

Advanced Deep Learning for Harvest Robotics



Harvest with a robot



Tasks:

1. Crop detection
2. Crop size estimation
3. Crop quality determination
4. Harvest



Challenges for harvest robotics

Environment



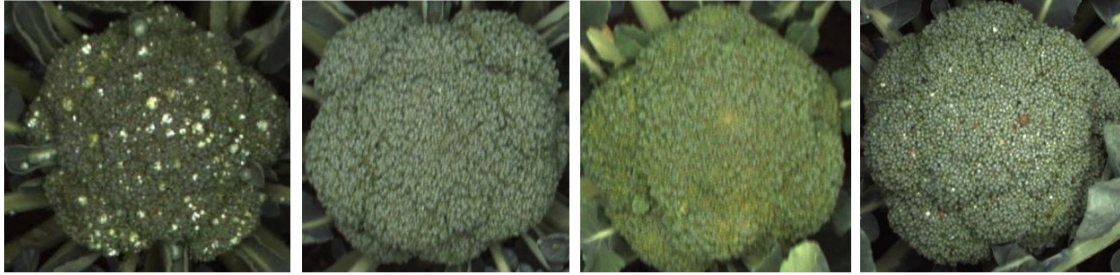
Occlusions



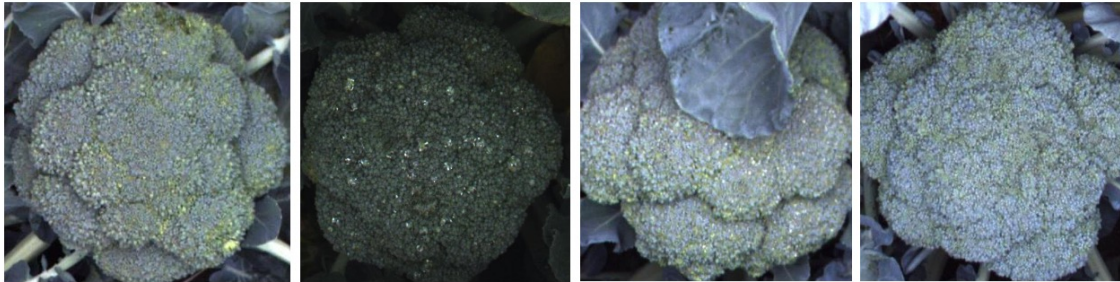
Crop variations



Topic 1 – CNN generalisation



Ironman

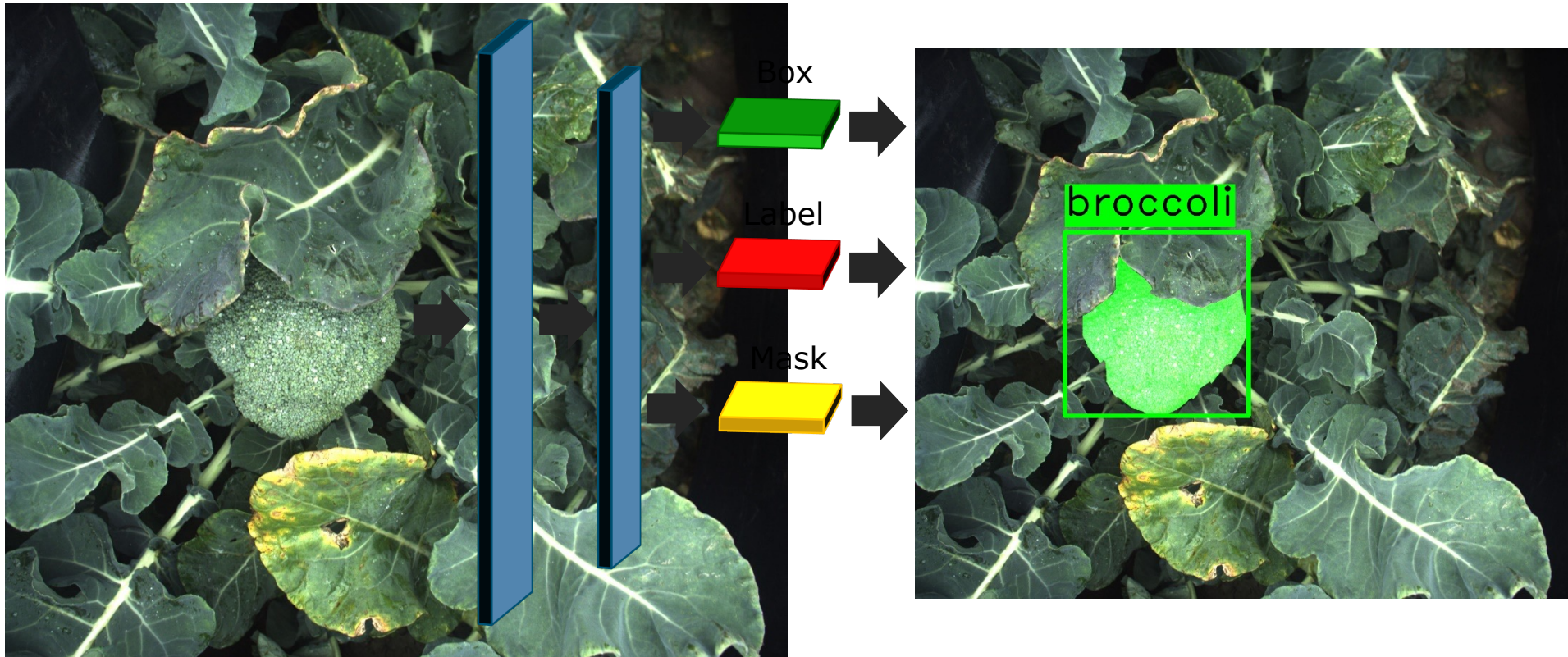


Steel

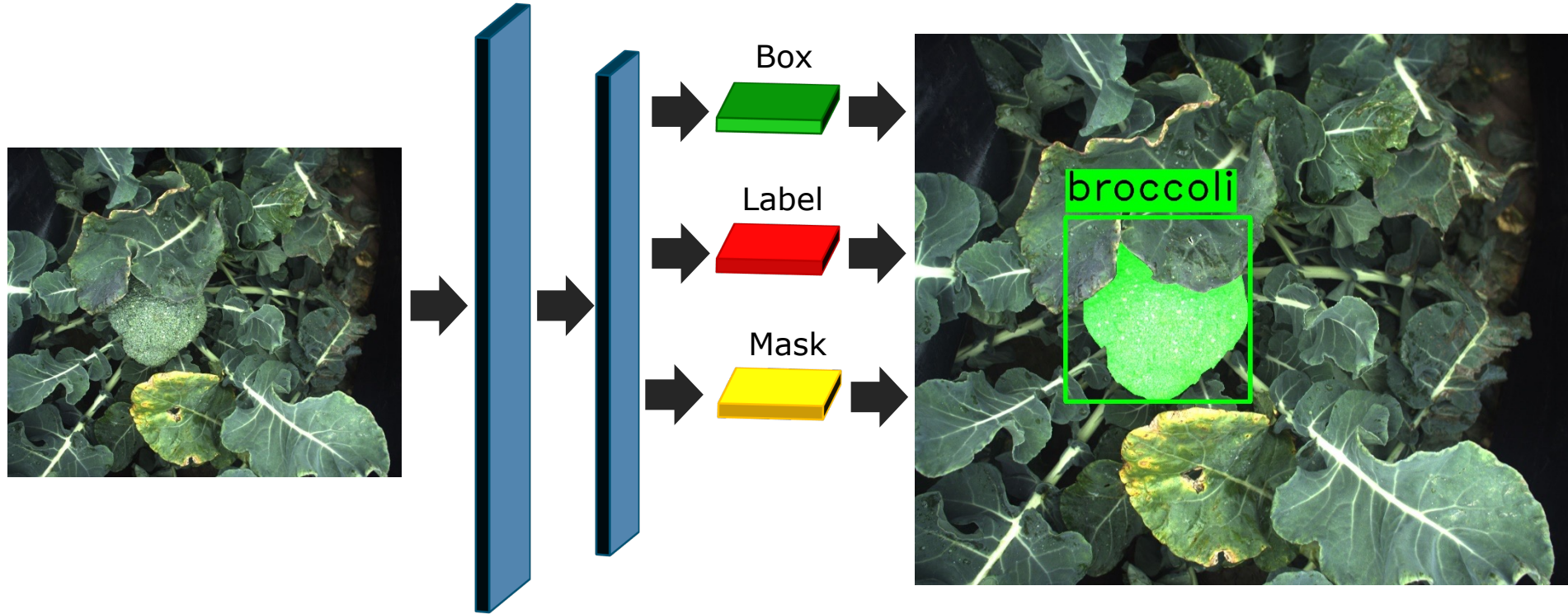


