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Sensors, Systems & Phenotyping

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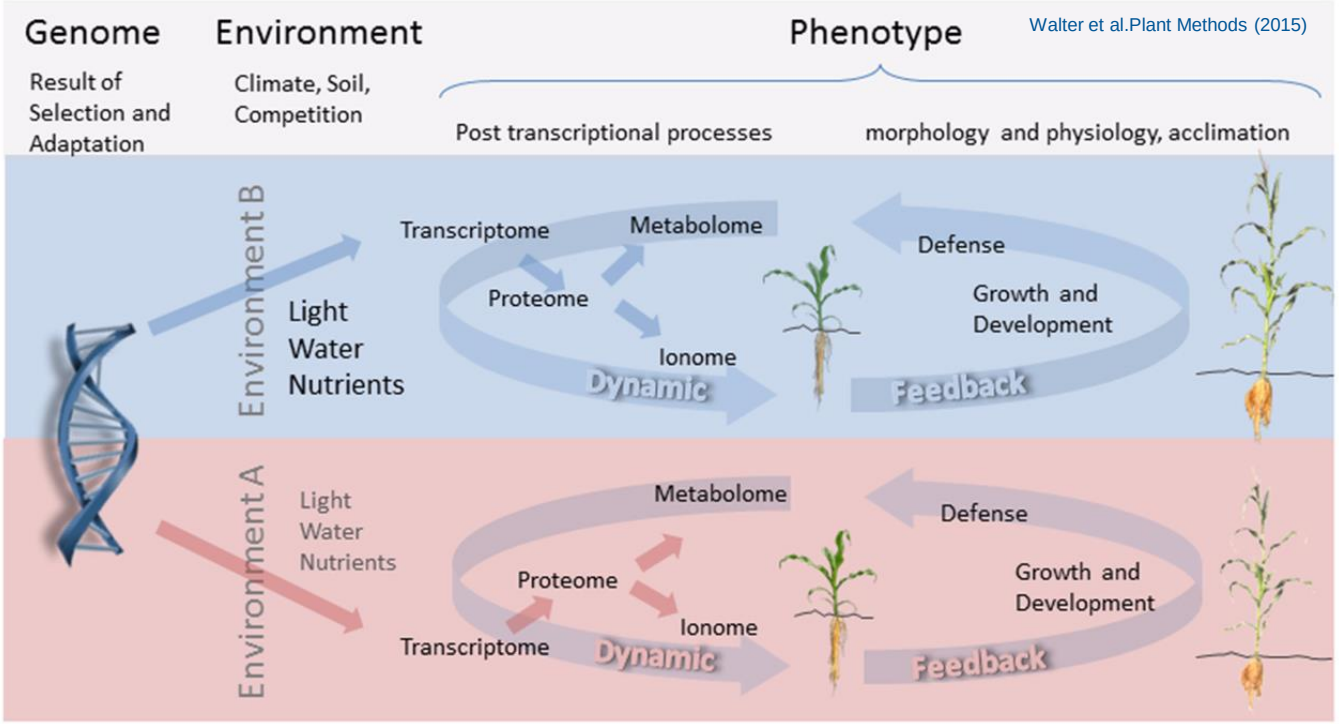
Phenotyping

- Create new varieties through cross-breeding.

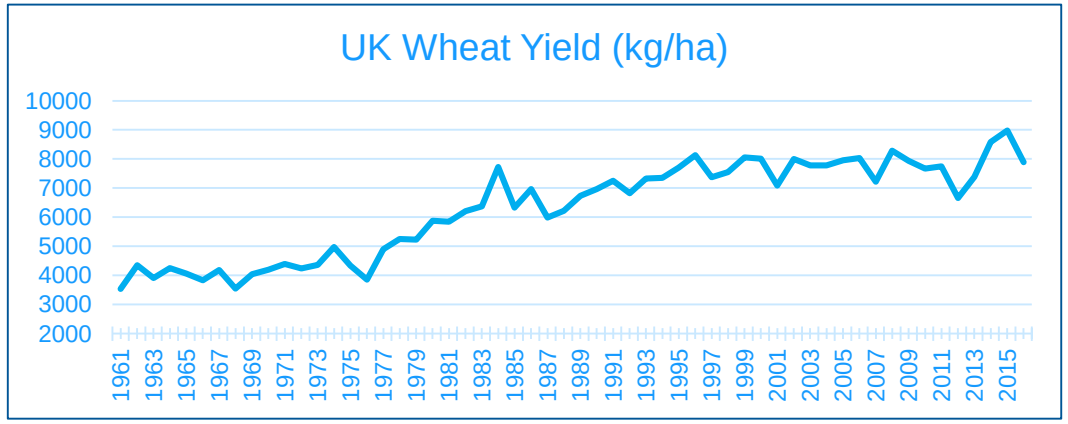


- Phenotype data gathered by manual measurement & post harvest analysis.
- In field 3D-imaging will increase the quantity of data available and advances the phenotyping process.

