

# AgriFoRwArdsS EPSRC Centre for Doctoral Training in Agri-Food Robotics

## Second annual conference

### 1-2 July 2021, University of East Anglia



## Welcome

Dear Agri-Food Robotics Conference delegate,

I am delighted to welcome you to the second AgriFoRwArDS Annual Conference, hosted by the University of East Anglia.

AgriFoRwArDS is the world's first Centre for Doctoral Training (CDT) in Agri-Food Robotics. Everyone attending this conference over the next two days is either an existing member of the AgriFoRwArDS CDT, or part of our wider research. Everyone attending shares a desire to gain new knowledge, share best practice and advance the state of the art of robotics and autonomous systems for the agri-food industry.

Agri-food is the largest manufacturing sector in the UK, twice the scale of automotive and aerospace combined. However, the food chain is under pressure from population growth, climate change, political pressures affecting migration, population drift from rural to urban regions, and the demographics of an ageing population. Current agricultural practices are also harming the natural environment, with many species of wildlife facing risk of extinction over the next decade.

Addressing these challenges requires a new generation of highly skilled researchers and leaders with interdisciplinary expertise at the crossroads of robotics and autonomous systems (RAS), computer vision, mechatronics, machine learning and artificial intelligence. Our second conference is a testament of how our CDT, established by the Universities of Lincoln, Cambridge, and East Anglia, is living up to this ambition. The Centre brings together unique collaborations of early career and well-established researchers located at the heart of the UK Agri-Food business, supported by leading industrial partners and stakeholders from across the food, farming and robotics industries – many of whom are here today.

The vision of the CDT is to create a new generation of smart, flexible, robust, compliant, interconnected robotic and autonomous systems working seamlessly alongside their human co-workers on farms and in food factories. The creation of our CDT is a step towards the realisation of these innovative concepts, and our conference will enable you to see first-hand, cutting edge research in Agri-Food robotics. I hope that you enjoy the variety of talks and presentations on the programme, and I look forward to seeing many of you at our virtual conference.

Sincerely



Marc Hanheide

Director of the EPSRC Centre for Doctoral Training in Agri-Food Robotics (AgriFoRwArDS)

## NOTES & HOUSEKEEPING

### Zoom

We recommend that you take a few moments to ensure you are running the most recent version of Zoom. Detailed instructions for doing so can be found [on the Zoom website](#).

The main conference is set up as a Zoom webinar. For attendees, this means that the conference will be largely a listen-and-watch only experience. However you will be able to use the chat function to communicate with other attendees, panellists, and hosts. Please be respectful in the conference chat.

Questions for our speakers are very welcome and should be posed using the Zoom Q&A function. Session chairs will moderate questions for the speakers.

The evening social is set up as [a separate Zoom meeting](#) (not webinar).

### Networking using Discord

After each "mini session", speakers will, where possible, make themselves available for individual discussions using our Discord server. All attendees are also welcome to use Discord for general discussions etc. As always, please keep messages respectful.

[Discord](#) works in a web browser or via the dedicated app. Access the conference server at <https://discord.gg/5pcV6A6d>.

### Social media

Please use **#Agriforwards**.

### Prizes

Prizes will be awarded for the following categories:

- Best speaker overall
- Most entertaining speaker
- Best student speaker
- Best summer school presentation

Awards will be made on the basis of votes from our delegates. Voting will be opened at midday on 2 July, and you can vote using [this online form](#).

### Feedback opportunities

We welcome all feedback on the conference so that we can improve future events. Please give your feedback [using this online form](#) (or by emailing [agriforwards.cdt@uea.ac.uk](mailto:agriforwards.cdt@uea.ac.uk)).

### Contacts

Urgent messages during the conference should be sent to the host using the chat function. Alternatively, you can email the conference organisers at [agriforwards.cdt@uea.ac.uk](mailto:agriforwards.cdt@uea.ac.uk). Contact details for the main AgriFoRwArDS EPSRC CDT support team can be found on [the CDT website](#).

