

AI for sustainable agriculture

Simon Parsons

Lincoln Institute for Agri-Food Technology
University of Lincoln

1 Background

2 Use cases

Monitoring

Crop care

Selective Harvesting

Supply chain

3 Open Agrirobotics

4 Getting involved

5 Conclusion

Food is important to us



Agriculture less so



Agriculture less so



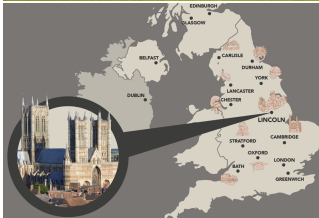
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Sustainable Agri-food

- To fight **climate change**, we need to:
 - promote carbon sequestration
 - offset GHG emissions
 - Use natural resources more efficiently
- To address **food security**, we need to:
 - make better use of existing farmland
 - farm more productively
 - respond to the ageing farmer phenomenon
- All within a complex socio-political landscape.



Lincoln Institute for Agri-Food Technology



(Visit Lincoln)



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Lincoln

Lincoln

- Population: ~ 100,000
- First settlement ~ 60 CE
- Cathedral founded: 1072



Vienna

- Population: ~ 2,000,000
- First settlement ~ 100 CE
- Cathedral founded: 1147



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Measuring growth



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Phenotyping



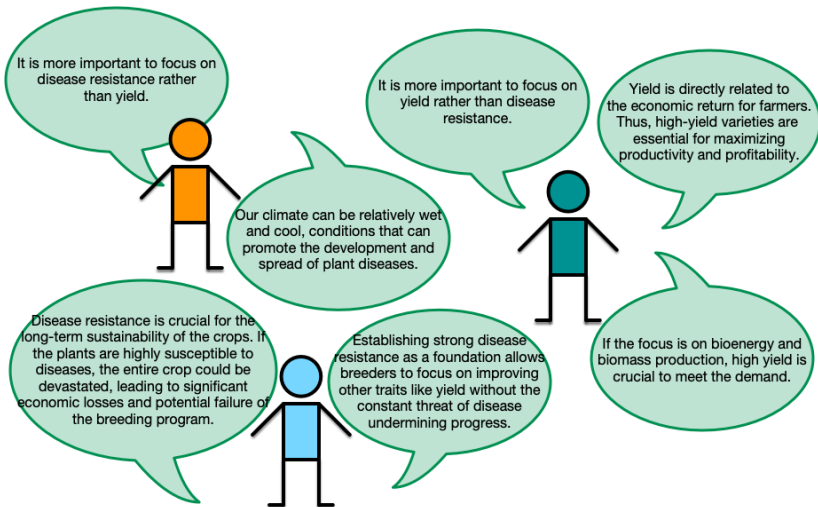
Sep 2023



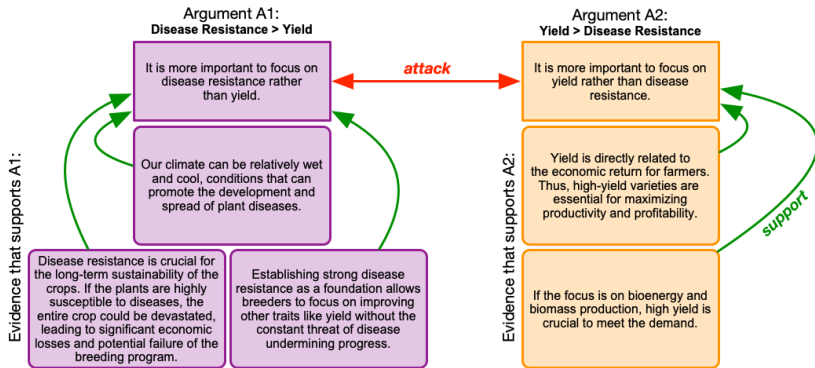
Nov 2023

- Measuring
- Modelling
- Decision making

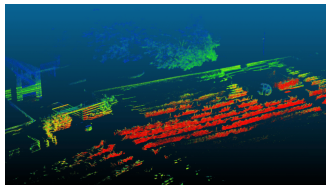
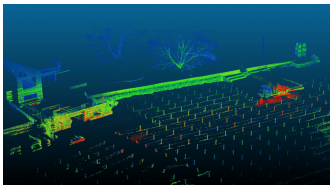
Phenotyping Decisions



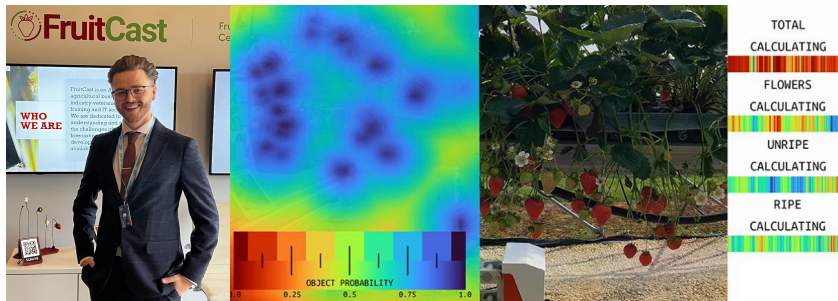
Phenotyping Decisions



Long term measurement



- Constructing 3D maps of agricultural areas.
- Localization, adaptation.



