Leveraging KNIME and machine learning to enhance asset management of South Australia’s power grid

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Forest Grove
Data-Driven Decision Making

ElectraNet

Speakers

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- Asset Information Analytics Engineer @ElectraNet
- Bachelor of Computer Systems Engineering
- Using KNIME since 2022

Jerome Treboux

- Senior Consultant @Forest Grove
- Ph.D. in Computer Science (Data Science)
- Using KNIME since 2011

Outline

- Introduction
  - ☐ ElectraNet and Forest Grove Technology
  - ☐ Business Case Presentation
- Insulator Detection and Identification
  - ☐ Machine Learning
  - ☐ Project presentation
  - ☐ Outcomes
- Conclusion and Q&A

Introduction

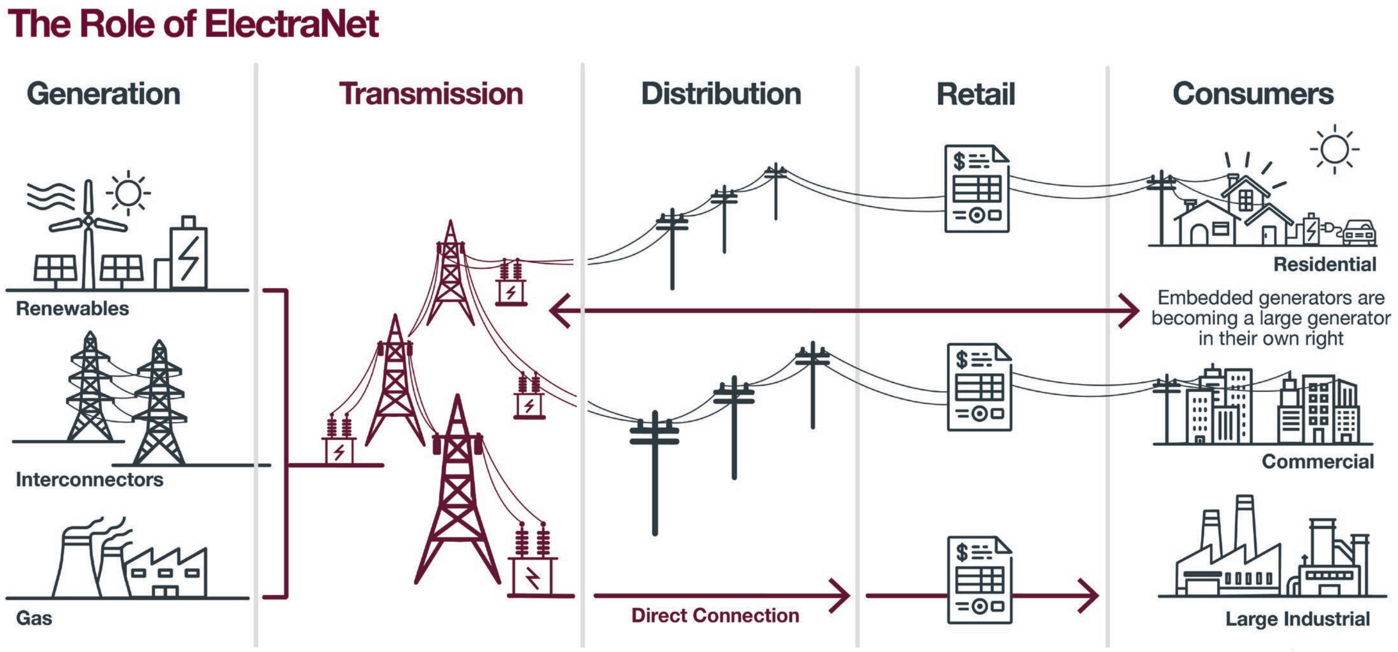
- ElectraNet and Forest Grove Technology
- Business Cases Presentation

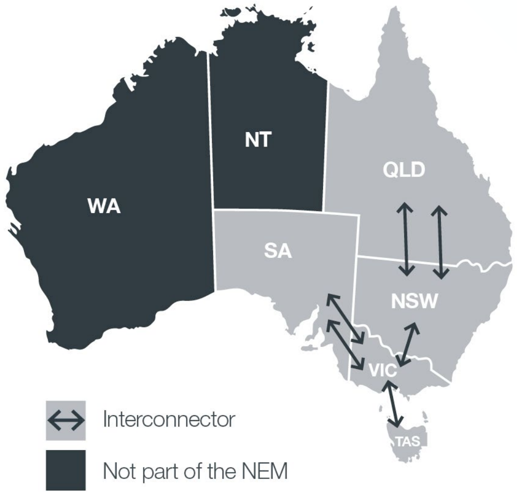
About ElectraNet

- Owner and operator of South Australia's electricity transmission network
- Extensive regional network covering 200 000 square km (~77 000 square mi)
- Supporting the $140+ billion economy in South Australia

Our Key Objectives:

- ☐ Affordability and reliability to our customers
- ☐ Transmission Network security and resilience
- ☐ Safety of our personnel
- ☐ Protect the environment





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Our Assets

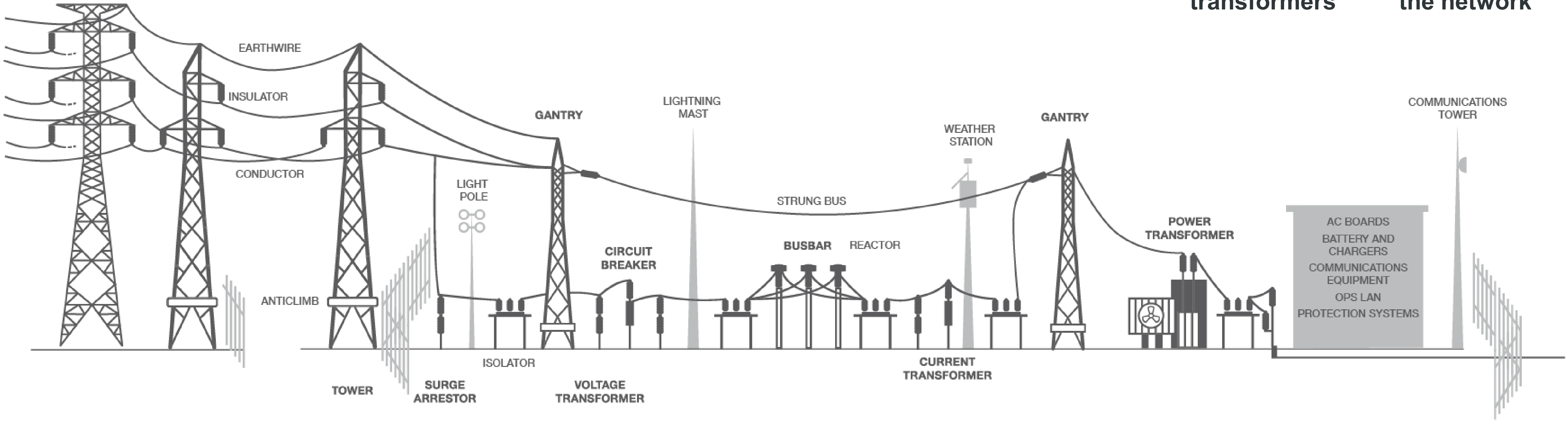
- About 100 substation sites
- 6 000 circuit km of transmission lines (~3 700 mi)
- 250+ main equipment types captured

166
power transformers

670
circuit breakers

3 700
voltage and current transformers

15 000
towers supporting the network



Data and Technology

Asset Information Team
(Asset Data)

Asset Data Maintenance, Governance and Compliance based on:

- Asset Data
- Geospatial Maps
- Current Asset Photos

Projects Team

Install & Commission Assets
Refurbish/Retire Assets

Engineering Technical Team
(Decision makers)

Routine Asset inspections
Bushfire Patrols

Technology Team
(Systems & Infrastructure)

IT Architecture, Infrastructure and Solution Management
Support & Service Management

Technology Selection

ElectraNet's Selection Criteria:

- ☐ GUI based workflow – Low Code/No Code
- ☐ Simple for analysts/engineers to utilise
- ☐ Faster and easy solution to deploy
- ☐ Flexible solution