## CONFERENCE PROGRAMME

1 JULY 2021 | SESSION 1

**Chair: Richard Harvey (University of East Anglia)**

### 9.00 **Keynote: Bob Fisher (Edinburgh University)**

*Panel discussion:*

Petra Bosilj (University of Lincoln)

Willow Mandil (University of Lincoln)

Sarah Taylor (University of East Anglia),

*Questions are invited from the audience*

### 10.30 **Break**

Head over [to Discord](#) if you'd like to continue discussions.

### 11.00 **Short presentations**

Howard Wu and Marc Jones (Antobot Ltd)

Grzegorz Sochacki (University of Cambridge)

Karoline Heiwolt (University of Lincoln)

Roopika Ravikanna (University of Lincoln)

### 12.00 **Closing remarks; lunch**

Head over [to Discord](#) if you'd like to continue discussions.

1 JULY 2021 | SESSION 2

**Chair: Marc Hanheide (University of Lincoln)**

### 14.00 **Keynote: Jeff Keiser (IBM-Watson)**

*Panel discussion:*

Fumiya Iida (University of Cambridge)

Simon Pearson (University of Lincoln)

Roopika Ravikanna (University of Lincoln)

*Questions are invited from the audience*

### 15.30 **Break**

Head over [to Discord](#) if you'd like to continue discussions.

### 16.00 **Short presentations | Chair: Fumiya Iida (University of Cambridge)**

*Postgraduate students will present findings from the inaugural Agriforwards summer school:*

**Apple Team:** 'Automatic Detection of Black Rot in Images of Grapes'

**Raspberry Team:** 'RAS Counter: Non-invasive yield prediction for vineyards'

**Strawberry Team:** 'Visual perception for harvesting grapes'

**Beetroot Team:** 'Automated Counting of Grapes'

**Lettuce Team:** 'Computer vision for quality assessment of apples'

**Spud Team:** 'Visual Servoing for Human Tracking and Counting'

**17.00** Closing remarks

Head over [to Discord](#) if you'd like to continue discussions.

## 1 JULY 2021 | EVENING SOCIAL

**19.00 Agriforwards Conference Robotics Quiz** with your host: Richard Harvey

Join the quiz here:

<https://eng-cam.zoom.us/j/83838034292?pwd=clZkTjdRaStBUGFEekhZeTRPQmtPdZ09>

Meeting ID: 838 3803 4292

Passcode: 707367

## 2 JULY 2021 | SESSION 3

**Chair: Mark Swainson (University of Lincoln)**

**9.00 Keynote: Tony Pridmore (University of Nottingham)**

Panel discussion:

Orbessy Gaju (University of Lincoln)

Karoline Heiwolt (University of Lincoln)

Grzegorz Sochacki (University of Cambridge)

Charles Veys (Fotenix Ltd)

*Questions are invited from the audience*

**10.30 Break**

Head over [to Discord](#) if you'd like to continue discussions.

**11.00 Short presentations**

Willow Mandil (University of Lincoln)

David Maxwell, Rebecca Skirrow, Joseph Ribeiro and Silvia Rodriguez-Climent (Cefas)

Charles Veys (Fotenix Ltd)

Simon Pearson (University of Lincoln)

**12.00 Closing remarks; prizegiving | Richard Harvey (University of East Anglia)**

**12.30 Close**

Head over [to Discord](#) if you'd like to continue discussions.

## CONFERENCE PRESENTATIONS

1 JULY 2021 | SESSION 1

### **Keynote: Bob Fisher | The TrimBot2020 gardening robot and other agricultural robot issues**

The TrimBot gardening robot was developed as a prototype in the EC funded TrimBot2020 research project. It was designed as a mobile largely autonomous robot for pruning bushes and rose plants. As an outdoor robot, it had to deal with changing lighting, targets moving in the wind, navigation problems, and natural plants with limited shape models. But the robot could successfully prune. The talk will concentrate on the technologies enabling the robot. I'll also present some work on weed identification (for which I was the PhD examiner), which was interesting because of the difficulties of identifying the weeds at an early stage in their growth. Finally, I'll introduce some ongoing work on classifying agricultural forests as needing thinning (or not).

