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Drones and UAVs

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They can monitor power lines and pipelines, be used for search and rescue and to spy on enemies. UNMANNED AERIAL VEHICLES (UAVs), commonly known as drones, can also help monitor crops and wildlife, assess the environment, patrol the Arctic, supplement news reporting and assist law enforcement.

Canadian researchers and engineers are developing technologies to create UAVs able to perform these jobs at far less cost than traditional solutions. With appropriate legislation and regulation, this research will be able to flourish while the safety and privacy of Canadians will be protected. For a country like Canada with vast expanses of wilderness and unprotected coastline, UAVs are especially appealing.

WHAT IS A UAV?

A UAV can be anything from a simple remote-controlled helicopter that can set down in the palm of your hand, to a pilotless combat plane able to land on an aircraft carrier, without control from a human on the ground(1).

Canadian airspace regulations define a UAV as any commercial aircraft without a pilot on board. Any hobby aircraft weighing more than 35 kg is also considered a UAV(2). As technology becomes more readily available to consumers the line between hobbyist and commercial operator will continue to blur(3). Today almost every UAV in use has a

Source: Eric Edwards

Source: Aeryon Labs Inc.

human operator on the ground directing the flight at all times.

Size and power are the limiting factors for UAV performance and what UAVs carry aboard determines the functions they can perform. Small UAVs risk being blown away by the wind. The power source can dictate not only the UAV's size, but also how long it can remain airborne. Sources of power include batteries, hydrogen-powered fuel cells, a laser on the ground transmitting energy to a photovoltaic receiver on the plane or even the sun. Solar-powered UAVs could theoretically remain airborne for as much as five years.

UAVs use sensors for collision avoidance(4), tracking(5) and positioning. There are systems using optical or acoustic sensors, radar and LIDAR.

The goal is a UAV that can take off, survey a target, report results, and land, all safely and with little or no input from a human operator.

Sensors are also added to a UAV's payload depending on the task, from cameras, such as infrared cameras able to detect forest fires, to radar to "see" inside buildings, or lasers to image the earth's shape.

UAVs come in many forms, from finger-sized insect like devices to full sized planes. Some of the most popular include:

<u>Helicopter-Style UAVs</u>: This type of UAV can have varying numbers of rotors, but a common form is the quadcoptor - a helicopter with four rotors. They can range from the size of a fist to the size of a microwave. They are stable, highly manoeuvrable and capable of vertical take off and landing. The most nimble can fly through windows and perform aerial acrobatics(6).

These aircraft are generally used for short-range data gathering. The Aeryon Scout quadcopter, a product of a successful Waterloo, Ontario start-up, has been used for aerial imagery of the B.C. forests(7), for monitoring salmon populations and for assessing derailment of a train carrying hazardous materials. For some tasks these UAVs can fly autonomously following a predefined GPS path.

Fixed-wing: Small airplanes, called fixed-wing UAVs, are normally propeller-driven and can be either gas-powered or electric. Canadian company Brican's TD100 has been used to detect fire hot spots in a forest with infrared sensors(8) and to map the shape of land with laser sensors(9) . One of the TD100's target applications is inspection of infrastructure, such as power lines and oil pipelines(10). In tests by McGill University's Gregory Dudek , smaller research planes, the size of a model plane, have autonomously followed a coastline using video data alone(11).

Drone: The term "drone" is usually used for UAVs in military operations. The American-made Predator B can operate for up to 28-hours in a single flight. It is remotely controlled via satellite by a human operator(12). The Predator B has a 14.8-meter wingspan, uses laser-guided Hellfire missiles(13) and flies military operations.

Despite their advanced capabilities drones are technologically similar to a recreational model plane, even when it comes to navigation. A researcher at the University of Texas, Todd Humphry, was able to transmit a fake GPS signal to a UAV and fool the navigation systems. This process is called "spoofing", and it is suspected that a U.S. military UAV was hacked and captured in Iran partially using this technique(14). Spoofing is a potential safety and security concern for the most current UAVs(15).

