UAVs for change detection in forestry: preliminary insights and assessment

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Remote sensing methods applied to forestry have been widely investigated with significant positive results in many aspects. Latest developments are bringing a reduction in weight and cost of materials related to the different components of a remote sensing system, i.e. positioning (GPS), orientation (INS), and active/passive sensors for digitizing incoming energy. This has brought to a proliferation of Unmanned Aerial Vehicles (UAVs) equipped with sensors for various applications. UAVs with passive optical sensors (i.e. spectral cameras) are now common, whereas lidar sensors are less so, due to payload limitations and energy requirements of emitting structured light pulses. Industry is succeeding into overcoming these limitations with two approaches: (i) producing lighter lidar sensors (UAV-specific) and (ii) increasing the capabilities of the flying vehicle (payload, battery duration, flight time etc…).

The focus of this note is to make initial considerations on the idea of employing digital surface models (DSMs), produced from photogrammetry with UAVs, for change detection in forests. We report some initial results from a first comparison of CHMs between an ALS survey (July 2012) and a UAV flight (July 2013) over one test area of the project (UNIPD see Table 1); harvesting took place one month before the UAV flight, therefore over the study area we have parts where no relevant changes took place and parts where we expect to detect change. Results are represented in Figure 1; the distribution of differences shows the position of an area harvested with cable-crane, where 234 trees (369 m^3) have been cut and removed. A slight spatial correlation can also be seen to be related to the morphology of the terrain (slope and aspect), (see Figure 1). Also the shadows projected by the canopies cause false differences, probably because the automatic point matching does not sample any points in those parts and therefore the height values get interpolated as can be seen in detail in Figure 2, where the visible ground surface surrounded by trees does not get any tie point from the matching and therefore is not modeled correctly.

This is the first part of a broader investigation which will see four distinct study sites in the Italian alpine area (Table 1), providing a range of different forest structures, i.e. even-aged high-forest, multi-layered high-forest and coppice, sampled with circular areas of 20 m radius stratified by forest structure categories. Lidar datasets are available and UAV flights will cover the sample plots used for ground-truth data. Considering the cost and complexity of national / regional / local airborne lidar campaigns, an ideal solution can be, in the case of even-aged high-forest, to use UAVs equipped with non-metric cameras for sampling change detection. A very close future will see lidar-equipped UAVs providing multi-echo datasets. A non-metric camera still has a much lower cost and can be used in some well-defined scenarios. The obstacles in photogrammetric-processing of images over forest areas is well known, and consists in the following: (i) low-cost position/orientation sensors give lower accuracy thus initial external orientation of image is less accurate, (ii) non-metric cameras have lower costs but have higher deformations which require more careful calibration, (iii) worst performance of automatic tie point matching algorithms due to limited contrast in the images, shadows, and difficulty in defining a robust network of control points, as well as accessing the control points for high-accuracy measurement. Also the terrain surface below canopy is not detected as it is in a lidar survey; therefore the DTM has to be provided from other source.

The final objective is to define a work-flow for using DSMs from photogrammetry integrated with DTMs from lidar surveys for extracting forest information. The method plans to integrate digital terrain models DTMs obtained from lidar surveys, carried out between long time-intervals (e.g. every 10 years), with DSMs from intermediate UAV surveys at a local scale. These can be planned at shorter time intervals and the resulting DSMs can be integrated with the lidar-derived DTMs to provide canopy height models (CHMs) which potentially reflect modifications in vegetation. Photogrammetry over vegetation is not capable of providing a DTM, but it is very unlikely that the ground surface will change significantly over a 10 year period, except in case of extreme events (e.g. landslides, earthquakes) which can, in case, be traced and isolated from the dataset.

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Table 1 Overview of characteristics of study areas and surveys for each partner.

	TESAF - UNIPD	**UNITO**	**PAT-SFF**	**ERSAF**
	Study area			
Area	5500 ha	3885 ha	1640 ha	200 ha
Tree species	spruce, fir, beech	larch, stone pine, spruce, scots pine	larch, spruce	ash, sycamore, beech
Remote sensing data	Lidar / RGBI images / UAV images	Lidar / RGBI images/ UAV images	Lidar / hyperspect. images	Lidar / UAV images
N° of sample areas	33	33	8	10
	Lidar flight			
Flight date	June 2012	June 2012	September 2012	May 2014
Echos (pts/m^2)	~11	~8	~10	~7 (pulses)
Sensor	Optech ALTM 3100EA	Optech ALTM 3100EA	Riegl LMS-Q680i	Optech ALTM 3100EA

