Hyperspectral remote sensing of plant pathogens: Detecting and monitoring Myrtle Rust

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Abstract:
Australia's natural and managed landscapes, dominated by the plant family Myrtaceae, are under threat from a devastating, invasive disease called Myrtle Rust (*Puccinia psidii*)(Glen et al., 2007). Already, the Lemon Myrtle (*Backhouse citriodora*) essential oil industry has suffered substantial yield losses from this disease (up to 70 percent per year). Due to recurring infections, natural populations of several highly susceptible species seem likely to go extinct (Carnegie et al., 2016). Currently, detecting and monitoring disease outbreaks is only possible by eye, aided by forecasting infection periods, including co-incident timing of spore release and host growth flush, using weather data. These methods can be resource intensive and sometimes unreliable. Fungicides can only be applied once clear disease symptoms are visible, which is less effective at preventing significant leaf area and yield loss, and can be wasteful resulting in high costs, and increased negative impact on soil, flora and fauna (Rumpf et al., 2010; West et al., 2003). However, optical remote sensing techniques are well known for objective and reliable automated diagnosis and detection of plant diseases. In combination with advanced data analysis techniques, sustainable and targeted pest management systems can be developed (Mahlein, 2015). This study aims at establishing proof-of-concept for monitoring and detection of Myrtle Rust. At the UAS4RS 2016 in Brisbane we presented a general concept of our experimental design. This year, we would like to show the results of our first sub-project where we could distinguish healthy and infected plants based on their leaf spectral characteristics. We measured spectral signatures on healthy, currently-infected and fungicide-treated (previously infected) Lemon Myrtle plants. State-of-the-art statistical classification techniques allowed us to identify the different leaf-types with an extremely high accuracy of 94.8%. At the UAS4RS 2017 in Hobart, we would like to present (i) the background of our successful classification of hyperspectral data collected at ground level; (ii) introduce the concept of a self-designed disease-specific vegetation index, validated with multispectral aerial imagery, and iii) provide an outlook on upcoming sub-projects, especially on data we

collected for other plant species to extend our spectral library of Myrtle Rust specific signatures.

References:

Carnegie, A.J., Kathuria, A., Pegg, G.S., Entwistle, P., Nagel, M., Giblin, F.R., 2016. Impact of the invasive rust Puccinia psidii (myrtle rust) on native Myrtaceae in natural ecosystems in Australia. Biol. Invasions. doi:10.1007/s10530-015-0996-y

Glen, M., Alfenas, A.C., Zauza, E.A.V., Wingfield, M.J., Mohammed, C., 2007. Puccinia psidii: a threat to the Australian environment and economy – a review. Australas. Plant Pathol. 36, 1. doi:10.1071/AP06088

Mahlein, A.-K., 2015. Plant Disease Detection by Imaging Sensors – Parallels and Specific Demands for Precision Agriculture and Plant Phenotyping. Plant Dis. 100, 241–251. doi:10.1094/PDIS-03-15-0340-FE

Rumpf, T., Mahlein, A.-K., Steiner, U., Oerke, E.-C., Dehne, H.-W., Plümer, L., 2010. Early detection and classification of plant diseases with Support Vector Machines based on hyperspectral reflectance. Comput. Electron. Agric. 74, 91–99. doi:10.1016/j.compag.2010.06.009

West, J., Bravo, C., Oberti, R., Lemaire, D., Moshou, D., McCartney, H.A., 2003. The Potential of Optical Canopy Measurement for Targeted Control of Field Crop Diseases. Annu. Rev. Phytopathol. 41, 593–614. doi:10.1146/annurev.phyto.41.121702.103726