Introduction of Machine Learning

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What is Machine Learning?

Learning is any process by which a system **improves performance** from **experience** (Herbert Simon)

Definition by Tom Mitchell (1998):

Machine Learning is the study of algorithm that

- improve their performance ***P***
- at task ***T***
- with experience ***E***

A well-defined learning task is given by <***P, T, E***>

Example: Defining the Learning Task

Improve on task T, with respect to performance metric P, based on experience E

T: Recognizing voices
P: Percentage of word sounds correctly detected and classified
E: Database of human-labeled sounds of words

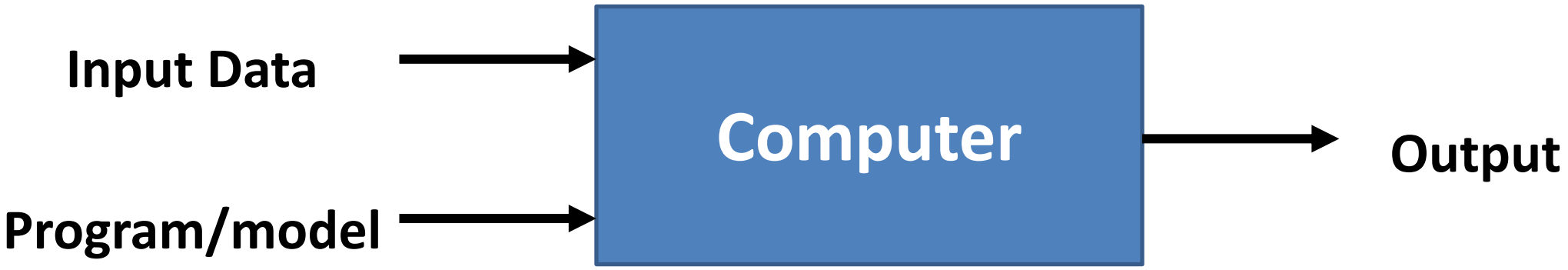
T: Detecting crack damage on images
P: Percentage of damage correctly identified and localized
E: Database of human-labeled images of crack damage

T: Driving on four-lane highways using vision sensors
P: Average distance traveled before a human-judged error
E: A sequence of images and steering commands recorded while observing a human driver.

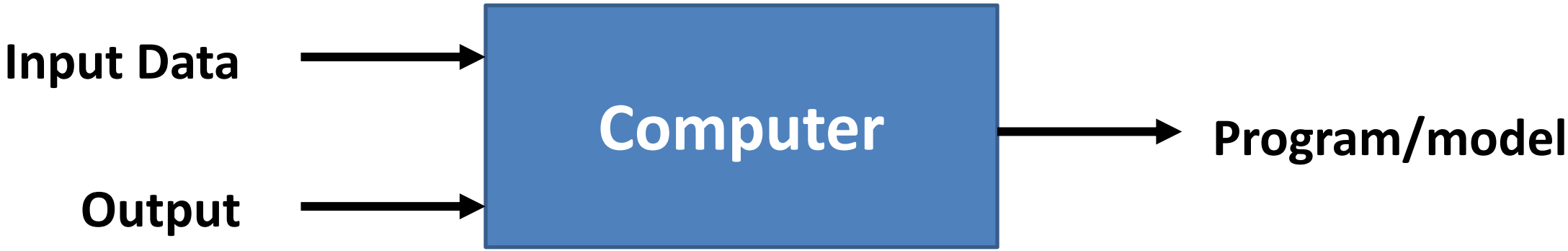
T: Classification of vehicle crossing and types using acceleration
P: Percentage of vehicle crossing, and types correctly estimated
E: Database of acceleration measurements collected under various vehicle crossing

Why is Machine Learning Different from Traditional Programming?

Traditional Programming

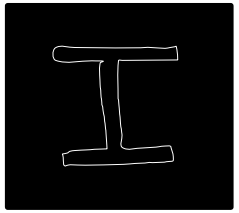


Machine Learning



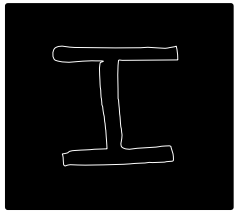
Example: Edge Detection

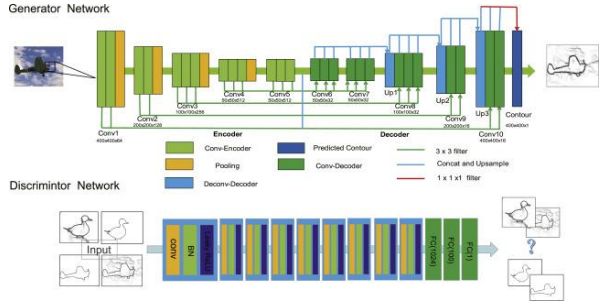
Traditional Programming



Edge detection, Hough transform

Machine Learning





Why is Everyone So Interested in Machine Learning Now?

