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The application of deep learning for quantitative disease phenotyping in UAV images

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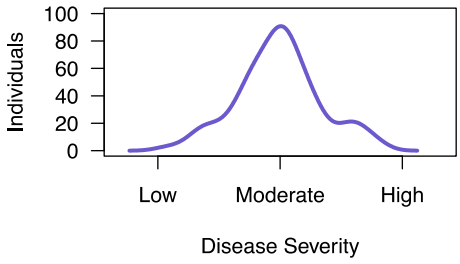
Cornell University
CornellCALS
College of Agriculture and Life Sciences

1

Why Quantitative Phenotyping?

Price *et al*. 2016 Plant Health Prog. 17(1) 49

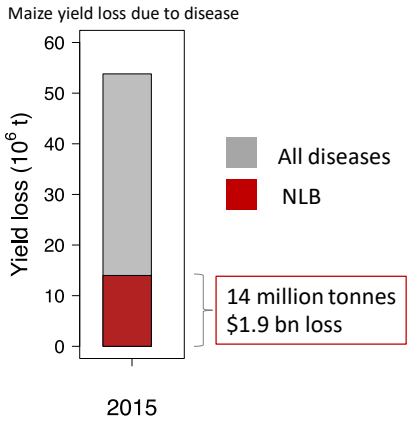


2

Northern leaf blight (NLB):
Foliar disease of maize

Fungal disease caused by
Setosphaeria turcica

Accounted for 25% of all yield losses from disease in 2015



Mueller *et al*. 2016 Plant Health Progress 17:211-222

3

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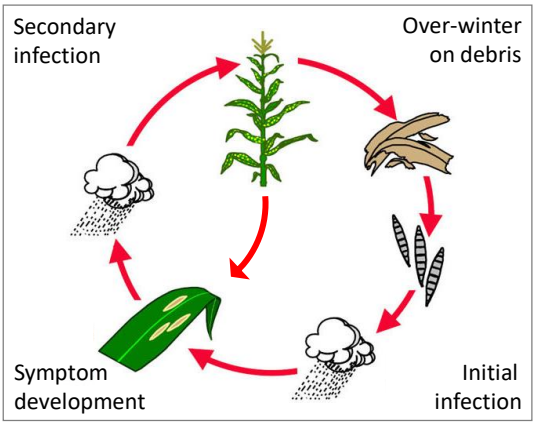

4

Machine learning & disease phenotyping

Previous Work:

Image Classification
96.7% accuracy

Present

Absent

Chad
De Chant

De Chant *et. al*, Phytopathology 2017 107(11):1426-1432

5

Machine learning & disease phenotyping

Previous Work:

Image Classification
96.7% accuracy

Present

Absent

Chad
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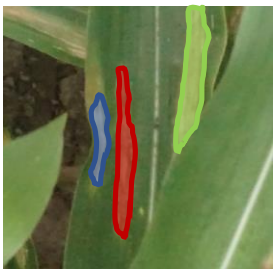
6

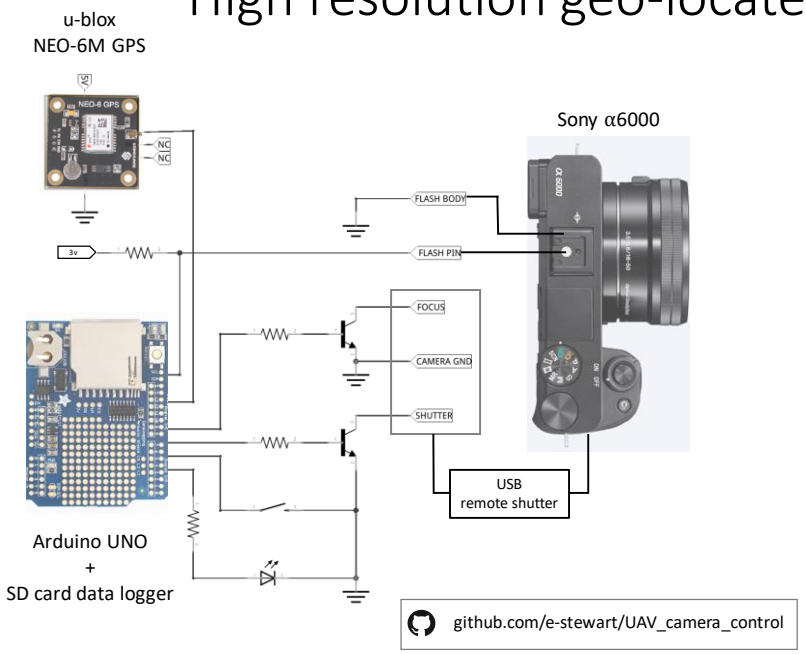
Goal:

