1st Call for Funding: Prof Bruce Grieve – Electronic Engineering, University of Manchester

October 7, 2020 (updated October 8, 2020)

Implementation of Active 3D Multispectral Imaging and Photometric Stereo systems as Early Stage Phenotyping Tool for Morphological Features and Biotic Stress Quantification within Complementary Demonstrator Phenotyping Centres (IBERS & P3)

Total Fund Requested: £18,480

Project Summary

The project will enable a new generation of, cost-effective, integrated Multispectral Imaging (MSI) and Photometric Stereo (PS) sensor system to be installed and commissioned, at cost, within two complementary Phenotyping Research Centres in the UK, i.e. The Institute of Biology, Environmental and Rural Sciences (IBERS), at Aberystwyth (UoA) and the Plant Production and Protection (P3) Centre, at Sheffield (UoS). The purpose of these installations will be to act both as Demonstrator and Development facilities within the UK, as to how such UK-manufactured systems may be deployed nationally and internationally, for quantitative plant morphology and biotic stress resistance breeding. To achieve this both the IBERS and P3 centres will integrate the units, with the assistance of Manchester (UoM) and the Centre for Machine Vision (CMV), University of West of England (UWE), within the existing semi-autonomous phenotyping facilities at each institution. The hardware and software for these units has been co-developed by the UoM and UWE under prior BBSRC funding ('4D-HSI-4-Free', ref: BB/N02107X/1) and has now resulted in a spin-out businesses being formed by the two Universities which is now a separate entity to those institutions Fotenix Ltd (www.fotenix.tech).

The UoM, UWE and UoS have partnered to deliver both IP and supporting publications upon which the originality of this type of approach has been demonstrated for phenotyping both in laboratory and, ultimately, in-field usage (see References section). The scope of this project will be to offer a showcase for how the new tools and techniques may add value to the broader industrial and academic research community. This will be specifically exemplified against how one, or more, of the following qualitative and / or labour intensive phenotyping duties may be both automated and increased in quantification, through the use of this 3D active MSI / PS imaging approach versus more traditional passive colour cameras and manual observations:

1. Seedling emergence (especially cereals where the initial shoot is nearly transparent). Note this is a significant problem to address, as scoring these using normal RGB (colour) computer vision is highly erroneous, so typically a manual 'clip board' scoring method is used in the growth chambers.
2. Rosette size under stress, where the plants tend to be any colour except a typical green. Automated segmentation from soil is difficult and needs lots of manual intervention

3. Disease symptoms, leaf ageing, pigments (due to cold response), etc.

For phenotyping, the Photometric Stereo modality will allow detection of changes in leaf morphology associated with abiotic and biotic stresses such as leaf curling, wrinkling etc. which are missed by, and confuse interpretation of, images obtained by traditional systems.

Where's the multispectral imaging aspects allow physiological processes associated with stress to be quantified. In addition to loss of chlorophyll, near-infrared (NIR) imaging allows changes in leaf structure to be determined, e.g. loss of epicuticular waxes, whilst visible images can detect and quantify changes in pigments such as carotenoids and anthocyanins.