Calving Front Detection in SAR Images using Deep Learning Techniques

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Introduction

- Calving front positions of marine-terminating glaciers are needed as parameters for ice-sheet models
- Manual delineation of calving fronts is time-consuming and expensive

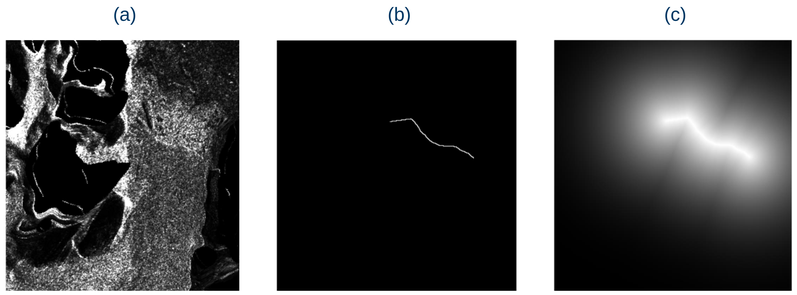


Figure 1: (a) shows the SAR image. (b) gives the corresponding front and (c) depicts the label for the pixel-wise distance regression.

Figure 2: Improved distance map loss. The image to the left depicts the weighting of the prediction shown in the middle. The image to the right is the front label.

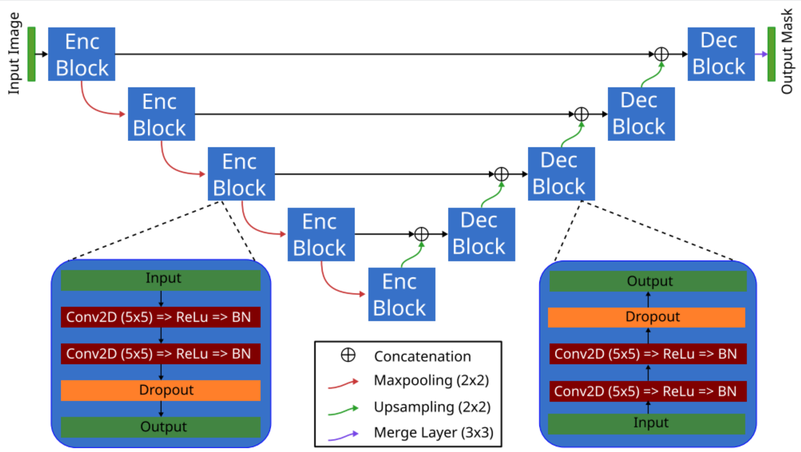
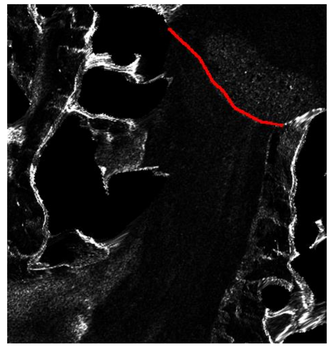


Figure 3: Probabilistic Bayesian U-Net architecture. Taken from [4].

Data

- SAR images of marine-terminating glaciers with corresponding front labels



Methods

→ ***Adapt U-Net [1] to tackle class-imbalance:***

Pixel-wise distance regression with a U-Net [2]

- Reformulates segmentation task into a pixel-wise regression
- Distance map of the front is used as label (see fig. 1)
- Three different post-processing schemes: statistical thresholding, conditional random field, second U-Net

U-Net with an improved distance map loss [3]

- Cross-entropy loss with weighted prediction (see fig. 2)
- Pixels on the front are weighted high; pixels at a certain distance from the front are weighted less the closer they are to the front; the remaining pixels are weighted with a constant factor

Probabilistic Bayesian U-Net [4]

- Calculate the uncertainty of the prediction by creating a sampling distribution through multiple forward passes of a U-net with dropout as random sampling layers (see fig. 3)
- Uncertainty map as input for a second U-Net

Attention U-Net [5]

- Attention gate in the skip connection of the original U-Net
- Insights into learning process through attention maps (see fig. 4)

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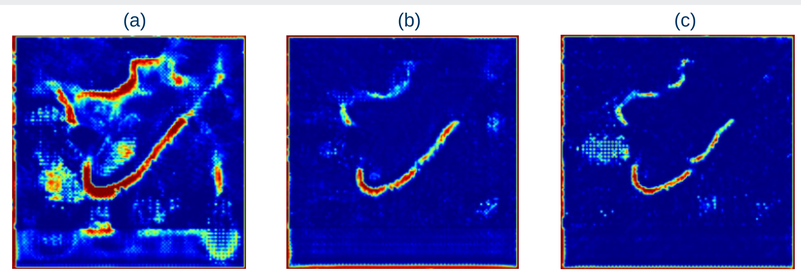
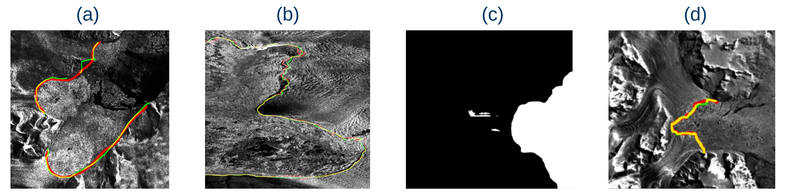


Figure 4: (a-c) show the attention maps after epoch 5, 10, and 36.

Qualitative Results

Prediction (red), ground truth (green), intersection (yellow)

a) Pixel-wise distance regression and second U-Net for thresholding
b) U-Net with an improved distance map loss
c) Probabilistic Bayesian U-Net with uncertainty map as second input (Segmentation into land and ocean)
d) Attention U-Net



Conclusion and Outlook

- Class imbalance is a major issue in calving front detection and needs to be considered during model design
- Future work will incorporate knowledge about the front's surrounding environment to improve the performance and robustness of front detection models

References

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