Emerald-Crown

Generalisation for Mask R-CNN



Data augmentation

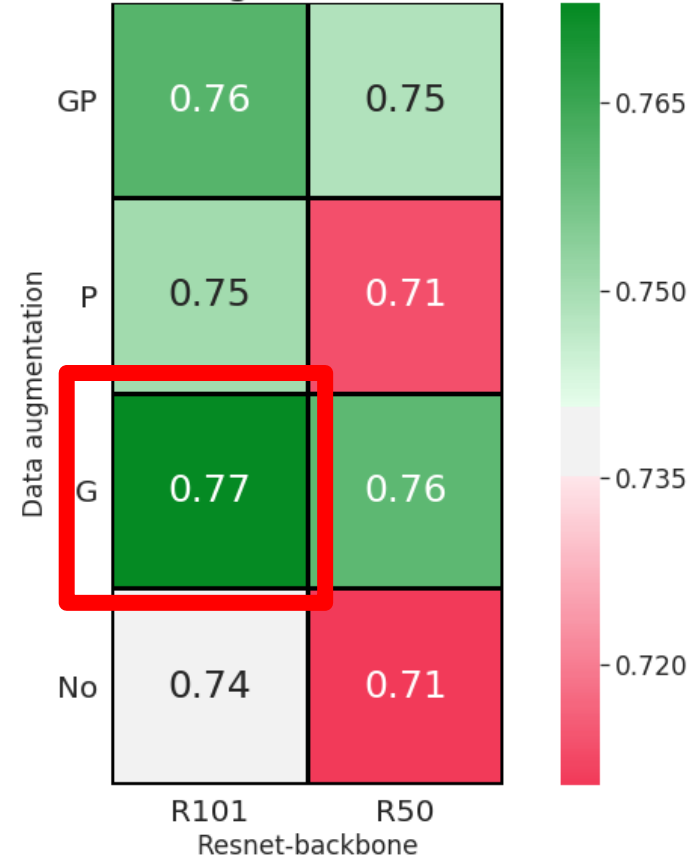
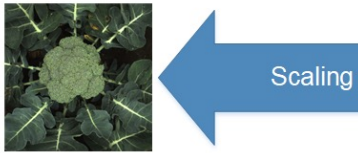
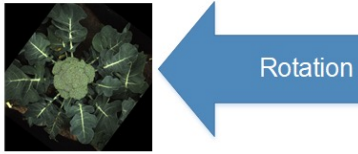
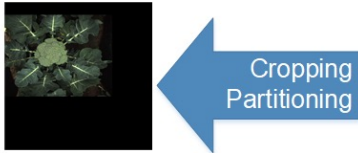


