Horticulture 4.0 Conference

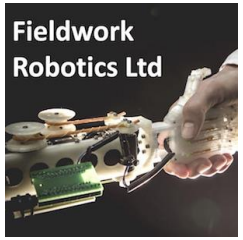
Dr. Martin F. Stoelen
University of Plymouth

Robotic selective harvesting projects at the University of Plymouth

Martin F. Stoelen, PhD

Lecturer in Robotics
Head of Soft and Adaptive Robotics (SAR) lab
Centre for Robotics and Neural Systems (CRNS)
University of Plymouth
Director, Fieldwork Robotics Ltd

ROBOTICS WITH PLYMOUTH UNIVERSITY



Agri-robots

Agri-robots

Farminguk
22 June 2017 | Online since 2003

26 October 2016 08:33:03 | Machinery and Equipment, News

Robotic agriculture: the battle between the big and the small

Leading tractor companies worldwide have already demonstrated master-slave or 'follow-me' unmanned autonomous tractors

Agricultural robotics can upend several commonly-held notions, amongst them is the idea that big is better.

In practise this has translated into ever larger and more powerful agricultural machinery.

Agri-robots

Robots
The Observer

If EU workers go, will robots step in to pick and pack Britain's dinners?

Automation is on the march on farms across the world, but it is costly, and may not come soon enough to fill the gap

325 367
Sarah Butler
@whatbutlersaw

Saturday 25 February 2017 16.00 GMT

Strawberry pickers, mostly from Poland, in poly-tunnels on a farm in Kent. Photograph: Graeme Robertson for the Guardian

Octopus-like robots are plucking strawberries in Spain, in the US machines are vacuuming apples off the trees, and in the UK they are feeding and milking cows. Robots are taking over fields around the world, and last week food and rural affairs secretary Andrea Leadsom suggested they could help replace the thousands of EU workers who currently help put food on British tables.

And it is not just Brexit that is forcing the agricultural industry to embrace the

News

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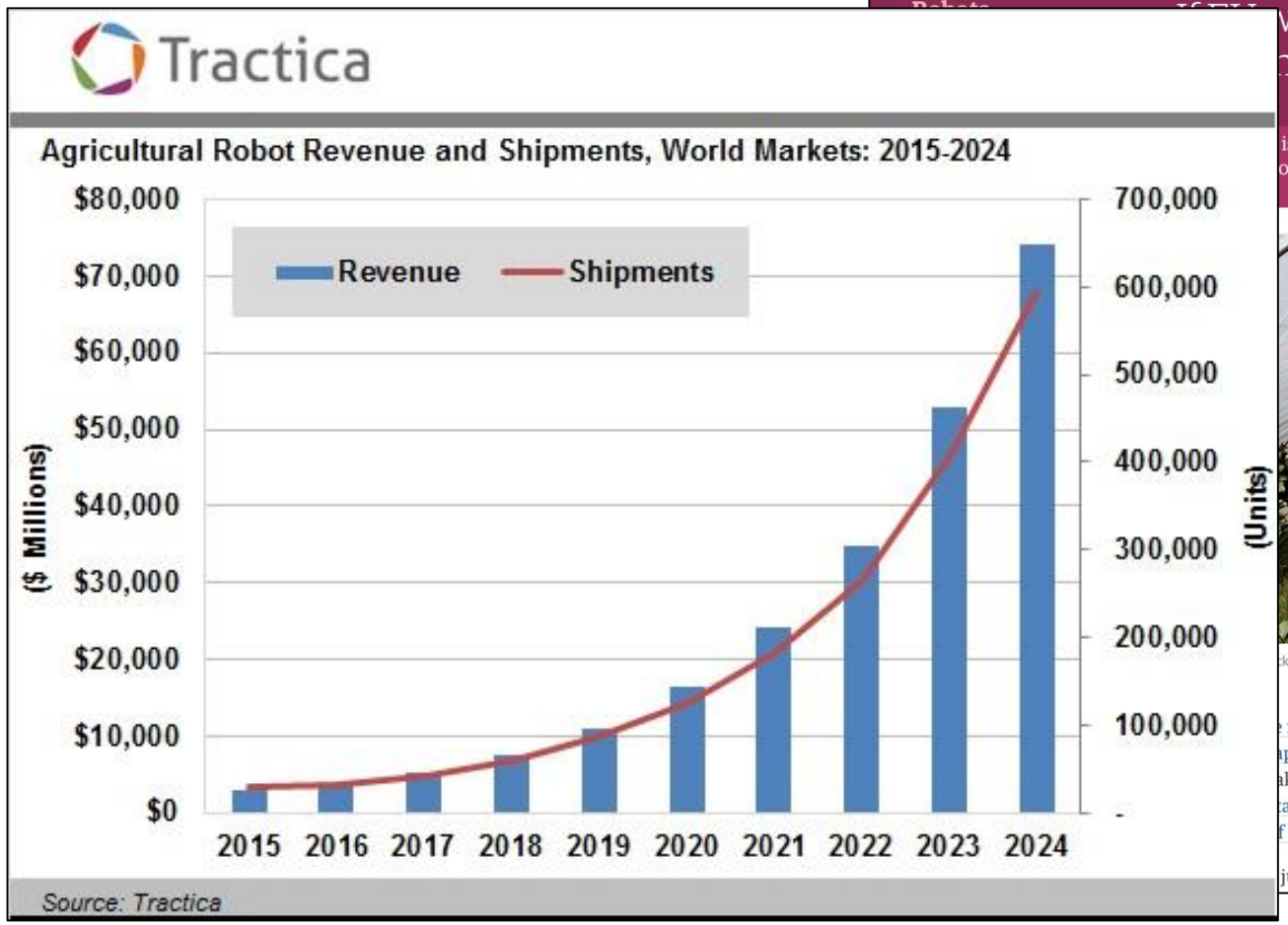
larger and more powerful

