Seg-Front: a Python library for segmenting glacier calving fronts from satellite imagery

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Introduction

- Currently, manual digitization is the only means for calculating the glacial calving rate which could introduce the following issues:

1.) A substantial investment of time is required from a human interpreter,
2.) Human interpretation is fundamentally subjective so that metrics are difficult to compare between interpreters,
3.) An interpreter must always be available to digitize new front positions as additional data is acquired,
4.) These data on front positions must be combined with data from other sources to derive parameters of interest, such as calving rate.

- Our goal is to automate this procedure in order to make larger global-scale studies more tractable.

Dataset

- We used Landsat 8 imagery, specifically the Pancromatic band (Band 8).
- Provided open-source by a collaboration between NASA and the U.S. Geological Survey (USGS).
- We used the Pancromatic band because it yields 15 meters of resolution, whereas other bands provide 30 meters.
- Imagery is assumed to have a low amount of cloud cover and low amount of sea-ice to obtain high contrast between ice and sea.
- Imagery of the entire earth is taken every 16 days.

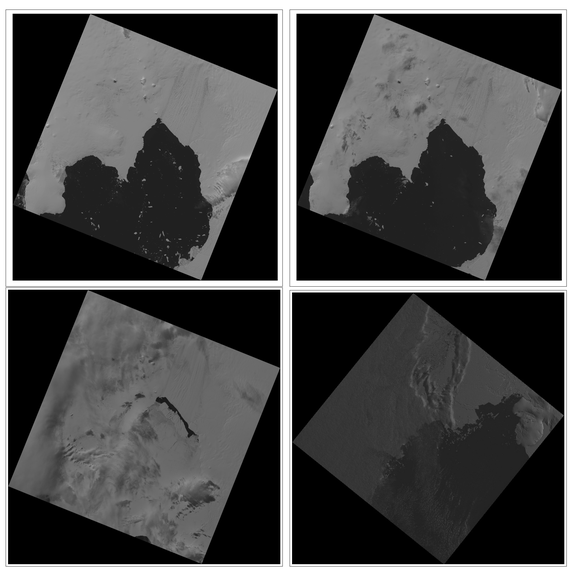

Figure 1: Above: Landsat 8 satellite imagery taken of Pine Island Glacier. Top Left: Taken Jan 8, 2017. Top Right: Taken Jan 24, 2017. Bottom Left: Taken Dec 10, 2017. Bottom Right: Taken Dec 26, 2017.

Segmentation Process

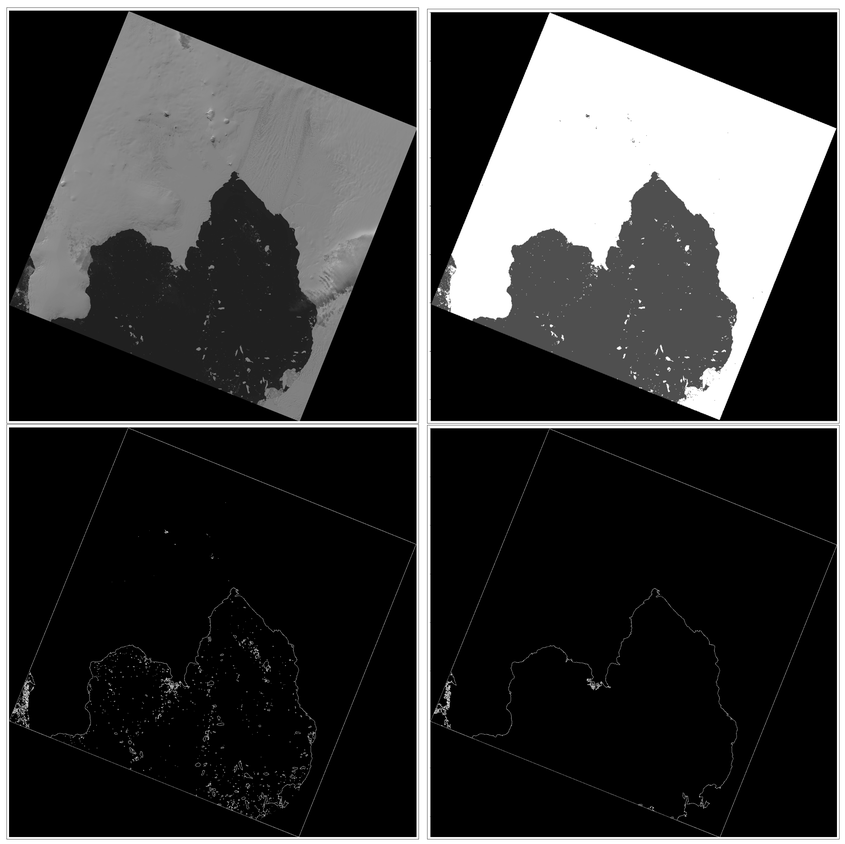

Figure 2: Top Left: Filtered image. Top Right: Result of k-means clustering algorithm. Bottom Left: Result of regional adaptive threshold. Bottom Right: Image after objects below certain threshold of connectivity have been removed.

Algorithmic Workflow

- Anisotropic filter to remove noise and preserve edges.
- K-means clustering algorithm is used to group similar pixels into three categories:
  1. Glacier
  2. Water
  3. Black Border
- Regional adaptive threshold to transform the image from gray scale into a binary image.
  - A regional method was chosen over a global threshold technique.
- Remove sea-ice and small objects by setting the pixels of objects below a certain threshold to zero.
- Remove outer border that is left around imagery after segmentation.

Results

The algorithm will return a binary image where a pixel is 'activated' if it is representing the coast and black otherwise. This allows us to get a vector of coordinates of the pixels representing the coastline.

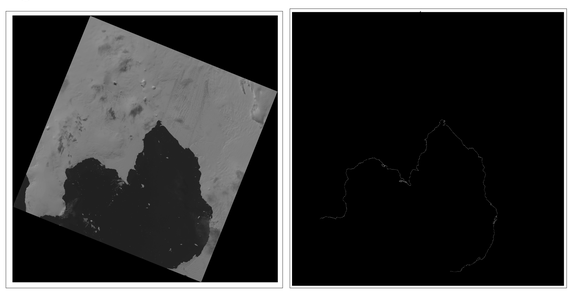

Figure 3: Left: Original image. Right: Segmented image.

Future Work

- Implement velocity fields to extract the calving front from glacial coastline.
- Optimize code and implement parallelism in bottlenecks.
- Use imagery from other glaciers with different conditions such as ice mélange.
- Use imagery from other bands.
- Implement quality checks by analyzing histogram of imagery.
- Test segmented images against manually digitized images in order to get an error measure.

References

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[2] H. Liu, K. Jezek. *Automated extraction of coastline from satellite imagery by integrating canny edge detection and locally adaptive thresholding methods.* *International Journal of Remote Sensing*, 25:937–958, 2004.

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Figure 4: QR Code for Github repository.