Image Segmentation



Quantitative measures:
Number of lesions
Size of lesions
Location

High resolution geo-located images

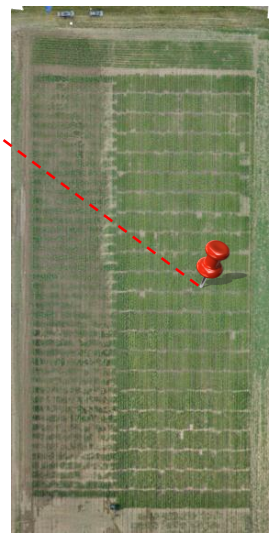


7

High resolution geo-located images

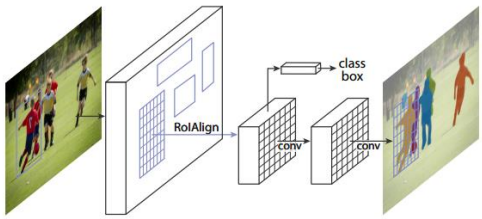
42.72928,
-76.65164
2018 07 06

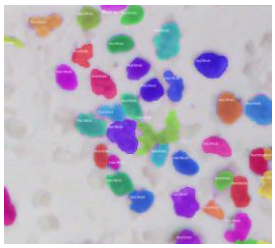
plot ID
genotype
treatment



8

Mask R-CNN:
versatile image segmentation





He et al, 2018. arxiv.org/pdf/1703.06870.pdf

github.com/matterport/Mask_RCNN

9

Mask R-CNN:
generation of training data

Crop & resize

Manual segmentation

3,000 annotated images

Wiesner-Hanks *et.al*, 2018. BMC Research Notes. 2018. 11:440

10

Mask R-CNN:
overview & training

Training input

3,000 images

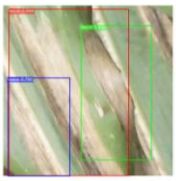
60 : 15 : 15
training : validation : test

Image

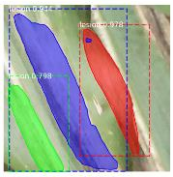
Ground truth

Output

"lesion" Class



Bounding Box



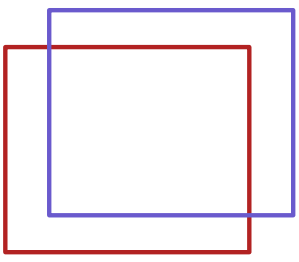
Mask

He et al, 2018. arxiv.org/pdf/1703.06870.pdf

github.com/matterport/Mask_RCNN

11

Model Evaluation:
Intersect Over Union



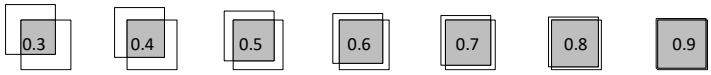
Intersect **O**ver **U**nion
"how much do 2 objects overlap"

=

Intersect
area of overlap

Union
total area

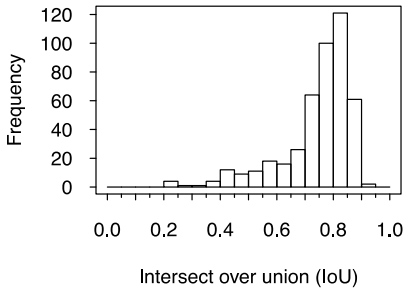
IOU = 0.5



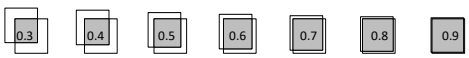
12

Model evaluation:
Intersect over Union

Mean intersect over union (IOU) = 0.73
93% > IOU 0.5



white = ground truth | magenta = prediction



60 : 15 : 15
training : validation : test

13

Model evaluation:
Robust to challenging images

14

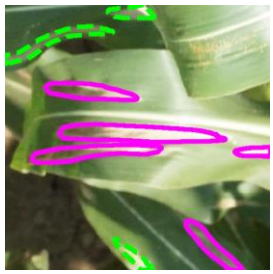
Model evaluation:
Examples of miss-classification

False positive



False negative





15

Model evaluation:
Model beats human

White =
'Expert' ground truth

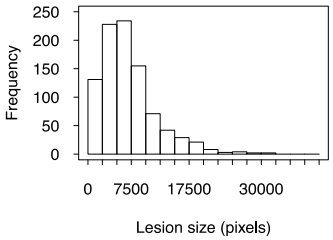
Cyan =
Lesions missed by human



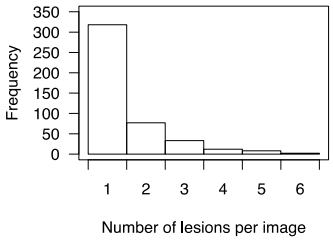
16

Quantitative measures of NLB

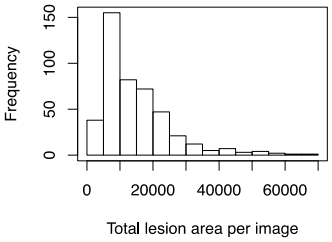
Size of lesions:



Number of lesions:



