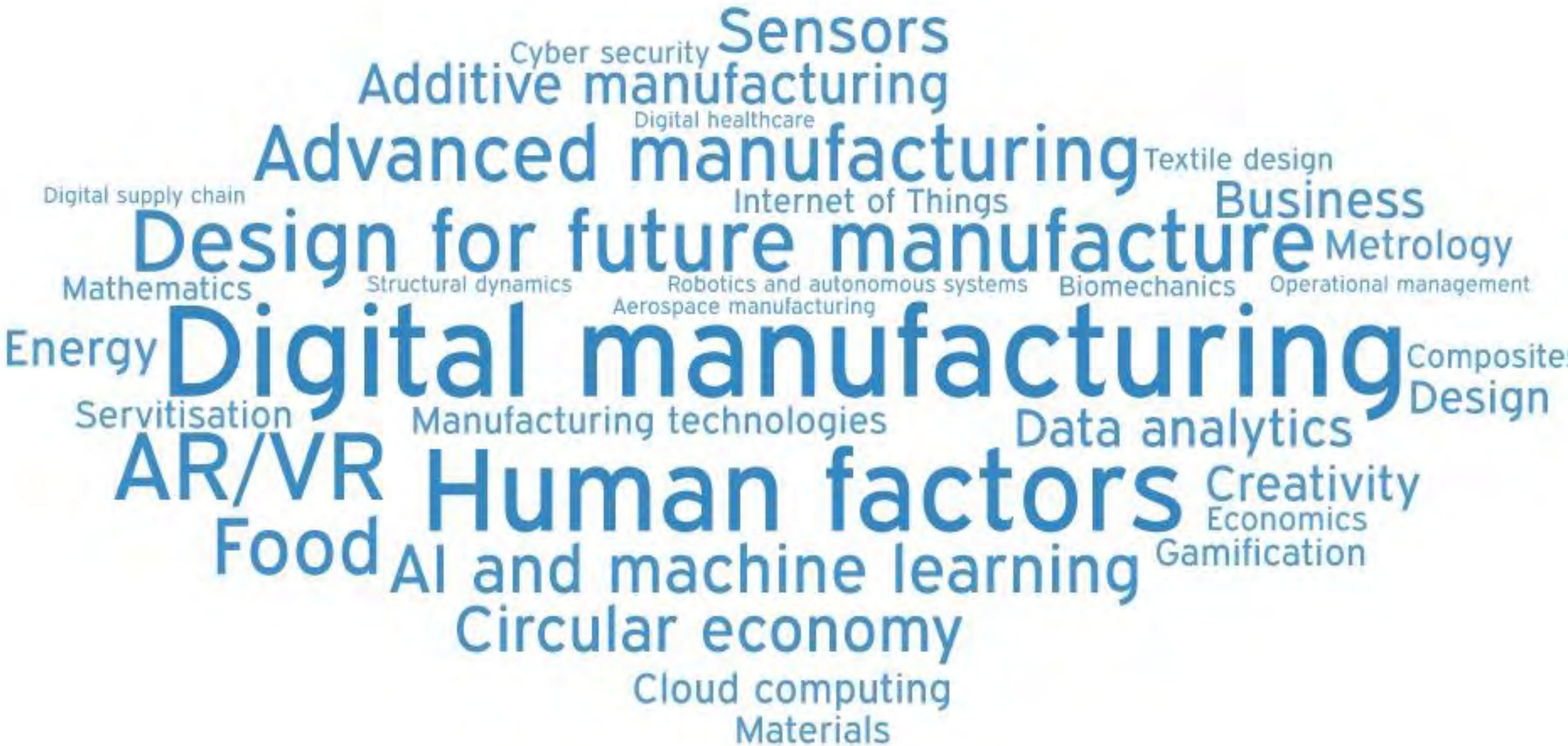
connected everything.

Connected Everything Network+ and digital technologies for intelligent process monitoring.

UKRI Engineering and Physical Sciences Research Council

Connected Everything: the story so far



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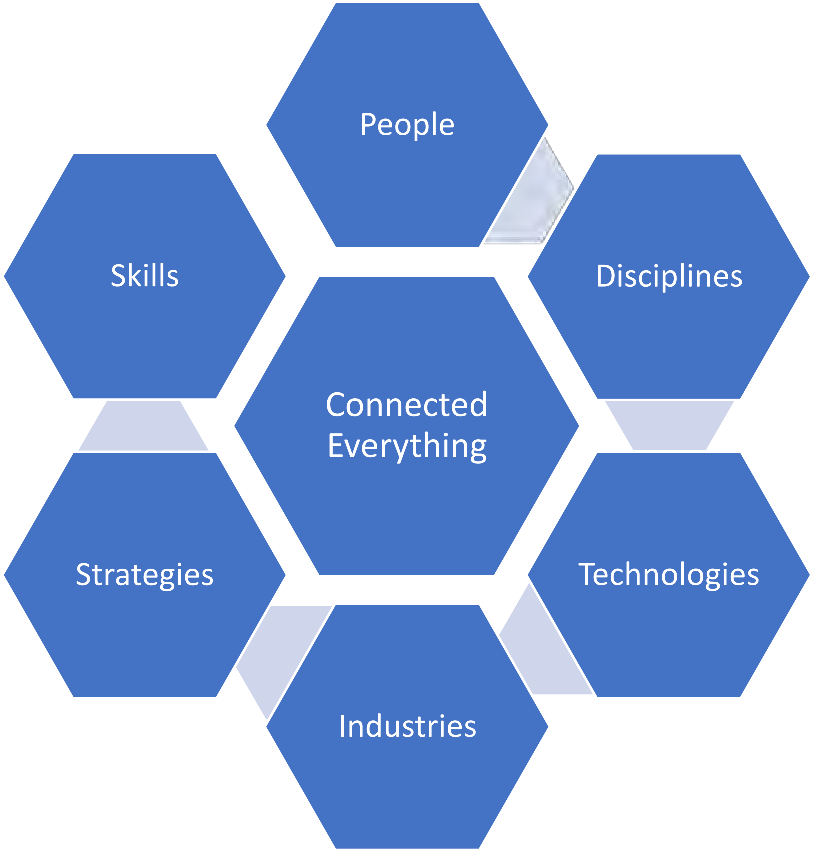
How do we support the future of manufacturing in the UK?



