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Quadcopter Safety

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**Fall**

 Only a few short years ago drone technology was new enough that only the military had the knowledge and funding to exploit it. The incredible capabilities of drones were showcased very soon after they were first tested and incorporated in to the battlefield. Drones allowed soldiers to stay out of harms way while accomplishing tasks that would have put soldiers behind enemy lines in the past. Soldiers were now able to perform tasks such as surveillance and reconnaissance, as well as delivering precise missile strikes to targets all while staying many miles away from danger.

 Most of these autonomous vehicles or “drones” were fixed wing aircraft that were capable of flying for many miles and carrying impressive payloads of reconnaissance equipment or weaponry. However, there were advances in technology that allowed engineers to create smaller and more stable aircraft that were capable of operating in tight spaces and could land and take off vertically. These aircraft came to be known as “quadcopters” thanks to their four distinct motors that provide lift for flight. While these aircraft were not capable of carrying a payload over a large distance it was their maneuverability and ease of use that made them popular. The quadcopter design was much more stable than a traditional helicopter, because the four motors could work together to create a stable platform and combat outside forces such as wind.

 The great flight characteristics of these quadcopters meant that the technology started to spread to the general public soon after their conception. Aviation hobbyists were the first to try to recreate the technology by wiring up and creating their own quadcopters to fly around their backyards. The idea caught on quickly and soon companies started to develop quadcopter kits and ready to fly quadcopters for consumers to purchase and enjoy. In the past couple of years quadcopters have really taken off (excuse the pun), and it appears that many kids, and even adults, in the U.S. and other countries have received them as gifts for Christmas and other holidays. While this may seem only fun on the surface it has created a logistical nightmare for the Federal Aviation Administration (FAA) as well as posing numerous health and safety risks across the globe.

 The nature of the threat created by quadcopters being wide spread is multifaceted. First of all there is the obvious issue of physical harm. This comes from the four high-speed blades that surround the periphery of the aircraft. Also quadcopters are capable of flying at fast speeds, so there is the danger that one could impact a bystander or passing civilian. There is another threat created by the use of cameras, which is very common now, on the quadcopter itself. It is very easy for an operator to fly their aircraft into someone else’s private space and film things that they should not be filming. Next, these quadcopters are capable of reaching pretty incredible heights without much difficulty, so one can see that this would be a threat to other air traffic such as commercial flights. Lastly, it is far too easy for an individual to attach a gun or other weapon and fly it into a populated area and create grave damage. All of these concerns will be explored in the following paper, and current or possible solutions will be shown to make the operation of quadcopters safe.

 The most obvious danger associated with flying drones is that of physical or bodily harm. There are two main aspects of quadcopters that make this bodily harm a real possibility. As mentioned before, quadcopters are surrounded by four high-speed propellers that create all of the lift needed to fly the aircraft. This creates a hazard, because these four propellers are the first things that will come into contact with an object in the event of a crash. In the case of a collision with a human these propellers can lacerate and cut flesh with terrifying ease. Luckily most of the smaller and more popular commercially available drones use thin plastic propellers that will not cause a lot of damage, because they will bend or break when they hit an object. However, some of the larger drones use carbon-nylon, glass filled nylon, and even carbon fiber in their construction. These propellers are much harder and stay together upon impact with smaller objects. Clearly these present a great danger because they will cut into flesh and even break and sever fingers if not handled carefully. One example of this took place in Virginia where a bull run was taking place. In this case the drone was being used to film the bull run from the air when the drone operator lost control of the aircraft. The drone then proceeded to crash into a crowd of spectators watching the event, but thankfully no one was seriously injured. One of the affected spectators did mention that they put their hands out to try to deflect the drone and that their fingers were damaged by the impact with the propellers. Thankfully, in the example of the drone crash in Virginia no one was seriously injured. Even though the spectators got lucky this crash shows the real threat that the propellers can be to human health.

 The second potential threat to physical health created by drones is from the great speed that drones can fly at. Many drone enthusiasts now fly drones that they call “racing quadcopters”. These aircraft are very powerful and are capable of making very sharp turns and flying at high speeds. Some of these aircraft platforms are capable of flying at speeds in excess of 80 miles per hour. Clearly this high-speed flight can lead to high-speed crashes, and these high-speed crashes have the potential to cause serious bodily harm if the drone involved is a larger size. One instance of a drone crash of this nature took place in Pasadena, California in 2015. In this case a drone operator was flying a DJI Inspire (a more popular drone brand) and crashed the drone at high speed near a mother on a walk with her baby. Thankfully the drone did not impact the people directly, however it did crash close to them and kicked up debris that left the baby with a cut on its head. This instance shows how dangerous high speed flying can be, and thankfully this crash was not a direct impact with people.

 Both of the two issues of physical harm caused by drones are real possibilities for both drone operators and innocent bystanders. Some companies have tried to mitigate this risk by making their drones out of lightweight materials, so in the event of a crash there is not much risk for bodily harm. Some companies even go as far as surrounding the propellers with bumpers, so that the propellers will not contact anything in the event of a crash. This however is not a very successful technique, because a lot of drone owners do not like the look and reduced performance that the bumpers create, so they remove them. The FAA has taken some measures to try to prevent crashes with humans as well. They have instituted a rule that says all recreational drone operators may not fly drones over unprotected civilians, and drones must stay at least 25 feet away from civilians while in flight. This is a good rule in theory, however this is also a rule that drone operators will find very tempting to break.