Agri-robots


Tractica
Agricultural Robot Revenue and Shipments, World Markets: 2015-2024
$80,000
$70,000
$60,000
$50,000
$40,000
$30,000
$20,000
$10,000
$0
($ Millions)
Revenue
Shipments
700,000
600,000
500,000
400,000
300,000
200,000
100,000
-
(Units)
2015 2016 2017 2018 2019 2020 2021 2022 2023 2024
Source: Tractica


UK politics world sport football opinion culture business lifestyle fashion environment tech
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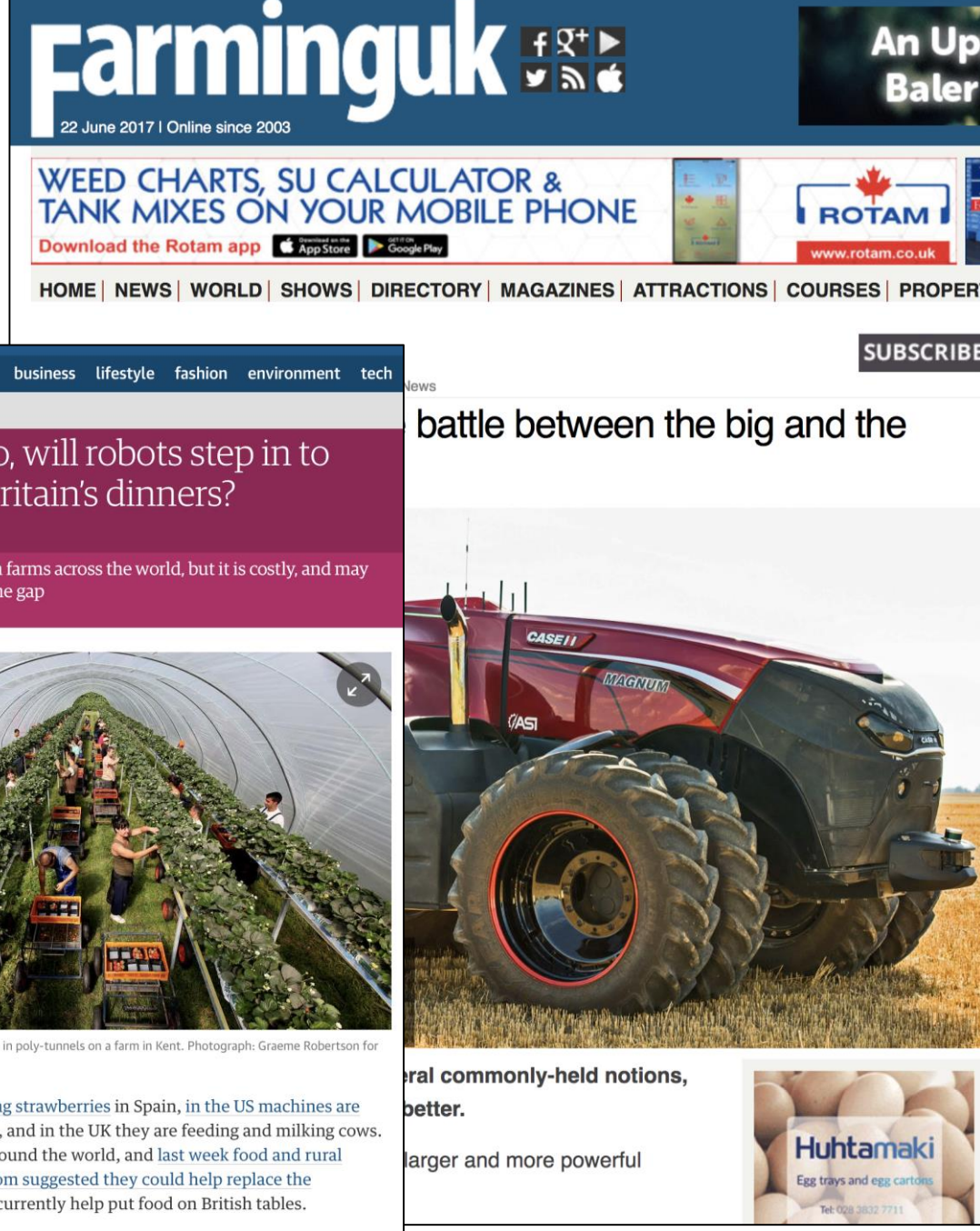
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CASE
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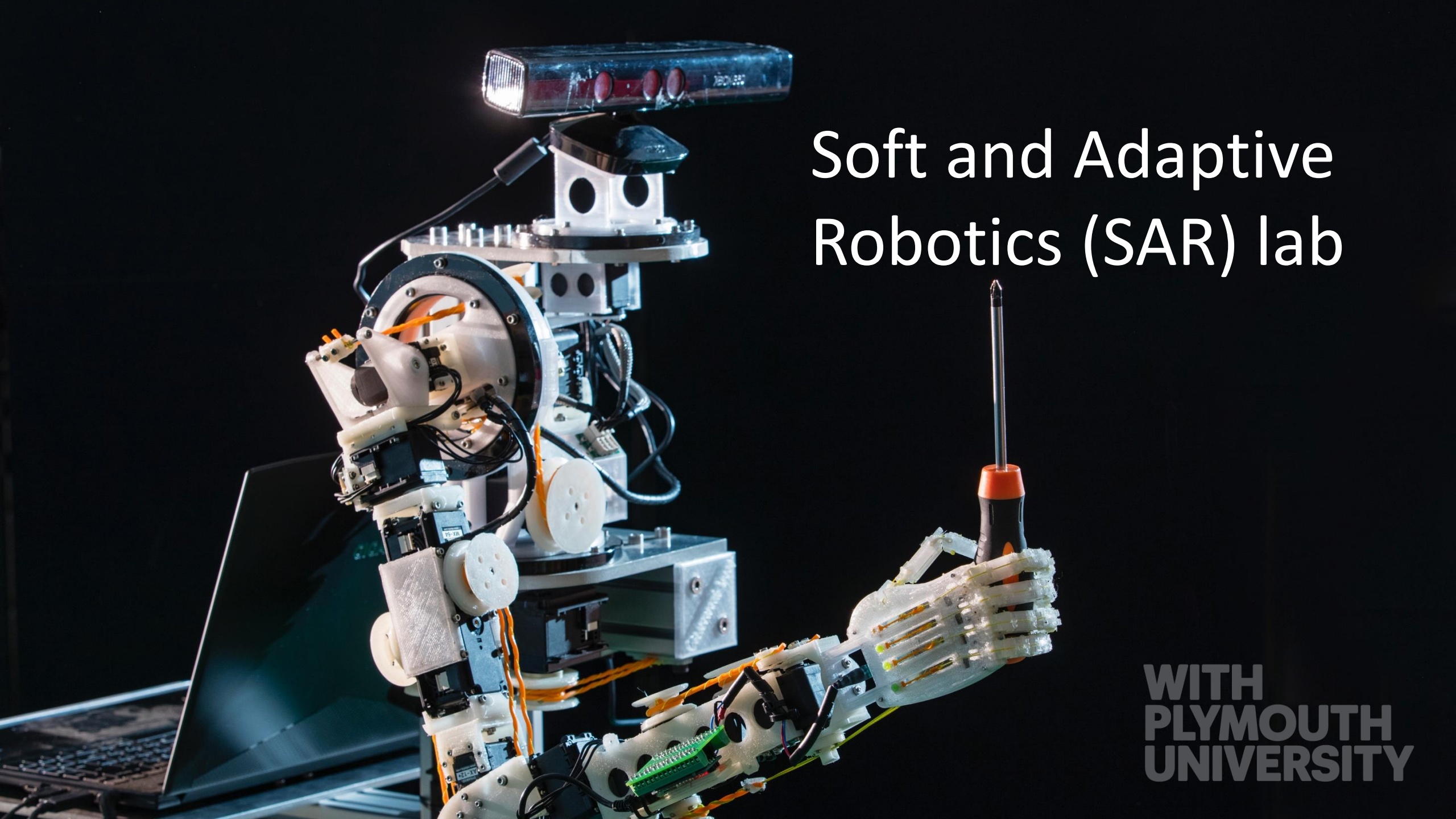
Huhtamaki
Egg trays and egg cartons

