ECT
Engineering College of Technology.

Practical Use of AI in Industrial Automation

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Dr. Hadi Harb



UKPRN: 10089771

Agenda

1	Welcome and Introduction
2	What is Artificial Intelligence?
3	Terminology
4	Building an Artificial Intelligence System
5	Case Studies
6	Conclusion and Q&A



Introduction – Presenter

Dr. Hadi Harb



- Dr Hadi Harb has more than 20 years of experience in the development and management of Artificial Intelligence and Audio Signal Processing projects.
- Hadi holds a MEng (2000) in electrical-electronic engineering. He earned his MSc in 2001 and PhD in 2004 both in computer science from the Institut National des Sciences Appliquées INSA Lyon, and the Ecole Centrale de Lyon respectively.
- In 2005 he co-founded and managed Ghanni, a company specialized in multimedia content recommendation and identification. His focus in on the application of AI techniques to solve real world problems.
- Hadi teaches units within EIT's Professional Certificates of Competency, Advanced Diplomas and Master of Engineering degrees.

What is Artificial Intelligence?

What is Intelligence?



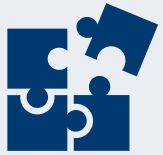
Is it having a consciousness?

What about animals?



Is it solving complex problems? What is a complex problem?

It is making calculations? Is it recognizing objects?



Is it making abstractions?



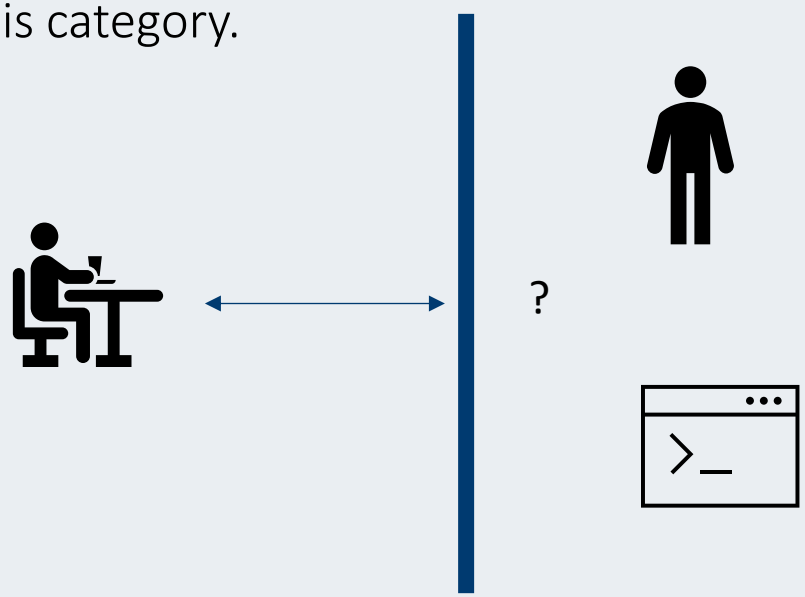
How do we gauge intelligence?

Act Like a Human

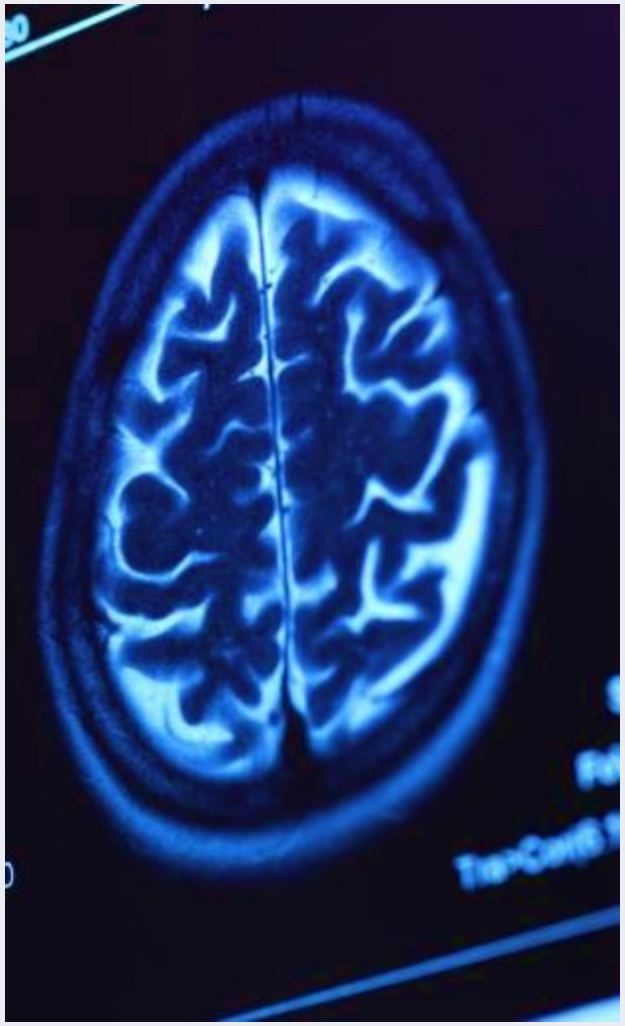
Turing Test

A method of inquiry in artificial intelligence (AI) for determining whether or not a computer is capable of thinking like a human being.

- A human judge interrogates another entity without knowing if it is a machine or a human. If the judge thinks the machine is a human, the machine passes the test.
- Chatbots fall into this category.



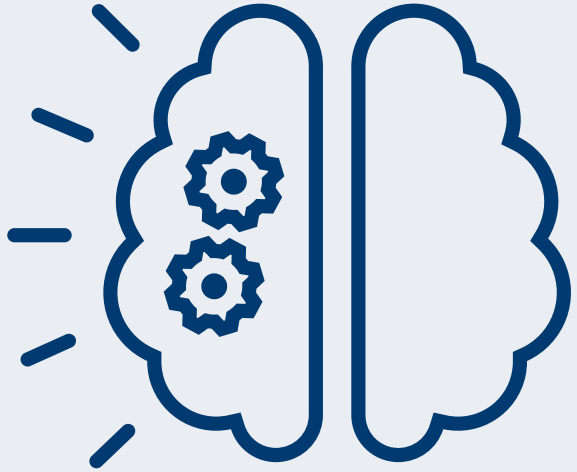
Think like a Human



- Thinking is the act of information processing
  - Cognitive Neuroscience
  - Connexionist approaches were inspired by this category

Think Rationally

- Logic and mathematics
  - *Aristotle*
- But not all intelligent behaviour is mediated by logical deliberation



Weak AI vs Strong AI



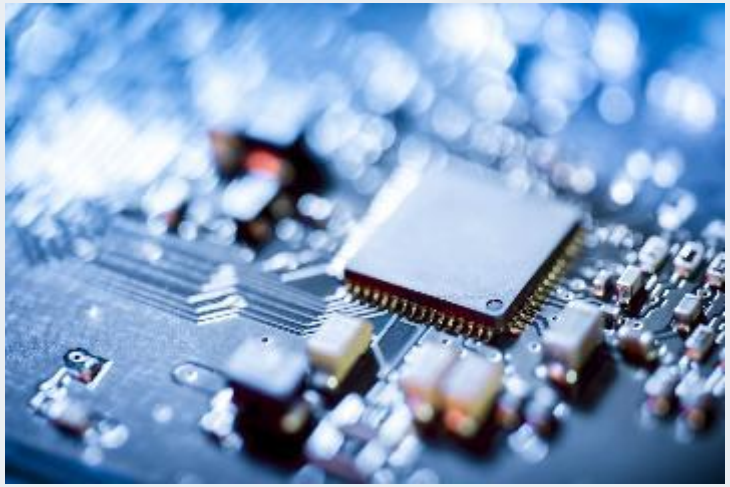
Terminator: Genesis (Paramount Pictures)

- Weak AI
  - AI is to solve real world problems even if solution is not “human-like”
- Strong AI
  - AI is to think and act like a human
  - Fantasies about AI is in fact about strong AI

Human vs Machine



- Human
  - Computing : 10^{11} neurons (100 billion)
  - Storage : 10^{11} neurons / 10^{14} synapses
  - Computing cycle time: 10^{-3} seconds



- Machine
  - Computing : 10^{9} transistors
  - Storage : 10^{11} bits RAM
  - Computing cycle time: 10^{-9} seconds

State of the Art



- Autonomous vehicles
- Facial recognition
- Speech recognition
- Virtual assistants
- Forecasting
- Medical diagnosis

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Terminology

Machine Learning

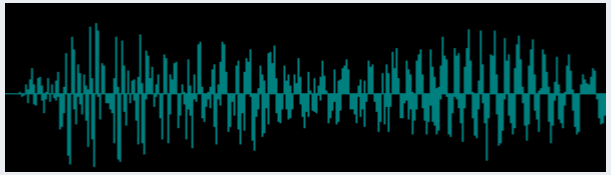


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- The ability of the machine to learn from data
  - To go beyond the initial program
- Supervised learning
  - Classification, regression
- Unsupervised learning
  - Clustering, pattern finding
- Reinforced learning
  - Agent interacts with the environment to maximize

