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# How is Artificial Intelligence and Automation changing the world?

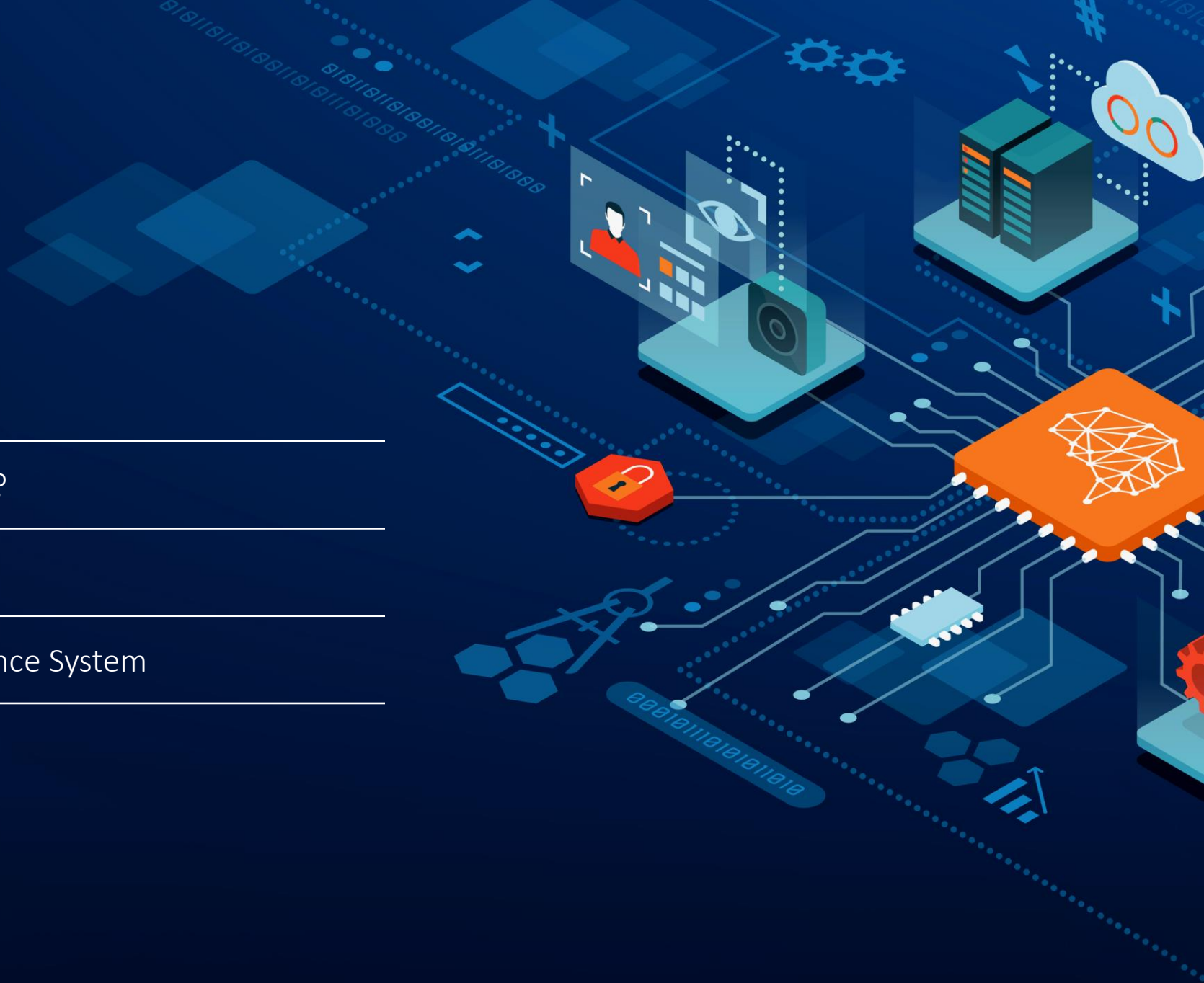
Thursday 28 January | Technical Topic Webinar

**PRESENTED BY**

**Dr Hadi Harb** | EIT Lecturer

# Agenda

- 1 Introduction
- 2 What is Artificial Intelligence?
- 3 Terminology
- 4 Building an Artificial Intelligence System
- 5 Case Studies





**Dr Hadi Harb** has more than 15 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.

He co-founded and managed Ghanni, a company specialized in multimedia content recommendation and identification. His focus is on the application of AI techniques to natural language understanding and human-like process control.

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?

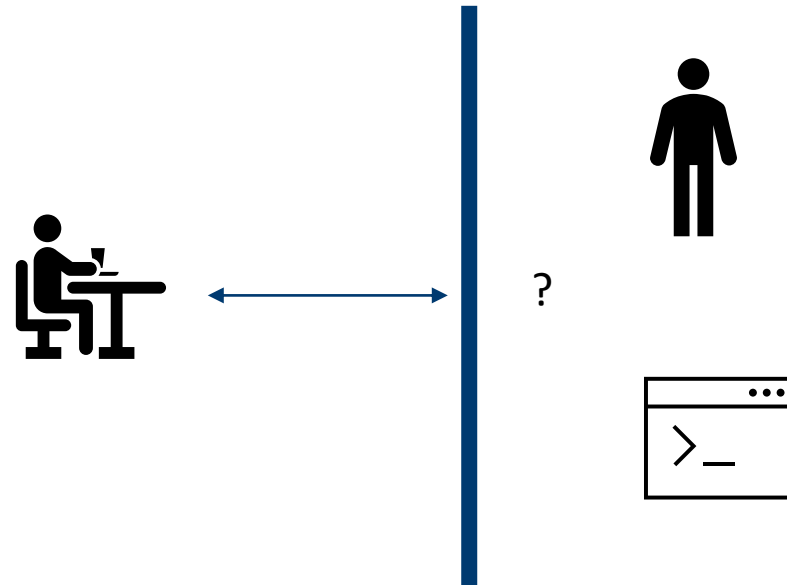


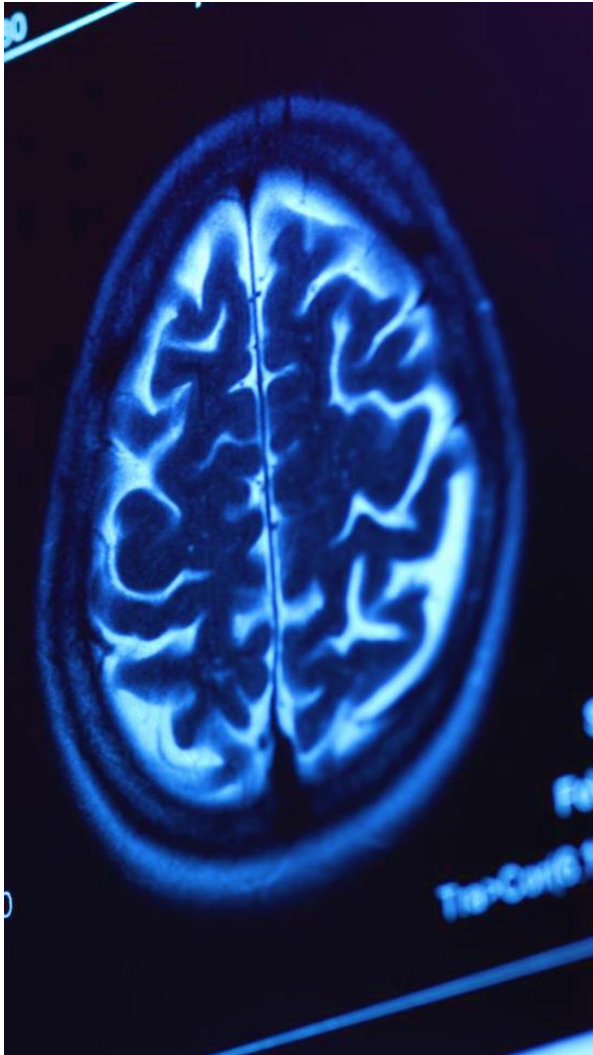
How do we gauge intelligence?

## 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.

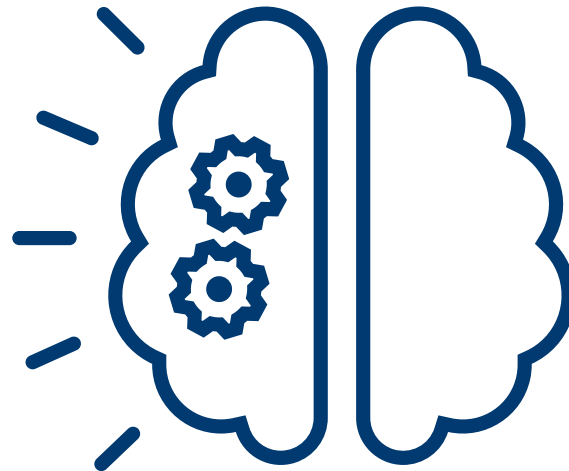
- › A human judge interrogates another entity without knowing if it is a machine or a human. If the judge thinks the machine is a human, the machine passes the test.
- › Chatbots fall into this category.





