ECHO photo mapping test

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Goal: positioning information that is independent and possibly more accurate than the UAV GPS. We would also like more accurate heading than the UAV autopilot compass/imu can provide.

Background: A typical aerial mapping survey records regular snapshots from a fixed downward-pointing camera and then uses a mosaicing software to build a model of the terrain. In the process of building this model, the algorithm solves for the position and orientation of the camera.

Test: In a hover test, when the UAV is maintaining its position roughly within a 1m box, how accurate is the GPS positioning? The rms position error of a 10 minute hover test is ~50cm.

Location: Baseball diamond south of the Tempe Historical Society near Papago park.

UAV report: Manual flight of Flamewheel 450 using DX8 controller with Canon power shoot mounted on arm, pilot B. Stinnett. Flight stability was noted to be mostly nominal but with multiple instances of unstable autopilot response. Throttle fluctuations and wobbling seemed to suggest some issue with an ESC, motor or power supply. On a landing flip the power did not automatically cut off as expected nor did the disarm throttle position have an immediate effect (took about 10 seconds to respond). These problems do not seem to happen when commanding autopilot via Tower or apmplanner. These last two facts suggest a possible controller issue, try testing with alternate controller.

Data report: We flew the Flamewheel 450 with a Canon powershot running CHDK set to take pictures every 2s. A scale grid was placed on the ground. In one ~10 minute flight we manually flew a grid to get a broad context map, and then hovered in loiter mode for about 5 minutes above the scale pattern. During this flight 153 images (see an example in Figure 1) were taken. The images are slightly over saturated and have an estimated angular resolution of about 10 arcminutes. The image series was reduced in Photosynth (Agisoft) to produce a scene model (Figure 2) and a set of XYZ coordinates of camera positions (Figure 3). The checkerboard scale was not used by photosynth. It is not clear how the scale is set, but given that the positions are available in seemingly accurate meters as well as latitude and longitude it is likely somehow using the GPS in the camera. During the hover portion of the test the standard deviation is 31cm in horizontal distance and 52cm in 3D distance.

Conclusion: The positional accuracy with this very basic setup appears to be as good or better than a GPS setup. The accuracy can be improved by increasing the angular resolution of the images. From inspection of the images the resolution appears to be a function mainly of camera settings (shutter speed, aperture and focus) rather than a fundamental limitation. The accuracy might also be limited by the resolution of the computed mosaic model.

The only downside is the processing requirement. This 7 minute mission amounted to about 500 MB and required about 45 minutes of processing time on a 16 core cluster. A nominal beam map might require hours of flight time, order 10GB of image data and 12 hours of processing time.

Figure 1: Example snapshot from the series of 153.

