AP SENSING
advanced photonic

## RAIL MONITORING

# The Use of Machine Learning for the Engineering of DAS Applications for the Railway Sector

# Presentation Overview

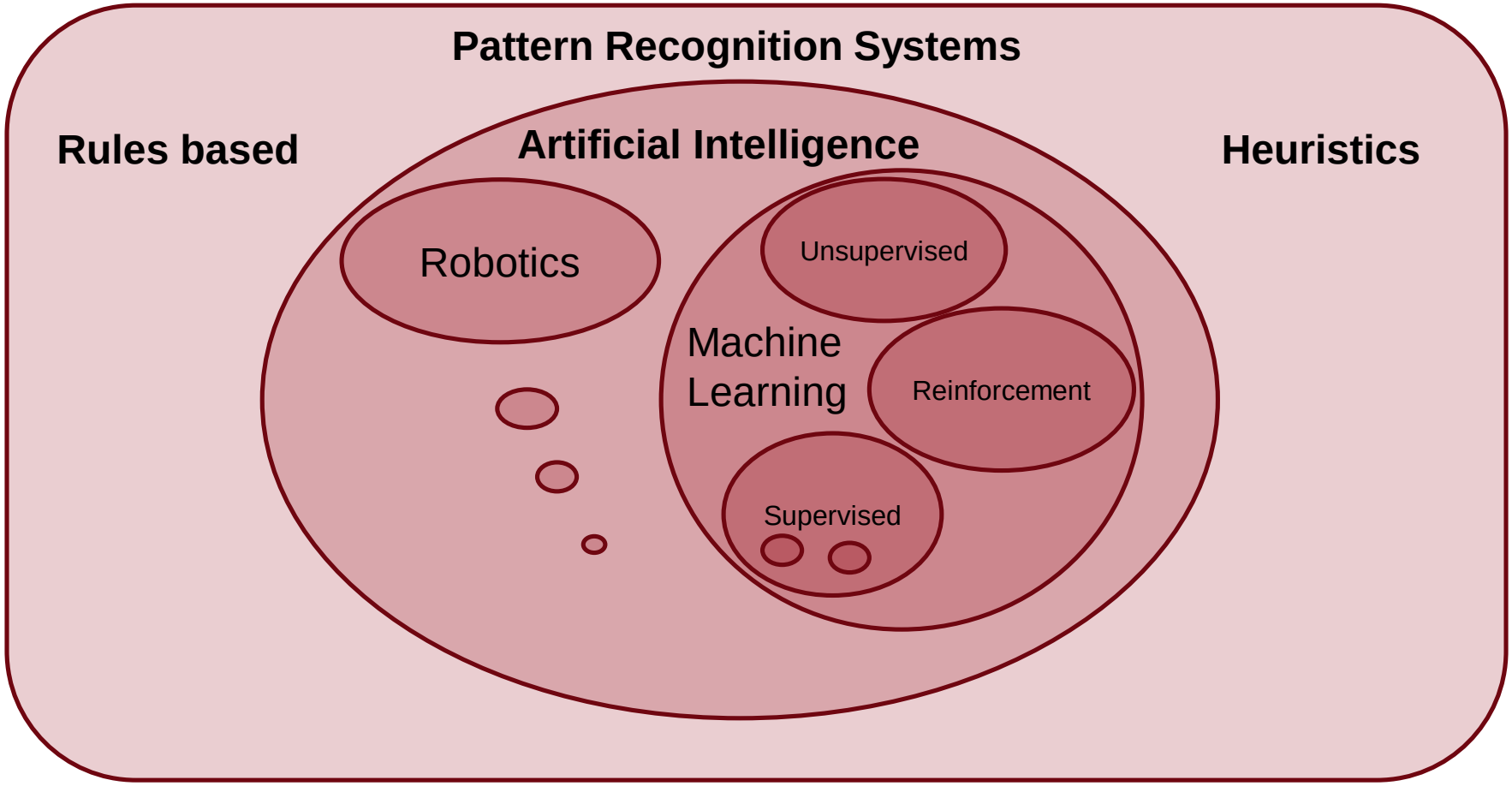
**Introduction**

- Terminology
- History
- Technology Enablers
- Technology Growth

**DAS and Machine Learning**

- Overview
- Machine Learning
- Examples

# Terminology



# Machine Learning Techniques

**Supervised Learning**

- Trained with known information
- We are training the system
- Linear / Logistic regression