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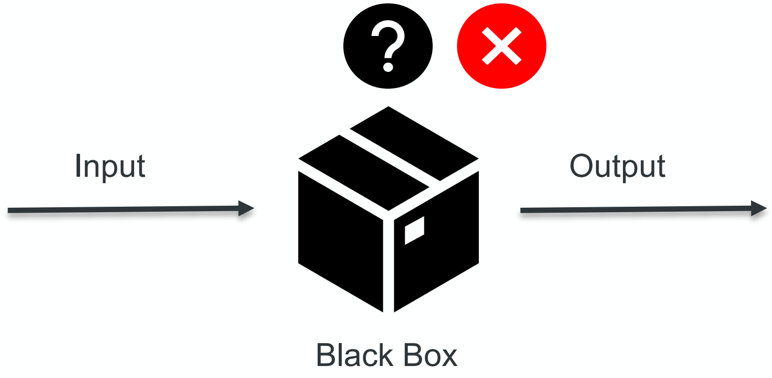
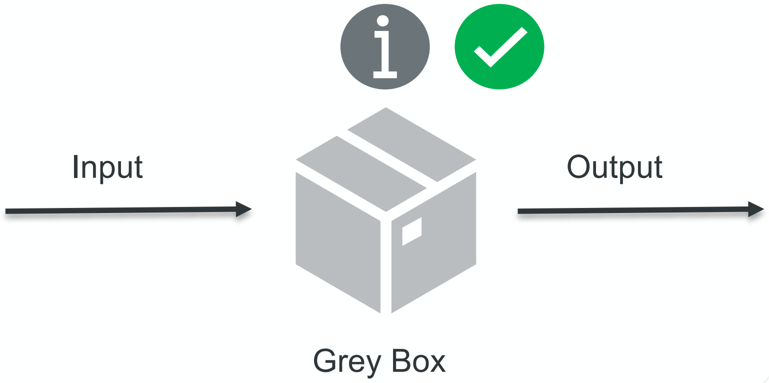
Open for Innovation
KNIME





Forest Grove Technology – Our History

- Founded and operating out of Perth, WA, Forest Grove is one of Australia and NZ's leading specialist consulting firms, delivering end to end finance transformation and data analytics solutions. We have been helping business achieve success with their data for nearly two decades.

04'
2004
Started operations as exclusive Prophix Partner for WA

06'
2006
Appointed exclusive Prophix Partner for AU & NZ

11'
2011
Appointed authorised Tableau Partner

15'
2015
Partnership with advanced analytics platform KNIME

17'
2017
Awarded Prophix International Partner of the Year

20'
2020
Awarded KNIME Global Partner of the Year

21'
2021
Awarded Prophix International Partner of the Year

21'
2021
FG Officially Launches own data product, Connected Services

22'
2022
Awarded KNIME Partner of the Year APAC

Today
Enabling over 100 businesses across Australia to make confident, data-driven decisions.

In 2014 we identified some key gaps in the market;

① Firstly, companies were struggling to **access their data**. They needed to **transform, clean, validate** & more. We needed an ETL tool that **both technical & non-technical** could work with to create a **single source of the truth**

② Additionally, **we knew that over 80% of analytics projects do not make it out of the data science team**. That is, deployment is a key issue. We chose **KNIME as our key data science tool** because its business model helped deal with this issue.

Forest Grove Technology – Snapshot

20 years experience in finance & analytics

- →End-to-end data solutions
- →Implementation & dedicated support

100+ customers across APAC

- → Headquartered in WA
- → Consultants in VIC, WA & QLD

Diverse, professional team of **data experts**

- → Specialist, varied skill sets & experience
- → 14+ countries

Leaders in **analytics deployment**

- → Helping clients solve real business problems
- → Growing data literacy across teams

Strategically chosen leading technologies

- → Innovation, self-service & support
- → Avoidance of black-box solutions

Proven success & credentials – ~10 years w KNIME

- → Long-term happy customers
- → International awards

APAC Partner of the Year 2022

Elite Partner

Image Analytics – SAP data vs Nameplates

Business Case

- Test feasibility to extract nameplate information (e.g., model and make)
- Evaluate KNIME capabilities
- Identify inaccuracies in SAP data

Outcomes

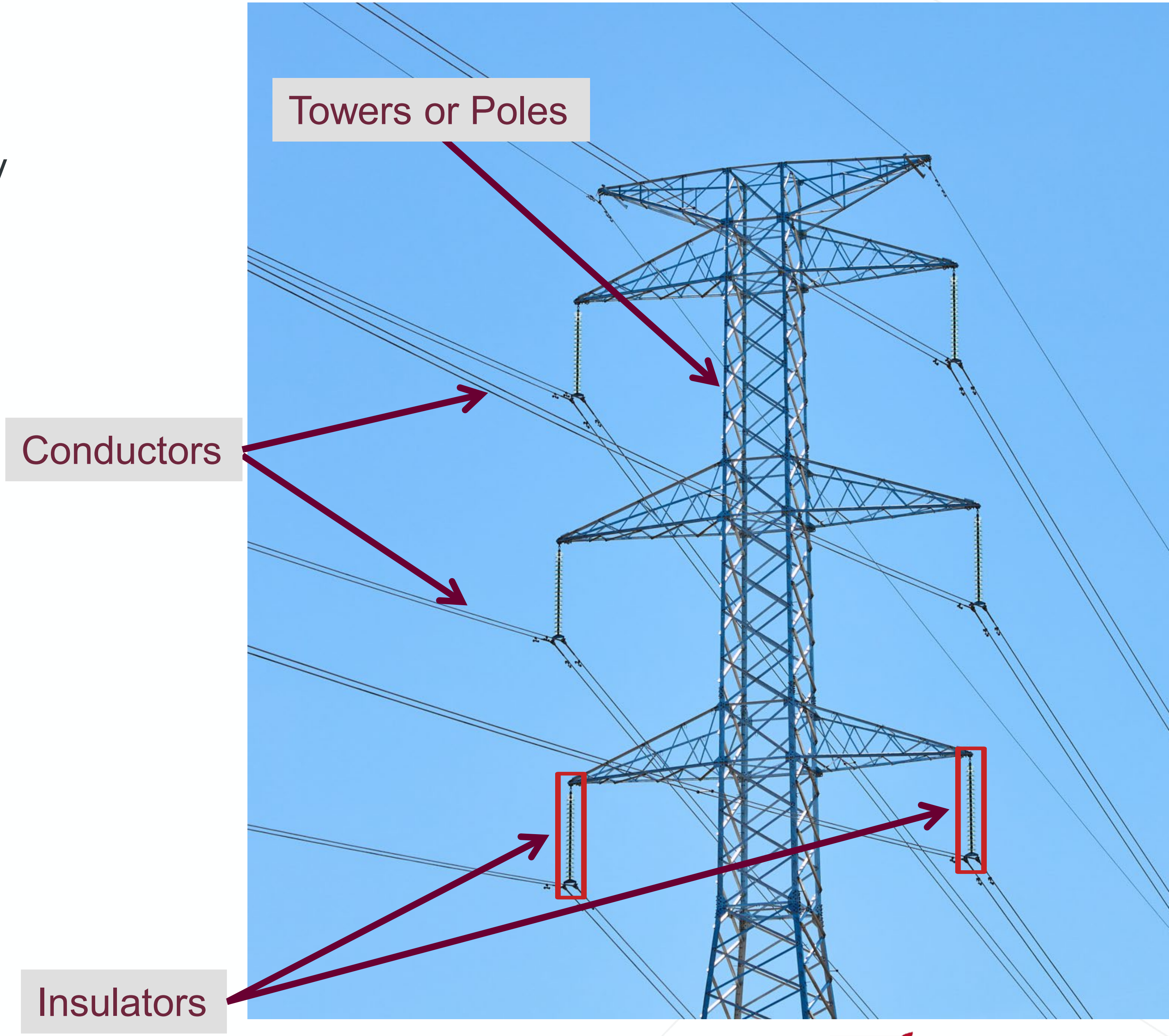
- Built workflow to extract equipment details from nameplate
- KNIME proved to be versatile and useful for other types of use cases