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Connected Everything: What we do

Feasibility studies	• Funding novel ideas including exploratory interdisciplinary projects • connectedeverything.ac.uk/feasibility-studies/ • Next call in Winter 2021
Thematic areas	• Our 7 themes cut across all our activities. • connectedeverything.ac.uk/activities/thematic-areas/
Strategic agenda setting	• We work with industry to identify partners for future research and opportunities for investment in new technologies • Digital World 2050 report will be written in year 3 (2021/22)
People movement and skills	• We offer ECR placements to go into industry and workshops to increase industry engagement • We will support summer schools and workshops
Conferences and networking	• Supporting leadership development and access to the best ideas within digital manufacturing • We deliver an annual conference, offer networking opportunities within and across other related networks
Dissemination and impact	• We share everything we do connectedeverything.ac.uk

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Connected Everything II: Accelerating Digital Manufacturing Research Collaboration and Innovation

Through Connected Everything II, we will deliver a network of networks which will accelerate multi-disciplinary collaboration, foster new collaborations between industry and academia and tackle emerging challenges which will underpin the UK academic community's research in support of people, technologies, products and systems for digital manufacturing

Our thematic focus is directly influenced by industrial need
- Working directly with catapults
- Linking with the KTN
- Representation on key industry groups,
- Delivering events that offer opportunities to develop new partnerships

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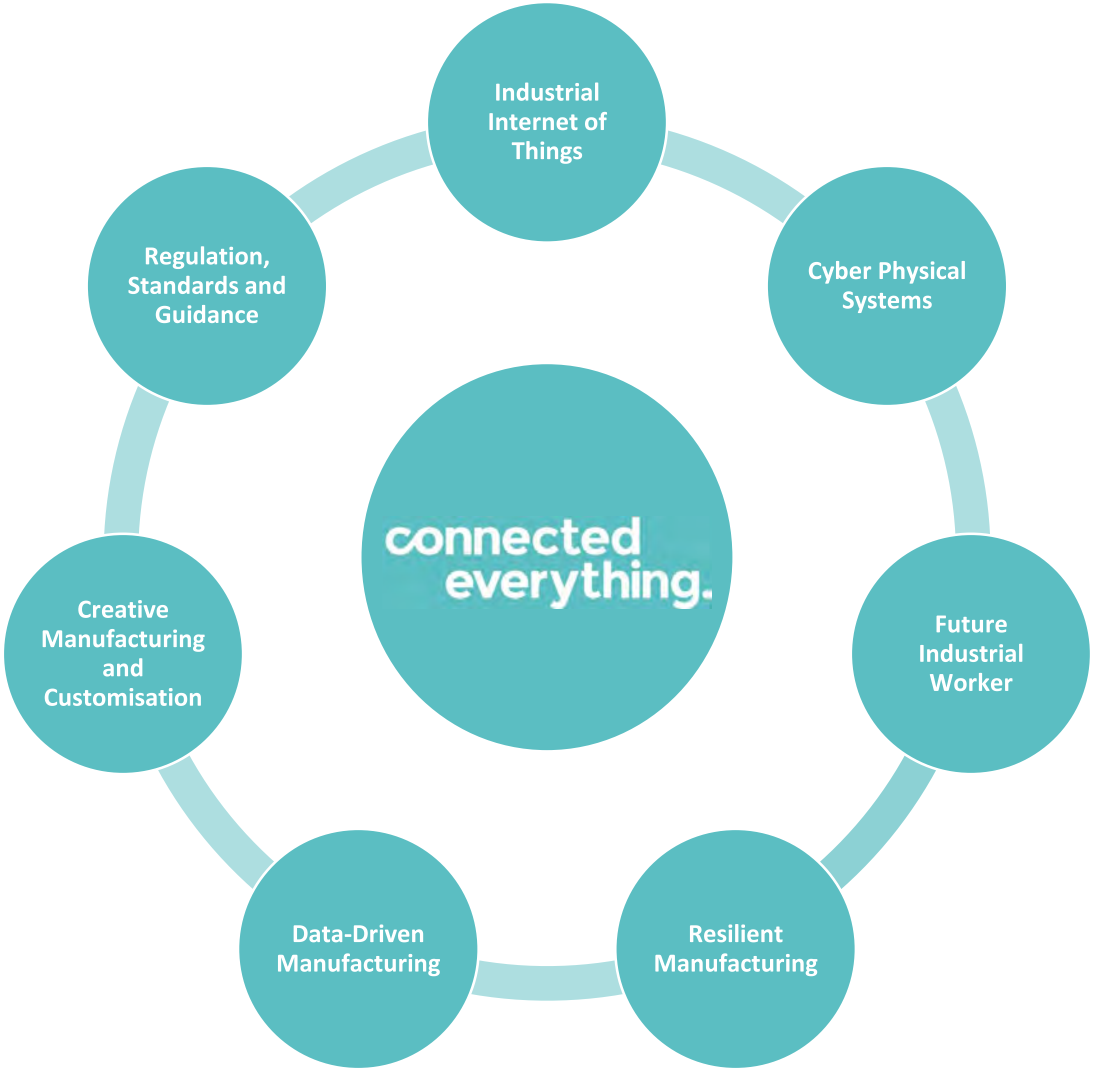
Thematic Areas

- Supported ISCF Made Smarter proposal
- Updated the Themes for CEII to identify areas of importance for future work around digital manufacturing



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Embedded Intelligent Empathy in Design

Dr Anna Chatzimichali (UWE)
Dr Merate Barakat (UWE)
Dr Yahya Lavaf Pour (UWE)
Dr Ying Liu (Cardiff University)
Dr Mirian Calvo (Lancaster University)