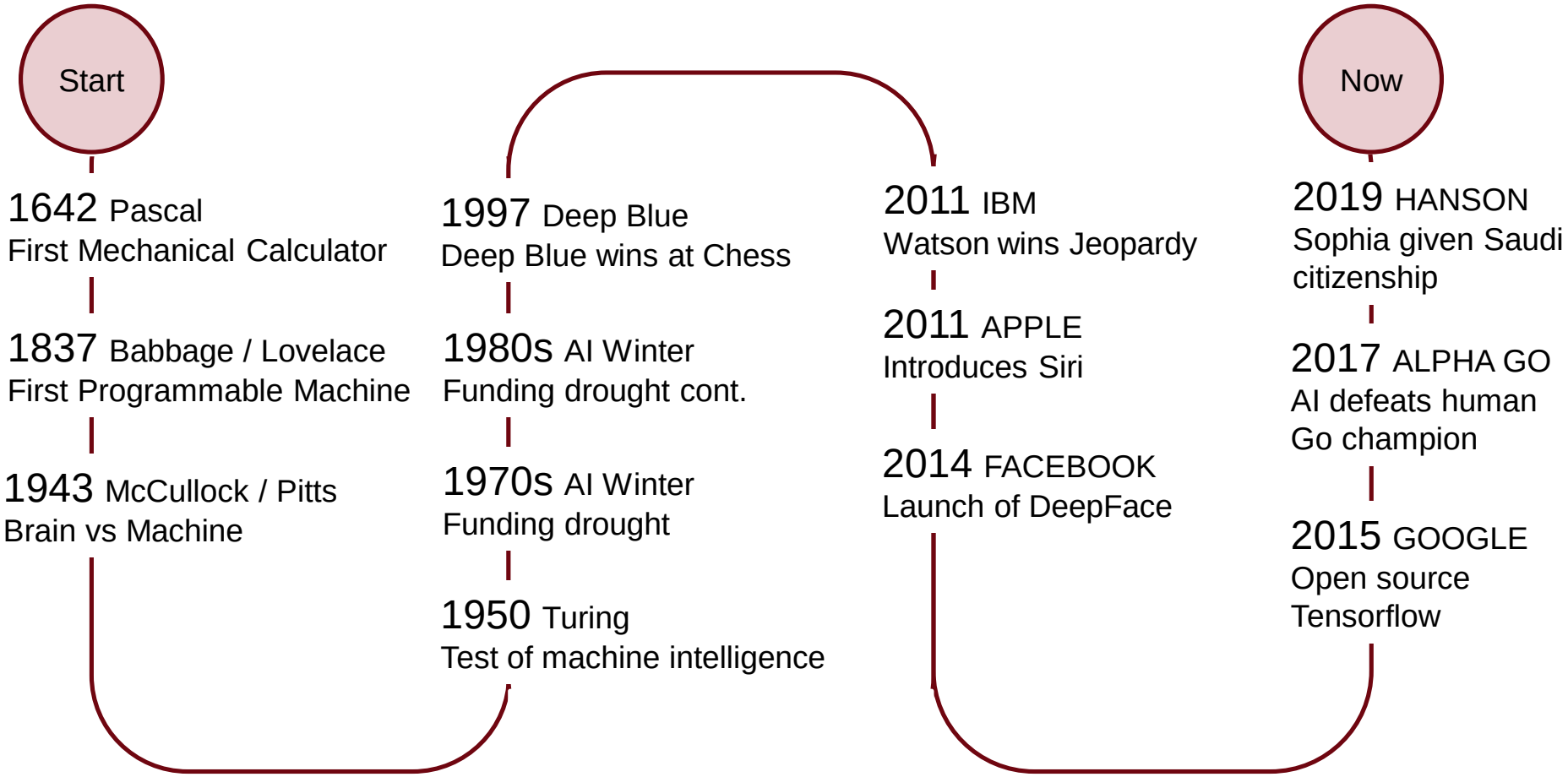
**Unsupervised**

- Expectation Maximisation
- Cluster analysis

**Reinforcement Learning**

- AI in machine learning
- Deep Mind
- Goal Based
- Action orientated system trains itself
- Deep Q

# History of Artificial Intelligence



# Technology Enablers

Initial models are prototyped and trained using a combination of:

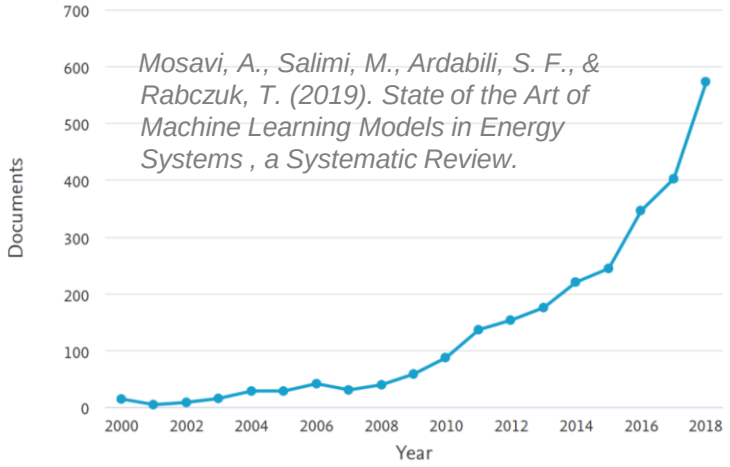
- Python
- Keras (Neural Network python wrapper)
- Sci-kit Learn ( Data pre-processing)
- Flask + Gunicorn ( Rest API)
- Tensorflow ( Google Neural Network Backend)