 While bodily harm is a clear danger that is associated with drones there is a much less obvious threat that most drone platforms are capable of producing. Most of the popular civilian drones are sold with some form of camera on them that is capable of taking pictures, recording video, and even live-streaming video back to the operator. While this may create the opportunity to take amazing pictures and videos, this also has the very real potential of creating an invasion of privacy. The maneuverability of the drone makes it very easy for an operator to take a camera into places that would have been much harder or impossible to get to in the past. This means that drone operators are now capable of invading people’s personal privacy by filming over their property and even into their homes. Another serious implication of such a maneuverable camera platform is that ordinary citizens now how the capability to spy on restricted and even secret areas. Many companies have proprietary information that is a key asset to their company, and they do not want public eyes to see how it works. This could cause an issue, because people could sell these trade secrets that they learn and then make the company lose sales on their product. This invasion of privacy can also apply to restricted government areas as well. People now are able to fly past traditional security measures and enter restricted areas that have sensitive government information in them. One example of this happening in recent news occurred near the White House. In 2015 an intelligence agency employee flew a drone near the perimeter of the White House, but lost control of the aircraft. The drone then proceeded to crash on the front lawn of the White House and was confiscated by the secret service. This mishap shows just how easy it is for drones to invade privacy and gain access to areas that were traditionally very secure.

 The FAA has tried to mitigate the invasion of privacy issues created by drones in recent years. They have instituted a law making it illegal for drone operators to fly over sensitive areas, such as government and company facilities. This appears to be a good deterrent along with stiff penalties that can come with breaking these laws. However, the best deterrents are the ones that simply don’t even allow a drone operator to wander into restricted territory in the first place. These devices will be discussed later on, as their main area of employment is near airports.

 Speaking of airports, the next threat to safety created by drones deals with commercial airline flights. Quadcopters are capable of flying to heights that are only limited by how high their battery will take them. This means that a quadcopter operator that flies a drone straight up would be capable of reaching altitudes of many thousands of feet. One can easily see how this could quickly become a problem for airline and recreational aircraft pilots. Drones that are capable of flying to these high altitudes are in danger of being in the flight path of on oncoming aircraft. This means that the commercial plane could crash into the drone, which could ruin engines and smash windshields on a plane. Recently there was a video of a drone operator that decided to see how high he could make his drone fly. In this instance the drone was flown up to an altitude of over six thousand feet above ground level. A drone at this altitude is in danger of being in the flight path of smaller aircraft as well as aircraft that are descending on their approach to an airport. There have not been any documented cases of a drone crashing into a plane and causing the plane to crash. However, there was one incident where a pilot at Heathrow airport believed that his plane had struck a drone while he was on final approach for landing. Thankfully it turned out that there was no drone involved in the incident and there were no major damages to the plane. As one would image the FAA has stepped in to try to mitigate the risk of drones entering the flight path of commercial airliners. They have created a rule saying that drone operators must not operate their drones within five miles of any airport. Also, if you for some reason want to or have to fly within that five-mile limit you must first contact the control tower of that airport and make sure it is ok with them.

 The last aspect of drone safety that needs to be reviewed in this paper is perhaps that most hazardous. While most drones are only capable of carrying payloads of a couple pounds some are able to carry objects that weigh up to fifty pounds. This may seem useful in many circumstances, however with this capability comes a lot of potential for hazard. Being able to carry a lot of weight on a drone means that someone could easily attach a weapon to the drone. The weapon could come in many different forms including guns and explosives. This is especially dangerous because drones are able to take that weapon into an area that would have been difficult to reach on foot without the drone. This means that the potential for danger is much higher and traditional terrorist attacks due to the maneuverability of the drone platform. Weaponizing a drone would allow a bad guy to fly a drone into a populated area, cause a lot of harm, and then either ditch the drone or fly away. This is especially worrying, because the operator of that drone could successfully carry out his mission while controlling the drone from over a mile away.

 Clearly there is a lot of potential for terrorists to use a drone platform to cause a lot of damage. This issue is one that has been considered by the FAA as well as other government agencies. In an attempt to stop most people from experimenting with weapons on drones the FAA has said that it is illegal to attach a weapon to any drone platform. This law will most likely stop most civilians from creating a potentially deadly weapons platform. However, there is one video that went viral a year ago because a guy strapped a handgun to his drone and then showed it firing at targets. This video showed the public just how easy it was to create a “flying gun” that could be maneuvered and aimed precisely.

 When it comes to drones there are many topics that need to be discussed to ensure safe operation. The goal of this paper was to outline these topics, show why each threat matters, and show how each threat is being mitigated. As an engineer that has the potential to create potentially life changing, but also potentially harmful technology, there is a great responsibility to understand the risks involved. By knowing the risks associated with a project, the engineer will hopefully take measures to ensure the safety of the public and follow the IEEE code of ethics. There is a big responsibility that comes along with creating an autonomous system, even if that system is intended to be used for recreation only. The engineers creating the autonomous drone platform must fully understand the capability of their technology. By understanding their technology they can proactively look for ways that their product can be misused or used for harm. This allows the engineers to build in safety measures that will keep the consumer and public safe while using their product.

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