AI-Enhanced Optical and Electrochemical Biosensing for High-Throughput Plant Phenotyping: From Nano-Scale to Whole Plant Analysis

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A method using automated hardware and software approaches for phenotyping model plants in multiple environmental conditions will be presented. Multi-trait high-throughput screening, which can test higher tens of variants in one experimental run (in total >25,000 plants), uses simple RGB imaging of Arabidopsis in controlled conditions. The variants represent combinations of concentration ranges of tested chemicals/products, genotypes, individual abiotic stresses (water and nutrient limitation, salinity, heavy metals), individual biotic stresses (Botrytis, Pseudomonas), and their multiple combinations. The tested agents can be applied through seed/seedling priming or root absorption. The methodology is powered by the use of an artificial intelligence model to identify plants within images, followed by the extraction of numerous parameters such as the area of the plant, its perimeter, and a detailed colour description. These parameters are automatically evaluated through a Python script, facilitating a standardized, comprehensive analysis of various phenotypic traits, including growth dynamics and morphological and stress response traits. Incorporating statistical analysis into the data processing is planned to evaluate the acquired data thoroughly. We aim to improve our phenotyping method by integrating electrochemical sensors for online monitoring of the chemical signals in and around the plants, allowing for continuous monitoring of critical parameters in plant physiology. This can help expand phenotyping methods to develop a robust system for selecting new technologies and plant varieties more resilient to environmental stressors.