Technical note

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Using eCognition Definiens for automated detection of snow avalanches from optical imagery

1 Introduction

Detection of avalanches from remotely collected optical imagery has been tested through analysis of image properties such as brightness, contrast, and different measures of texture. There have been few publications on the subject, providing an excellent opportunity for new developments. The work conducted at NGI in 2011 aimed at detecting fresh snow avalanches from very-high resolution (VHR) optical imagery. The research presented in this Technical Note has been supported by the Ministry of Petroleum and Energy (OED) through the Norwegian Water Resources and Energy Directorate (NVE).

1.1 Data collection platforms

The data used in this study were collected from one space borne and one airborne platform. The space borne imagery has been collected by the QuickBird satellite which orbits at 450 km and collects panchromatic imagery at a resolution of 60 cm. The QuickBird imagery used in this project was collected over Norway. The second sensor is an airborne digital camera ADS40-SH52 from Leica-Geosystems, Switzerland. Data is collected from a fixed wing aircraft at an average altitude of 2 km above the ground surface. The data collected has a panchromatic resolution of 20 cm. The ADS40 imagery used in this project was collected over an area in the Eastern Alps, Switzerland (Bühler, 2009; Bühler et al., 2009).[1]

[1] This dataset was made available to us by courtesy of Dr Yves Bühler, WSL Insitute for Snow and Avalanche Research SLF, Davos, Switzerland (email communication on Oct 24th 2011) and Leica-Geosystems, Heerbrugg, Switzerland (email communication with Mr Jacques Markram, Jacques.Markram@leica-geosystems.com on Dec. 9th 2011). This dataset has been thoroughly analysed by Bühler (2009) and Bühler et al. (2010). From these studies excellent ground truth is available for our project.

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2 Data processing

Previous research in the development of algorithms for the automatic detection of snow avalanches has been done using custom software implemented in commercial packages such as ENVI (Frauenfelder et al., 2010; Larsen et al., 2010; Larsen et al., 2011; Salberg et al., 2011). The research conducted at NGI aimed to use custom workflows in combination with previously developed off-the-shelf algorithms available in the eCognition-Definiens software package. Due to the large variability in the resolution, clarity, and ground characteristics of the different data collection platforms, two processing chains were developed. The main processing difference between the QuickBird imagery and the ADS40 imagery is the need for multiple processing paths which are dependent on the type of avalanche the user is attempting to detect.

In total four eCognition rule sets were developed, two for the ADS40 imagery and two for the QuickBird imagery. In two of rule sets the data will be processed at the resolution of the imported image. In the other two rule sets the data will be sub-sampled down converting 3 x 3 grids of pixels to individual pixels. This reduces the number of pixels by a ratio of 1:9.

Within the ADS40 rule sets, the workflow is fully automatic, all detectable avalanches will be found. However within the QuickBird rule sets, the user must select if the workflow should look for avalanches in fully illuminated regions, shady regions, or for partially melted avalanches.

The development of the algorithms went through numerous iterations. The first step was to identify that avalanches could be detected, the subsequent stages were with respect to producing a clean image with minimal noise and streamlining the process so that multiple images could be processed using the same basic algorithm.

Figure 1 visualizes the classification steps toward identifying snow avalanches and removing erroneous selections from the classification:

- *Stage 0*: Initial data
- *Stage 1*: Brightness test
- *Stage 2*: Neighbourhood assessment
- *Stage 3*: Test for Grey-Level Co-occurrence Matrix (GLCM) Dissimilarity.
- *Stage 4*: Number of similar/non-similar cells around a given cell.
- *Stage 5*: Buffering in order to re-include avalanche edges that were erroneously filtered out during *Stage 4*.

