Ground Camera Packages For UAV Distance Calculation

Nolan Shute[1], Asifuzzaman Khan[1], Mark Zheng[1], Joud Satme[1], Austin R.J. Downey[1]

[1]Department of Mechanical Engineering, University of South Carolina

ARTS-Lab
Adaptive Real-Time Systems Laboratory

Background

- To eliminate the risk that comes with measuring the seismic activity of unstable buildings, research into automated sensor placement through Unmanned Aerial Vehicles (UAV's) has become a solution to this challenge.

Figure shows unstable building after a landslide compromises its structural integrity.

- A fully automated process will require as much information about the complex aerospace as possible for the drone. With a network of ground camera packages to provide different fields of view, a fully-reconstructed flight path can be created to measure distances for the drone based on the camera's pictures. Applications of this procedure will need to instantly process the images and display a distance from an identified point in real-time for complex maneuvering.

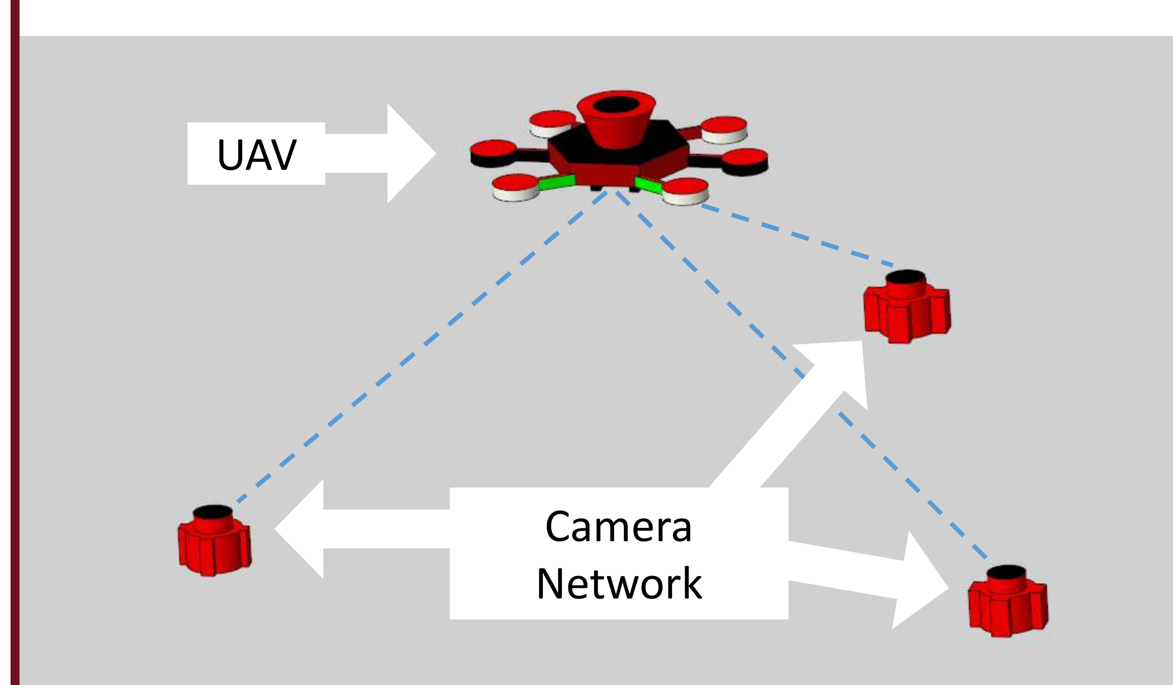


Figure shows model camera package network, each camera tracking the drone. Each camera provides a different frame of reference, allowing for a larger rendering to be created.

Methods

- Custom Camera Package created that features a FLIR Blackfly 32S4 camera facing upwards using a fisheye lens to capture as much range as possible.