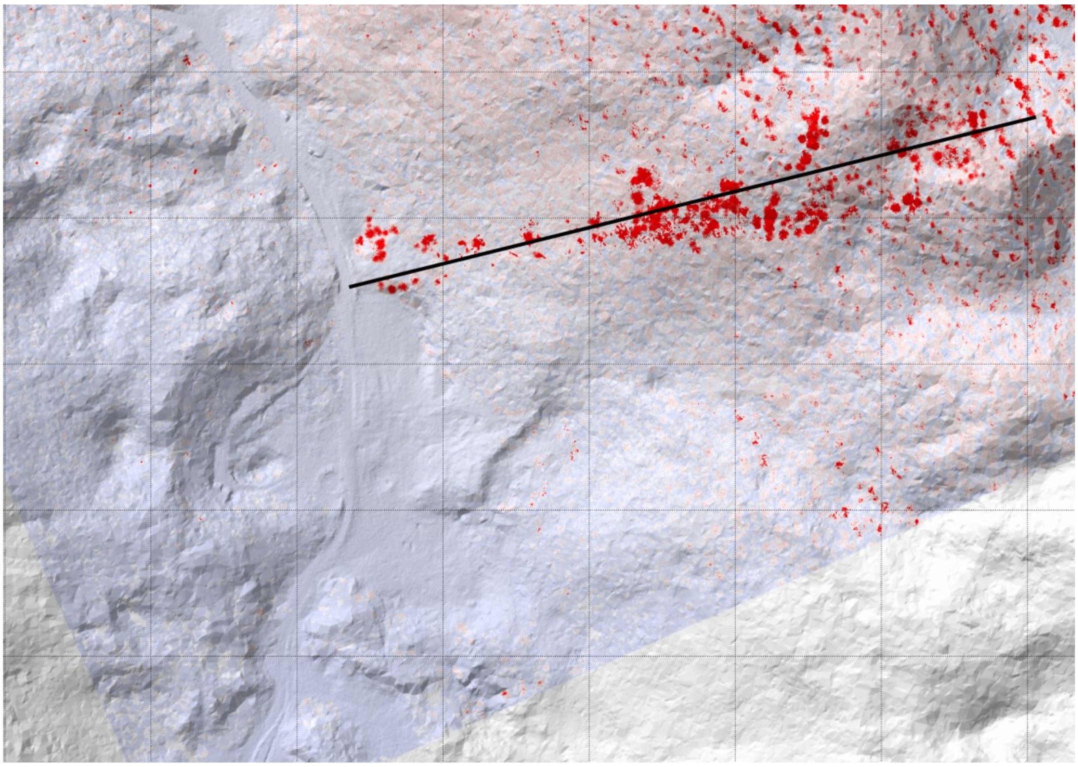

Figure 1 Color scale representation of differences between UAV-derived and lidar-derived DSMs – the black line represents the cable crane, the red color a decrease in CHM value, blue color an increase.

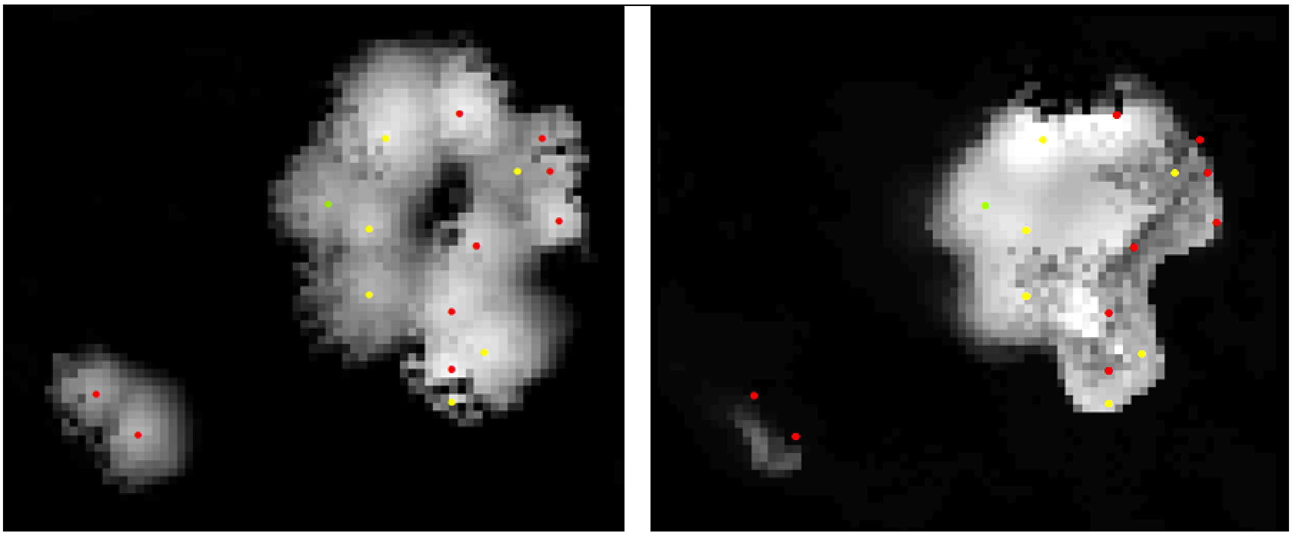

Figure 2 Visual comparison of (left) lidar-derived DSM and (right) UAV-derived DSM.