Wheat target

- Wheat accounts for 20% of globally consumed calories.
- Farming methods area allowed global wheat yield to be increased 300% between 1960 and 2000, but growth has slowed.

- In 2050, it is predicated a 60% increase in production is needed.



Data from http://www.fao.org/faostat/en/#data/QC/visualize

- Phenotyping for new varieties is a key challenge
- Field phenotyping remains challenging requiring multiple technologies and skills
- However, field data is critical for new wheat varieties

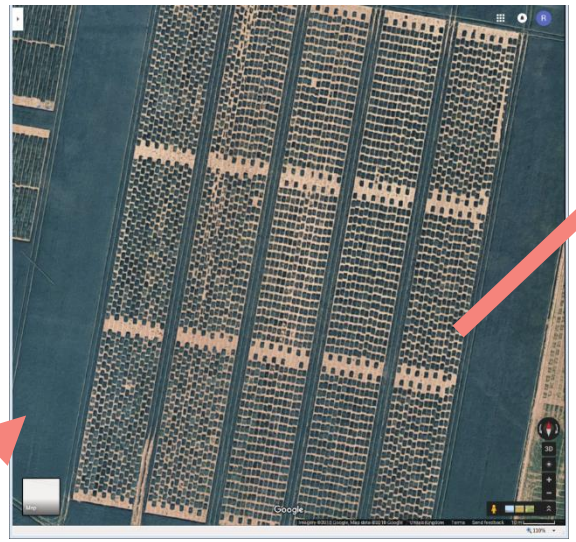
Fixed Phenotyping System

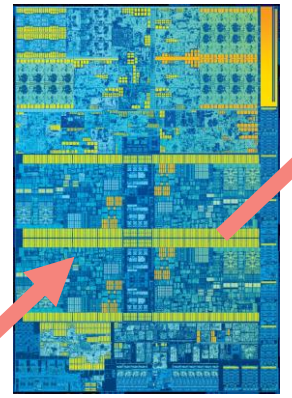
NPL Mobile Phenotyping Platform

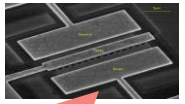
In 2018 set challenge for summer 2019

1. Deliver a field-deployable 3D imaging demonstrator capable of covering 2.5 hectares/hour with centimetre positioning accuracy and millimetre spatial resolution.
2. Manage, store and analyse data to provide key dimensional measurements such as ear length, volume, floret number, biomass, height, etc… for individual plants and regional averages.
3. Develop platform into a customer accessible service for deployments within UK.