Bigger Data

Flood of digital information that doubles every three years

Better Hardware

Optimized chips improving faster than Moore's law

Cheap storage and bandwidth

Smarter Algorithms

Ability to handle real-world complexity

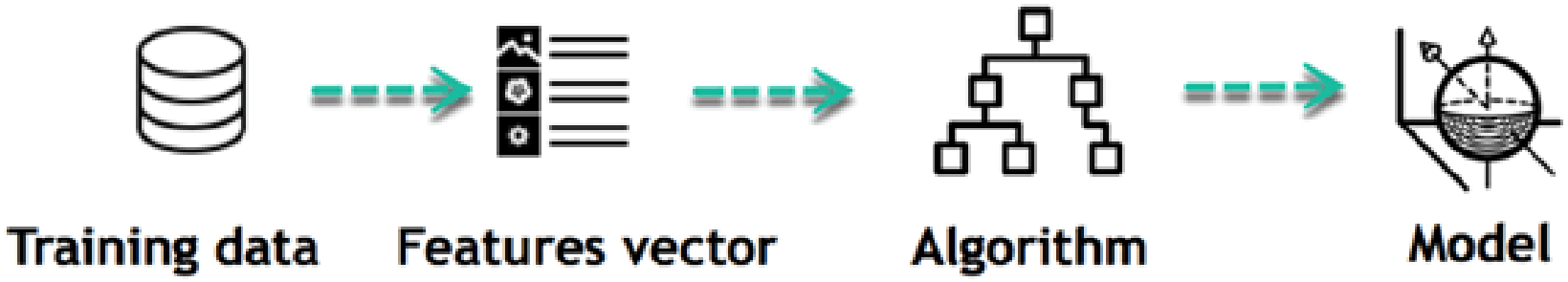
Training time down ~80% since 2010

Sample Applications

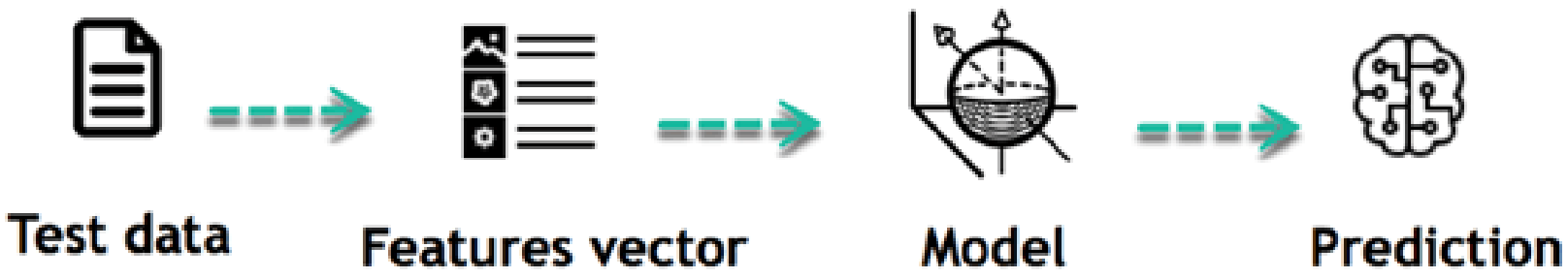
- Web search
- Computational biology
- Finance
- E-commerce
- Robotics
- Information extraction
- Social network
- Debugging Software
- Inspection

What are your applications?

How Does Machine Learning Work?

