UAVs Towards Sustainable Crop Production

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1 Abstract

One of the greatest challenges for humanity is to produce sufficient food, feed, fiber, and fuel for an ever-growing world population while simultaneously reducing the environmental footprint of agricultural production. Productive arable land is limited, and the input of agro-chemicals needs to be reduced to curb environmental pollution and halt the decline in biodiversity. Climate change poses additional constraints on crop farming. Achieving sustainable crop production with limited resources is, thus, a task of immense proportions.

We believe that a major shift toward sustainable crop production can be achieved via two approaches: (1) multi-scale monitoring of plants and their environment using autonomous robots with automated and individualized intervention and big data analytics combined with machine learning to improve our understanding of the relation between input and output parameters of crop production, and (2) assessing, modeling, and optimizing the implications of the developed technical innovations in a systemic manner.

The DFG-funded Cluster of Excellence "PhenoRob" addresses the hypothesis above and develops an approach that is characterized by the integration of robotics, digitalization, big data analytics, and machine learning on one hand, and modern methods of plant phenotyping, modeling, and crop production on the other, taking a technology-driven approach. Especially UAVs will play an important role for managing fields, reducing the environmental footprint of crop production, and maintaining the quality of soil and arable land.

Our UAV-based in-field monitoring activities generates heterogeneous data on plants, crop stands, and fields. This data includes geometric and semantic models of individual plants, multispectral images at different scales using optical and non-optical sensors, distributions of plant species in and around the fields, the status of plant health, nutrient as well as water contents of soil.

Besides several other scenarios of UAVs in agriculture, we focus on two central use cases for the integration of UAVs into crop production processes. First, UAVs will be a main source of information to identify the weed pressure in the field and in this way form the basis for robot-driven field management. The information will enable plant-specific treatments of individual plants at high accuracy, providing each plant the care it requires. Second, by combining the UAV data with predictive models of the agro-ecosystem on farm level, we can even identify nutrient deficiencies from UAV data. The discrepancies between the model prediction, weather models, and the UAV perception, form the basis for location-specific fertilization minimizing negative impacts on our ecosystem.

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