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

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







## › 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

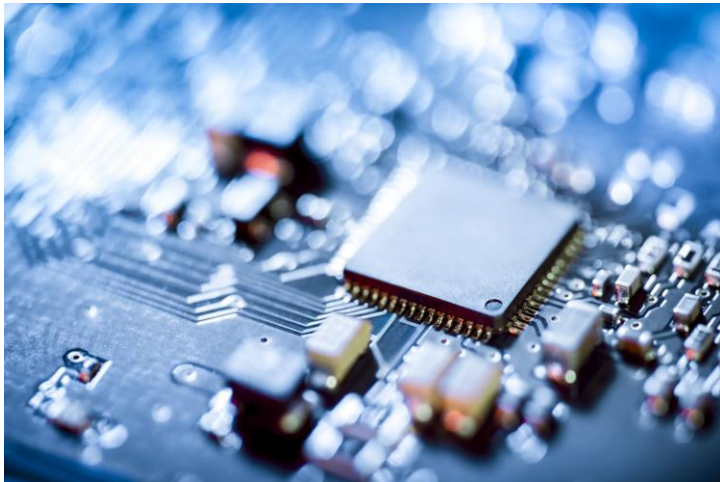
Terminator: Genesis (Paramount Pictures)

# 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



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



# Terminology

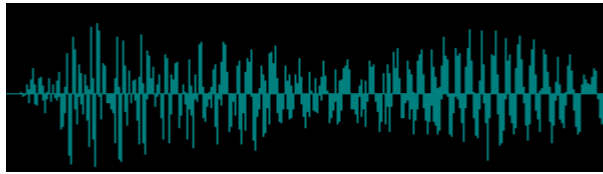


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- **The ability of the machine to learn from data**
  - To go beyond the initial program
  
- **Supervised learning**
  - Classification, regression
  
- **Unsupervised learning**
  - Clustering, pattern finding
  
- **Reinforced learning**
  - Agent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

# Supervised Learning - Classification

- › Classification problems



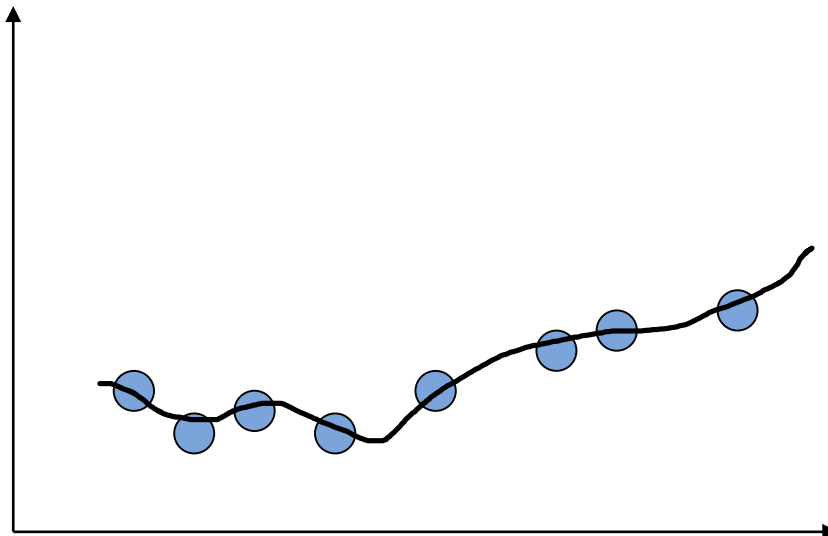
Who is the founder of **Apple**



[ORGANIZATION]

- › **An input-output training set is given**
  - Day: Monday, Hour: 10am, Month: February, Temperature: 4°C → Electricity demand = 1450
  - Day: Monday, Hour: 10am, Month: February, Temperature: 5°C → Electricity demand = 1410
  - Day: Monday, Hour: 10am, Month: February, Temperature: 10°C → Electricity demand = 1380
  
- › **Find a function that estimates the output for a new entry**
  - Day: Monday, Hour: 10am, Month: February, Temperature: 7°C → Electricity demand = ?

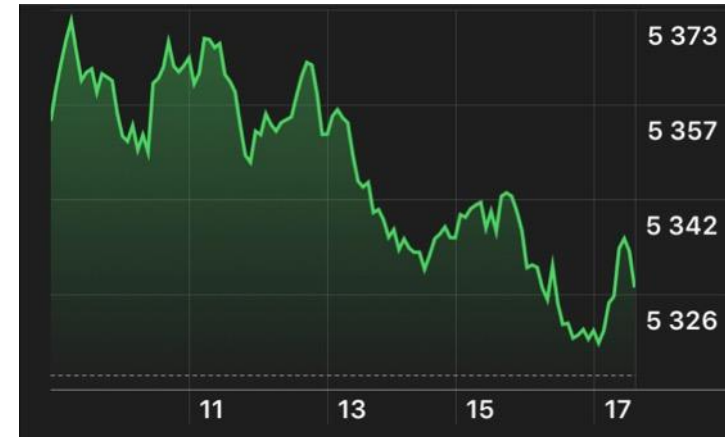
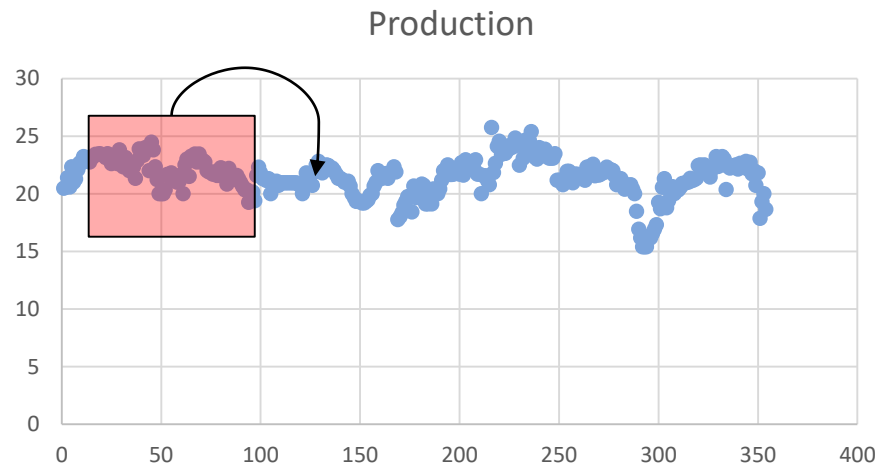
- Forecasting, pricing models, performance models, weather ...





# Supervised Learning - Time Series Analysis

- Economic forecasting, stock market predictions...



