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Using Unmanned Aerial Vehicle Technology to Enhance Conservation Biology Research

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to Enhance Conservation Biology Research

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Abstract

This study examined the most effective ways to utilize unmanned aerial vehicles (UAV) for wildlife conservation. More specifically, a UAV platform was created that can perform multiple data collection tasks by utilizing interchangeable modules. The prototype produced in this study has the capability to perform many tasks through the use of interchangeable modules. These tasks include, but are not limited to aerial surveys and collection of biological samples. This innovative technology will provide invaluable assistance to conservation efforts by reducing research and subject injury or death while maximizing efficiency. The modular design of the prototype was developed for retail to major UAV manufacturers and individual researchers.

By utilizing a remotely operated system, biologists will be able to collect data in more remote areas, cover a larger area in the same amount of time, and have a safer distance between themselves and potentially harmful wildlife. A modular design will limit the amount of individual supplies needed for multiple samplings.

This modular UAV system helps to extend current research done in remote locations, protects researchers working with dangerous wildlife, and provides a more effective and efficient method of data collection.

Introduction

Unmanned aerial vehicles or UAVs (hereafter – drones) have been applied to many fields of use and study as their technology progresses. Drones were first developed for military use around World War II (Sandbrook 2015). National Aeronautics and Space Administration (NASA) began completing high-altitude research with drones in the 1970's. As technology improved in the past 15 years, drone prices dropped significantly, making them more accessible for research, recreation, and many other applications (Marris 2013). What makes drones so useful? They are generally easy to pilot and have the capability to carry a variety of tools. These tools include still and video cameras with or without reflected thermal and infrared radiation and emitted thermal radiation sensing devices, audio monitoring devices, loud speakers, liquid sprayers, accelerometers, GPS, and light emitting devices (Sandbrook 2015).

As technology in this field continues to advance, drones have the opportunity to be used in many diverse ways: to deliver goods to underdeveloped countries, to monitor the quality of crop growth, and to inspect buildings after fires and other natural disasters (Floreano 2015). The number of applications for drone use is endless because drones are capable of providing high resolution data that are systematic while having low operational costs and low-risk for operators (Linchant et al. 2015).

There are two major types of drones: fixed wing and multirotor. Fixed wing drones operate like small airplanes while multirotor drones operate more like small helicopters. Fixed wings generally have longer flight times but multirotors are more stable and can hover, providing different applications. Multirotors are also less expensive, they don't require a large amount of space to take off and land, and the battery life has become comparable to fixed wings (Linchant et al. 2015). For these reasons, multirotors have more applications for research.

In recent years, drones have been used by researchers for various scientific studies. This shift in application began when drones became more agile, autonomous, and better able to work in groups. Drones allow researchers to gather data in cases where conditions would otherwise be too extreme. Since these advances, drones have been used for polar research, volcano studies, and wildlife biology, amongst other projects (Marris 2013). At the University of California in Santa Barbara antennas were attached to quadrotor drones to gain measurements of high-frequency oceanographic radars to observe surface currents in the ocean (Washburn et al. 2017). Drones have been used internationally to monitor and research landslides without needing people to be present at the site (Al-Rawabdeh et al. 2017). In the Midwest, drones are often used to take photographs of a field and apply software to analyze the images for data about plant health, field mapping, and crop variability (Smith 2017). Web services like Drone Deploy allow individuals to access this image analyzing software without needing to create it themselves.

Drones have wide applications in terms of spatial ecology research. The combination of sensors found on most drones can create maps and numerical representations of wildlife and natural resources. This ‘birds eye view’ provides a new perspective to this kind of field research. This technology is often used to identify and locate invasive and native species so they can be more effectively managed (Avron 2017).

Wildlife research has been greatly expanded by the use of drones but is also limited by the drones themselves. Research that benefits from the use of drones is often done in remote locations or poor conditions, making the use of drones a helpful addition to the project. Because of these conditions researchers often have to use light weight drones with limited fuel capacity rather than heavy systems that can fly longer, simply for ease of use (Marris 2013). There is a delicate balance between the quantity and quality of the sensors and the payload and flight time of the drone, making the model selection critical to the effectiveness of the project (Linchant et al. 2015).