Realtime system uses C++ / Tensorflow

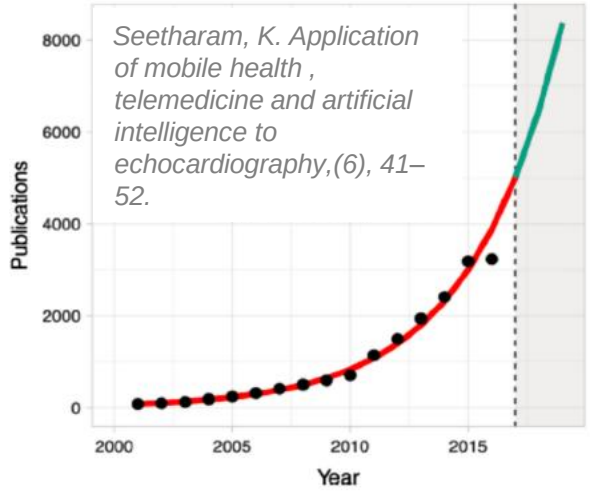




# Growth in Machine Learning

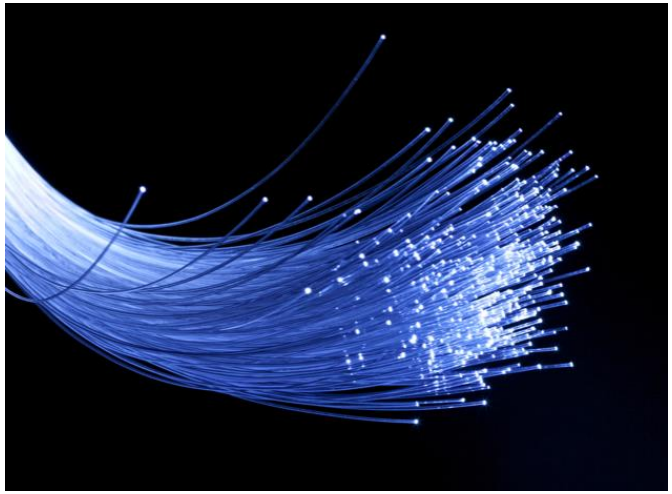


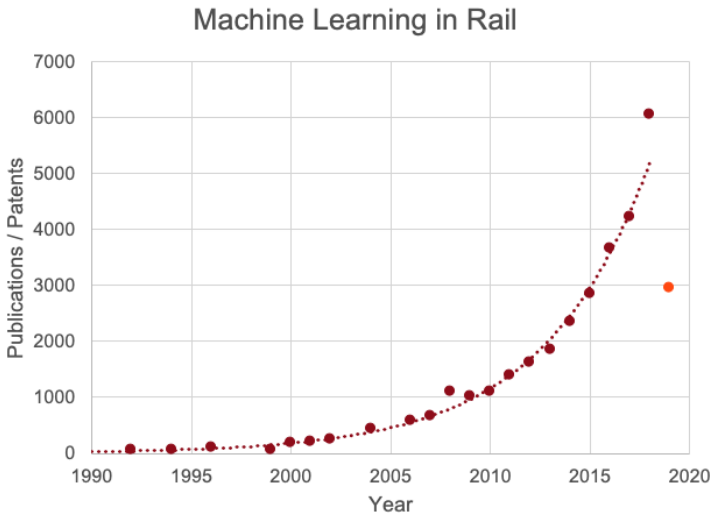

Energy Systems

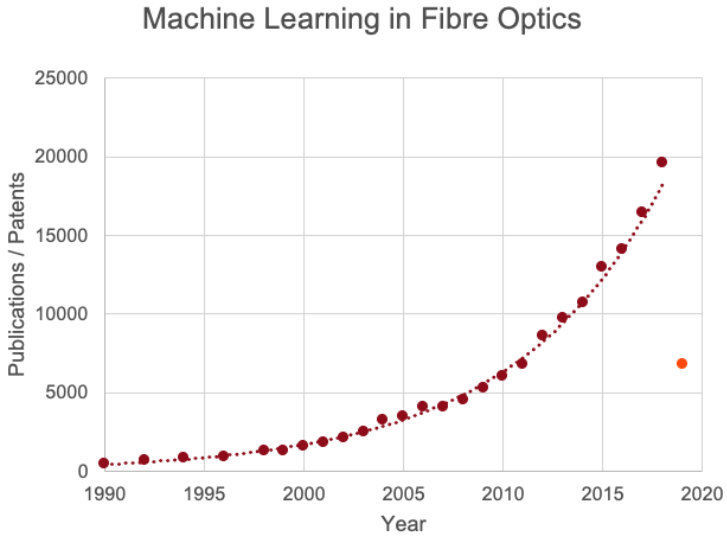



Medical Science

# Growth in Machine Learning






# DAS and Machine Learning

# DAS Overview


## N5200A Distributed Acoustic Sensing

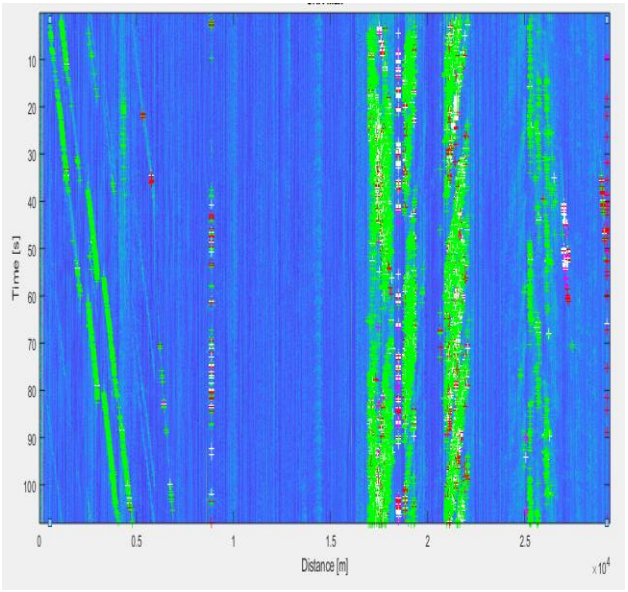