Effect of data augmentation

Geometric transformations

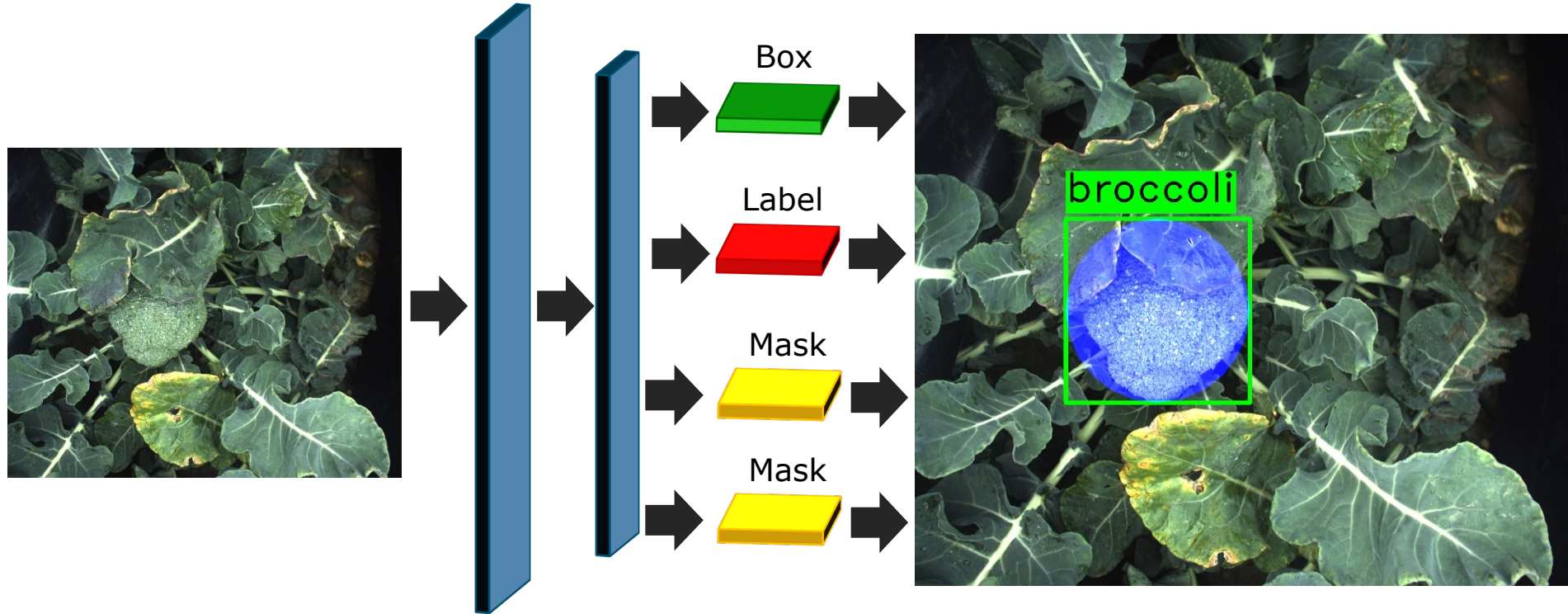
Photometric transformations

Original image

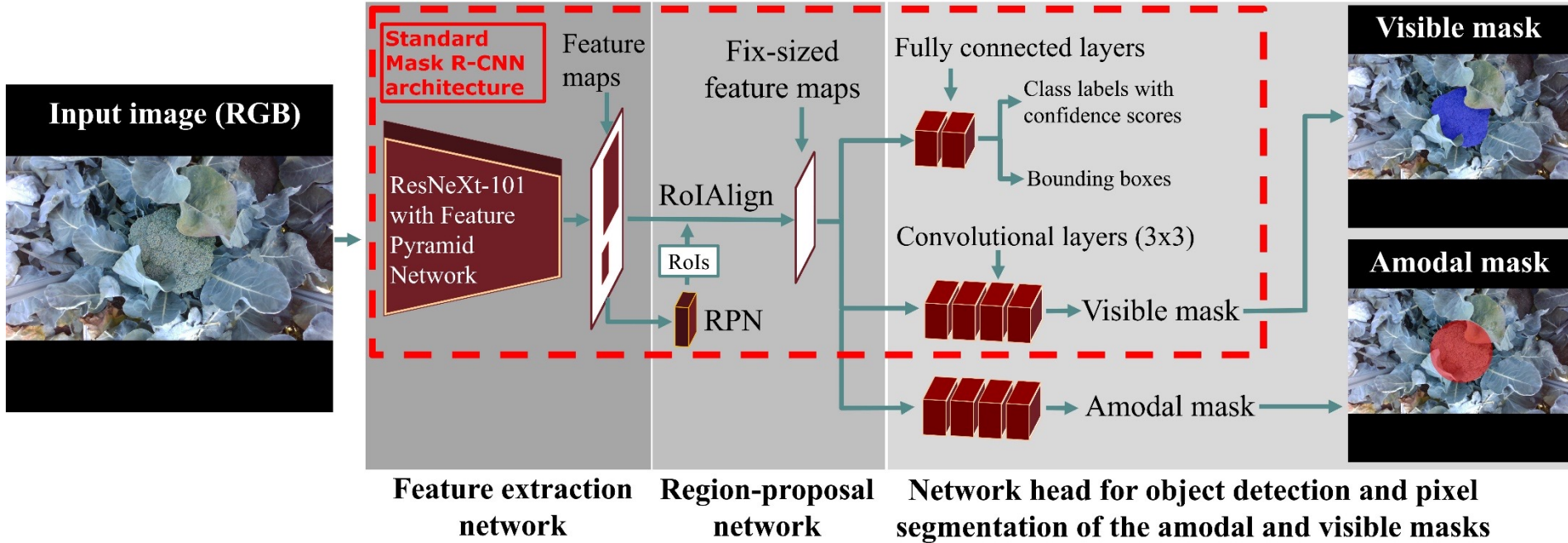




Topic 2 – Amodal perception



Upgraded network architecture







Standard Mask R-CNN

OCR: 0.89

AIoU: 0.31

VIoU: 0.84

Est: 60.1 mm

Diam: 109 mm

Diff: -48.9 mm



Occlusion R-CNN (ORCNN)