Phenotyping in Cambridge





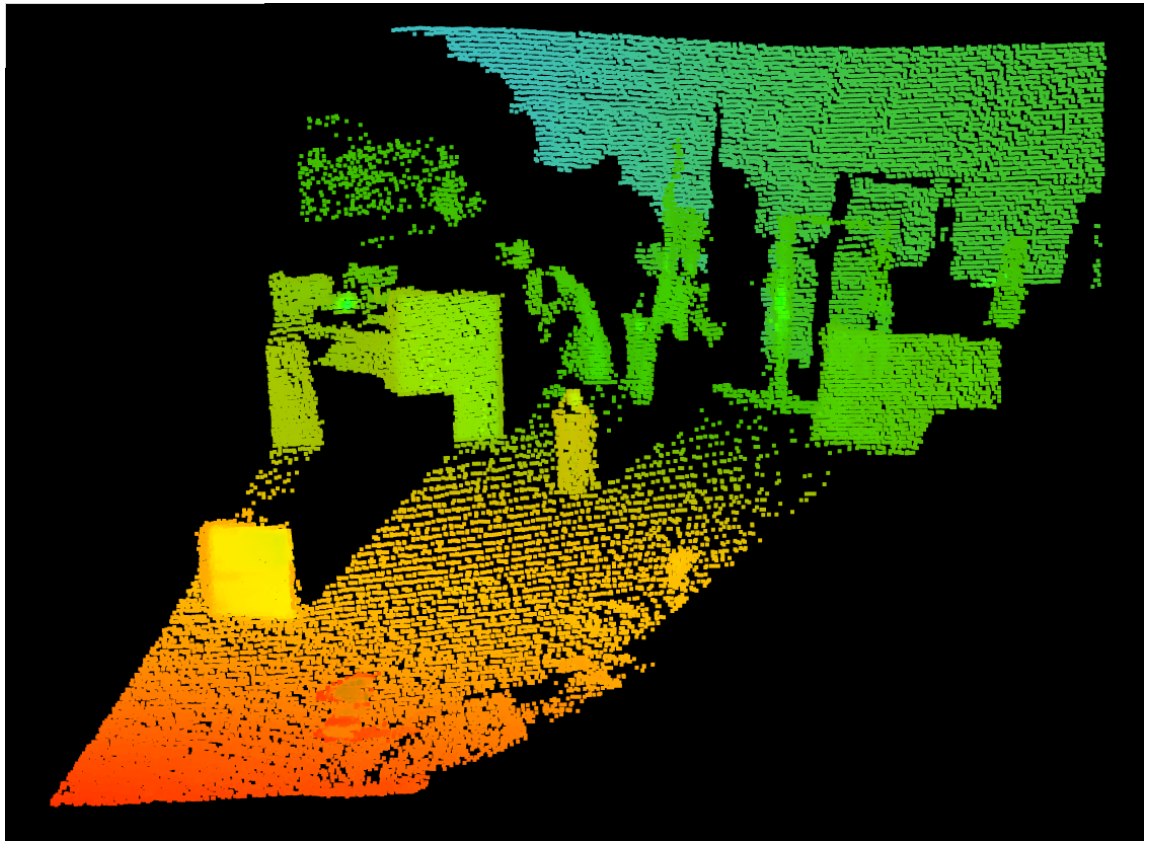


Same challenge as measuring individual FETs (14nm) on latest intel chips

NPL's Wheat Trial Plot

- 2m × 2m : wheat, oats and barley.
- Mobile scanning frame for imaging instruments.
- Moisture & temperature sensors also embedded in plot.
- **Main purpose:** Trial latest imaging hard/software outdoors

  Lidar, TOF, Multi-Stereo, Line Scanner, Structured Light, Hyperspec, MS Kinect, Sense, etc….



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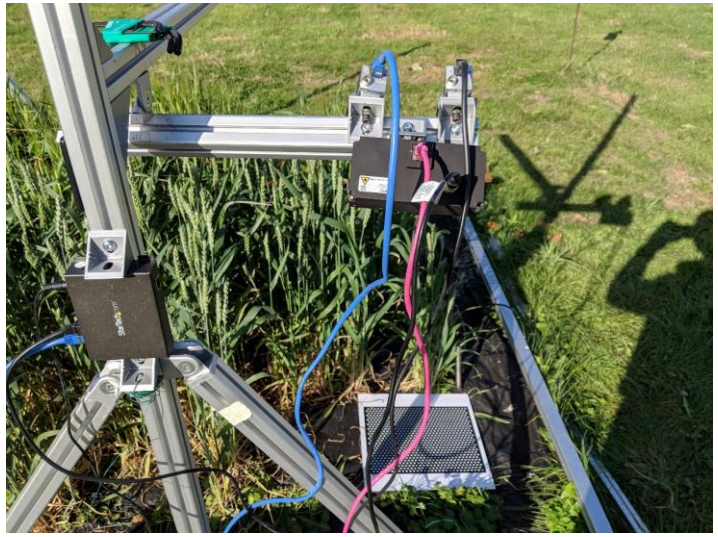
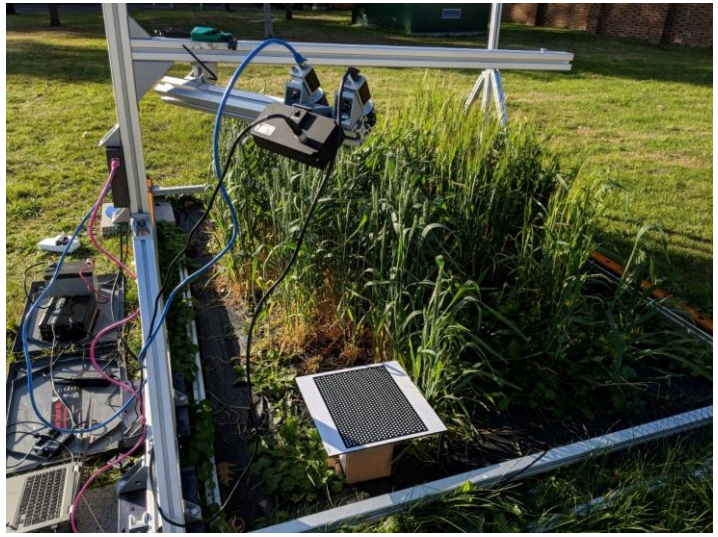
3D IMAGES & POINT CLOUDS

3D Imaging Comparison (Stereo, TOF, Laser Scan)

- Capture point cloud on outdoor wheat
- Compare capture challenges, stability accuracy and effectiveness of measuring wheat ear dimensions

