DIGITISING THE VINEYARD: DEVELOPING NEW TECHNOLOGIES FOR VITICULTURE IN AUSTRALIA

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Abstract:

Context and purpose of the study - New and developing technologies, that provide sensors and the software systems for using and interpreting them, are becoming pervasive through our lives and society. From smart phones to cars to farm machinery, all contain a range of sensors that are monitored automatically with intelligent software, providing us with the information we need, when we need it. This technological revolution has the potential to monitor all aspects of vineyard activity, assisting growers to make the management choices they need to achieve the outcomes they want. For example, a future vineyard may possess automated imaging that generates a three dimensional model of the vine canopy, highlighting differences from the desired structure and how to use canopy management to improve fruit composition, or generates maps with yield estimates and measurements of berry composition throughout the growing season. That same imaging may also provide whole of vineyard data on vine nutrition or early warning of disease, allowing proactive management on a rapid timescale. We are working with a range of technologies to develop such capabilities for Australian viticulture.

Material and methods – A variety of technologies are being deployed at the whole block scale to address a number of management questions. Early indicators of yield variation are being assessed shortly after budburst, using video imaging with consumer video cameras and machine learning, to determine inflorescence numbers. Canopy growth and structure are being monitored using (i) photogrammetry with drones imagery, (ii) video imaging from vehicles and (iii) a spinning LiDAR system using Simultaneous Localisation and Mapping (SLAM) to register the data. The latter is also being used to develop novel indices of canopy structure. Hyperspectral imaging is being used to segment vine images into their constituent parts and analyse them for fruit and canopy composition and presence of disease. Finally, yield estimation from veraison onwards is being developed using (i) video imaging in daylight, (ii) digital imaging with depth perception and (iii) foliage penetrating (FOPEN) technology. These technologies are being trialed at commercial vineyards in multiple winegrape growing regions of South Australia, concentrating on vines grown with the locally common 'Australian sprawl' trellis type, where the fruit are typically highly occluded by leaves, compared to vertical shoot position trellis types.

Results – The technologies described are at various stages of development, from the lab to field application at vineyard scale, but all have produced results with potential commercial application. Initial imaging work with inflorescence counts produced 94% accuracy; a preliminary pipeline to analyse drone imagery with depth data from photogrammetry for estimating vine cover irrespective of cover crop has been developed; a preliminary pipeline to analyse video imagery from the ground and map canopy gap fraction and leaf area index has been developed; the ability to accurately register 3D LiDAR data using SLAM and only basic GPS data has been demonstrated and use the results to develop models of seasonal light interception and indices of canopy light penetration; further, the ability of the FOPEN to determine the presence of fruit within a 'sprawl' canopy has been demonstrated.We are continuing to develop these technologies and apply them at the whole block scale in order to produce accurate yield estimates that do not rely on point measurements and spatial maps to allow fine-grained vineyard management decisions.

Keywords: digital technologies, FOPEN, LiDAR, photogrammetry, proximal sensing, RGB imaging, viticulture.

1. Introduction.

Digitising the Vineyard: Developing New Technologies for Viticulture in Australia

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New and developing technologies are becoming pervasive through our lives and society. From smart phones to cars to farm machinery, all contain a range of sensors that are monitored automatically with intelligent software. This technological revolution has the potential to affect all aspects of vineyard activity, assisting growers to make the management choices they need to achieve the outcomes they want. We are working with a range of technologies to develop such capabilities for Australian viticulture.

The Canopy

Canopy management can be key to producing fruit of a desired quality, furthermore, it is normally the canopy (typically the leaf petiole) that is assessed to ensure that fertiliser inputs are appropriate.

Canopy size & structure

Trawling LiDAR, spinning LiDAR, drone RGB imagery and RGB imagery from consumer video cameras are all being used to develop vineyard maps of canopy size and gap fraction. Novel LiDAR canopy indices are being developed and RGB imagery is being analysed with both photogrammetry, to produce 3D data, and traditional image analysis techniques.

Canopy composition

Hyper- and multi-spectral techniques have the potential to measure a range of vine nutrients, including N, P & K. At present we are working with NIR hyperspectral imaging and machine learning to do this. To date, this has been primarily lab based, but with initial field tests (not shown).

Figure 1: Spinning LiDAR scanning system mounted on vineyard vehicle (left), 3D mesh over point-cloud (top right) and greyscale rendering of canopy area per metre map at 10 cm resolution for the start of five vineyard rows.

The Fruit

Whole-field assessment of fruit sugar content during maturation will enable much improved accuracy in prediction of harvest date and winery intake planning. Further, when combined with in-field assessment of berry quality characteristics, such as anthocyanins and organic acids, these data will allow feedback for growers to optimise their production and for wine companies to optimise their planning throughout the value chain.

Again, hyper- and multi-spectral imaging techniques are key. When combined with machine learning approaches, we are able to reliably segment images into tissue types and then analyse those pixels relating to berries for their composition.

Furthermore, the same data can be used to assess damage or disease (not shown).

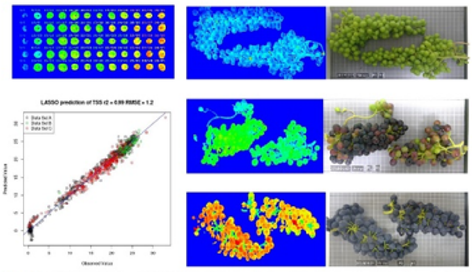

Figure 2: Predicted total soluble solids (°Brix) for individual berries (top left), whole bunches (right) at pea-size (top), 75% veraison (middle) and harvest (bottom) and the relationship between predicted total soluble solids and observed values for 2400 individual berries (bottom left).

Yield Estimation

Accurate yield estimation is the most common request from the Australian wine industry, as it has implications for planning and improved efficiency throughout the value chain.

Early estimation

Approximately 60% of inter-seasonal yield variation for a vineyard in Australia is due to bunch number. We are developing early estimations of this through automated counting of inflorescence number in RGB videos.

Pre-harvest composition

Several groups around the world are estimating yield from RGB imagery. We are also using this, but in combination with depth estimation to determine bunch size, and with the difficult environment of Australian 'sprawl' vines. In addition we are trailing foliage penetration technology.

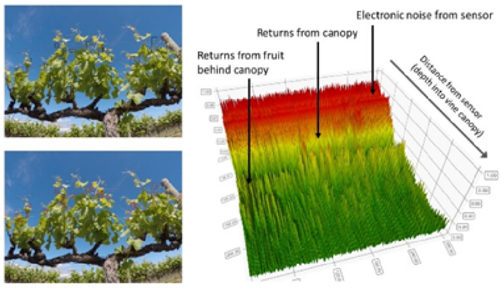

Figure 3: Manually labelled still image with inflorescences (top left), machine learning output of same image (bottom left) and 2D scan (y dimension is return intensity) of sprawl canopy pre-harvest using foliage penetration technology.

FOR FURTHER INFORMATION
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Wine Australia