**Product Specifications**

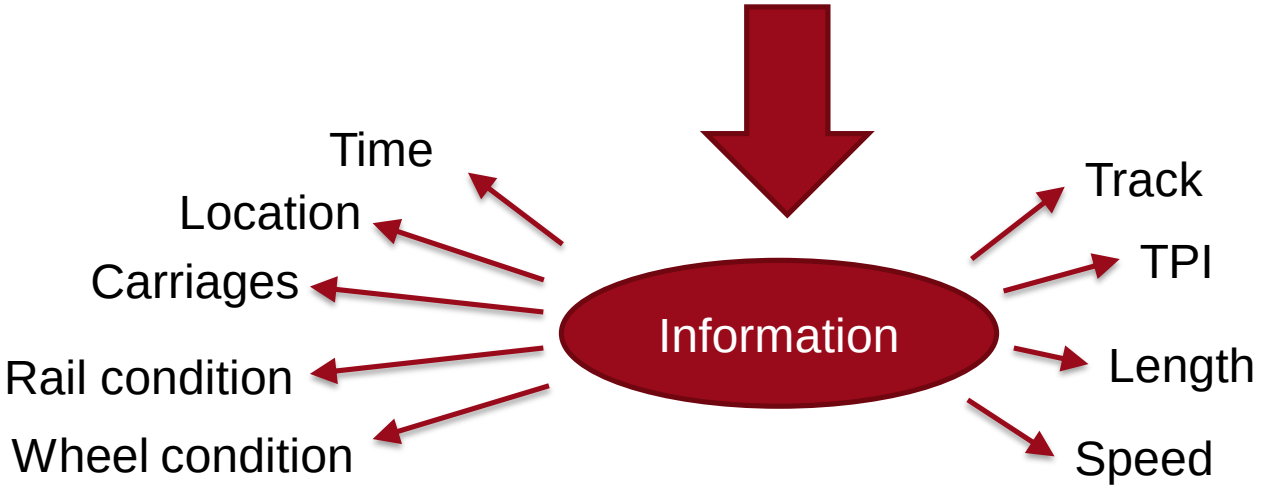
Each DAS instrument is individually tested before shipping. This ensures that every DAS unit will meet or exceed the specifications in this datasheet. Adhering to our stringent quality control measures guarantees optimal performance and a long product life.