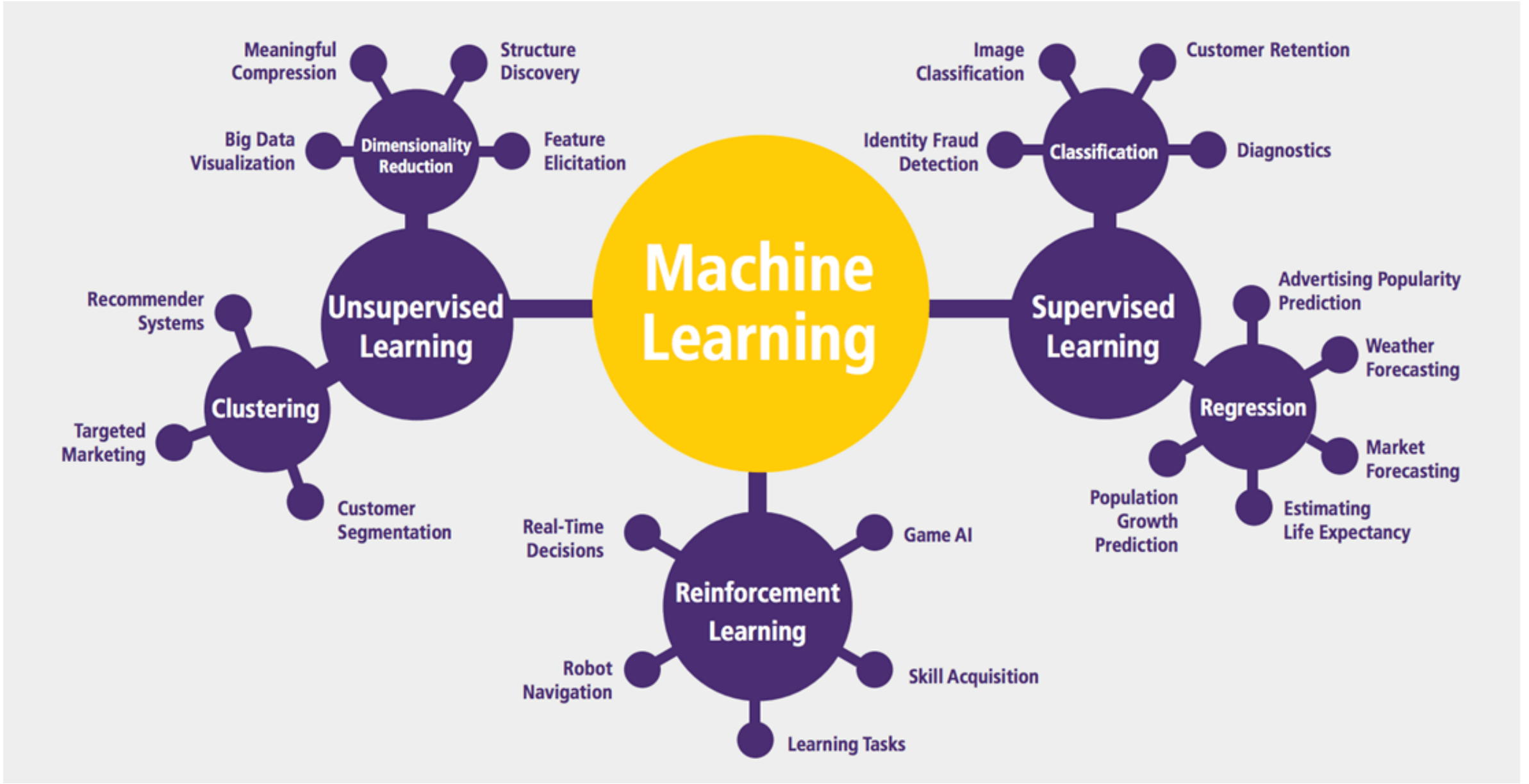


Learning (Training) Phase

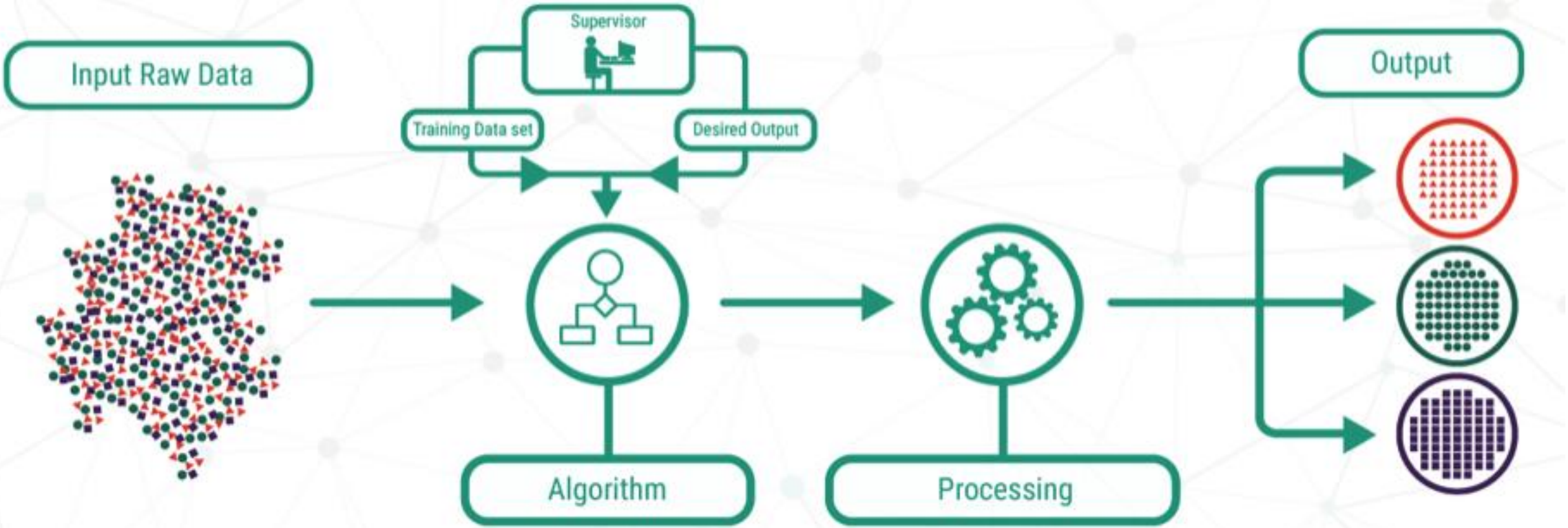


