Pruning Automation

AUTOMATION OF DORMANT PRUNING OF SPECIALTY CROPS

Automating Pruning

Pie in the Sky or Rubber meets the Road?

Peter Hirst, Tara Baugher, Leland Glenna, Jayson Harper, Avinash Kak, Tony Koselka, Johnny Park, Anouk Patel-Campillo, Jim Schupp, Julie Tarara, Bret Wallach

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Pruning

- Essential horticultural practice
- Carried out manually – often by migrant labor
- Accounts for 20-25% of labor costs (apple and grape)
- Access to required labor in future?
- Automation required to stay cost competitive



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Attempts at mechanical pruning have not been successful – needs to be more discriminating






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AUTOMATION OF DORMANT PRUNING OF SPECIALTY CROPS

- Project funded by USDA-SCRI
- Total project: $6,055,622
- 2012 - 2016
- Match from cooperating orchards/vineyards, commercial partner, universities

Leveraging combined expertise

- Electrical and computer engineering (Purdue)
- Industrial development (VRC)
- Horticulture and extension (Purdue, Penn. State, USDA/ARS)
- Rural sociology (Penn. State)
- Ag. Economist (Penn. State)

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Horticulture
Jim Schupp
Peter Hirst
Tara Baugher
Julie Tarara

Engineering
Johnny Park
Avinash Kak
Tony Koselka
Bret Wallach

Socio-economic
Leland Glenna
Jayson Harper
Anouk Patel-Campillo

Extension
Tara Baugher
Peter Hirst
Jim Schupp
Julie Tarara

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Working with two crops

Grapevines

- Simpler canopy structure
- Some preliminary work - CASC
- Closer to application
- Functional prototype
- Goal is to develop a commercially available product
- Need to refine technology

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Apple

- Complex canopy structure
- Need to define canopy systems
- Develop the science and eliminate the “art”
- Leverage technology from grape project
- Evaluate sensing systems

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AUTOMATION OF DORMANT PRUNING OF SPECIALTY CROPS

Goal 1: Describe pruning

Goal 2: 3D imaging, robotics

Goal 3: Social and economic impacts

Goal 4: Communicate results

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Goal 1: Formulate and evaluate rules that describe optimal pruning in terms of measurable physical attributes of canopy structure

Pruning rules are well advanced for grapevines – making good progress with apple (tall spindle and axis-style trees)

Pruning rules for axis-style trees

1. Once the leader reaches ~14 feet, it is headed to a short side branch by cutting into 2-3 year-old wood to maintain tree height at 11-12 feet. If desired, a taller tree ht. can be maintained in plantings with >14 feet between rows.
2. Maintain the narrow cone shape by thinning out shoots that are > 30 in. long in the top.
3. Remove any secondary limb when the limb diameter becomes half as large as the diameter of the leader or >1.5 inches in diameter near the base, whichever occurs first.
4. Select and remove the (choose your number) 2 / 3 / 4 largest side branches remaining from leader, leaving a short duckbill stub.
5. Remove all damaged or diseased limbs.
6. Thin out some otherwise good branches, spacing them out, to reduce the number of secondary branches to a total of 30 - 36 (choose your number, based on yield expectations).
7. Remove all other vertical shoots with an angle of < 40 degrees.
8. Each remaining side branch is also pruned to a single axis, either bythinning any tertiary branches that are > half the diameter of the secondary branch, or by stubbing the drooping limb back to a new axis.

Jim Schupp, Penn. State

Evaluating pruning rules for axis-style trees

- Pruning rules
- Commercial crew
- Grad student

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Pink Lady/B.9 planted in 2006

Purdue

Commercial

Rules

3 Indiana orchards

	PL/B.9	GD/M.26	Fuji/B.9	Fuji/B.9	GR/B.9
Yield	-	Com highest	-	-	-
Fruit size	-	Com lowest	Com lowest	-	-
Sol. solids	-	-	-	-	-
Starch	-	-	-	-	-
Blush	-	-	-	-	-
Light - up	-	-	-	-	-
Light-lower	-	-	Com lowest	-	-
Cuts/tree	-	-	-	Com highest	Rules lowest
% large	-	-	Com lowest	-	Rules highest

Axis-style trees

- 8 rules can define pruning
- Refine pruning rules
- Evaluate
- Use rules for training human workers


Did I prune too much?