Transmission Lines

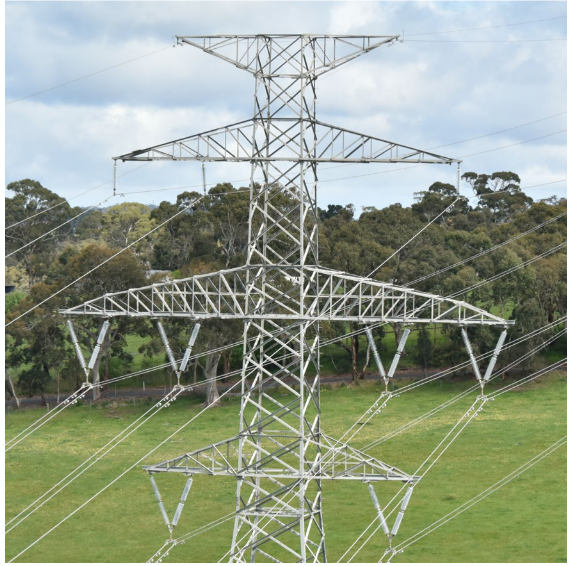
- Overhead transmission lines are supported by several unique tower types.
- Over 15 000 towers supporting the network
- 72 000 insulators recorded in SAP
- 41 000 photos of structures

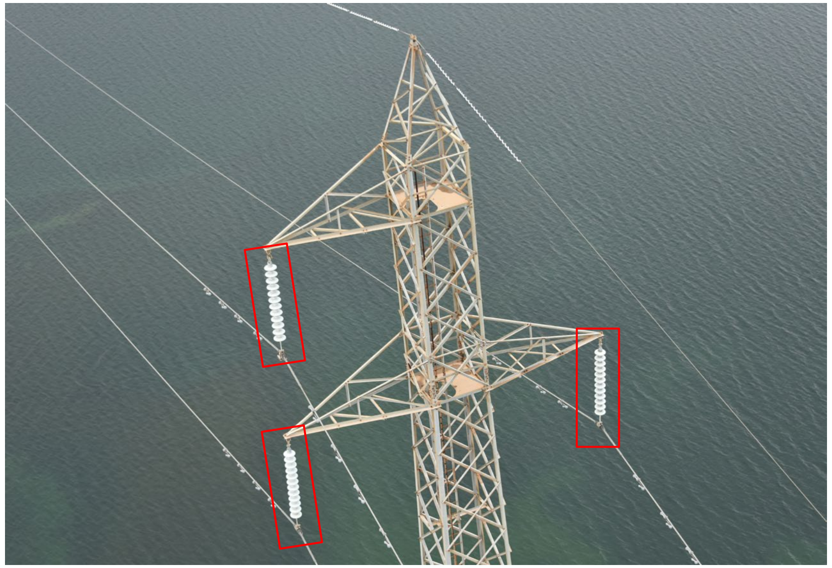
Some important components for a Transmissions line are:

1. **Conductor**
2. **Towers or Poles**
3. **Insulators**



Transmission Lines





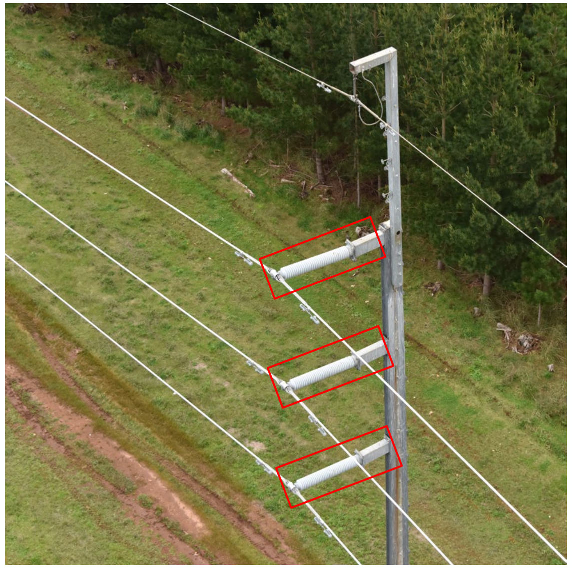


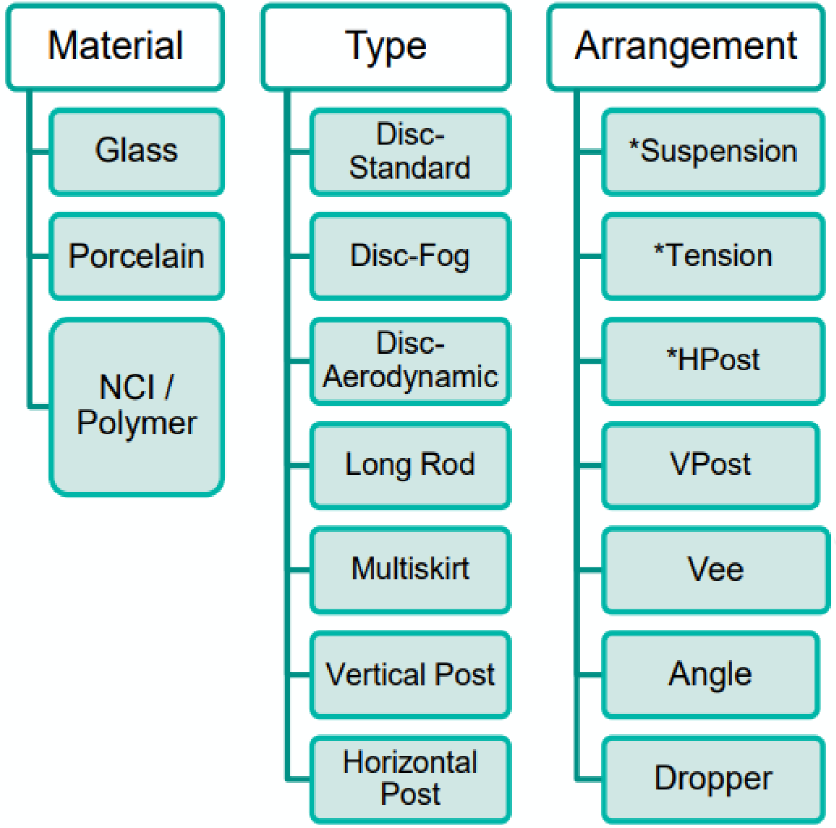
Image Analytics – Insulator Recognition

Business Case

- SAP Data timely update
- SME’s conduct manual audits to verify accuracy of data
- SAP Data validation and assessment using a second data source

Analytical Solution

- KNIME Workflow to detect insulators
- Recognise insulator attributes
- Deployment KNIME Workflow for SMEs to utilise



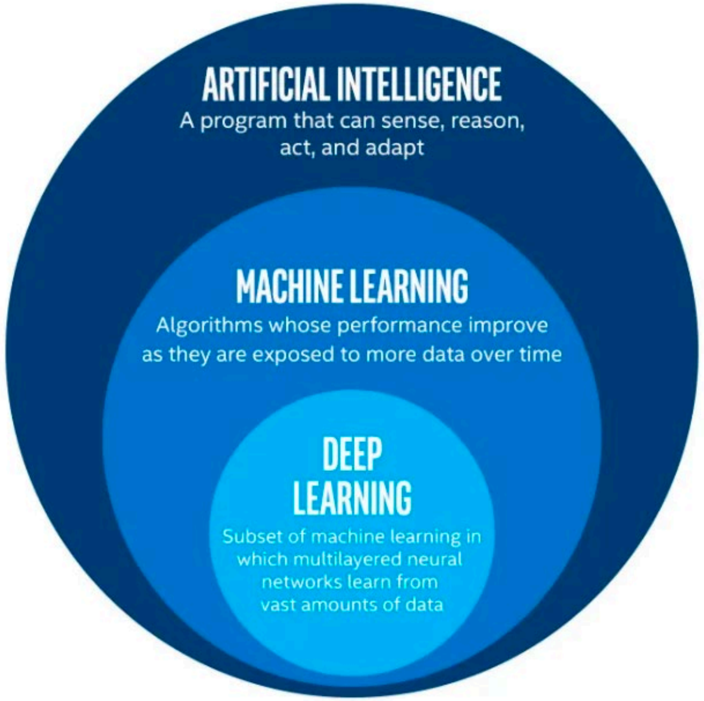
Insulator Detection and Identification

- Machine Learning
- Use Case Presentation
- Outcomes

Machine Learning - Definition

“Machine learning (ML) teaches computers to do what comes naturally to humans: learn from experience” [1]