Even with these limitations, drones remain a cost and time effective way to survey wildlife, map terrain, and monitor ecosystems. They provide more precise population counts, especially for species that aggregate like birds (Penberthy 2016). Drones do not require a landing strip like traditional light-weight aircraft do, allowing them to take off vertically, operate in rugged environments, and fly below cloud cover (Krause et al. 2017).

In recent years, drones have been used in the wildlife field in several different ways. Drones are commonly used to survey large terrestrial animals including deer, elephants, and orangutans, aquatic animals including dugongs, manatees, and whales, and birds including geese, gulls, and various wading birds. Anti-poaching is an area of high interest and many studies to control poaching have been based off the effectiveness of using drones to survey areas that have a high number of poaching incidents (Linchant et al. 2015). The organization Conservation Drones uses custom built drones to find and monitor poaching and illegal activity in protected areas while training other researchers to do the same (Penberthy 2016, Rutkin 2015).

Drones are often used to survey species from a distance and gather many kinds of data that would take much greater time and effort from individual biologists. Body size and nutritive condition of leopard seals near Livingston Island, Antarctic Peninsula, were surveyed using drones rather than small aircraft. This allowed the research to be conducted in a much safer and time effective manner (Krause et al. 2017). Similarly, population stability of loggerhead sea turtles and future stability from sex ratios was determined by using drones to survey when male loggerhead sea turtles left the breeding grounds (Schofield et al. 2017). Drones were used in

Labrador to track radio signals from tagged woodland caribou (Rutkin 2015). This is just a sampling of the conservation projects that have benefitted from the use of drones.

Most drones come equipped with electro-optic or infrared cameras (Linchant et al. 2015) while other drones come equipped with a standard camera that can provide both still images and video. Still others come equipped with no sensors other than the GPS system needed to fly the drone, and often times the cost of the drone and the funds of the research project determine which model is purchased rather than what sensors are needed to complete the task. Because of this limitation in drone models themselves, there is a need to attach different sensors to perform different tasks. This potential formed the basis of our research. Our goal was to create a single system that could be attached to the drone and have sensors interchanged to perform different research tasks. Specifically, we designed an attachment device for the DJI Phantom 3 Professional and also tested how the attachment may influence operational capacity (e.g., battery usage).

Methods

We selected the DJI Phantom 3 Professional as the basis of our study because it is in the middle of the market price-wise and is available from many retailers. DJI produces a variety of drone models, making them a prime company for manufacturing this design for retail. This drone came equipped with a 4K camera and the GPS system that is standard for most drones. Additional sensors that are useful for conservation research include infrared sensors, red-green-blue (RGB) cameras, and sensors to gather environmental data including temperature, wind speed, and moisture levels. Google Sketchup was used to design the platform. We specifically designed the prototype to attach snugly to the landing gear of the drone without interfering with take-off or landing. The most important aspect of the design is the dovetail clip. This allows any sensor to be attached to the drone as long as it is attached to the corresponding dove tail.

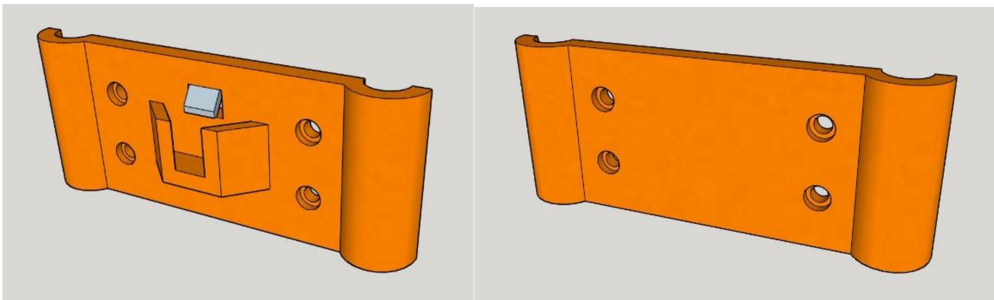

Figure 1: The Google Sketchup design of the front (left) and back (right) of the prototype, including the dovetail clip.