Fieldwork Robotics Ltd

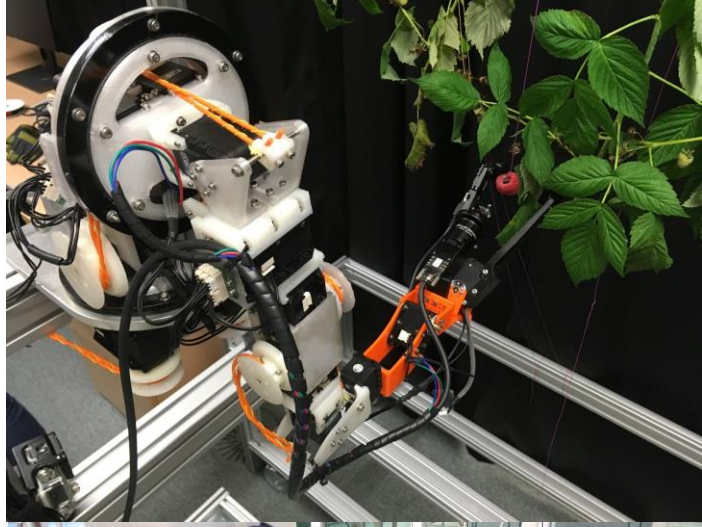
WITH PLYMOUTH UNIVERSITY


Soft and Adaptive Robotics (SAR) lab
WITH PLYMOUTH UNIVERSITY

- Soft and Adaptive Robotics (SAR) lab
  - Soft/variable-stiffness robots for real-world applications
    - Picking soft fruits and vegetables
    - Research and education
  - Substantial Research/Innovation funding (>£1M)

- Fieldwork Robotics Ltd
  - Plymouth University spin-out company
  - Drive SAR research to commercialization
  - Multi-crop robotic harvesting technology as a service

