Design of an Early Detection Method for Emerald Ash Borer

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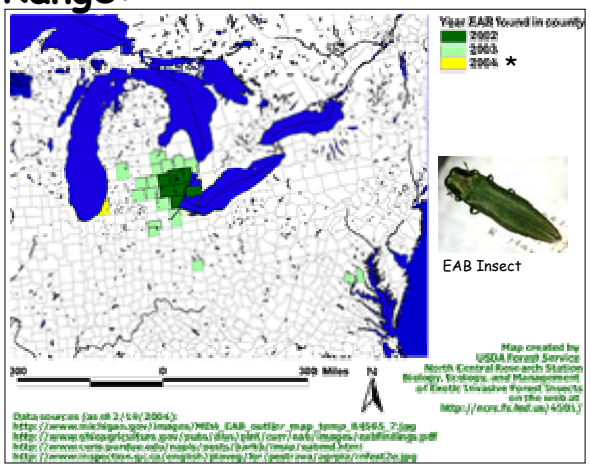
April 22, 2004

Background:

The Emerald Ash Borer (EAB), a native insect of China, was introduced into Detroit in the mid 1980's. Since its introduction, it has killed an estimated **6,000,000 ash trees** in the Detroit area.

Range:



*It is believed to already be present in Indiana around the Ft. Wayne and Lake Michigan areas, although as yet remains undetected.

Life Cycle and Pathology:

- The EAB Insects oviposit in bark crevices of ash trees
- Larvae hatch and burrow into cambium layer and consume vital nutrient carrying tissue
- In spring adult EAB emerge from tree, leaving D-shaped exit holes (see above).
- Trees begin to show signs of stress in two years, and the main trunk dies in 3-5 years.
- **Mortality is 100%**

Impact:

- Virtual elimination of the *Fraxinus* (Ash) genus from North America
- Loss of 150,000,000 Cubic Feet of ash wood products each year
- Loss of one of the most popular specimen trees in the Midwest

Objective of Design:

To design an economical proof-of-concept detection method based on **machine vision technology** to permit early detection of EAB infestations in ash trees, and allow for effective containment.

Acknowledgements:

Let it first be noted all of the people who have provided help and support to this project,
Thank You,
John Gallien

Cliff Sadof, Project Advisor and Funding
Bernie Engel, Project Advisor
Buddy Miles, Technical Advisor
Scott Brand, Provided Assistance and Materials
Tim Detzner, Provided Materials
Department of Agriculture and Biological,
Provided Resources and Funding

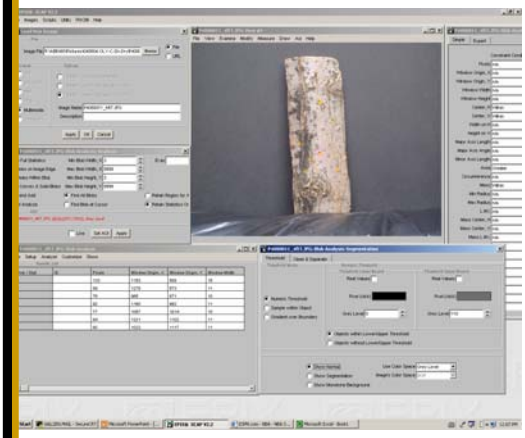
Why Machine Vision?

- Ease of Implementation
  - Entire system can be moved easily by one person
- Portability
  - One Laptop and one camera is all that needs to be moved from on location to the next
- Cost of Components
  - Entire System <$2000
- Availability of Components
  - BestBuy has all necessary hardware
- Ever Increasing Capabilities
  - 8 mega pixel cameras with lenses capable of 8x optical zoom are now available for under $1000

All the hardware that is needed for this detection method

How Does Machine Vision Work?

Epix Software Interface



- A digital photo is loaded into Epix XCAP Software
- The software locates objects based on contrasting regions of light and dark
- The objects are then analyzed based on parameters set by the user.
- Objects that fall within the range of the multiple parameters will then be recognized as a detection
- This process is then automated with a program known as a script

What Else Do You Need?

- Camera

  The camera is the single most import component. The resolution of the camera determines how far one can be from the tree and still maintain image quality.

  For example, our maximal detection for a 4 megapixal camera is approximately 6 feet with 3 times zoom. With an 8 megapixel camera and 8x optical zoom, we could expect similar detection success from 32 feet, which is well beyond the range of detection for someone with 20/20 vision

- Computer

  With the increase of pixel number and complexity of parameters, the processing speed becomes increasingly important. Some images take 30 seconds or more to process. For video capture, this is prohibitively long.

And of course, your Father's Car

Step 1: Borrow your father's car when you need to get samples back to the lab.

Experimental Design

- Vary Lighting Conditions:
  - Sun vs. Shade
  - Direct vs. Diffuse
- Vary Samples:
  - Light vs. Dark Bark
  - Smooth vs. Rough Bark
- Vary Surface Conditions:
  - Dry vs. Wet
- Vary Distance:
  - Distance Increased at 1ft Increments
- Control:
  - Shade, Diffuse, Dry, 2 ft

Results

- Best Conditions to Accentuate Contrast of Hole:
  - Shade, Overcast, Dry
- Maximal Distance for Reliable Detection:
  - 6 feet in optimal condition with 3x optical zoom
- Robust Parameters for image processing:
  - Roundness (Dimensionless)
  - Elongation (Dimensionless)
  - Minor Axis Length

Equations:

$$\text{Roundness} := \frac{\text{Circumference}^2}{4 \cdot \pi \cdot \text{Area}}$$

$$\text{Elongation} := \frac{\text{MaxRadius}}{\text{MinRadius}}$$

Where to go from here?

- Prepare scripts for automation
- Test in real-world conditions at EAB infested sites
- Test video capture as real-time detection method
- Compare optical zoom and digital zoom performance

The real world will be the proving ground for this detection method