Phenotyping vineyards

by means of airborne hyperspectral imaging

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Airborne hyperspectral imaging has proven to be a valuable method for plant phenotyping. For six production vineyards in South Australia, hyperspectral data acquisition was undertaken in February 2018 with an ECO Dimona airplane. The imagery is being used to assess and map a range of canopy characteristics relevant to both vineyard management and grapevine breeding. Here we present the first results and mapping for leaf chlorophyll.

Chlorophyll Content Estimation

Leaf chlorophyll was estimated at six commercial vineyard blocks (A-F), four located in Coonawarra (A-D) and two in McLaren Vale (E-F). Although potentially useful in itself as a measure of photosynthetic capacity, here chlorophyll content primarily serves as a test scenario for ground-truth sampling strategy of leaf compositional parameters in production vineyards. The output will also be utilized to develop and test novel spectral indices for estimation of photosynthetic capacity.

Data Acquisition

Ground-based sampling was undertaken with an Apogee MC-100 Chlorophyll Content Meter and expressed as a Chlorophyll Content Index (CCI). Approximately 300 measurements were made per vineyard block (total dataset > 1,600), but this still limited the ground-truth data to a maximum of only two leaves per 'panel' of vines (a panel being between 2-4 vines, depending on vineyard). Consequently, the sampling strategy used was low density, with an even spatial distribution. Consensus between the two leaf measurements was used as criterion to ensure the data were representative of a panel.

Airborne measurements were conducted with NEO Hyspex VNIR 1600 and NEO Hyspex SWIR 320m-e to obtain high-resolution hyperspectral images of the vineyards. Altitude of the aircraft was approximately 800 m above ground level. Hyperspectral line scanning images are orthorectified and resampled to a 0.12 m grid (VNIR) and 0.4 m grid (SWIR) for subsequent processing.Data Modelling

The MC-100 CCI measurements were used to calibrate statistical models and to train regression models using machine learning algorithms.

For model training, a skeletonized representation of each vineyard row was calculated based on strength of the NDVI at each pixel.

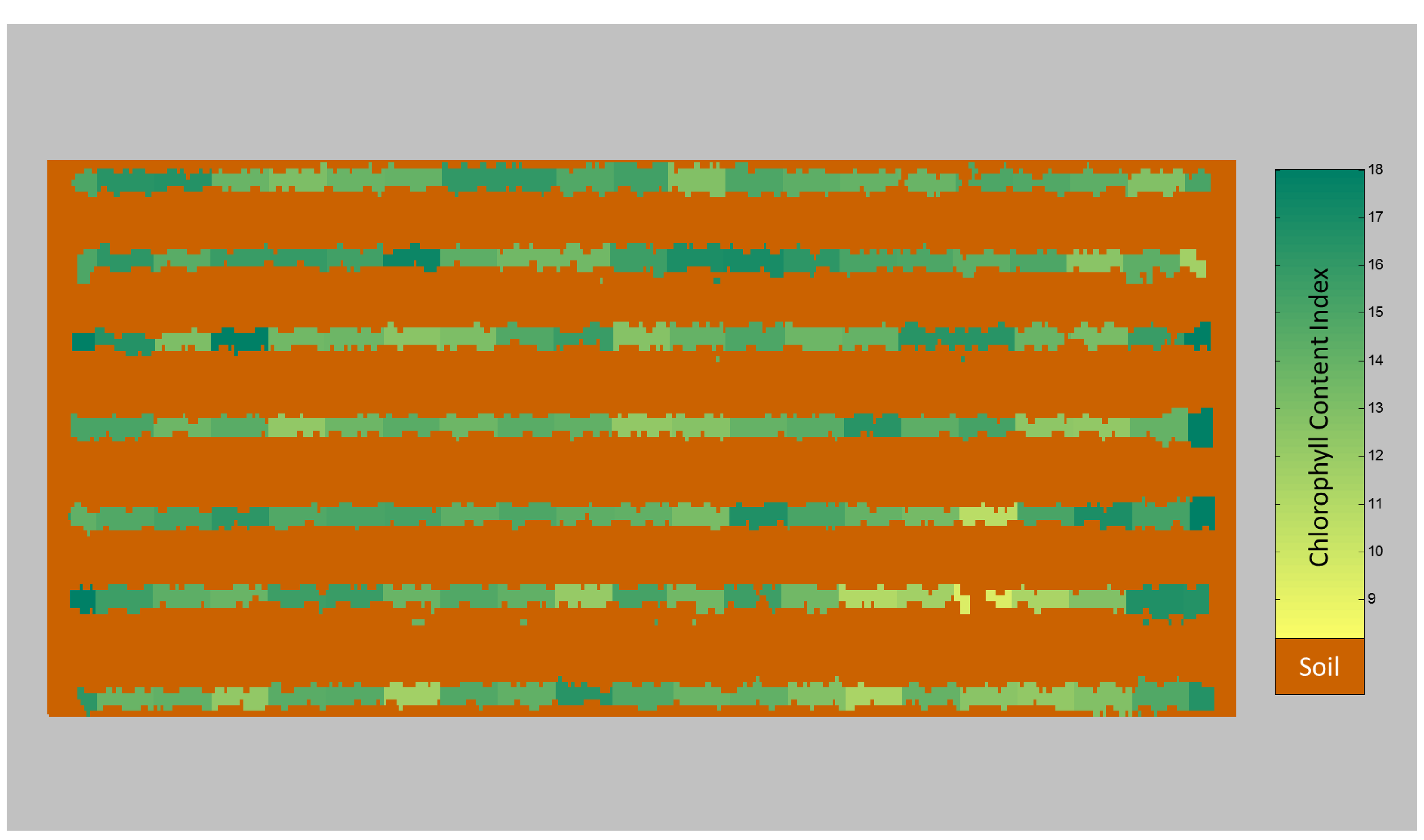

Figure 1: Using the MC-100 measurements, the CCI values can be calculated at different scales. Here, the measured variation within seven rows of a vineyard at McLaren Vale (Block F) is shown. CCI values are averaged over panels which typically represent four vines.

