloted aircraft. I explain the reluctance of our society to embrace this innovation, despite the many benefits it offers to mankind. Any new technological development is initially accompanied by misconceptions and fear from the general public. It is important that all users who employ UAVs do so responsibly.

Keywords: unmanned aerial vehicle, UAV, UAS, remotely piloted aircraft, drone.

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Introduction

The world is obsessed by drones. They are now starting to shape today's society just as all previous revolutionary technologies did. Unmanned aerial vehicles are used for business, science and military applications. They are both a blessing and a threat. But how will this relatively recent human development affect our future? Where did these "drones" come from and how will they change our lives?

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Unknown to most people, first model sailplanes were built by ancient Egyptians and date back to around 200 BC (Corliss, 1980). The history of powered model airplanes is as old as powered flight itself. These model aircraft were traditionally designed, built, and flown by hobbyists and enthusiasts, who had the required expertise.

Recent advances in technology, such as micro-controllers, miniaturized inertial measurement units (IMUs) and the widespread use of the Global Positioning System (GPS), have permitted the boom of unmanned aerial vehicles (UAVs) in recent years. When combined with traditional model aircraft components, such as electric motors, battery packs and servos, these new technologies allow the construction of sophisticated flying machines that are extremely easy to operate and can be flown by inexperienced pilots. Some are even capable of fully autonomous flight. This fact, combined with the ever-decreasing cost of electronic components (Dulberger, 1993), allows the general public to use UAVs for purposes never previously dreamt of. The possibilities are endless. Some of the more sophisticated technologies are referred to as unmanned aerial systems (UAS), which comprise the vehicle as well as all its accessories (ground stations etc.).

This article deals with the emerging uses of so-called drones, which are attainable today and/or in the near future. It specifically discusses the ethical issues related to the ubiquitous use of UAVs, privacy concerns, as well as the prevention of accidents and incidents. The UAV industry originates from two different backgrounds: Hobby and the military. This article focuses on the civilian uses of drones, therefore I will cover hobby and recreational use of drones and delve into the newly introduced commercial applications.

Hobby and recreation

Unmanned aerial vehicles can be considered the first sector, where the hobbyists actually surpass the military industry in the development of new technologies (Williams, 2015). This is true to such an extent, that the military and some of its contractors hire candidates with previous hobby UAV experience. Never before has the path from a simple toy to state-of-the-art technology been so short. In the Control Systems courses at Instituto Politécnico Nacional, we have proven that a sophisticated UAV, capable of fully autonomous flight including automatic takeoff and landing, can be built in less than two weeks by a group of engineering students with no prior experience.

Today, recreational drones can be divided into the following main categories: Aerial photography and videography, first person view (FPV) flying, drone racing and small indoor and outdoor drones flown purely for the joy of flying. Additional to these principal recreational uses, are other specific non-commercial applications. One can, for instance, use their personal UAV equipped with an infrared camera to determine which areas of their home let the most heat out during the winter and might require additional insulation.

Aerial photography and videography has traditionally been the principal use of UAVs. Hobbyists today use both commercially available quadcopters, such as the DJI Phantom, as well as custom made projects, using open-source technologies. The advantage of turnkey solutions such as DJI, 3DR or Walkera is that they do not require any prior experience or skills. They allow virtually any untrained person to fly their own UAV, which raises serious ethical issues addressed in the final part of this article. Hobbyists with some experience in the topic and a desire to learn can use open-source technologies, such as APM, MultiWii, KK or Naza, to build their own multicopter. The advantage of this approach is that it gives more flexibility in terms of payloads (cameras) carried and other specifications, such as time of flight, can be optimized to match one's particular needs. Additionally, the building of a customized drone requires a phase of flight testing, during which the operator is likely to become familiar with unsafe flight conditions that may lead to an accident. Inexperienced drone owners who opt to buy a turnkey solution are often stripped of this learning phase and are likely to fly their UAV without a clear understanding of the risks involved. Overall, aerial photography and videography is an exciting field, which can be considered a stand-alone art discipline. The following photograph shows an example of event photography, one that provides lasting memories to all participants involved.

Event photography using a custom-built quadcopter (Reyes, 2016).

A camera mounted on a drone allows its user to experience firsthand what it would feel like to be on board. Ever since the boom of aerial videography, hobbyists have searched for a solution to

downlink that video to the ground in real time, allowing them to fly using the same visual cues, as if they were on board. This method is called "first person view" or FPV. The technology soon caught up, offering long range video transmitters at a reasonable cost, and the thrill of FPV flying has made it highly popular.