- This autumn 15 staff and funded students across groups



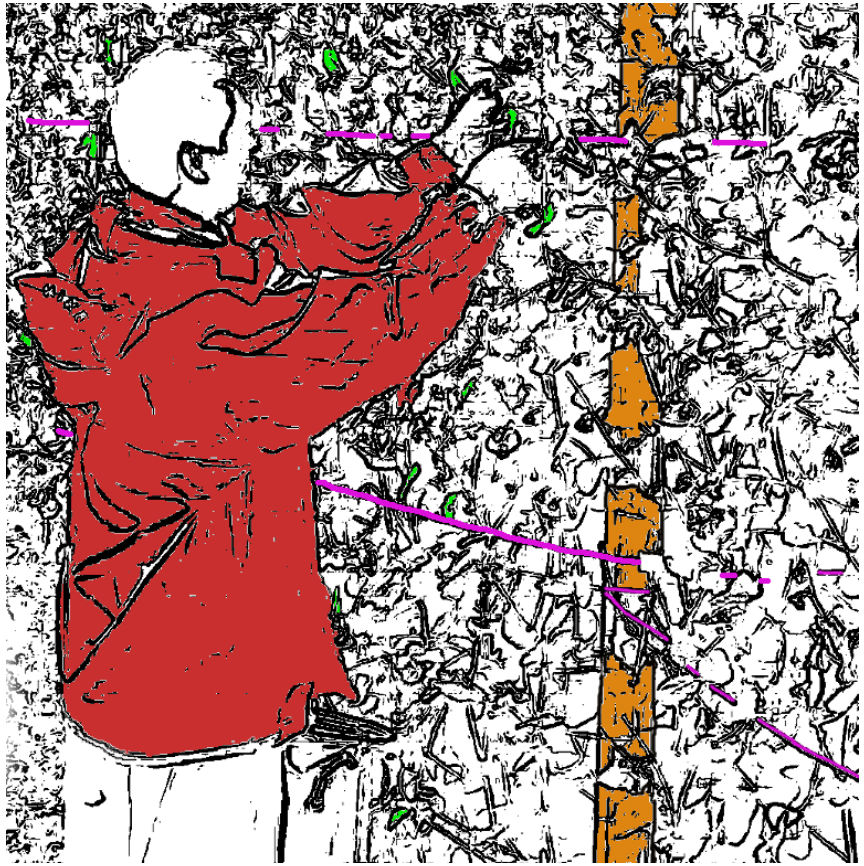
ROBOTICS WITH PLYMOUTH UNIVERSITY

Fieldwork Robotics Ltd

Frontier IP Group plc

- Innovate UK (Fieldwork Robotics Ltd)
  - Project: “Soft and Selective Raspberry Harvester (SoSeRaH)”
  - 2018-2020, Principal Investigator (**PI**). **£507,000**.
- Agri-Tech in China: Newton Network+ (ATCNN), UK
  - Project: “China Robot Harvest ++”, Principal Investigator (PI): Martin F. Stoelen.
  - Newton Fund, UK, 2018-2019. **£72,000**.
- Agri-Tech in China: Newton Network+ (ATCNN), UK
  - Project: “China Robot Harvest”, Principal Investigator (PI): Martin F. Stoelen.
  - Newton Fund, UK, 2017-2018. **£44,000**.
- European Regional Development Fund (ERDF), Agritech, Cornwall, UK
  - Project: “Autonomous Brassica harvesting in Cornwall (ABC)”, PI: M.F. Stoelen.
  - European Union, 2017-2020. **£216,000**.
- UoP Proof of Concept funding, “Compliant Autonomous Systems for Agriculture (CASA)”
  - University of Plymouth, 2016-2019. **£79,000**.
- Marie Curie Intra-European Fellowship (IEF)
  - Project: “Developmental Context-Driven Robot Learning (DeCoRo)”
  - PI: Angelo Cangelosi, Researcher: Martin F. Stoelen.
  - European Union, 2014-2016. **€230,000**.
- NILS Science and Sustainability Mobility Grant
  - Project: “Robotics for Sustainable Farming of High-Value Crops in Norway: A Case Study on Sugar Pea Harvesting”
  - Researcher: Martin F. Stoelen.
  - European Economic Area (EEA), 2014. **€12,000**.

Fast manipulation in close proximity to people/obstacles, with noisy sensory data

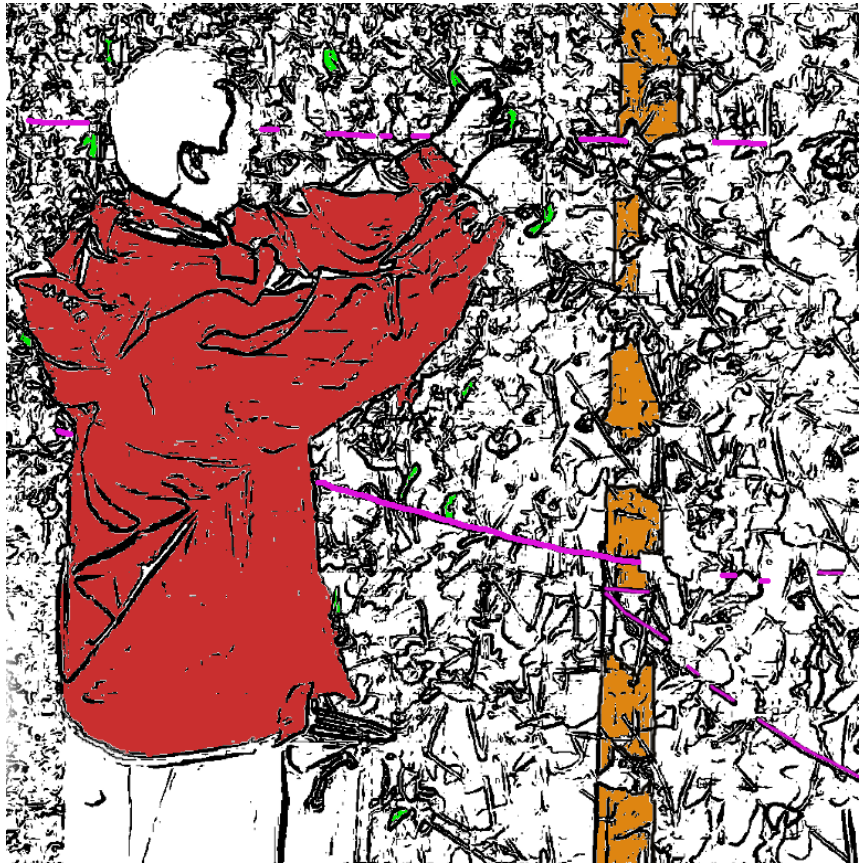


** Zinn et al., The international journal of robotics research, 2004*

Fast manipulation in close proximity to people/obstacles, with noisy sensory data

