Conductor recognition using semantic segmentation

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About Unison Networks

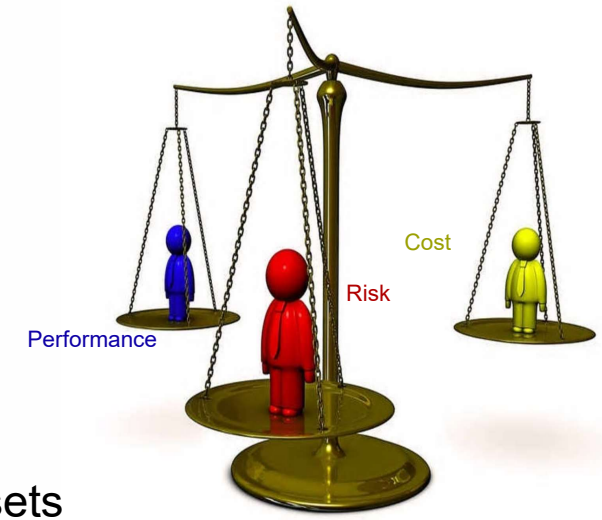
- Unison owns, manages and operates distribution networks in the Hawke's Bay, Taupo and Rotorua
- 100% owned by the Hawke's Bay Power Consumers' Trust
- **ISO 55001** certified since 2018
- Serving approximately **114,000** consumers
- **5th** largest Electricity Distribution Business (EDB) in New Zealand
- **9,313 km** energised circuits

Content

- Introduction & Context
- Conductor segmentation
- Semantic segmentation
- Post-processing
- Results
- Conclusion & Future work

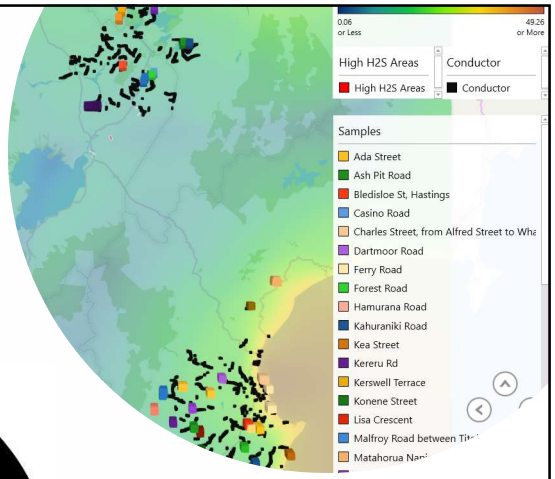
Introduction

- What to replace & When?
- EDBs have no shortage of challenges
  - Affordability & Alternatives
  - Reliability & Resilience
  - Safer Work Practices & Assets
  - Increasing Costs…
- Increasing pressure to efficiently replace assets
  - Optimise Performance, Cost and Risk
- Knowledge is the key
  - What's the asset condition?



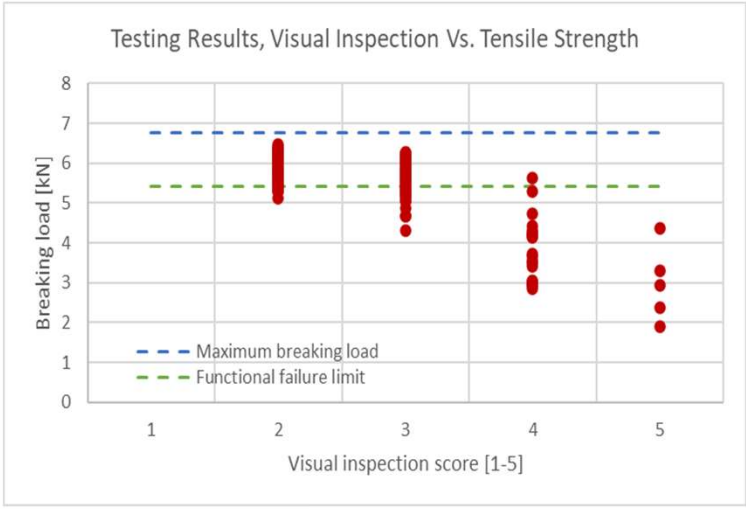
Context

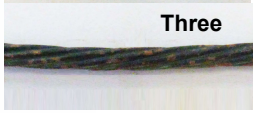
- Year 2018, with University of Canterbury
- Focusing on worst performing conductor - 7/0.064 copper
- Tested (Tensile Strength):
  - 21 different locations
  - 215 tensile tests
- Result: Improved understanding of fleet condition and degradation mechanisms