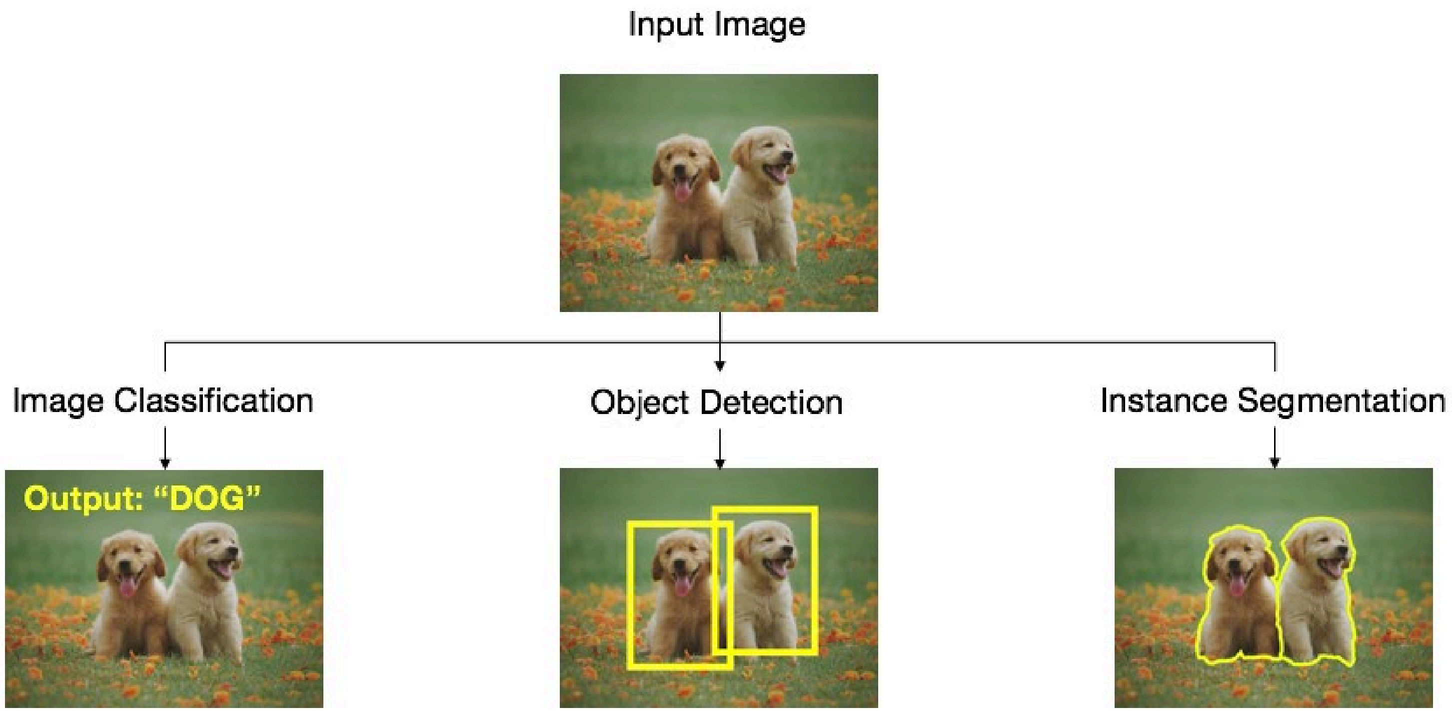
- Arthur Samuel (1959) [2]
- Algorithms “learn” information from data and improve their performance
- Training an algorithms result in a ML model
- Daily usage: deepl, chat GPT, Siri, …



[1] Peck W.G., *Machine Learning Techniques Using MATLAB*, North Charleston, SC: CreateSpace Independent Publishing Platform, 2017.
[2] SamuelA.L.,“SomestudiesinmachinelearningusingthegameofCheckers”,*IBMJournal of Research and Development*, 1959, 3(3): pp. 210–229, https://doi.org/10.1147/rd.33. 0210.
Image source: https://ai.stackexchange.com/questions/15859/is-machine-learning-required-for-deep-learning

Image Classification, Object Detection, and Instance Segmentation

- **Image classification** is a task in computer vision that aims to understand and categorize an image as a whole under a specific label.
- **Object detection** involves classification and location of multiple objects within an image.
- **Instance segmentation** is a computer vision task that involves identifying and separating individual objects within an image, including detecting the boundaries of each object.



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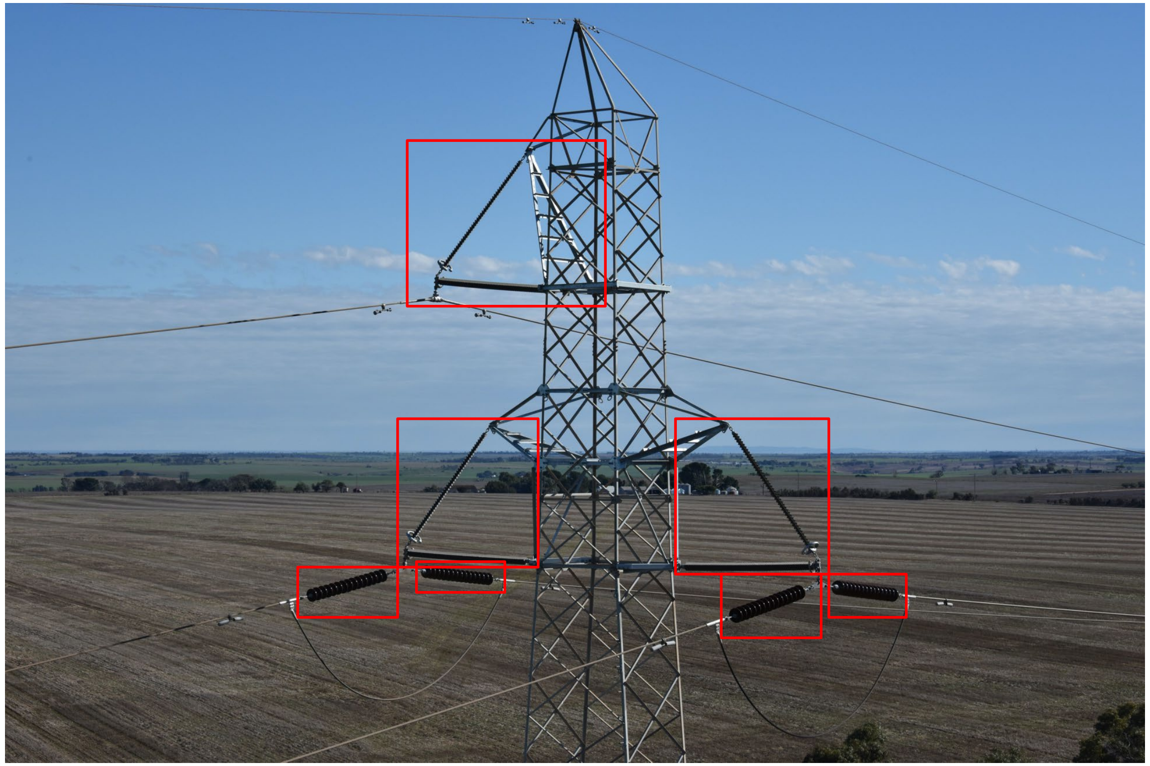
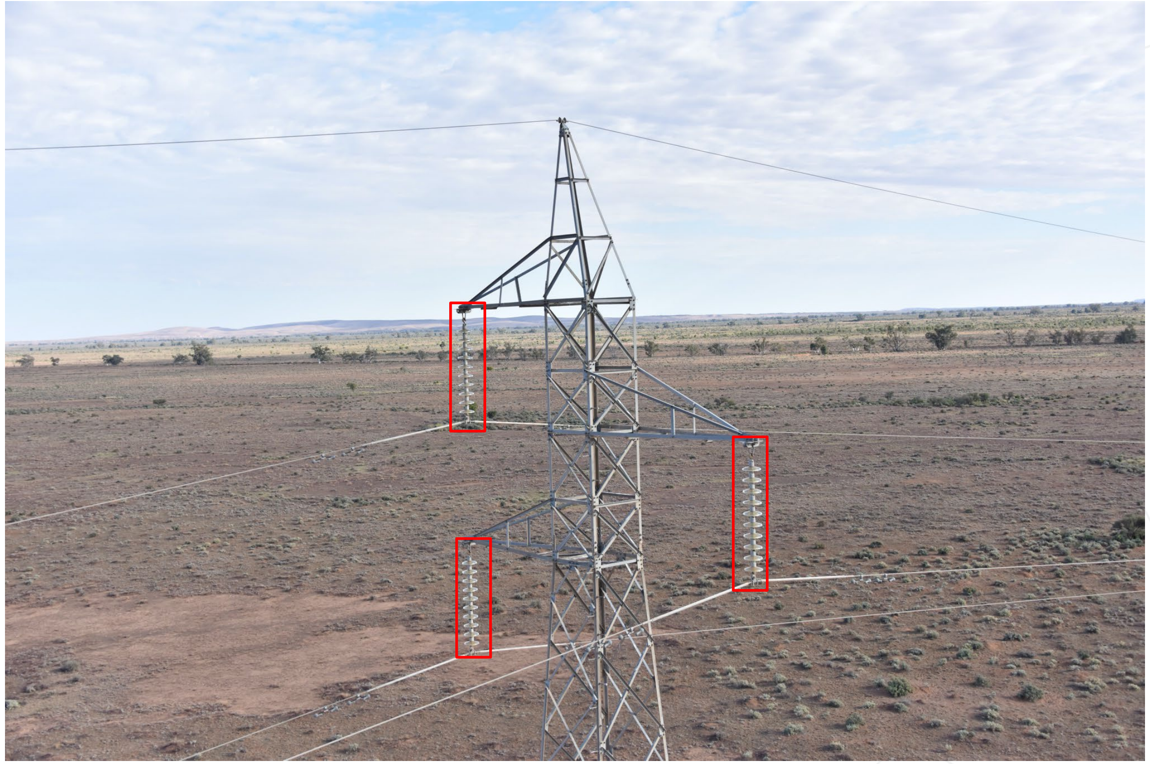
Insulator Detection





