Harvester-mounted laser scanning to improve log making

BY TOM ADAMS AND CHRIS GOULDING, SCION

A FEW YEARS AGO, a study by Glen Murphy of Oregon State University showed that mechanised log making by a harvester was losing an average of 21% of the potential value from the stand, for a variety of reasons. Some operations were much worse than this.

Mechanisation of harvesting in New Zealand is increasing but we need to find ways to reduce these value losses. One answer is coming from manufacturers of harvesters and felling heads, who are introducing computer-based log making optimisation, which we are seeing in a number of operations already.

For European species such as Scots Pine or Norway Spruce, stem diameter and distance from the butt are often good indicators of stem quality. Unfortunately, New Zealand-grown Radiata Pine is different. How Radiata stems should be cross-cut into logs depends on pruning, branch size, branch clustering, malformation, sweep, wobble and kink, not to mention problems with ensuring the measuring wheel is taking an accurate reading.

A lot more information is required to optimise log making for ever-changing market needs. A visual assessment of each tree by the operator followed by keying the information into a computer is slow – for fast yet effective log optimisation, the answer may well be found in automated, harvester-mounted, whole-tree scanning in cut-to-length operations.

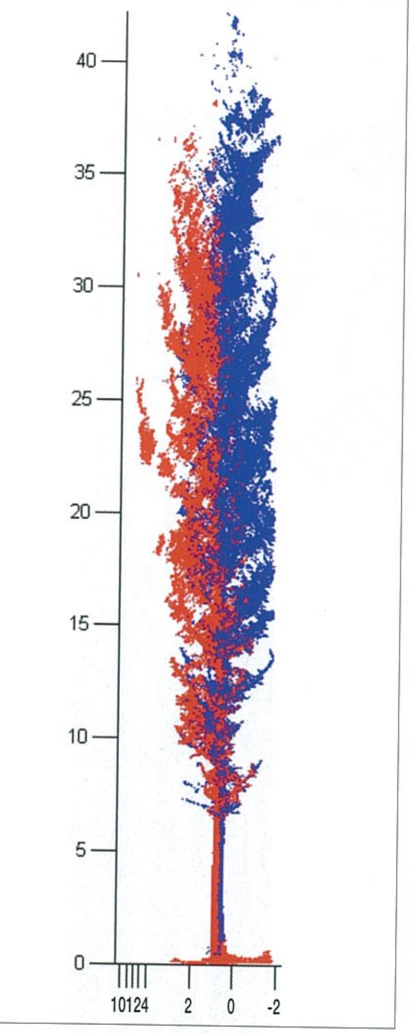


Figure 1 - Point cloud of radiata pine, taken from two scans (coloured)

SCANNING TREES FROM HARVESTER BEFORE FELLING

Whilst a harvester is operating in a harvest area, there is now the potential for it to collect information on surrounding trees before they are felled.

A suitably mounted LiDAR scanning device combined with GPS and movement sensors can gain information on nearby trees from multiple angles and send it to an on-board computer for processing. Data for each tree can be recalled at felling and the optimiser will then issue log making instructions with minimal operator intervention.

WHAT DATA CAN SCANS PROVIDE?

LiDAR - or Light Detection And Ranging - is a remote sensing technology that measures the distance to a target by timing the return of reflected laser pulses.

It provides millimetre accuracy, which in itself is useful for positioning and automation, but when the laser is scanned across an object you get a 3D 'point cloud' of the object made up of potentially millions of data points. Figure 1 shows the point cloud of a tree in Kaingaroa produced from two such scans taken on opposite sides of the tree.

These two scans were taken from a static unit, but work by Finnish researchers has shown that a unit mounted on a moving harvester or ATV - when used in conjunction with a GPS and Inertial Measurement Unit (IMU) - can construct 3D point clouds of trees on the fly.

As the harvester moves through the setting, it could scan trees it was passing, storing the stem information and its position to combine it with data from other perspectives of the stem (for more information on the Finnish Metrix and Forestrix programmes see the Further Reading section at the end of this article).

HOW CAN POINT CLOUDS BE USED?

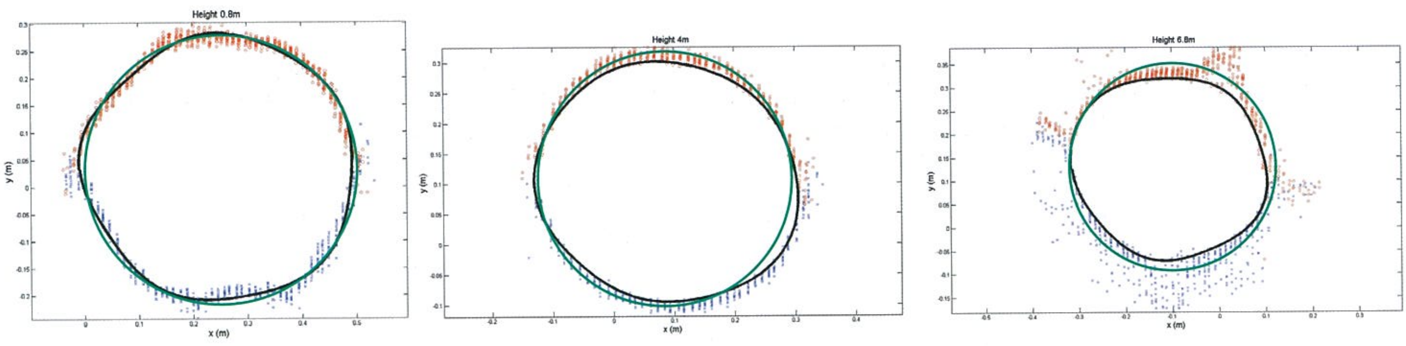
At Scion we have been developing algorithms to analyse tree point clouds (Figure 1) for use in wood quality surveys. Combining our work with the 'on the move' work of the Finns could prove extremely rewarding to a harvest head manufacturer considering onboard scanning.

