

Introduction

One of the fundamental parameters during the flight of an unmanned aerial vehicle (UAV) is the altitude at which it is flying at. One method is to use sonar sensors, which emit a pulse of sound and uses the time-of-flight of the echo to calculate the distance. It is however unreliable due to slow refresh rates and erroneous readings caused by interfering echoes.

This research project aims to determine the feasibility of implementing a laser-distancing system for a small UAV in order to determine its altitude. It is known that the distance between a projected laser dot on a camera focal plane and the center of the focal plane can be related through triangulation. This can be used to find the distance to the surface that the laser was projected onto. The results from this research project will provide a proof-of-concept for the laser-distancing system, which can potentially replace current unreliable sonar distancing implementations.

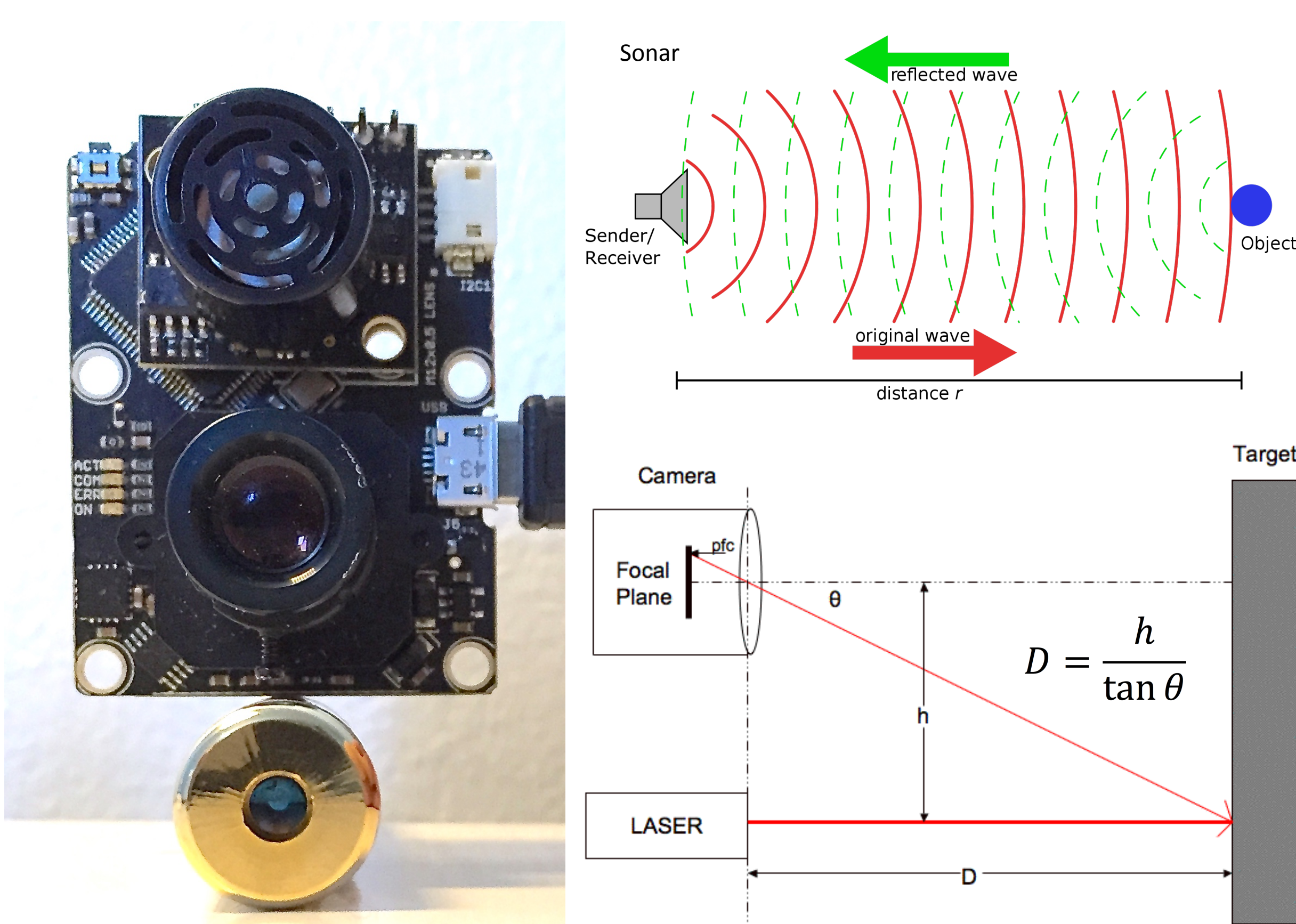


Figure 1. Sonar, camera, and laser set-up (left)¹; Sonar distancing (top right)⁴; laser distancing using a camera (bottom right)⁵.

Methods and Materials

To determine the feasibility of using this laser system, MATLAB will be used to develop a model to test the system. A webcam will send real-time video of the laser projection to the computer, and the distance from the wall to where the laser was projected from will be calculated. The webcam and laser set-up will then be moved around to vary the distance. See Figure 1 for a picture of the webcam and laser set-up as well as the theory behind the measurements.