Insulator Detection

The dataset is split into three subset:

1. **Train** – Used to train (or retrain) a ML model. The model learns from the available data. The data needs to be representative from the reality.
2. **Validation** – Used to validate the ML model after each epoch or training iteration. It assesses the quality of the ML model and allows to identify overfitting.
3. **Test** – Used as test dataset once the ML mode is ready to be deployed.

We labeled **257 images** for insulator detection. Using data augmentation allowed us to obtain **1492 labeled** images.

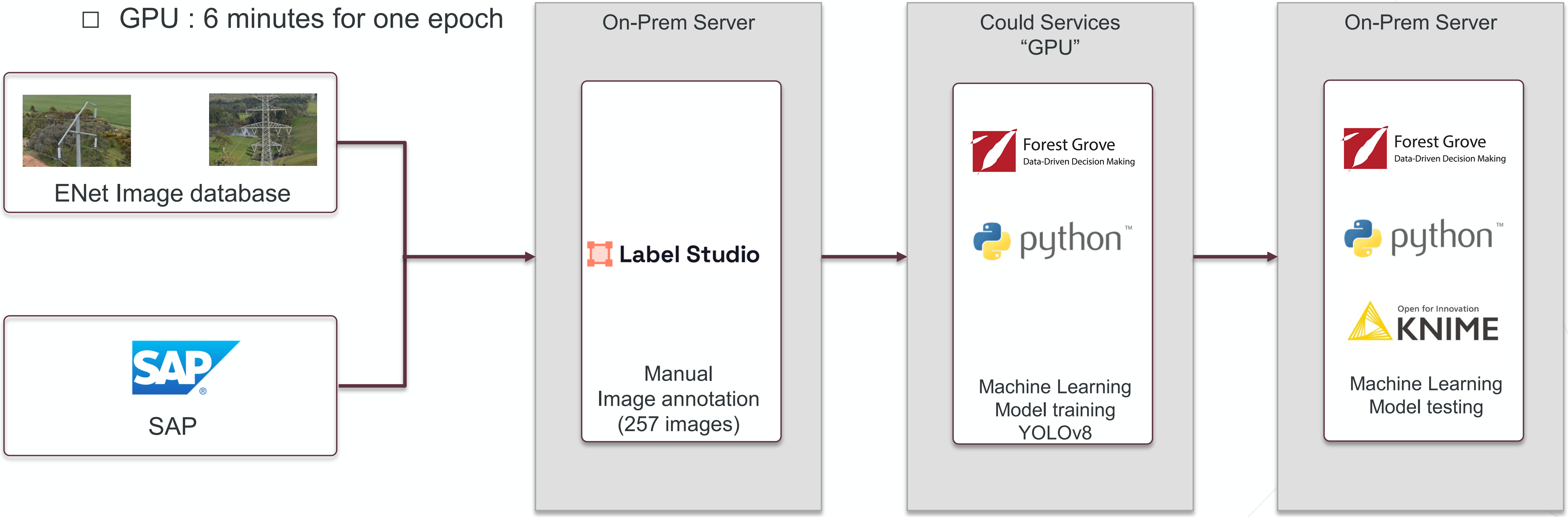
We changed the color, the orientation, the brightness, the blur, and the contrast.





Image Analytics – Insulator Recognition

- Training framework
  - ☐ CPU vs GPU
  - ☐ CPU : 11 hour for one epoch
  - ☐ GPU : 6 minutes for one epoch



ML Model

- YOLO (v8) - You Only Look Once
  - ☐ Popular object detection and image segmentation model
  - ☐ Fast and accurate – close to realtime
  - ☐ Continuous support of the community
  - ☐ Existing Python frameworks
- Retrain of a pre-trained model
  - ☐ 300 epochs (training iteration)
  - ☐ Batch size of 2
  - ☐ Initial Learning rate of 0.01
- Images of various dimensions
- Cross Entropy Loss