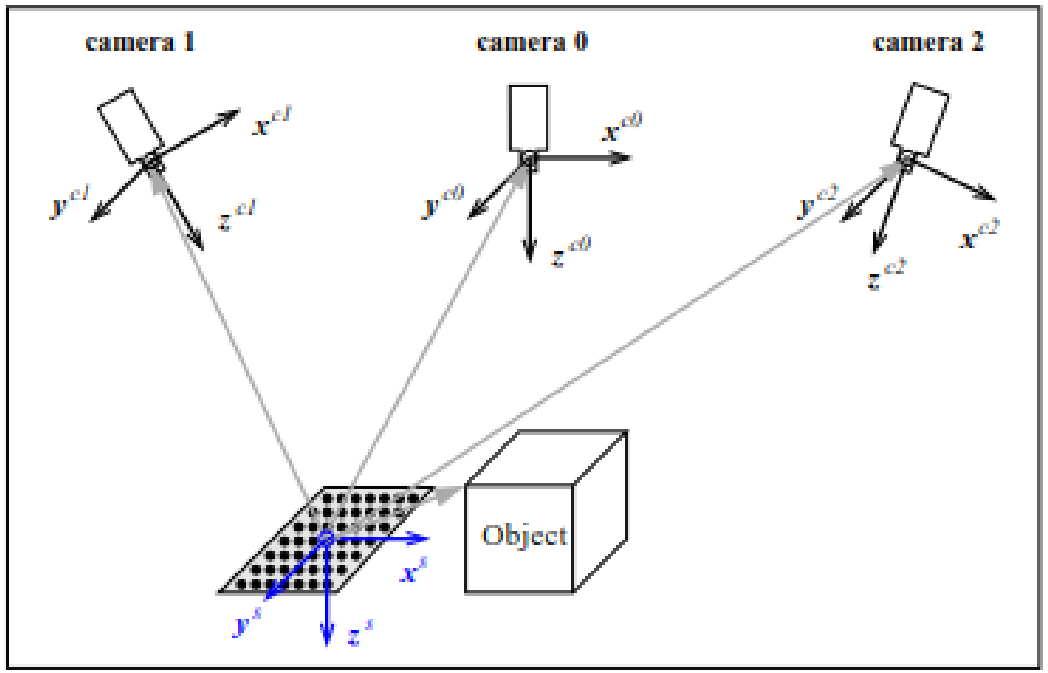
- LIDAR not suitable !





Multistereo Imaging

- Observe scene from multiple positions with cameras.
- Combined with data on cameras' positions, algorithms can determine real-world