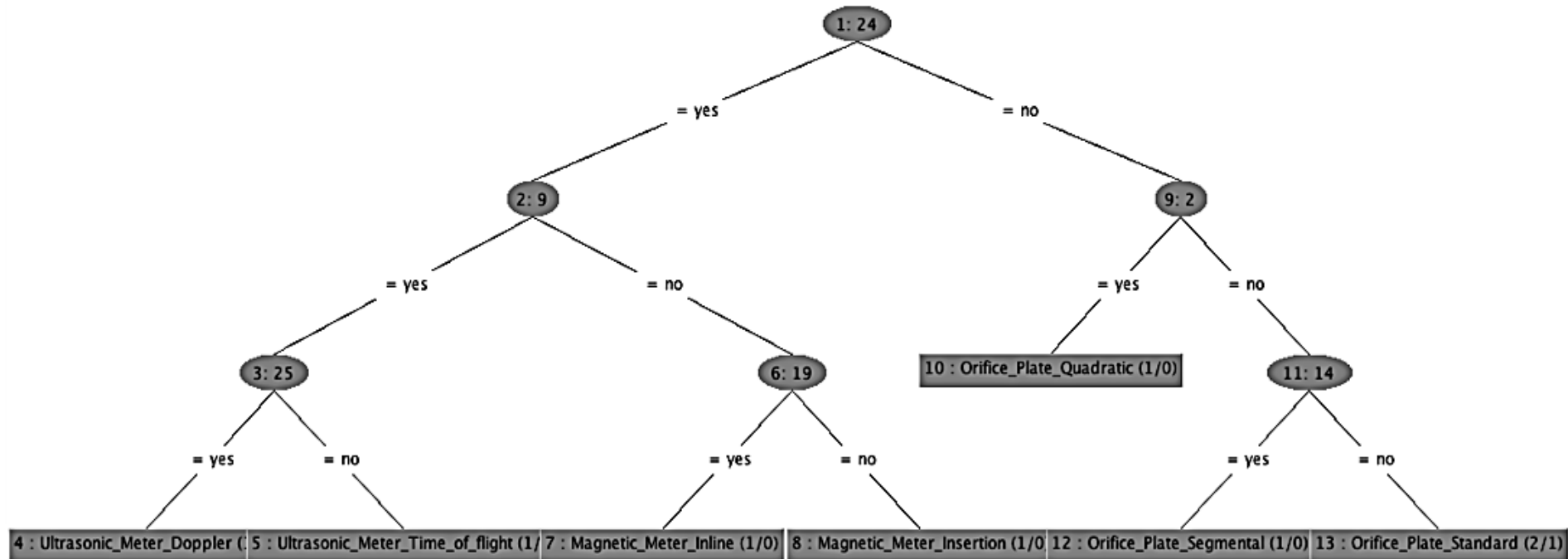
# Unsupervised Learning – Clustering

- › **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



- › Decision trees, ontologies, question-answering, diagnosis...

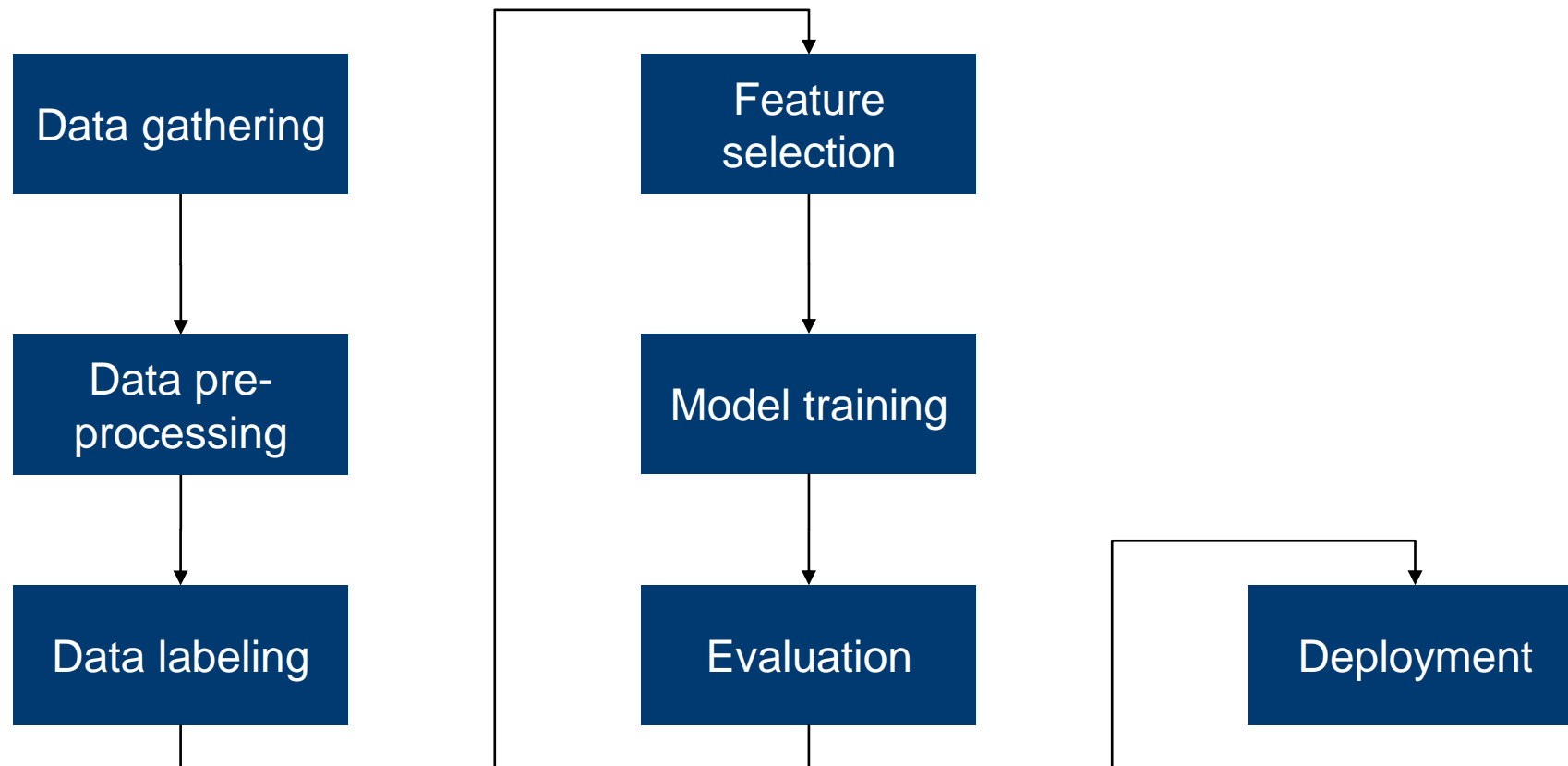


- › An agent interacts with the world
  - Observes
  - Performs actions
- › At every action done the agent is punished or encouraged
- › The agent must make sure to have the maximum of encouragement