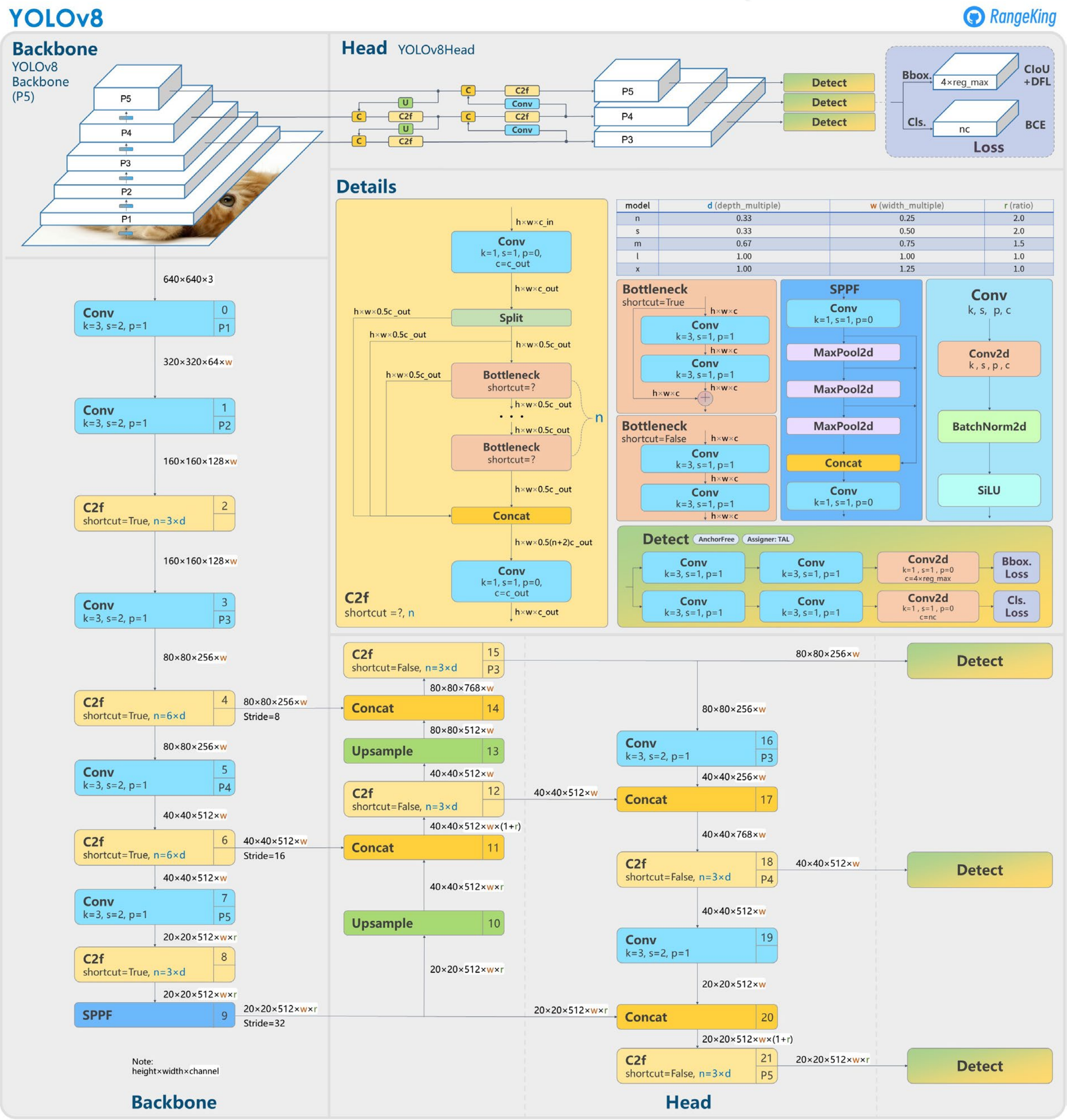


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Image Analytics – Insulator Recognition

Design: Deployment

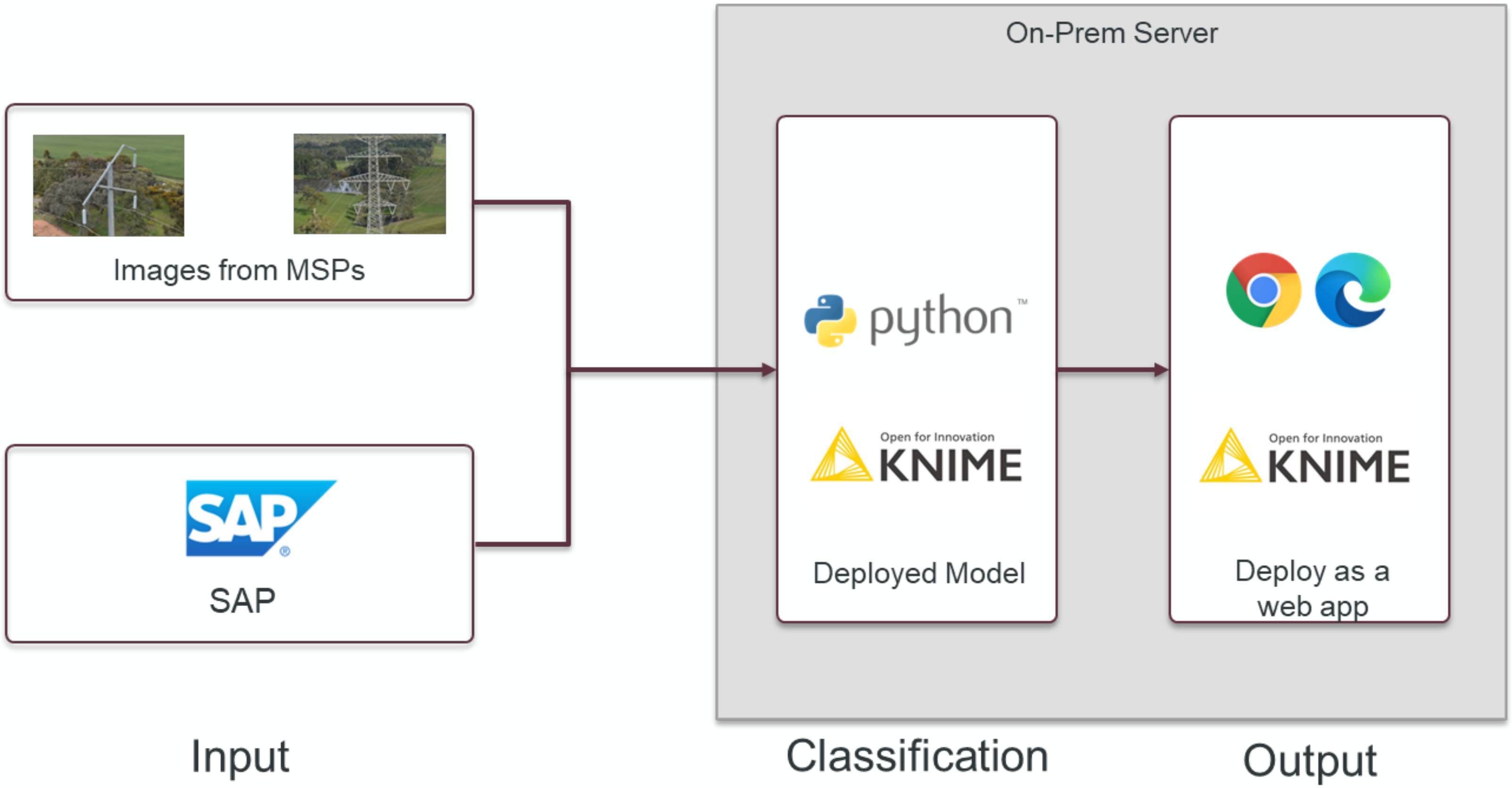


Image Analytics – Insulator Recognition

- Asset Information Team within ElectraNet
- Deployed in **production** as a **Data Apps** on KNIME Server
- Insights for the business