Context

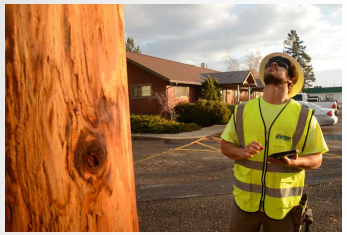
- Assessing condition
  - Strong **correlation** between **visual inspection score** and **tensile strength**





Context

- Overhead conductor inspection
  - A way to view the lines



Inspector from the ground

OR

Drone from the air

  - A method to consistently assess the condition of the lines

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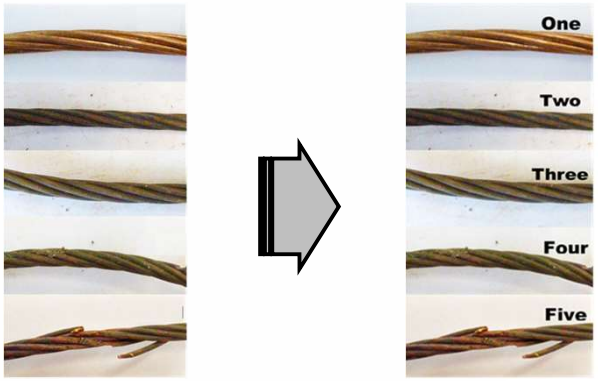
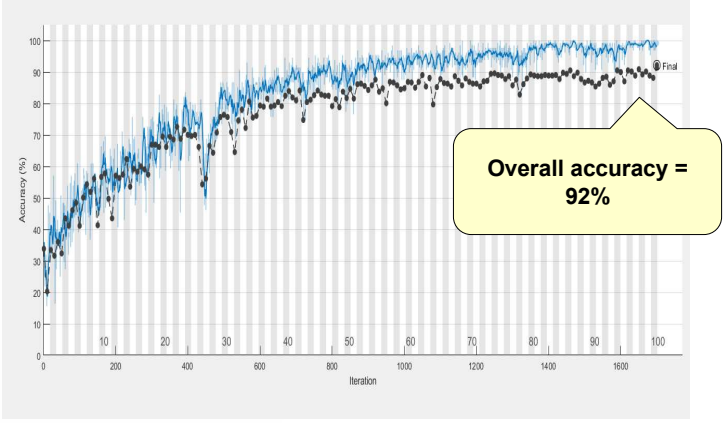
Context

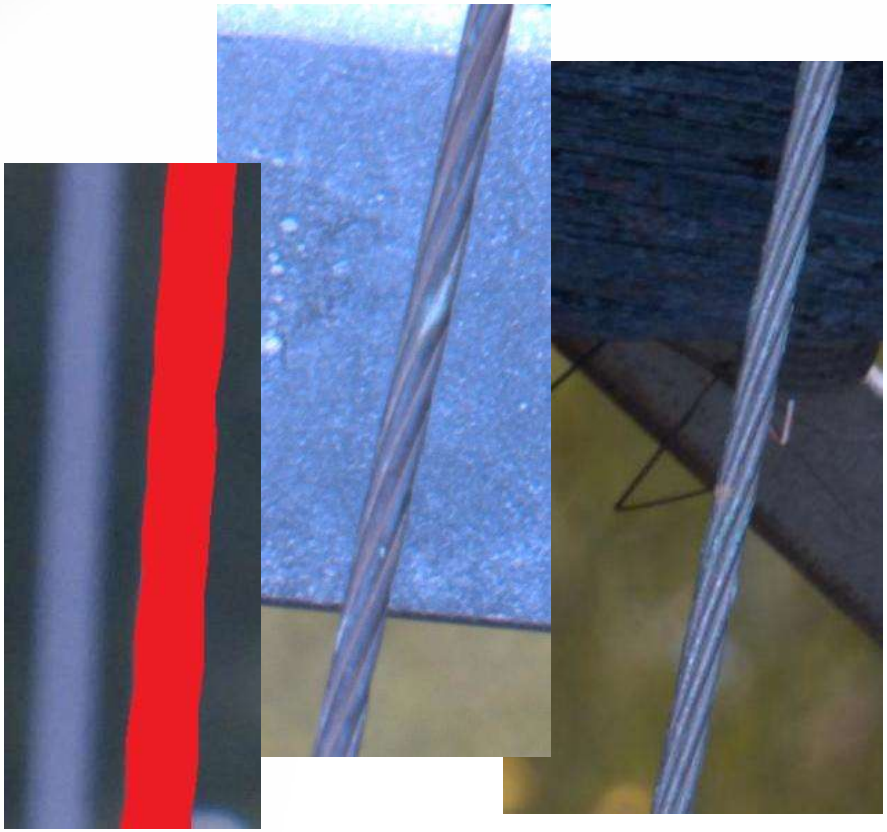
- Automation of visual assessment
  - (2019) Bespoke machine learning model with sample conductor images as **proof-of-concept**