The prototype was made with a 3D printer. This method of making custom, small, lightweight aircraft components is fairly common and has been used in other studies (Washburn et al. 2017). This method of printing is effective because it is relatively inexpensive and provides custom parts with a quick turn-around. Four different prints were done to adjust the design to fit the landing gear and to reach the quality and strength of material needed to withstand the attachment of different sensors.

All four prints were made of polylactic acid (PLA) and were printed with the same 3D printer. For the first print, the quality and density settings on the printer were too low. This created a shell of our prototype that had no internal support structure, causing the prototype to be too flimsy to be able to carry anything. The second print was done on a higher quality and density setting but did not fit the landing gear of the drone. The third print properly fit the landing gear, but the full geometry of the dovetail clip did not fully print. The fourth and final print fit the landing gear, printed the full dovetail clip, and had the appropriate quality and density settings on the printer, providing enough strength to withstand flight and carry additional attachments.

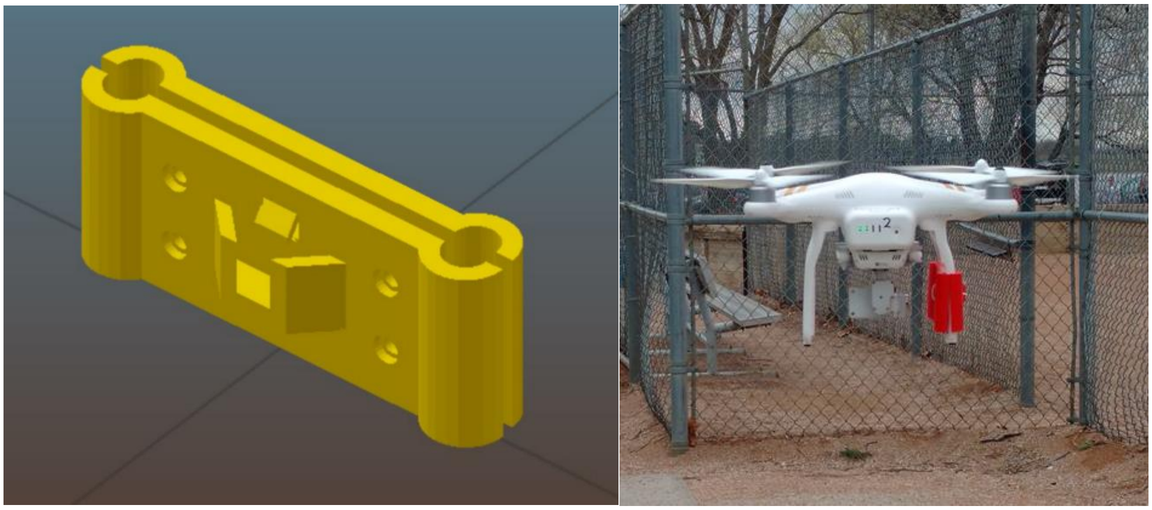

Figure 2: The complete Google Sketchup design of the prototype (left) and the prototype attached to the landing gear of the DJI Phantom 3 Professional (right, red item on right side of landing gear in the image).

We tested the impact our platform had on the flight of the drone. Payload and battery life are often the most important limitations of research that can be done with a drone. To test the impact the prototype had on the payload and battery life of the drone, we conducted a power test. The drone was taken from the ground to 200 feet at the fastest ascent possible. These test flights were piloted by my research partner and I recorded the results. We then recorded the time it took and the percent of the battery that was required. This test was done five times without the prototype attached as a control group and five times with the prototype attached as the experimental group.

Results

During the power test we recorded the time the drone took to ascend to 200 feet and the percent of battery needed to complete this task. For the control group, the average time to ascend to 200 feet was 17.07 seconds and 4% battery was used per flight. For the experimental group, the average time to ascend to 200 feet was 18.94 seconds and 7% battery was used per flight. A t-test was used to determine if the results were statistically significant. The p value of the battery life was 0.1038, meaning the battery used for each flight was not statistically significant. The p value of the time of each flight was 0.0044, meaning the difference in time between the control and the experimental group was very statistically significant. These results are acceptable for the purpose of this study. While the drone is significantly slower when the prototype is attached compared to when it is not, the slower drone would still be faster than collecting the data without using the drone at all. Battery life is often the bigger concern in the field because it is a limiting factor of how much research can be done. Our results show that the change in battery life with or without the prototype attached is not statistically significant.