RHEON LABS

BONNIE BINARY

VASTU ARCHITECTURAL INTERIOR DESIGN

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Benefits from joining the network

- Pool of knowledge
- Feasibility studies

Over 90% of our feasibility studies have SMEs partners

Connected Everything supported ISCF Made Smarter proposal

- Influence policy
- Mentoring
- Develop collaborations
- Knowledge transfer

The network host annual conferences, summer school and thematic events

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How to join Connected Everything

connectedeverything.ac.uk

Introduction and Content

- Digital food and drink manufacturing
- Ultrasonic and optical process analytical technologies
- Machine learning, predictive analytics, multi-sensor data fusion
- Sustainability, safety and productivity
- Appropriate technologies for SME's

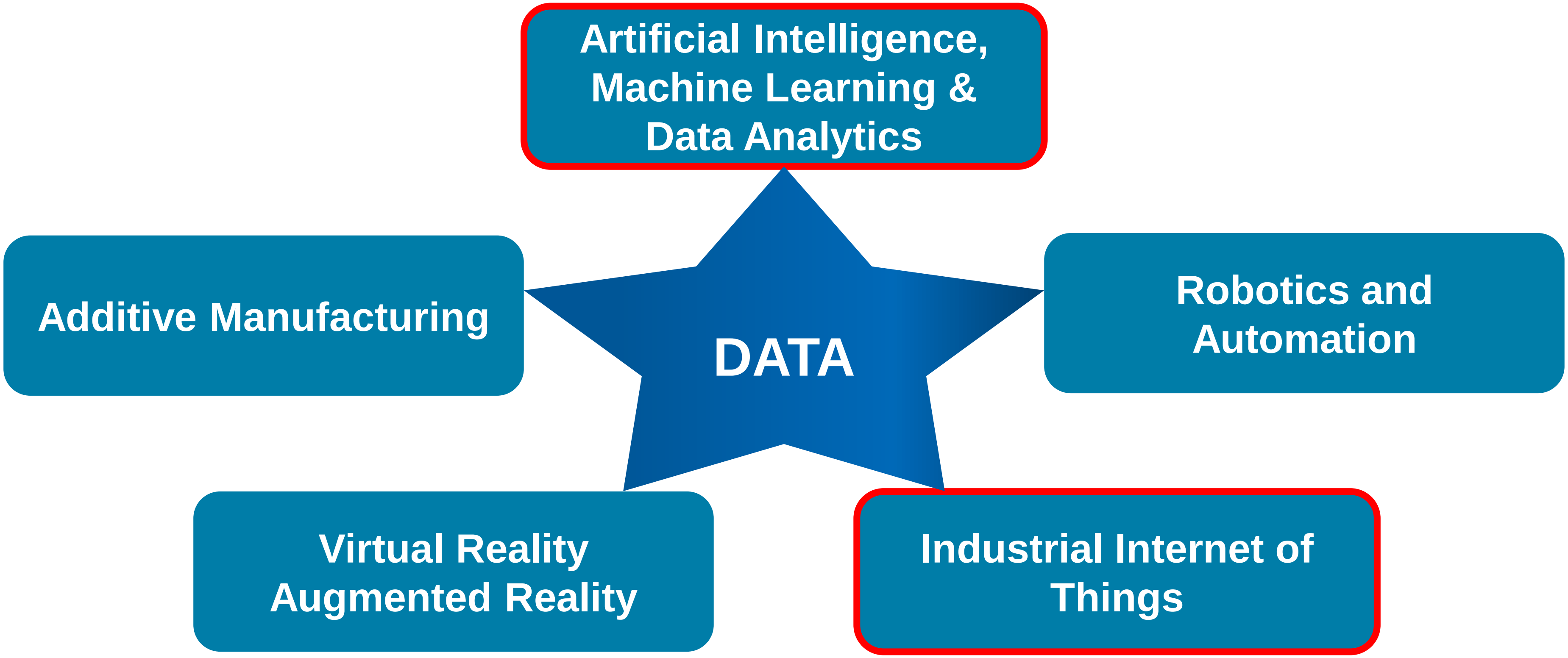
Dr Nicholas Watson
Associate Professor of
Chemical Engineering

EPSRC
BBSRC bioscience for the future
Innovate UK
Science & Technology Facilities Council

Presentation Topics

- Industry 4.0 and 5 enabling Industrial Digital Technologies (IDTs)
- Intelligent in-process sensing for food and drink production
- Clean-in-place
- Mixing
- Summary

Industry 4.0 and 5 Enabling IDTs

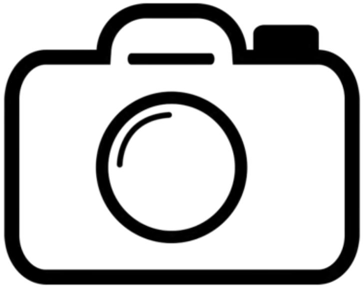


What about the Food and Drink sector?

- High volume, low value products sector (different investment models)
- Many SMEs in sector
- Legacy equipment
- Highly variable biological materials
- Hygiene and food safety
- Many manual operations