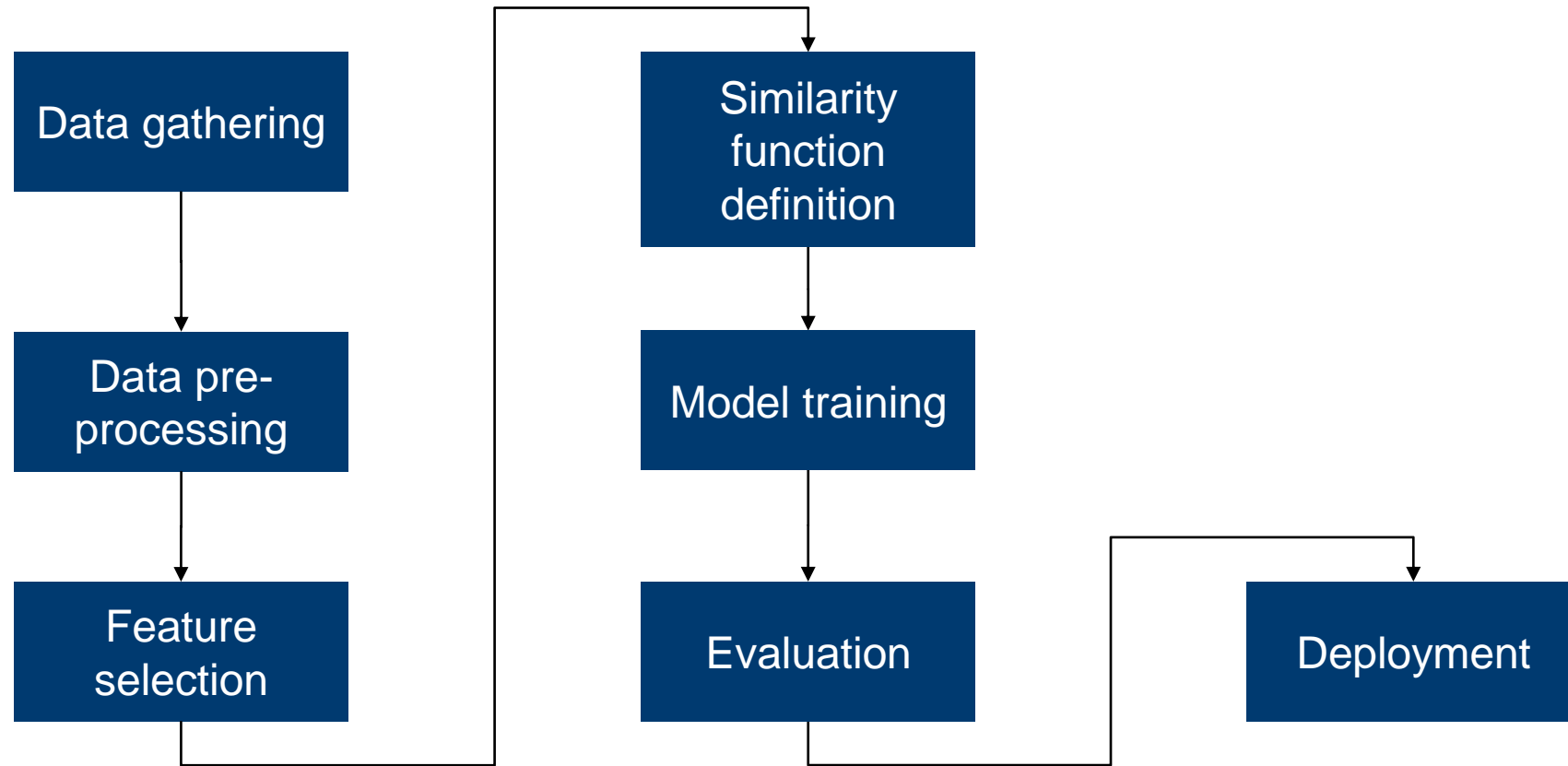


# Building an Artificial Intelligence System

# Building a Supervised System

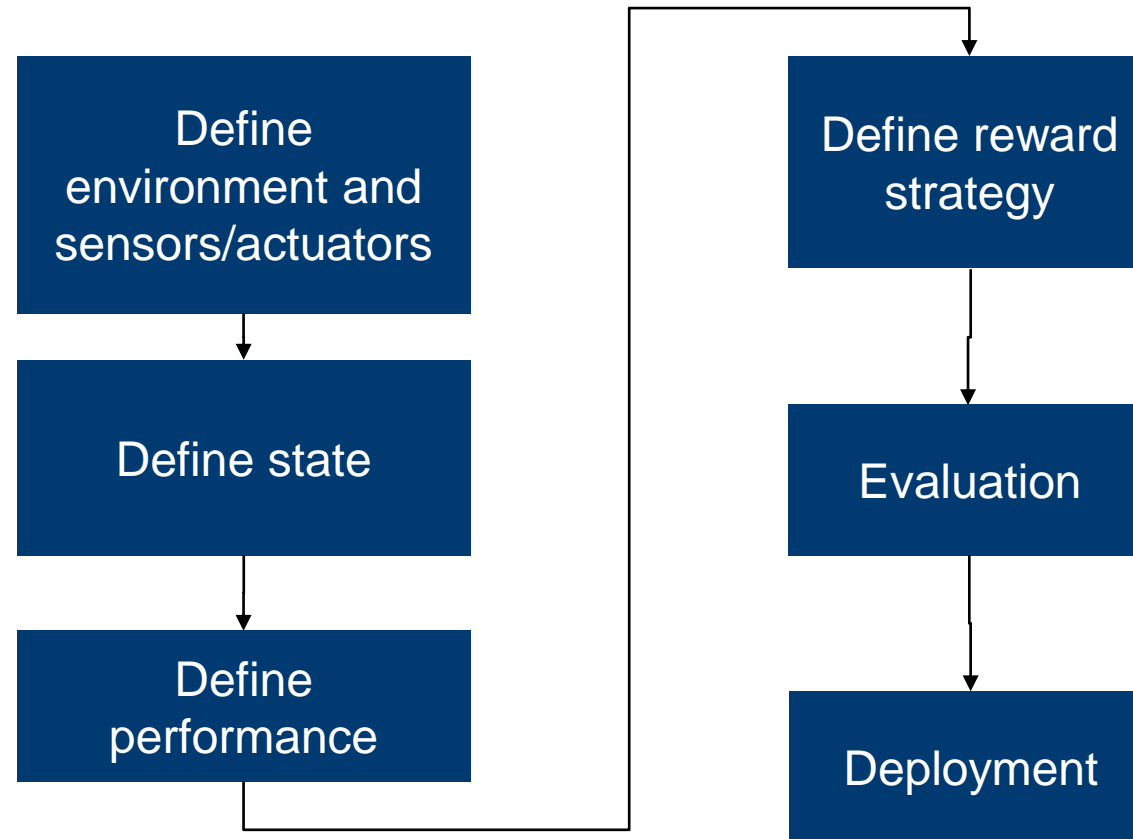


# Building an Unsupervised System





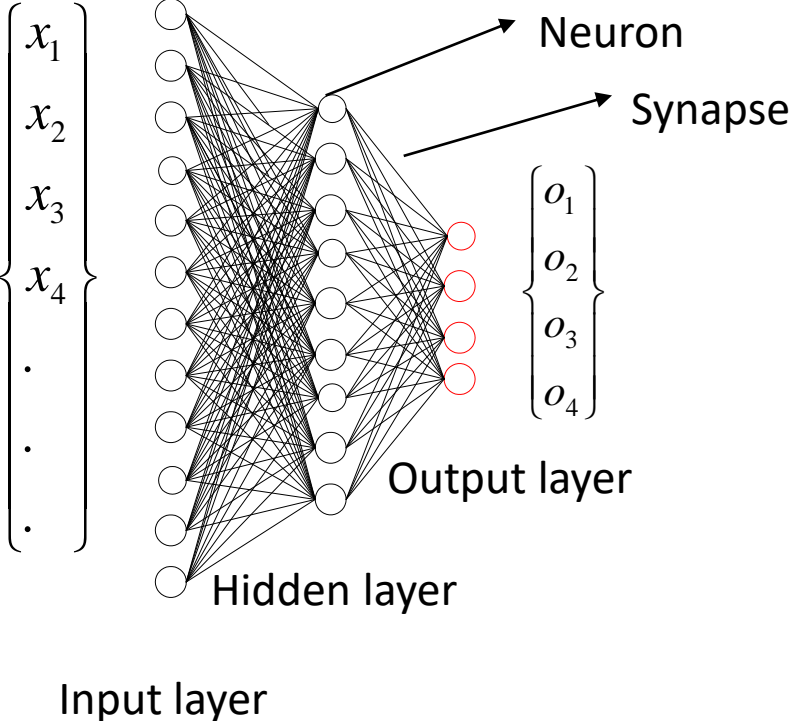
# Building a Reinforcement System



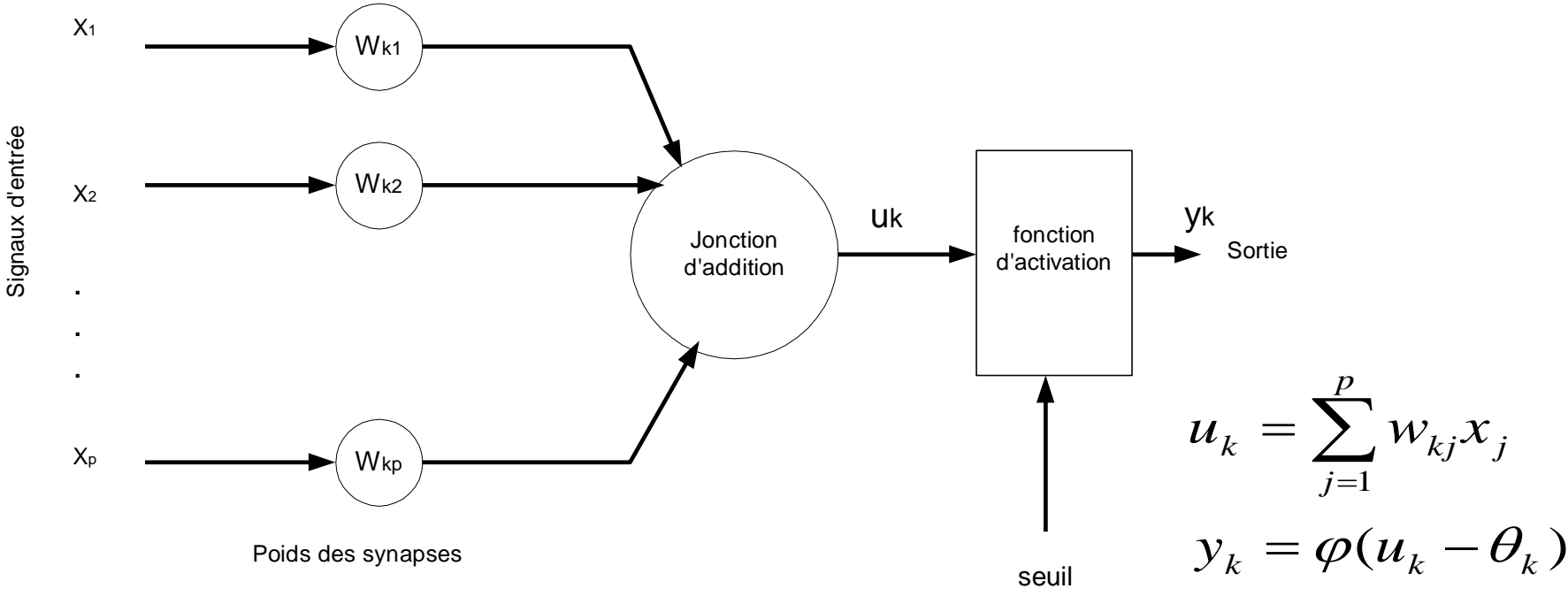
# Commonly Used Techniques

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