Specifically, the live video stream from the webcam will be displayed on the computer screen. Since the display area will be known, it will be possible to see how many pixels away the laser dot is from the center of the screen (pfc). Thus, also knowing the distance between the center of the camera lens and the center of the laser lens, triangulation can be used to determine the distance to the wall. The experimental results will be compared to the actual distances to determine the accuracy of the laser system.

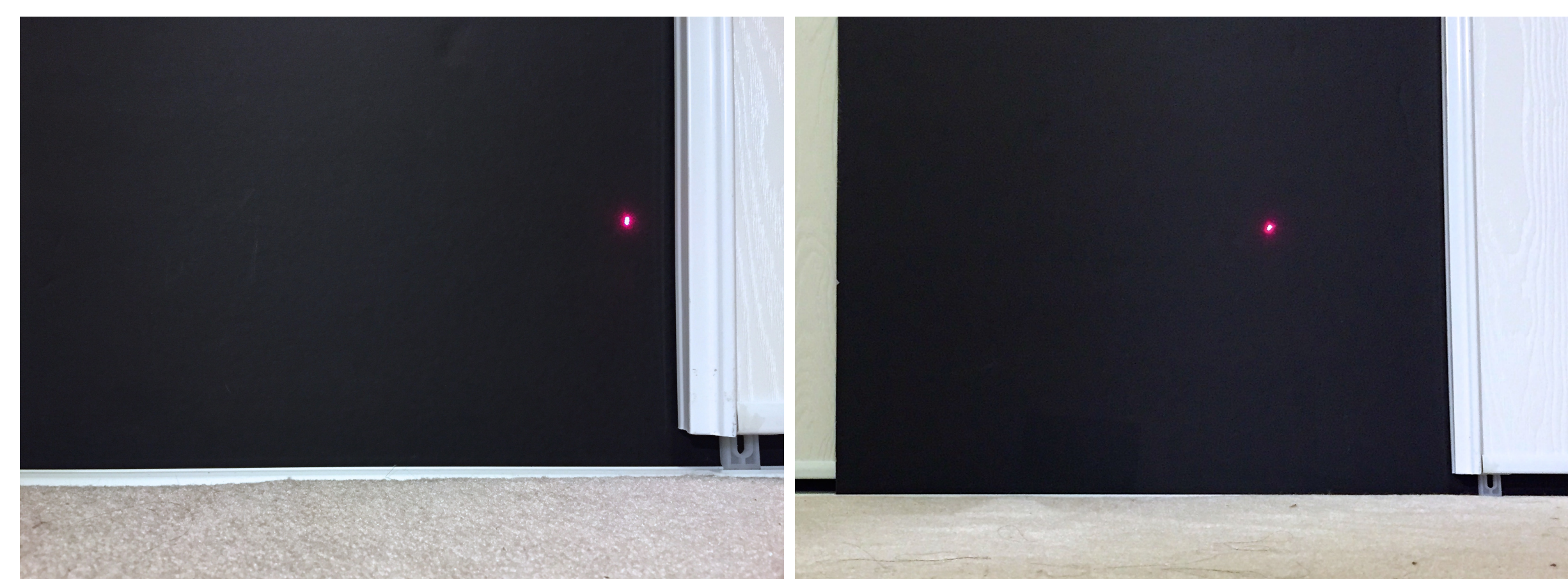


Figure 2. Laser dot through a camera-lens at close range (left) and at far-range (right)².

Results

The measured experimental distances were accurate when compared to the actual distances. The percent error ranged from 3.76% to 9.97%, and the average percent error was 5.46% (see Table 1 and Figure 3). As seen in Figure 2, when the camera and laser set-up was farther away from the wall along the same axis, the laser appeared closer to the center of the focal plane. Similarly, the laser would appear farther away from the center of the focal plane as the camera and laser set-up is moved closer to the wall.

Table 1. Experimental distances compared to actual distances measured at different pixels from center (PFC).

PFC (pix)	Experimental D (cm)	Actual D (cm)	% Error
109	32.99	30	9.97
84	52.62	50	5.23
70	78.87	75	5.16
63	105.08	100	5.08
59	129.70	125	3.76
56	157.36	150	4.90
54	183.43	175	4.82
52	219.85	200	9.93