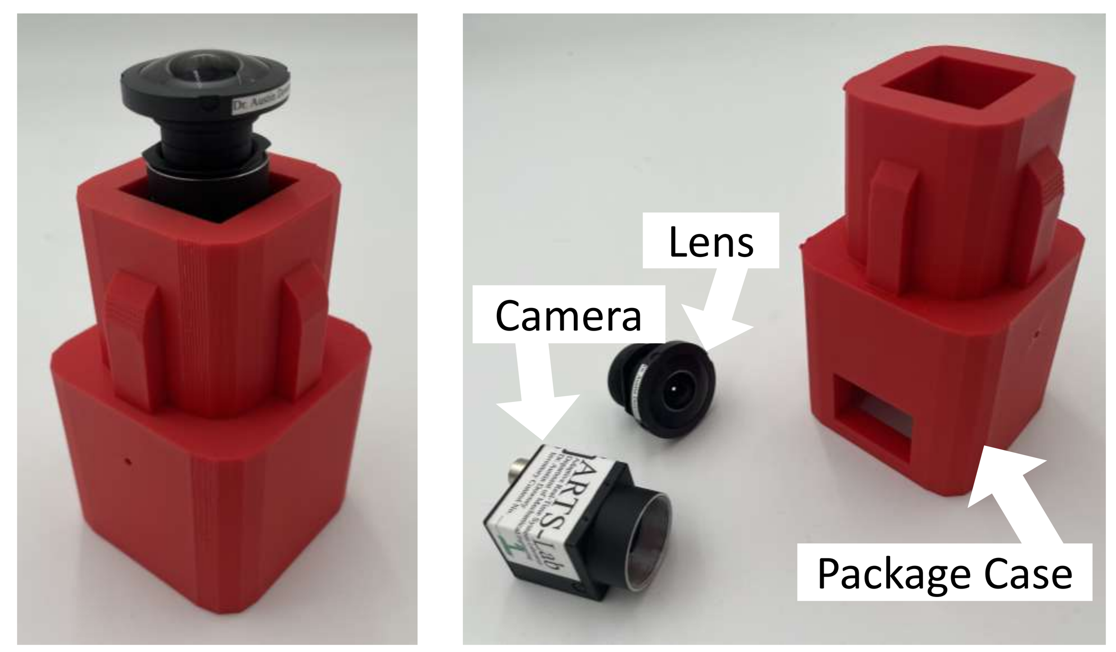


Figure shows assembled and unassembled camera package.

- Software developed utilizes a camera projection matrix that digitally calibrates each fisheye picture to more accurately measure distances.

$$[K] = \begin{bmatrix} f_x & 0 & c_x & 0 \\ 0 & f_y & c_y & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

Figure displays the model of projection matrix used to calibrate each picture. Each value in the matrix represents a different point to be manipulated and stretched

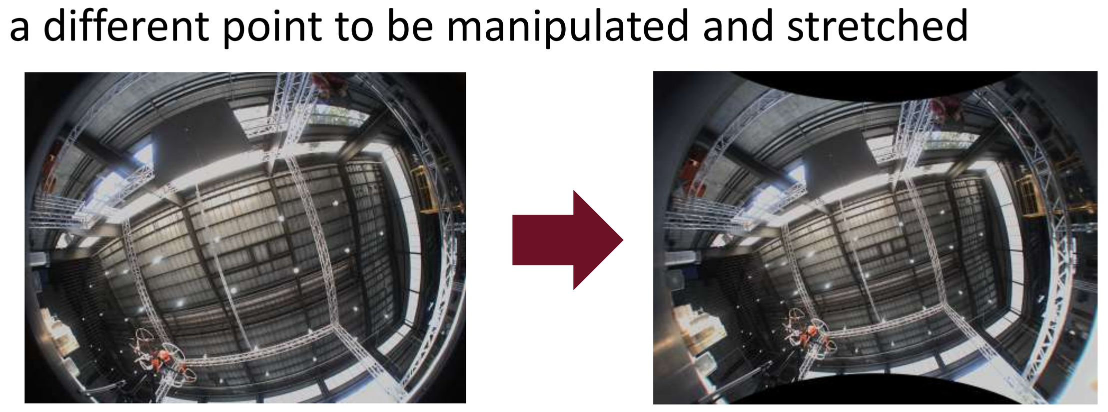


Figure displays the application of projection matrix when calibrating fisheye lenses.