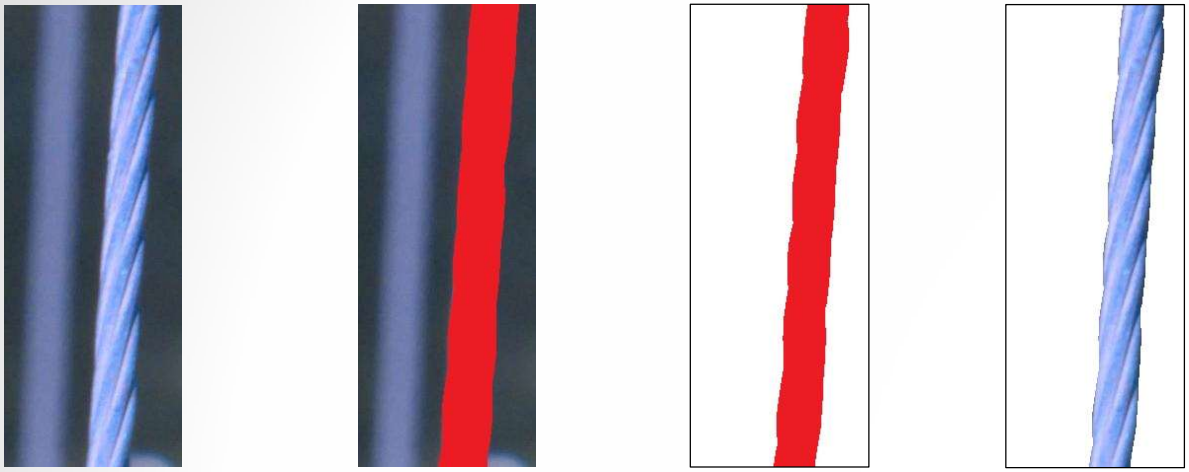
Context

- Automation of visual assessment
  - In 2020, Unison started project to expand machine learning model to field images
  - Prerequisite: identify the **conductor Region of Interest (ROI)** in the image.
  - Using **image semantic segmentation**



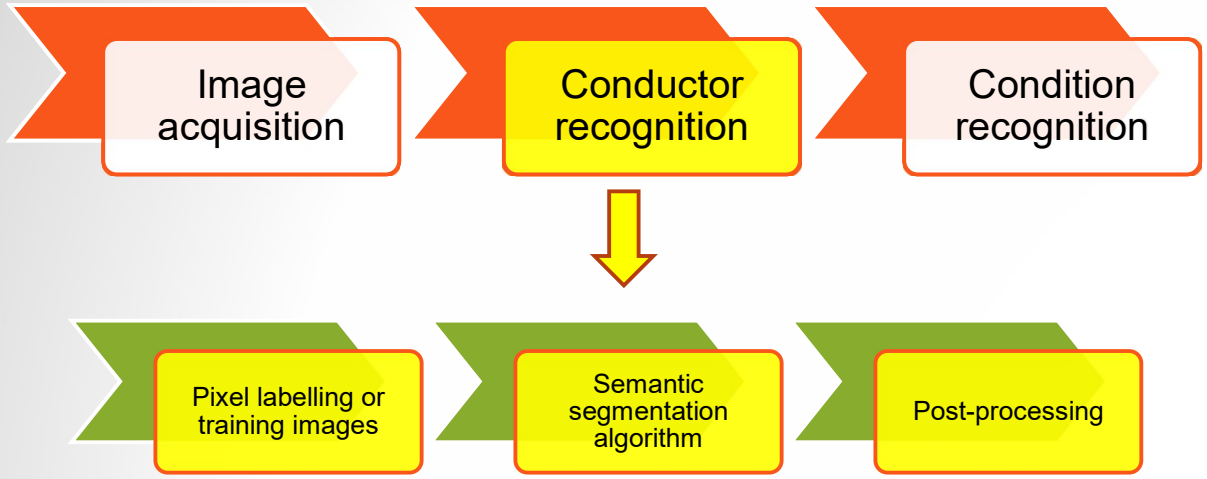
Conductor segmentation

- The goal is to segment each image into two regions of interest,
  - the conductor (foreground), and
  - all remaining background information