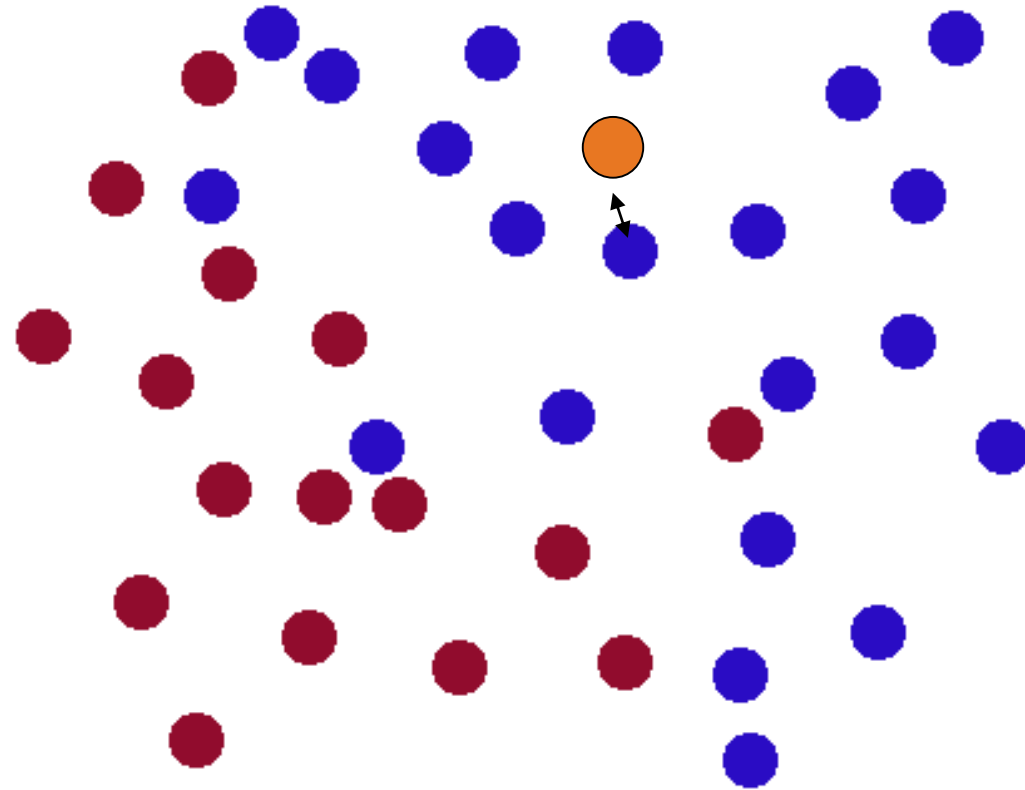
# Commonly Used Techniques - ANN



# Commonly Used Techniques - ANN



# Commonly Used Techniques - ANN



- › **Python: scikit-learn, TensorFlow..**
- › **WEKA**
- › **MATLAB**
- › **Cloud-based**
  - IBM Watson
  - Google Machine Learning
  - Microsoft Azure
  - Amazon Machine Learning