OCR: 0.89

Alou: 0.85

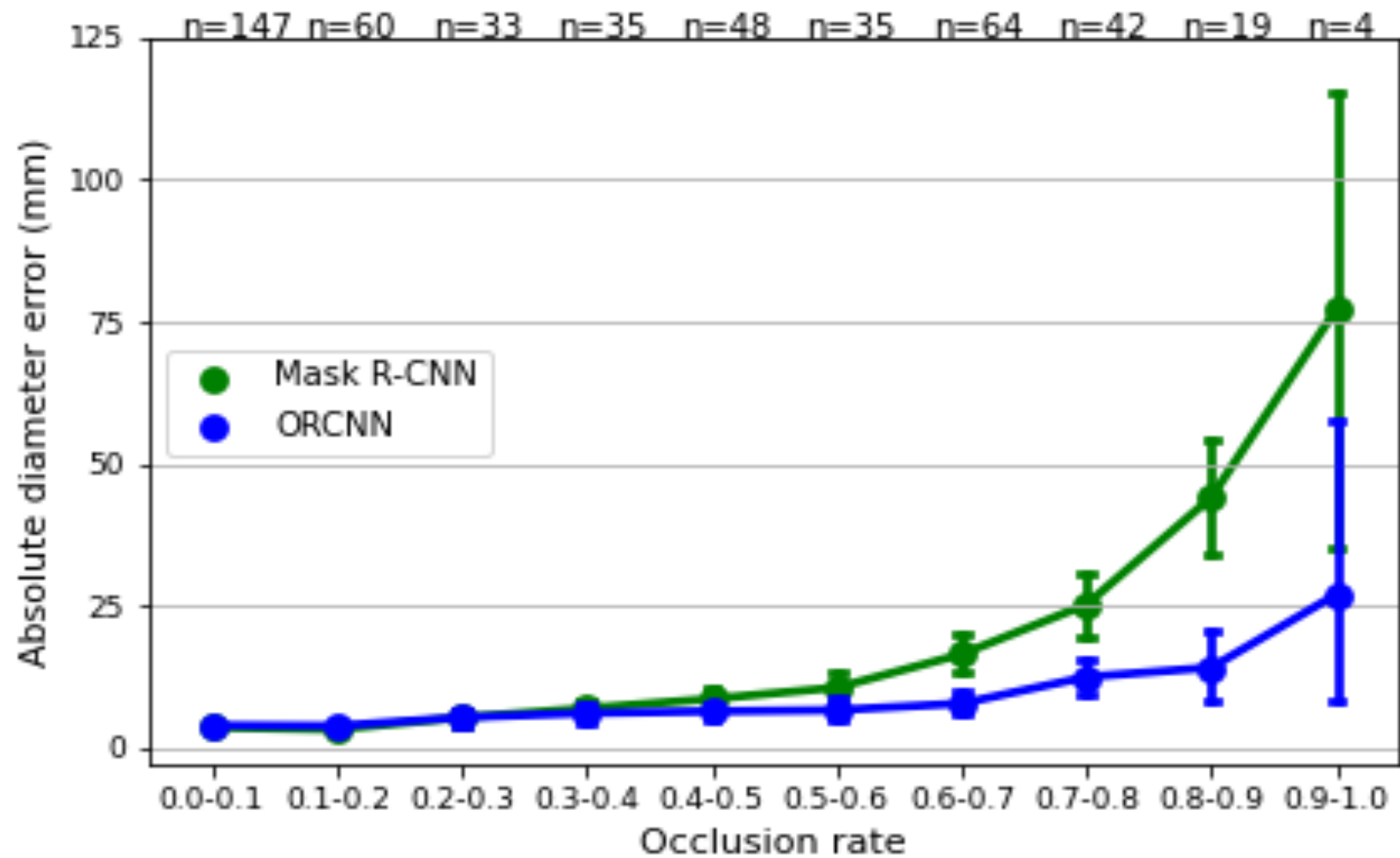
VloU: 0.84

Est: 102.4 mm

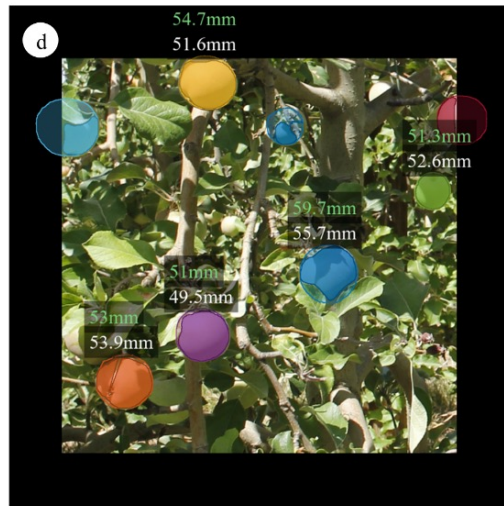
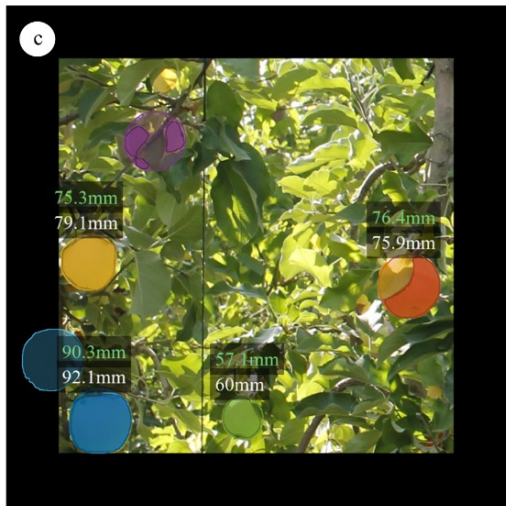
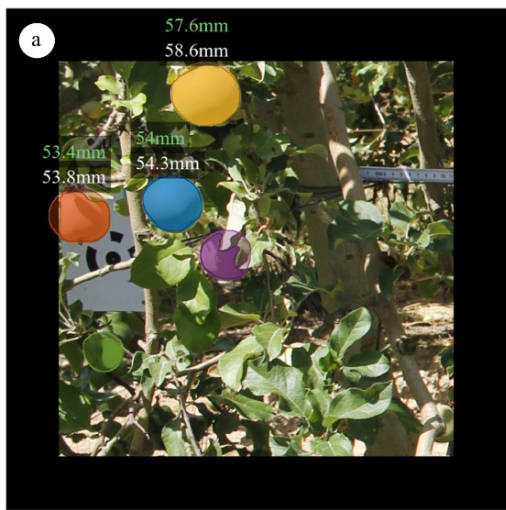