CASE STUDY 1: KEEPING AN EYE ON THE CROPS

When pests attack a crop, the sooner they are discovered, the less pesticide is required and the less time it takes for the plants to recover. However seeing the first signs of infestation can be difficult(34). Having a UAV monitoring the health of the crops regularly could help save money, be easier on the environment and increase yield.

Agriculture and Agri-Food Canada (AAFC) is testing that idea. They have equipped a four-foot-long quadcopter UAV with a multispectral camera to collect high-resolution images of cropland for assessing plant health. Using different amounts of fertilizers in different fields, the researchers at St-Jean-sur-Richelieu hope to be able to tell how healthy the plants are by analyzing the kind of light the plants absorb(35,36).

Source: Eric Edwards

CASE STUDY 2: BELOW THE WATER AND OUT OF THIS WORLD

For unmanned systems, imagination goes farther than airspace. In outer space, teams of robots are being considered as multi-armed floating construction workers for the International Space Station(38).

Surveying in the hostile underwater Arctic environment is made possible partly thanks to Autonomous Underwater Vehicles (AUVs). The Arctic Explorer AUV has been used to map 1,000 kilometers of sea floor under the arctic ice. This would have been prohibitively difficult without unmanned systems(39).

GETTING OFF THE GROUND: THE LEGISLATIVE AND REGULATORY CLIMATE

In Canada, flying a UAV for any reason besides recreation requires a Special Flight Operations Certificate (SFOC)(16), The operator must submit detailed information on the UAV specifications, the purpose of the flight and permissions from local authorities. The need for such a strict regulatory process primarily rests on safe operation in the airspace.

The lack of sophisticated collision-avoidance systems has lead Transport Canada to tightly regulate the industry by limiting UAV flights to line of sight. This currently limits the use and research of UAVs in Canada. In the U.S. new legislation to simplify research applications is widely anticipated.

Source: Eric Edwards

CASE STUDY 3: GOING HEAD TO HEAD

Commercial UAV applications are limited because of BVR legislation. Auto-piloting UAVs risks midair collisions. To address this, a Canadian team from R^3 Rcubed Engineering, Vincent and Mark Contarino, visited the Arizona desert in April 2013. Using grey 38 kg planes called Tiger Sharks they tested the All-Weather-Sense-and-Avoid-System (AWAS).

The system monitors the internal sensors and the ADS-B position reports for risks of a collision. If the risk is high, the AWAS program changes the UAV's course. The team flew two UAVs toward each other to test their avoidance system and the aircrafts didn't crash. Further development of such systems could mean that UAVs may someday fly without supervision over crops and forests(40).

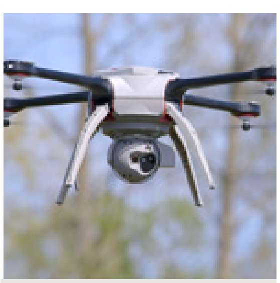
AVOIDING TROUBLE

While the official numbers for aircraft flights in Canada on a given day are approximately 100 manned for every three unmanned(17), all sectors including Transport Canada foresee exponential increases in UAVs in the near future. These numbers don't take into account UAVs being operated privately, a huge potential market only beginning to mature.

With the number of flight hours ticking up daily and expansion of the industry, the likelihood of a collision increases. For small UAVs weighing less than two kg and flying at a height of 500 metres there might be a low probability of trouble. But for larger UAVs it's essential to develop sense-and-avoid technology that would automatically detect oncoming (or "intruding") aircraft(18).

All commercial aircraft have collision-avoidance systems, automated warning transponders that detect and alert intruding aircraft. But most recreational aircraft do not.

Currently, air traffic controllers are able to monitor airspace with powerful radars for busy air corridors. In more remote locations private pilots use visual cues to avoid collisions(19).