**DAS Specifications – Typical Performance**

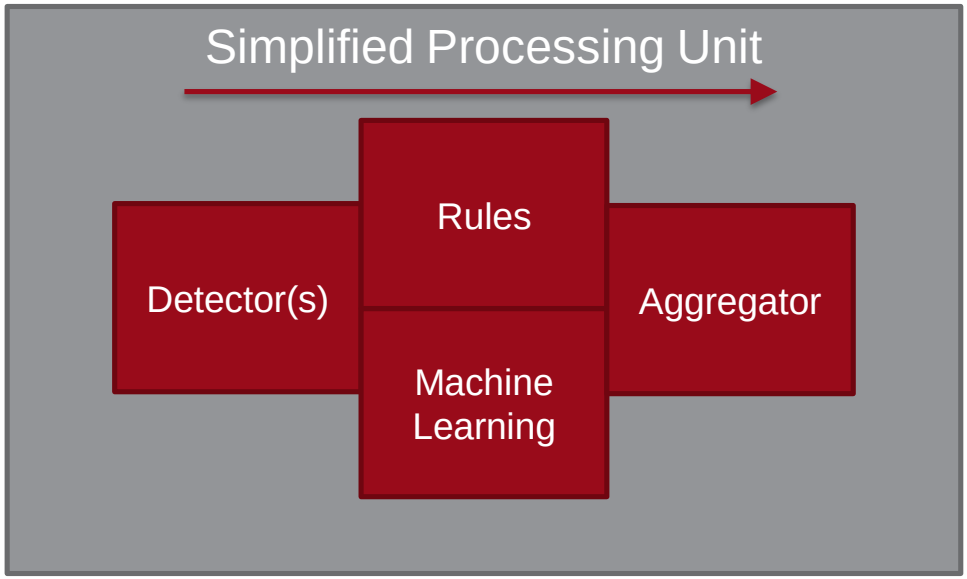
| | Distributed Acoustic Sensing N5200A |
|---|---|
| Distance range | 70 km (N5200A-R70)<br>50 km (N5200A-R50)<br>20 km (N5200A-R20) |
| Channel option | 1 (N5200A-C01)<br>2 (N5200A-C02)<br>4 (N5200A-C04)<br>8 (N5200A-C08) |
| Output Spatial Sampling interval | 1.25 m, 2.5 m and 5 m |
| Spatial resolution (gauge length) | 5 m, 10 m, 20 m and 40 m |
| Acoustic sampling rates | 1 kHz, 2 kHz, 2.5 kHz, 5 kHz<br>10 kHz and 20 kHz |
| Sensor fiber | 9/125 µm single mode |
| Operating wavelength | 1550 nm |
| Laser class<br>(IEC 60825:1 (2007)) | LASER CLASS 1 (invisible laser radiation) |
| Connector | E2000 APC 8° SM |

