Pine Seedlings Measured with a Low Cost Machine Vision System

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PC-based machine vision system for measuring pine seedlings.
More than 1.5 billion pine seedlings are planted in the South every year. The success of forest regeneration activities is strongly influenced by seedling quality. Better quality seedlings tend to have higher survival and growth rates. AAES research may soon provide a fast, economical way to assess seedling quality.

Quality is usually assessed by evaluating morphological properties, such as root collar diameter and shoot height. However, typical forest nurseries bundle and ship up to several hundred thousand seedlings per day, making quality assessment of every seedling impractical. Nurseries therefore use sampling techniques to monitor seedling quality, but the measurement of large numbers of seedlings is still required. Research on seedling quality improvement also involves the measurement of large numbers of seedlings.

Measuring seedlings by hand is slow and subject to measurement and recording errors. Available electronic measurement methods are either destructive or nearly as slow as manual measurements because extensive operator input is required for every seedling measured. AAES investigators have developed a low-cost machine vision system to quickly measure and record pine seedling properties.

The PC-based system, which uses Charge-Coupled-Device (CCD) video cameras and digital image processing techniques, relies on backlighting and manual seedling placement in a specified location to simplify image processing requirements. An important feature of the system is the use of multiple cameras to maximize resolutions for different seedling parts. The system measures root collar diameter, shoot height, and shoot and root projected areas. Seedling measurements are acquired and automatically recorded with a single flip of a switch.

Tests were conducted with both two-camera and three-camera configurations of the system. The two-camera configuration had one camera focused on the root collar area, while the other camera had a field of view encompassing the entire seedling. The three-camera configuration had one camera focused on the root collar area, one on the shoot area, and one on the root area. This configuration gives higher image resolutions for the shoot and root projected area measurements. Tests evaluated how well machine vision measurements of root collar diameter and height compared to manual measurements and how well machine vision projected area measurements compared to dry weights and to projected area measurements obtained destructively with an infrared line-scan device.

For the manual comparison tests, each seedling was measured by two persons so that the variability inherent in manual measurements could be assessed. Root collar diameter and height results showed good agreement between machine vision and manual measurements. Variability

for machine vision measurements compared to manual measurements was no greater than variability for manual measurements compared to each other.

Projected area measurements, which cannot be measured by hand, are of interest because of their potential for predicting weight, surface area, and volume. Machine vision shoot and root projected area measurements were moderately correlated to dry weight measurements. The line scan device, or area meter, was used as an independent standard to assess the accuracy of the machine vision projected area measurements. Machine vision and area meter projected area measurements were highly correlated.

The two-camera system had a much shorter cycle time than the three-camera system (about six seconds per seedling versus 18 seconds per seedling), but both of these cycle times can be reduced substantially by upgrading the microprocessor used in this study. A fast cycle time is desirable for making measurements on a large number of seedlings, but manual seedling placement will require at least a few seconds for each seedling, so there is a limit to how rapid the cycle time can be.

The higher resolution of the three-camera configuration did not improve the accuracy of projected area measurements as expected, although it is difficult to make a direct comparison because separate tests were conducted with each configuration. For seedling measurements in a nursery production setting, the two-camera configuration may be better because of its simplicity and speed. For research purposes, there may be additional measurement requirements, especially related to roots, that can be met with a three-camera configuration.

This study demonstrated the feasibility of rapidly measuring pine seedling morphological properties using low-cost machine vision technology.