Developing an Active Contours Model for Layer Detection from Polar Radar Imagery

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Abstract

- The rise of the planet's temperature has a very negative impact on the subsurface dynamics of Earth's Polar Regions.
- Analyzing the polar subsurface is typically performed manually by examining echograms acquired by radar sounder instruments operated in Greenland and Antarctica. It is necessary to develop data analysis techniques for automatically identifying and tracing bedrock and surface layers.
- To address this problem, we have identified a set of values for α, β, and γ, which are important parameters for controlling an active contour towards the surface and bedrock layers.

Associated Challenges

- Automated processing and extraction of information from radar imagery is challenging.
- Radar inherently records noise, which is electromagnetic interference (EMI) from other electronics, such as components near the sensing equipment in the frequency band of focus.
- Analog-to-digital convertors, which convert the received energy signals for digital storage can introduce artifacts.
- Vertical and horizontal intensity variations across an image introduce additional difficulties for identifying and tracing near surface layers.

Methodology

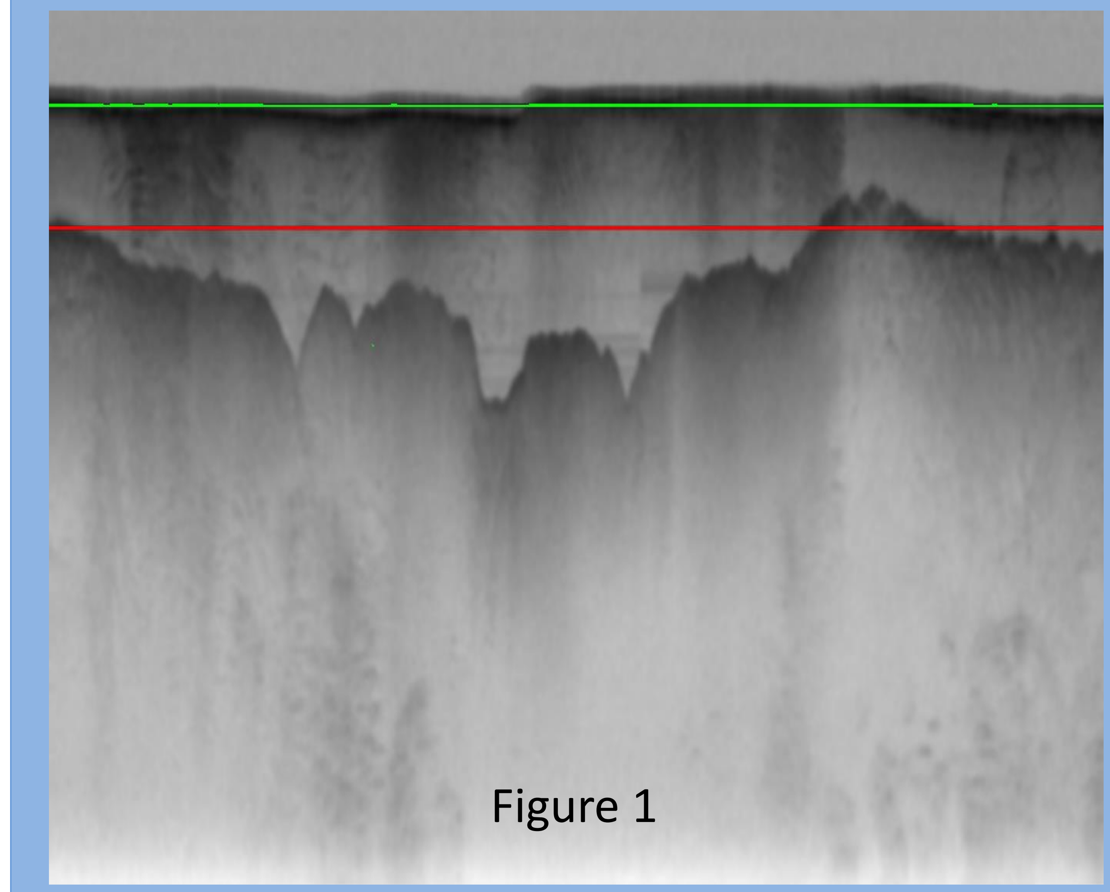
Active Contours (Snakes)