Supervised Learning - Classification

- Classification problems







Who is the founder of Apple

↓

[ORGANIZATION]

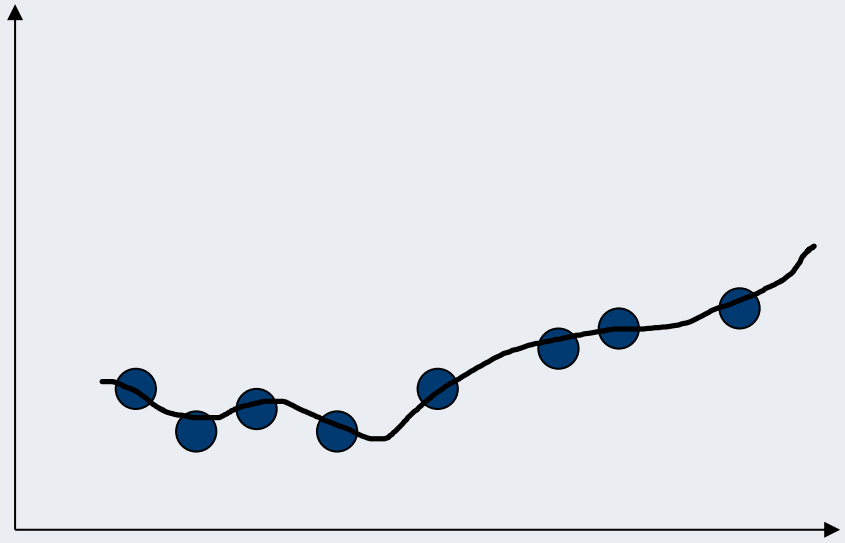
Supervised Learning - Regression

- An input-output training set is given
  - Day: Monday, Hour: 10am, Month: February, Temperature: 4ºC ➔ Electricity demand = 1450
  - Day: Monday, Hour: 10am, Month: February, Temperature: 5ºC ➔ Electricity demand = 1410
  - Day: Monday, Hour: 10am, Month: February, Temperature: 10ºC ➔ Electricity demand = 1380

- Find a function that estimates the output for a new entry
  - Day: Monday, Hour: 10am, Month: February, Temperature: 7ºC ➔ Electricity demand = ?

Supervised Learning - Regression

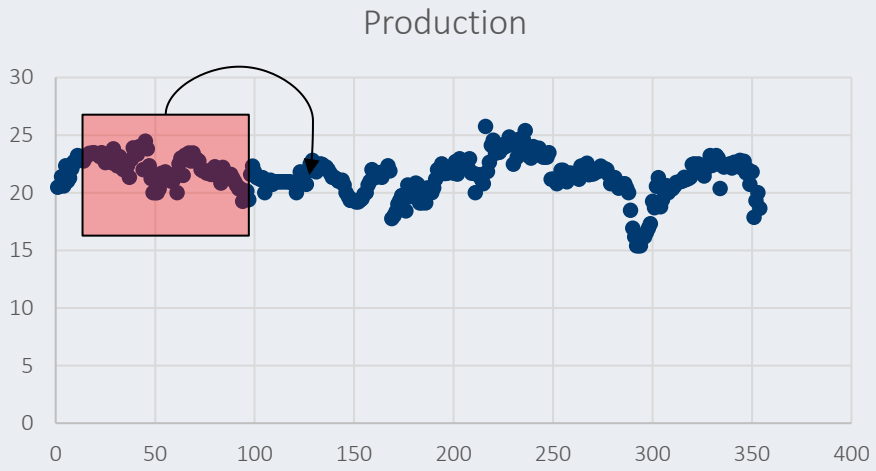
- Forecasting, pricing models, performance models, weather …

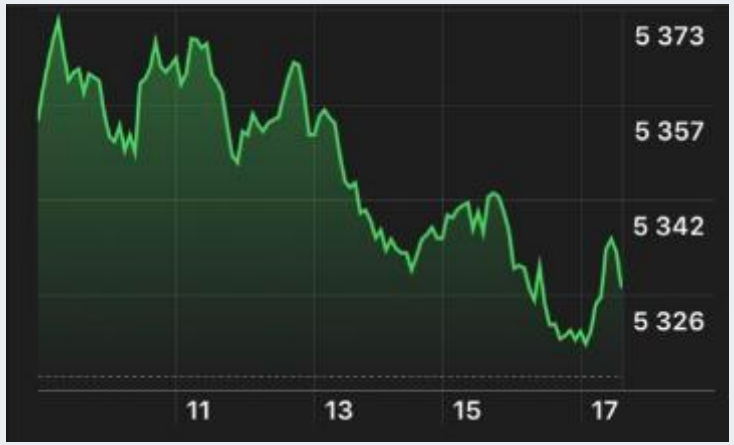




Supervised Learning - Time Series Analysis

- Economic forecasting, stock market predictions…





Unsupervised Learning – Clustering

- A set of examples is given
  - Human1 (Height = 180, Mass = 80)
  - Human2 (Height = 160, Mass = 53)
  - Human3 (Height = 190, Mass = 70)
  - Human4 (Height = 167, Mass = 56)

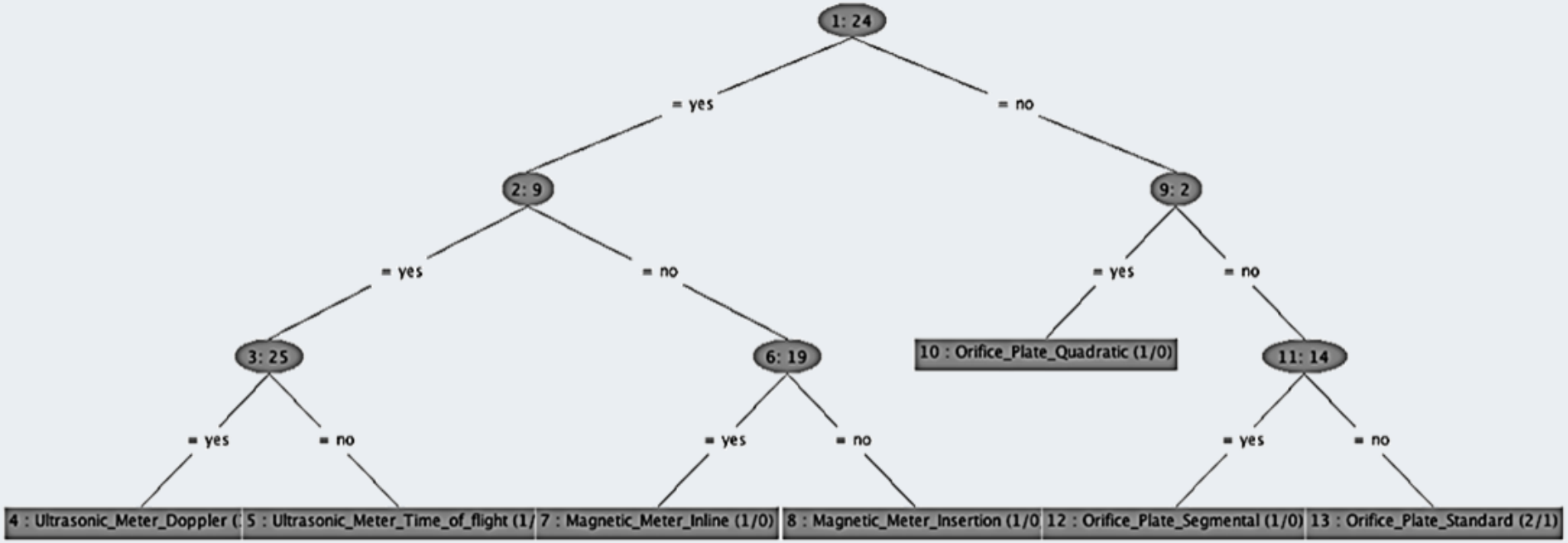
- Group the examples into "natural" clusters
  - Cluster1: Human1 & Human3
  - Cluster2: Human2 & Human4