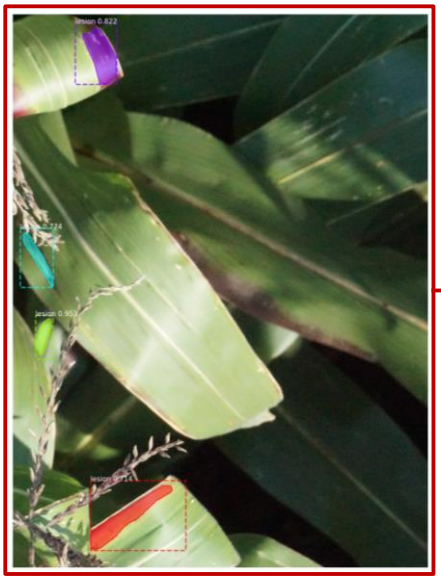
Disease area:



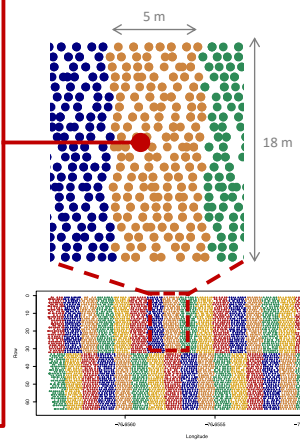
60 : 15 : 15
training : validation : test

17

Real world images

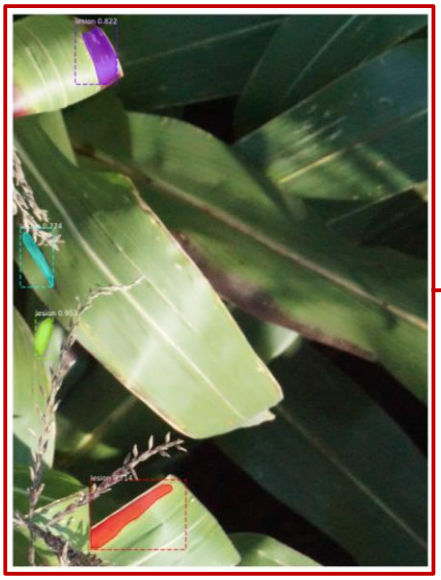


Plot: 7
Row: 50
Lesions: 4
Area: 28,000 pix



18

Real world images



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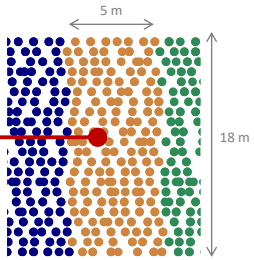
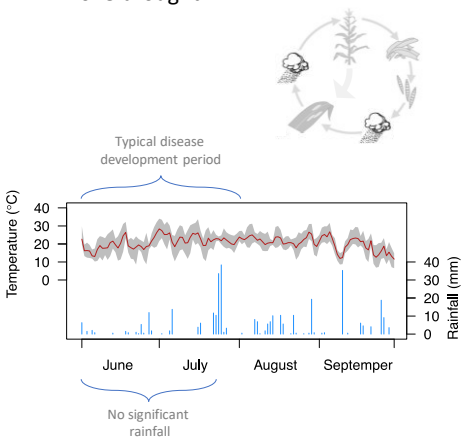


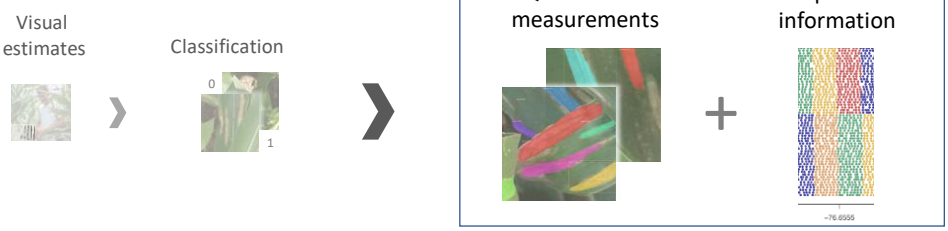
But…

2018 drought:



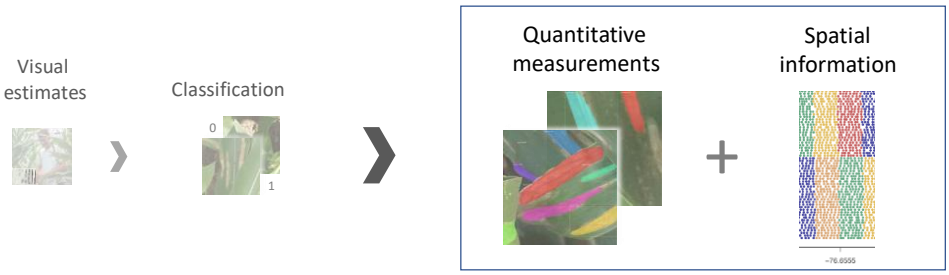
19

Summary



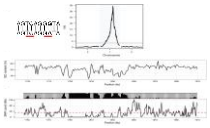
20

Summary

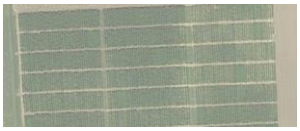


APPLICATIONS

Research



Breeding



Disease monitoring

21

Acknowledgements

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Mike Gore
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WHERE DISCOVERIES BEGIN

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22

23