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Calving Front Detection in SAR Images using Deep Learning Techniques

Abstract

Ice discharge at the calving front of marine-terminating glaciers has a strong impact on the global hydrological cycle as well as on the buttressing forces stabilizing the glacier itself. In current ice-sheet models, which are incorporated in global climate models, the calving is underrepresented, as up-to-date calving front annotations are not readily available. This may lead to uncertainties e.g., in ice volume reconstruction of up to 30 %. Calving fronts can be located in Synthetic Aperture Radar (SAR) images. Manual delineation of the fronts is however not feasible for huge amounts of images, as it is a time-consuming, tedious and expensive task. Hence, this research project focuses on automatic extraction of calving fronts from SAR images. The automation is realized using deep learning techniques, as deep learning approaches have achieved tremendous success in various disciplines, such as medical image processing and computer vision.

The state-of-the-art in deep learning for semantic segmentation is the U-Net architecture, which we have employed in all our experiments so far in order to identify which pixels of the image belong to the front and which to the background. A challenge in this task is the class imbalance, as the front has significantly fewer pixels than the background. This class imbalance prevents the U-Net from learning efficiently and ultimately leads to low accuracy of the extracted front line. Therefore, we have adapted the U-Net to our needs so that it can handle the class imbalance in the data. This resulted in different successful variants of the U-Net including a probabilistic Bayesian U-Net, an Attention U-Net, and a U-Net with a distance map-based binary cross-entropy (BCE) loss function. Future work will incorporate knowledge about the surrounding environment of the front line into the segmentation process of the front itself. The knowledge about the surroundings (location of rocks, glacier, and ocean) is extracted from the SAR image itself using the U-Net, which will be trained jointly on the front line segmentation and the segmentation into the different surface types by using a multi-task learning approach. The goal of this integration of knowledge about surface types is to further improve the quality of the front detection and make it more robust.