coordinates for matching pixels in the images.



Multistereo Imaging at NIAB Site

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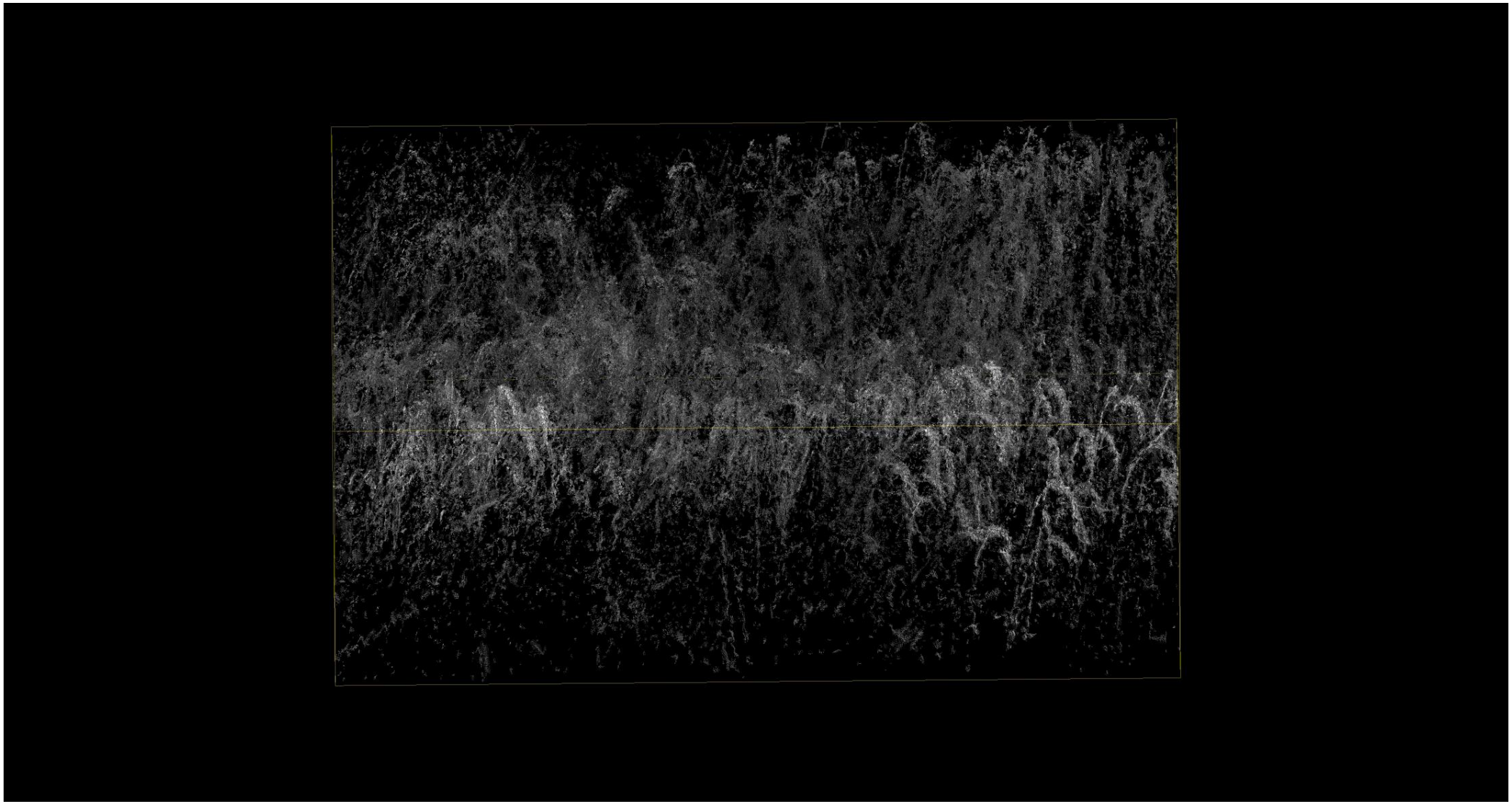
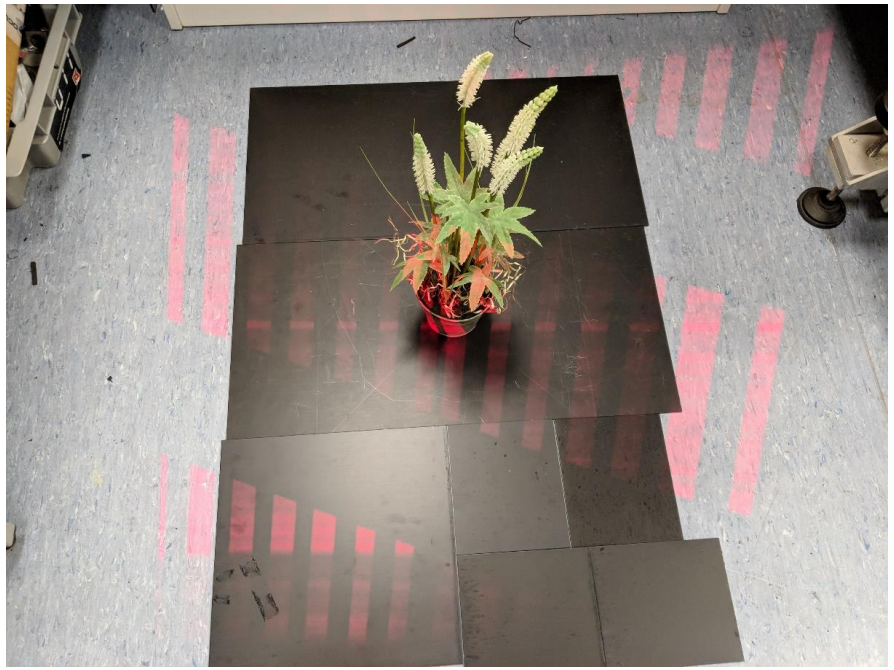


