Enhanced grading system

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Goal: build a strength grading system using imaging technologies.

- The modern mills are equipped with high-performance computers that can process images in real time speed.
- Cameras and tracheid laser equipment are easy to install and safe to operate compared to X-ray or CT scan based imaging equipment.
- Image based strength grading system can output continuous valued quantities that are more accurate and useful compared to the current grading system.
- It can lead to efficient use of the forest resources and potentially higher profit.
Data

Enhanced grading system
Pipeline

Knot Detection

Knot Matching

Strength Prediction

Model

Prediction Interval

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Professional quality image processing system needs to be developed.

1. **Image localization and classification:**
   - Identify locations for the knot faces on the board: \((x, y, z)\)-coordinate.
   - For each knot identified, output a probability of positive classification.

2. **Segmentation or shape detection:**
   - Identify the knot, output size and shape.
Localization and detection example
Segmentation example
Knot localization and detection

- Classical approach to localization is the sliding window technique combined with classifier such as SVM.
- Deep Neural Networks have arose as the state-of-the-art in image processing tasks, including localization and detection.
- Need fairly large number of training instances to properly train neural nets.
- There exist advanced techniques developed fight the data scarcity problem. E.g., random modification of the existing dataset or more principled approach would be to train a generative adversarial networks (GAN).
An accurate description of the size and shape of the knot for prediction of strengths.

- Need calibration of coordinates of the color images and the laser data.
- Many ways to define a shape. For example, representing knot faces as ellipses may be sufficient.
Path ahead 2: strength prediction

- Given the locations, sizes, and shapes of the knots, predict the strength.
- Try a regression model using the knots as covariates?
- **Problem**: There are different number of knots for each lumber. How many knots should we use in the regression model? The worst 3? How to define worst?
Desiderata of strength prediction model

1. Need a model that captures how the knots of different sizes and shapes interact with each other spatially.

2. Model needs handle unknown number of knots.

An initial direction of research may be to use Gaussian process defined over the Euclidean 3-D space. Repulsive point processes may also be considered.