### **Howard Wu and Marc Jones | Antobot Insight – Digital intelligence for sustainable agriculture**

Labour shortages, climate-change and increasing pressure on productivity in agriculture can only realistically be addressed by increasing automation and digital technology. Antobot is meeting this need with its novel crop scouting robot, Insight, initially targeting the high value fruit sector, with the aim of digitalising the earliest growth stages. The product is highly innovative by using advanced technologies such as stereo computer vision and autonomous navigation at an affordable level - a key factor for wide adoption. The data from Insight will transform the grower's business and wider value-chain with accurate yield estimation, real-time crop management and increased efficiency of labour and resources.

### **Grzegorz Sochacki | Closed Loop Action for Robotic Chef Implementation**

Implementation of a robotic chef is a challenge attempted by numerous start-ups and institutions. It is a task that combines various challenges to robotics and machine learning including manipulation of soft and delicate objects, design of soft grippers, computer vision, sensor fusion, dealing with a variety of non-standardized products, and many more. The talk will talk about introducing feedback to robotic cooking in order to deal with generalizing and refining cooking actions. Initial experimentation with tactile and salinity feedback will be discussed. Tactile feedback use in combination with a thermodynamical model of vegetable to evaluate "cookedness" of potatoes will be covered. The combination of proprioception in a compliant gripper with a soft tactile sensor, used to model the cooking time will be presented. Salinity sensing implementation to robot-learned imitation of human cooked scrambled eggs will be presented. The feedback adjusts the amount of added salt and mixing, hence producing a dish specific to the user's taste. Moreover, plans to combine computer vision and salinity sensing to develop heuristics for the robot, allowing "sensing fast and slow" arrangement while cooking.

## **Karoline Heiwolt | Using deep learning for semantic segmentation of 3D plant point clouds**

Plant phenotyping is an essential step in the plant breeding cycle, necessary to ensure food safety for a growing world population. Standard procedures for evaluating three-dimensional plant morphology and extracting relevant phenotypic characteristics are slow, costly, and in need of automation. Previous work towards automatic semantic segmentation of plants relies on explicit prior knowledge about the species and sensor set-up, as well as manually tuned parameters. In this presentation I will give an overview of the relatively few existing approaches using deep learning for 3D plant segmentation, and present my recent work using the PointNet++ neural network architecture to predict per-point semantic annotations directly from point cloud data of whole plants. I will demonstrate how the network is capable of distinguishing between the semantic classes of leaves, stems, and soil based on structural data only, indicating that deep learning is a promising approach towards replacing the current complex, laborious, species-specific, state-of-the-art plant segmentation procedures.

## **Roopika Ravikanna | Allocation of Parking Spaces for Autonomous Agricultural Robots**

Autonomous Agricultural Robots play an important role in tasks such as transportation, crop monitoring, weed detection etc. In case of a requirement for these robots at particular positions in the field, the efficiency of time they take to arrive at the said positions is vital for reducing the global task completion time. This research deals with the design of various algorithms for automated allocation of parking spaces for the on-field robots, so as to make them most accessible to preferred areas of the field. These parking space allocation algorithms are tested for their performance by varying initial parameters like the size of the field, number of farm workers in the field, position of the farm workers etc. Various experiments are conducted for this purpose on a simulated environment. Their results are studied and discussed for better understanding about the contribution of intelligent parking space allocation towards improving the overall time efficiency of task completion

1 JULY 2021 | SESSION 2

**Keynote: Jeff Keiser | 30+ Years of AgriTech...What have we learned? ...and, How do we apply that for the Future?**

The Journey began with 'Efficiency' - Whether it's welded together in a farm shop, or constructed by robots on an assembly line...farmers have invested in products for years to improve efficiencies on farms. These innovations have largely been applied to reduce or manage farm operational and input costs, but more recently new challenges emerge that bend the focus of Ag Tech

Farm Data - Enough, or Too Much - Considering that in the past many farm decisions were made based on "experience", the rapid expansion of various sensors and IoT capabilities enable dizzying amounts of data to accumulate, and often hard to make sense of.