Table 1: Results of the control group for the power test. No prototype was attached.

	Flight 1	Flight 2	Flight 3	Flight 4	Flight 5
Time to 200’ in seconds	17.38	17.61	17.04	16.47	16.86
Battery Percent Used	5%	2%	4%	5%	4%

Table 2: Results of the experimental group for the power test. Prototype was attached.

	Flight 1	Flight 2	Flight 3	Flight 4	Flight 5
Time to 200’ in seconds	20.55	18.09	19.11	18.38	18.60
Battery Percent Used	8%	5%	4%	5%	6%

Discussion

The prototype we created met the goal of creating a UAV platform that can perform multiple data collection tasks by utilizing interchangeable modules. The prototype produced in this study has the capability to perform many tasks through the use of interchangeable modules. These tasks include but are not limited to aerial surveys and biological samples. This innovative technology will provide invaluable assistance to conservation efforts by reducing risk while maximizing efficiency. By using this prototype alongside a drone, researchers can perform more tasks in the field with fewer supplies because multiple types of data can be gathered using the same system. This will make data collection faster and require fewer field technicians to complete. Attaching various sensors to the drone allows data to be gathered in places researchers have been unable to reach before.

However, our platform is specifically designed for use with the DJI Phantom 3 Professional. To duplicate these results with a different drone would require the platform to be redesigned. This is a simple enough task now that the initial design has been created and tested, but multiple prints are to be expected to troubleshoot any additional problems with fit and quality. By allowing DJI to manufacture our design for the consumer market, individual researchers would not have to redesign and test the platform for use with drone models other than the Phantom 3 Professional.

Even with a system that allows for different sensors to be used at different times, there are pros and cons to using drones for conservation efforts. One con particularly for any research done in the United States is the regulations surrounding UAV use. The Federal Aviation Administration or FAA requires potential drone operators to apply for and receive a certificate if they want to fly outdoors. This is done to limit hazards to aircrafts, people, and property on the ground, which means flights often are not authorized inside city limits (Marris 2013). Flights also cannot be taken over unprotected people who are not directly participating in the drone operation (American Society of Safety Engineers 2016). This is not the biggest problem for wildlife research as most would occur in remote locations, but other limitations are in place as well: drones must be flown during the day, be in sight of the operator, and be flying lower than the lowest limit for manned aircraft (Linchant et al. 2015). Specific airspaces have limits as well, including airspace over national parks and hospitals and other emergency facilities.

Different countries have different regulations. In Australia and Canada, most types of drone operation are allowed without acquiring individual permits (Marris 2013). Overall, European countries agree with American regulations and require permits and certificates before drones can be flown (Floreano 2015). Even countries that have few regulations regarding the use of drones have had issues. In both Mozambique and India drone flights were planned for conservation purposes but their deployment was prevented by the military (Sandbrook 2015). Researchers working across international borders often have to contend with the rules of both countries, limiting the actual effectiveness of this technology.

In many cases, what drones can be used for is often limited by regulations before they are limited by technology (Sandbrook 2015). These limitations prevent researchers from testing all possibilities and decrease the amount and type of research that can be done with drones (Linchant et al. 2015). The system designed in this project can still assist researchers even in this time of regulations. Once researchers are authorized to access an area via drone, utilizing this system will make their research more effective. These authorizations often come with a specific time frame and having many sensors that can be attached to the same drone will allow the necessary research to be completed within the available time frame.

The safety of drones is often brought into question as well. From the researcher's point of view, drones make many surveys much safer than the alternative. Aviation accidents accounted for 66% of deaths of researchers in the field in the United States between 1937 and 2000 (Rutkin 2015, Sasse 2003). Environmental conditions can also limit the research that can be done with aircrafts and they are very expensive to rent and use (Linchant et al. 2015).