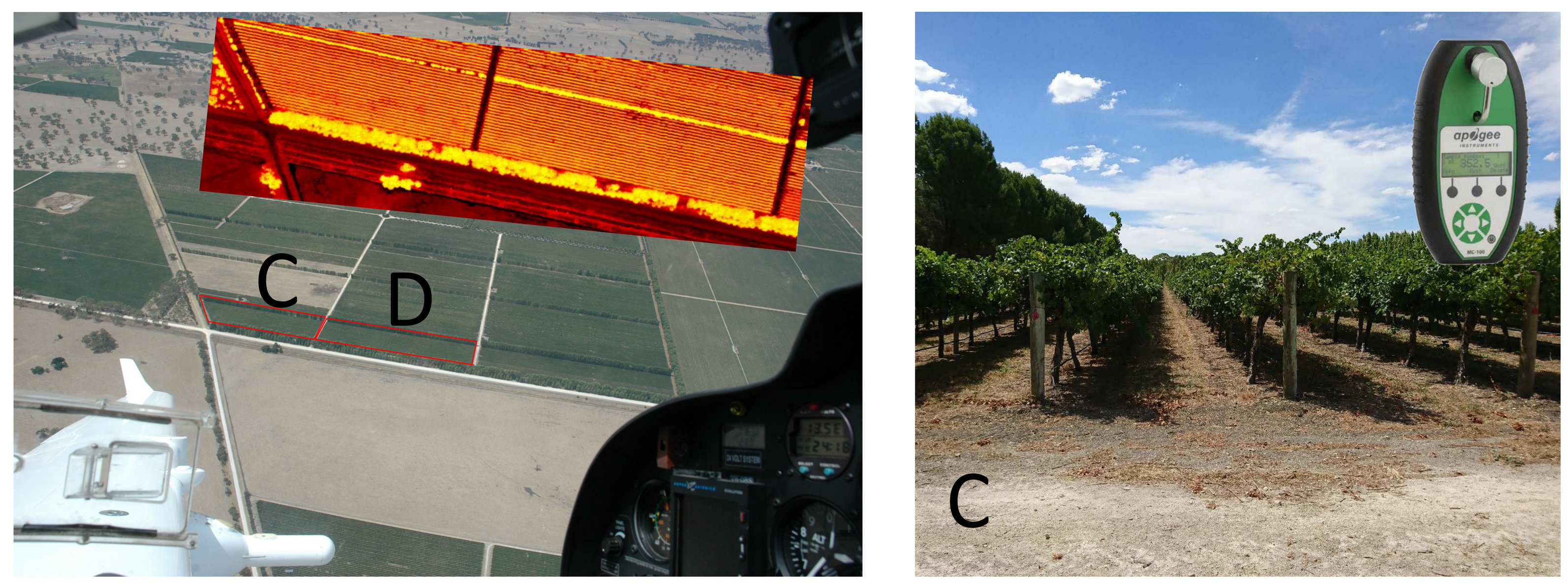

Figure 2: Vineyard plots C and D at Coonawarra. Hyperspectral images can be analysed, transformed and visualized in multiple ways to reveal properties of the observed vines. The above shown normalized burn ratio (NBR) was developed to detect burned areas, but can be used to separate vegetated areas from soil based on SWIR data.

Spectral signatures along the rows were collected and mapped to target CCI values. Multiple spectral signatures within each panel were mapped to the same CCI value due to the differences in spatial resolution between ground-based leaf measurements and airborne imaging.

CCI was predicted for all vegetation pixels (where NDVI exceeded a threshold) and could be averaged at different scales to compare with photosynthetic capacity.

Table 1 provides the correspondence between average MC-100 measurements and averaged CCI predictions at the broadest scale (vineyard plot), while Fig. 1 shows a visualization of average CCI at patch level and variations within and between rows.

Table 1: Comparison of **mean Chlorophyll Content Indices** (CCI) between handheld Apogee MC-100 Chlorophyll Content Meter and predictions from hyperspectral imaging data. Mapping of spectral data to CCI was calibrated with the CCI measurements.

VINEYARD	APOGEE MC-100	AIRBORNE HYPERSPECTRAL
Block A @ Coonawarra	9.7	10.4
Block B @ Coonawarra	8.2	8.3
Block C @ Coonawarra	12.6	13.4
Block D @ Coonawarra	14.1	14.1
Block E @ McLaren Vale	13.5	12.6
Block F @ McLaren Vale	14.7	14.5
R^2=0.94		

Conclusions

We developed a processing pipeline to match ground-based CCI and airborne hyperspectral measurements.

Validation of statistical models shows that a good correspondence between average ground-based measurements and average predictions from airborne imaging can be obtained when comparing vineyards or large blocks within a vineyard.

Prediction of CCI at a high spatial resolution yield the potential to better understand and judge different treatments.

FOR FURTHER INFORMATION
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REFERENCES
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