Name: Michael A. Bermudez

Name of Project Advisor(s): Dr. Halser

Group Name: AutoQuads

9/30/19

Review of the autonomous quadcopter project, specifically the autonomous movement of the drone. This paper looks at what's currently out on the market in terms of autonomous drones and the type of software.

The autonomous quadcopter project involves the ability for a drone to autonomously move and go about a specific area and map in-real time a 3D model of the area. The drone could use that map to find survivors in a cave or map out a building or structure to get the layout of the area. This paper will primarily focus on the flight autonomy of the drone, precisely the types of drones out on the market and the type of software that is currently available on the market.

The first type of drone currently out there involves the Intel® Falcon™ 8 System. It uses a Sony Alpha 7R camera or an Inspection Payload to deliver real-color, time-stamped, and georeferenced RGB and 14-bit RAW thermal images. The Falcon comes with Intel's Mission Control Software that enables the user to create 2D and 3D flight plans for the current objective. The software allows the user to efficiently develop automated flight plans in both 2D and 3D missions and includes automatic adaptive elevation terrain planning [1]. The Intel® Falcon™ 8 System seems impressive with all the capabilities of the drone to fly in an area and survey the area in detail, accompanied by software allowing customization of general flight plans.

Another type of drone currently in the market is the Yuneec drone. This drone uses Intel's top-of-the-line RealSense Technology to handle obstacle collisions. Essentially RealSense gives the drones depth perception capabilities, which allows them to see objects in the environment and react accordingly to avoid a collision. The RealSense technology uses vision processors that use a combination of infrared sensors, RGB sensors, depth, and tracking modules. RealSense combines visual tracking and GPS technologies to follow a target even when it becomes obscured. It uses data combined from the camera and sonar sensors to make a 3D model of the environment continuously and navigate through the area accordingly. By continuously updating the 3D model of the environment, the drone is then able to make intelligent decisions to take the most optimal routes. In addition, to continuously create a 3D model of the environment, RealSense can remember areas where the drone has previously traveled through and pull up the data previously recorded to navigate in real-time [3]. Intel's depth and tracking cameras that allow the RealSense technology to run go for as low as $359.00 [4].

NVIDIA's Jetson and Redtail drone is another drone available in the market that has autonomous capabilities. *Drone Rush* labels the Jetson as an artificial intelligence (AI) supercomputer that has a higher performance than two core i7 PCs combined, and all packed into the size of a credit card. The Jetson allows the drone to identify obstacles and calculate the path of flight to the destination almost instantly. NVIDIA has been testing the Jetson on a Redtail drone. *Drone Rush* says that along with the Jetpack API and the open-source software TrailNet, one could build the same drone system at home and have it navigate autonomously [2].

Finally, the PX4 software is currently available as an open-source flight control software for drones. According to the developers, the project has flexible tools for drone developers to make individually tailored solutions for their drones. The flexible tools can be seen in the documentation section of the website, which shows basic configurations, hardware configurations, and advanced configurations on drones. Since PX4 is open-source software, it benefits from having many contributors looking over the code, thus making the autonomous flight of the drone as best as possible. The website also has a section listing some drones that have used the PX4 to fly autonomously. Some of these drones include the Yuneec drones and Qualcomm drones [5].

Another autonomous drone software currently out in the market is DJI AirWorks. DJI's software was tasked to make the drone take flight off of a moving vehicle and scan a perimeter while looking for any survivors. At the end of the mission, the drone is tasked to land on a moving vehicle at a speed of about 20 mph. For obstacle avoidance, the DJI used stereo vision cameras with a guidance system which can be bought from DJI directly. Through the cameras, the drone is then able to map out the area and establish optimal flight paths while avoiding collisions. DJI's software can do close-up inspection with one-meter altitude and millimeter resolution, and it can provide high-level mapping at altitudes of 100 meters with centimeter resolution. In addition to obstacle avoidance, DJI's software can run onboard computer vision which allows it to identify and lock onto moving targets. DJI has a flight stack that runs on a companion computer that can run on open source technologies such as Ubutu and OpenCV. It utilizes DJI software development kits (SDK) such as onboard SDK, guidance SDK, and mobile SDK [7].

Everdrone is a company that offers a software program for drones to operate autonomously and beyond visual line of sight (BVLOS). *Everdrone*'s software uses Intel® RealSense™'s stereoscopic cameras allowing it to have 360 degrees of sense supporting 3D vision. The drone also comes in with a ADS-B receiver, which allows the system to detect an aircraft from hundreds of kilometers away. When another aircraft equipped with an ADS-B transmitter enters the drone's airspace, the drone descends and waits for approval to continue the current mission autonomously. The drone can use a mixture of GPS and optical flow tracking (visual odometry) in order to navigate without losing its position consistently. By only relying on GPS tracking, this creates a single point of failure to the system. *Everdrone* solves the single point failure by adding an extra layer of security with the visual odometry [6].

References

[1] “Intel® Falcon™ 8 System,” *Intel*. [Online]. Available: https://www.intel.com/content/www/us/en/products/drones/falcon-8.html. [Accessed: 30-Sep-2019].

[2] “NVIDIA Jetson and Redtail drone - the future of autonomous UAVs,” *Drone Rush*, 29-Jul-2019. [Online]. Available: https://dronerush.com/nvidia-jetson-redtail-drone-10506/. [Accessed: 30-Sep-2019].

[3] J. Crea, “What is Intel RealSense in Yuneec Drones?,” *3D Insider*, 29-Jan-2019. [Online]. Available: https://3dinsider.com/intel-realsense/. [Accessed: 30-Sep-2019].

[4] “Intel® RealSense™ Store – Buy depth and tracking cameras,” *Intel® RealSense™ Store – Buy depth and tracking cameras*. [Online]. Available: https://store.intelrealsense.com/. [Accessed: 30-Sep-2019].

[5] “Open Source for Drones,” *PX4 Open Source Autopilot*. [Online]. Available: https://px4.io/. [Accessed: 30-Sep-2019].

[6] “Offer,” *Everdrone*. [Online]. Available: https://www.everdrone.com/offer. [Accessed: 30-Sep-2019].

[7] D. J. I. Enterprise, *YouTube*, 28-Jul-2017. [Online]. Available: https://www.youtube.com/watch?v=2uy7j_3oTQA. [Accessed: 30-Sep-2019].