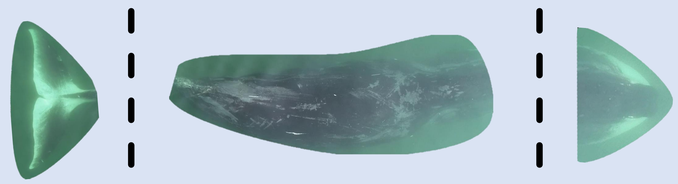
Automated Approaches to Bowhead Whale Identification

Ursinus College

Sam Gregory, Kacey La

Advised by Dr. Chris Tralie and Dr. Leslie New



Abstract

This project aims to automate the identification of bowhead whales using convolutional neural networks. The initial neural network identifies key points to outline each whale and uses these points to divide each whale into three sub-sections: the fluke, the back, and the head. Upon segmenting the whale, each sub-section was used to identify individual bowhead whales through the white patterns and scarring on their backs. The results from each segment were then combined into a final classifier to identify bowhead whales.

Key Terms

Bowhead Whale (*Balaena mysticetus*) – A predominantly arctic species of whale which can grow up to 60 ft long and are entirely black except for white markings on the jaw and fluke.

Canny Edge Detector – A multi-stage algorithm used to detect edges within images.

Active Contour – An active model for image segmentation that uses constraints to separate pixels of interest from the rest of the image.

Catmull-Rom Spline – A type of line that passes through a set of control points and is continuous.

Neural Network – A computer vision algorithm structure designed to mimic the human brain and allows programs to solve complex problems, such as pattern recognition and identification.

Convolution – A mutated version of an image that has had each pixel adjusted by a matrix of weights that allows a neural network to focus on the collective features of the original image.

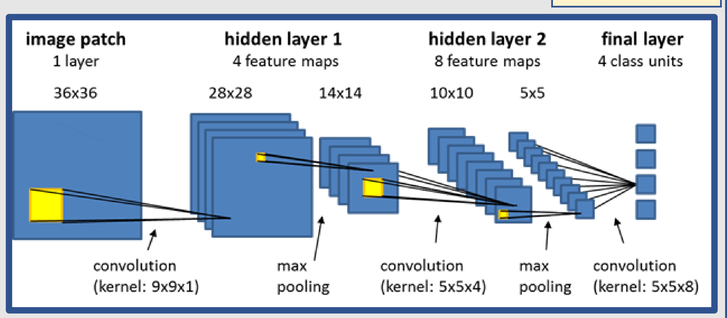


Figure I
An illustration of a **convolutional neural network.**

Segmentation & Key Point Identification

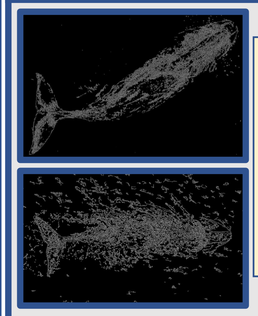


Figure II and III
Images obtained after using the **Canny edge detector** on bowheads.

Identifying bowhead whales is a difficult problem.

- The most identifiable sections are **scarring on the back and white on the fluke and head.**
- The **Canny edge detector** and other classic image processing tools were used to segment the whale into these subsections **but found little success**.

Classic image processing techniques were not powerful enough to do this**,** so **convolutional neural networks** were employed.

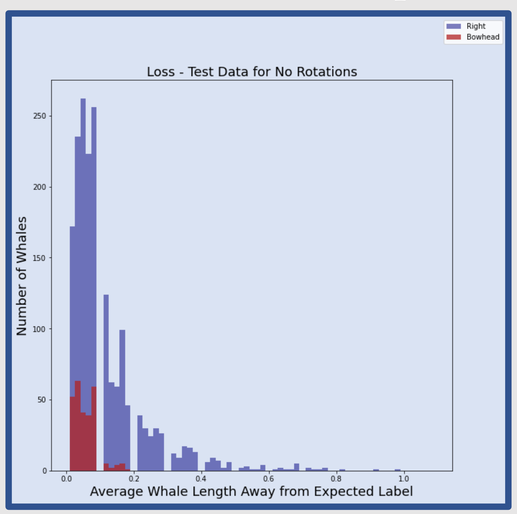
- The networks identified **key points** to separate the whale from the water.
- Due to **limited bowhead data**, pictures of **right whales** (*Eubaleana glacialis*) were used to increase the size of this dataset.
- Thousands (or even millions) of pieces of training data are required by neural networks for accurate results.
- **It took over 40 hours to label the 2114 images.**

