SmartHort 2019, AHDB Horticulture, Crowne Plaza Stratford-upon-Avon

# Soft robotics and handling delicate crops

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

Robotic agriculture: the battle between the big and the small



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.





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



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# Fieldwork Robotics Ltd





# Soft and Adaptive Robotics (SAR) lab



- 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 (>£1.2M)
- Fieldwork Robotics Ltd
  - Plymouth University spin-out company
  - Drive SAR research to commercialization
  - Multi-crop robotic harvesting technology as a service
- Winter 2019: 10+ staff and funded students across groups









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**.



Collisions with obstacles

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



### Collisions with obstacles

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

#### Injury to human co-workers

- Dynamic environment
- Head Injury Criterion\*
- Cutting mechanisms



### Collisions with obstacles

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

### Injury to human co-workers

- Dynamic environment
- Head Injury Criterion\*
- Cutting mechanisms

### Entanglement

- Cords, wires
- Branches, stems, leaves



# The human muscle-tendon system



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## The human muscle-tendon system



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Vanderborght et al., Robotics and Autonomous Systems, 2013

# The human muscle-tendon system



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Vanderborght et al., Robotics and Autonomous Systems, 2013

#### GummiArm

# Family of VSA robot arms

- Dexterous 7 DOF VSA robot arms
  - All ROS and Movelt! integrated
  - 5-7 variable-stiffness joints
  - Uni- or bi-directional antagonist setup
  - High degree of modularity
- Started life as a research platform
  - Open source and DYI 3D printable
  - Rapid co-development of hardware and software

2 kg payload

- Now being applied in our agricultural projects
- Range of capabilities to fit different crops:
  - GummiArm: 1 kg payload
  - GummiHeavy:
  - GH2: 4+ kg payload



GummiHeavy







**COLLABORATIONS IN CHINA** 

### AGRI-TECH IN CHINA: NEWTON NETWORK + (ATCNN)

# China Robot Harvest ++











# 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









# China Robot Harvest project

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

With thanks:



# 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** 





# Fieldwork Robotics Ltd



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





### 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
  - Start: December 1<sup>st</sup> 2019
  - End: November 30<sup>th</sup> 2020
- Inter-disciplinary team
  - Fieldwork Robotics Ltd (Dr Stoelen)
  - National Physical Laboratory (Dr Dudley)
  - University of Plymouth (Dr Howard)
- Hall Hunter Partnership for field-testing
- Field-test complete raspberry picking platform





ROBOTICS WITH PLYMOUTH UNIVERSITY

Innovate UK

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







- 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







# Collaborators

- Riviera Produce (Hayle)
  - End-user input and field-testing sites
- CNC Design Ltd (St Columb Major)
  - Motor control and Cartesian robot mechanisms
- University of Plymouth
  - Sensors, software and robot manipulators for agriculture
  - Ongoing projects on raspberry and tomato harvesting
- Robotriks Ltd (Par)
  - Industrial-grade servo actuators
- Teagle Machinery Ltd (Truro)
  - Strategic partner, consult on agricultural machinery







3D vision and modelling



First experimental in-field deployment



Cutting and grasping approaches and mechanisms



Real-time centroid localization



Growing experimental crop on UoP campus

Maturity check (summer varieties)













**Applied Sciences** 

## Fieldwork **Robotics Ltd**

# Thank you

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