Commercial applications

According to the Association for Unmanned Vehicle Systems International (AUVSI), the drone industry is projected to create over 100,000 new jobs between 2015 and 2025 in the United States alone (Jenkins and Vasigh, 2013). UAVs used to be a relatively expensive technology. Today, one may find aerial footage in almost any TV commercial or news report.

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Drones are very well suited to replace humans at tasks that are generally categorized into the "three Ds": dull, dirty, or dangerous (Diab, 2014). A person carrying out a dull endeavor for an extended amount of time may easily lose focus and concentration. A dirty and dangerous task can imply entering a contaminated area, such as a disaster sone. This type of mission was already carried out by UAVs, for example, in case of the radiation leaks after reactor meltdowns at the Fukushima nuclear power plant (Sanada, Kondo, Sugita, Nishizawa, Yuuki, et al., 2014)

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Professional UAVs as we know them today still require a skilled human operator, but this will not be true for much longer. The vision of the near future is a fully autonomous drone, which will fly on pre-programmed (or even automatically generated) trajectories, and monitor an industrial area, construction zone, power line, highway or any other point of interest. The unmanned aerial system will either be solar-powered, or it will be equipped with charging stations, where the drone will automatically land and recharge itself. It will not require any human supervision, it will only "wake up" its operator, when it detects a potential problem that needs to be taken care of. This will save an enormous amount of the so-called "dull" human labor.

In order to bring this vision into reality, UAV engineers will need to address several critical safety issues. To prevent midair collisions, aviation relies on the see-and-avoid principle. Fully autonomous drones will need to be able to detect obstacles (newly built towers or cranes, that are not yet included in chart databases), other aircraft and non-cooperating flying objects (birds). They will need to be resistant to any external signal interference, immune to loss of communication, and able to complete their mission and safely land at their destination or an alternate location.

Given that in a UAV there is a large variety of potential failures, it is extremely difficult to program control laws that are able to handle each one

Self-diagnosis is another important feature, which will be required on future UAVs. It is essential that flight control systems are able to determine a fault exists and adjust the flight routing, vertical path, and control algorithms to ensure a safe landing. Given that in a UAV there is a large variety of potential failures, it is extremely difficult to program control laws that are able to handle each one. On the other hand, human pilots can do this naturally, by using their instincts, learning and adaptation skills. Hence, in the recent years, researchers have focused on imitating these human skills and implementing adaptive control laws on UAVs. This is typically done by using computer-generated neural networks, which simulate the functionality of a human brain (Perez, Moncayo, Moguel, Perhinschi, Al Azzawi and Togayev 2014).

The expansion of commercial drones has recently been accelerated by the new rules drafted by a panel of experts coordinated by the Federal Aviation Administration known as CFR (Code of Federal Regulations) 14 Part 107. These regulations are in effect since August 29th, 2016 and they permit any operator to obtain an sUAS (small Unmanned Aerial System) pilot certificate by passing a required knowledge test. This certificate is required for all commercial operations and permits the holder to fly unmanned aircraft up to 55 pounds of weight (Federal Aviation Administration, 2016). Typical commercial applications of drones include professional aerial photography and videography. UAVs are well suited for these tasks, since they offer an unusual vantage point for the photo or video recording. However, these applications require much more skill and technology than hobby-style FPV flying. Typically, two camera feeds are required: one forward-pointing camera feed for the pilot and the main camera feed for the video operator. The pilot must be able to maintain visual contact with obstacles and other hazards, as well as the attitude of the aircraft, while the video operator needs to focus their undivided attention to frame the main camera. Excellent coordination is essential to obtain professional-grade recordings. Often, additional ground observers are used to reduce the hazard to the UAS, as well as persons and property on the ground.

Another future commercial application is distribution and delivery. Large companies, such as Google, Amazon, or DHL are developing unmanned aerial systems capable of autonomous package delivery. This service will require fully autonomous UAVs, capable of detecting and avoiding obstacles. It will also require a method for automatic charging, loading and unloading of the vehicles. DHL is already testing this concept in the Bavarian community of Reit im Winkl, where the UAV delivers packages between two autonomous docking stations separated by over 8 kilometers of horizontal distance and 500 meters of altitude. These tests have proven that drones can be extremely helpful in delivering critical supplies to hard-to-reach areas.

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The DHL Parcelcopter 3.0. (Deutsche Post DHL Group, 2016)

In addition to classical commercial applications, drones are also increasingly used by law enforcement, emergency response personnel and even for medical purposes. UAVs can help in search and rescue efforts, by locating survivors and directing rescuers to their location. Drones may even be designed to take initiative in time critical situations. Coast guards worldwide are considering drones to carry floats to drowning victims, before a human lifeguard can arrive and save them.