STEM SHAPE

Scion has developed advanced computer code (a circular harmonic algorithm) to assess stem shape in slices up the stem.

The programme can fill in sections that have been obscured or missed, whilst capturing nodal swellings, buttressing and large scars. Three cross-sections at 0.8m, 4m and 6.8m of a scanned tree are shown in Figure 2, whilst Figure 3 shows a side view of the complete 25 m stem alongside its photograph.

The horizontal scale is exaggerated in the



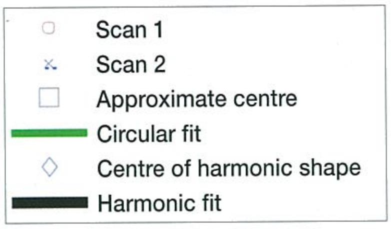


Figure 2 – Stem cross section fitting from scanned laser point cloud.

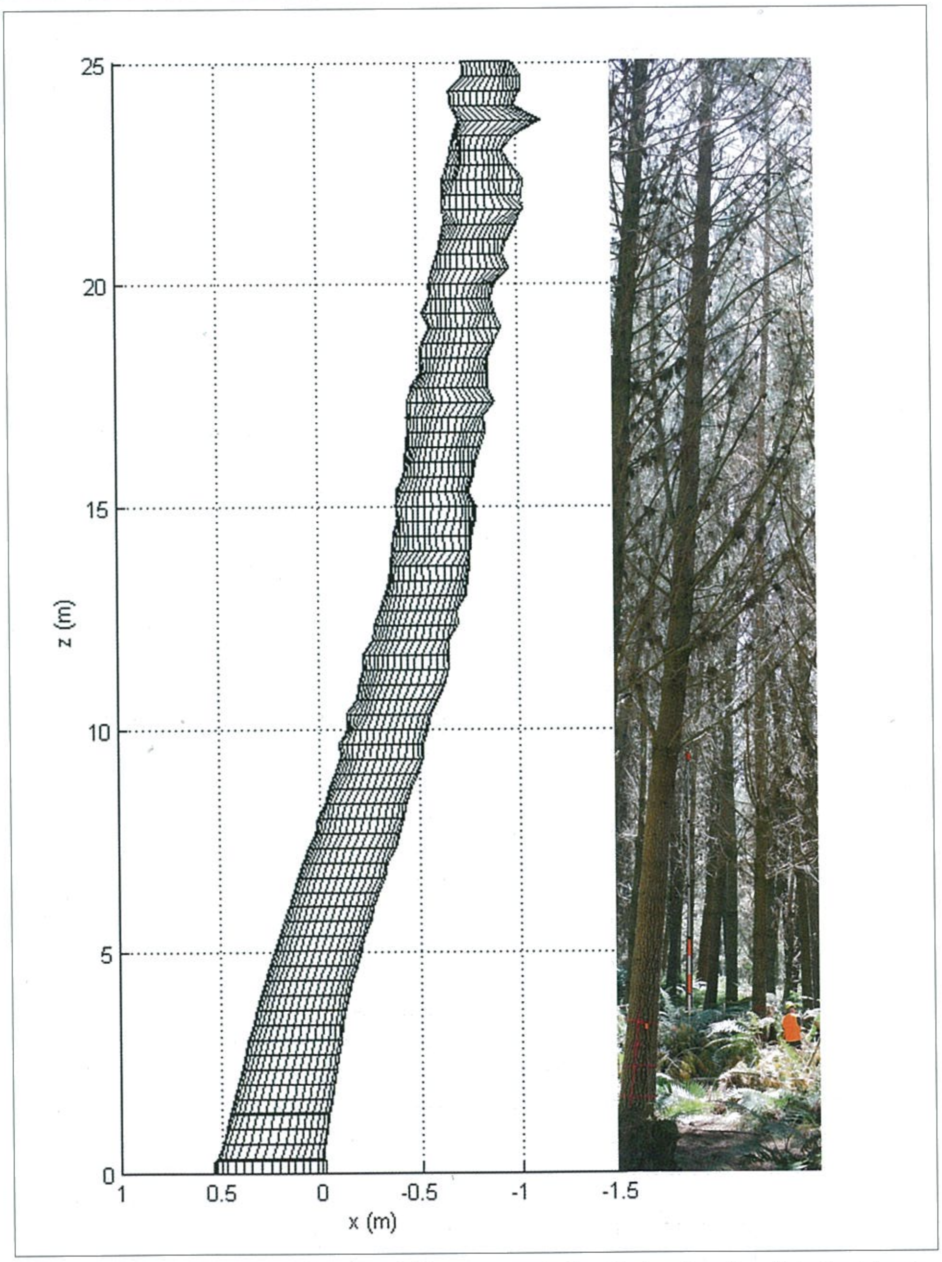


Figure 3 – Photograph and side view (with exaggerated scale to show form) derived from the scanned laser data.