AgriTech Solutions! - Over the past few years, and with a renewed focus on sustainability and environmental impact, agriculture has been a significant focus for innovators of many new technologies and tools. Do they really Solve crop production and agribusiness challenges?

Projecting Forward - Many folks are looking forward to a safer and more productive global agricultural system through leveraging agritech of all sorts. Let's image together what this could look like and how that impacts what is happening now.

**Presentations from the inaugural AgriFoRwArDS summer school**

Agriforward students will have spent three days during the week of conference at the first CDT summer school. Working in groups with an industry partner and a student leader, they will have developed a visually guided robot to solve a problem in the industry partners' business, and tried to produce a rapid-prototype solution for a proof-of-concept demonstration using a robot kit provided.

Here the groups will present their work.



2 JULY 2021 | SESSION 3

**Keynote: Tony Pridmore | Plant Phenotyping: Getting to the root of the problem**

This talk will consider the value of and problems associated with structural phenotyping of plant roots before reviewing the imaging modalities currently supporting studies of root architecture and anatomy at the University of Nottingham. Analysis of the resulting images to recover trait data is achieved via a set of novel tools now based upon deep machine learning methods. Two of these tools - capable of extracting anatomical measurements from laser ablation tomography images and 3D root architecture from x-ray computed tomography of roots grown in soil - will be presented. Discussion will focus on the transfer of these controlled environment methods to the field.

**Willow Mandil | Tactile prediction for controlled manipulation**

Integrating and exploiting tactile sensation enables robotic systems to perform a wider variety of manipulation tasks in unstructured environments relative to pure vision based systems. While slip detection and grip force control have been the focus of many research works, investigation of tactile dynamic behaviour based on robot actions is not yet sufficiently explored. In this work, we present a data driven approach to predicting tactile sensation when manipulating an object. Having evaluated the performance of the trained models, it is shown that the tactile action conditional behaviour can be predicted in a sufficiently long time horizon to enable robot motion control, which is then presented in a real world experiment on a 7DOF robot showing the models ability to predict tactile sensation and, with a separate model, classify the tactile predictions to predict when object slipping will occur.

**David Maxwell, Rebecca Skirrow, Joseph Ribeiro and Silvia Rodriguez-Climent | Computer vision in fisheries science**

Cefas (the Centre for Environment, Fisheries, and Aquaculture Science) works to keep seas, oceans and rivers healthy and productive and seafood safe and sustainable, by providing research, data and advice to Government, national and international partners. We see many opportunities for computer vision to enhance fisheries data collection and marine science more widely, and are collaborating closely with UEA and other partners. This talk describes projects on automatic analysis of CCTV footage aboard fishing vessels, video data collection from fish markets and systems for shellfish processing, and briefly considers further applications and opportunities.

**Charles Veys | Spectral Imaging for Crop Diagnostics; the Researcher to Commercialisation journey**

FOTENIX are an ability provider, enabling smart operation of agricultural machinery. They combine cameras, deploying colours of light, with machine learning to monitor crop status, such as disease. The protected key technology is three-dimensional multispectral imaging which allows laboratory analysis at an economic cost. A FOTENIX enabled sprayer provides the next step of data-driven farming to producers, whilst the cloud platform ensures agronomic insights that compound with each use.

**Simon Pearson | Why agriculture needs robotics and why robotics needs agriculture...**

No details provided.

## DELEGATES

As at 23 June 2021

Mr. Adeayo Adewumi | [University of Lincoln](#)

Dr. Mohammed Al-Fadhli | [University of Lincoln](#)

Mr. Elijah Almanzor | [University of Lincoln](#)

Dr. Graham Anderson | [Beko Plc](#)

Mrs. Amelia Armour | [Amadeus Capital Partners](#)

Mr. Kai Armstrong | [University of Lincoln](#)

Dr. Amir Badiie | [University of Lincoln](#)

Mr. Matt Bagley | [University of Lincoln](#)

Mr. James Baker | [Amadeus Capital Partners](#)

Miss Ridhi Bansal | [Bristol Robotics Lab](#)

Dr. Nicola Bellotto | [University of Lincoln](#)