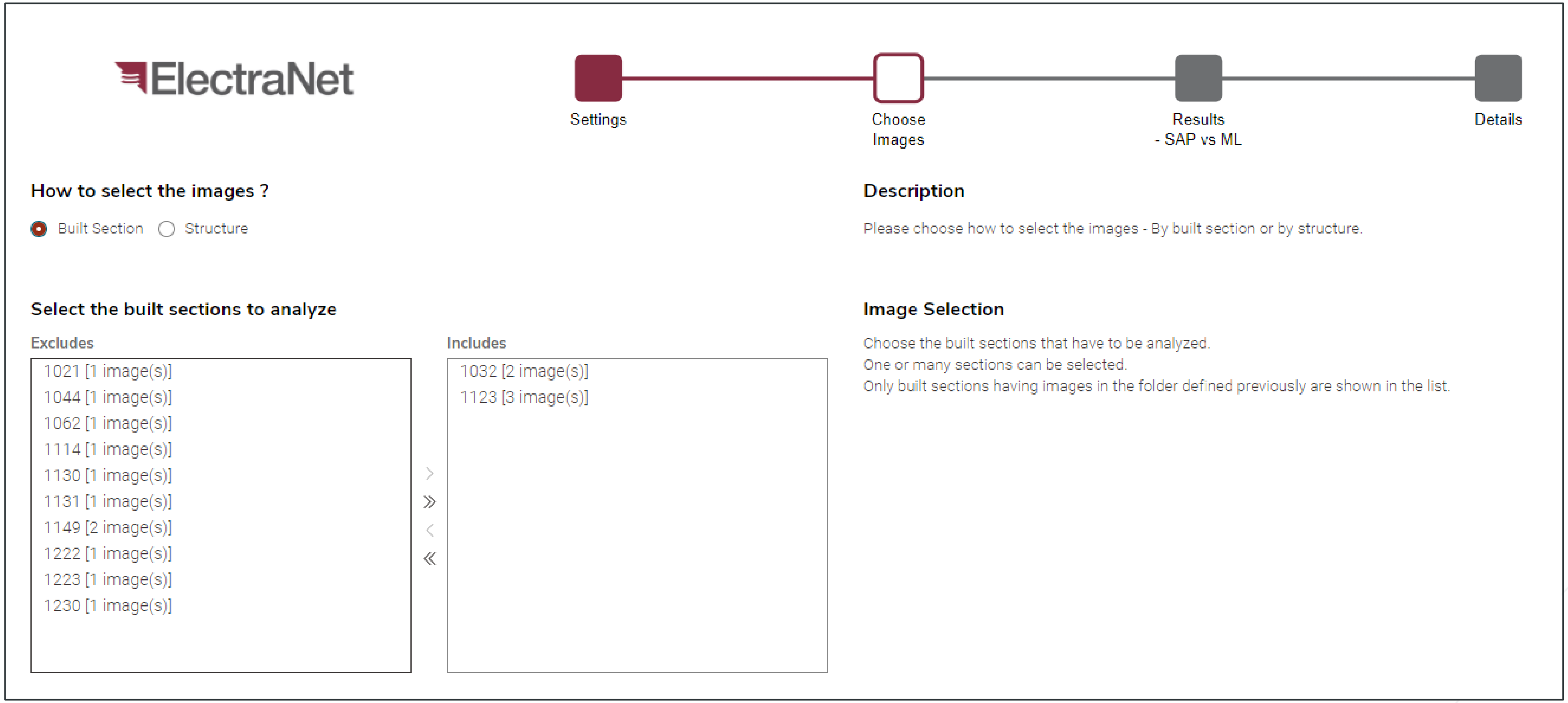
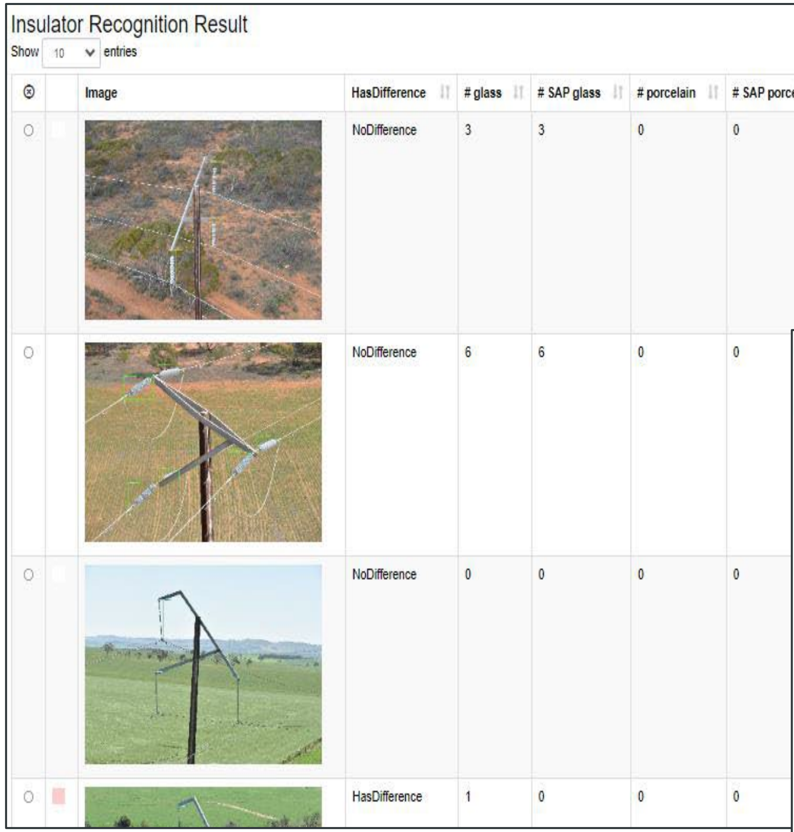


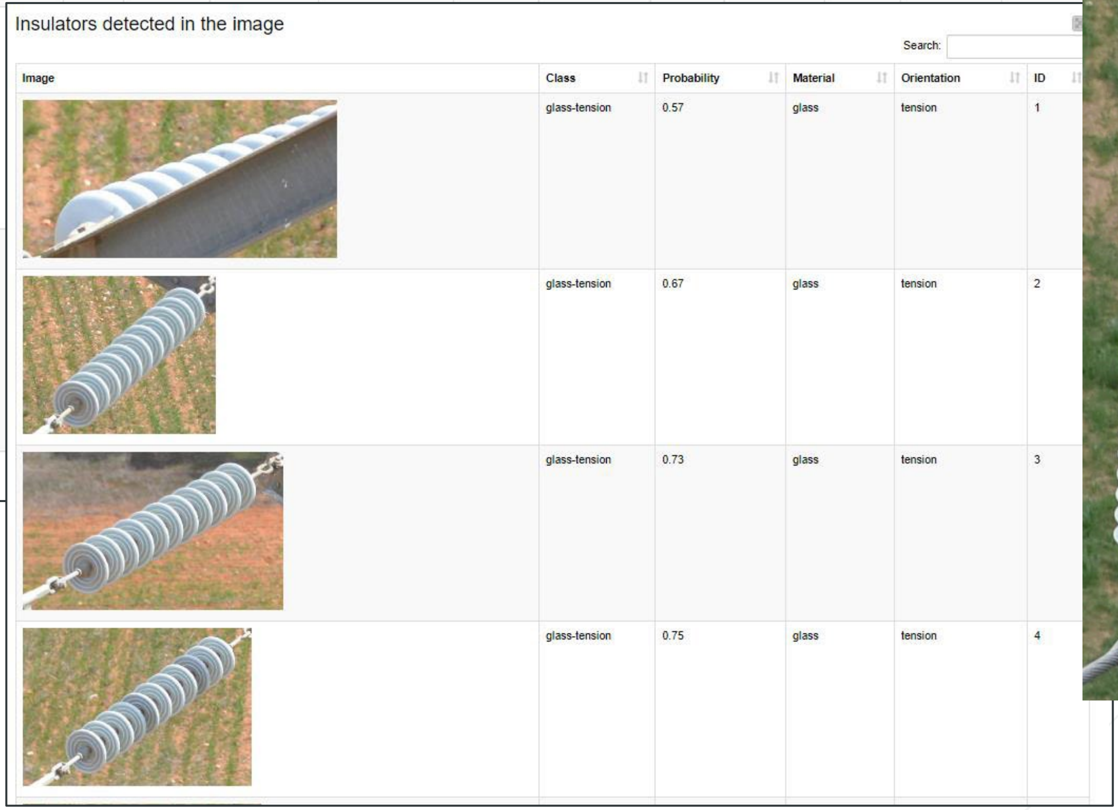
Image Analytics – Insulator Recognition



Insulator Recognition Result

Show 10 entries Search:

