Application of LiDAR to determine vine growth in the vineyard

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The Grapevine Rover (GRover) is an adaptable proximal-sensing platform designed to provide rapid, high-quality information of plant performance in the field. GRover currently uses light radar (LiDAR) to produce precise (±3mm), high resolution (300 scans/second), three-dimensional point clouds of vine growth. This poster explains: how LiDAR scans of vine growth have been collected in the vineyard, processed computationally and correlated with plant growth. Results from field trials have shown that LiDAR can accurately capture leaf area and pruning weight. Continued efforts will make data processing more automated and focus on capturing additional vine-traits with LiDAR and other instruments.

The Grapevine Rover (GRover), how LiDAR is deployed in the vineyard

LiDAR operates in a similar way as sonar. Instead of using sound, though, it uses light. The LiDAR used on GRover is the Sick LMS-400-200 (Sick, Germany; Fig. 1,1). An eye-safe line-scanner that emits laser pulses 300 times a second in a 70 degree field of view (Fig. 1,1). Those pulses reflect off of a target and are returned to the LiDAR sensor, providing information about the position of the return in 3D space and the reflectivity of the target's surface.

Scans of vine growth are visualized and analysed using the open source 3D point cloud and mesh processing software Cloud Compare (http://www.danielgm.net/cc/). Figure 2a shows an example canopy and 2b an example of what a 3D point cloud of a vine looks like in Cloud Compare. The colours in 2b illustrate the differences in reflectivity of the different surfaces in the scan: leaf, wood, grass and even the plastic tag.

Developing relationships between LiDAR scans and vine growth. Field trials and computational analysis

After producing 3D point clouds, the challenge is to correlate scans with meaningful biological parameters. To that end, field work was conducted at the South Australian Research and Development Institute (Nuriootpa, SA), scanning vines before and after destructively quantifying the leaf area, cane weight, bunch number and cordon volume. The example canopy (Figure 2a) shown on the left had its leaves plucked off and the area of those leaves measured with a LiCOR 3000C. The vine on the right, with leaves intact, is for comparison.

By eye it’s easy to distinguish stem and leaf or bunch material but there are no programs available where one can upload a scan of a vine and it will quantify the amount or volume of material present. The first attempts to correlate vine-scans with known amounts of plant growth have been through voxelization (Fig. 2c). Voxels recursively split the point cloud into regular sized cubes (for more information see [1]). The number of cubes can be counted within each scan and then compared to, say, the measured amount of leaf area.

LiDAR scans correlate strongly with destructive measures of vine growth

Figures 2d and 2e demonstrate how well voxel counts of LiDAR scans correlate to conventional, destructive measurements of vine growth. Both leaf area (2d) and pruning weight (2e) correlate strongly with voxel count ($R^2 = 0.9$).

Encouragingly, voxelization is a simple computational procedure. With the help from specialists within CSIRO, development of more sophisticated algorithms should improve the richness of the data that can be extracted from point clouds.

Expanding GRover and LiDAR use in vineyards:

LiDAR technology appears to be a intriguing and useful tool in vineyards. But before this technology is ready for broader use, there is still a lot of development that needs to be done.

For example, further LiDAR scanning needs to be carried out at multiple locations and on a number of varieties under varying environmental conditions to see if the destructive measurements and the scans continue to correlate.

Additionally, computational analysis needs to be streamlined. The end aim is to have panels or plots identified and the analysis run automatically.

Finally, LiDAR scans are not a solution for imaging every vine trait. GRover will soon be equipped with stereoscopic and hyperspectral cameras to explore yield quantification, bunch quality and disease monitoring.

**FOR FURTHER INFORMATION**
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**REFERENCES**
1: http://docs.pointclouds.org/trunk/group__octree.html

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