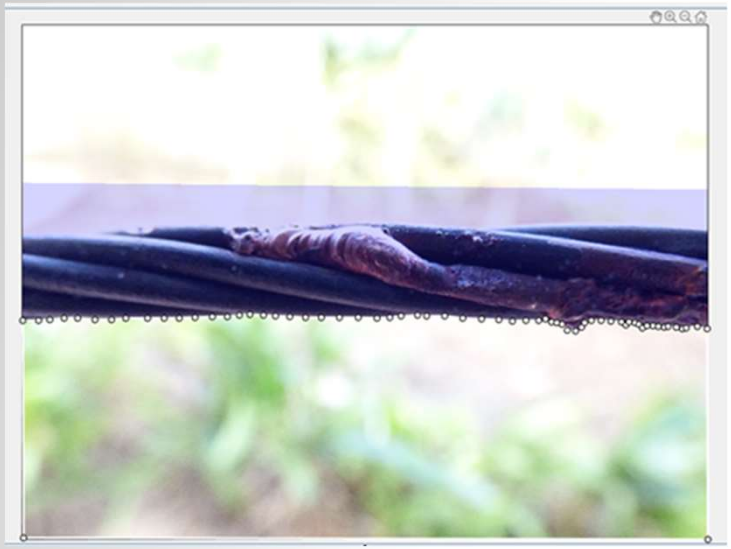
Conductor segmentation

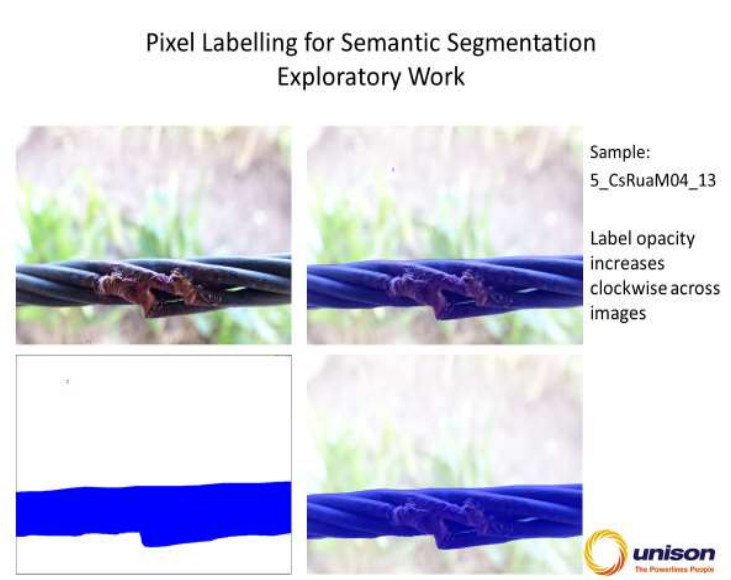
- Unison called this “conductor recognition”



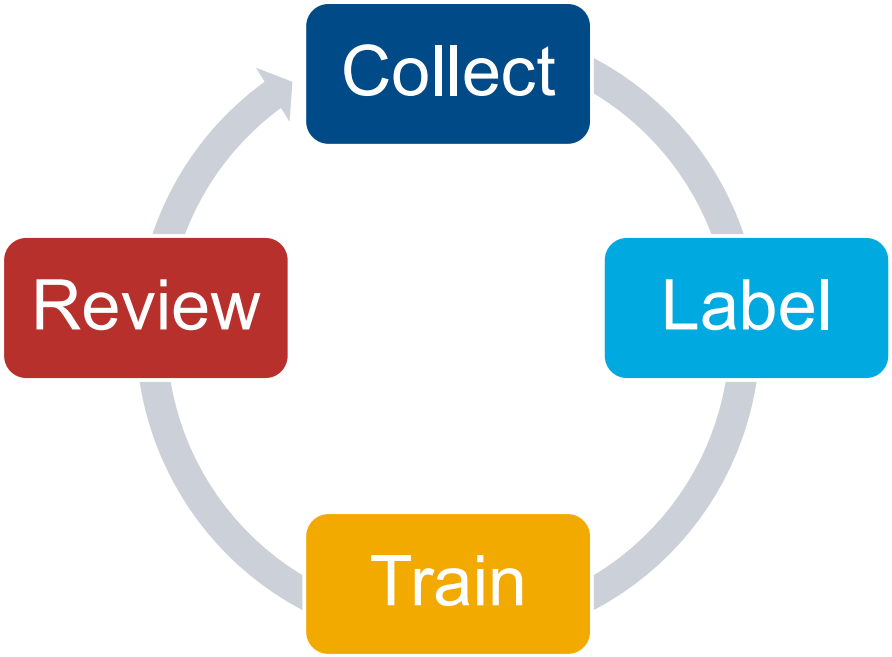
Manual pixel labelling

- Matlab's Computer Vision Toolbox
- Used to train a Machine Learning (ML) semantic segmentation algorithm





