

CEJS Final Report

Remote Aerial Vehicle for Environmental Management

By Jon Polka, Faculty Advisor: Dr. Wes Lauer, PE

The primary goal of the project was to develop a remote aerial vehicle for Seattle University's Center for Environmental Justice & Sustainability that can be used for environmental management applications, specifically to acquire high resolution aerial images. A secondary goal was to test the platform as part of a long-term research project focused on floodplain sediment deposition associated with the Elwha River Restoration.

The project began with a broad literature review that was conducted over the summer of 2013. Dr Lauer and I discussed the many available directions, while we performed field work along the Middle and Lower Elwha in August. Additionally, we set aside two days to use a helium balloon with an attached camera to acquire aerial images of engineered log jams along the lower Elwha on the Lower Klallam Tribal Reservation to see the quality of images and get an idea for desired altitudes. We utilized a Canon digital camera loaded Canon Hackers Development Kit (CDHK) open-source firmware, so this exercise provided an opportunity to learn the software and the nuances of the camera. CDHK expands the capability of a point camera to include features such as longer exposures, an intervalometer, and manual exposure control.

During the fall of 2013, the goal was to assemble a quadcopter and prepare it for initial flight testing during winter break. Unfortunately, the first month and half of this period was filled with supply chain challenges, as I had to wait for over three weeks for an overseas manufacturer to send me some of the required parts (specifically, a transmitter and some batteries). When I received the package, it contained an incorrect order, so another three weeks were spent returning the equipment and finally deciding to go with another manufacturer. Despite these small setbacks, by the end of the quarter, the quadcopter was fully assembled and nearly calibrated and ready for flight. Assembly was fairly straightforward. The main challenge with assembly was learning how to solder.

Winter break was an exciting time for the project because it involved the first flight tests (see Appendix A for photographs). Initial flight testing was performed on Seattle University's campus. Ardupilot, open-source flight software designed for small autonomous helicopters and fixed wing model airplanes, was utilized to create flight paths. Once the flight path was created, it was uploaded to the quadcopter's onboard flight computer. The flight path was initialized by toggling a switch on the RV controller while flying the quadcopter. The flight testing was largely successful, but crashes and difficulty in manually controlling the quadcopter illuminated specific challenges associated with a layperson (i.e., not a regular hobbyist) piloting the drone. Specifically, determining which side of the quadcopter is the "front" (as indicated by the two blue quadcopter landing gear legs) is very difficult when the quadcopter is above 100 feet due to the silhouetting effect. Crash landings were a common occurrence during flight testing, which also led to structural improvements for the quadcopter. Stronger and longer carbon fiber landing gear legs were purchased for a nominal cost and proved to be much sturdier than the stock legs. Also, the additional height had an added benefit of keeping the camera higher off the ground and making damage less likely.

A field test was conducted on the North Fork Snoqualmie River. While the quadcopter was successful in grabbing some images of the river at that site, a difficulty was encountered related to altitude limitation. The quadcopter would not ascend beyond approximately 475 feet above ground level. The cause for this was never determined. Due to the limited range of photographs collected during the field test at the North Fork Snoqualmie River, photographs from the helium balloon were used for subsequent photo processing and DEM creation.

In the spring and summer of 2014, photos were input into Agisoft Photoscan, which is a stand-alone software program that allows photogrammetric processing of digital imaging. The helium balloon test provided ample coverage for a portion along the lower Elwha River near engineered log jams. We surveyed ground control points, which consisted of brightly colored plates with tape on them. These ground control points show up in the photographs taken and serve as points to georeference for digital images and/or a digital elevation model (DEM).

During processing of the photographs, a sparse point cloud and then a dense point cloud was generated. From a dense point cloud, a DEM could be created. Repeating the process and generating a DEM at another point in time would allow for a DEM of difference, which would make quantifying geomorphic change a realistic endeavor with the platform. Additionally, with a DEM, 2-D hydraulic modeling and/or landscape evolution modeling could also be performed.

In summary, a quadcopter platform was assembled and tested, which showed that collection of aerial images is possible and realistic. One important point is that there is certainly a learning curve and ample time and effort should be dedicated to learning the craft of flying the quadcopter safely. Another important issue with this is emerging and evolving regulations associated with flying automated drones. Due diligence is required to ensure that flying a drone is within the confines of local and national laws. Images collected were also used to create a dense point cloud, which could be processed to make a DEM and quantify geomorphic change in a river context.

APPENDIX A: Aerial Images



Figure 1: Flight test on January 1, 2014. This flight was done completely manually, so the altitude is unknown, but is estimated to be between 300 to 400 feet above ground level.



Figure 2: Flight test on January 4, 2014. This image was taken when the quadcopter was flying on autopilot at 400 feet above ground level.