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

```
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()
```





```
import tensorflow as tf
from tensorflow import keras

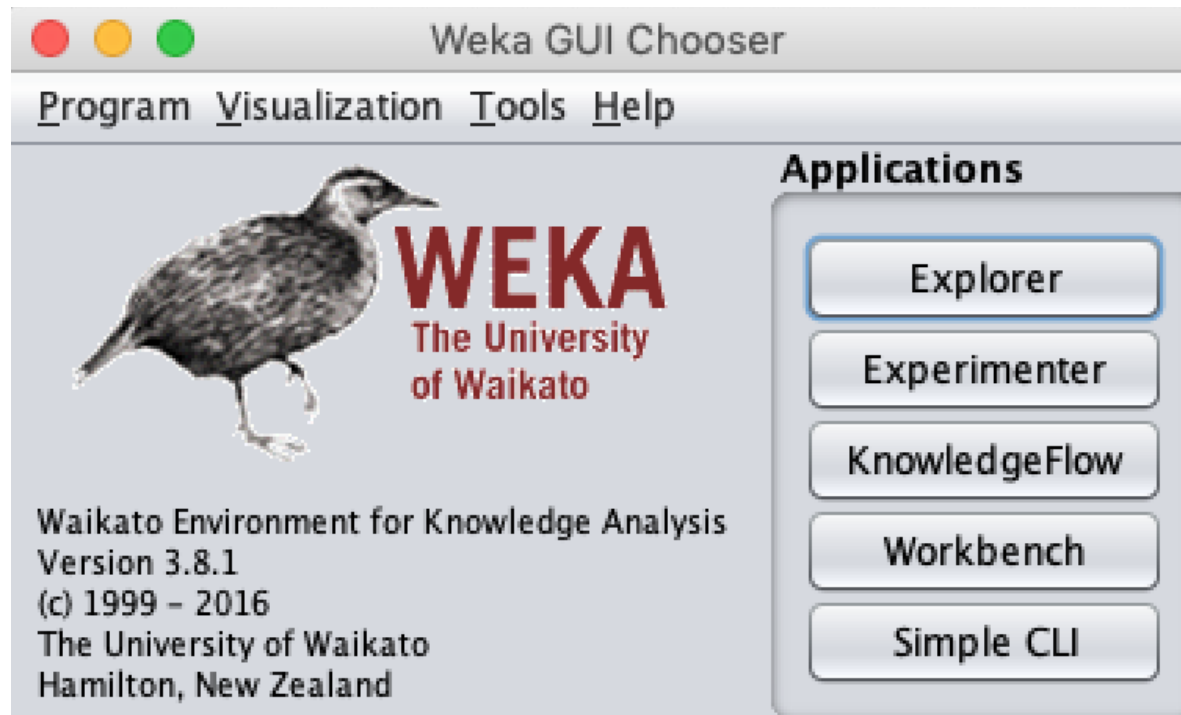
import numpy as np
import matplotlib.pyplot as plt

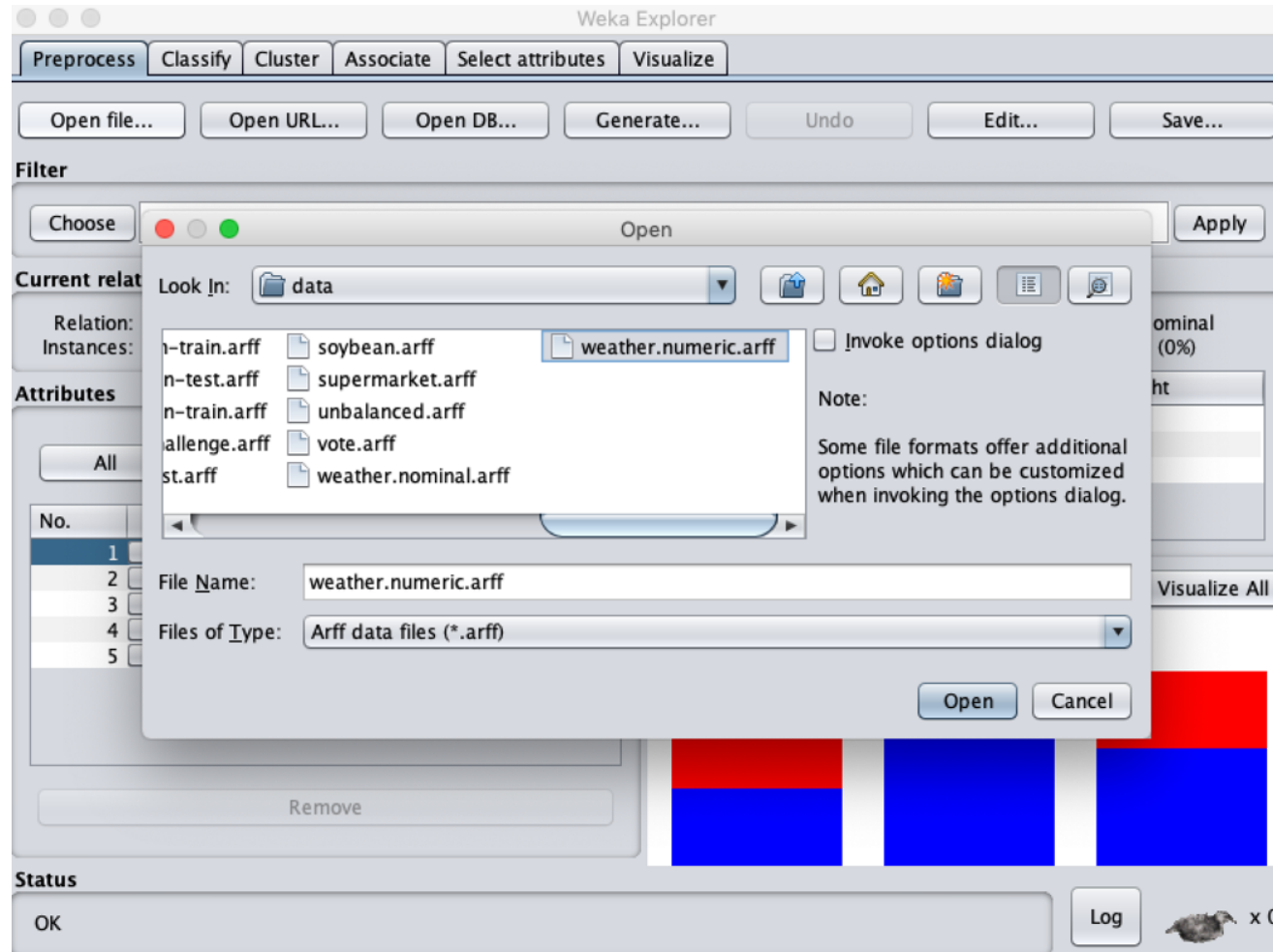
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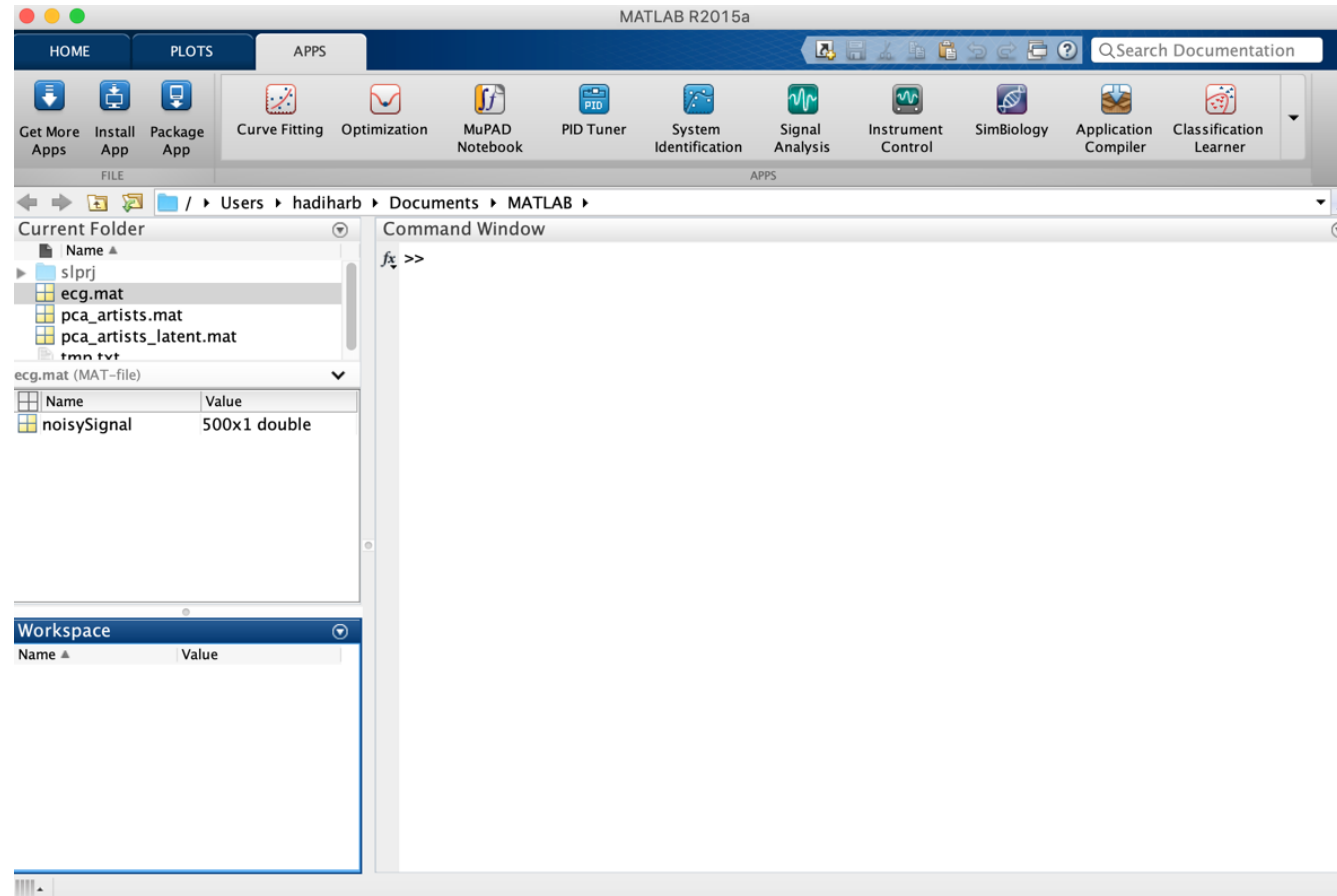
model = keras.Sequential([
    keras.layers.Flatten(input_shape=(28, 28)),
    keras.layers.Dense(128, activation='relu'),
    keras.layers.Dense(10)
])
model.compile(optimizer='adam',
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
              metrics=['accuracy'])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

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






- A commonly used software by engineers and scientist



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.

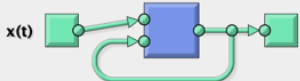
There are many applications for prediction. For example, a financial analyst might want to predict the future value of a stock, bond or other financial instrument. An engineer might want to predict the impending failure of a jet engine.