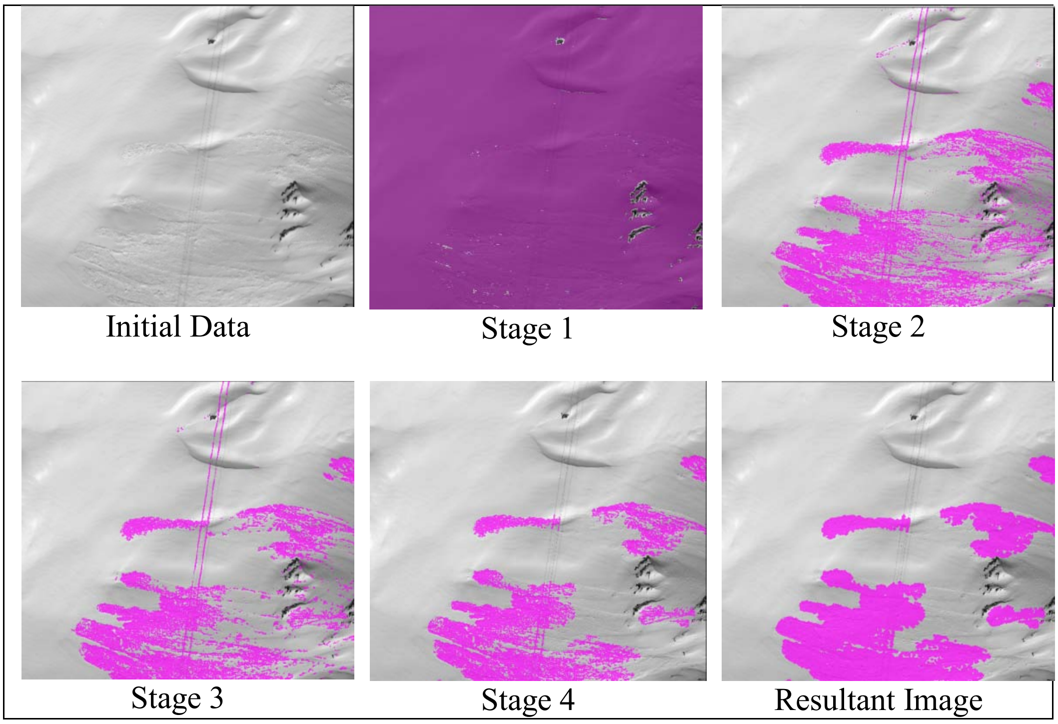

Figure 1: Visual representation of the classification steps toward identifying snow avalanches and removing erroneous selections from the classification for a section of the ADS40 data set. See text below for more explanation. Source data: ADS40©Leica-Geosystems.

3 Results

The results of the processes are quite positive; the algorithms are efficient, robust, stable, and reliable. The following sections illustrate a few results.

3.1 QuickBird Imagery

The following images (Figures 2 and 3) illustrate the identification of avalanches. Pink regions are located using the algorithm for the detection of avalanches in fully illuminated image sections, while the turquoise regions were detected using the algorithm for the detection of avalanches in (partly) shady image sections. Partially melted avalanches are also illustrated as pink.

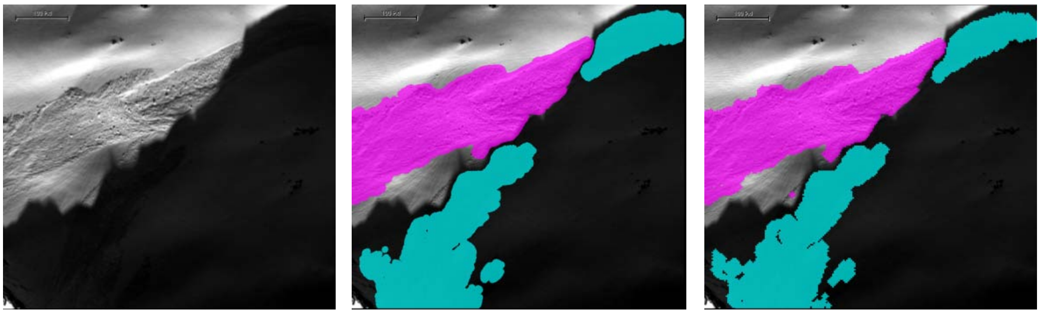

Figure 2: Dalsfjorden Imagery – Original data, 1:1 and 1:9 algorithms. Source data: Quickbird.

