A LiDAR crop scanner for managing pesticide dose adjustment

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Introduction

This paper gives a brief description of a LiDAR Crop Scanner (LCS) and associated software for recording and processing sequential range measurements of tree-row structures. The data processing methods have been described in previous publications (Walklate et al., 2002 and Walklate and Cross, 2013). The results of apple orchard measurements show examples of outputs from the software that are aimed at improving grower access to information about Pesticide Adjustment to the Crop Environment (PACE) for making orchard-to-orchard dose adjustments with conventional sprayers and for making tree-to-tree dose adjustments with precision sprayers.

Materials and Methods

The photograph of atypical tractor mounted LCS (Fig.1a) identifies the off-the-shelf systems that are used (i.e. PC, LiDAR and GPS). In this case the PC is mounted inside the tractor cab for operator convenience. The LiDAR is mounted 1 m above the ground at the front of the tractor to facilitate scanning of two tree-rows during a single traverse of a typical orchard. The GPS is mounted above the tractor to minimise the potential degradation of the satellite signal by the surrounding trees and windbreaks. In addition to these systems special software has been developed to facilitate: (1) - the simultaneous recording of sequential output from the LiDAR (Sick LMS100) and sequential output from the GPS (SiRF Star IV chipset) and (2) - the analysis of recorded data and presentation of different types of summary output.

The software uses published methods of analysis (Walklate et al., 2002) based on the formation of gridded data models to describe the distribution of key aggregates of LiDAR output (Fig.1b and Fig.1c). The aggregated data for different path-lengths of tractor movement may be used for different applications. For conventional spraying the path-length of data aggregation should be large enough to represent the full orchard. For precision spraying the path-length of data aggregation is equal to the spacing of trees along the tree-row. The gridded data models are filtered to remove ground interception data before they are aggregated further to determine the values of PACE dose adjustment (Walklate and Cross 2013).

Results

Examples of gridded data models, based on aggregates of LiDAR output from a 100m tree-row recording, are presented (Fig.1b & 1c).The cumulative probability of transmission (Fig.1b) decreases with distance from the LiDAR (i.e. from right-to-left) and in this case the local differential probability of interception (Fig.1c)is distributed almost symmetrical about the tree-row centre-line. Examples of output from further processing of gridded data models are presented (Fig.2). The orchard-to-orchard variation of PACE dose adjustment versus tree height to row spacing ratio, are presented (Fig. 2a & 2b). These examples are based on replicated LiDAR recordings of 14 different orchards at various growth stages. Different PACE orchard standards are used to simulate pesticide registration of products with different uses: pre-blossom(Fig. 2a) and post-blossom(Fig. 2b). The predicted range of dose adjustments are compared with two characteristic lines of constant Leaf-Wall-Area (LWA) dose (i.e. different coloured diagonal lines; where the black line represents the full LWA dose and the blue line represents75% of the full LWA dose). Some exceptional orchards (2 of 14 post-blossom orchards in Fig.2b) show PACE dose adjustments that exceed the maximum dose per hectare (i.e. the red horizontal line). Therefore, the efficacy of treatment of these two exceptional orchards may be compromised when the maximum dose per hectare is applied. Better management of tree growth could be considered in the future to improve post-blossom pest control in these two orchard. Finally, an example of output showing the tree-to-tree variation of PACE dose adjustment is presented (Fig.2c). Here the LiDAR and GPS summary data have been transformed into KML formatted files for Google Earth to display a colour coded decision-map, where light green areas identify trees suitable for dose reduction and orange areas identify trees with excessive growth where the efficacy of pesticide applications at full-dose may be compromised.

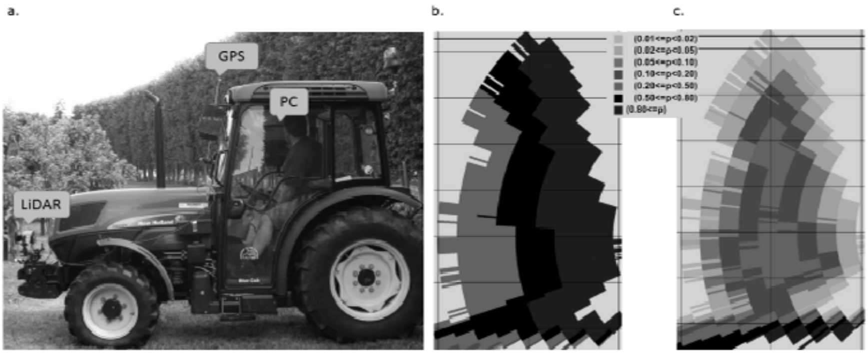

Figure1. (a) The off-the-shelf systems of a tractor mounted LiDAR Crop Scanner,
(b) cumulative probability of the LiDAR beam transmission,
(c) local differential probability of the LiDAR beam interception.

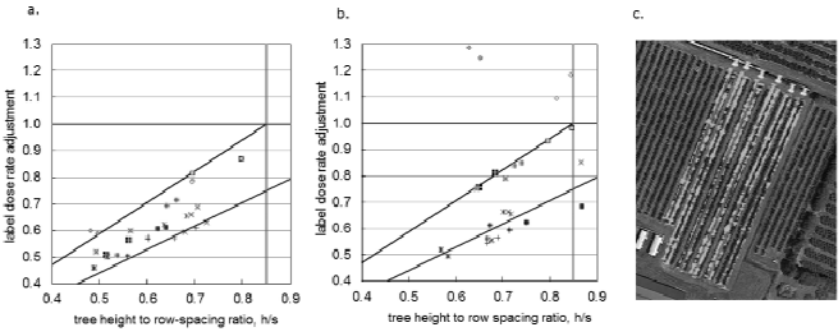

Figure 2. (a) PACE dose adjustments: pre-blossom label dose,
(b)PACE dose adjustments: post-blossom label dose,
(c) Google Earth decision-map of the tree-to-tree variation of PACE dose adjustments within a single orchard.

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