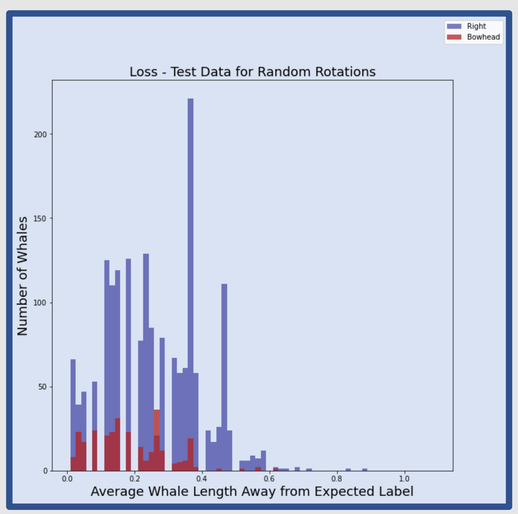
Figure IV, V, and VI
Key points identified in white. Expected output in black.

Experimentation: It is not immediately obvious which network architectures would work best. We tried various activation functions, histogram equalization, random rotation, max pooling between layers, and more.

Figure VII and VIII
Results of different **neural network** experiments.

Ultimately, the simplest neural networks performed the best.





Classification

Now with key points identified, the whale was segmented into its **back**, **fluke**, and **head**.

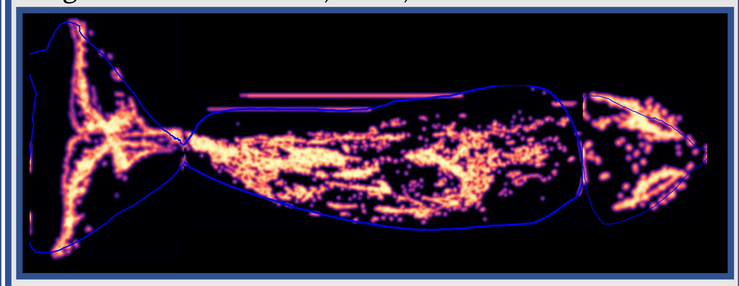


Figure IX
Photos cropped from a **Catmull-Rom spline** with an **active contour** drawn in blue.

A **Catmull-Rom spline** was applied to each section to carve out the head, body, and fluke. From there, an **active contour** (snake) algorithm was applied, but was highly unpredictable and unused in the final product.

These cropped images would ultimately be used by classic image recognition techniques like **visual bag of words** and compared to the efficacy of a **classification neural network**. Unfortunately, due to a **limited amount of data**, this was impossible to accomplish.

Data limitations mean that this project is ongoing, and classification is untested.

Acknowledgements

This project would not have been possible without the help and support of our mentors, Dr. Tralie and Dr. New, as well as the rest of the awesome professors in the Math & Computer Science department.

In addition, we would like to thank the Ukrainian and Alaskan bowhead whale researchers, Olga Shpak, Geof Givins, Craig George, John Citta, and William Koski who were kind enough to share their bowhead data with us.

Works Cited

Bogucki, Robert & Cygan, Marek & Khan, Christin & Klimek, Maciej & Milczek, Jan & Mucha, Marcin. (2018). *Applying deep learning to right whale photo identification*. Conservation Biology. 33. 10.1111/cobi.13226.

Trimble Inc. (2022.) *Using Deep Learning Models / Convolutional Neural Networks*. https://docs.ecognition.com/eCognition_documentation/User%20Guide%20Developer/8%20Classification%20-%20Deep%20Learning.htm

Rugh, David & Zeh, J.E. & Koski, William & Baraff, L.S. & Miller, G.W. & Sheldon, K.E.. (1998). *An improved system for scoring photo quality and whale identifiability in aerial photographs of bowhead whales*. Report International Whaling Commission. 48. 501-512.