- Counts existing and developing fruit.
- Predicts near-future yield.

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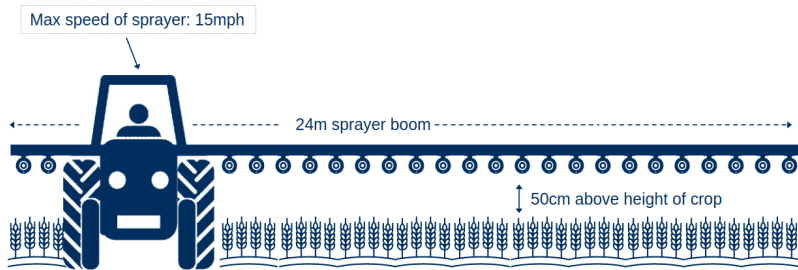
Supply chain

3 Open Agrirobotics

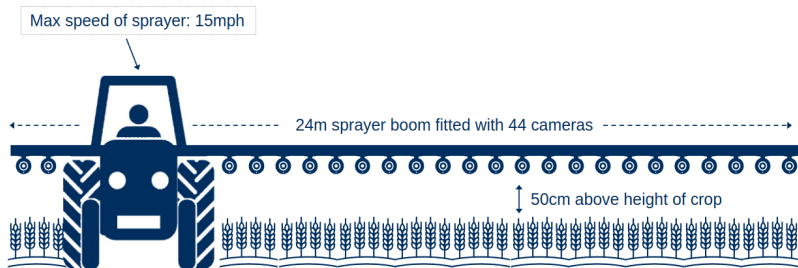
4 Getting involved

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Precision spraying



Precision spraying



- How can we process images fast enough to precision spray?

Practical aspects of deployment

GPU		GTX 2080Ti			Tesla T4		
Model	Backbone	35 batch	18 batch	9 batch	35 batch	18 batch	9 batch
yolov5m	DN-53	212	238	222	158	169	166
Yolov4	DN-53	150	144	144	110	100	96
Yolov3	DN-53	128	151	147	93	96	93
Faster R-CNN	R-50	34	33	32	25	25	24
Faster R-CNN	R-101	31	30	29	23	23	21
Faster R-CNN	Rx-101	25	26	25	20	19	19

GPU		GTX 2080Ti			Tesla T4		
Model	Backbone	35 batch	18 batch	9 batch	35 batch	18 batch	9 batch
yolov5m	DN-53	263	277	263	163	169	166
Yolov4	DN-53	185	169	158	120	110	97
Yolov3	DN-53	175	166	163	105	107	103
Faster R-CNN	R-50	36	33	33	26	25	24
Faster R-CNN	R-101	30	30	30	19	18	18
Faster R-CNN	Rx-101	24	25	24	17	16	16

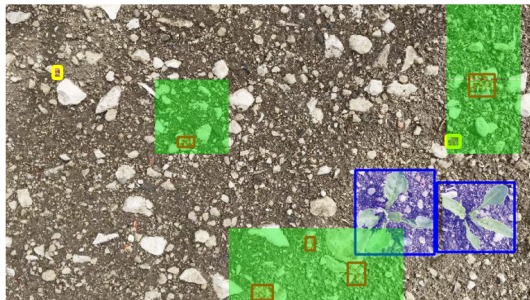
- Still need 4–6 GPUs to operate a sprayer.
- Experimenting with FPGAs and quantization.

Practical aspects of deployment



- What about off-board control?

Measures of performance



Spray Area

19

Weed Coverage Rate

86

- How good is good enough?



- UVC for treating mildew.

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Crop care

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Strawberries



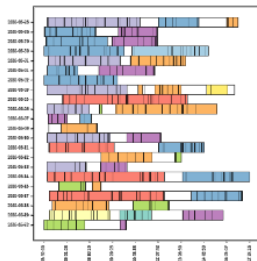
- Strawberries are an important high-value crop worldwide.
- UoL work has concentrated on safe, autonomous navigation.

