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New Approach for Environmental Monitoring and Plant Observation Using a Light-Field Camera

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The aim of gaining a better understanding of ecosystems and the processes in nature accentuates the need for observing exactly these processes with a higher temporal and spatial resolution. In the field of environmental monitoring, an inexpensive and field applicable imaging technique to derive three-dimensional information about plants and vegetation would represent a decisive contribution to the understanding of the interactions and dynamics of ecosystems. This is particularly true for the monitoring of plant growth and the frequently mentioned lack of morphological information about the plants, e.g. plant height, vegetation canopy, leaf position or leaf arrangement. Therefore, an innovative and inexpensive light-field (plenoptic) camera, the Lytro LF, and a stereo vision system, based on two industrial cameras, were tested and evaluated as possible measurement tools for the given monitoring purpose. In this instance, the usage of a light field camera offers the promising opportunity of providing three-dimensional information without any additional requirements during the field measurements based on one single shot, which represents a substantial methodological improvement in the area of environmental research and monitoring. Since the Lytro LF was designed as a daily-life consumer camera, it does not support depth or distance estimation or rather an external triggering by default. Therefore, different technical modifications and a calibration routine had to be figured out during the preliminary study. As a result, the used light-field camera was proven suitable as a depth and distance measurement tool with a measuring range of approximately one meter. Consequently, this confirms the assumption that a light field camera holds the potential of being a promising measurement tool for environmental monitoring purposes, especially with regard to a low methodological effort in field. Within the framework of the Global Change Experimental Facility Project, founded by the Helmholtz Centre for Environmental Research, and its large-scaled field experiments to investigate the influence of the climate change on different forms of land utilization, both techniques were installed and evaluated in a long-term experiment on a pilot-scaled maize field in late 2014. Based on this, it was possible to show the growth of the plants in dependence of time, showing a good accordance to the measurements, which were carried out by hand on a weekly basis. In addition, the experiment has shown that the light-field vision approach is applicable for the monitoring of the crop growth under field conditions, although it is limited to close range applications. Since this work was intended as a proof of concept, further research is recommended, especially with respect to the automation and evaluation of data processing. Altogether, this study is addressed to researchers as an elementary groundwork to improve the usage of the introduced light field imaging technique for the monitoring of plant growth dynamics and the three-dimensional modeling of plants under field conditions.