- Depth estimation in Python OpenCV was used to develop a 3D Point Cloud based on the picture and then ran through distance measuring software for Point Clouds.

Experiment

- Drone was placed on stand to mimic "in flight". Pictures were taken from three separate distances from the stand.

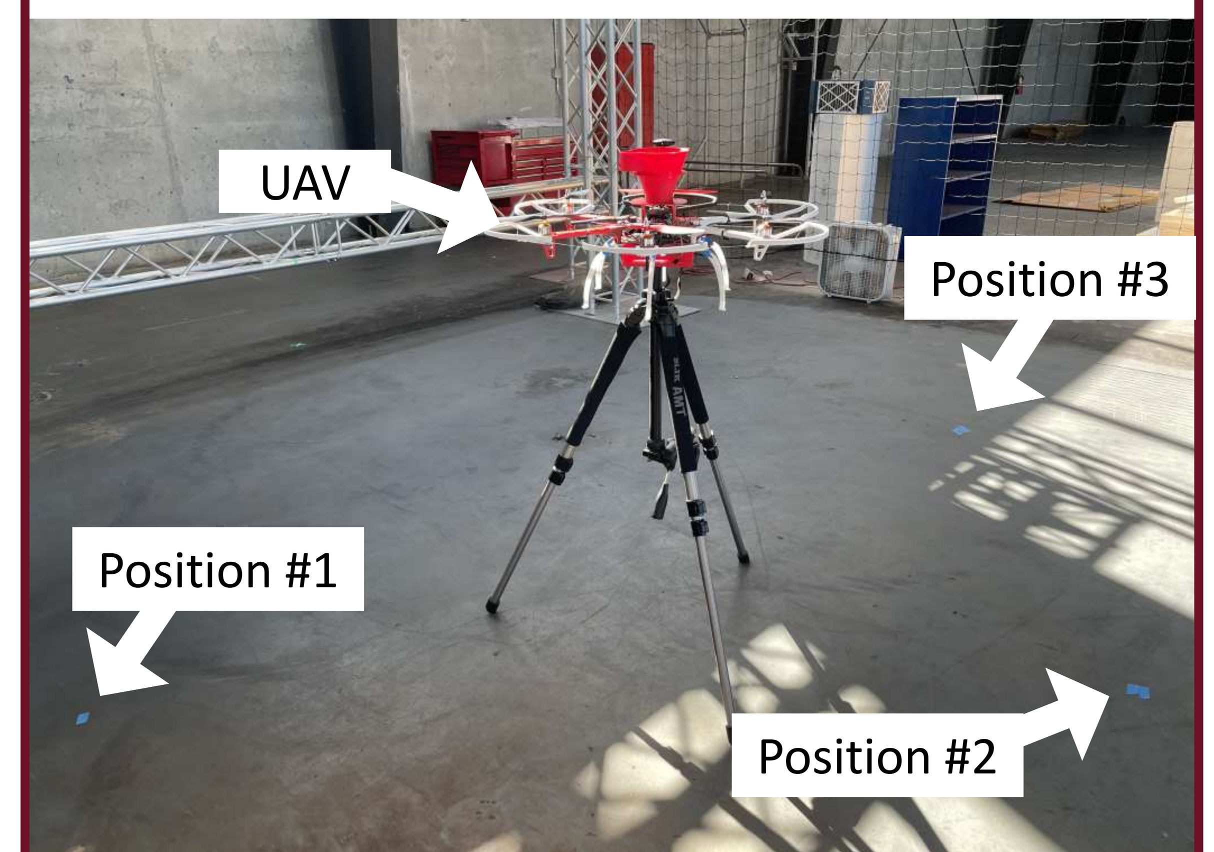


Figure shows setup that utilizes a prototype "Camera Network" to render a 3D space of the testing facility.