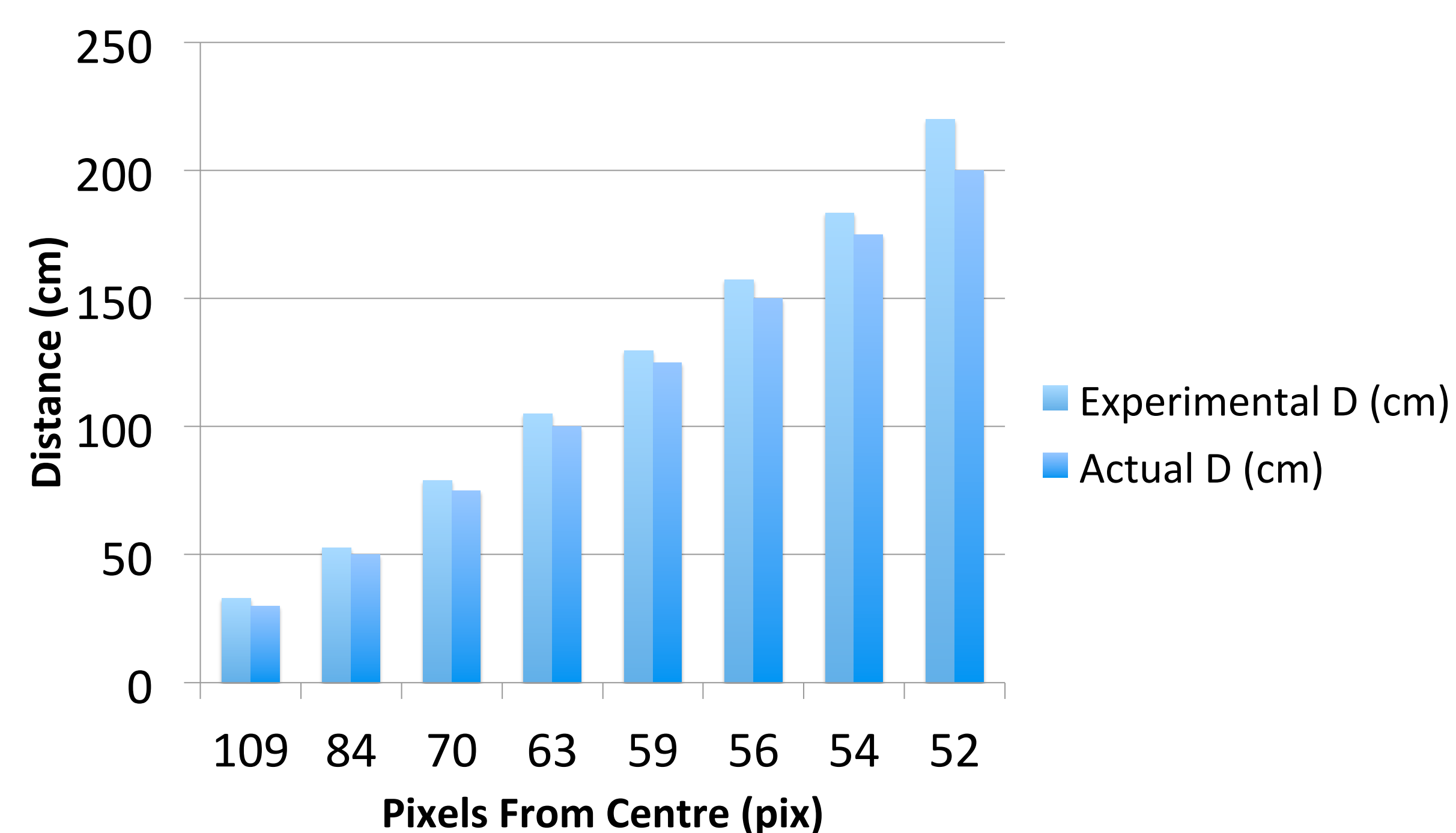


Figure 3. Graphical representation of experimental vs. actual distance.

Discussion

The black background used during the experiment was necessary because of the difficulty recognizing the laser through the Matlab software. There were not enough parameters to filter out the excess noise; the main parameter used to sift through the noise was a red threshold that would only take pixel values above a certain value. As a result, other red objects that were not intended to get detected were unintentionally detected. The implication of this is that in real-life situations, the background of the laser projection will not always be a perfectly uniform colour, thus further measures must be taken.

To improve the reliability of the laser set-up, further parameters could have been implemented. For instance, the detection size could have been reduced to sizes near the laser dot size, which would filter out a lot of unintended red objects. As well, since the laser is fixed to the camera, the laser dot projection on the computer screen will only shift in a linear fashion in one axis. This means that the detection area could be reduced to only a rectangular sliver along the axis of movement. Finally, infrared lasers should be used in order to completely filter out most of the visible spectrum, which would simplify the detection of the laser dot.



Figure 4. The UAV being developed by Tyto Robotics that would benefit from implementing a laser-distancing system (notice the small size)³.

Conclusions

Through this research project it was determined that implementing a laser-distancing system is feasible. The average percent error of 5.46% indicated that the triangulation method used for calculating the distance between the laser and the wall was accurate.

Future improvements to laser-distancing systems would include implementing more parameters to filter out the laser dot. A possible parameter would be to reduce the detection size to near the size of the laser dot. As well, an infrared laser could be used to completely filter out the visible spectrum, thus simplifying the detection process.

The next step would be to apply this model from Matlab to create an actual implementation on the small helicopter UAV from Tyto Robotics (see Figure 4). This would require hardcode to be written for the specific microchip of the UAV. The entire laser-distancing system for the UAV would have to meet the requirements of being both lightweight and energy-efficient, in addition to being able to share the same camera as the one used for detecting the optical flow.

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Acknowledgements

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