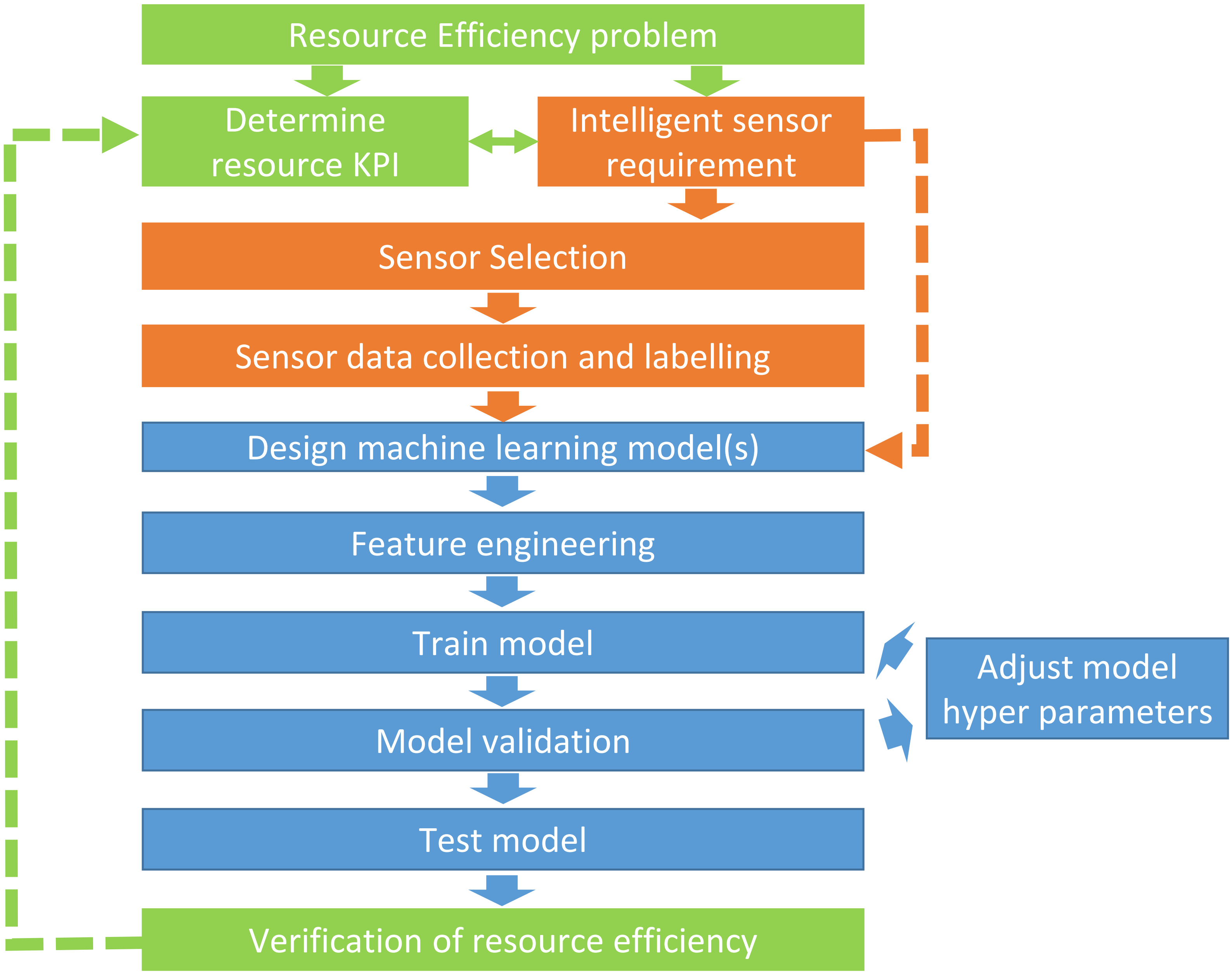
Humans in the loop

Ingredients for successful intelligent sensing in food and drink production requires a diverse range of expertise:

Materials	Process	Sensor	Data
			

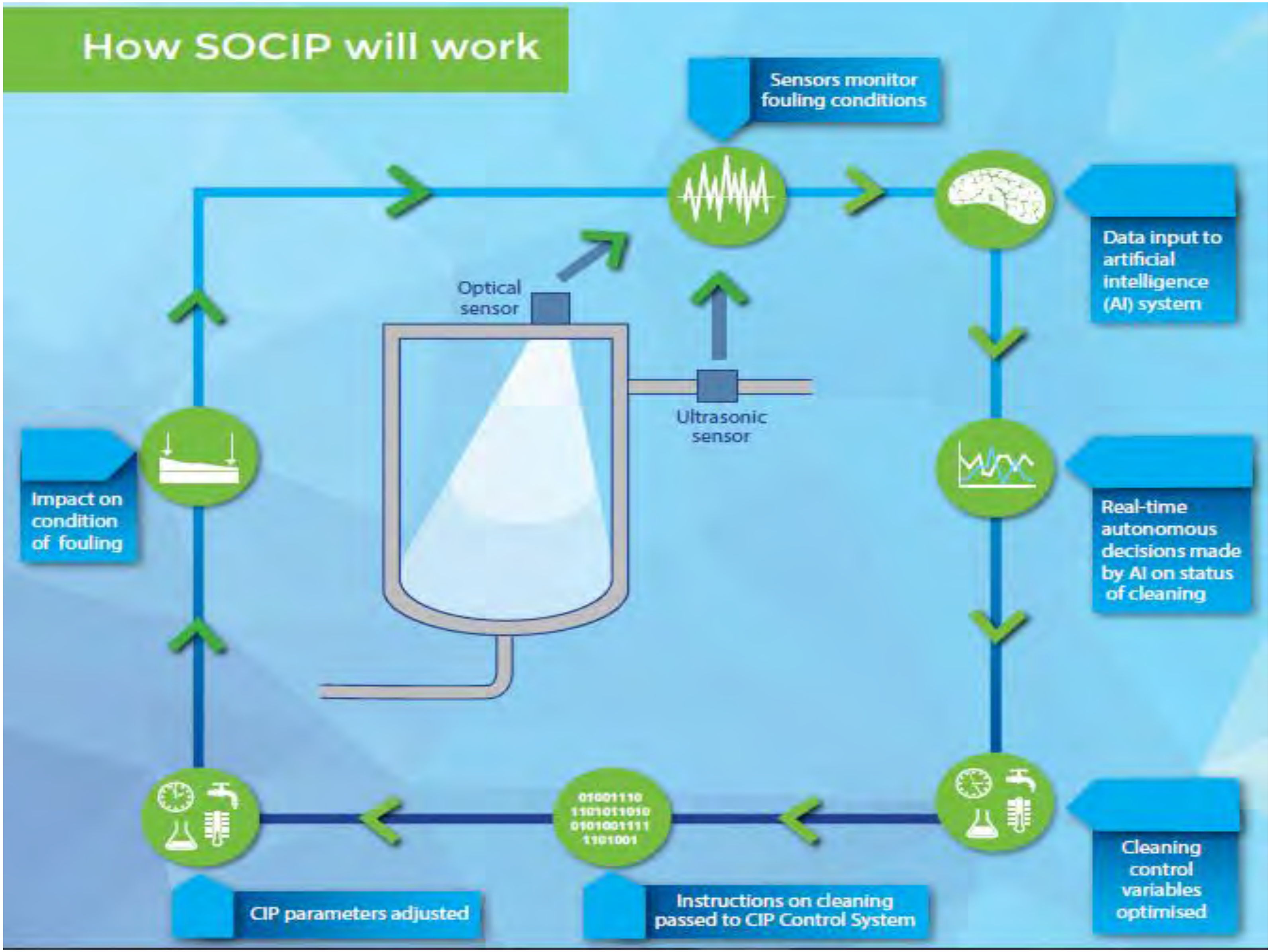
Important to have champions within an organisation and engagement with all job families