- Pictures were manually processed and reconstructed in a 3D environment that mimicked the testing area, with a separately rendered in "floor" of filler points to measure from.

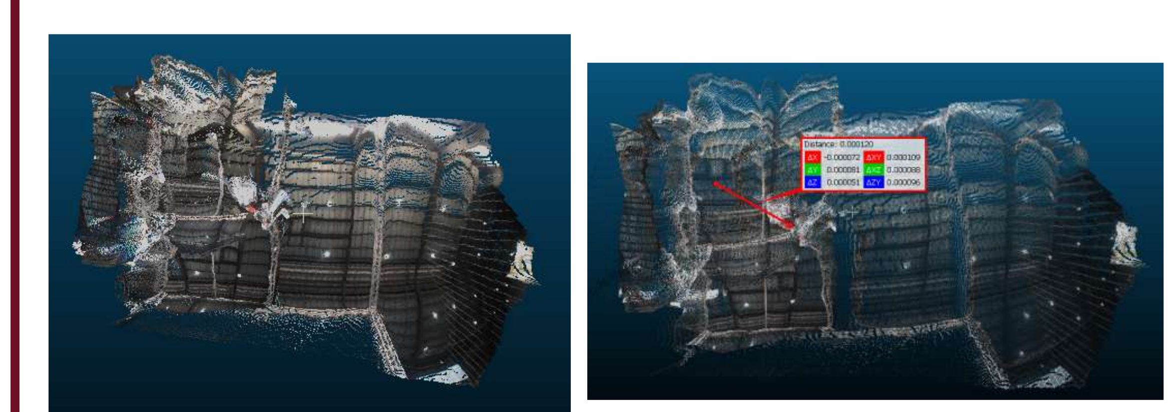
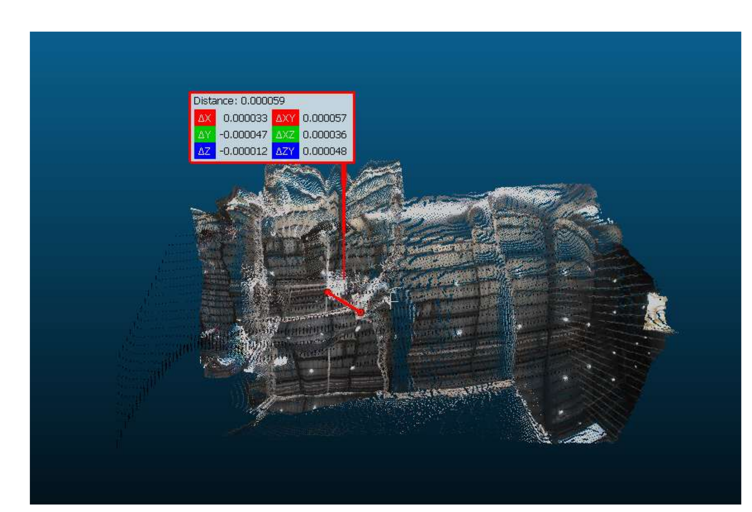
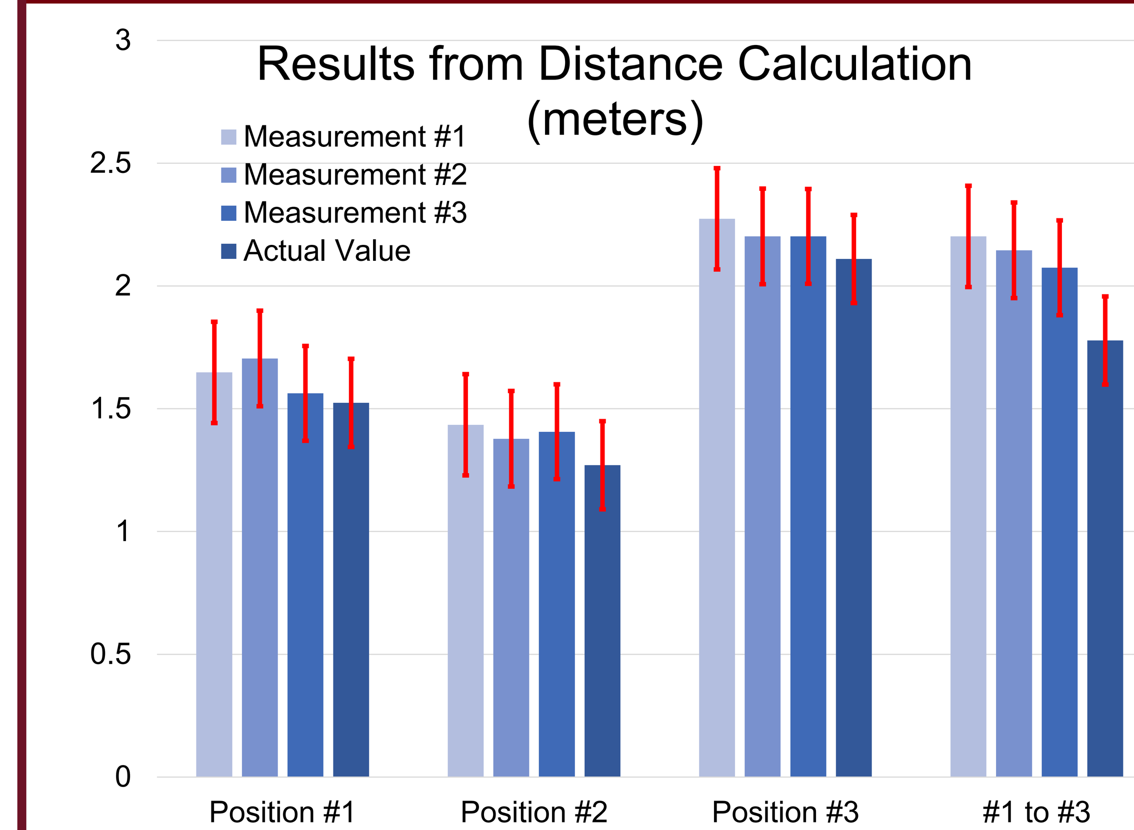