Unsupervised Learning – Clustering



Unsupervised Learning – Knowledge Representation

- Decision trees, ontologies, Large Language Models (LLMs), diagnosis…

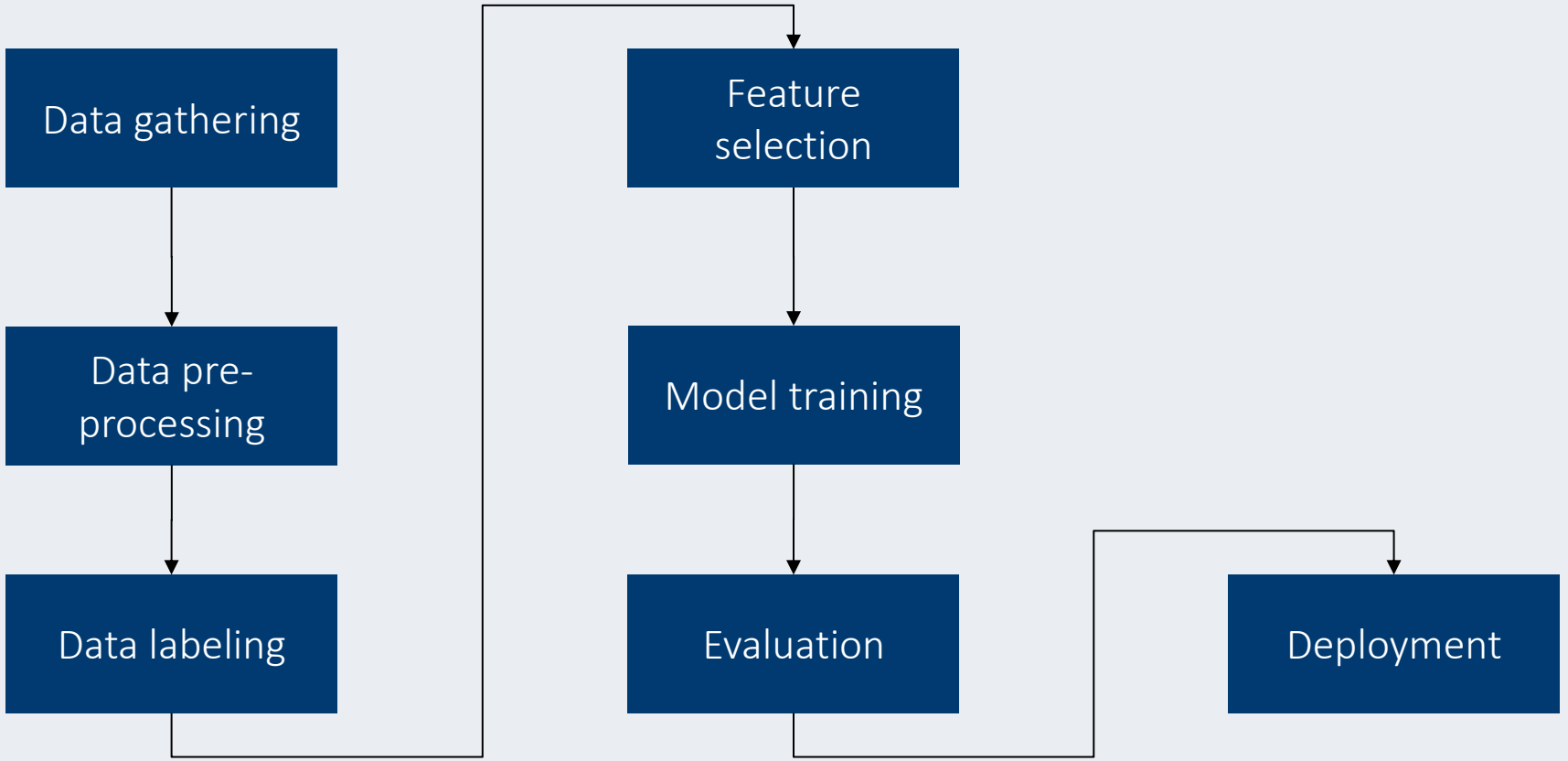


Reinforcement Learning

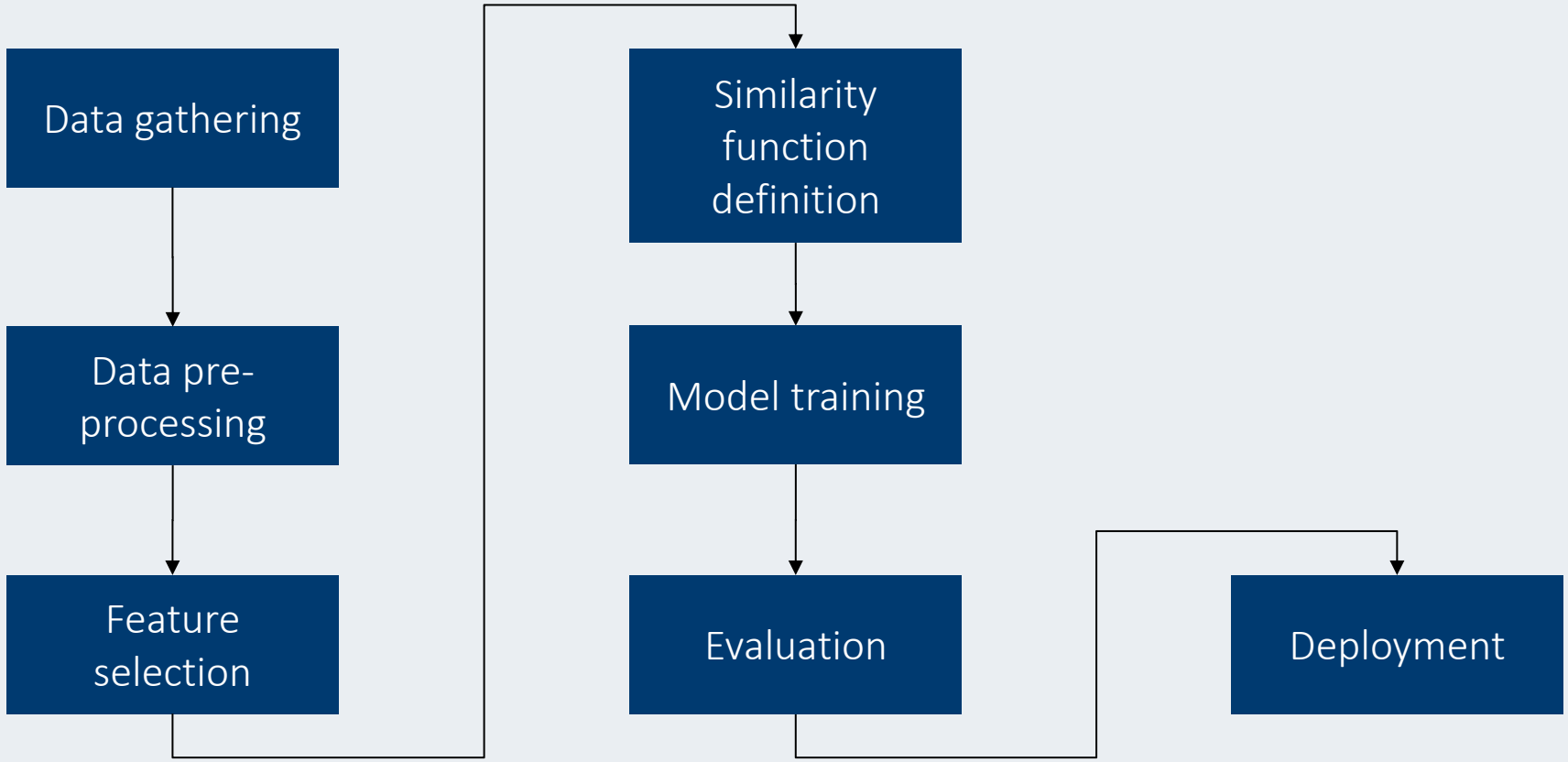
- An agent interacts with the world
  - Observes
  - Performs actions
- At every action done the agent is punished or encouraged
- The agent must make sure to have the maximum of encouragement