LASER CLASS 1



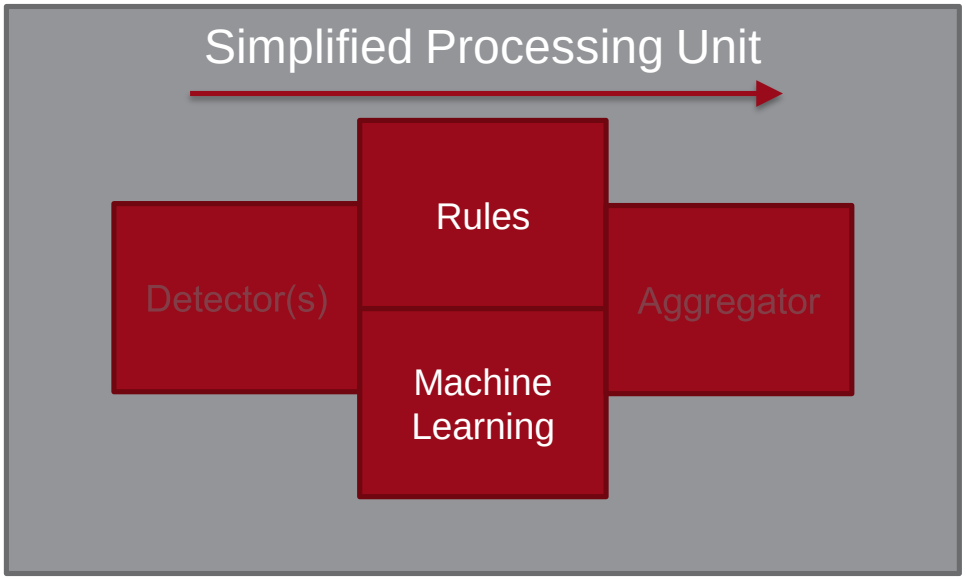



# DAS Processing .. 1


Information

# DAS Processing .. 2




**Rules**

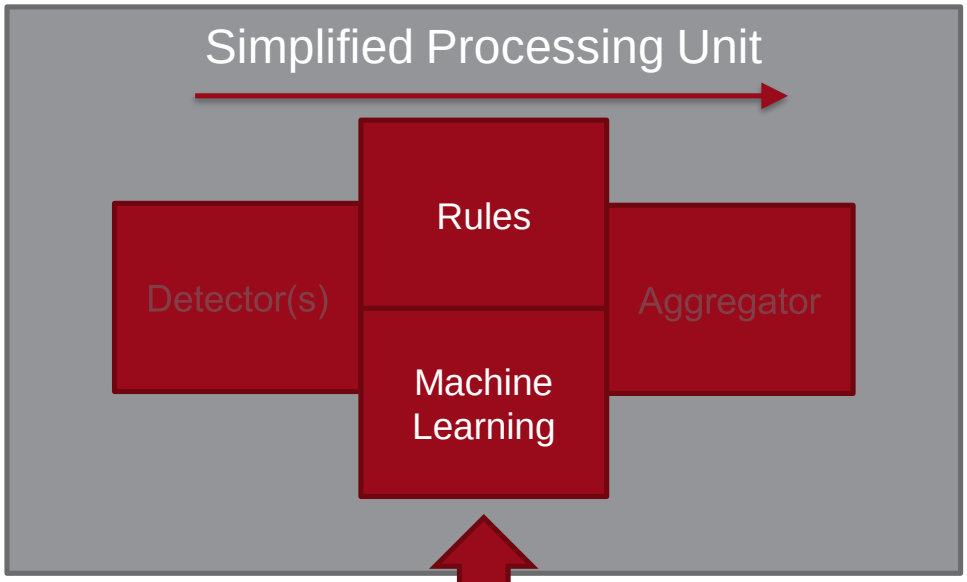
Is it moving or stationary?
Velocity (max / min)
Size (width / extent)
Duration
Location

**Machine Learning**

Do the features match any trained events?