Machine Learning Big Picture



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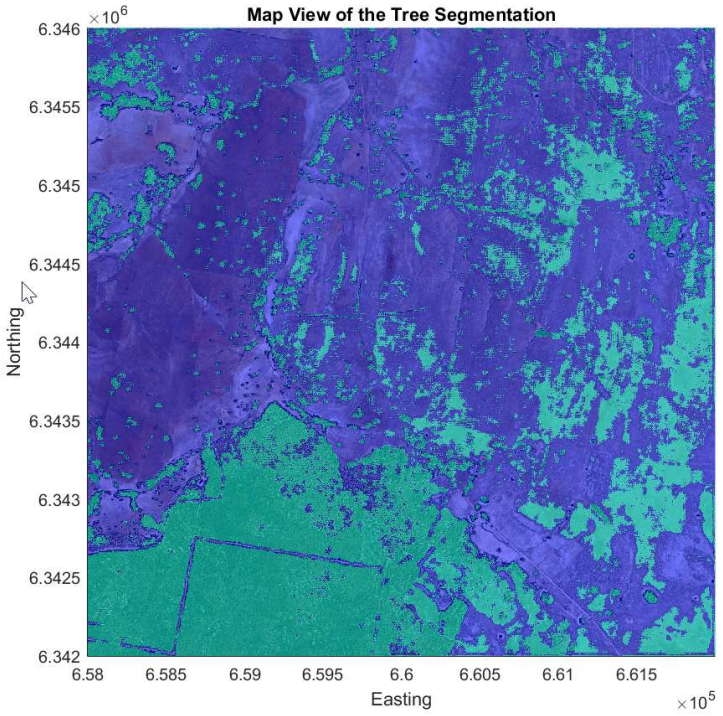
What does labelling entail?

- The process of attaching a classification to each pixel
- Two step process
  - Decide categories
  - Apply



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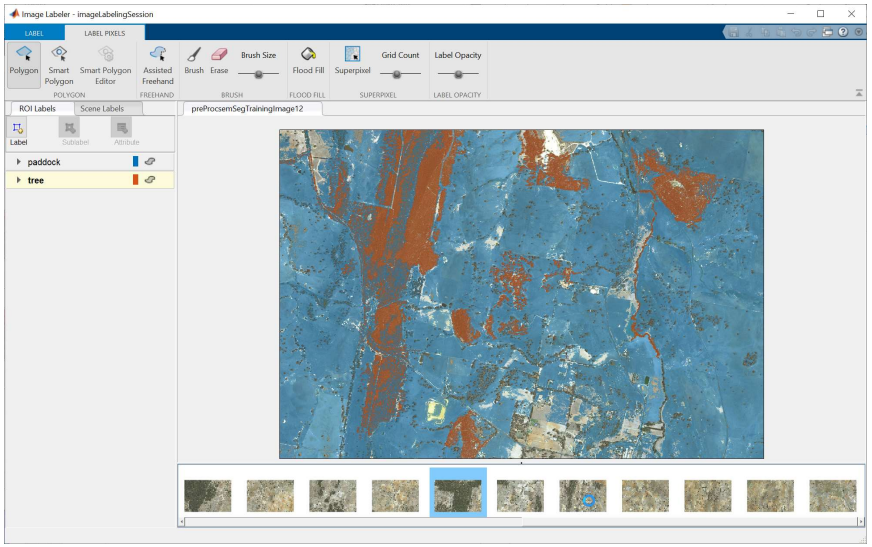
How does this work in practice?

- Apps to the rescue
  - Image Labeller App
  - Video Labeller App
- Iterative process
  - Start manually
  - Move to automated



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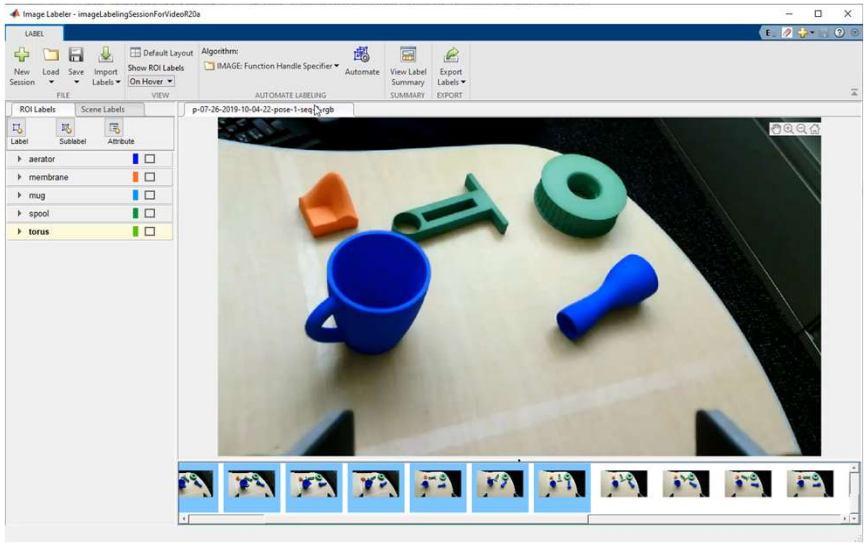
But you just said automated? I thought this was manual?