Source: Aeryon Labs Inc.

Source: Eric Edwards

IT'S ALL ABOUT LETTING GO - BEYOND VISUAL RANGE

One of the most exciting developments for UAVs involves autonomous or semi-autonomous flights on missions, so-called Beyond Visual Range (BVR). There are many researchers working on systems for UAVs to reliably detect and avoid other aircraft.

The National Research Council along with Canada's ING Engineering has been testing collision avoidance systems. using Automatic Dependent Surveillance-Broadcast System (ADS-B)(20). The network (ADS-B Out) regularly broadcasts each aircraft's ID, position, airspeed and altitude to transponders in all other aircraft (ADS-B In). Thus all aircraft can "see" approaching aircraft and change course to avoid collision(21).

The NRC and ING Engineering's Serenity UAV(22) successfully tested ADS-B transponders on two aircraft over an Ottawa park in November, 2012. This is a first step towards UAVs operating autonomously in Canada's remote regions.

CASE STUDY 4: MYSTERY SOLVED – UAVS IN LAW ENFORCEMENT

Traffic accidents can be difficult to unravel and investigators must piece together what happened using images, witnesses and physical evidence. A bird's eye view of the accident scene can bring a whole new perspective but it can be costly and time-consuming to use a helicopter for aerial photos.

In 2011, small UAVs were deployed and tested in B.C. to capture both high-resolution photos and real-time videos of accident scenes(37). The information collected was so useful that B.C. police expanded its UAV fleet in 2013.

KEEPING AN EYE OUT

With the sophisticated monitoring capabilities that even the most inexpensive UAVs have, privacy is a continuing concern. Several UAV technologies will test the robustness of Canada's privacy protection regimes.

Long-range military UAVs in use today can capture high-resolution images and track moving objects from kilometers away, day or night, in any weather. The use of ultra-wide-band short-pulse radar now allows tracking through walls, and may soon be in use on military UAVs(23). A relatively cheap quadcopter(24) streams HD video from an onboard camera, which anyone can purchase and fly without regulation.

Better software for parsing images complements these data-gathering capabilities. For example, facial recognition technologies may make it possible to identify individuals at political protests, or automatically build a database of where certain groups of people drive their vehicles(25).

On the other hand there are ways to use technology to limit privacy concerns. For example, facial recognition software can be used to automatically find all human faces in images captured by UAVs and blur them(26).

Covert uses of UAVs are also possible. High- and medium-altitude UAVs are making use of stealth technologies(27), but even without this, civilians would have no idea that they were being surveyed. Quadcopters, though operated at much closer range, still have the ability to observe situations without being themselves noticed. Their electric motors are very quiet, and the trend towards smaller size makes them not only less obtrusive but also exponentially more manoeuvrable.

Technology is available for UAVs the size of baseballs to navigate inside buildings and map unfamiliar environments as they go(28). By making more environments accessible, and making UAVs more inconspicuous, these technologies enhance data-gathering capabilities.

Currently, regulations are mainly concerned with safety. However, the private sector is obliged to respect the federal Personal Information Protection and Electronic Documents Act (PIPEDA)(29). The federal government is bound by the Privacy Act(30) and three provinces have their own privacy legislation.

In Canada, the use of electronic surveillance generally requires a warrant(31). The courts have found that even when traveling in public, citizens have a reasonable expectation of some level of privacy, although somewhat less than when in one's own home(32).

The Privacy Commissioner recently released a report specifically examining the implications of UAV technology. The report concludes that although UAV use in Canada is "still fairly limited" due to regulation, the mobility and persistence they bring to surveillance will make them a "game-changer" as the technology proliferates(33).

CONCLUSION

Canadian scientists and engineers, in academia, industry and government are helping to advance the technology and applications of UAVs. The country's vast expanse of wilderness and unprotected coastline highlights the need and potential for this kind of technology.

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Source: Eric Edwards

About SciencePages

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