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# Laser- and Multi-Spectral Monitoring of Natural Objects from UAVs

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The paper describes the research, development and evaluation of a lightweight sensor system for UAVs. The system is composed of three main components: (1) a laser scanning module, (2) a multi-spectral camera system, and (3) a processing/storage unit. All three components are newly developed. Beside measurement precision and frequency, the low weight has been one of the challenging tasks. The current system has a total weight of about 2.5 kg and is designed as a self-contained unit (incl. storage and battery units).

The main features of the system are: laser-based multi-echo 3D measurement by a wavelength of 905 nm (totally eye save), measurement range up to 200 m, measurement frequency of 40 kHz, scanning frequency of 16 Hz, relative distance accuracy of 10 mm. The system is equipped with both GNSS and IMU. Alternatively, a multi-visual-odometry system has been integrated to estimate the trajectory of the UAV by image features (based on this system a calculation of 3D-coordinates without GNSS is possible). The integrated multi-spectral camera system is based on conventional CMOS-image-chips equipped with a special sets of band-pass interference filters with a full width half maximum (FWHM) of 50 nm. Good results for calculating the normalized difference vegetation index (NDVI) and the wide dynamic range vegetation index (WDRVI) have been achieved using the band-pass interference filter-set with a FWHM of 50 nm and an exposure times between 5.000 $\mu$s and 7.000 $\mu$s.

The system is currently used for monitoring of natural objects and surfaces, like forest, as well as for geo-risk analysis (landslides). By measuring 3D-geometric and multi-spectral information a reliable monitoring and interpretation of the data-set is possible.

The paper gives an overview about the development steps, the system, the evaluation and first results.