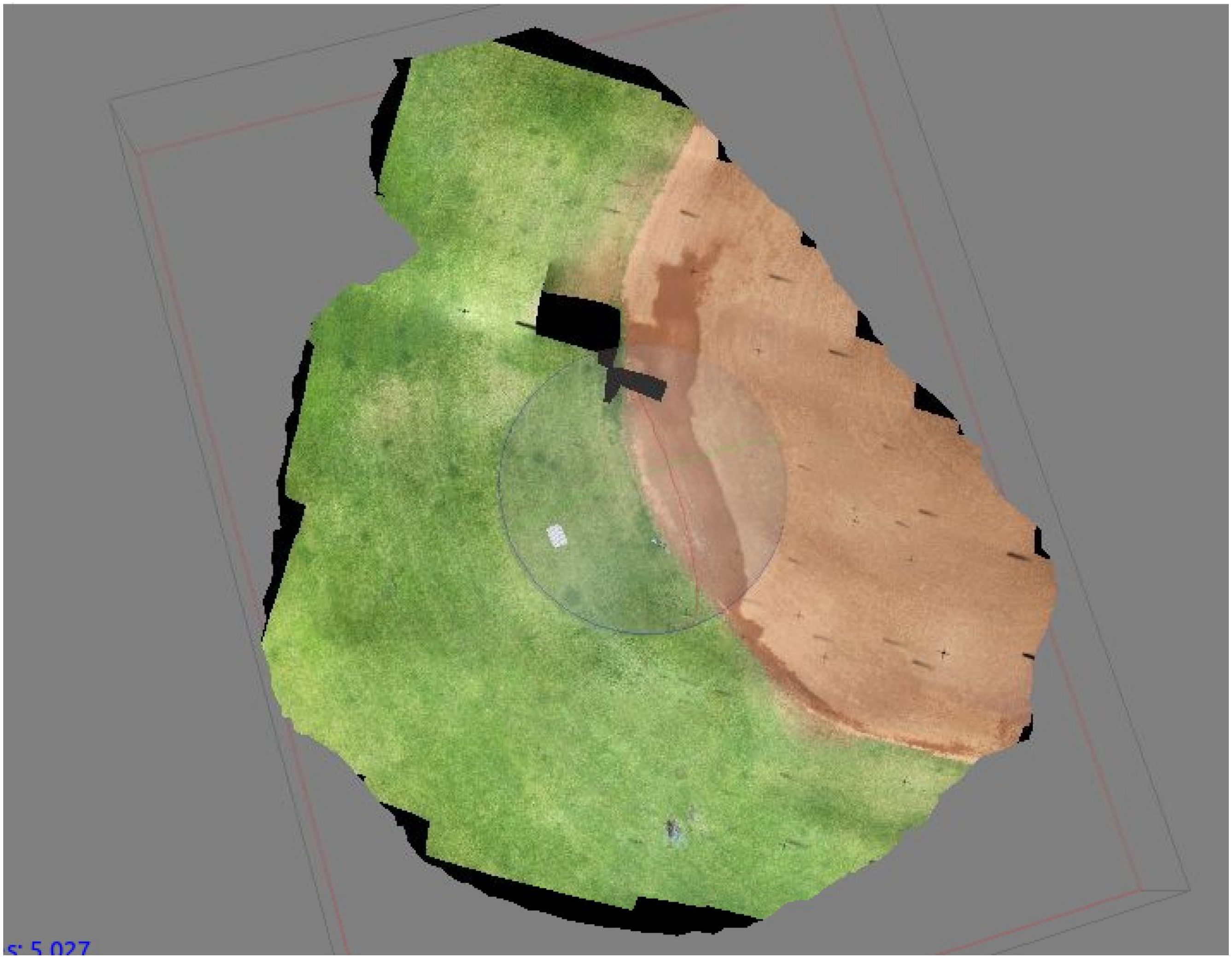

Figure 2: Mosaic map of the flight area made using images taken at a 2s interval, flying in a manual grid followed by a 5 minute hover over the scale grid (white and black squares visible at center). The black marks are due to a UAV leg in the field of view (cf Figure 1)

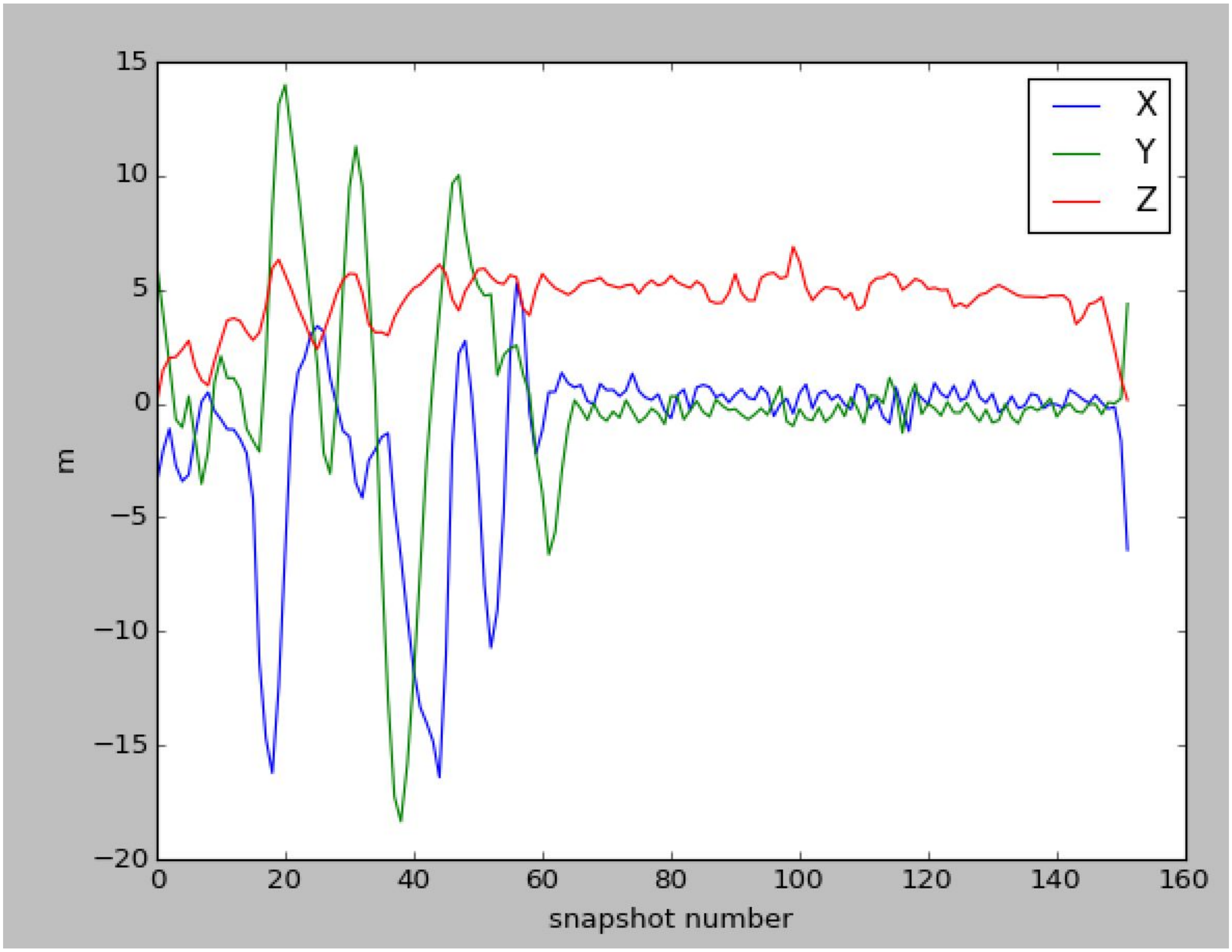

Figure 3: XYZ positions in meters output by the mosaicing algorithm. The RMS during the hover test (beginning at number 67) is 31cm in horizontal distance and 52cm in distance. The large fluctuations in height are likely real and likely reflect an observed thrust instability.