Environmental Monitoring with a new UAV based multi-sensor system

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INTRODUCTION

The use of UAV (Unmanned Aerial Vehicle) quickly gains an increasing presence in civil and research applications.

The usage of UAV in research provides:
- cost and time efficiency
- human protection in exposed regions
- flexibility in application

In the following two experiments in the field of environmental monitoring are presented.
They are part of a collaboration project at the Sustainability Center Freiburg.

OBJECTIVE

Using an UAV based multi-sensor system in the field of fast arising natural hazards like floods and avalanches

CHARACTERISTICS OF THE MULTI-SENSOR SYSTEM

components
laser scanning device (accuracyabout 10-15 millimeters)
camera
4-channel mulitspectral camera

advantages
adaptable to any UAV
low weight (less than 2 kilograms)
low cost system

developed by Fraunhofer IPM

DETECTION OF WATER LEVEL AND WATER SURFACE EXTENT

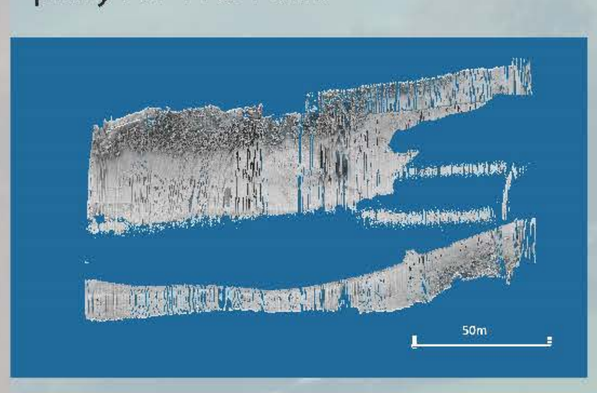
Floods ares a serious natural hazard in Germany. At the chair of hydrology the Runoff Generation Research model (ROGeR) was developed for scale independent modeling of runoff generation during extreme flooding. Information about water levels and the water surface extent during a flood will help to benchmark the model and can be used for model parametrization. Measurements via UAV can be used for spacious areas.

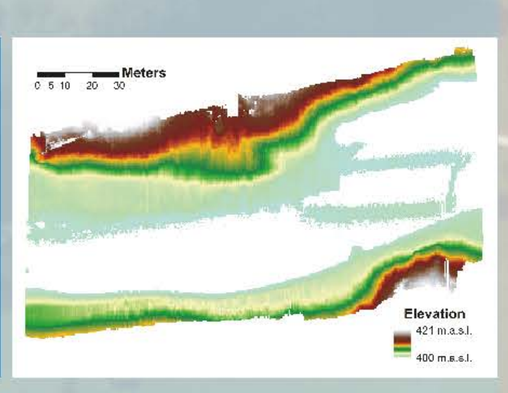
To verify the multi-sensor system´s ability to detect water level and water surface extent, test flights were conducted at the Wehra Reservoir, which is used by a pumped storage hydropower plant and is located in the southern Black Forest, Germany.

Due to the pumping operations daily water level changes in the range of meters are observed by a gauge. This data is compared to the minimum shore heights generated by the laser scanning module.

Measurements were taken at a cloud-free day in October 2015. During that time a water level change of three meters occurred.

The following graphs show the point cloud generated by the laser (left), and a derived digital elevation model (right) exemplary for 11:51 am.





One scan comprises 1000 points within a scan angle of -45° to +45°. An elevation of 400.7 m.a.s.l. was measured at the gauge. Within the scanning data a height of 401.0 m.a.s.l. was detected.

As seen above, low reflection occurs from smooth water surfaces. So, water surface extent could easily be detected. For turbulent water there is a much higher response, as a test showed that was made at the river Dreisam in Freiburg. In this case, a calculation of NDVI via the 4-channel multi-camera system enables shore detection.

MONITORING OF SNOW DEPTH DISTRIBUTION

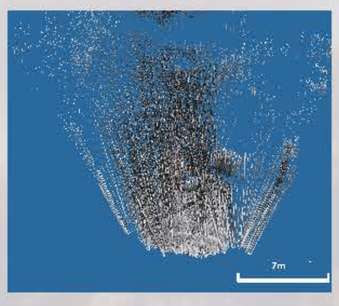
Furthermore the multi-sensor-system is tested for an application in the detection of snow depth patterns. Monitoring of snow depth is essential in avalanche research and hydrological modeling. Two measurements were conducted at the Schauinsland tower (~1290 m.a.s.l.) in the southern Black Forest, Germany.

11/03/16 View scan 1

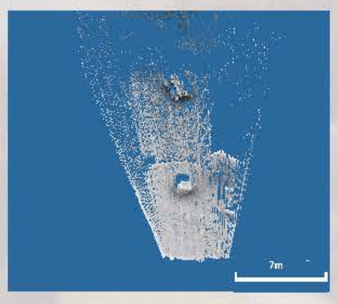
04/05/16 View scan 2

Methodology

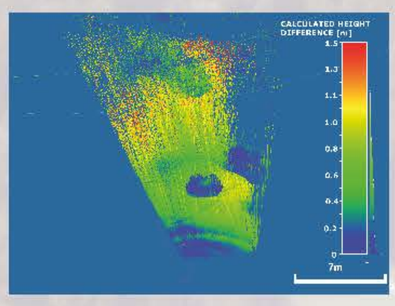
1) development of a data referencing method
2) calculation of cloud distances
3) comparison of resulting snow depths with reference values taken at defined ground control points



Point cloud scan 1



Point cloud scan 2



Calculated snow depth

The graphs show a smoother signal for scan 2 than for scan 1. Within the further proceeding the lower accuracy of scan 1 leads to uncertainty in the calculation of snow depth. The measured average snow depth is 48 cm. The average scan difference for non vegetated areas is 36 cm. A point to point comparison with the control measurements show similar differences.

CONCLUSION

The water level detection at Wehra Reservoir delivered promising results. Additional measurements with the multi-sensor system are planned at this site to receive statistically significant information about the accuracy of the system to derive water depths.
In snow depth detection, improvements need to be done to guarantee an exact alignment of conducted point clouds via a geo reference system and to recieve a more precise signal from snow covered areas.

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