Collisions with obstacles

- Hard to prevent 100%
- E.g. wooden poles, infrastructure, ground



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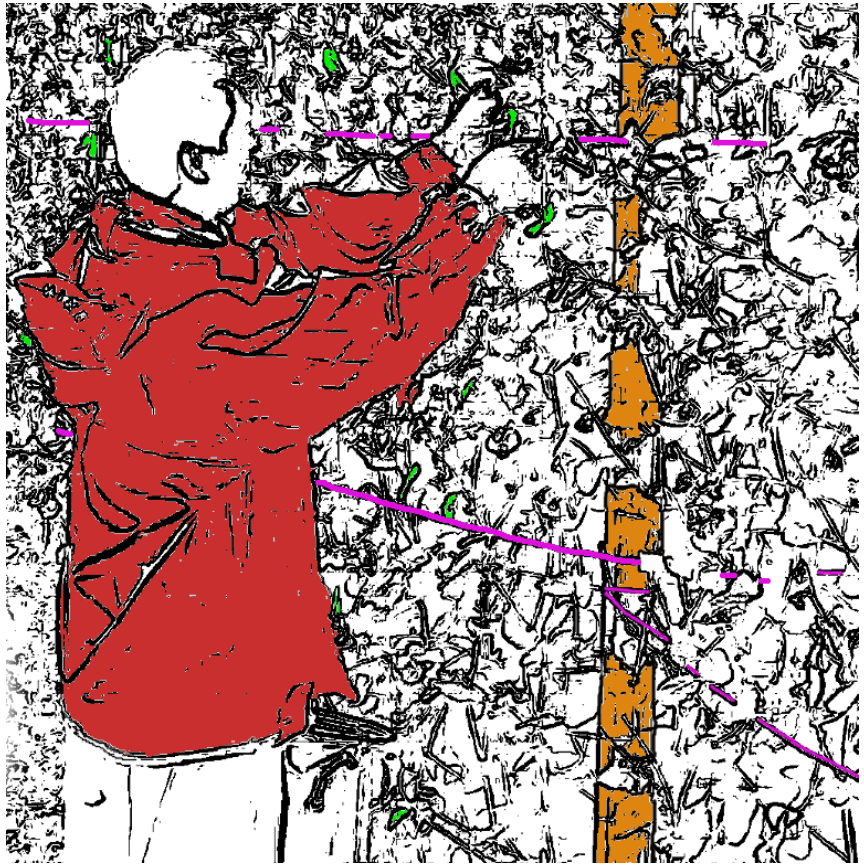
Injury to human co-workers

- Dynamic environment
- Head Injury Criterion*
- Cutting mechanisms



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Fast manipulation in close proximity to people/obstacles, with noisy sensory data

Collisions with obstacles

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Injury to human co-workers

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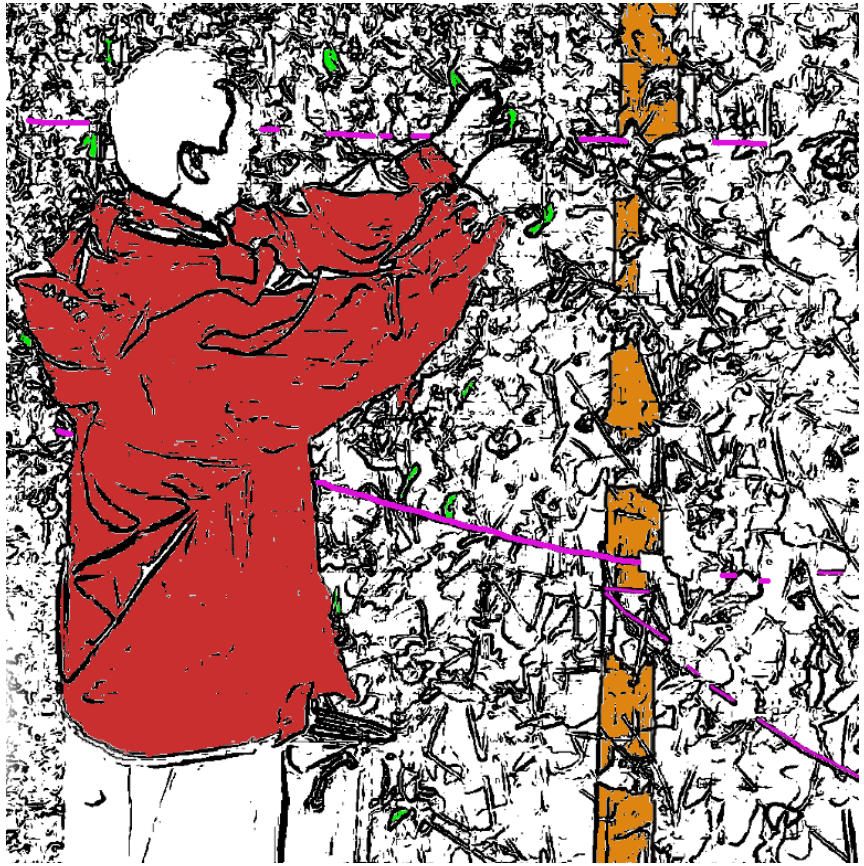
- Head Injury Criterion*
- Cutting mechanisms