Mr. James Bennett | [University of Lincoln](#)

Dr. Thomas Bohné | [Cyber-Human Lab, University of Cambridge](#)

Dr. Petra Bosilj | [University of Lincoln](#)

Dr. Laura Bouvet | [Agri-TechE](#)

Dr. Richard Boyle | APEX Horticulture

Dr. Julie Bremner | [Cefas](#)

Dr. Marcello Calisti | [University of Lincoln](#)

Dr. Carolina Camacho Villa | [University of Lincoln](#)

Mr. Samuel Carter | [Ross Robotics](#)

Miss Yoon Ju Cho | [University of Lincoln](#)

Dr. Taeyeong Choi | [University of Lincoln](#)

Mr. Dave Churchill | [University of Lincoln](#)

Dr. Grzegorz Cielniak | [University of Lincoln](#)

Mr. Garry Clawson | [University of Lincoln](#)

Mr. David Craythorne | [University of East Anglia](#)

Miss Marie Daniels | [University of Lincoln](#)

Miss Madeleine Darbyshire | [University of Lincoln](#)  
Dr. Gautham Das | [University of Lincoln](#)  
Mr. Josh Davy | [University of Lincoln](#)  
Mr. Rajitha de Silva | [University of Lincoln](#)  
Mr. Johann Dichtl | [University of Lincoln](#)  
Mr. Eliot Dixon | [Agri-EPI Centre](#)  
Mr. Harriet Duncalfe | [Berry Gardens Growers Ltd](#)  
Mrs. Veronica Egorova | [University of Cambridge](#)  
Mr. Alex Elias | [University of the West of England](#)  
Dr. Geoffrey Elliott | [Ceres Agri-tech](#)  
Dr. Thomas Engel | [John Deere GmbH & Co. KG](#)  
Dr. Amir Esfahani | [University of Lincoln](#)  
Dr. Paula Eves | [University of Lincoln](#)  
Prof. Robert Fisher | [University of Edinburgh](#)  
Mr. Kyle Fogarty | [University of Lincoln](#)  
Mr. Edward Ford | [Dyson Farming](#)  
Mr. Jack Foster | [University of Lincoln](#)  
Mrs. Mavis Foster-Nyarko | [University of East Anglia](#)  
Mrs. Helen Francis | [University of Cambridge](#)  
Dr. Oorbessy Gaju | [University of Lincoln](#)  
Dr. Junfeng Gao | [University of Lincoln](#)  
Mr. Xumin Gao | [Beijing Mcfly Technology Co. Ltd](#)  
Dr. Michael Gifford | [NIAB](#)  
Mr. Ravikanna Gopalakrishnan | Sun Machine Works  
Mr. James Green | [G's Fresh](#)  
Mr. Halvard Grimstad | [Saga Robotics](#)  
Mr. Mazvydas Gudelis | [University of Lincoln](#)  
Dr. Gabriel Hamid | [Buhler UK Ltd](#)  
Prof. Marc Hanheide | [University of Lincoln](#)

Dr. Helen Harman | [University of Lincoln](#)

Prof. Richard Harvey | [University of East Anglia](#)

Ms. Karoline Heiwolt | [University of Lincoln](#)

Mr. Edward Herbert | [Dogtooth Technologies](#)

Mr. Zeke Hobbs | [Sheffield University](#)

Prof. Simone Hochgreb | [University of Cambridge](#)

Dr. Matthew Howard | [King's College London](#)

Mr. Bradley Hurst | [University of Lincoln](#)

Dr. Fumiya Iida | [University of Cambridge](#)

Miss Katherine James | [University of Lincoln](#)

Mr. Marc Jones | [Antobot](#)

Mr. Alexander Jones | [University of Cambridge](#)

Mr. Jeff Keiser | [IBM](#)

Mr. Samuel Kihara | [University of Lincoln](#)

Mr. Justin Le Louedec | [University of Lincoln](#)

Dr. Xuemei Li | [University of Cambridge](#)

Dr. Rob Lloyd | [University of Lincoln](#)

Mr. Joe Louca | [University of Bristol](#)

