Inventing an Artificially Intelligent Autonomous Drone to Secure School campuses and Businesses Utilizing Computer Vision Technology to Detect Suspicious and Irregular Behavior

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Abstract

Unmanned Aerial Vehicle technology is growing in usage by companies and governments. Inventing an inexpensive autonomous drone capable of capturing recordings and providing security for its users using security hardware would make public and work environments safer. The drone will be developed to scan for human behavior using custom haar cascades or the tracking of objects through video. The drone will fly autonomously by tracking its user and mapping its user's position. The student-designed and created the drone utilizing a flight controller and DIY drone equipment assisted by additional components such as a camera and sensors. The autonomous system will be programmed utilizing Python and will run on a Raspberry Pi which will produce signals that a flight controller would look for to fly autonomously. The first test will have ten trials to determine the drone's accuracy in determining a disturbed body posture or suspicious activity. The second test will have five trials which will be measuring for a six by six-foot distance from the user. Lastly, the drone will be tested three times for its autonomous flight time on a full charge. Current drone operations in security are highly supervised and aren't effective. People in cities, college campuses, and businesses will now have drones that require little to no supervision while securing facilities and alerting the public about disruptions or accidents with its user base.

Research Plan

The autonomous drone will need to face several criteria including: A. The drone must have the ability to fly completely on its own when commanded to. B. It must keep a six by six foot distance from the surveilled people. C. The drone must be able to fly at least twenty minutes autonomously. D. The drone must be able to recognize when the surveilled user or users are being disturbed or if there is any kind of unusual activity. This autonomous drone project will face limitations including the consumer-grade technology onboard, the slightly high costs associated with the development of drone technology, and the amount of time provided to develop all of these components of the project. An autonomous drone will be developed to scan for human behavior using custom haar cascade technology otherwise known as the tracking of objects or specific objects, video tracking, and computer vision technology. The drone will fly autonomously by tracking its surroundings and user and mapping its movement to be always aware of its user's safety status. The drone will be designed and created by me with the assistance of Dr. Zhao and it will utilize an inexpensive flight controller along with heavy-duty DIY drone equipment such as a 3s lipo battery, a power distribution board, and wiring along with additional components such as a camera, sensors, and an alarm. The autonomous system will be programmed using Python and Computer Vision, and will run on a Raspberry Pi which will produce radio signals that a flight controller would look for from an RC controller to ultimately fly autonomously. The autonomous drone project will potentially be tested for its ability to understand its user's status, its autonomous flight stability and comfortable flight distance from the user, and lastly, its flight time when flying autonomously on a full charge. This drone will be tested for detecting the user's or users' status which will be tested ten times for the drone's accuracy in determining the user's disturbed body posture or any other suspicious activity. The drone will then be tested for a comfortable flight distance from a user and will have five trials which will be measured for its distance from the user. Lastly, the drone will be tested for its flight time on a full charge. This will be tested for three trials and the drone will be fully charged and set to autonomous flight. Current drone operations in security are highly supervised and aren't as secure. People in cities, college campuses, and businesses will now have drones that require little to no supervision while securing facilities and alerting the public about disruptions or accidents with its user or user base.

Results

The Unmanned Aerial Vehicle or UAV was tested for its ability to understand the user, ability to track and determine the user's status, ability to fly for prolonged periods of time, and ability to keep a comfortable flight distance from a user or user base. The postures that were tested were hands in the air, a fall on the floor, hands at the neck, a right turn, and a left turn. There were two trials to double-check the accuracy of the computer vision on the drone during flight and it was found that the program was able to detect the “hands in the air” and a right turn posture for both trials. Furthermore, the program was able to detect the “left turn” and “hands at the neck” posture once out of the two trials. Lastly, the program was unsuccessful in determining if a person is on the floor or not. In figure one, you will find exact data on what postures the program successfully detected along with the ones it did not detect.

Fig. 1: 10 Trials (Yes and No Trial Results. Yields % Accuracy from 5 different Postures)

Postures (5 different postures and 2 trials per posture with 10 Total Trials)	**Trial Result: (Detection of situation)**	**Percent Accuracy from Total 10 Trials (Amount of “Yes” the program scored from 10 trials)**
Trial 1: Hands in Air	Yes	///
Trial 2: Hands in Air	Yes	///
Trial 1: Fall on Floor	No	///
Trial 2: Fall on Floor	No	///
Trial 1: Hands at Neck	Yes!	///
Trial 2: Hands at Neck	No	///
Trial 1: Right Turn	Yes	///
Trial 2: Right Turn	Yes	///
Trial 1: Left Turn	Yes	///
Trial 2: Left Turn	No	60% Accuracy

When testing the drone’s flight time capabilities, the most important factor was keeping the drone in autonomous mode and fully charged before testing. In the first trial, the drone was able to keep approximately thirteen and a half minutes of flight time autonomously before beginning to shut down. In the second trial, the flight time was approximately twelve minutes. In the third trial, the drone flew for about thirteen minutes to then give an average flight time of about twelve and four fifths minutes of flight time. In figure two, you will find exact data per trial for the drone flight times.