Structured Light Laser Scanner

- A known pattern is projected on to surface and recorded by camera.
- Distance / point cloud calculated based on distortion seen in pattern.



Structure Light Laser Scan at NIAB Site

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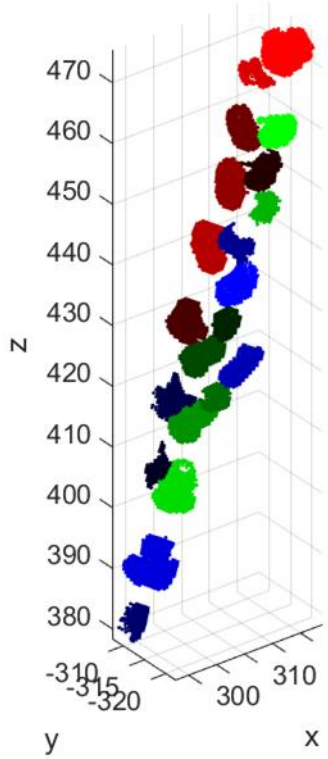
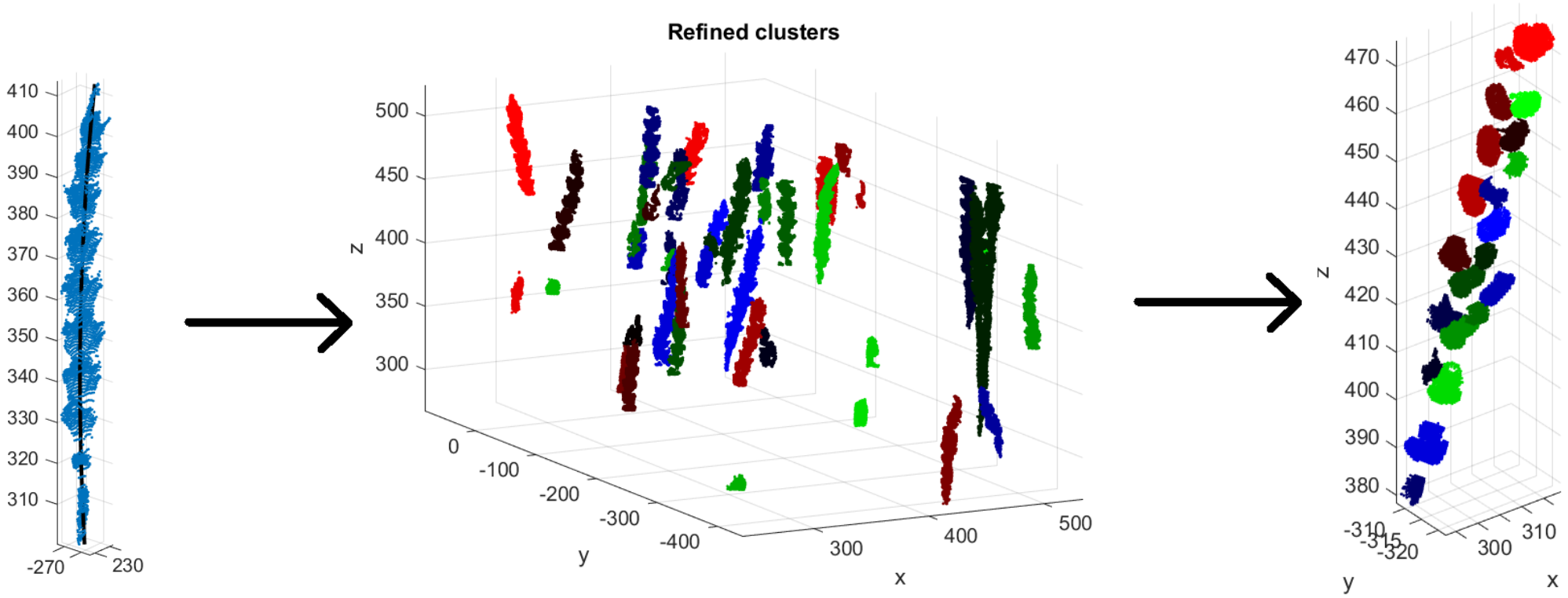


FEATURE IDENTIFICATION

Data analytics tools: data fitting

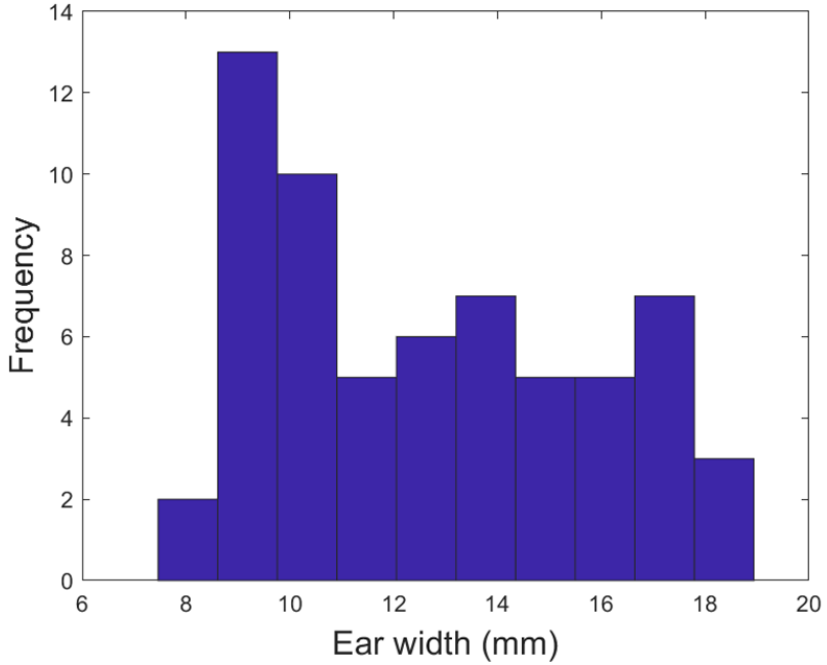
- 3D data fitting can be used to model each of the clusters.
- Estimated average width can be used to refine the clusters, leaving only the wheat heads.