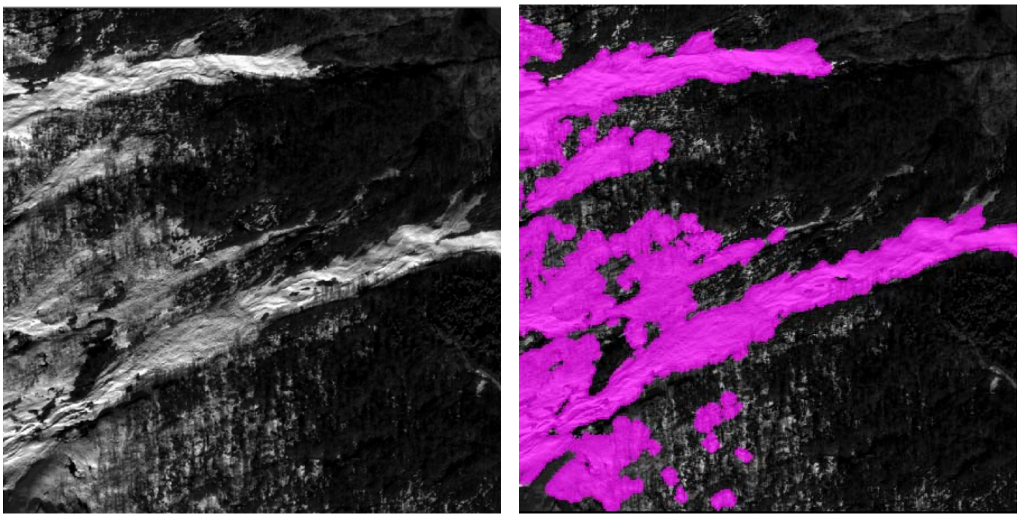

Figure 3: Hellesylt Imagery – Original data and 1:1 algorithm (for partially melted avalanches). Source data: Quickbird.

3.2 Leica Imagery

The following images (Figures 4 and 5) illustrate the results of the algorithm tested on Imagery generated by the ADS40 sensor.

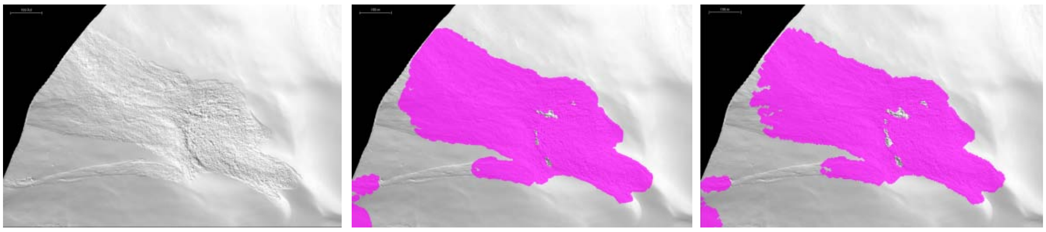

Figure 4: Davos Imagery – Original data 1:1 and 1:9 algorithms. Source data: ADS40©Leica-Geosystems.

