Hyperspectral Imaging for the Detection of Dothistroma Needle Blight in Scots Pine Trees

Michelle Hamilton[1], Hugh Mortimer[1], James Woodhall[2], Kate Perkins[2], Anna Brown[3], Kath Tubby[3], Richard Baden[3] and William Cornforth[4]

[1] RAL Space, STFC Rutherford Appleton Laboratory, Harwell Oxford, Didcot, OX11 0QX.
[2] FERA, National Agri-Food Innovation Campus, Sand Hutton, York, YO41 1LZ .
[3] Forest Research, Alice Holt Lodge, Farnham, Surrey, GU10 4LH.
[4] University of Edinburgh, School of GeoSciences, Crew Building, The King's Buildings, Alexander Crum Brown Road, Edinburgh, EH9 3FF.

Dothistroma septosporum (Red band needle blight) is a fungal disease which affects pine trees within the UK; it is a controlled disease which organisations such as FERA and Forest Research are trying to prevent moving around the UK. The work being carried out in this project as part of the BBSRC tree health initiative is developing spectral, particularly hyperspectral, techniques to aid inspectors in the early detection of diseased seedlings involved in trade and in nurseries. By detecting diseased plants at this early stage it is hoped that we can prevent the disease moving into areas which are currently disease free while also managing areas where the diseased trees have been found.

Method and the building of a spectral database

One of the major parts of this work is the statistical model which can be used to distinguish between health and diseased speicmens. To do this we have been building up a healthy and infected spectroscopic database which can be used for model building and evaluation. Although this database is derived from single spectroscopic measurements for a sample we have data from a variety of techniques collected from a variety of samples over varying conditions which include:

- Field samples from around the UK
- Seedlings grown in a controlled environment
- Single spectra from an entire seedlings
- Spectra collected from a single needles
- Multiple measurements from a single samples to determine technique reproducibility and robustness

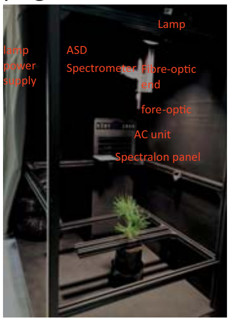

Figure 1: Setup used by William Cornforth as part of his PhD collection program to collect spectra collected from inoculated and control seedlings.

The majority of the spectra in the database are collected from samples of single needles.

- Needles are introduced individually to an integrating sphere
- Needles on the same tree separated by years growth
- Needles are collected from different trees with various levels of infection
- The presence of disease is initially classified by an expert as: diseased, at risk or disease free
- Once spectra are collected the disease status of the needle is confirmed using genetic PCR analysis

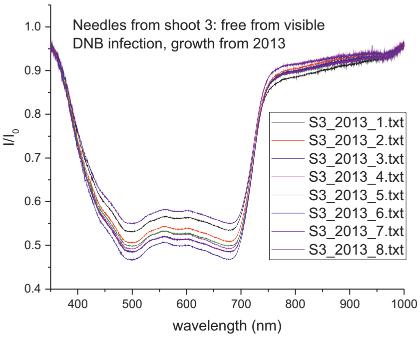

Figure 2: the spectra collected from eight individual needles collected from 2013 growth on a Scots pine which appeared free from Dothistroma infection. The plot shows the general shape of spectra collected from a healthy plant whilst also demonstrating the variation between individual needles.

Instrumentation and the development of a Hyperspectral imaging system

Alongside the development of a spectral model we are developing instrumentation which can be used to aid plant inspectors to discriminate between healthy seedlings and saplings and those which have been infected with Dothistroma. We ideally want to build a small robust system which could be deployed in either a handheld device or mounted on a unmanned aerial vehicle, UAV.

We have purchased a couple of XiSpec hyperspectral cameras which use a mosaic of interference filters in front of a 2D CCD array to detect narrow bandwidths of light.

Figure 3: 670 - 965 nm xiSpec camera

- 25 spectral bands
- FWHM spectral bandwidth of ~11 nm for each band*
- maximum capture rate is 170 cubes/sec*
- weight: 31g and size: 26.4 x 26.4 x 31 mm without lens or mounting brackets*
- * same for 470 - 620 nm xiSpec camera except only 16 spectral bands

Current work is focussed on writing software to collect and process spectral data from these cameras and to assessing their capabilities.

Figure 4: traditional RGB image of red lily

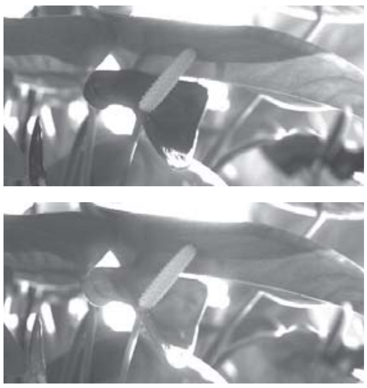

Figure 5 and 6: 2 of the 16 images using the 460 - 620 nm xiSpec camera showing the difference in contrast at different wavelengths this is particularly evident in the red lily flower

Future work will focus on calibration and integration of these cameras with the models from the spectral database to detect diseased and health plant specimens.