Figure shows 3D point cloud generated from pictures as well as measurements taken.



Knowing the length of the drone, the measurements in the point cloud can be scaled to real-life measurements (meters).

Results



- Method for Point Cloud Rendering Distance Calculation was successful in estimating the distance from each camera position to the Drone Stand, but not for precise measurements.
- Issues could have arose with placement of each Point Cloud and their scaling to the drone.
- Future iterations will focus on automating this process, either with graph and coordinate generation through depth estimation software in a video or in real-time camera tracking. This process prototypes an automation level that could utilize Edge Intelligence (AI applications, etc.) to pilot the UAV.

References

Background Picture:
Huang, J. (2015, December 21). China searches for 91 missing in country's "worst" urban landslide. Voice of America. https://www.voanews.com/a/more-than-90-missing-china-landslide/3111598.html

Calibration Matrix:
Berny, M. (2023, June 26). Camera calibration: Principles and procedures. EikoSim. https://eikosim.com/en/technical-articles/camera-calibration-principles-and-procedures/

Point Cloud Rendering:
Dai, P., Zhang, Y., Li, Z., Liu, S., & Zeng, B. (n.d.). Neural point cloud rendering via multi-plane projection. Computer Vision Foundation. https://openaccess.thecvf.com/content_CVPR_2020/papers/Dai_Neural_Point_Cloud_Rendering_via_Multi-Plane_Projection_CVPR_2020_paper.pdf

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University of South Carolina