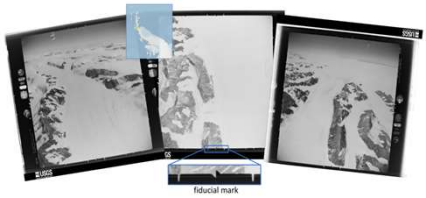
Semantic segmentation of historical images in Antarctica with neural networks

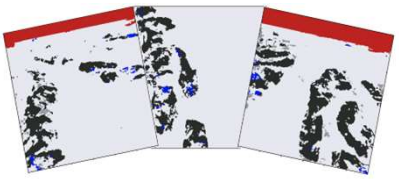
Felix Dahle[1], Julian Tanke[2], Bert Wouters[1,3], Roderik Lindenbergh[1]

[1] Dept. of Geoscience & Remote Sensing, Delft University of Technology
[2] Dept. of Information Systems and Artificial Intelligence, University of Bonn
[3] Institute for Marine and Atmospheric Research Utrecht, Department of Physics, Utrecht University, Utrecht



Historical Imagery

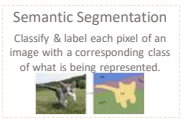
to



Segmented Imagery

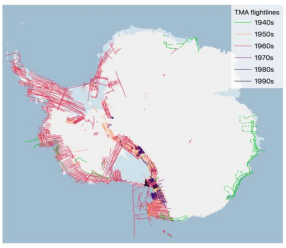
Introduction

Many archives of **historical images** are digitized and available for the public. Yet, it is difficult to use these archives, as they consist of scanned image files without any context or georeferencing **Semantic segmentation** can help to add semantic information to these images. Typical applications are excluding images (*"Exclude images with a cloud cover over 20%")* or filtering images (*"Search for images containing Water"*). In this work, we are training a **neural network** for an automatic semantic segmentation of these images in different classes



Use Case

We are using an archive of **historical aerial images** from Antarctica from different years (see right figure). It consists of **grayscale imagery** with images taken top-down or by side-view. The final segmentation will contain **6 different classes**: (I) Ice; (II) Water; (III) Snow; (IV) Clouds; (V) Rocks; (VI) Sky

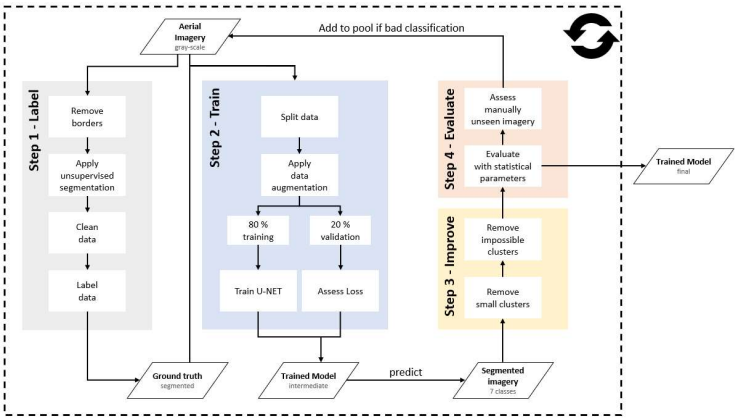


Methodology

The complete workflow can be divided in **four different steps:**

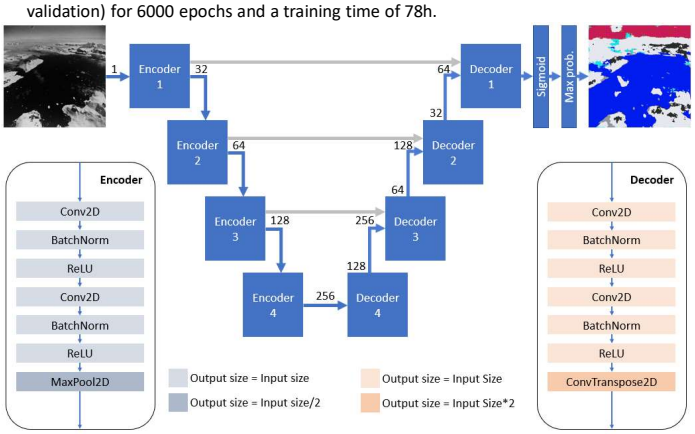
1. Label: The aerial images must be prepared and labelled (manual labelling)
2. Train: The labelled data is used to train a U-Net to automatically segment the images
3. Improve: Rules are applied on the labelled images to improve the quality
4. Evaluate: Unseen images are evaluated manually to check the performance (and added to the pool of training images if the segmentation failed)

This is **repeated** until the overall quality of segmentation is satisfying.



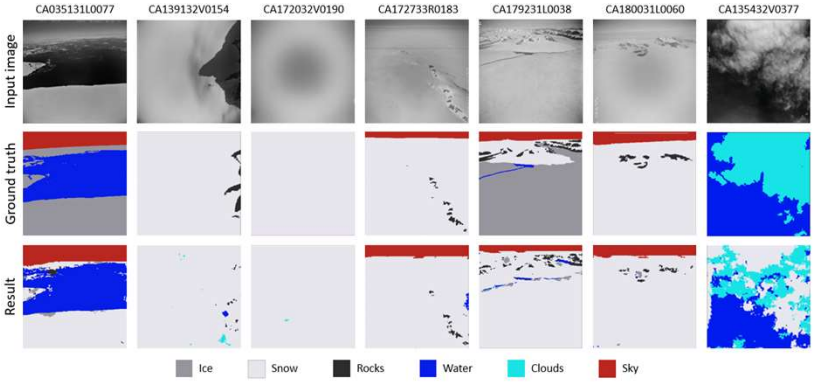
To achieve a successful segmentation, a **U-Net** will be applied. This is a special type of neural network based on **convolutional neural networks**. It works especially good for segmentation of imagery with few training data. It consists of a contracting path followed by an expansive path, resulting in a U-shaped network structure.

- In total this network contains two million trainable parameters.
- The average weighted **cross-entropy** was used a **loss**, as the dataset is very imbalanced.
- For the final iteration, the network was trained with 67 images (52 training, 15 validation) for 6000 epochs and a training time of 78h.



Results

These images were segmented for testing of the algorithm. They were never used for training or validation and were prior unknown to the model.



Discussion

The average accuracy of this model on the test set **is 74% over 6 classes**. However, most errors can be attributed to the model misclassified ice as snow.

Generally, the model is able to distinguish between different classes and catch the semantic meaning of a scene. Following remarks can be noted

1. High percentage of snow for the pixels:
   For almost any pixels of the images, regardless of the ground truth, there is a high probability for the snow-class.
2. Ice gets confused with snow
   Often both classes are close together and have a very similar semantic structure. This effect is reinforced by snow often covering the ice fields.
3. Segmentation of clouds failing for some cases
   A complete segmentation of this class is difficult. Dependent on the thickness of the clouds, the land beneath the cloud is completely obscured or only partly covered, which can lead the model to wrong assumptions

Software & Data

- Methodology & segmented images available at
  `github.com/fdahle/antarctic_segmentation`
- The raw images are available at
  `https://www.pgc.umn.edu/data/aerial/`

Contact: f.dahle@tudelft.nl

TU Delft Delft University of Technology

NWO

EGU General Assembly 2022