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Tracing Extended Internal Stratigraphy in Ice Sheets using Computer Vision Approaches

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Polar ice sheets Greenland and Antarctica are integral parts of the climate system. Understanding their history, dynamics and past accumulation rates determines projections of sea level change. Ice englacial stratigraphy is used to assign ages, taken from ice cores, to radar reflections and subsequently connect these known layers over large areas. One of the main methods to investigate these characteristics is radar reflections. Ground-penetrating radar (GPR) has been used as the primary technique to detect internal ice architecture.

Mapping the internal reflection horizons in order to study and investigate the features, accumulation rates, and ice streams is an important step, which is conventionally done through a semi-automatic process. Such methods are prone to shortcomings in terms of continuity and layer geometry. Moreover, it is highly time-consuming to map an entire profile, the abundance of unmapped radar profiles especially from antarctic ice sheet is an evidence for this. Thus, there is the need for more comprehensive and efficient methods.

The use of machine learning to perform this task automatically will make a significant difference for internal layer detection in terms of efficiency and accuracy. Such machine and deep learning methods would be a suitable fit for radar surveys with different properties, such as center frequencies, making them appropriate for both ice, firn and snow data. In this project, apart from classical computer vision methods and image processing, deep learning methods are used to map the internal reflection horizons (IRH). Convolutional Neural Networks (CNN) are a powerful tool to learn features and track the IRHs continuously.

In this talk, the implemented classical computer vision methods are enumerated, and the machine learning methods that have been used (the specific pre-processing methods unique to this project, labeling method, architecture and hyperparameters) are explained. The results from some more promising architectures such as U-net are presented and compared to the results from image processing methods. The main challenges in this project are lack of complete training data, unknown number of IRHs in a profile, and abundance of features in a single radargram. These challenges are shown and possible solutions are presented.