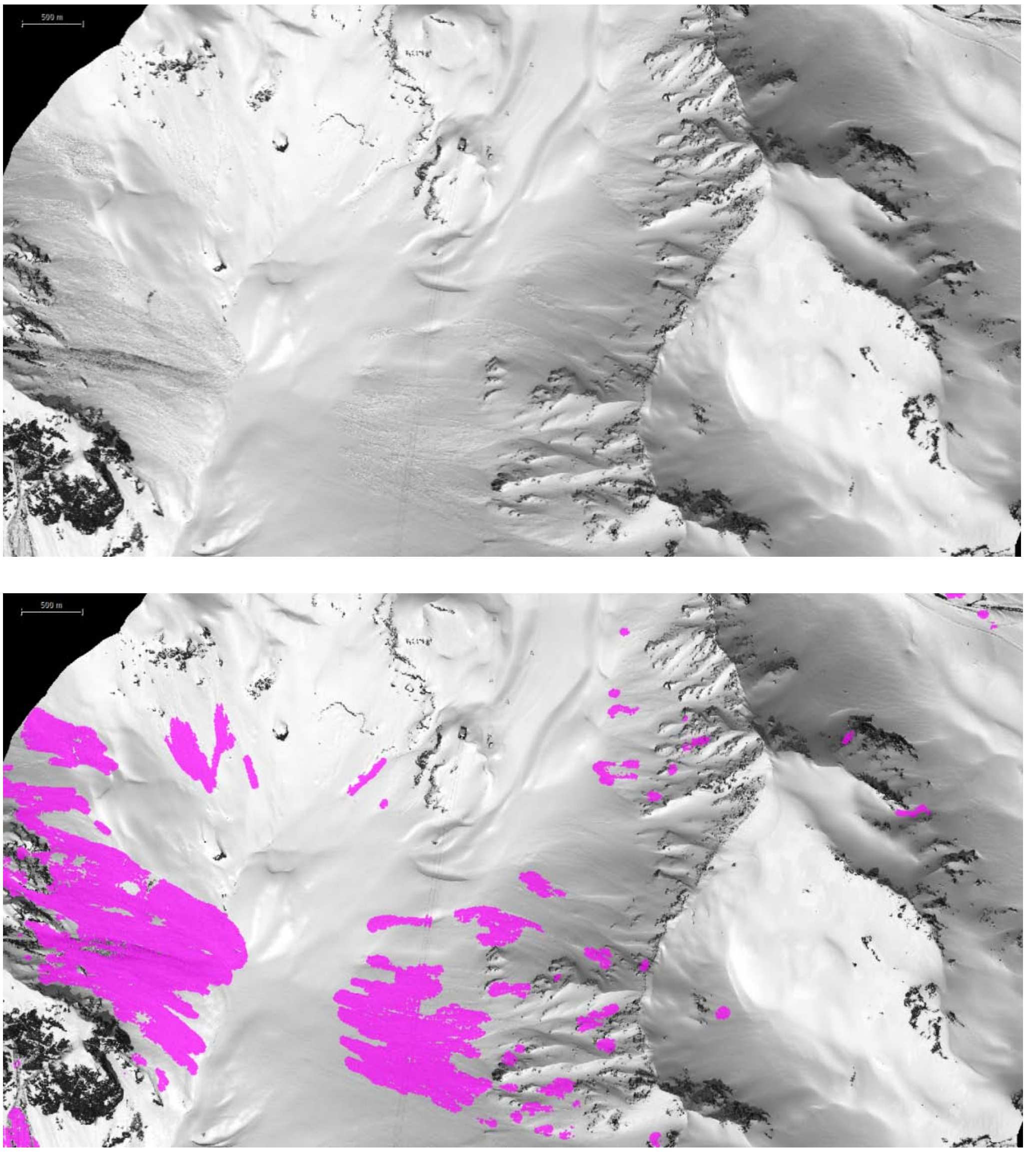

Figure 5: Davos Imagery – Original data and 1:9 algorithm. Source data: ADS40©Leica-Geosystems.

4 Discussion and Challenges

The methods illustrated in the above examples demonstrate a significant ability to automatically detect snow avalanches in optical imagery. The results indicate a low rate of false identifications. Of note, the algorithms are able to distinguish between rock boulders and avalanches, coniferous trees and avalanches. The workflows developed can detect fresh clean avalanches as well as avalanches with dirt in them.

One main area in which the detection algorithm fails is between avalanche material and deciduous trees without leaves. Although many sensitivity tests were conducted there is still a significant amount of uncertainly when such conditions are present in the imagery. An example of this situation is illustrated in the analysis in Figure 6; the regions of light deciduous trees are identified as avalanche material.

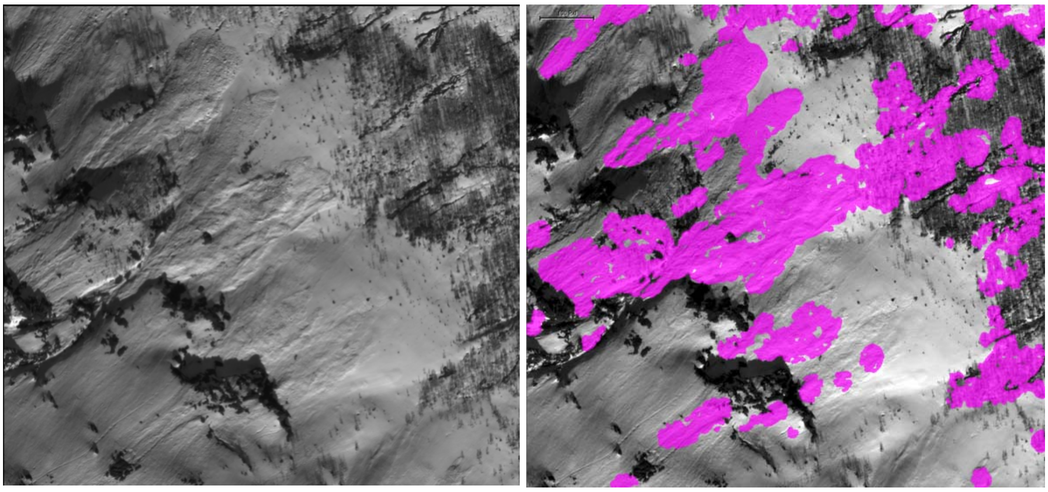

Figure 6: QuickBird Imagery – Original and 1:1 algorithm, note that regions lightly populated by bare deciduous trees (upper right) are identified as avalanches. Source data: Quickbird.

5 Conclusions

Before the algorithms can be used in a more operational setting, they need more research and testing. Also, the eCognition software package is not designed for geospatial data. The avalanche regions detected in eCognition can be exported to ESRI Shape Files and imported to ArcGIS. One challenge is, however, that the spatial information is missing and the new data are in local coordinates.

The implementation of this process into a state-of-practice mapping and inventory application would require the detected avalanches be visualized in ArcGIS and stored in a proper database. Future activities should focus on research into the export functions from eCognition through the import into ArcGIS, geospatial rectification, and digitization of avalanche outlines into a spatial database.

6 References

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