- Yes and no
- Some projects lend themselves to automation
  - Consistent colour
  - Shapes
- Reuse your algorithm on new data



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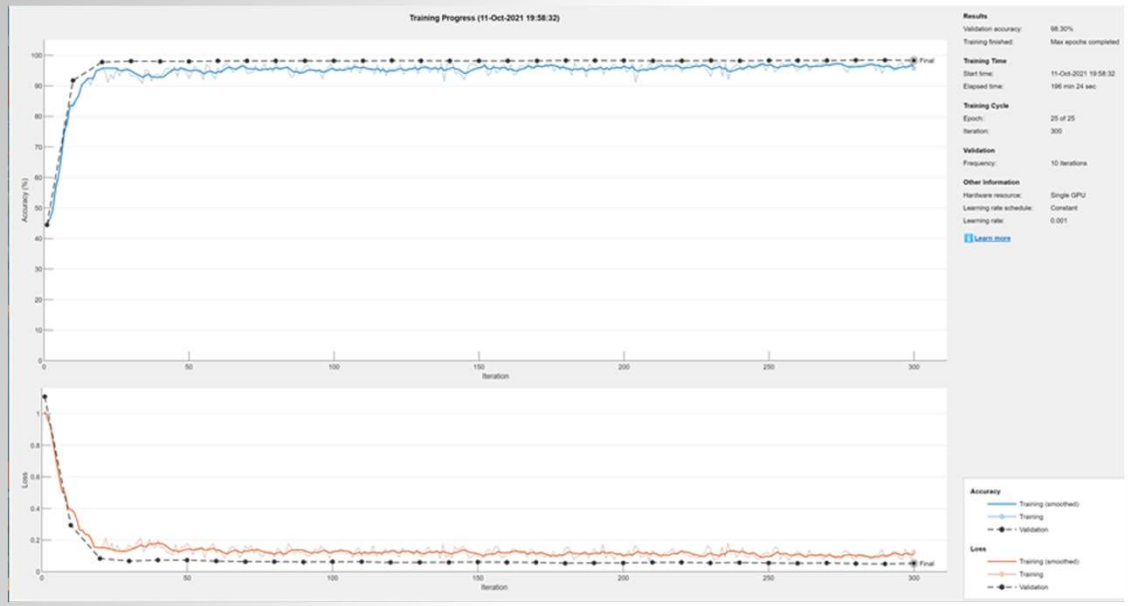
Semantic segmentation, ML algorithm

- Matlab's Deep Learning Toolbox
- Using "BF score" (Boundary F1) as performance criterion in training



	Mean BF Score	Overall Mean BF Score
Conductor	0.83	0.85
Background	0.87	

Networks and Training

- Network shape can be a major choice
- Option 1: from scratch
- Option 2: reuse

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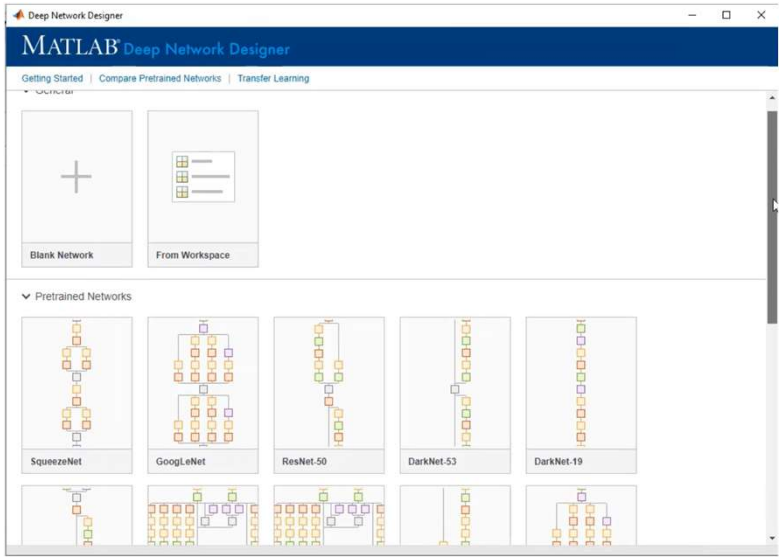
Generally Best Idea to Reuse Work

- Shipping in MATLAB
  - DeepLab v3+
  - Generalised Dice Loss
  - Fully Convolutional
  - Pixel Classification
  - Segnet
  - U-Net
  - Focal Cross Entropy
- More at GitHub
- Or use a research paper