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  $x(t)$ .



$$y(t) = f(x(t-1), \dots, x(t-d), y(t-1), \dots, y(t-d))$$


Nonlinear Autoregressive (NAR)  
Predict series  $y(t)$  given  $d$  past values of  $y(t)$ .




$$y(t) = f(y(t-1), \dots, y(t-d))$$

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.



$$y(t) = f(x(t-1), \dots, x(t-d))$$

 Choose a problem, then click [Next].

Neural Network Start
Welcome
Back
Next
Cancel

	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		



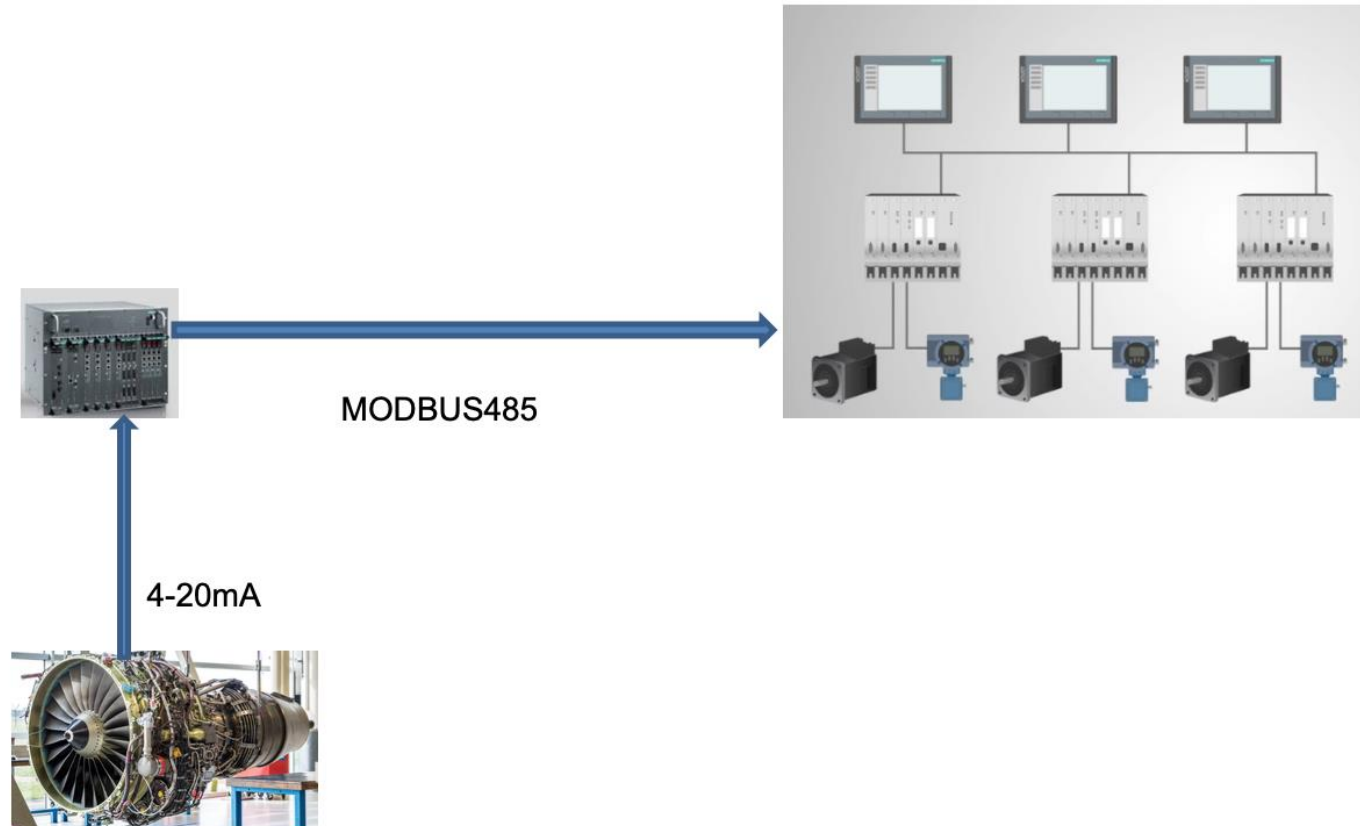
# Case Studies



# Examples of Applications in the Industry

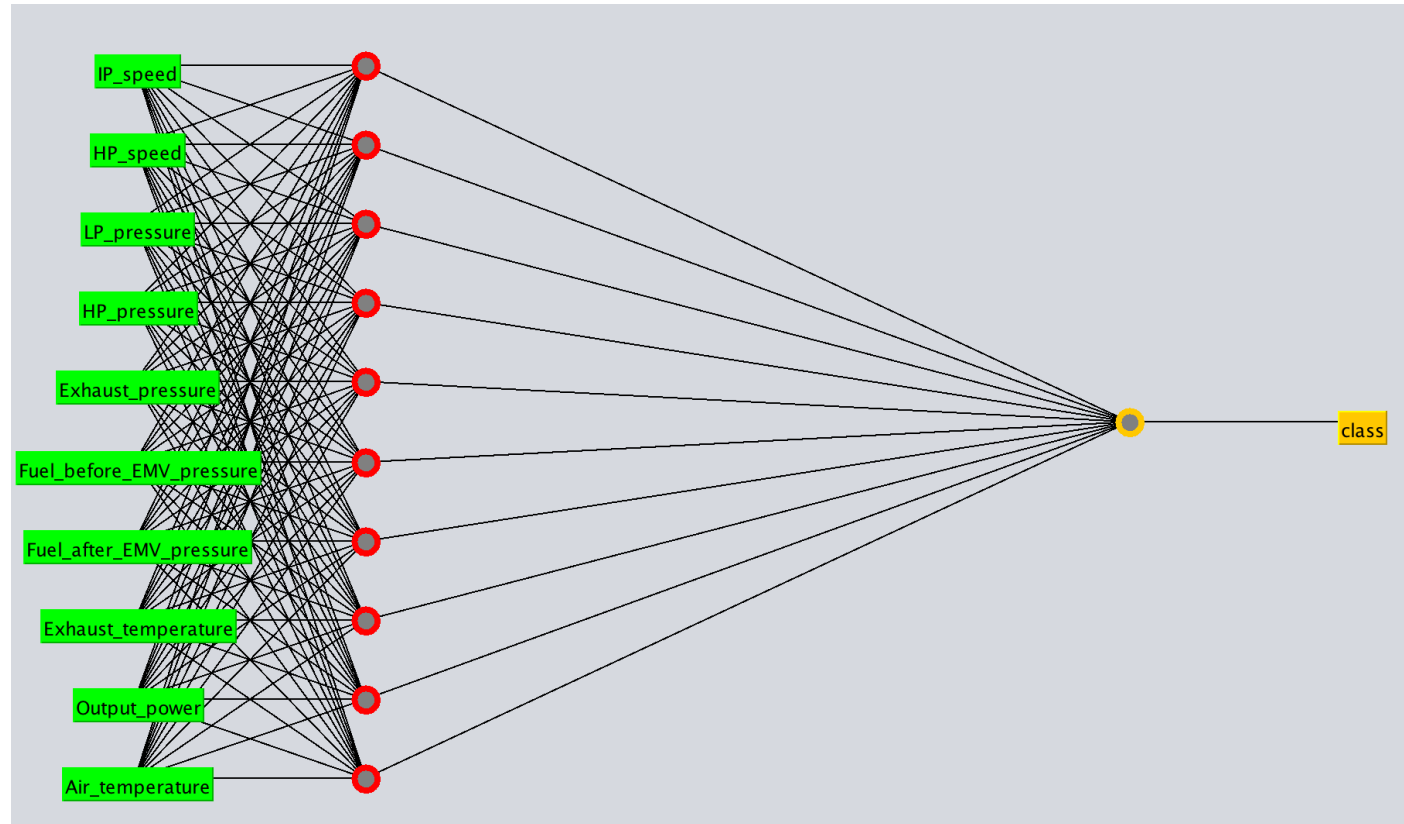
- Predictive maintenance
- Predictive control
- Fault detection
- Recommendations
- Operator assistants

## ➤ Predictive Maintenance



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

## ➤ Predictive Maintenance



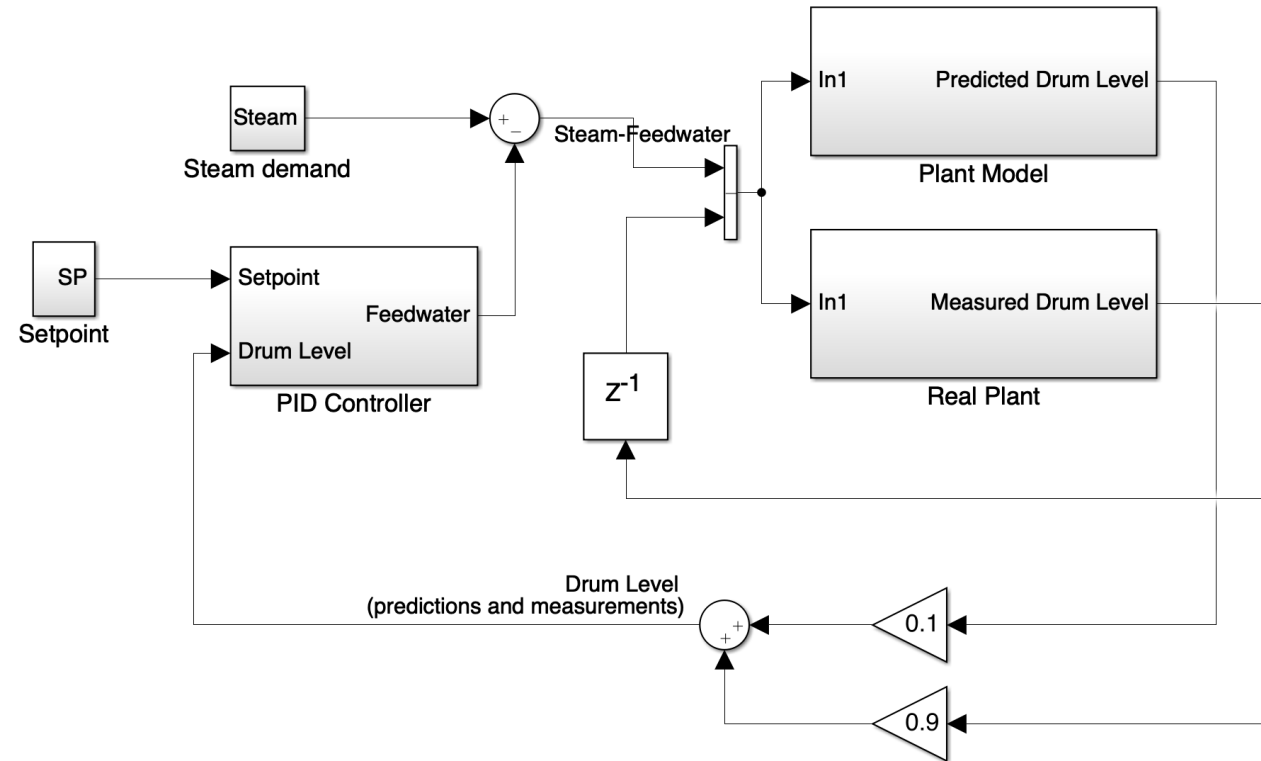
Khalid Salmanov (2020) Data analysis for the aero derivative engines bleed system failure identification and prediction, Master thesis, Engineering Institute of Technology

## › Predictive Maintenance



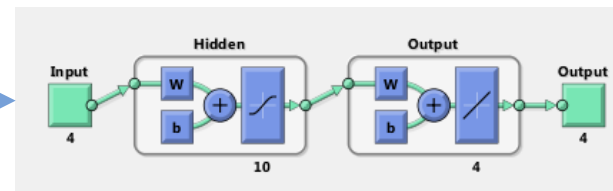