Building an Artificial Intelligence System

Building a Supervised System



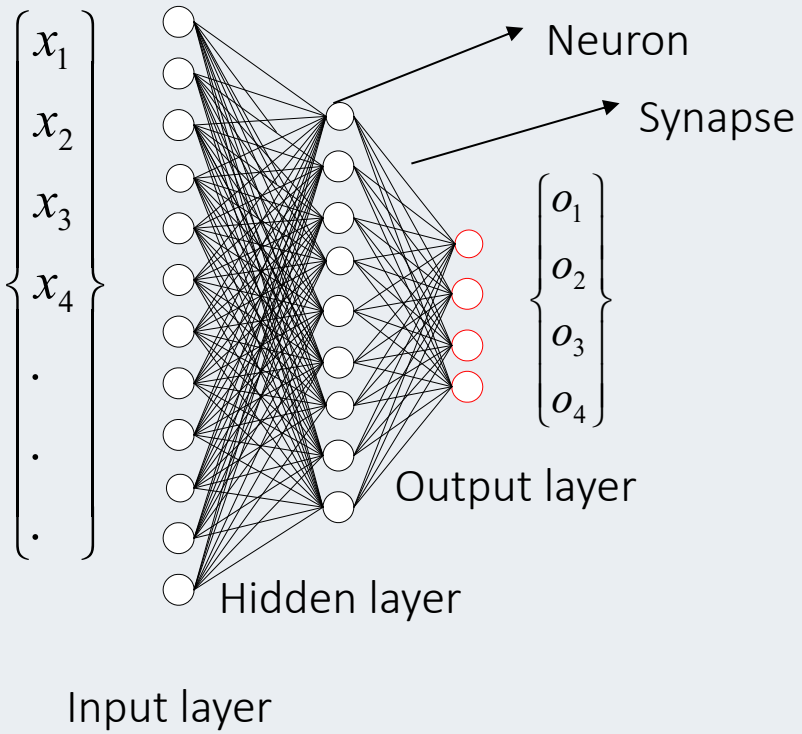
Building an Unsupervised System



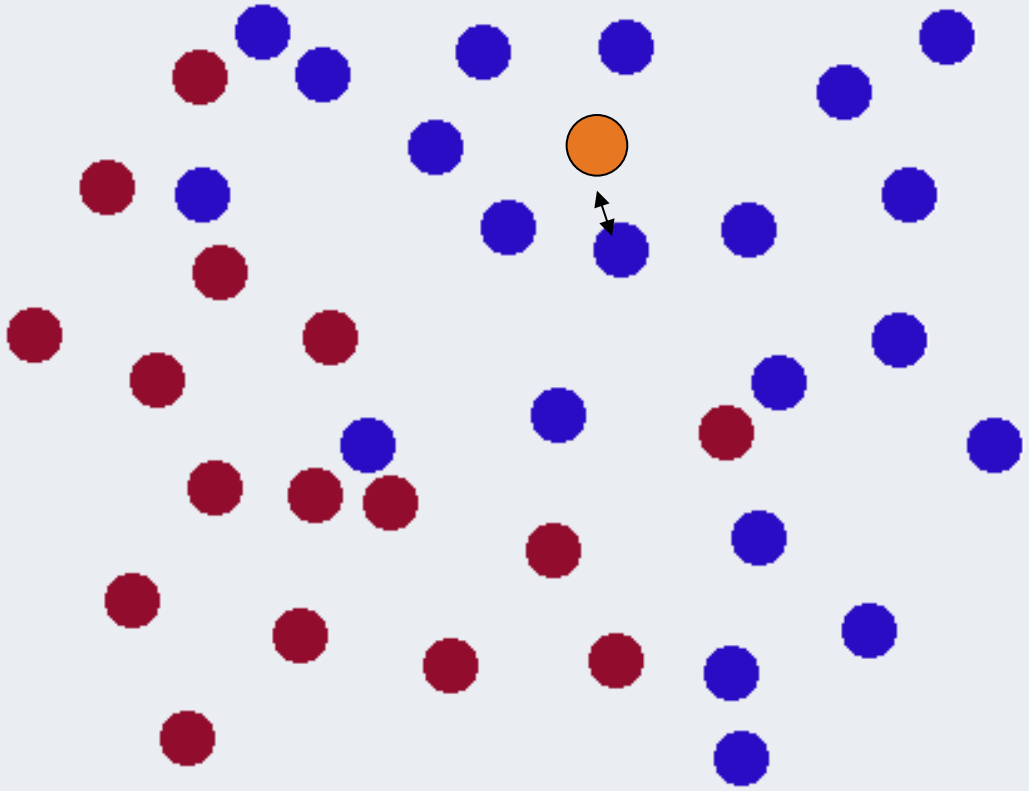
Commonly Used Techniques

- Artificial Neural Networks (ANN)
- K-Nearest Neighbours (KNN)
- Support Vector Machines
- Gaussian Mixture Models
- Hidden Markov Models
- Expectation-Maximisation
- K-Means clustering
- Genetic Algorithms

Commonly Used Techniques - ANN



Commonly Used Techniques - ANN



Tools

- Python: scikit-learn, TensorFlow..
- WEKA
- MATLAB
- Cloud-based
  - IBM Watson
  - Gemini Enterprise Agent Platform
  - Microsoft Azure Machine Learning
  - Amazon SageMaker AI

Python – TensorFlow

- Tensorflow is an open source library for Machine Learning
- Complex models could be built using Tensorflow
- https://www.tensorflow.org/

Python – TensorFlow

```
import tensorflow as tf
from tensorflow import keras

import numpy as np
import matplotlib.pyplot as plt

fashion_mnist = keras.datasets.fashion_mnist

(train_images, train_labels), (test_images, test_labels) = fashion_mnist.load_data()
class_names = ['T-shirt/top', 'Trouser', 'Pullover', 'Dress', 'Coat',
               'Sandal', 'Shirt', 'Sneaker', 'Bag', 'Ankle boot']
train_images = train_images / 255.0
test_images = test_images / 255.0

plt.figure(figsize=(10,10))
for i in range(25):
    plt.subplot(5,5,i+1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(False)
    plt.imshow(train_images[i], cmap=plt.cm.binary)
    plt.xlabel(class_names[train_labels[i]])
plt.show()
```

Python – TensorFlow



Python – TensorFlow

```
import tensorflow as tf
from tensorflow import keras

import numpy as np
import matplotlib.pyplot as plt

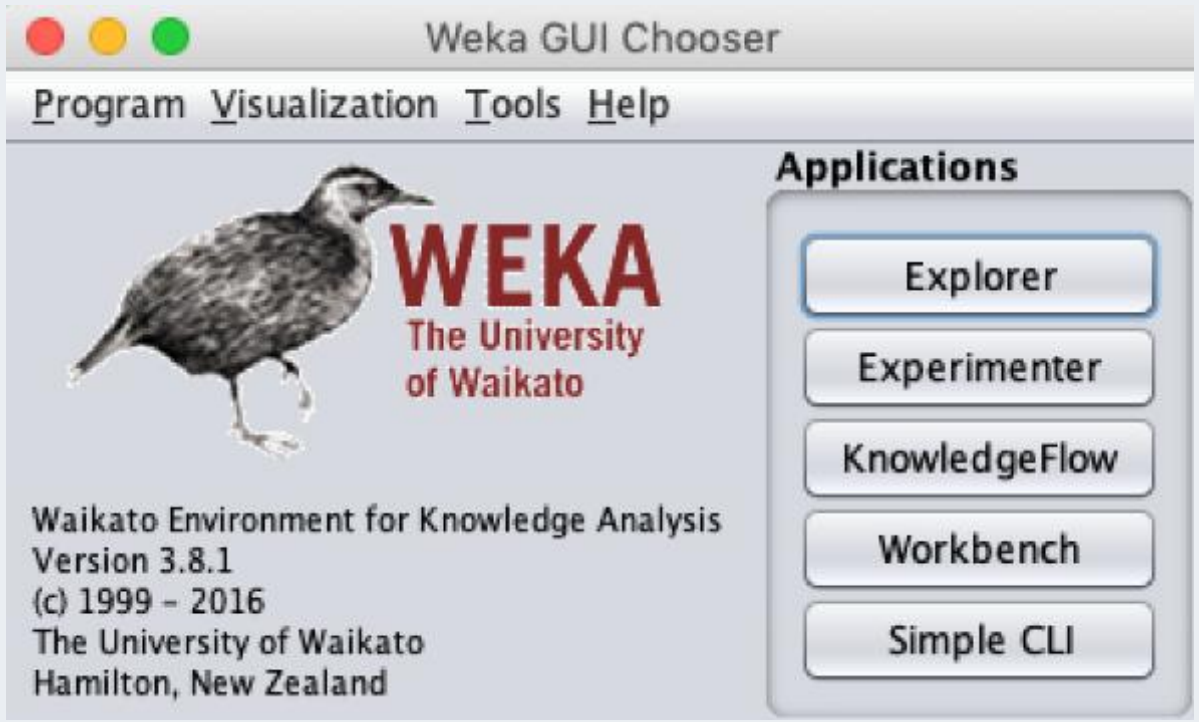
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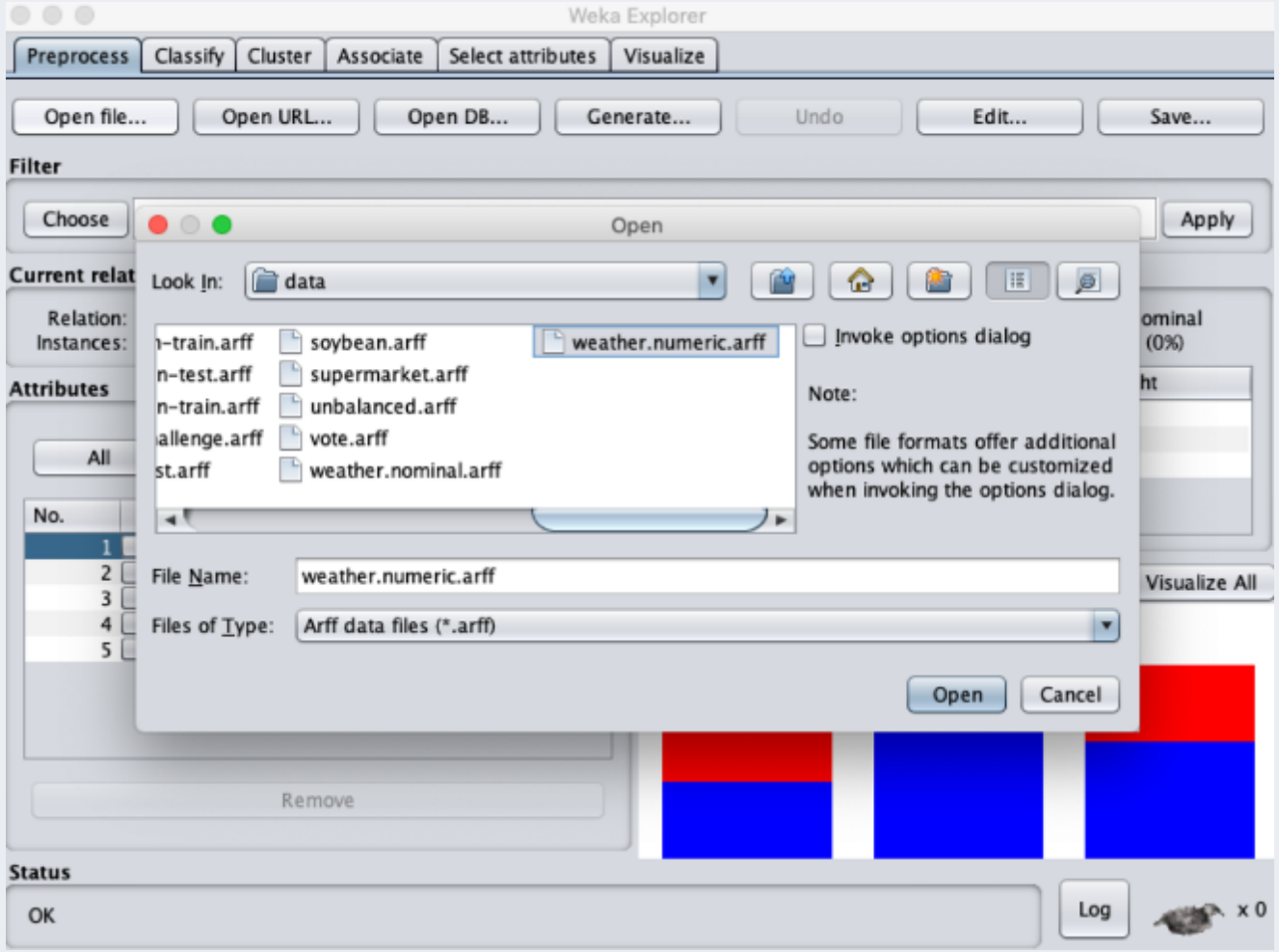
model = keras.Sequential([
    keras.layers.Flatten(input_shape=(28, 28)),
    keras.layers.Dense(128, activation='relu'),
    keras.layers.Dense(10)
])
model.compile(optimizer='adam',
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
              metrics=['accuracy'])
model.fit(train_images, train_labels, epochs=10)
probability_model = tf.keras.Sequential([model,
                                         tf.keras.layers.Softmax()])
predictions = probability_model.predict(test_images)
```