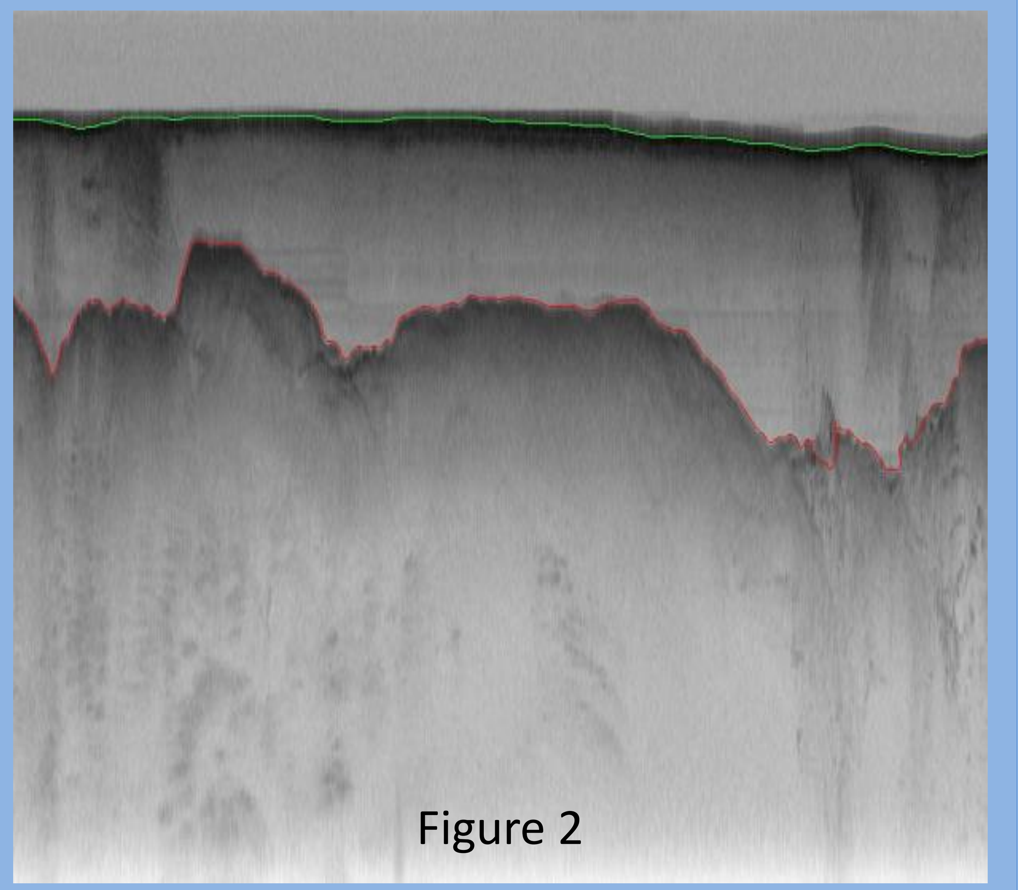
- In active contours [4], a snake is defined as an energy minimization spline, which deforms to minimize the energy.
- Internal energy, which represent the tension and rigidity while the external energy attracts the snake to the target object.
- The parameters α, β, and γ as coefficients of each term represents weighting functions.

How It's Used:

- The initial contour must be close to the bedrock and surface layers in order for the snake to move from noises or other undesired edges in the image.
- Selecting α, β, and γ values were chosen arbitrarily through trial and error depending on the best fit for a particular layer. A layer is fit when the maximum number of iterations has reached its threshold.

