Structured Light 3D Surface Reconstruction of Birds

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In my research with the Lentink Lab, I am designing a system that will track the 3D surface of the wings of birds using stereoscopic vision implemented using a high speed projector and camera setup at 3000 Hz. In previous studies, laser scanning has been successfully used to map stationary objects [1], [2] and has also progressed for more rapid data collection [3], [4], but has never been used before in birds. Data has already been collected using the setup seen in Figure 1 and a sample image captured by the high speed camera can be seen in Figure 2. The projector uses a binary striped encoding pattern as shown in Figure 3 in order to generate correspondences between projected and captured stripe edges. This stripe pattern was motivated by work by Holt in 2001 [5]. While image analysis has been already conducted on these images, much higher quality work needs to be done in order to increase the accuracy of the final 3D data points and to increase the quantity of data gained from these images. Below I will describe the ways I plan on making these improvements using skills learned in CS 232.

As seen in Figure 4, a red-channel global threshold was used to detect the stripes on the bird. This threshold was tuned by hand and is misses some data especially around the head and other areas of shallow light incidence. I would like to use methods in this class to make a robust and automated filter that will work even at lower camera exposure times. Next, in Figure 5, four consecutive images are compared in order to detect the identity of each stripe. This algorithm need much work however. As seen in Figure 6, it does not work for thinner projected stripes as it does not take into account the possibility of the bird moving. Fixing this issue along with finding a better method for noise reduction than getting rid of blobs below a threshold area will be a primary focus of this project. In Figure 6, white lines are added which define the potential zones for edge boundaries. The simplistic nature of the current algorithms does not capture much of the data as it is filtered out. This data is of key importance as it lies at the edges of the wings and will be of great scientific importance. Thus, new algorithms to capture the full amount of data present will need to be written. Lastly, I would like to increase the accuracy of the edge detector shown in Figures 7 and 8 in order to get subpixel accuracy. These improvements will greatly increase the accuracy and quantity of 3D data points.

Note: no DROID camera phone will be needed.

References

[1] M. Levoy, "The Digital Michelangelo Project," Versione Italiana, 2009.

[2] J. Bouguet and P. Perona, "3D photography using shadows in dual-space geometry," *International Journal of Computer,* vol. 35, no. 2, pp. 129-149, 1999.

[3] S. Runsinkiewicz, O. Hall-Holt and M. Levoy, "Real-time 3D model acquisition," in *SIGGRAPH*, San Antonio, 2002.

[4] J. Takei, S. Kagami and K. Hashimoto, "3,000-fps 3-D Shape Measurement Using a High-Speed Camera-Projector System," in *IEEE/RSJ International*, San Diego, Ca, 2007.

[5] H. Holt, Olaf and Rusinkiewicz, "Stripe boundary codes for real-time structured-light range scanning of moving objects," in *IEEE International Conference*, 2001.