WEKA

- An open source Machine Learning software with a GUI
- https://www.cs.waikato.ac.nz/ml/weka/downloading.html

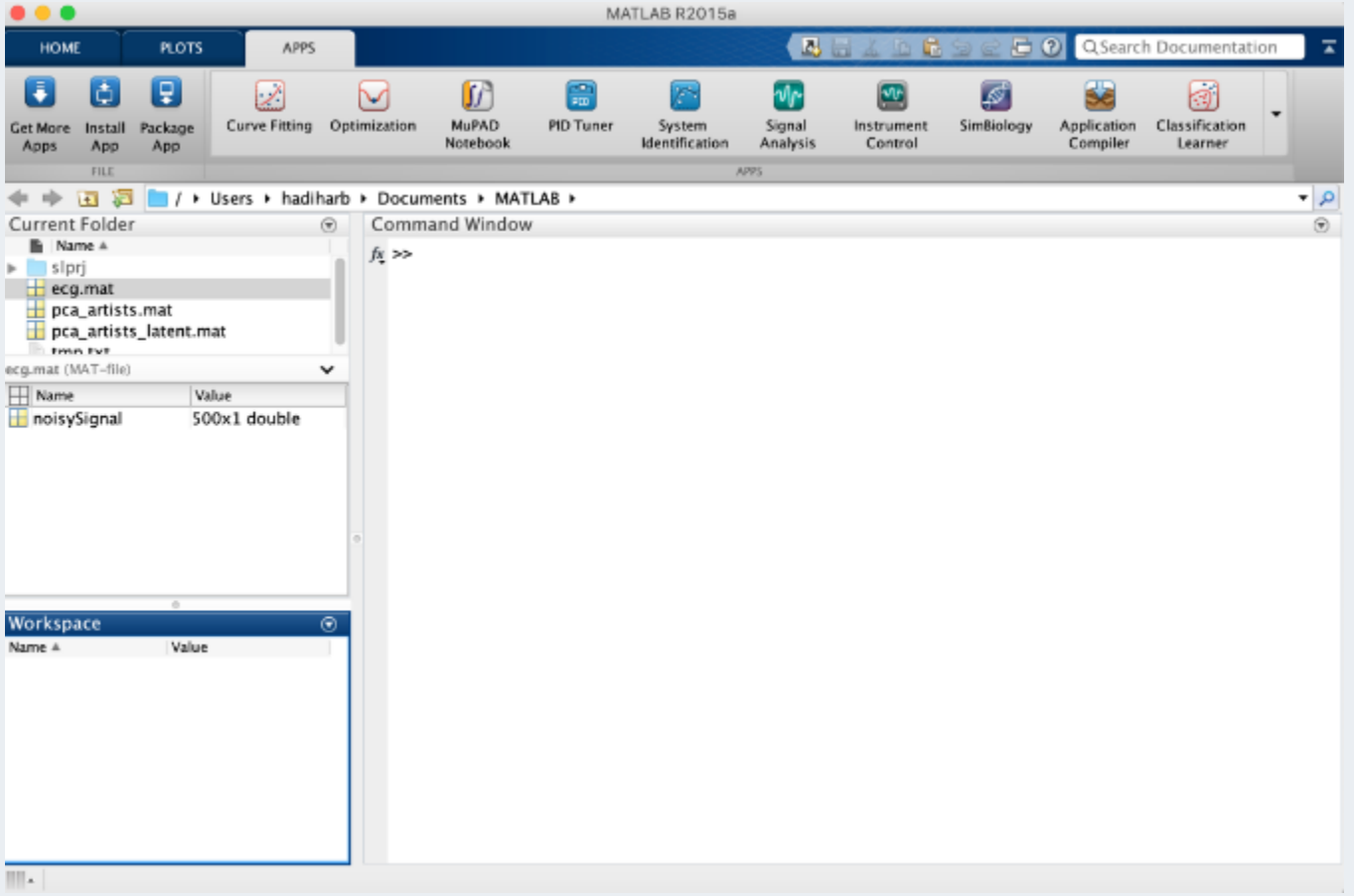


WEKA

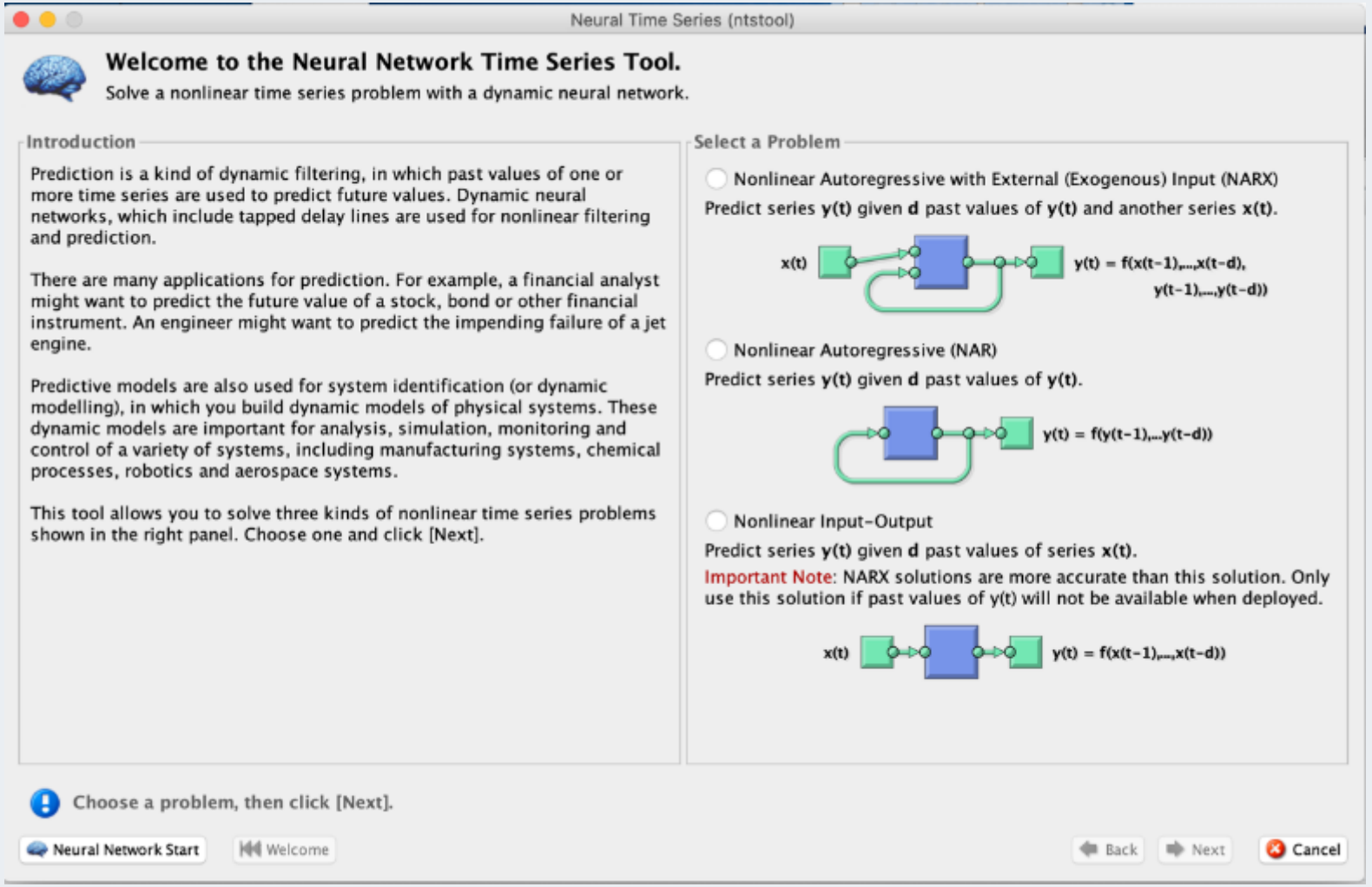

Weka Explorer
Preprocess
Classify
Cluster
Associate
Select attributes
Visualize
Open file...
Open URL...
Open DB...
Generate...
Undo
Edit...
Save...
Filter
Choose
Apply
Current relat
Relation:
Instances:
Attributes
All
No.
1
2
3
4
5
Remove
Visualize All
Status
OK
Log
x 0
Open
Look In:
data
n-train.arff
n-test.arff
n-train.arff
allenge.arff
st.arff
soybean.arff
supermarket.arff
unbalanced.arff
vote.arff
weather.nominal.arff
weather.numeric.arff
Invoke options dialog
Note:
Some file formats offer additional options which can be customized when invoking the options dialog.
File Name:
weather.numeric.arff
Files of Type:
Arff data files (*.arff)
Open
Cancel

MATLAB

- A commonly used software by engineers and scientist



MATLAB


Neural Time Series (ntstool)
Welcome to the Neural Network Time Series Tool.
Solve a nonlinear time series problem with a dynamic neural network.
Introduction
Prediction is a kind of dynamic filtering, in which past values of one or more time series are used to predict future values. Dynamic neural networks, which include tapped delay lines are used for nonlinear filtering and prediction.
There are many applications for prediction. For example, a financial analyst might want to predict the future value of a stock, bond or other financial instrument. An engineer might want to predict the impending failure of a jet engine.
Predictive models are also used for system identification (or dynamic modelling), in which you build dynamic models of physical systems. These dynamic models are important for analysis, simulation, monitoring and control of a variety of systems, including manufacturing systems, chemical processes, robotics and aerospace systems.
This tool allows you to solve three kinds of nonlinear time series problems shown in the right panel. Choose one and click [Next].
Select a Problem
Nonlinear Autoregressive with External (Exogenous) Input (NARX)
Predict series y(t) given d past values of y(t) and another series x(t).
x(t)
y(t) = f(x(t-1),...,x(t-d), y(t-1),...,y(t-d))
Nonlinear Autoregressive (NAR)
Predict series y(t) given d past values of y(t).
y(t) = f(y(t-1),...y(t-d))
Nonlinear Input-Output
Predict series y(t) given d past values of series x(t).
Important Note: NARX solutions are more accurate than this solution. Only use this solution if past values of y(t) will not be available when deployed.
x(t)
y(t) = f(x(t-1),...,x(t-d))
Choose a problem, then click [Next].
Neural Network Start
Welcome
Back
Next
Cancel

Tools - Summary

	Python	MATLAB	R	Weka	Cloud	From scratch (C++)
I have experience in programming	X					X
I need flexibility	?	?				X
I have MATLAB experience		X				
I have R experience, interest in statistics			X			
I have no experience in programming				X	X	
I need free GUI solution				X		

