Webcam imagery rectification and classification: Potential for complementing satellite-derived snow maps over Switzerland

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INTRODUCTION

Satellite remote sensing data is widely used to study snow cover variability and can provide spatially comprehensive information on snow cover extent. However, cloud cover strongly impedes the surface view and hence limits the number of useful observations. Therefore, outdoor webcam images not only offer a unique potential for complementing satellite derived snow retrieval under cloudy conditions but serve also as validation reference for satellite based approaches.

The overall aim of this work is to elaborate a snow cover extent data set based on webcam images over Switzerland. We use daily and freely available webcam imagery of Swiss landscapes and apply and improve existing approaches dealing with:
(1) the positioning of photographs within a terrain model
(2) the appropriate rectification
(3) the automatic snow classification

DATA

The swissALTI3D digital elevation model (DEM) is used to position and rectify the webcam imagery. It is a precise DEM with a spatial resolution up to 2m describing the surface of Switzerland without vegetation and infrastructure. To obtain webcam imagery, we have been archiving imagery from 520 different webcams in Switzerland daily since 2011. The data is freely available and has a high temporal and spatial resolution.

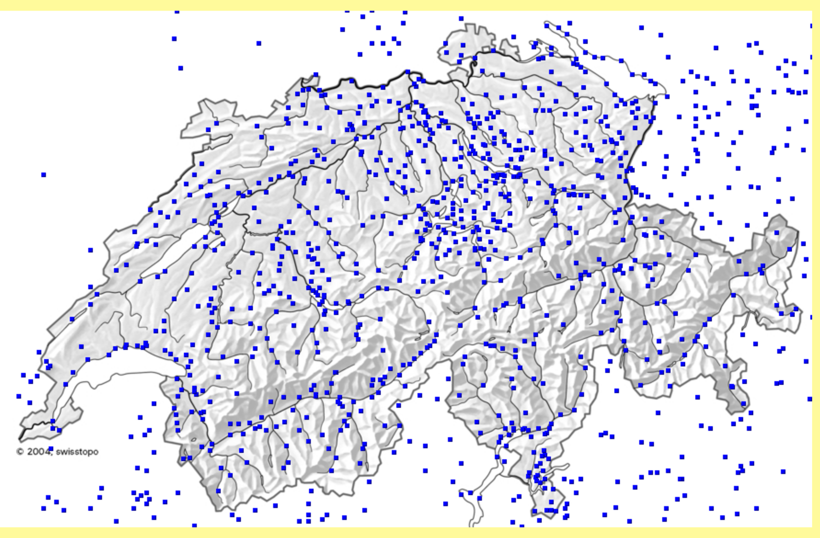

Figure 1: *A selection of Webcams in and around Switzerland (http://www.camscollection.ch). Even though this map is far from complete, it shows how densely the webcams are distributed. Therefore, webcam imagery represent a valuable source of information.*

Webcams must fulfill the following requirements for an accurate snow map derivation:
- high sensor quality and accurate resolution
- elevated position with a steep view (to minimize projection distortion)
- covering a large area
- constant viewing direction and field of view
- containing mountain contours (to simplify the alignment in the terrain)

Figure 2: *Example of a webcam image in Erzegg (OW) (http://www.melchsee-frutt.com). It fulfills all the mentioned conditions and is therefore well suited for our study.*

METHODS

Positioning of webcam imagery within a terrain model

Our first goal is to estimate the pose of a webcam, given its position. Mountain contours are the most reliable structural information to reach this goal using a DEM. We will use an automatic technique by Baboud et al. (2011). The algorithm obtains silhouette edges from a photograph and searches for the best match by rendering the DEM from the position of the camera in various viewing directions. The workflow of the algorithm is shown in **Figure 3**. To further improve the result, ground control points (GCPs) and calibration images will be used.

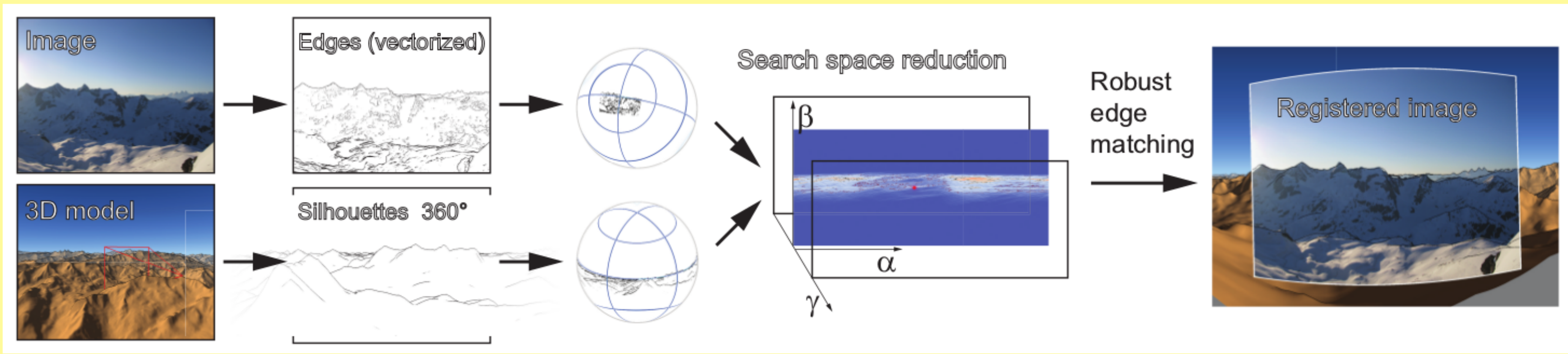

Figure 3: *Overview of the approach by Baboud et al. (2011)*

Orthorectification

To rectify a webcam image a mapping procedure relating its pixels to three-dimensional points is required. The technique by Corripio (2004) is based on two main steps: First, a viewing transformation of the DEM into the camera coordinate system is performed. Second, a perspective projection has to be applied to transform from camera space to image space. After these steps, the projection of the DEM grid points match the webcam image, as shown in **Figure 4.** The visual information of the picture can then be extracted and mapped onto the DEM.