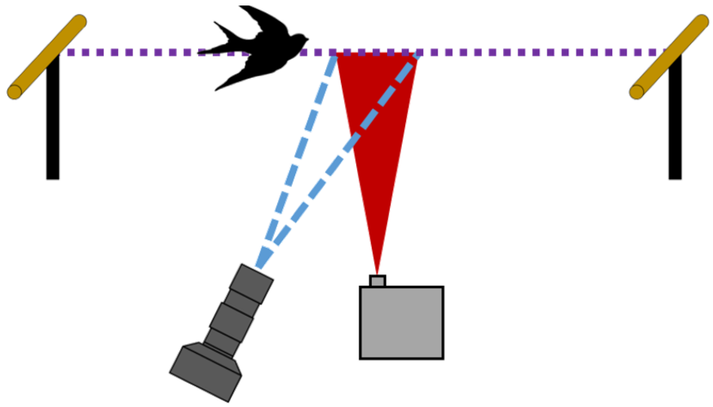

Figure 1: Experimental setup

Figure 2: Original image enhanced with $\gamma = 1.25$

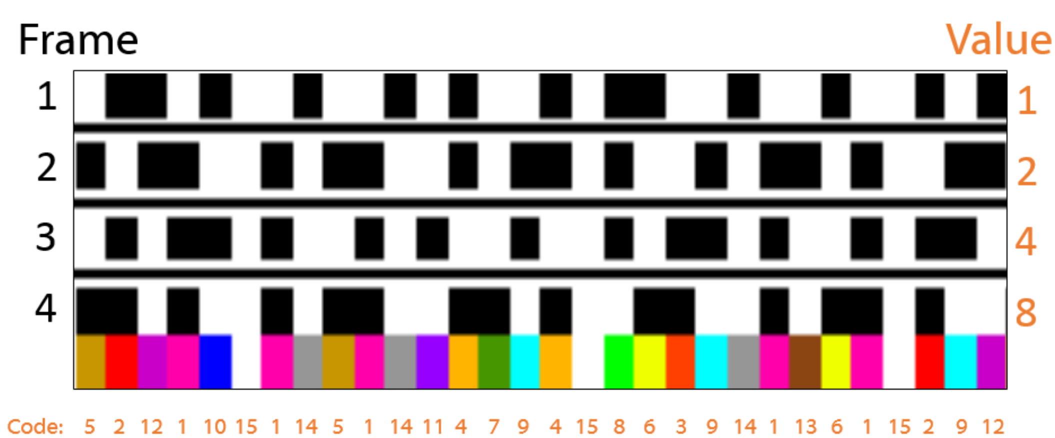

Figure 3: Binary stripe logic scheme

Figure 4: Simple threshold of image

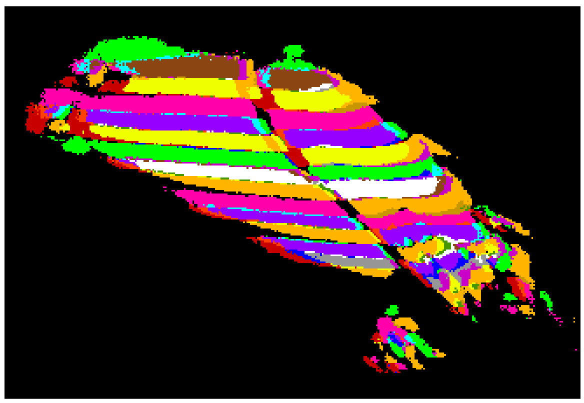

Figure 5: Four consecutive images combined and color-coded for visual purposes

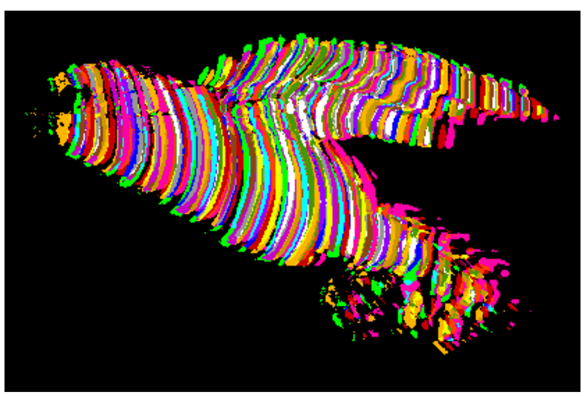

Figure 6: Unsuccessful combining of images for thinner stripes

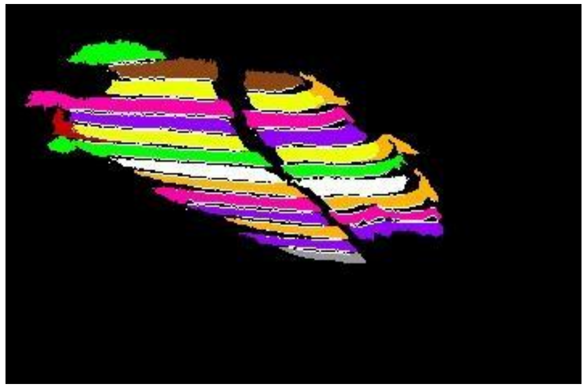

Figure 6: Noise removal via small blob removal and potential edge zone detector

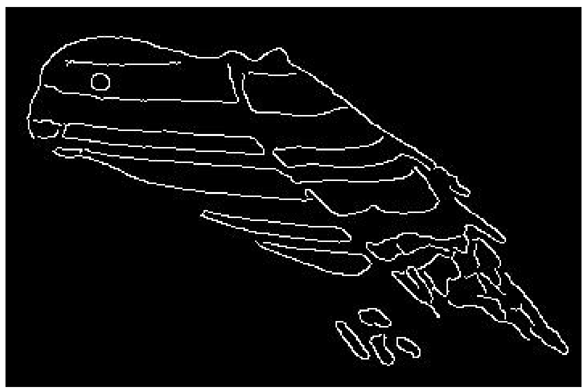

Figure 7: Canny edge detection of original image

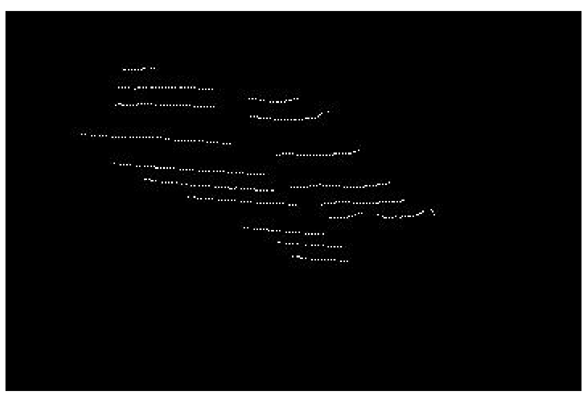

Figure 8: Edge data by comparing potential edge zone detector with Canny edge detector