Case Studies

Examples of Applications in the Industry

Predictive maintenance

Predictive control

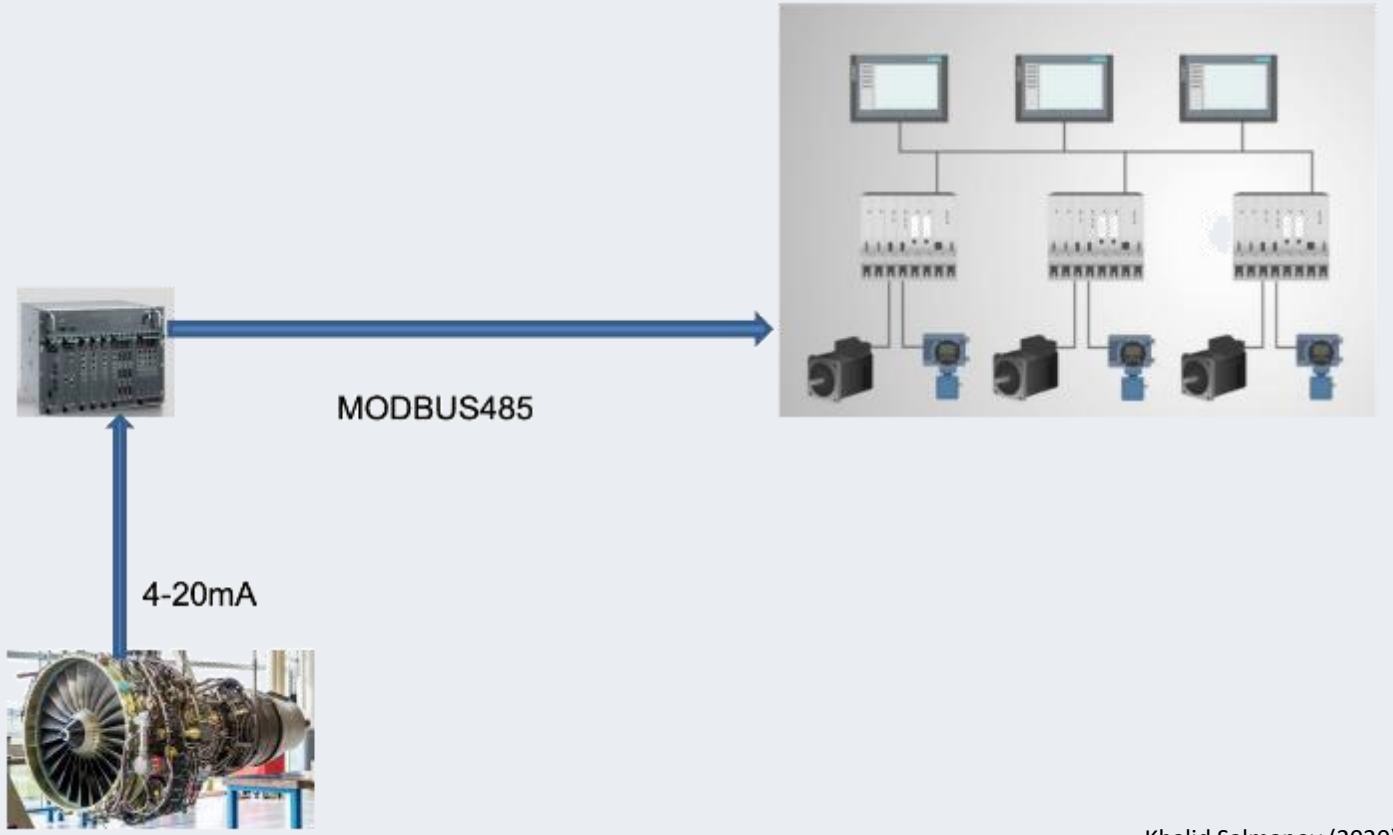
Fault detection

Recommendations

Operator assistants

Examples of Applications in the Industry

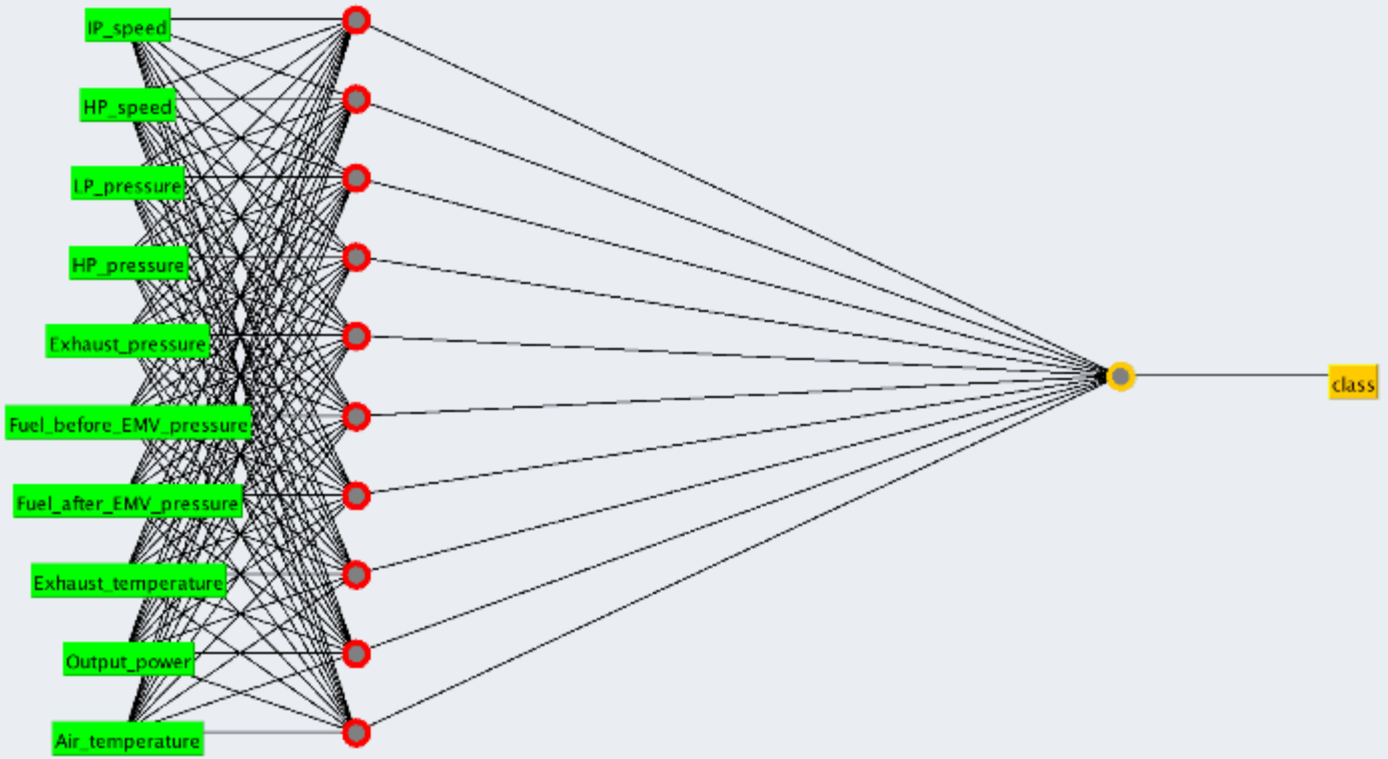
- Predictive Maintenance



Khalid Salmanov (2020) Data analysis for the aero derivative engines bleed system failure