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Estimating snow depth in real time using unmanned aerial vehicles

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In frame of the project no. LIDER/012/223/L-5/13/NCBR/2014, financed by the National Centre for Research and Development of Poland, we elaborated a fully automated approach for estimating snow depth in real time in the field. The procedure uses oblique aerial photographs taken by the unmanned aerial vehicle (UAV). The geotagged images of snow-covered terrain are processed by the Structure-from-Motion (SfM) method which is used to produce a non-georeferenced dense point cloud. The workflow includes the enhanced RunSFM procedure (keypoint detection using the scale-invariant feature transform known as SIFT, image matching, bundling using the Bundler, executing the multi-view stereo PMVS and CMVS2 software) which is preceded by multicore image resizing. The dense point cloud is subsequently automatically georeferenced using the GRASS software, and the ground control points are borrowed from positions of image centres acquired from the UAV-mounted GPS receiver. Finally, the digital surface model (DSM) is produced which – to improve the accuracy of georeferencing – is shifted using a vector obtained through precise geodetic GPS observation of a single ground control point (GCP) placed on the Laboratory for Unmanned Observations of Earth (mobile lab established at the University of Wroclaw, Poland). The DSM includes snow cover and its difference with the corresponding snow-free DSM or digital terrain model (DTM), following the concept of the digital elevation model of differences (DOD), produces a map of snow depth. Since the final result depends on the snow-free model, two experiments are carried out. Firstly, we show the performance of the entire procedure when the snow-free model reveals a very high resolution (3 cm/px) and is produced using the UAV-taken photographs and the precise GCPs measured by the geodetic GPS receiver. Secondly, we perform a similar exercise but the 1-metre resolution light detection and ranging (LIDAR) DSM or DTM serves as the snow-free model. Thus, the main objective of the paper is to present the performance of the new procedure for estimating snow depth and to compare the two experiments.