Transport

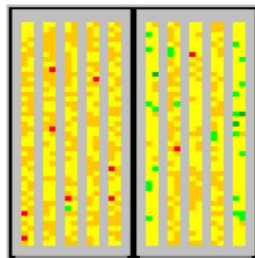


- Autonomous movement.
- Robots summoned by pickers.

Scheduling



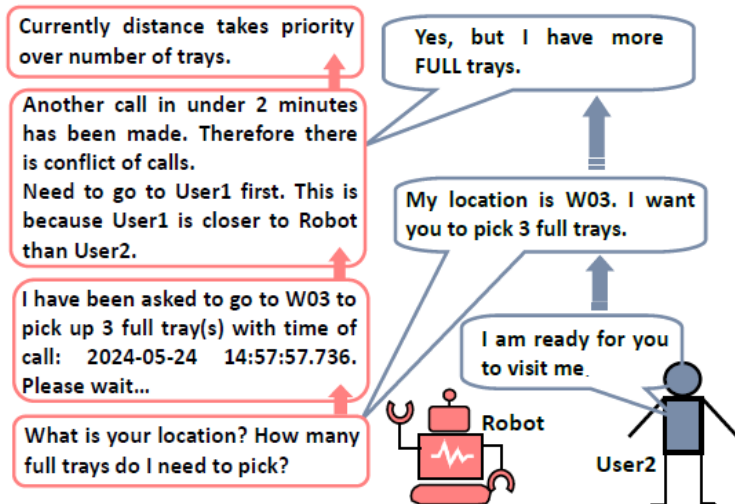
worker model
(scarce resource)



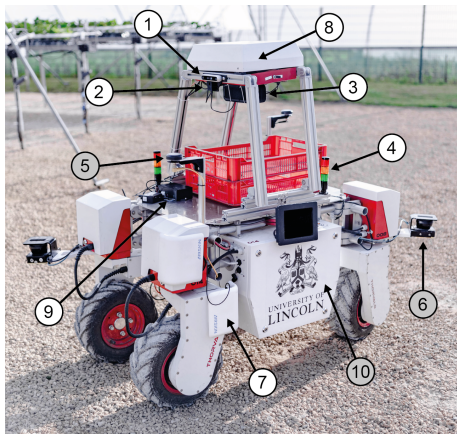
yield model
(high demand)

- How to schedule pickers to areas on the farm.
- How to schedule robots to attend pickers.
- How to best plan activity.

Conflict resolution & explanation



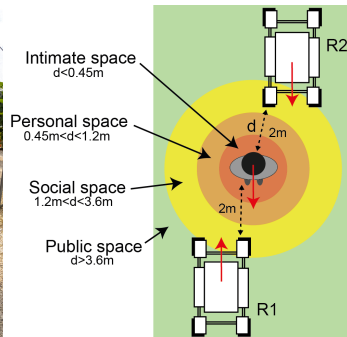
Safety



- ① RGB-D camera / Realsense D455 (x2)
- ② Thermal camera / FLIR Lepton 3.5 sensor + Purethermal 2 I/O Module (x2)
- ③ Portable Speaker / 50W 6600mAh
- ④ LED Beacon Tower / 3 Light Elements (x2)
- ⑤ GNSS antenna for Dual Compassing (x2)
- ⑥ 2D LiDAR / Sick NanoScan3 (x2)
- ⑦ Safety Bumpers / AIRSKIN pads (x8)
- ⑧ Second PC / Intel NUC 11 Enthusiast Series with RTX 2060 6GB GPU
- ⑨ Arduino UNO + Interfaces to convert 24V to 5V and 5V to 24V signals
- ⑩ Thorvald II robotic platform + Main PC

- Human-aware navigation.
- Reduce the probability of injury.

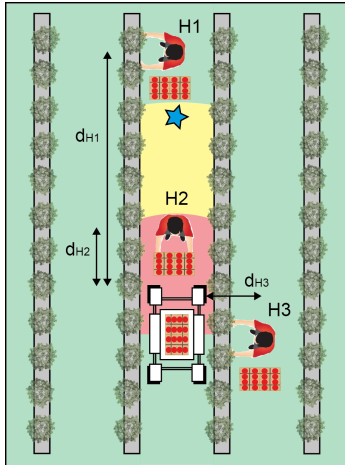
Safety



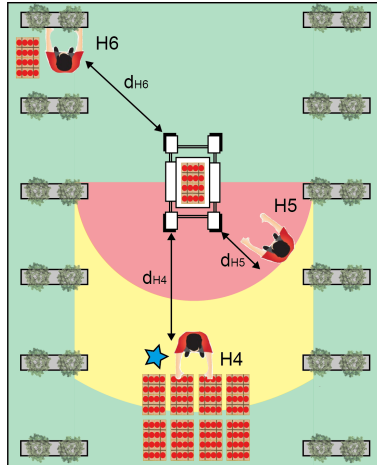
- Robot navigates differently in different zones.
- Model Checking: establish probabilistic bounds on performance.