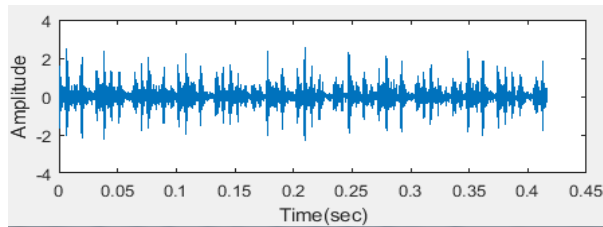
Khalid Salmanov (2020) Data analysis for the aero derivative engines bleed system failure identification and prediction, Master thesis, Engineering Institute of Technology

## ➤ 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

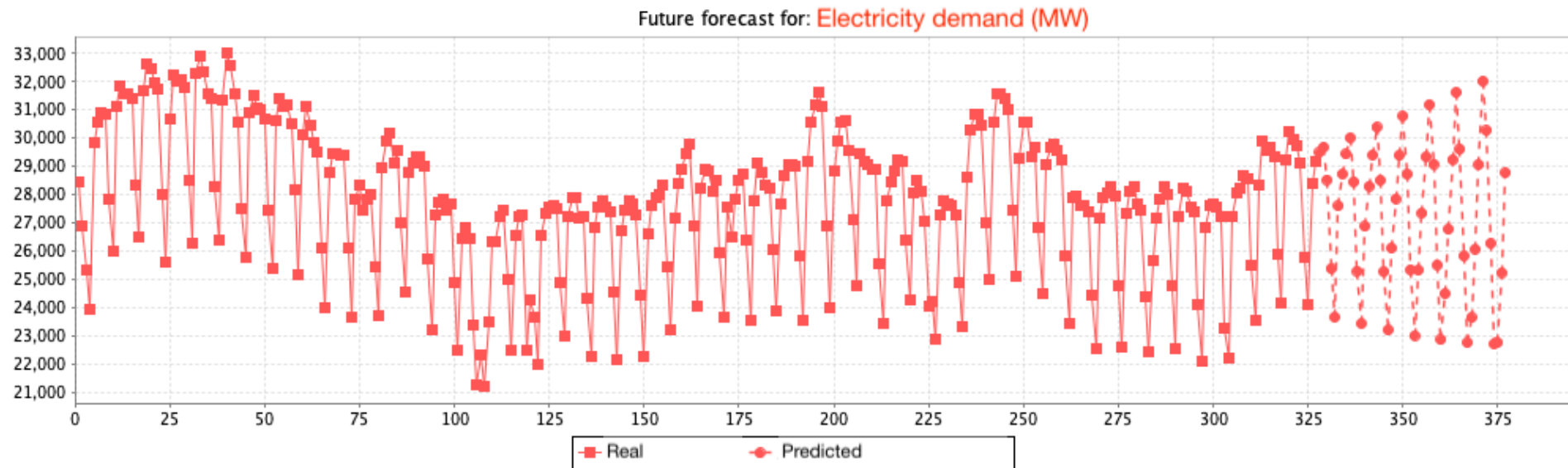
## ➤ Electric Motor Bearing Fault Detection



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

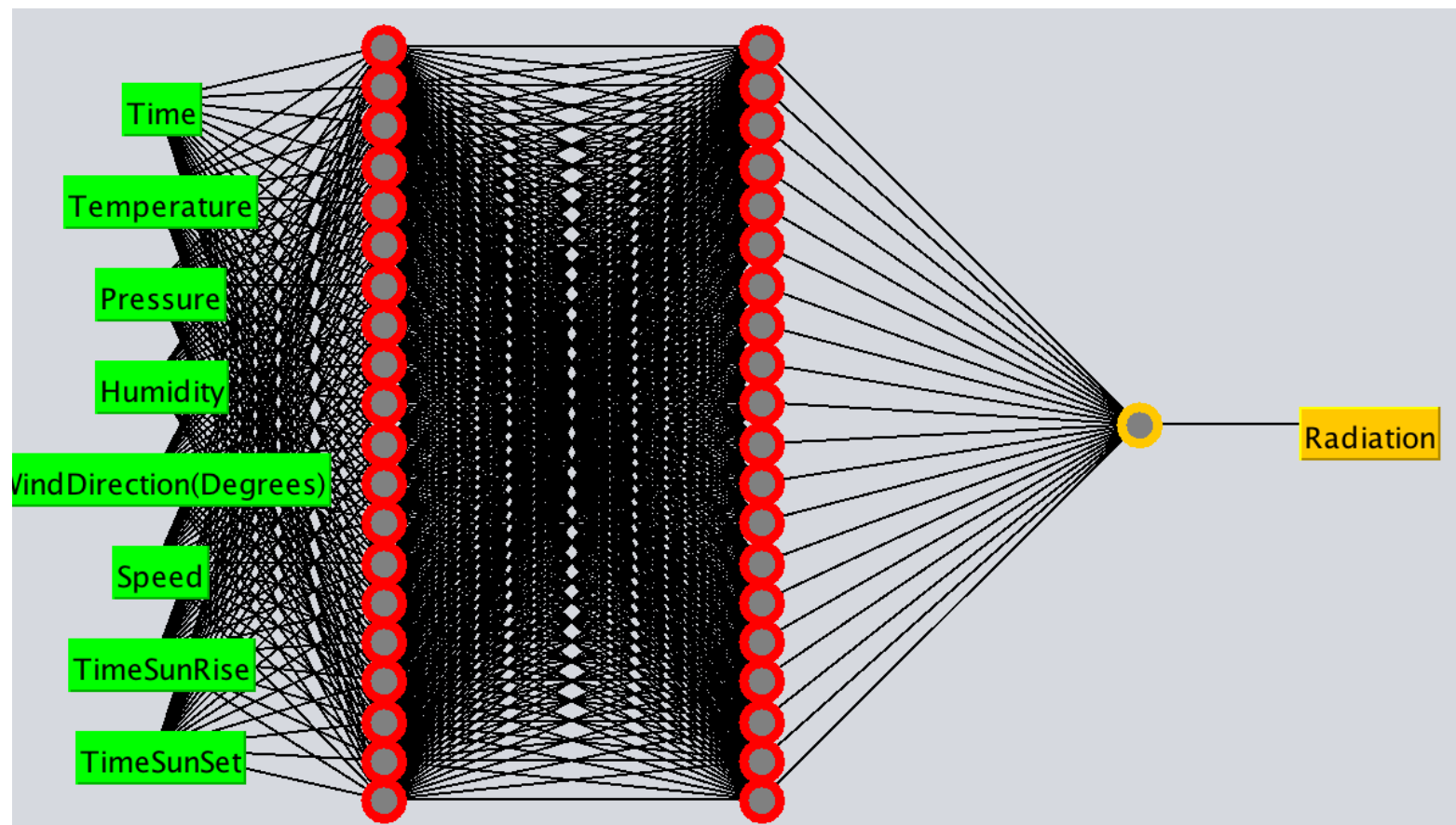
## ➤ Electricity Demand Forecasting



<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>



## ➤ Chatbot using Recurrent Neural Networks

**Q: HI**  
HI THERE

**Q: WHERE WERE YOU LAST NIGHT?**  
I WAS IN THE BATHROOM .

**Q: WHAT'S YOUR NAME?**  
MY NAME?

**Q: YES YOUR NAME PLEASE**  
MY NAME IS JOHN

**Q: HOW ARE YOU TODAY?**  
FINE, I'M DOING GREAT.

**Q: DO YOU LIKE TO GO OUT WITH ME?**  
SURE.

**Q: I LIKE YOU**  
I LIKE YOU.

**Q: I LOVE YOU. YOU KNOW THAT?**  
I LOVE YOU.

**Q: LET'S GO GRAB A BEER**  
COME ON!

**Q: I GOTTA GO NOW**  
BYE

# 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

# Q&A



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