Diam: 109 mm

Diff: -6.6 mm





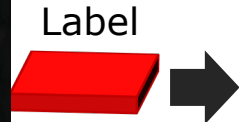
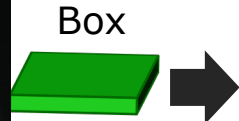




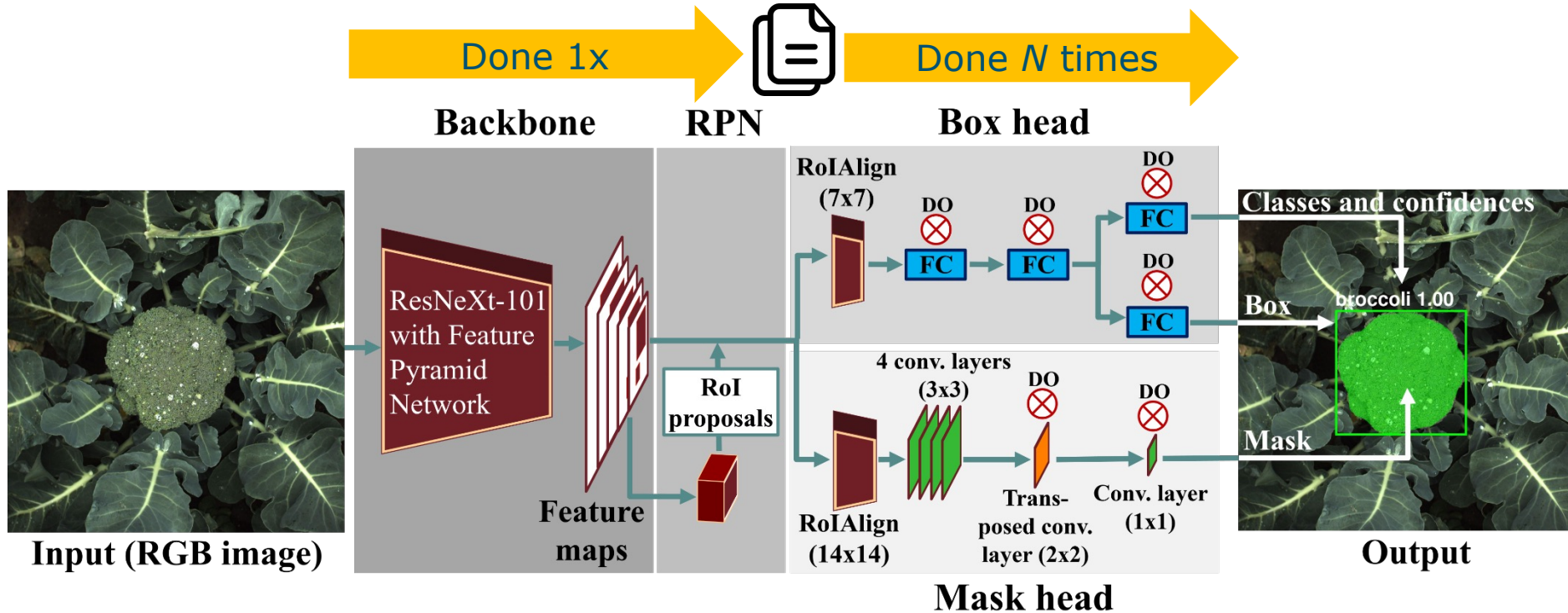
The amodal software and dataset were made publicly available...