LiDAR image to show the form of the tree. This stem model can be used to assess diameter, taper, sweep, crook, lean and malformation.

BRANCHES

Laser scanning can be used to locate major branches or branch clusters that will change the log grade. Figure 4 shows automatically detected branch cluster locations versus the actual locations measured in the field.

The blue bars were measured and are scaled by average branch size, whereas the red bars (automatically detected) are scaled by n(h), a calculated branch score from the LiDAR data. The automatic method picks up the pruned height perfectly and spots all the major branch clusters in the lowest 20m of the tree. Obscuration prevents the algorithm picking up the branches reliably above this point.

HOW LONG WILL A SCAN TAKE?

The Finnish work has shown that these scans can be made on the go. Modern systems can collect over 10,000 points per second and if this data was collected continuously for many trees whilst the harvester was on site there would be no delays.

Scanners are rapidly improving in speed and efficiency, and using multiple scanners could further improve the resolution without adding any extra time costs.

WHAT ARE THE BENEFITS?

LiDAR scanning is available today. It can give quantitative information on the key factors of stem shape, sweep and branching that affects Radiata Pine log quality in New Zealand.

This information when passed to a log making optimiser in the on-board computer of a harvester will greatly improve the value recovery of "cut-to-length at stump" harvesting operations.

It should displace the need for separate log making by motor-manual methods on the skid, or a central log yard or super skid. If a system is developed that scans trees as the harvester is passing, minutes if not hours before they are felled, it will assist in logistics planning and contract delivery, permitting dynamic real-time change to log cut plans.

Harvesting crews that offer this advantage could charge higher rates, affording the increased equipment cost. It all adds up to better technology delivering a better product with more value.

Tom Adams is presenting his research on LiDAR in forestry to the ForestTECH 2011 conference which takes place in Rotorua on December 6 & 7.

FOR THOSE WHO WOULD LIKE FURTHER READING ON THE SUBJECT OF THIS ARTICLE, THEY SUGGEST THE FOLLOWING:

Marshall H. and Murphy G.E. 2004. Economic evaluation of implementing improved stem scanning systems on mechanical harvesters/processors. New Zealand Journal of Forestry Science 34: 158–174.

FOR MORE ON THE METRIX AND FORESTRIX PROGRAM READ

Miettinen, M., Kulovesi, J., Kalmari, J., and Visala, A. (Eds.). (2010). New Measurement Concept for Forest Harvester Head. Springer.

FOR MORE ON SCION'S WORK WITH LASER SCANNING SEE

Adams, T. (2011). Remotely Sensed Crown Asymmetry as an Indicator of Wood Quality. Conference paper delivered at SilviLaser 2011 in Hobart, Tasmania

FOR A GENERAL INTRODUCTION TO LIDAR READ

Lim, K., Treitz, P., Wulder, M., St-Onge, B., and Flood, M. (2003). LiDAR remote sensing of forest structure. Progress in Physical Geography, 27 (1): 88.

Adams, T., Brack, C., Farrier, T., Pont, D., and Brownlie, R. (2011). So you want to use LiDAR? - A guide on how to use LiDAR in forestry. New Zealand Journal of Forestry, 55 (4): 19–23. NZL

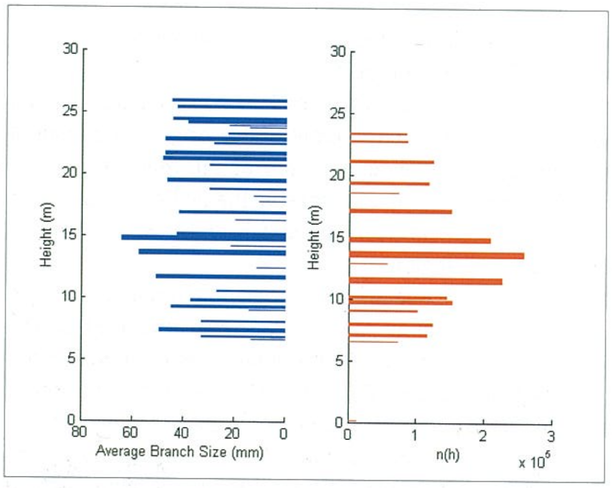


Figure 4 – Measured branch clusters (blue) and detected branch clusters (red) from a 30-year-old Radiata Pine tree in Kaingaroa Forest.