Safety

HRI inside polytunnels

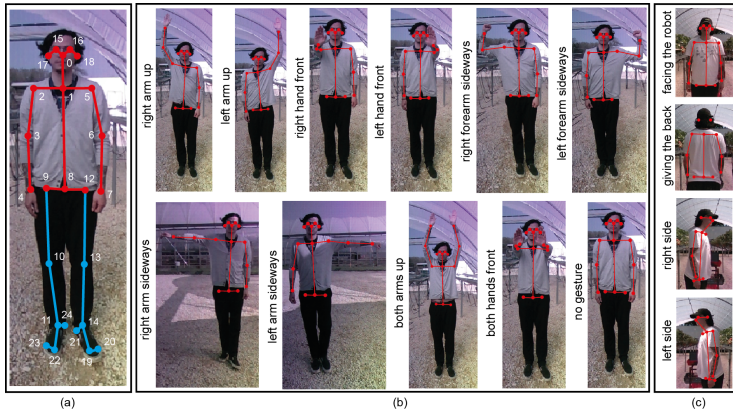


HRI at footpaths



$d_{H1} = 4m$	$d_{H2} = d_{H3} = d_{H5} = 1m$	$d_{H4} = d_{H6} = 2.5m$	
★ robot's current goal	● danger zone	● warning zone	● safe zone

Safety



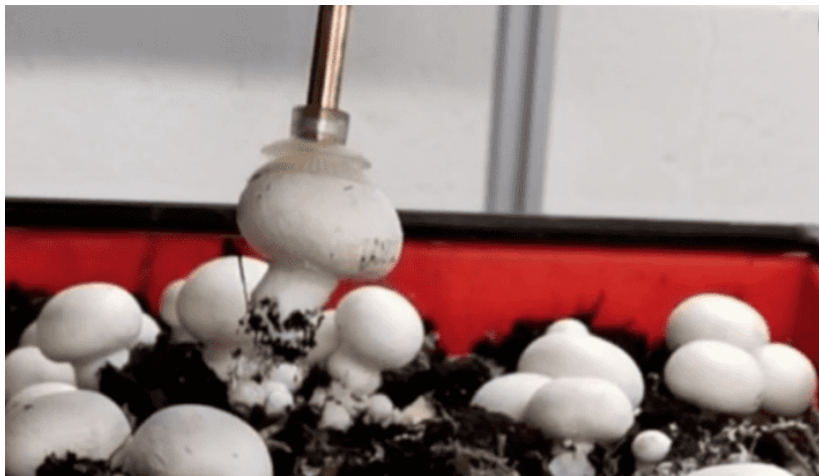
- Vision aspect is effectively solved.
- Scope for more complete human-robot communication.

Dogtooth



- Currently in commercial operation.
- UoL is providing safe autonomy.

Agaricus



- Fresh mushrooms are an important (£450m) crop in the UK.



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Digital Sandwich



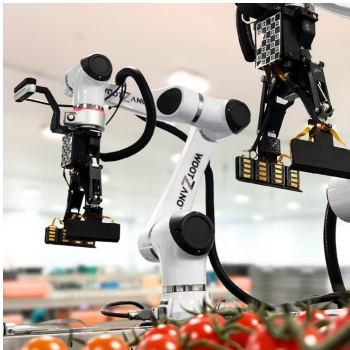
- Multiagent modelling of supply chain.
- Provenance of food items.



(Carrier Transicold/FreshLinc)

- Effective use of transportation.
- Planning/optimization.

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Wootzano



Muddy Machines

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Welcome to the UKRI AI Centre for Doctoral Training in Sustainable **Understandable** agri-food Systems Transformed by Artificial INtelligence (SUSTAIN).

SUSTAIN is a collaboration between the Universities of Lincoln, Aberdeen, Queen's Belfast and Strathclyde, and focuses on the application of Artificial Intelligence (AI) to sustainable agri-food.



Where the next generation of AI science takes root.

The SUSTAIN Centre for Doctoral Training (CDT) empowers the next generation of AI scientists to invent, develop and deploy technologies, co-created with growers and agri-food practitioners.

SUSTAIN facilitates meaningful partnerships between academics and industry, investing in stakeholder-driven innovation.

- Spread the word.
- Join us in the next step.

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Conclusion



- Sustainable agriculture is a major challenge
 - Could argue it is existential.
- AI can help from farm to fork.
- Provided some use cases from work at Lincoln.
- Lots more to do!

Thanks

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Thanks



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