Figure 4: *Superimposition of the perspective projection of a DEM of the Mer de Glace over a photograph of the area. Red dots are the perspective projections of the original DEM grid cells, and green dots are the ground control points (GCPs). (Corripio, 2004)*

Snow classification

Since the RGB values in a webcam image can vary strongly, simply using a global threshold will not work. The method by Salvatori et al. (2011) uses a statistical analysis of the blue channel using a digital number (DN) frequency histogram (see **Figure 5**). The first local minimum above 127 is selected as the snow threshold. The DN frequency histogram is smoothed to remove single outliers avoiding false positives.

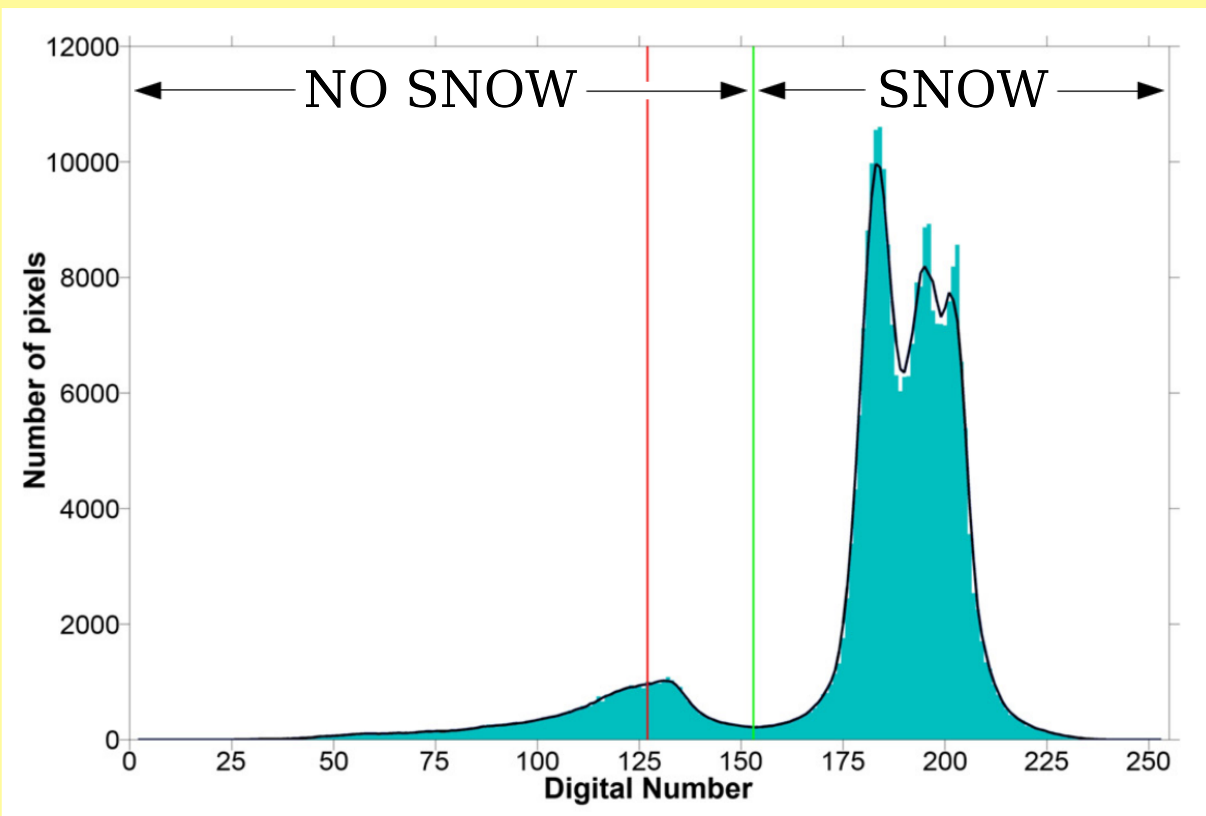

Figure 5: *A DN frequency histogram of the blue band values (blue-green bars) overlaid by a moving average (black line). The snow threshold (green line) is selected at the first local minimum beyond a DN > 127 (red line). (Salvatori et al.,2011)*

CONCLUSION

Combining and improving the mentioned techniques results in a high resolution snow cover map. This map will indicate for each grid cell whether the cell is snow-covered, snow-free or invisible from the webcams' positions. The procedure is expected to work under various weather conditions and with a high temporal and spatial resolution. Ultimately, this offers an enormous potential to serve not only as complementary information for real-time satellite snow applications but also as validation reference for existing interpolation techniques.

REFERENCES:
Baboud, L., Cadík, M., Eisemann, E. & Seidel, H.-P. (2011) Automatic photo-to-terrain alignment for the annotation of mountain pictures. CVPR (p./pp. 41-48), : IEEE.
Corripio, J. G. (2004) Snow surface albedo estimation using terrestrial photography, Int. J. Remote Sens., 25, 5705–5729, doi:10.1080/01431160410001709002.
Salvatori, R., Plini, P., Giusto, M., Valt, M., Salzano, R., Montagnoli, M., Cagnati, A., Crepaz, G., and Sigismondi, D. (2011) Snow cover monitoring with images from digital camera systems, Ital. J. Remote Sens., 43, 137–145.

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