→ the software is now being reused for size estimation of apples in orchards

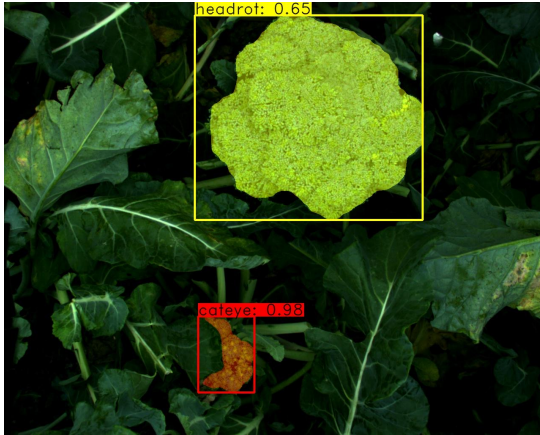
Topic 3 – Active Learning



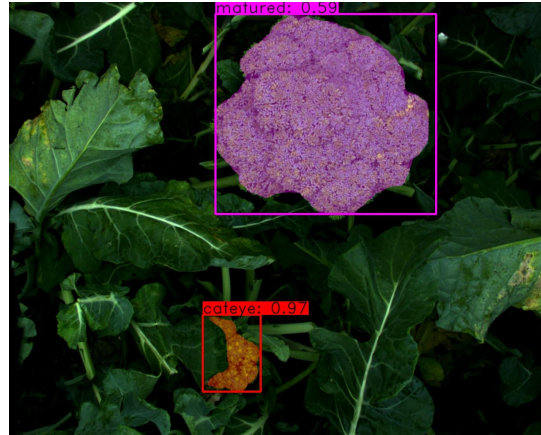
Monte-Carlo dropout



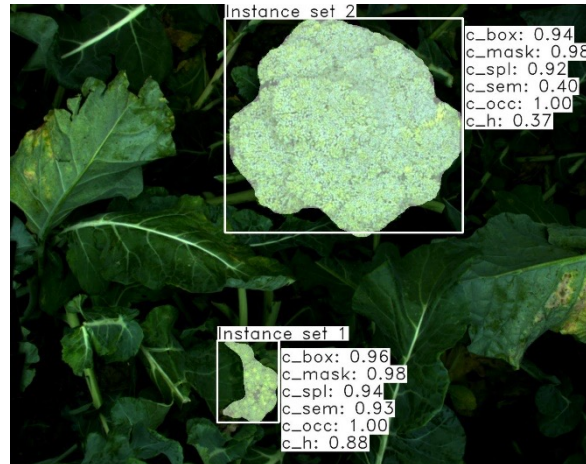
Forward pass #1

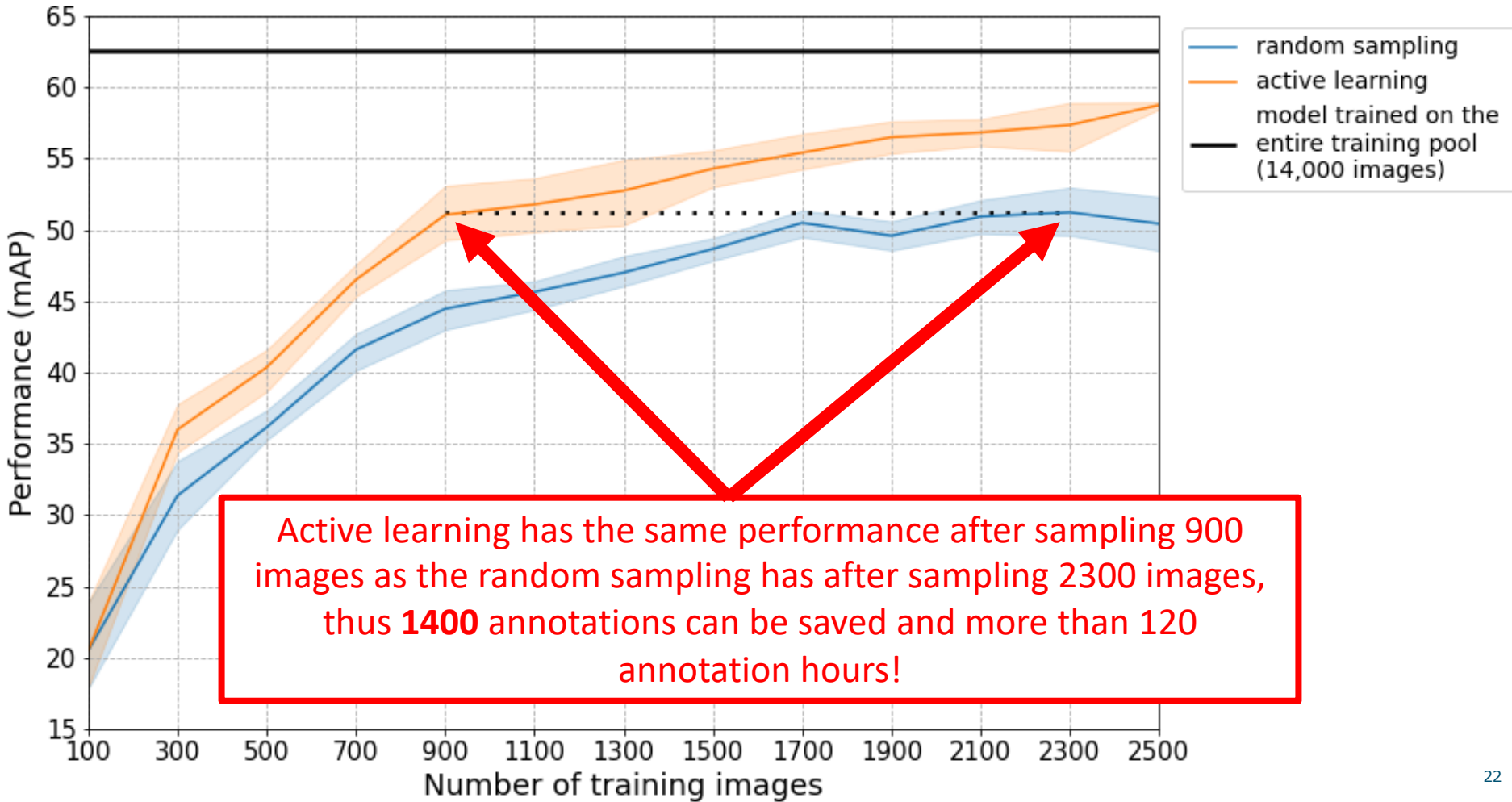


Forward pass #2



Forward pass #3





Active learning has the same performance after sampling 900 images as the random sampling has after sampling 2300 images, thus **1400** annotations can be saved and more than 120 annotation hours!





In summary...

1. I have developed novel deep learning methods that have contributed to the successful commercialisation of five selective harvesting robots for broccoli
2. I have contributed to alleviating industry-wide machine vision challenges that go beyond agriculture: variation, occlusion, selection and annotation of images
3. I have publicly released the dataset and source codes
4. The dataset and source codes have been successfully reused in research and commercial applications

Advanced Deep Learning for Harvest Robotics



Contact: pieter.blok@wur.nl