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Adaptive Multichannel Radiation Sensors for Plant Parameter Monitoring

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Nutrients such as nitrogen are playing a key role in the plant life cycle. They are much needed for chlorophyll production and other plant cell components. Therefore, the crop yield is strongly affected by plant nutrient status. Due to the spatial and temporal variability of soil characteristics or swaying agricultural inputs the plant development varies within a field. Thus, the determination of these fluctuations in the plant development is valuable for a detection of stress conditions and optimization of fertilisation due to its high environmental and economic impact. Plant parameters play crucial roles in plant growth estimation and prediction since they are used as indicators of plant performance. Especially indices derived out of remote sensing techniques provide quantitative information about agricultural crops instantaneously, and above all, non-destructively.
Due to the specific absorption of certain plant pigments, a characteristic spectral signature can be seen in the visible and IR part of the electromagnetic spectrum, known as narrow-band peaks. In an analogous manner, the presence and concentration of different nutrients cause a characteristic spectral signature. To this end, an adequate remote sensing monitoring concept is needed, considering heterogeneity and dynamic of the plant population and economical aspects.
This work will present the development and field investigations of an inexpensive multichannel radiation sensor to observe the incoming and reflected specific parts or rather distinct wavelengths of the solar light spectrum on the crop and facilitate the determination of different plant indices. Based on the selected sensor wavelengths, the sensing device allows the detection of specific parameters, e.g. plant vitality, chlorophyll content or nitrogen content. Besides the improvement of the sensor characteristic, the simple wavelength adaption, and the price-performance ratio, the achievement of appropriate energy efficiency as well as a suitable protection against disturbances and environmental influences are key challenges of this work. The multichannel sensors were tested in a mobile wireless sensor network in the frame of the Static Fertilisation Experiment in Bad Lauchstädt, Germany. The sensor nodes were permanently installed for one crop cycle on three different spring barley plots with diverse nitrogen fertilisation levels. In addition, weekly surveys of field spectrometer and chlorophyll meter measurements as well as tissue analyses of plant samples were implemented. The results of this experiment show a strong correlation of chlorophyll and nitrogen content indices in comparison to the simultaneously running commercial radiation transmittance or reflectance sensors.