AVALANCHE DETECTION IN SAR-IMAGES USING DEEP LEARNING

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Introduction

Snow avalanches cause loss of lives and material every year. Keeping inventory of avalanches is important in order to give better prediction of when and where there is increased risk of avalanches. Automatic avalanche detection using earth observation satellites may give a better and more complete mapping of avalanches than with manual reporting of observations.

Dataset

- Sentinel-1 SAR images over Troms county, Norway.
- Acquisition mode: Interferometric Wide Swath (IW),
- Polarization: VV/VH.
- Geo-coded to 15 x 15 m grid. (UTM 33)
- Event images were recorded from December 2014 to April 2015.
- Reference images were recorded from July to August 2015.

Convolutional Neural Network

- ResNet 34 [He et al, 2016], pre-trained on ImageNet [Russakovsky et al, 2015] and fine-tuned on SAR images.
- Adam optimizer – learning rate: 0.0001.
- Random augmentation: scaling (30%), random shearing (10%), random flipping of axes, Gaussian noise.
- Early stopping on best class-balanced validation accuracy.
- Batch size: 64.
- Iterations: 1000.
- Validation rate: 1/25 iteration.

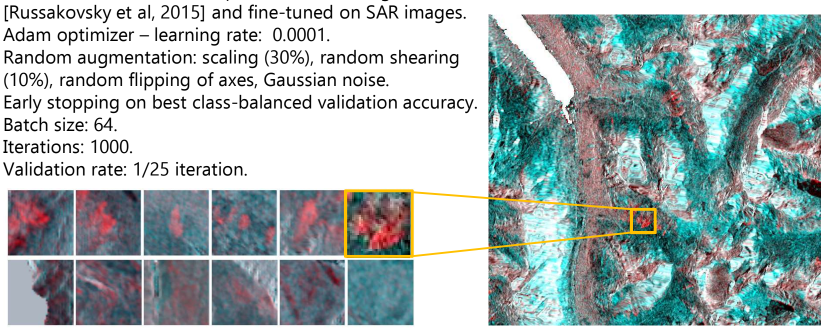

Figure 1: Extracted avalanche candidate regions based on method by [Hamar et al. 2016]. Top row shows avalanches, Bottom row shows non-avalanches. The visualized images are RGB images where the red channel is event image and the green and blue channel are the reference image.

Results

The method were evaluated using a 9-fold cross-validation. For each split, all the labeled data was separated into training (7/9), validation (1/9) and test (1/9). The network was then trained on the training set. Finally, the test set results for all of the cross-validation splits was combined to access the performance of the proposed method. The results show that the proposed method achieve a high accuracy. After optimizing on f1-sore, the false positive rate is significantly lowered.

	Non - Avalanche	Avalanche	Error	f1
Non - Avalanche	29307	780	2.6%	
Avalanche	10	233	4.1%	
				0.37

Table 1: Cross-validation results before optimizing threshold based on f1-score.

	Non - Avalanche	Avalanche	Error	f1
Non - Avalanche	29459	264	2.4%	
Avalanche	46	197	19.2%	
				0.56

Table 2: Cross-validation results after optimizing threshold based on f1-score.

Proposed method

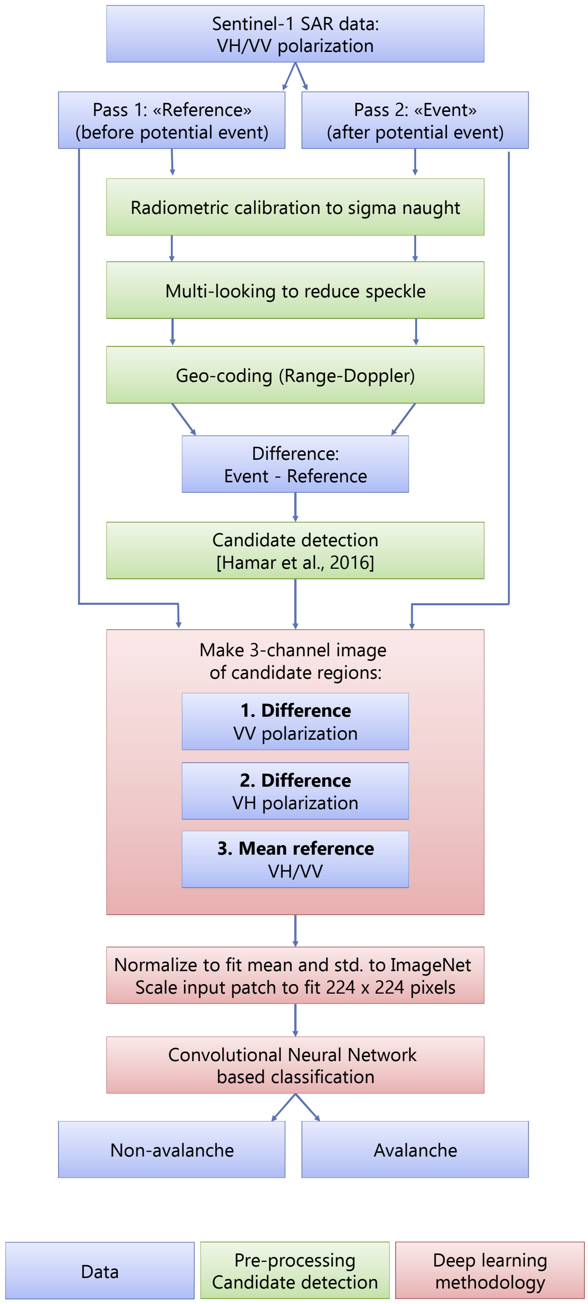

Figure 2: Overview of the proposed method

Discussion and further work

- Convolutional neural networks can be used to detect avalanches in Sentinel-1 SAR-images with high accuracy.
- Cross-validation does not necessarily represent accuracy for new data sets from different regions,
- Class-imbalance cause high false-positive rate.

Future work includes:
- Evaluating proposed method on new data.
- Bypassing candidate detection algorithm to by applying CNN directly to SAR images.
- Add additional features such as slope, aspect and upslope contributing area.

References

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