HyperPatches - a pipeline for reconstructing 3D plant models with registered hyperspectral data

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Hyperspectral imaging has become accessible and affordable in recent years; this has increased research potential in precision horticulture for the early detection of stress and disease within crops. Plants are being imaged at close proximity, such that features on individual leaves can be resolved and used in stress detection. Ultimately such analysis will have to happen in a high throughput manner. For this to happen crops need to be imaged in their normal growth state. In the past, effective hyperspectral measurement required the removal of leaves or fruit, ideally pinning down and imaging flat. This removes artefacts caused by lighting and orientation; however it takes time, will cause an unwanted stress response, and requires manual labour. To improve the process, plants should be imaged in situ; however the leaves are now at different inclinations and distances to the camera. Imaging such 3D objects with a hyperspectral camera can affect the reflectance profile (spectral signature) because the incline and angle of the object increases or decreases the light reflected [4]. A second influence over the profile can happen with shadows over the object [6].

Existing work points to using 3D information (such as point clouds) to assist hyperspectral data analysis [1]. One such approach utilises multiple hyperspectral images, but this requires a large amount of data and processing time [3]. Here, instead we propose to combine several side view RGB images of the plant with a single top-down view of the plant from a hyperspectral camera, producing a 3D model with the hyperspectral information mapped onto it.

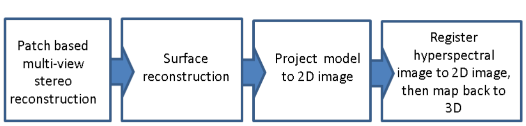

Figure 1. Overview of proposed pipeline

The pipeline, Figure 1, consists of first building a 3D reconstruction surface-patch model, then taking a 2D top-down view of the model and using this as a mid-point step to register the hyperspectral data, followed by mapping the registered hyperspectral data back onto the 3D patches. The first two steps of the pipeline are based on existing techniques. Patch based Multi-View Stereo reconstruction (PMVS) is used for stereo reconstruction where multiple views of an object are captured; pairs of images are matched and the features are used to build the point cloud, with small patches at the points containing texture [2] Figure 2 displays the process. This works well for the viewpoints near where the images have been captured, and if a lot of images are captured the missing information would be reduced; however from a restricted point of view (top down in this case) much of the plant can be missing from the model. Therefore surface reconstruction is used to fill in some missing information and make the patches fit with the model [5]. The final two steps are focused on the registration process. There is an extensive range of image registration possibilities for 2D-2D and some for 2D-3D, and 3D-3D. Here 2D-2D is selected to be a mid-point for the registration due to the model and the hyperspectral image being captured from different sensors, therefore scale and translation transformations are applied until an image registration similarity measure is optimised. The final stage is to map the data back to the 3D model, mapping hyperspectral measures to the underlying patches; these HyperPatches can then be analysed taking orientation and distance from the camera into consideration

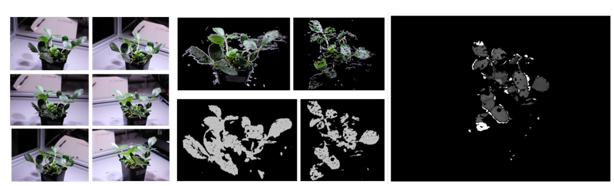

Figure 2. Left: 6 RGB images for the 3D reconstruction. Middle top: PMVS model. Middle bottom: Surface reconstruction. Right: White sections are omissions from the model.

References

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