identification and prediction, Master thesis, Engineering Institute of Technology

Examples of Applications in the Industry

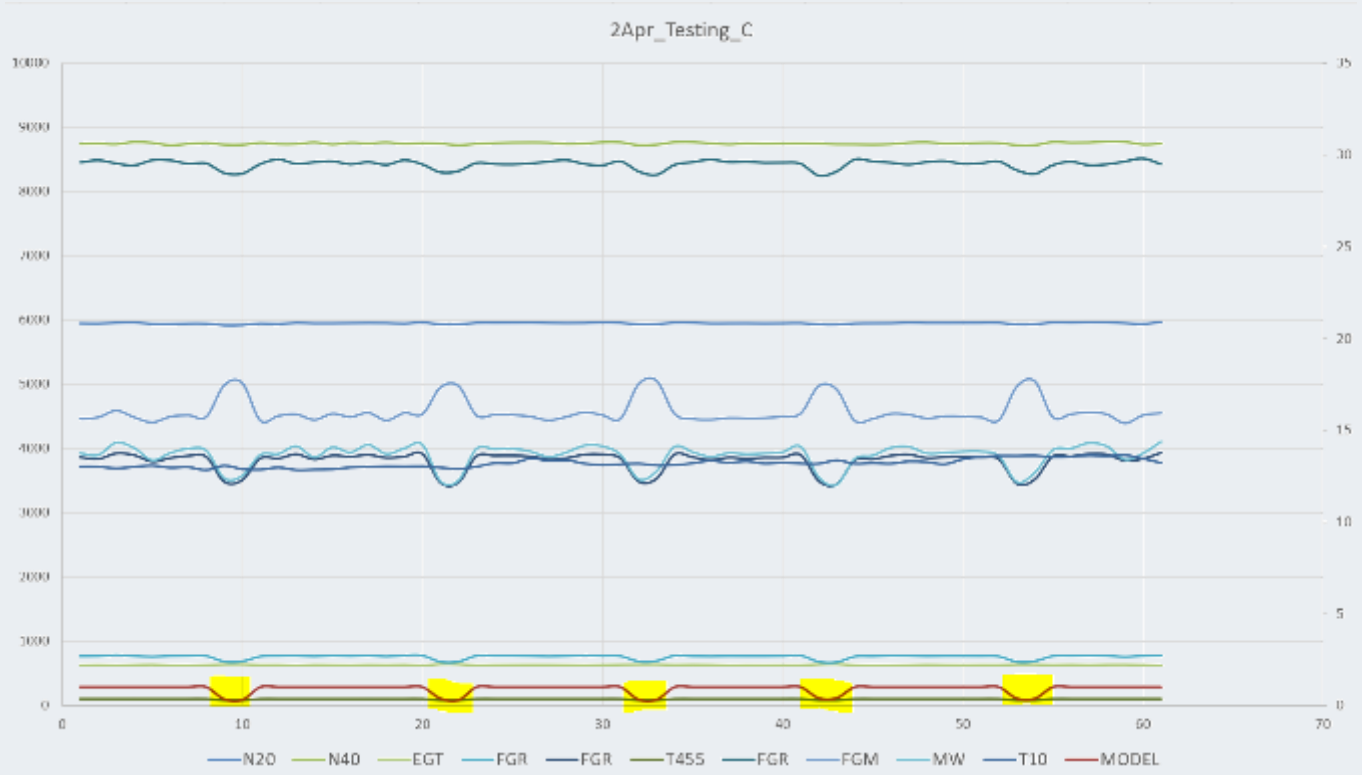
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Examples of Applications in the Industry

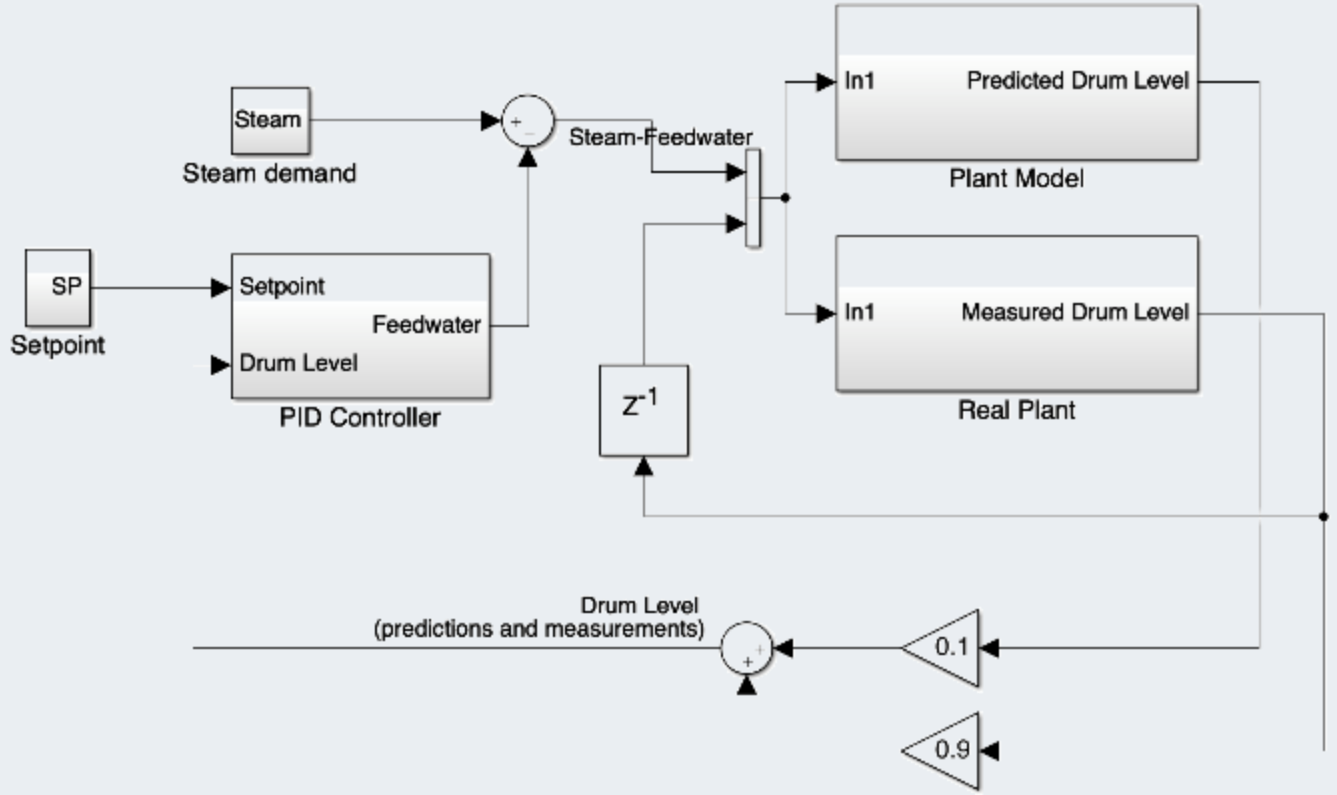
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Examples of Applications in the Industry