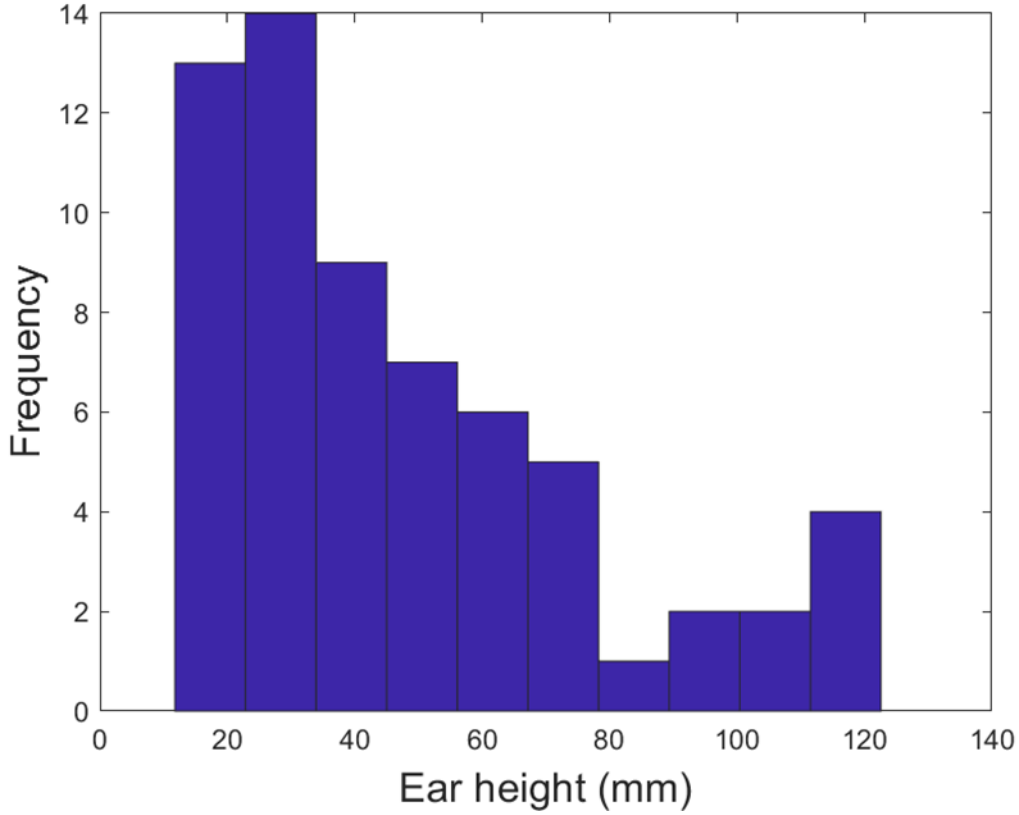


Extracting quantitative traits

We can extract:

- Crop height
- Number of wheat heads
- Width of each wheat head
- Height of each wheat head
- Number of spikelets on each wheat head.





Next Steps

- Quantify accuracy of our imaging and automated trait fit against ground truth.
- Build upon the model-based approach, and investigate supervised learning approaches for learning features of interest.
- Extend to other crops (barley, tomatoes, etc.)
- Investigate relationships between crop yield and atmospheric measurements (temperature, humidity, etc.)

Phenotyping in Cambridge

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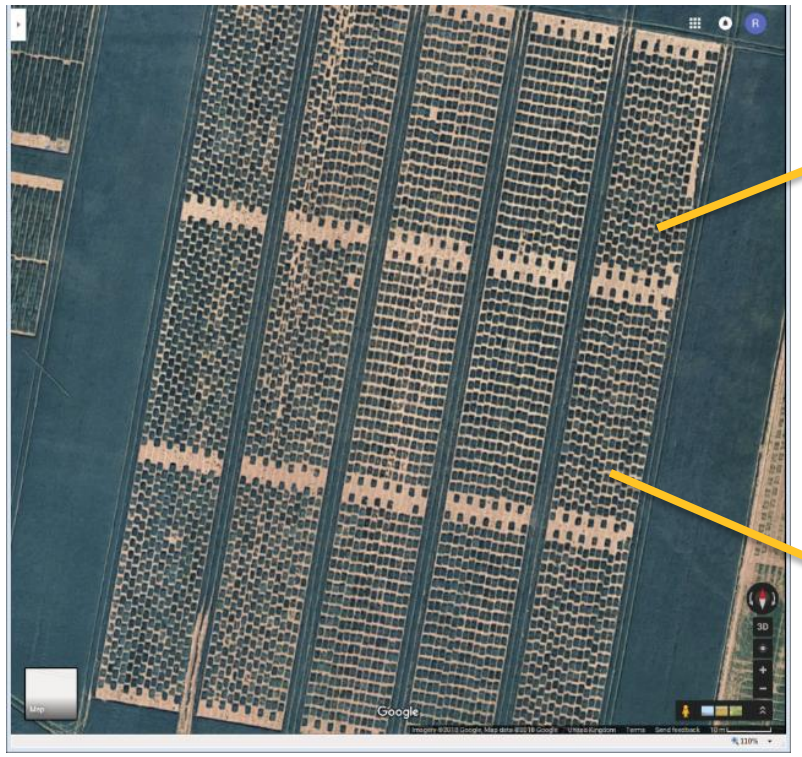