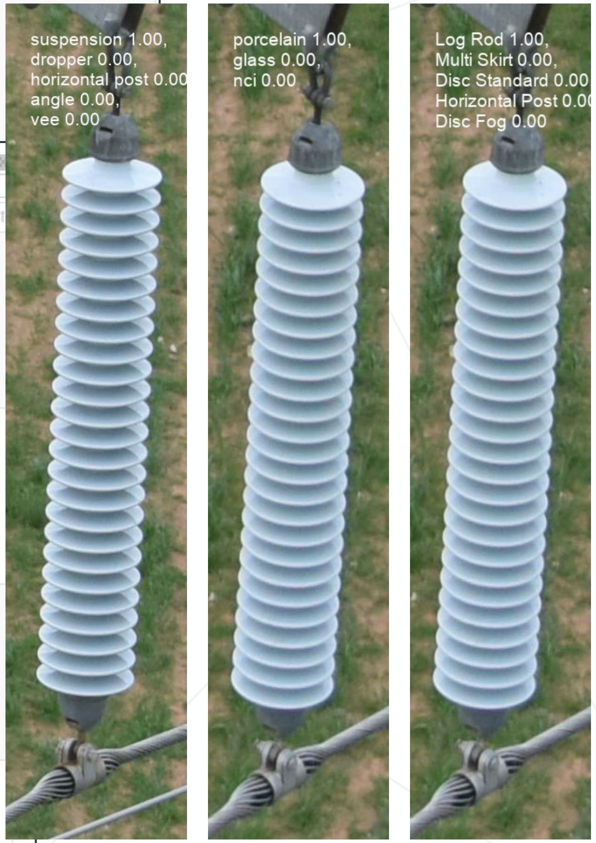
Image	HasDifference	# glass	# SAP glass	# porcelain	# SAP porcelain	# nci	# SAP nci	# suspension	# SAP suspension	# tension	# SAP tension	# angle	# SAP angle	# hpost	# SAP hpost	filename-link
	NoDifference	3	3	0	0	0	0	3	3	0	0	0	0	0	0	1032-STR-1084 [GLASS+SUSPENSION]
	NoDifference	6	6	0	0											
	NoDifference	0	0	0	0											
	HasDifference	1	0	0	0											



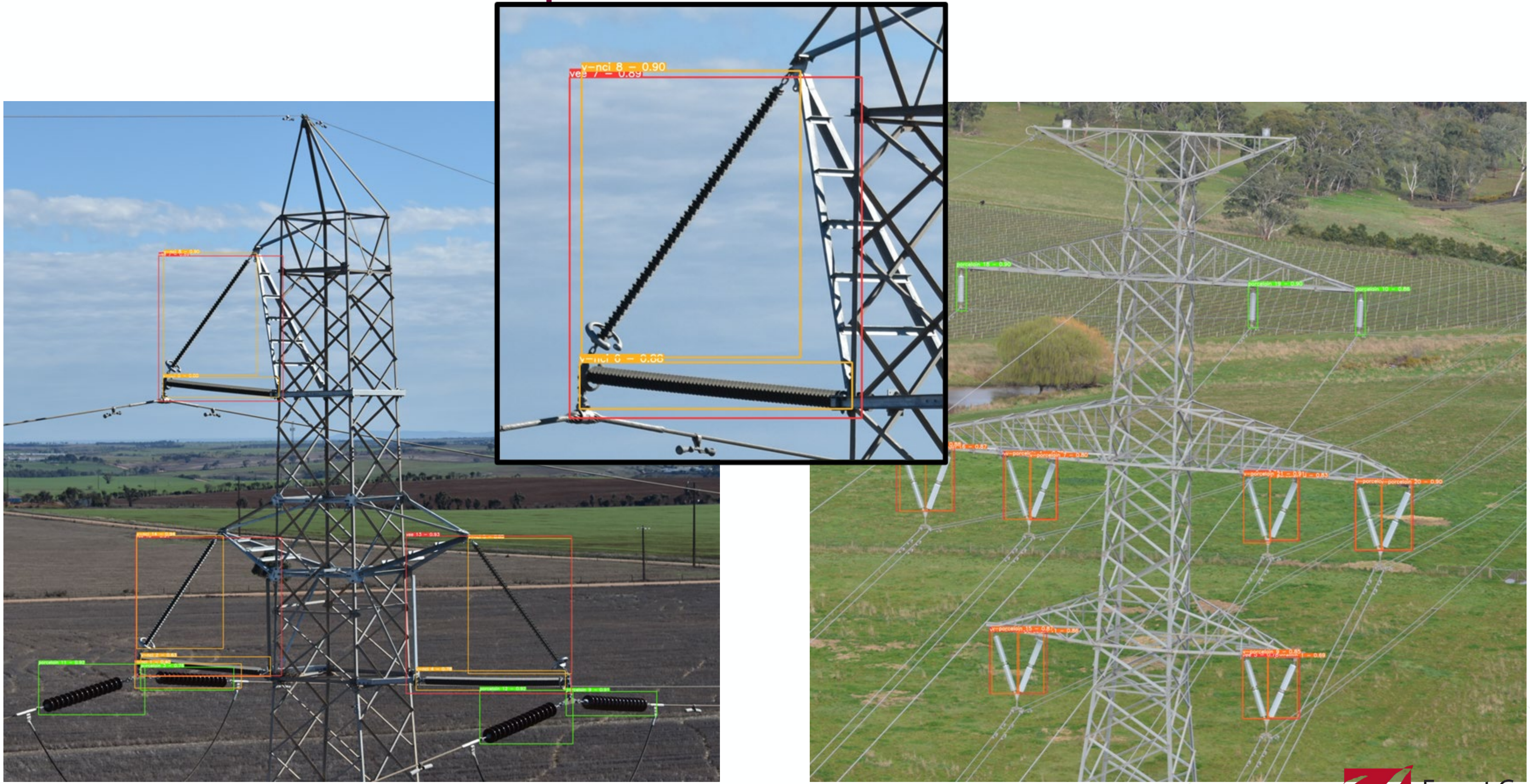
Insulators detected in the image

Search:

Image	Class	Probability	Material	Orientation	ID
	glass-tension	0.57	glass	tension	1
	glass-tension	0.67	glass	tension	2
	glass-tension	0.73	glass	tension	3
	glass-tension	0.75	glass	tension	4



Insulator Detection Output



Insulator Detection Output and Error Analysis

- Overall accuracy : ~98% (±0.25%)

Scorer View

Confusion Matrix

	glass (Predicted)	nci (Predicted)	porcelain (Predicted)	
glass (Actual)	78	0	1	98.73%
nci (Actual)	0	29	0	100.00%
porcelain (Actual)	0	2	158	98.75%
	100.00%	93.55%	99.37%	

Scorer View

Confusion Matrix

	Disc Fog (P...	Disc Standa...	Horizontal ...	Log Rod (Pr...	Long Rod (...	Multi Skirt (...	
Disc Fog (A...	3	0	0	0	0	0	100.00%
Disc Stand...	0	146	0	0	0	0	100.00%
Horizontal ...	0	0	30	0	0	0	100.00%
Log Rod (A...	0	0	0	26	0	0	100.00%
Long Rod (...	0	0	0	0	39	0	100.00%
Multi Skirt (...	0	0	0	0	0	24	100.00%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	

Scorer View

Confusion Matrix

	angle (Pred...	dropper (Pr...	horizontal p...	suspension...	tension (Pr...	vee (Predict...	
angle (Actual)	9	0	0	0	0	0	100.00%
dropper (A...	0	6	0	0	0	0	100.00%
horizontal ...	0	0	14	0	0	0	100.00%
suspension...	0	0	0	134	0	0	100.00%
tension (Ac...	0	0	0	0	49	0	100.00%
vee (Actual)	0	0	0	0	1	55	98.21%
	100.00%	100.00%	100.00%	100.00%	98.00%	100.00%	

Project Outcomes

- Improving the SAP database accuracy
- Reducing the human error in analysis
- Generic methods
  - Useable for other applications
  - Retraining of the model
- Opened discussions with SMEs on how we can Utilise KNIME and ML to provide meaningful solutions
  - Success of the project and flexibility of KNIME
- Reducing manual work (Estimated to around 80%)
  - Team focusing on our task of the business
- Can be run on demand
- Running over 24/7

Estimate for 1 image per Tower – If no Human Interaction required

- ~15,000 images of towers
- Manual check takes ~2 minutes for a human (~21 days)
- Working days (~63 days)
- Loading and Auto check takes ~10 seconds for the ML model (~2 days)
- Saving ~61 days (~95%)

Estimate for 1 image per Tower – Interaction required on 20%

- ~3000 images requiring human interpretation
  - Manual check takes ~2 minutes for a human (~12 working days)
- Saving ~51 days (~81%)

What's Next ? Shackle Steel Loss Measurement

The shackle holding the insulators and electrical cables deteriorate due to the weather and the continuous strain.

Currently, engineers are manually measuring the steel loss proportion using images acquired by helicopter patrols.

This project aims to help ElectraNet engineers to evaluate the steel loss and to measure the size of the remaining hardware.

Thank You

For more information please contact:

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