Modelling methodology



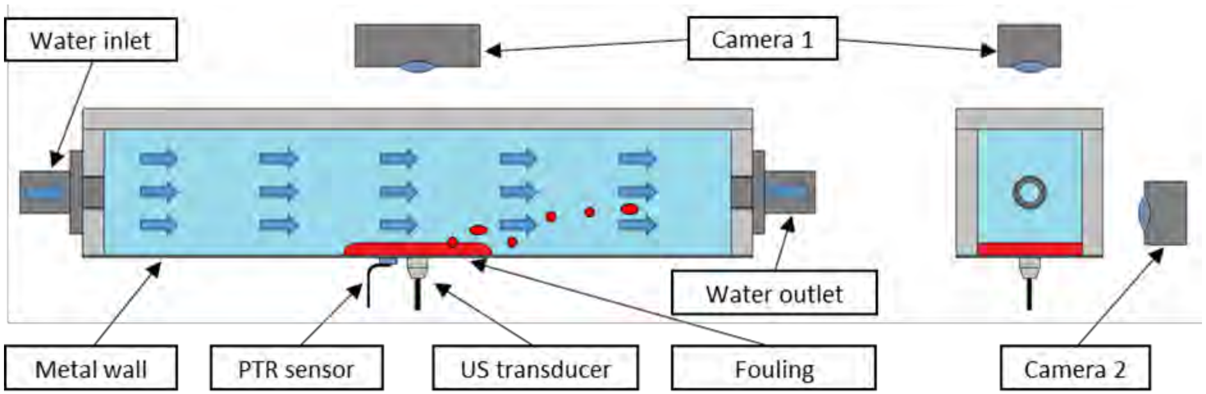
Self-Optimising Clean-in-Place

Self-Optimising Clean-in-Place



Scale

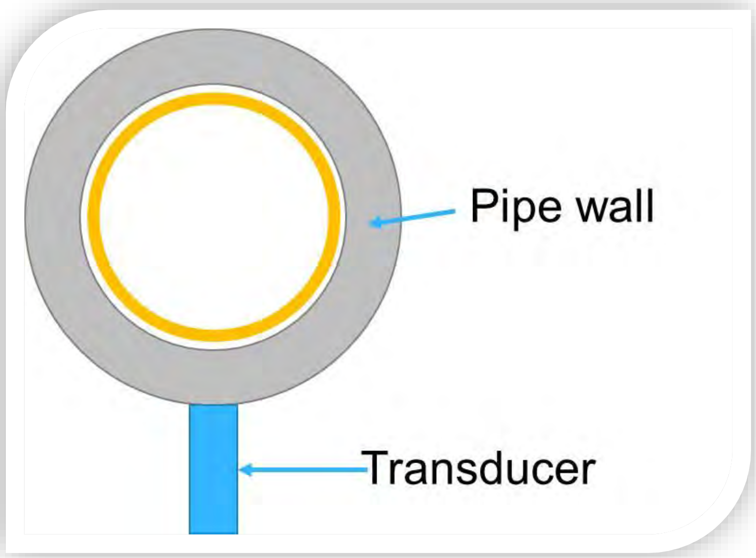
1) Laboratory

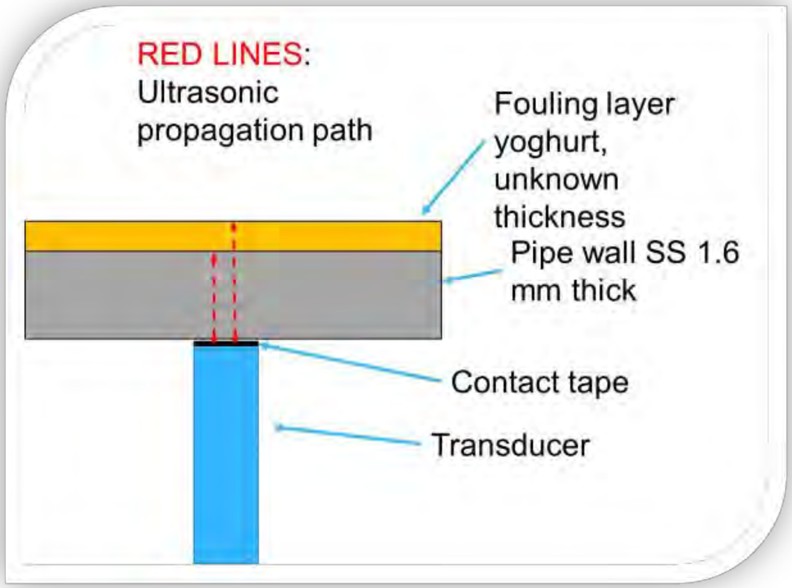


2) Pilot

3) Production

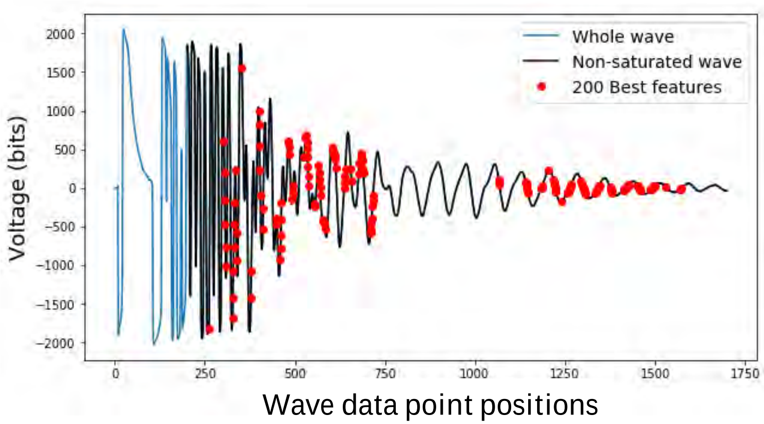