Results





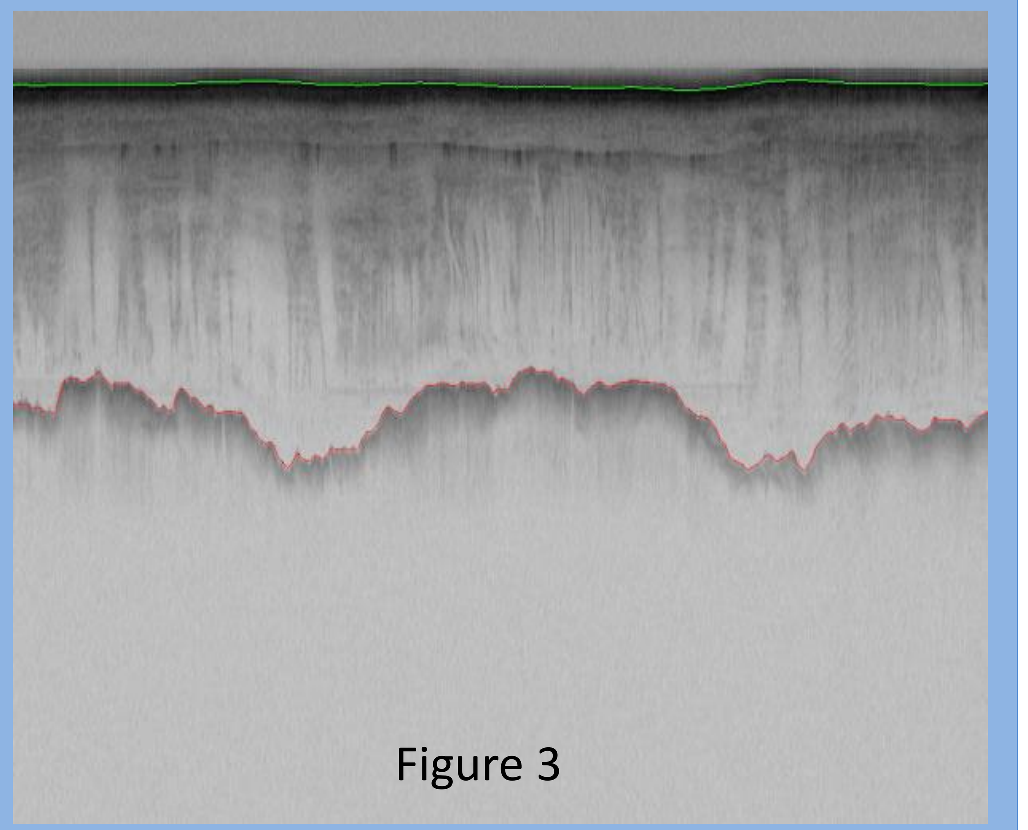


Figure 1: Represents the initializing of the boundaries

Figure 2: Represents the Active Contour not detecting the boundaries accurately

Figure 3: Acceptable Image after Active Contour

Introduction

- Understanding the ice flow dynamics in Greenland and Antarctica poses a significant climate problem. A modest change in ice sheet volume could strongly affect future sea level and freshwater flux to the oceans.
- This uncertainty could be substantially reduced by more and better observations of the polar ice sheets' subsurface structure.
- The Center for Remote Sensing of Ice Sheets (CReSIS) has developed a Multichannel Coherent Radar Depth Sounder (MCoRDS) radar in order to image surface and bedrock layers for producing high-resolution ice thickness maps.
- Identifying bedrock and surface layers require significant resources to complete a single radar data file consisting of thousands of measurements.
- Given the volume of radar data acquired in the past and its growth each year, automating this task is necessary for providing results to the scientific community.

$$E_{snake} = \int_0^1 (\alpha * E_{elastic(v(s))} + \beta * E_{bending(v(s))} + \gamma * E_{image(v(s))})\, ds$$

Conclusion

- We have used an active contours ("snake") model, which would estimate surface and bedrock layers in depth sounder radar imagery.
- By providing tools to the polar science community, high resolution ice thickness maps can be readily processed to determine the contribution of global climate change on sea.

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