Alec Momont of TU Delft has designed a hexacopter (6-rotor UAV), which can deliver a defibrillator to a person suffering from cardiac arrest within seconds of the receipt of an emergency call. The aircraft travels at 100 km/h and it is extremely useful in densely populated areas, where it can increase the chance of survival of a potential victim from 8% to 80% (Webredactie Communication, 2014). Numerous similar projects are under development today, which can deliver medicine, tools, and other equipment to help save human lives. The main advantage of these solutions is that they do not require existing road infrastructure and they can reduce the response time dramatically. Research teams worldwide are already working on determining the optimal locations, where these vehicles should be placed within large metropolitan areas (Pulver, Wei, Clay, 2016).

The TU Delft Ambulance Drone. (Webredactie Communication, 2014)

As seen in the examples above, commercial UAV use is not limited to business applications and profit making. Drones may also be used for humanitarian and altruistic purposes.

Ethical issues

Many of the emerging drone uses described above involve the uses of various sensors, such as optical and infra-red cameras. This naturally leads to serious privacy concerns, due to the fact that a UAV can be virtually invisible, positioned at any angle above a person or property, while taking high definition photographs or even video. This is a valid concern, which needs to be addressed by legislation. Current regulations prohibit flight over non-participating people; however, they do not limit flight near non-participating structures or property. This means that, as long as a drone does not endanger someone's safety, it is perfectly legal to use it to take photographs or video of other person's property.

Despite the fact that UAVs can be seen as a threat to privacy and today's regulations fall behind the technology available, it is believed that very few drone operators might have the interest in "spying" on other people. If a person feels harassed by a UAV, they may express their concerns to the operator, as well as the authorities, just as they would, if they were being recorded via a conventional camera. As drones will become more and more popular, today's society will need to determine where the border lies between one person's freedom (use of a drone), and other person's private space. The 3rd dimension will need to be taken into account when specifying private property.

For instance, the Tesla autopilot, has been subject to intense public scrutiny, after it was claimed to have caused the first fatal accident in May 2016

Furthermore, as in any autonomous system, liability in case of an accident is a prime concern. For instance, the Tesla autopilot, has been subject to intense public scrutiny, after it was claimed to have caused the first fatal accident in May 2016. This, so-called "robot car", crashed into a white truck which was parked partially obstructing a lane on a highway. The driver was believed to be watching a Harry Potter movie while the autopilot was in charge. Although research shows that the use of autopilot actually reduces the likelihood of an accident while driving long-distance, the fact that blame cannot be assigned to an autonomous system has raised concerns, which may ultimately hinder research into self-driving technology (Lin, 2016).

A UAV is not analogous to a robot car, but one can easily imagine how the concern described above may impact the industry, if even a single drone hits and kills a person on the ground, not to mention an airliner with hundreds of passengers on board. This kind of event has a great potential to create public outcry for a worldwide restriction of UAVs. It is the responsibility of the drone industry and wider community to address these concerns before such event happens, as this is only a matter of time. Those who build, use, or are knowledgeable about UAVs need to be ready to explain to a wider public that, just as with any technology, accidents are bound to happen and our only protection is to maintain a responsible safety culture while operating this technology. Even a single fatal accident is a disaster; however, the likelihood of that accident must be put into perspective. On average, over 3,000 people worldwide die in car crashes every day. Despite this

fact, we are not ready to give up the technology and exchange our car for a horse or donkey. It is reasonable to expect that once we start facing UAV-related accidents, the general public perception will be the same.

Finally, just as any technology, old or new, unmanned aerial vehicles can be misused for criminal purposes. A number of occurrences of drug smuggling across borders and even into prisons has already been registered. Drones are regularly used by the military to find and prosecute (kill) those who are believed to be terrorists. Security experts are concerned that it is becoming too easy to create harm using a UAV equipped with weapons of mass destruction. Just as with guns, bombs, and other weapons that have previously been used to carry out terrorist attacks, it is impossible to prevent drones from getting in the wrong hands. We can, however, take certain precautions as a society and strive for taking away the reasons why people might want to go harm to each other, rather than limiting their access to the technology.

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Drones are here to stay for generations and they will inevitably become part of our everyday lives. Rather than being concerned about what might happen, we need to educate ourselves about the capabilities, advantages, possible uses, and limitations of UAVs. Only in such a way we can adopt a responsible attitude and create fair and reasonable legislation that will help seamlessly integrate drones into our society.

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