Ultrasonic Principle of Operation

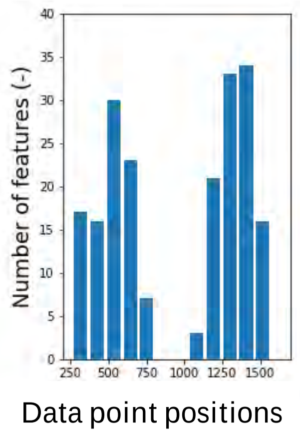




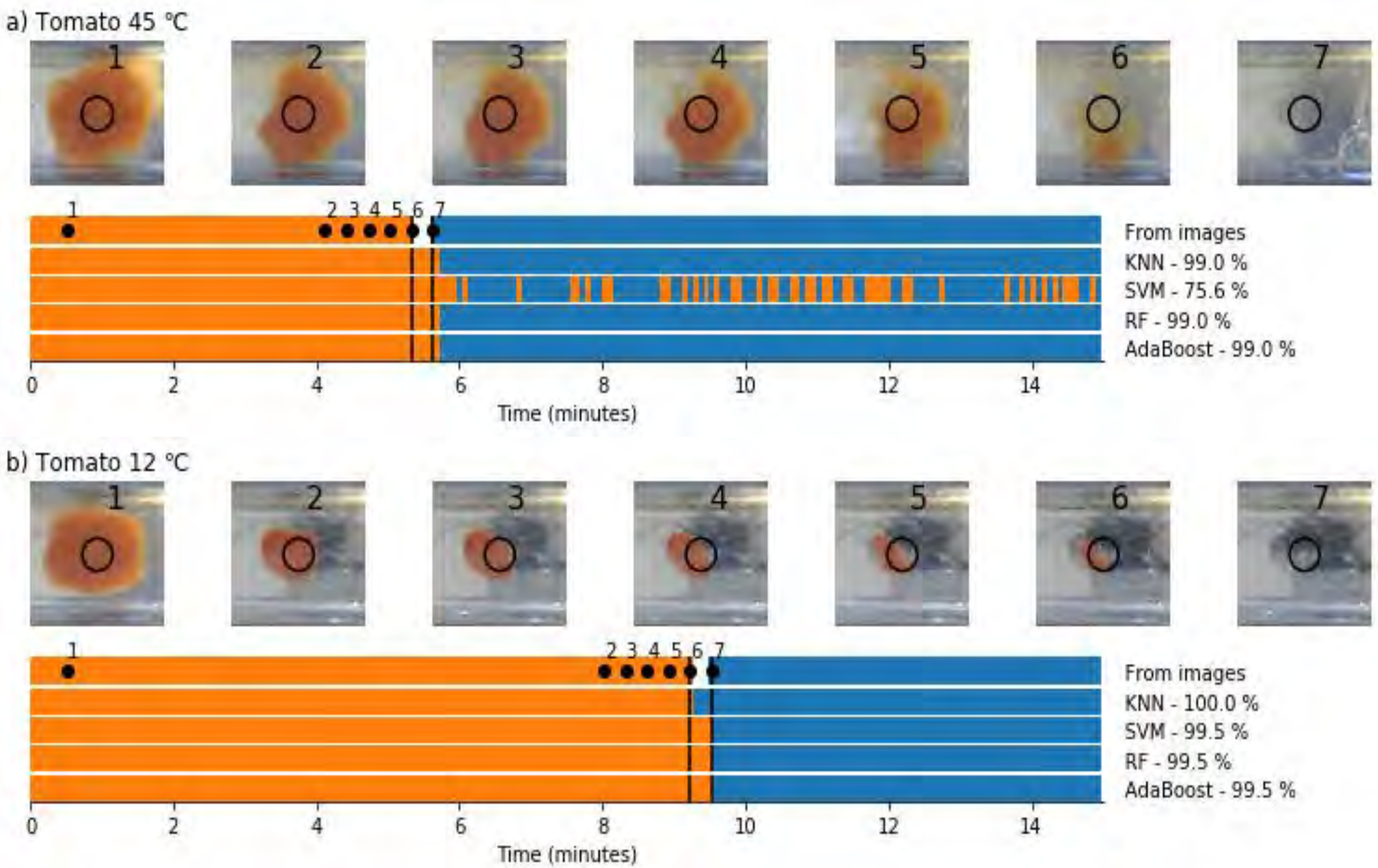
Supervised binary classification models (dirty or clean)

Model features selected from waveforms





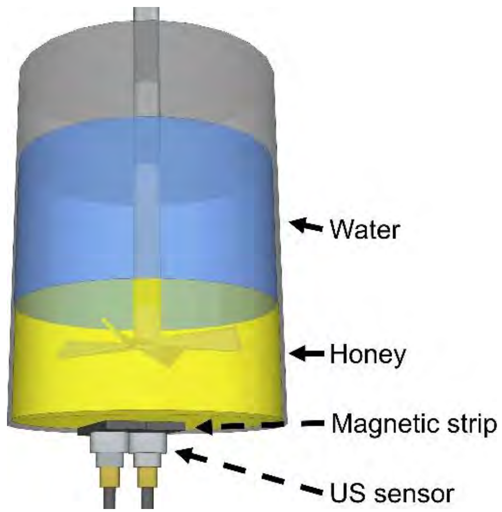
Classification results (Flat rig)