- Cars
- Digging
- Walking
- Trains

# Data Processing .. 3



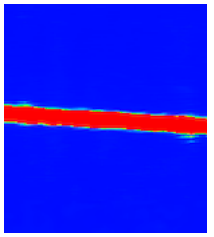

Information

Event Library

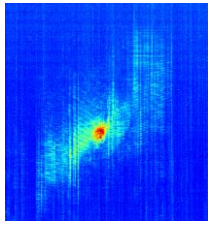
Neural Network Classifier

Trained Model

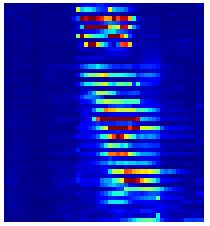
trains



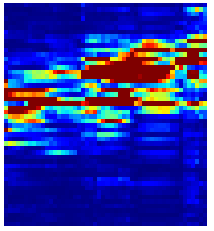
shipping



walking

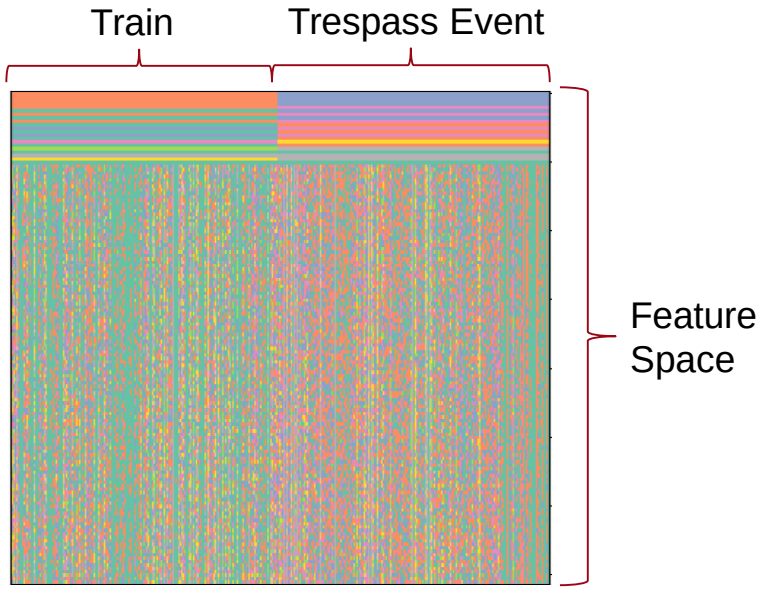


cars



# Machine Learning

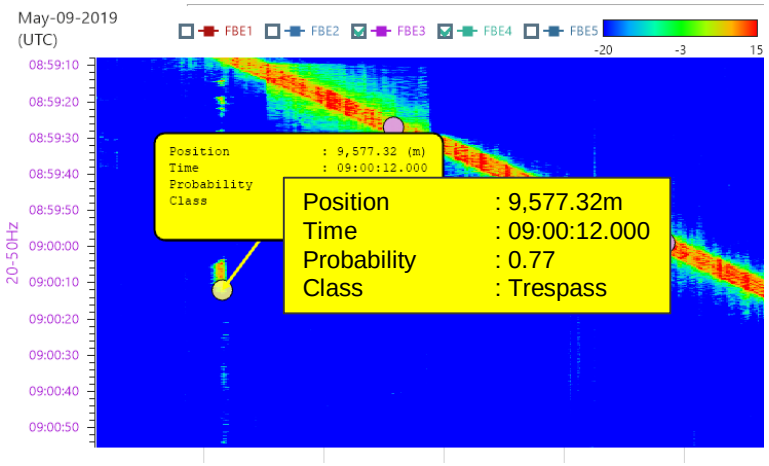
Using unique features of the AP Sensing DAS and some intelligent digital signal processing it is possible to create a “feature space” in which an ANN model can discern between trespass events and other events such as trains.



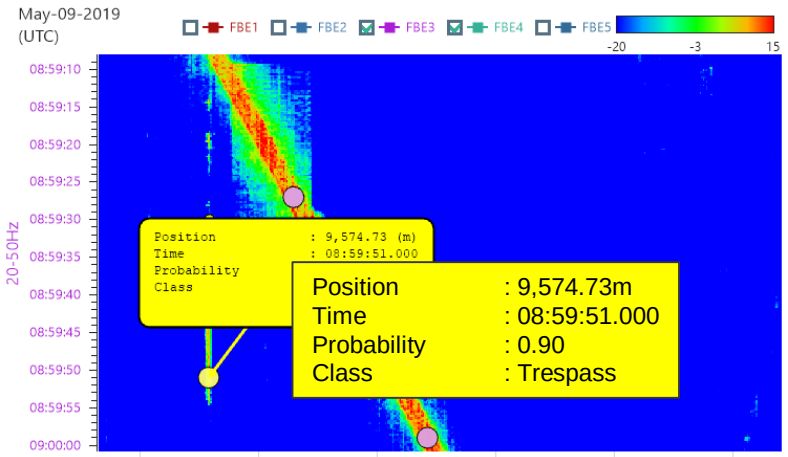

This model contains two classes (many events) and many features. The ANN uses the features to make a decision which the class of an input event.