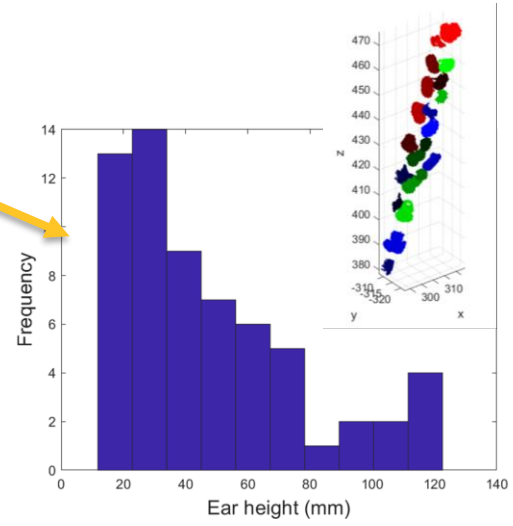

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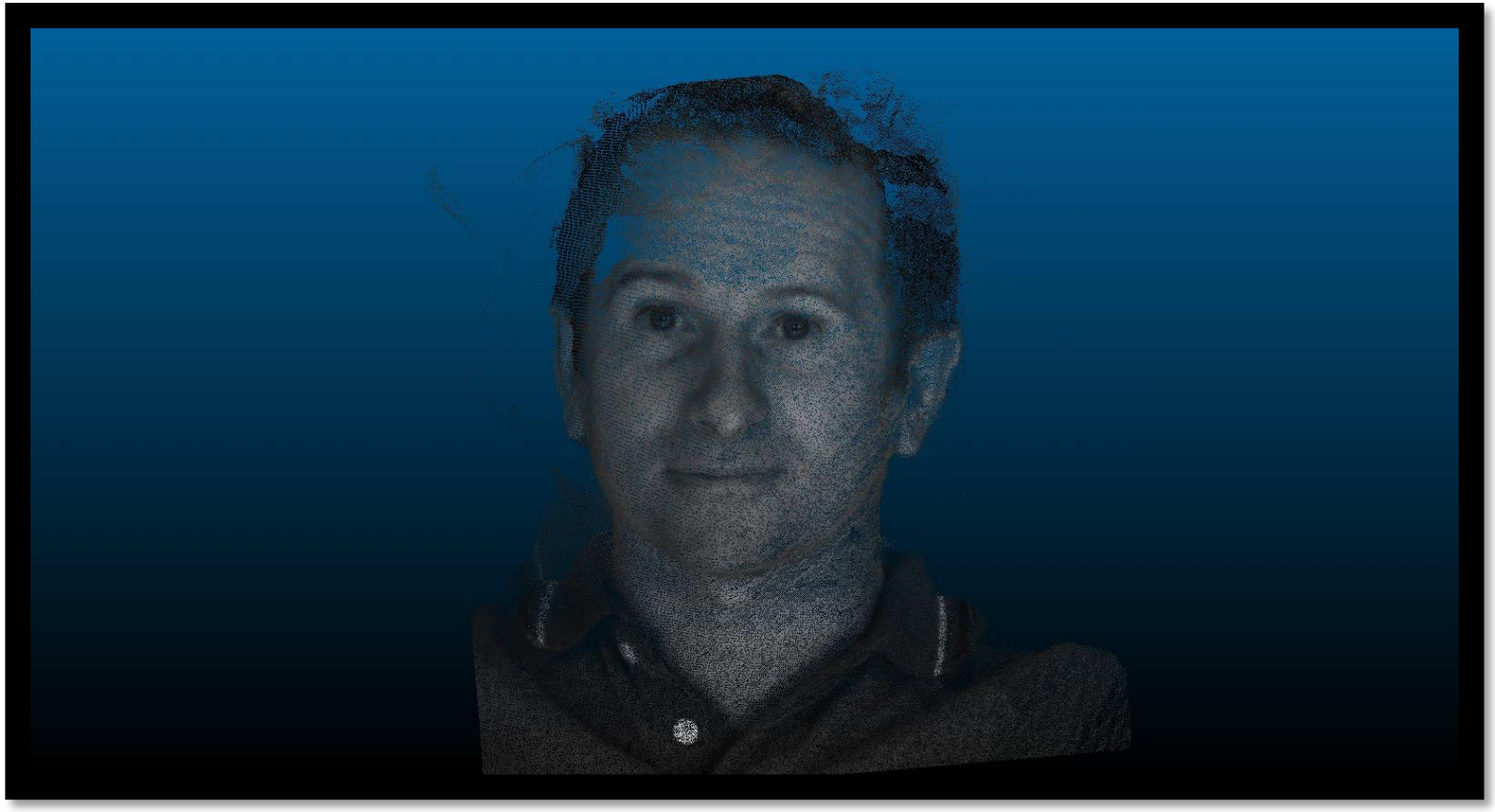

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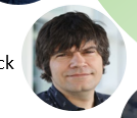
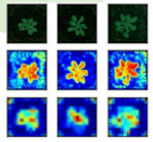


Nick McCormick

Osman Ajmal



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Challenges

- Data storage & communication.
- Monitoring crop health and disease/pest detection.
- Yield prediction methods – quality of the input data
- Reduce food’s environmental impact.