From the public's point of view, worries about infringement of privacy and civil liberties surround conversations of drone usage. Since drones were used for military purposes long before they were used for conservation, miscommunication about the actual purpose of the drone are common and can cause fear, confusion, and hostility. These worries are often lower with drones used for conservation because they are being deployed in remote areas with few people, but there are still concerns to be considered. However, it has also been argued that drones could be socially empowering if local people are using drones to survey their own land, forests, or animals. Drones are safer when crashes occur because there is no pilot inside and they are potentially safer to people on the ground because they are much smaller than the small aircraft that would have otherwise been used (Sandbrook 2015, Wilkins 2017). Ultimately, these factors should be considered when drones are going to be used in an area but in most cases drones used for conservation are not impacted by these social questions.

The last potential problem to consider is the impact drones have on the wildlife being surveyed. In most cases the drones are being used because the population is difficult to reach and they stay far enough away from the animals to cause no disturbance. This is the same case with drones being used to survey poachers and other illegal activity. Studies have shown that both wildlife and poachers do not notice the drones surveying them because they are quieter than the aircraft that would have been used in the past (Penberthy 2016, Rutkin 2015).

Another factor for potential wildlife disturbance in the flight pattern of the drone. Studies have shown that if the drone approaches quickly and directly, the animal is more likely to be disturbed by its presence. This flight pattern is target oriented and used for photography, nest inspections, and animal control. It is also performed at lower elevations. On the other hand, if the drone takes a 'lawn mower' flight pattern (Figure 4), the level of disturbance is limited. This flight pattern is more common in the type of survey work drones are often used for so in most cases animal disturbance is fairly low. 'Lawn mower' flights are used for mapping, surveillance, and wildlife census and are performed at higher altitudes following regular trajectories. Studies have shown that species living underwater had the lowest response to drones, followed by terrestrial mammals and then birds, with flightless and large flying birds seen to be more likely to respond to the presence of a drone (Mulero-Pazmany et al. 2017).

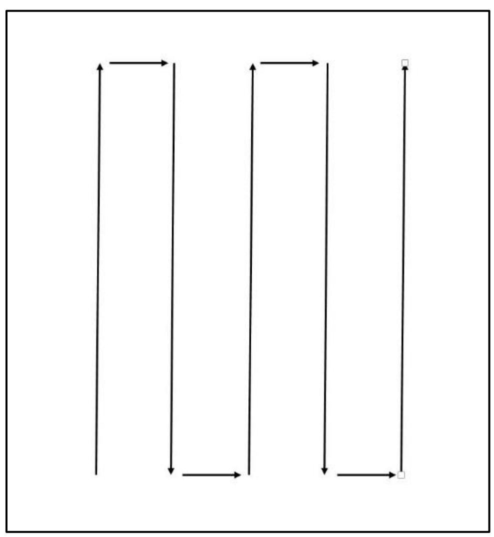

Figure 3: 'Lawn mower' flight pattern.

Conclusion

Overall, drones can add a lot to conservation efforts. They have the ability increase the time and cost effectiveness of field research and can be applied to many other fields. The potential to have interchangeable sensors will increase the effectiveness of field research projects. The prototype we created has the ability to improve field research but is currently only designed to be used with a DJI Phantom 3 Professional drone. By allowing DJI to manufacture our design for the consumer market, individual researchers would not have to redesign and test the platform for use with drone models other than the Phantom 3 Professional. Any time drones are used, there are many factors to be taken into account. It is important to be aware of the regulations and people involved as both may limit what can be done in a certain area. As with any research, it is important to consider the impact the research methods will have on the species in question. In most cases drones do not disturb animals and have more benefits than costs.

There are many drone attachments available on the marked including specialized landing gear, extra lighting and cameras, and more advanced GPS systems. Each attachment is made for a specific type of drone and is attached individually. Finding the attachments on the market that could be useful for the research being done is an option but leaves researchers with fewer choices for the types of sensors they can use and the types of data that can be collected. Our system looks to bypass the market options and allow researchers to customize their data collection needs by attaching any sensor to the system and then attaching it to the drone itself. To our knowledge, this system has not been created by drone manufacturing companies but individual researchers have made their own. Making this technology available to researchers would allow them to customize the drones they are already utilizing and gather more data with fewer devices.

The specific design of the system would need to be altered to fit drones other than the DJI Phantom 3 Professional, but this can be done fairly easily. 3D printing is cost effective and often easily accessible. This system has the potential to be applied to many different drones and used to attach many different sensors to more easily complete data collection.

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