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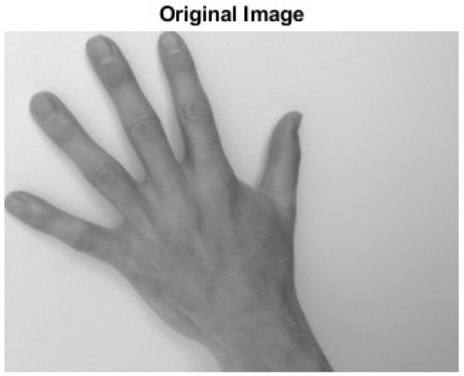
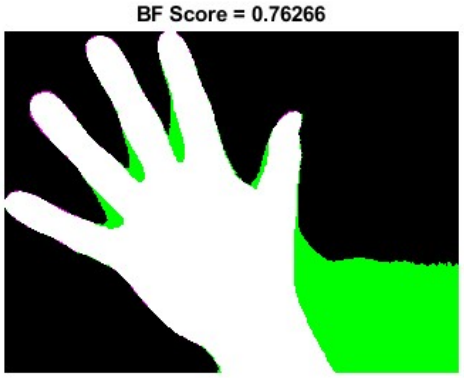
Key to success is evaluation

- Unison used bfscore
- Other metrics exist
- Pros and cons





Evaluating semantic segmentation results
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* Selected metrics: global accuracy, class accuracy, IoU, weighted IoU, BF score.
* Processed 100 images.
* Finalizing... Done.
* Data set metrics:

GlobalAccuracy	MeanAccuracy	MeanIoU	WeightedIoU	MeanBFScore
0.90624	0.95085	0.61588	0.87529	0.40652

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Post processing

- After the ML semantic segmentation, postprocessing is needed to achieve the desired result

Post Processing with Image Processing Tools

- So far: Semantic Segmentation
- Don’t forget the basics!

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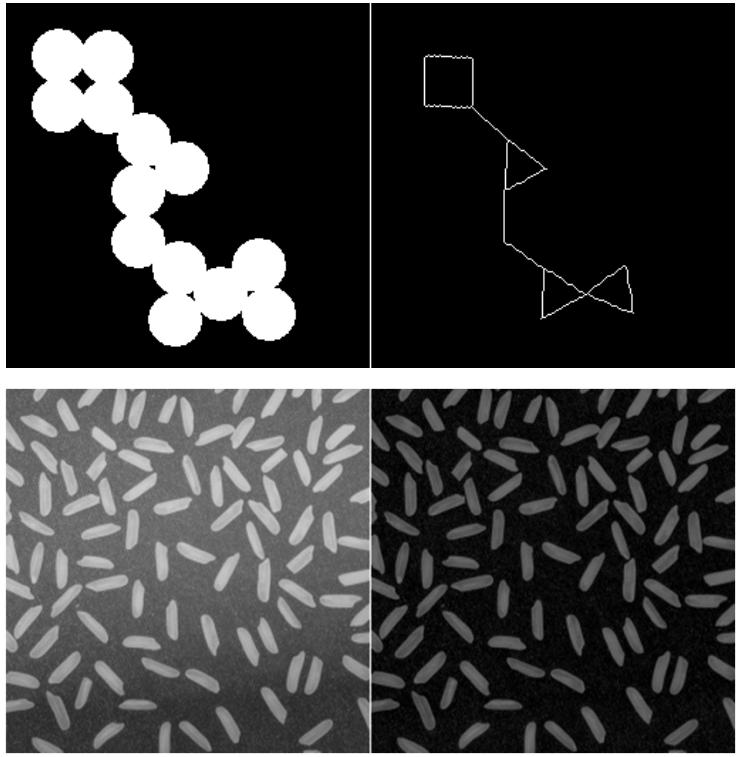
Use Image Processing Tools to Support

- Morphology
  - Dilate
  - Erode
  - Reconstruct
- Filtering
  - Convolutions
  - Non-linear
  - Edge preserving
- And so much more



