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Unmanned Aerial Vehicles as a Versatile Research Tool

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Unmanned Aerial Vehicles (UAVs) has been around for many years. While the current public impression of UAVs as influenced by news outlets has formed mostly around their military applications, it may soon change with the penetration of UAVs into the civilian airspace. Infact, with increasingly small and sophisticated components and designs, small UAVs can now be purchased from on-line stores, or assembled by hobbyists at home. Adding to this increasing popularity, a new wave of UAV designs from universities, private companies, and government labs are now tailored for a diverse range of research applications. These new research tools, in the author's opinion, can be categorized into three broad groups based on their intended goals:

1. As an autonomous vehicle: In this sense, a UAV is viewed as a robot that can move around freely in 3D space. This gives researchers plenty of freedom for evaluating sensing and control methods, to explore interactions among groups of vehicles, and to mimic natural flyers with engineered systems;

2. As a sub-scale test bed: For example, a fixed-wing UAV is a small fixed-wing aircraft after-all. They share a similar set of actuators and sensors, operational procedures, and underlying mathematical equations. A small UAV can be a flexible, low-cost, and low-risk alternative for testing new designs, methods, or devices prior to being used on manned aircraft;

3. As a remote sensing platform: Single or multiple UAVs carrying cameras, LIDARs (Light Detection and Ranging), and other sensors could provide situational awareness on demand, especially in a potentially dangerous environment. Compared to manned aircraft or satellites, a small UAV based remote sensing system could be more flexible, intelligent, and effective.

Depending on their different applications, research UAVs can have different sizes, shapes, and functionalities. For example, UAVs for robotics research, such as quadrotors, are often small, easy to control, and can operate within an indoor environment [1]. They can work alone or sometimes in groups linked wirelessly [2,3]. UAVs for mimicking natural flyers are often based on flapping wing designs [4], with emphasis on modeling, control, and miniaturization of components.

UAVs that serve as a sub-scale testbed need to resemble the targeted full-scale vehicles as closely as possible, which could either be a design concept or something that is already operational. In the first case, the UAV provides a proof of concept for new vehicle designs, advanced materials, new types of propulsion systems, or novel sensing and control capabilities. A good example is the Boeing X-48C aircraft, being tested at NASA Dryden Flight Research Center, as a step towards quieter, cleaner, and more fuel-efficient airplanes for the future. In the latter case, sub-scale testbeds can help to characterize aircraft behaviors in dangerous, off-nominal flight conditions or for validating mitigation approaches following these events. For example, the NASA AirSTAR (Airborne Subscale Transport Aircraft Research) testbed is a dynamically scaled transport aircraft model that has been used extensively for aviation safety research [5]. A sub-scale testbed can also be used for simulating aircraft damages or accidents. For example, in a DARPA (Defense Advanced Research Projects Agency) sponsored project, a sub-scale F/A-18 was used to demonstrate recovery methods after the loss of a significant portion of the right wing [6].

Remote sensing platforms are typically optimized for range and endurance. They are often launched and recovered from a tight space. Usually, they carry mission specific sensors and have a tight tolerance on the aircraft navigation performance. Some UAVs have been designed to work under extreme weather conditions, such as inside hurricanes or polar regions.

So, who can benefit from this new generation of research UAV development? Almost everyone who is interested in reading this so far. For examples, aeronautical engineers can test new design concepts with a small unmanned prototype; control researchers can validate adaptive and fault-tolerant algorithms without accessing a full-scale aircraft; computer scientists can develop vision-based navigation methods, or study the interaction of multiple intelligent agents; geologists, meteorologists, and oceanologists can use UAVs to collect scientific data; entomologists and engineers can work together to build insect-like flyers; students can acquire hands-on and team work skills by participating in experimental flight testing research. The application of research UAVs is limited only by our imagination. Of course, no one is good at everything; but if we could share our ideas, designs, and results in an open-access platform, progress can be made much faster.

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