# Machine Learning .. Trespass Events

ML module disabled




ML module enabled

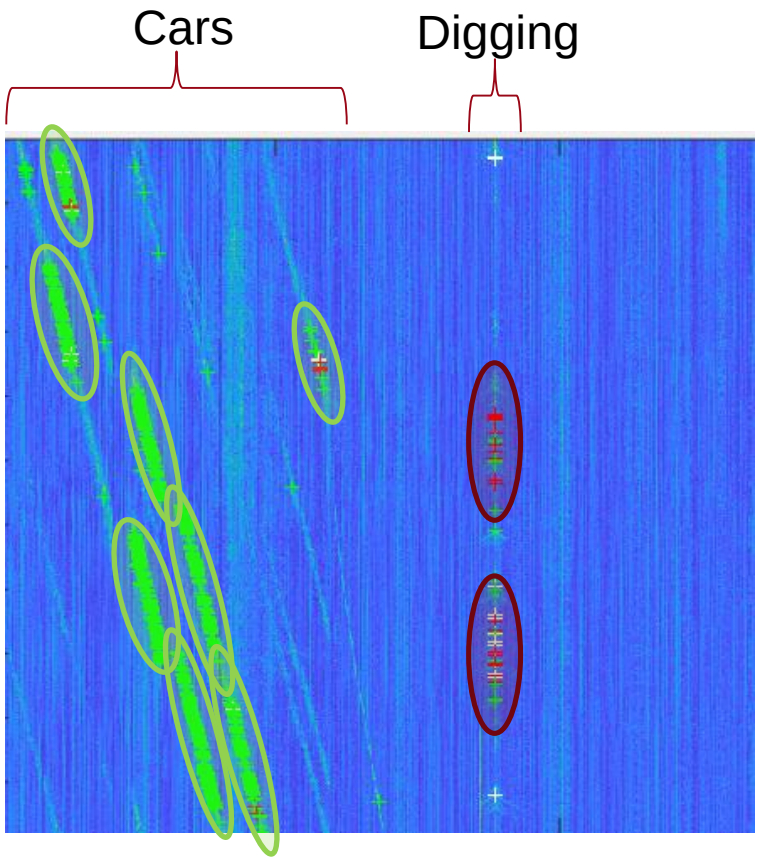



Improved event knowledge can lead to lower false alarm rates

# Machine Learning … TPI

Early example of ML application
Each marker is an ML tagged event

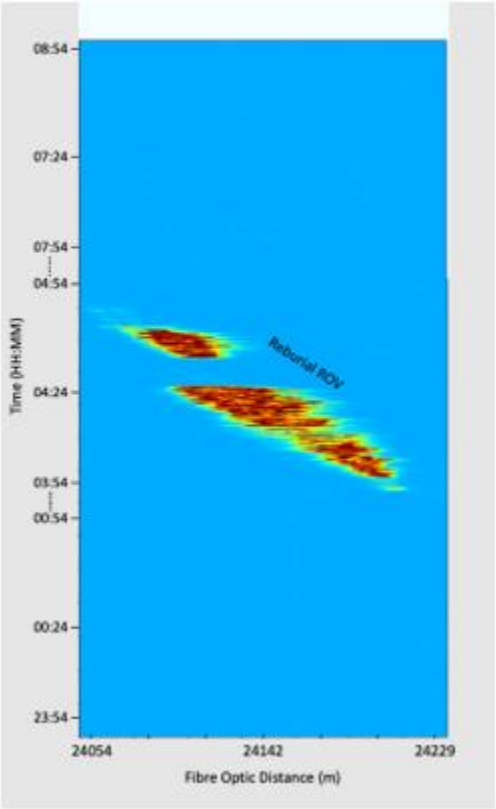
AP Sensing ML library contains millions of events

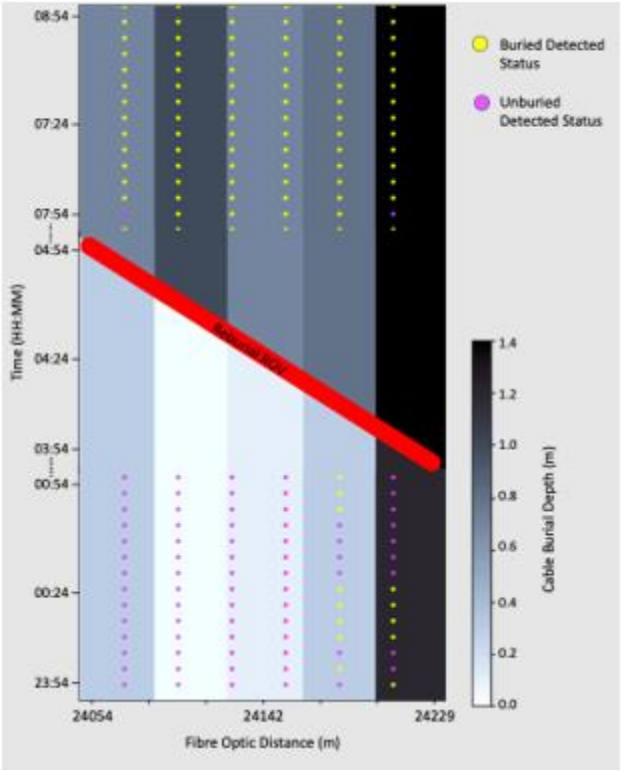



Unclassified
Car
Digging
Walking

# Machine Learning .. Ship Monitoring

Reburial of Subsea Power Cable
Machine Learning used to determine buried vs exposed sections



# Machine Learning … Telemetry

Prognostic Health Monitoring

- Use machine learning for prediction of failures in components
  - Fan filter replacements
  - Hard drive failures
- Changes in Environment
  - Failure of air-conditioning

**Features**

- Enclosure Fan Speed
- CPU Fan Speed
- CPU temperature
- Disk Temperatures
- CPU Utilization
- Disk SMART outputs

**Labels**

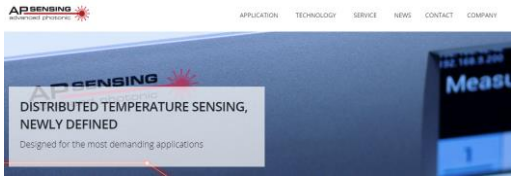
- Reduced air flow due to blocked filter
- Higher temperatures due to AC failure
- Failing disks
- Normal Operation

# Summary

- Machine Learning techniques are a powerful tool in the toolbox of signal processing techniques
- DAS data quality is important, high dynamic range and repeatable signals are an essential part of successful deployment
- Machine Learning is one part of a system which when combined with other signal processing techniques can be used to minimize false / nuisance alarms whilst maximizing the probability of detection
- Will continue to improve over time
- Readily available tools to increase speed of deployment

Questions ?

## More Information




http://www.apsensing.com

https://www.linkedin.com/company/ap-sensing/

**Acknowledgements**
Claudia Cantini, Jacques Malaprade, Rosalie Rogers, Andrew Pearce, Ryan Hunt