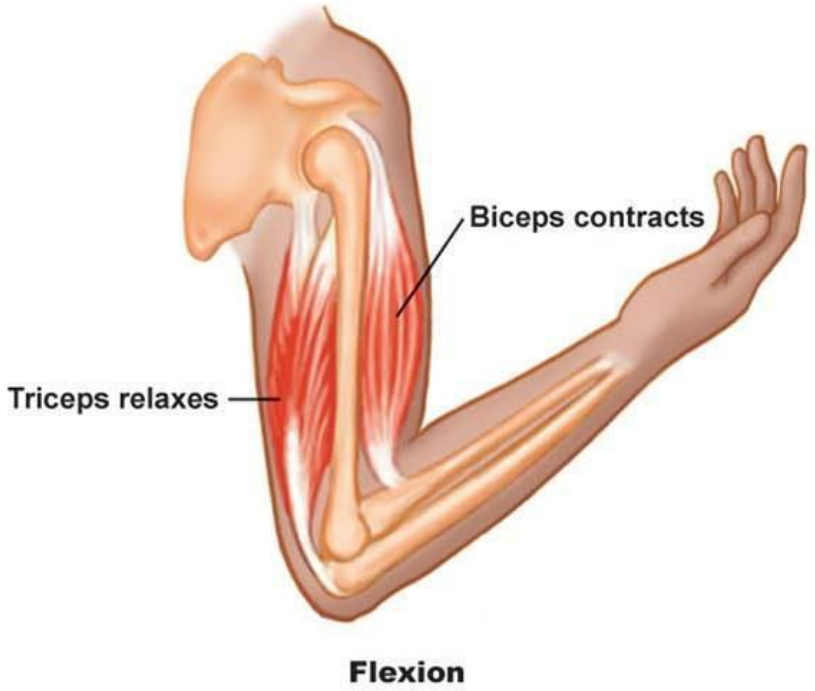
Entanglement

- Cords, wires
- Branches, stems, leaves



** Zinn et al., The international journal of robotics research, 2004*

The human muscle-tendon system



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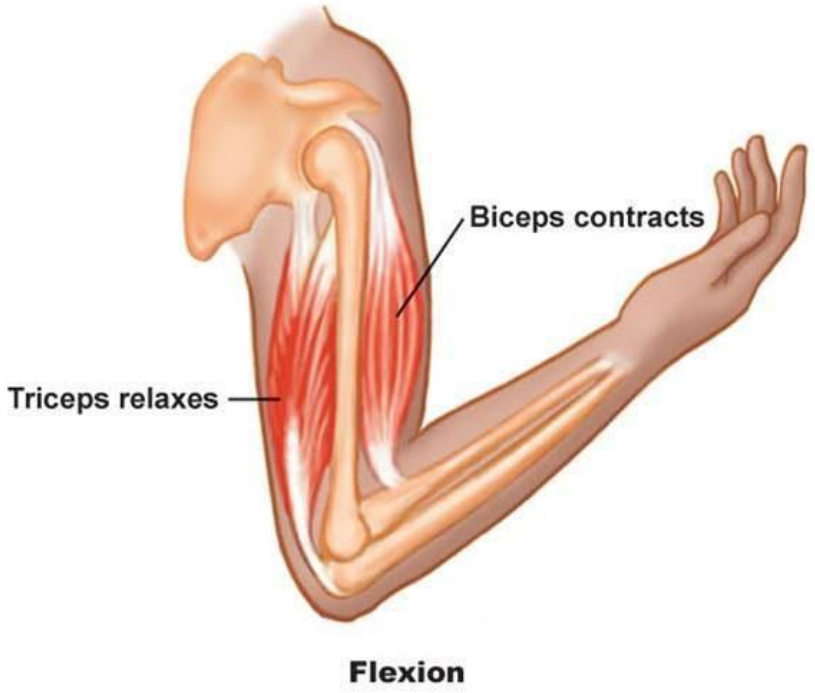

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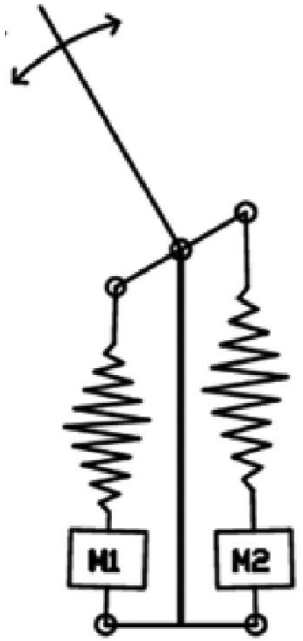

Vanderborght et al., Robotics and Autonomous Systems, 2013

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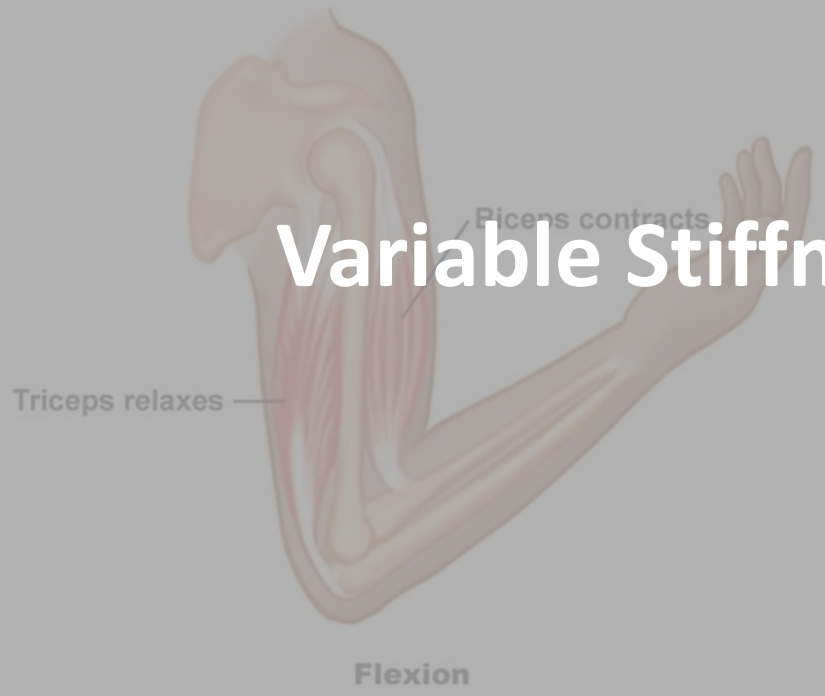