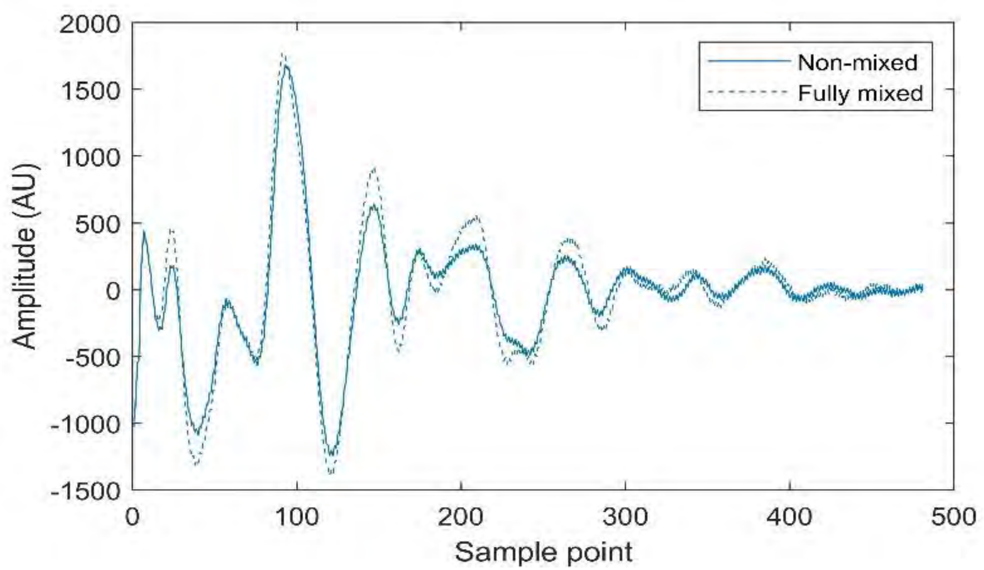


Mixing

Introduction

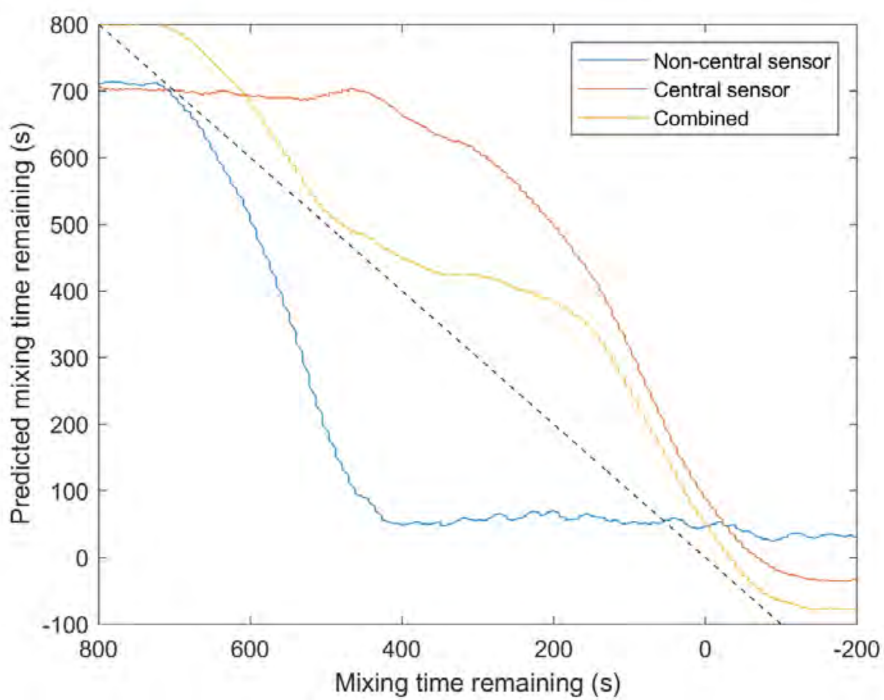
- Supervised machine learning. Classification to predict optimal end point (fully mixed) and regression to predict time remaining to optimal end point.
- Combining data from multiple sensors
- Two fluid blending and batter formation
- Shallow and deep learners
  - ANN, CNN, LSTMNN
- Transfer learning to overcome labelling challenge





Model Results

- Data from multiple sensors improves prediction accuracy
- Transfer learning methods work effectively. This enables us to develop a model in the lab and deploy in the factory



Source domain	Target domain	Transfer learning method	Accuracy (% correct)	Algorithm	Features
Dataset 1	Dataset 2	SF	92.5	LSTM	E, G
			96.0	LSTM	E, G, T
		TCA	92.2	LSTM	E
			92.6	LSTM	E, G, MT
		NTL	94.4	LSTM	E, G
			95.9	LSTM	E, T
Dataset 2	Dataset 1	SF	92.8	LSTM	E, G
			93.8	LSTM	E, MT
		TCA	87.6	LSTM	E
			89.9	LSTM	E, MT
		NTL	96.7	LSTM	E
			95.1	LSTM	E, G, T

