Three-dimensional phenotyping of peach tree crown architecture utilizing terrestrial laser scanning

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January 10, 2023

Abstract

Tree training systems for temperate fruit have been developed throughout history by pomologists to improve light interception, fruit yield, and fruit quality. These training systems direct crown and branch growth to specific configurations. Quantifying crown architecture could aid the selection of trees that require less pruning or that naturally excel in specific growing/training system conditions. Regarding peaches [Prunus persica (L.) Batsch], access tools such as branching indices (BIs) have been developed to characterize tree crown architecture. However, the required branching data to develop these indices are difficult to collect. Traditionally, branching data have been collected manually, but this process is tedious, time-consuming, and prone to human error. These barriers can be circumnavigated by utilizing terrestrial LiDAR (TLS) to obtain a digital twin of the real tree. TLS generates three-dimensional (3D) point clouds of the tree crown, wherein every point contains 3D coordinates (x, y, z). To facilitate the use of these tools for peach, we selected four young peach trees scanned in 2021 and 2022. These four young trees were then modeled and quantified using the open-source software TreeQSM. As a result, "in silico" branching and biometric data for the young peach trees were calculated to demonstrate the capabilities of TLS phenotyping of peach tree-crown architecture. The comparison and analysis of field measurements (in situ) and in silico branching data (BD), biometric data, and residual ground truth data were utilized to determine the reconstructive model's reliability as a source substitute for field measurements. Mean average deviation (MAD) when comparing young tree height was approx. 8.2%, with crown volume (crV) was approx. 7.6% across both 2021 and 2022. All point clouds of the young trees in 2022 showed residuals $<$ 10mm to cylinders fitted to all branches, and mean surface coverage $>$50% across all branching orders.

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