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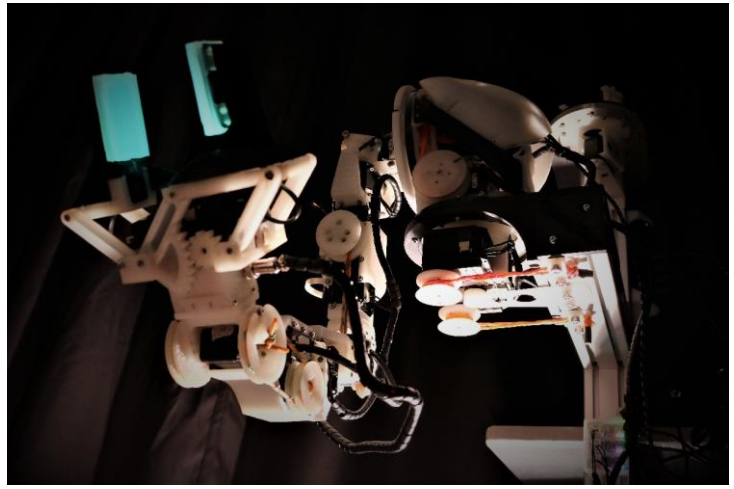
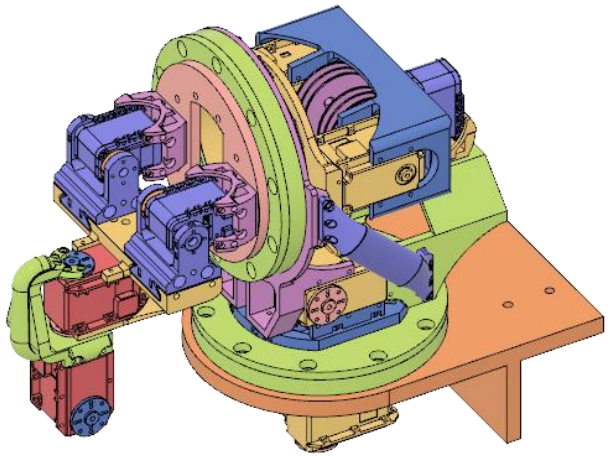
Variable Stiffness Actuator (VSA)

Vanderborght et al., Robotics and Autonomous Systems, 2013

The GummiArm/Heavy platform

- Dexterous 7 DOF VSA robot arm
  - ROS and MoveIt! integrated
  - 5 variable-stiffness joints
- Started life as a research platform
  - Open source and DYI 3D printable
  - Rapid co-development of hardware and software
  - Now being applied in our agricultural projects
- Uni- or bi-directional antagonist setup
  - GummiArm: 1+ kg payload
  - GummiHeavy: 2+ kg payload





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ROBOTICS WITH PLYMOUTH UNIVERSITY

SHANGHAI JIAO TONG UNIVERSITY
1896

China Robot Harvest project

Agri-Tech in China Newton Network+ (ATCNN), UK

With thanks:

ROTHAMSTED RESEARCH

Newton Fund

DE TAO GROUP 德稻

Fieldwork Robotics Ltd

Selective harvesting of tomatoes in Shanghai

- Government goal to reduce labour requirements in intensive crop production
  - Shanghai is a fast growing, affluent region
  - Hard to attract workers, age is increasing
- Cross-disciplinary consortium
- 4-month Proof-Of-Concept (POC)
  - 2 trips to China, early July and August 2017
  - 2 part-time Engineers hired for 4 months
  - Robotics equipment and prototyping

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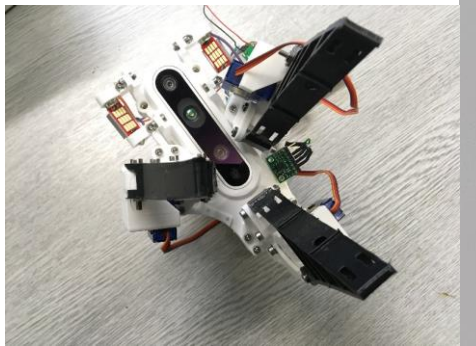
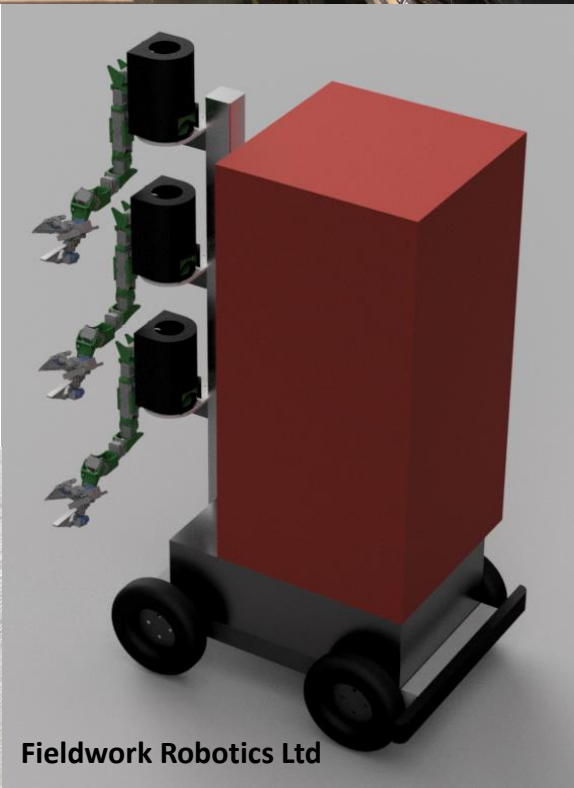
DE TAO GROUP 德稻

China Robot Harvest ++

- Build on successful POC demonstration of robot arm for selective tomato harvesting
- Quantify and improve performance in longer-duration field testing
  - UK testing summer/autumn 2018
  - Shanghai, China testing January 2019
  - Robustness to variability from lighting conditions, crop variability and in-field conditions
- Draft commercialization plan for full mobile robot platform (image right) with partners





Fieldwork Robotics Ltd

WITH PLYMOUTH UNIVERSITY

Autonomous and selective raspberry harvesting

- Raspberries - A market ripe for picking robots
  - Manual labour often > 50% of cost
  - No current automated solutions for fresh cons.
- Complex foliage, sunlight, poles, soft fruit ++
  - Local farmers in Plymouth used as testbeds
  - Experimental raspberries grown at UoP
- Recent collaboration agreement with Hall Hunter Partnership