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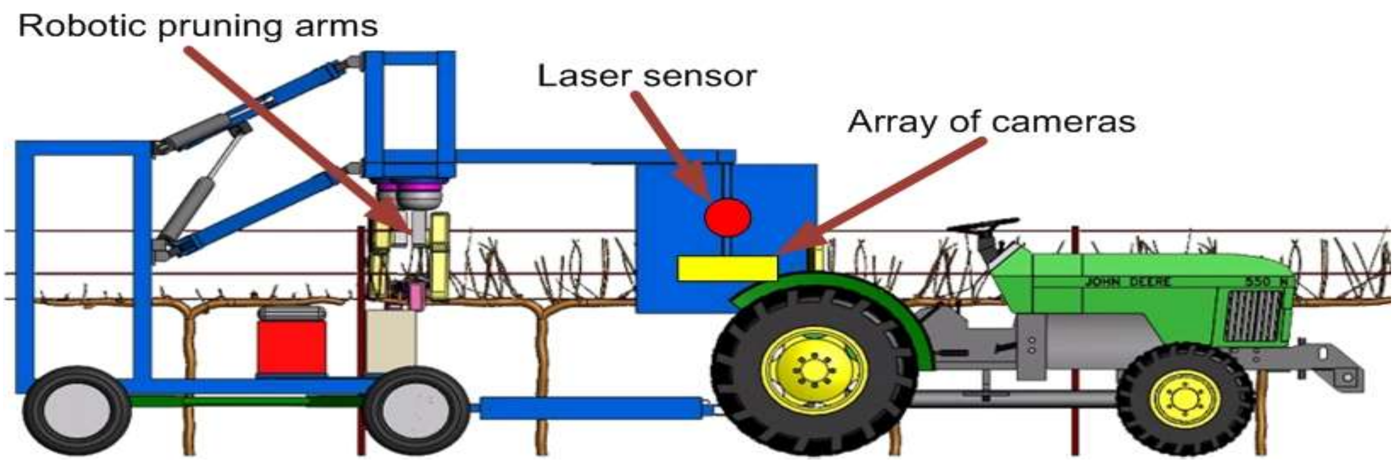
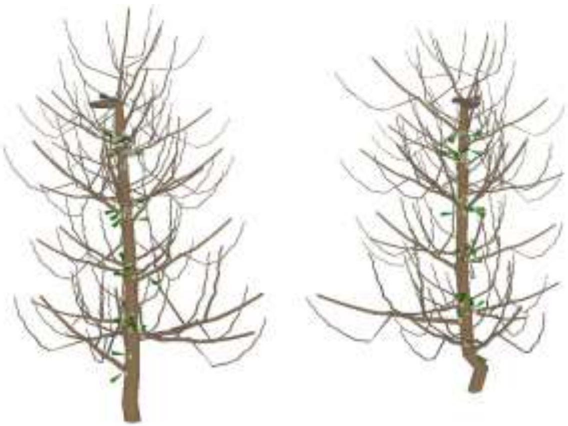
Tall spindle trees

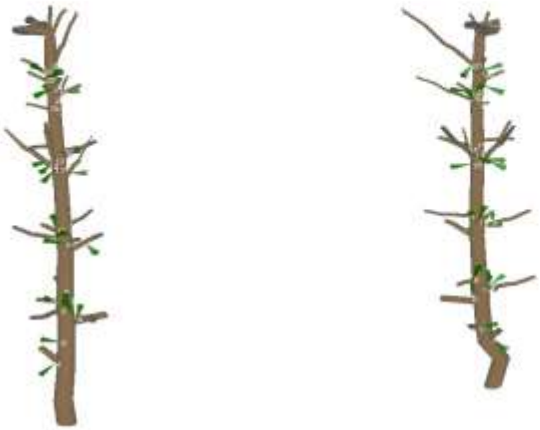
OK, listen up

Goal 2: Develop 3D imaging, decision system, and robot control technologies for automating pruning operations



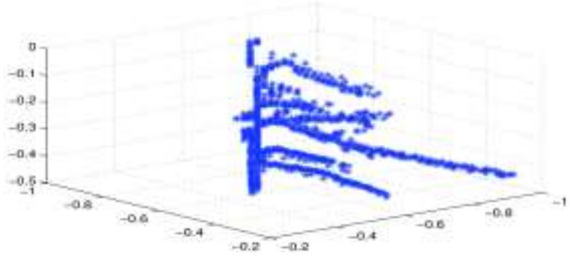
Branch Detection on Complex Simulated Data