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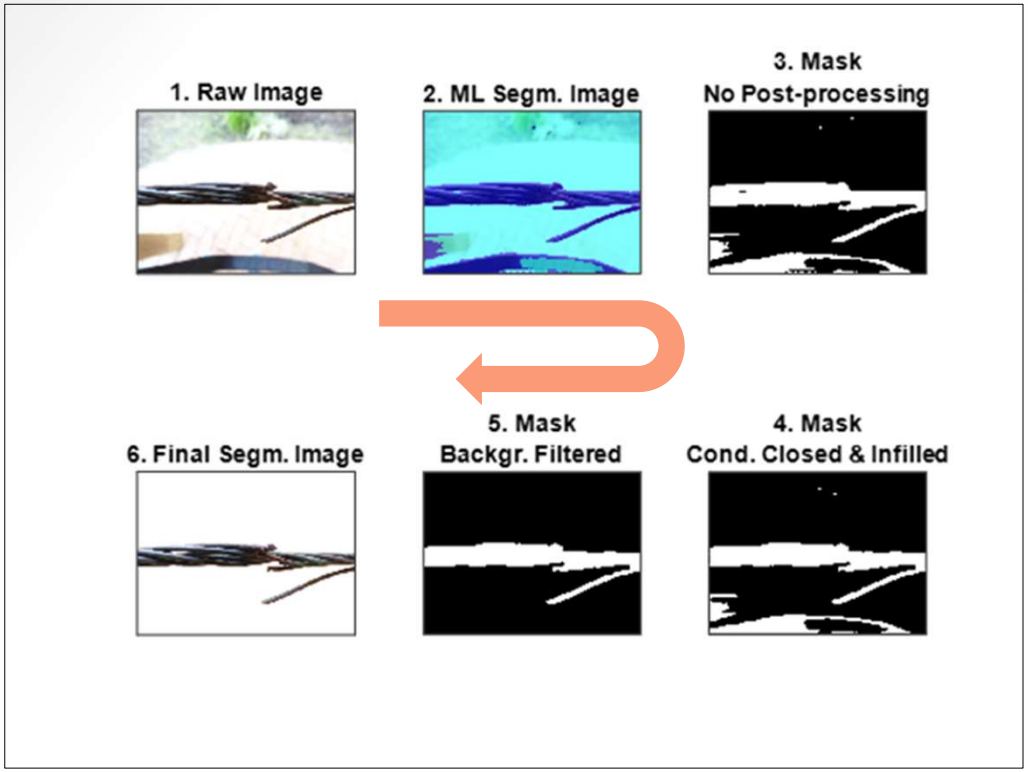
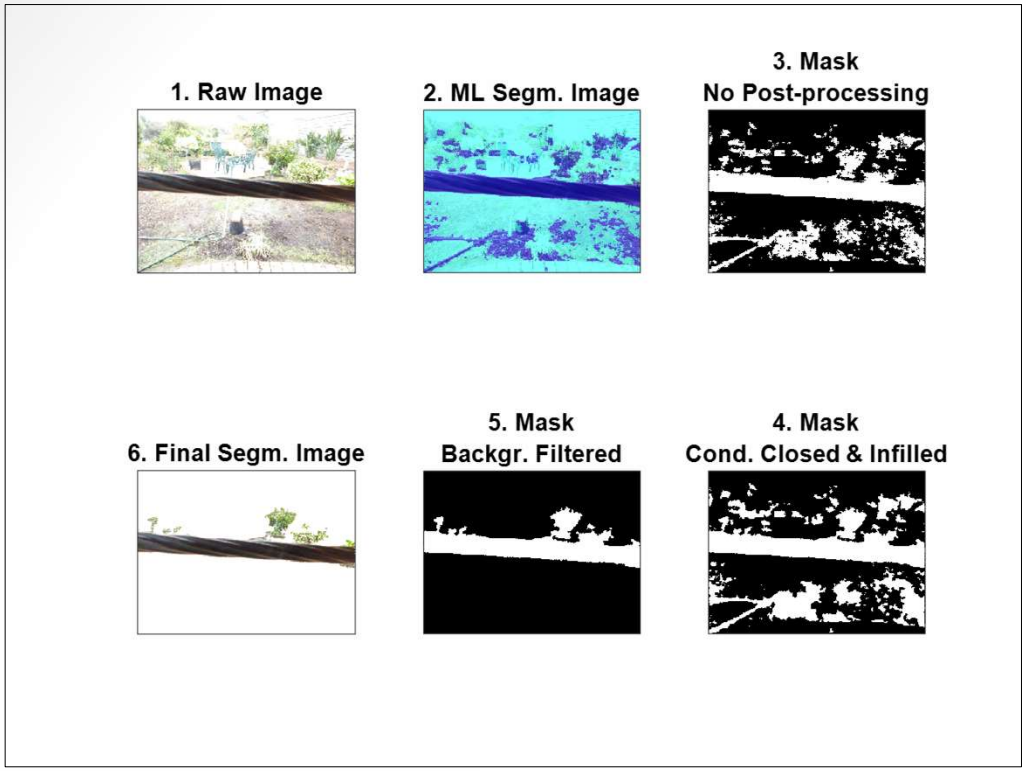
Results

- Algorithm worked near-consistently well (in some 99% of out-of-sample images used for this project)…



Results

- … provided unwanted “objects” are not contiguous with the conductor



Conclusion & Future work

- Process developed to segment and isolate the conductor in images containing both conductor and background information – and to then remove the image background, works well except for very limited number of cases where noise in background is contiguous to conductor.
- Future training with larger number of images, derived from field images, is expected to improve results.

Questions?

Thank you!

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