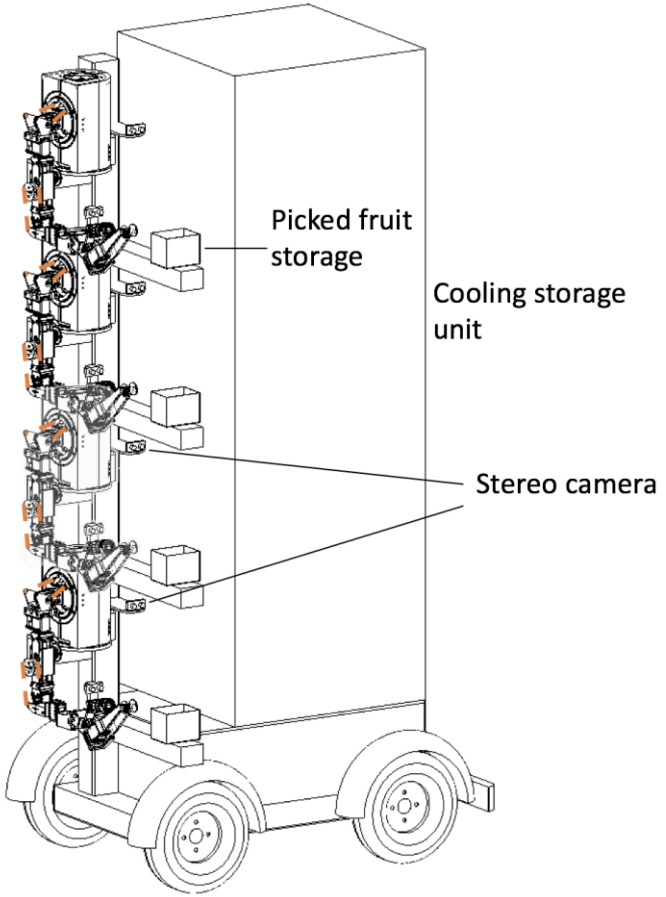
ROBOTICS WITH PLYMOUTH UNIVERSITY

Fieldwork Robotics Ltd

HALL HUNTER PARTNERSHIP
SUSTAINABLY PRODUCING QUALITY BRITISH BERRIES

SoSeRaH project

- Successful Innovate UK proposal
  - 24 month project (> £600k in total)
  - Led by Fieldwork Robotics Ltd (> £500k)
  - Starting October 2018
- Inter-disciplinary team
  - Fieldwork Robotics Ltd (Dr Stoelen)
  - National Physical Laboratory (Dr Dudley)
  - University of Plymouth (Dr Howard)
  - Hall Hunter Partnership
- Field-test complete raspberry picking platform



HALL HUNTER PARTNERSHIP
SUSTAINABLY PRODUCING QUALITY BRITISH BERRIES

NPL National Physical Laboratory

United Kingdom Patent Application No. 1715007.9
United Kingdom Patent Application No. 1715006.1
United Kingdom Patent Application No. 1715005.3

ROBOTICS WITH PLYMOUTH UNIVERSITY

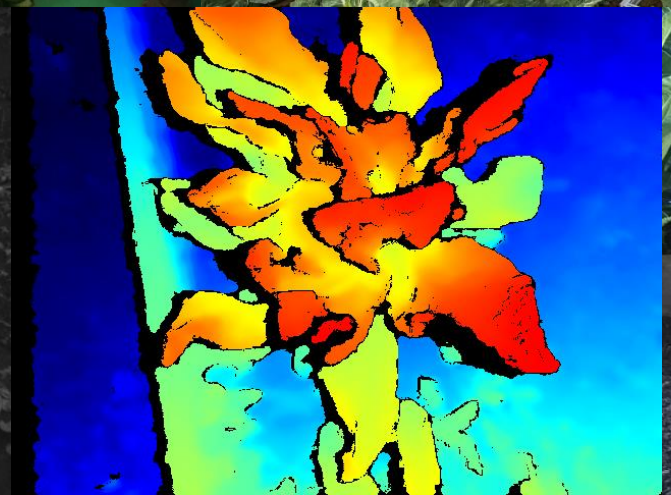
Riviera Produce
Cornwall's grower of choice

- Explore selective harvesting for Brassica production in Cornwall
- PI: M. Stoelen, co-I: M. Fuller (Plymouth)
- Part of EU ERDF agri-tech bid
- Use extensive local knowledge in farming, manufacturing, and robotics
- £216k funding, 2017-2019

CNCDesign Limited

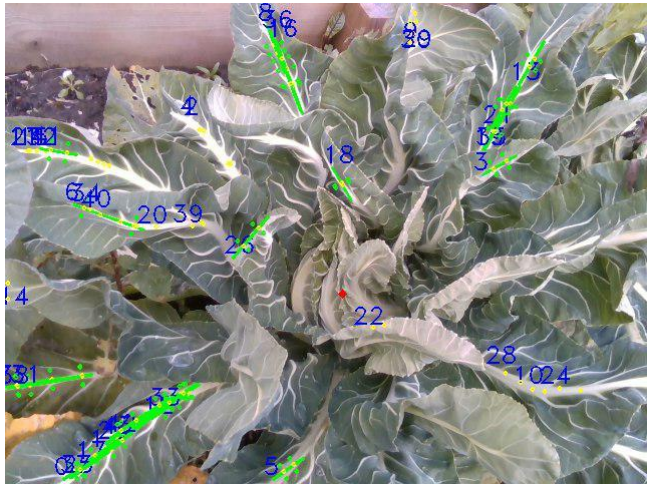
Teagle

Spring/summer 2018



Autumn 2018

First experimental in-field deployment



Real-time centroid localization

Cutting and grasping mechanisms

Maturity check (summer varieties)

Thank you

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