SICK LMS111 Laser Measurement System used to build 3D models of the trees

- Measures distance and signal strength
- Fast scanning rate
- High resolution
- Weather resistant
- Relatively inexpensive ($5k)



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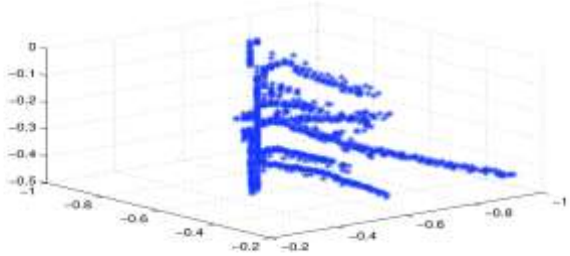

But wait

There's a better (and much cheaper) way

Goal 3: Determine social and economic impacts of the proposed autonomous pruning system

Will these technologies be used?

Will the rubber actually meet the road?

Pruning Running Late—Time to Automate

Jayson Harper, Leland Glenna, Anouk Patel-Campillo

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Goal 4: Communicate results and involve stakeholders and students so they can adopt these technologies and incorporate knowledge gained into their orchards, vineyards, businesses, classrooms, and laboratories

Summary project status

- Considerable industry interest in grape pruner
- Moving towards commercialization
- Apple pruning can be described in terms of “rules”
- Constructing 3D images of apple trees is challenging
- Decision systems should be possible
- Potential to use results to improve human pruning
- Robotic pruner for apple?
- Technology applicable to other crops?



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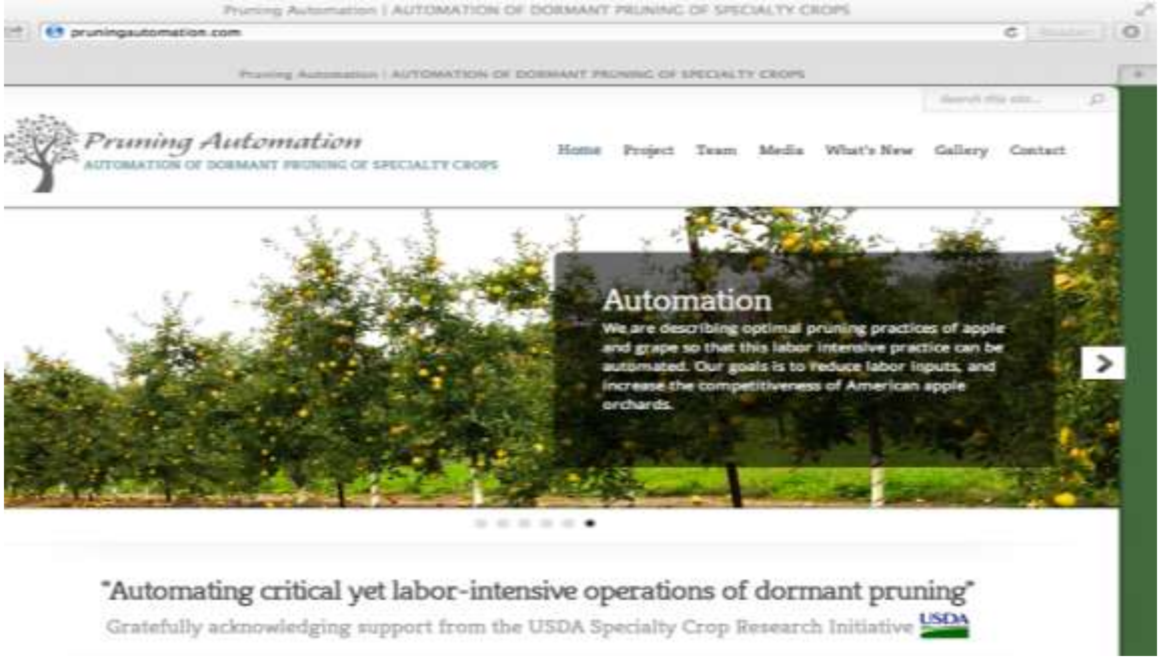
and commercial partners



For more information:

pruningautomation.com

hirst@purdue.edu

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