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Development of Innovative and Inexpensive Optical Sensors in Wireless Ad-hoc Sensor Networks for Environmental Monitoring

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Due to the heterogeneity and dynamic of ecosystems, the observation and monitoring of natural processes necessitate a high temporal and spatial resolution. This also requires inexpensive and adaptive measurements as well as innovative monitoring strategies. To this end, the application of ad-hoc wireless sensor networks holds the potential of creating an adequate monitoring platform. In order to achieve a comprehensive monitoring in space and time with affordability, it is necessary to reduce the sensor costs. Common investigation methods, especially with regard to vegetation processes, are based on optical measurements. In particular, different wavelengths correspond to specific properties of the plants and preserve the possibility to derive information about the ecosystem, e.g. photosynthetic performance or nutrient content. In this context, photosynthetically active radiation (PAR) sensors and hyperspectral sensors are in major use. This work aims the development, evaluation and application of inexpensive but high performance optical sensors for the implementation in wireless sensor networks. Photosynthetically active radiation designates the spectral range from 400 to 700 nanometers that photosynthetic organisms are able to use in the process of photosynthesis. PAR sensors enable the detection of the reflected solar light of the vegetation in the whole PAR wave band. The amount of absorption indicates photosynthetic activity of the plant, with good approximation. Hyperspectral sensors observe specific parts or rather distinct wavelengths of the solar light spectrum and facilitate the determination of the main pigment classes, e.g. Chlorophyll, Carotenoid and Anthocyanin. Due to the specific absorption of certain pigments, a characteristic spectral signature can be seen in the visible part of the electromagnetic spectrum, known as narrow-band peaks. In an analogous manner, also the presence and concentration of different nutrients cause a characteristic spectral signature. 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 and the price-performance ratio, the achievement of appropriate energy efficiency as well as a suitable protection against disturbances and environmental influences remains to be a challenging issue. However, results of recorded long term in-situ data and linear regressions compared to commercial products show good performances (coefficient of determination higher than 0.99) of the PAR sensors simultaneous to the cost cutting. In addition, the PAR and the hyperspectral sensors were tested in a mobile wireless sensor network under field conditions. The development and evaluation of a Nitrogen sensing device is still in progress and one of the scopes of this work.