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Monitoring of recreational trail erosion using terrestrial structure-from-motion approach

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Protected natural areas (PNAs) such as national and landscape parks as well as suburban green areas often constitute areas very popular among the visitors. Visitor pressure in PNAs is focused mainly on recreational trails, which facilitate activities such as hiking, cycling, horse riding. Trails prepared for different groups of users are among the most common types of infrastructure in PNAs, facilitating access to these areas. However, high visitor pressure can lead to increases in trail width and an associated increase in soil erosion. In case of extensive protected areas, the performing of regular geodetic monitoring using dGPS or laser scanning is expensive and therefore park managers often face a problem in selecting sites for impact monitoring. However, recent advances in technology enables the development of low-cost alternatives for traditional surveys. Consumer-grade cameras can be used to rapid acquire of photographs. The ground-based photographs can be subsequently processed through the structure-from-motion approach to generate detailed mosaics and digital elevation models of trail surfaces. It is possible to apply such models to study, monitor and quantify processes like soil erosion and vegetation trampling.

In this study, we present methodological framework for monitoring of trail impact with the use of structure-from-motion approach and demonstrate its application based on examples from recreational trail located in suburban settings of Poznań. The data were collected on 10-meter long trail segment in June, July and October 2016 capturing the initial condition at the beginning of the months, and then two session pre-, and immediately after intense rainfall event, and the last session after termination of summer season. The total number of images was between 150 and 300 for each of the survey session. Dens point clouds were from 18 to 29 million points and were downsampled to DEM with 1 mm resolution. To detect surface changes, Digital elevation model of differences were produced by subtraction of DEMs from subsequent periods. Error propagation was calculated for each pair of DEMs.

The proposed methodological framework can enhance the ability of land managers to prioritise their trail management activities, enhancing trail conditions and visitor safety, while minimising adverse impacts on the conservation value of the ecosystem.

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