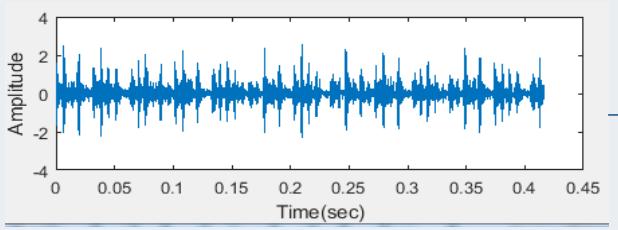
- Predictive control

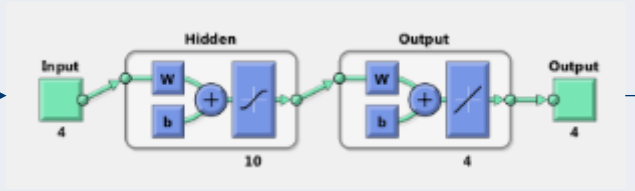


Tawonei Douglas Mugweni (2019) Neural Networks-based Process Model and its Integration with Conventional Drum Level PID Control in a Steam Boiler Plant, Master thesis, Engineering Institute of Technology

Examples of Applications in the Industry

- Electric Motor Bearing Fault Detection



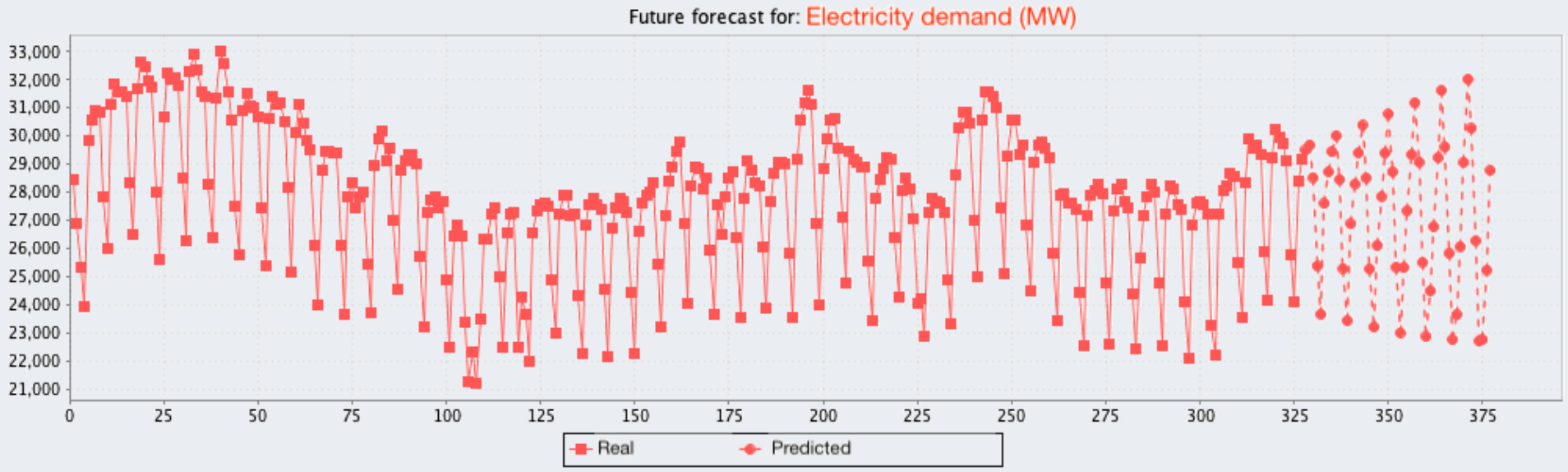


Outer fault
Raceway fault
Ball fault
Normal bearing

W T Abdisa, H Harb, A Neural Network Based Motor Bearing Fault Diagnosis Algorithm and its Implementation on Programmable Logic Controller, International Journal of Intelligent Systems and Applications, 11 (10), 1-14, 2019

Examples of Applications in the Industry

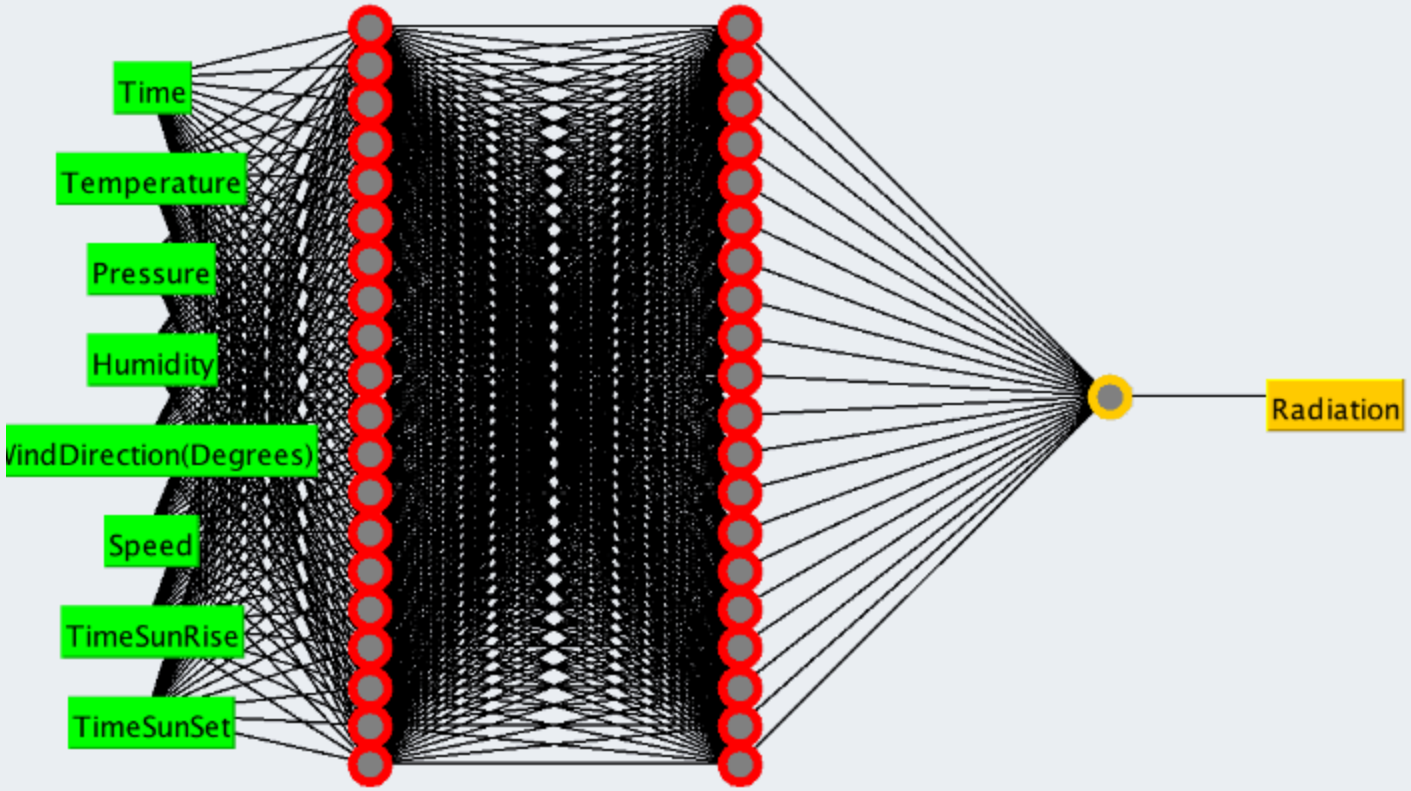
- Electricity Demand Forecasting



https://www.kaggle.com/manualrg/spanish-electricity-market-demand-gen-price

Examples of Applications in the Industry

- Solar Radiation Prediction



https://www.kaggle.com/alexanderthestudent/solar-radiation-prediction

Examples of Applications in the Industry

- Large Language Models (LLMs)
  - Summarising documents
  - Comparing scenarios
  - Explaining consequences
  - RAG (Retrieval Augmented Generation) from the organisation's documents
  - Explaining legacy code
  - Producing scripts/code
  - …

Examples of Applications in the Industry

We are still quite far from general AI, however, specialised AI can be used if:

- You have data
- You need to make predictions
- You need to optimise operations/control

Thank You!

Upcoming Programmes

Engineering College of Technology (ECT) *UK-Recognised Qualifications*	Start Date
Bachelor of Engineering (Honours) in Industrial Automation	February 2027
Bachelor of Engineering (Honours) in Electrical Engineering	February 2027
Master of Science (Power System Analysis and Renewable Integration)	February 2027
Master of Science (Industrial Automation and Instrumentation Control)	February 2027

Contact Us:

Website
www.ect.ac.uk

Programmes
https://www.ect.ac.uk/programmes/

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