Brewnet

Motivation

1700 Breweries within the *UK*.

Fermentation effects beer quality and downstream processes

Traditional processes still dominate

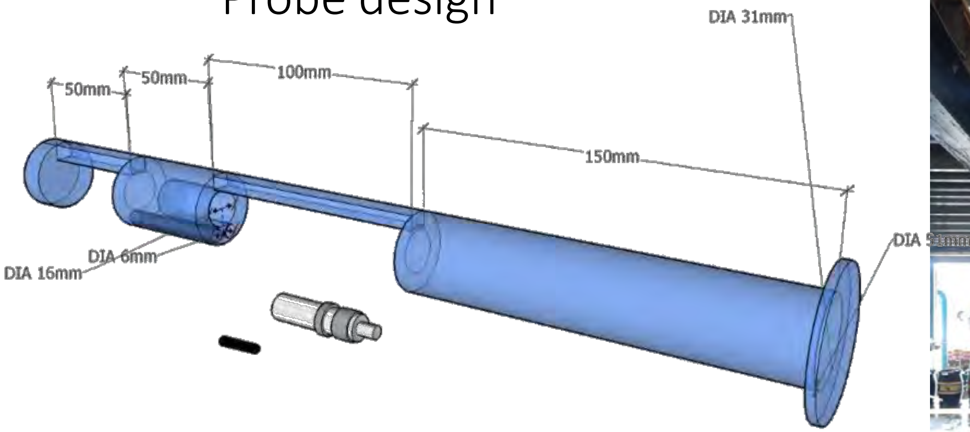
Opportunity for fermentation PAT

New technologies must be:
1) Cost effective 2) Simple to use

connected everything. industrial systems in the digital age
EPSRC
Totally Brewed Artfully Crafted Beers
University of Nottingham UK | CHINA | MALAYSIA
UNIVERSITY OF LEEDS

Probe design

Probe design



Probe with US and temperature sensor

2000 Litre Fermenter

Tri-Clamp port for sensor housing

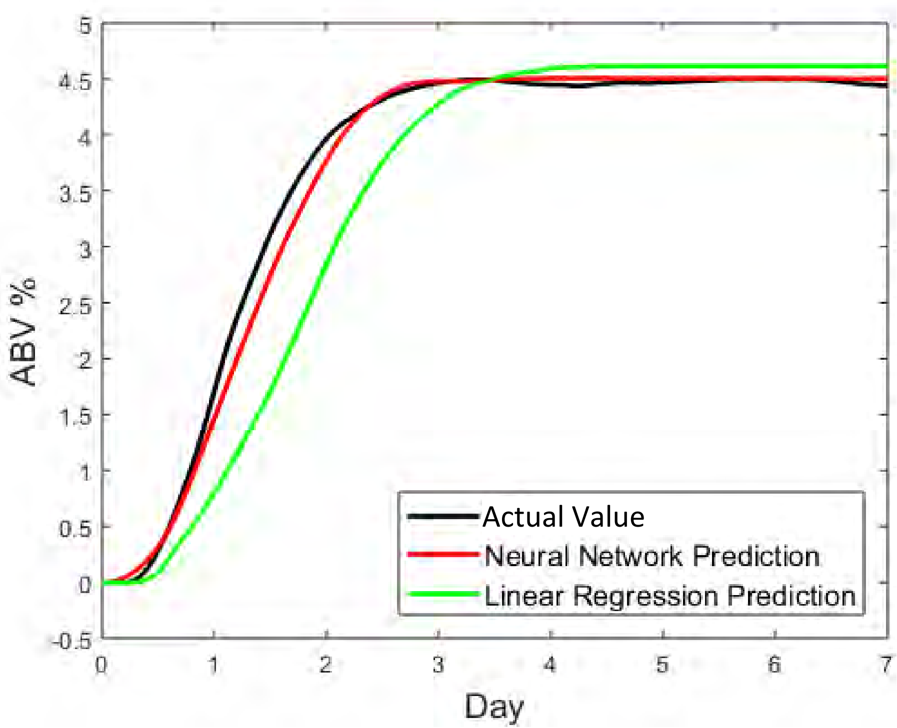
Initial sensor attached to laptop streaming data to the cloud

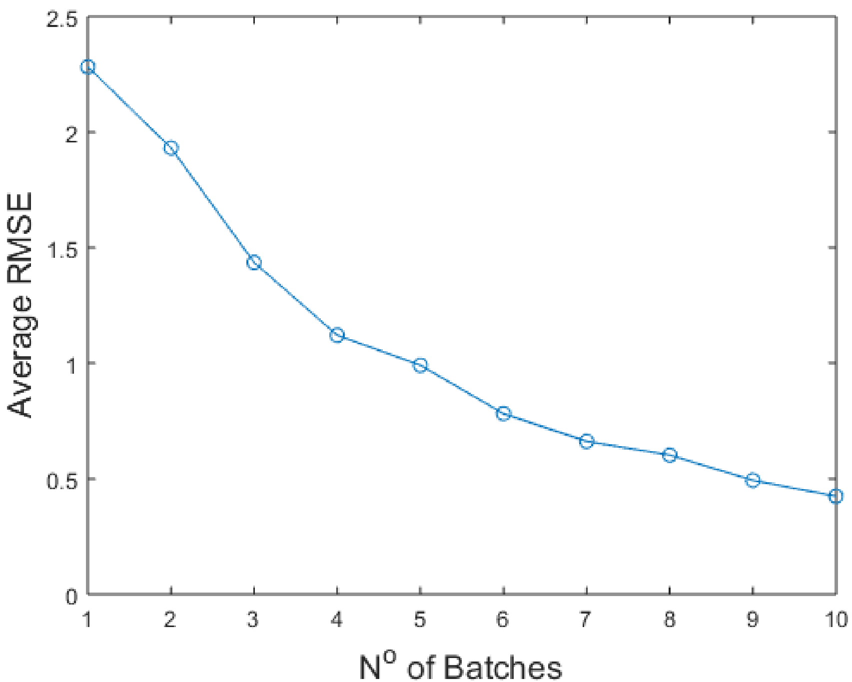
Model results

Different machine learning techniques utilised:

- Linear regression
- Artificial Neural Networks
- Gaussian methods

Error between predicted and actual value reduces with more data. It is challenging to acquire sufficient data from craft brewers





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Summary

- Low-cost in-process ultrasonic sensors and machine learning can effectively monitor industrial processes
- Humans in the loop is key
- Challenges remain before widespread adoption (e.g. data collection and labelling, interpretation, explainability, bias)

Acknowledgments:

Josep Escrig, Alex Bowler, Elliot Woolley, Alessandro Simeone, Syed Ali Raza Zaidi,Martec of Whitwell, Totally Brewed

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