Fig. 2: 3 Trials (Total minutes flown before battery fully depleted per trial)

Trials	**Full Flight Time Before Battery Depleted (3500 mAh 3S Lipo)**
Trial 1	13.49 Minutes
Trial 2	≈ 12 Minutes
Trial 3	≈ 13 Minutes
Averaged Times	≈ 12.83 Minutes

The last test was to see if the drone can fly a high enough distance from a user for people to be comfortable while also allowing the drone to perform its duties. The goal was to have the drone keep a six by six-foot distance as this is high enough for both the user to be comfortable and the drone to fully function. The drone was unsuccessful in all attempts to keep this flight distance. It typically kept a two to three-foot by five-foot flight distance but never higher.

Drone technologies have become increasingly prevalent in the work we do today. From agriculture to construction, drones assist us in shaping our future and executing it efficiently and effectively. While many industries have adopted them, they are still riddled with logistical and physical problems. According to the *Capital Projects & Infrastructure* magazine, the United States has been a particularly strong source of commercial growth, with the value of drone activity rising from $40 million in 2012 to about $1 billion in 2017 (McKinsey and Company, 2017). Between crashing, widespread deployment, and buggy behavior, drones and especially autonomous drones need more revisions and scientific research before they can become a critical part of our lives. Currently, there is approximately 19.5% of on-campus crimes reported per 10,000 full-time-equivalent students (NCES 2016). With this project, autonomous drones play a more important role and display capabilities that can be widely adopted between schools and businesses for a faster, safer, and more secure way to protect students from violence, distress and crimes.

For testing, the goal for the drone's accuracy in determining violence or distress was eighty percent, the goal for the drone's ability to fly autonomously and continuously was twenty minutes, and the last goal was to have the drone fly a comfortable distance of six by six foot distance away from a user or user base. While none of the goals were met, the drone has shown progress through each iteration.

When it comes to determining the distress, the program achieved a sixty percent accuracy. The majority of outliers or failed assessments of the posture are likely due to the computer vision's training time and how much it actually learned from the postures. A potential solution to this issue could be an increase in training data and training time, e.g. additional postures, positions, and potential participants making these postures. With the implementation of newer technologies, the drone should also have higher accuracy percentages. Looking at the patent Christopher P. Woods and his colleagues had written up called *SYSTEMS AND METHODS FOR THREAT RESPONSE*, new microphone technologies can be implemented in drones to efficiently, effectively, and safely secure areas (Woods et al., 2020). Along with newer microphone technologies, new infrared technologies can allow for the drone to better detect postures in low light areas potentially raising the accuracy of the detection.

In the power endurance testing phase, the idea was to put the drone in a real life situation for truly accurate testing. When testing finished, the average flight time came out to be approximately twelve and a half minutes long before fully discharging. The variations in flight times became apparent and may have been due to the second battery involved in powering the computer vision side of flight. This battery is responsible for autonomous flight and may have played a large role in the results of the flight times. Other factors likely responsible for the variations in flight times may have been wind and weight imbalances as the drone flew. Winds caused the drone to readjust using more power to re-center and a weight imbalance may have caused the drone to require more power directed towards the motors on the heavier portion of the drone to center itself.

The final test in mind for this project was to have the drone fly a comfortable distance from the user so that the drone wasn't a burden on people in a real world environment. The drone currently adjusts its position using computer vision to determine the user's position and convert it into a set of coordinates.

These coordinates are then used to adjust itself to follow a user. While unsuccessful in keeping the ideal flight distance, the drone will most definitely experience new improvements and adjustments to create a comfortable experience from re-working flight plans to potentially a new autonomous flight program.

Conclusion

With this project, the various limitations faced included a small window of time to complete a functioning drone, consumer grade hardware, and the slightly high costs associated with the development of the drone technology. Future plans include potentially designing a smaller, lighter, and smarter drone capable of swarming in groups, collecting more information, flying for longer periods of time, and communicating with people better than ever before. With drone technology emerging in practically every industry, there is no better time to build a more streamlined, modern, and secure system to eliminate the need for antiquated stationary cameras with limited ranges of motion. Security can finally experience a revolution.

Works Cited:

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