Dr. Michal Mackiewicz | [University of East Anglia](#)

Mr. Will Mandil | [University of Lincoln](#)

Mr. Charalampos Matsantonis | [University of Lincoln](#)

Mr. David Maxwell | [Cefas](#)

Mrs. Sarah McLeod | [Institution of Agricultural Engineers](#)

Dr. Alan Millard | [University of Lincoln](#)

Mr. Mohammad Mohajeran | Self-employed

Miss Bethan Moncur | [University of Cambridge](#)

Mr. Hector Montes | [University of Lincoln](#)

Mrs. Louise Motala | [Bridge Farm Group](#)

Mr. Kiyanoush Nazari Sasikolomi | [University of Lincoln](#)

Mr. Charlie Nicklin | [Institution of Agricultural Engineers](#)

Dr. Eric Ober | [NIAB](#)

Ms. Amie Owen | [University of Lincoln](#)

Prof. Simon Parsons | [University of Lincoln](#)

Prof. Simon Pearson | [University of Lincoln](#)

Dr. Athanasios Polydoros | [University of Lincoln](#)

Prof. Tony Pridmore | [University of Nottingham](#)

Ms. Roopika Ravikanna | [University of Lincoln](#)

Dr. Joseph Ribeiro | [Cefas](#)

Mr. Laurence Roberts-Elliott | [University of Lincoln](#)

Dr. Silvia Rodriguez Climent | [Cefas](#)

Mr. Harry Rogers | [University of Lincoln](#)

Mr. Will Rohde | [University of Lincoln](#)

Mrs. Jane Rueb | Jersey Farmers Union

Prof. Mini Saaj | [University of Lincoln](#)

Mr. Adrian Salazar Gomez | [University of Lincoln](#)

Dr. Karthik Seemakurthy | [University of Lincoln](#)

Miss Rebecca Skirrow | [Cefas](#)

Prof. Elizabeth Sklar | [University of Lincoln](#)

Mrs. Kate Smith | [University of Lincoln](#)

Dr. Hazel Smith | [Vitacressv](#)

Mr. Grzegorz Sochacki | [University of Cambridge](#)

Ms. Melanie Steele | [University of East Anglia](#)

Ms. Zoe Stockton | [Antobot](#)

Prof. Mark Swainson | [National Centre for Food Manufacturing](#)

Dr. Sarah Taylor | [University of East Anglia](#)

Mr. James Tombling | [University of Lincoln](#)

Mr. Nikolas Tsagkopoulos | [University of Lincoln](#)

Dr. Ravi Valluru | [University of Lincoln](#)

Dr. Charles Veys | [Fotenix Ltd.](#)

Mr. Nikolaus Wagner | [University of Lincoln](#)

Miss April Walker | [University of Lincoln](#)

Ms. Ni Wang | [University of Lincoln](#)

Mr. Emlyn Williams | [University of Lincoln](#)

Mr. Mike Wilson | [The Manufacturing Technology Centre Ltd.](#)

Dr. Howard Wu | [Antobot](#)

Miss Haihui Yan | [University of Lincoln](#)

Dr. Usman Zahidi | [University of Lincoln](#)

Dr. Tahmina Zebin | [University of East Anglia](#)

## CONNECT

To connect with AgriFoRwArDS or to request a facilitated meeting with any of the delegates, please email [agriforwards.cdt@lincoln.ac.uk](mailto:agriforwards.cdt@lincoln.ac.uk).

Information about AgriFoRwArDS for supervisors, industry, and students can be found [on the CDT website](#).

## CONFERENCE ORGANISERS

Richard Harvey, University of East Anglia, School of Computer Sciences

David Craythorne, University of East Anglia, Postgraduate Research Service

Mavis Foster-Nyarko, University of East Anglia Postgraduate Research Service

Ismat Imaan, University of East Anglia Postgraduate Research Service

Rob Lloyd, University of Lincoln, Centre for Autonomous Systems

Kate Smith, University of Lincoln/AgriFoRwArDS CDT

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Veronica Egorova, University of Cambridge, Department of Engineering

George S Walker, University of Cambridge, Department of Engineering