Inference (Testing) Phase

Machine Learning Applications

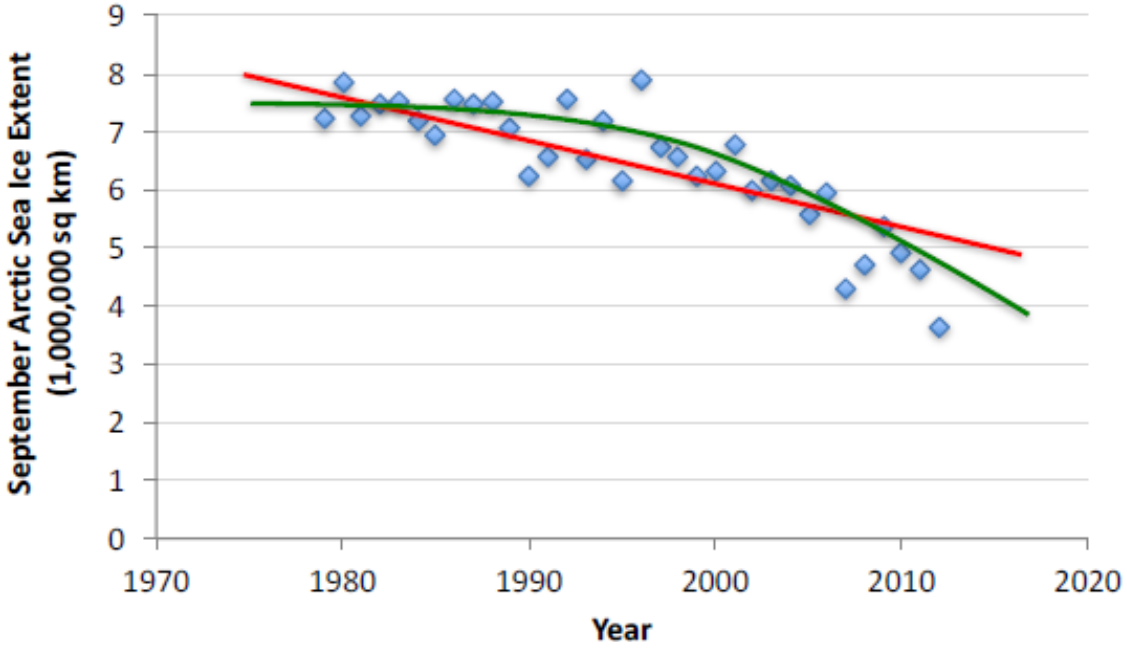


Supervised Learning

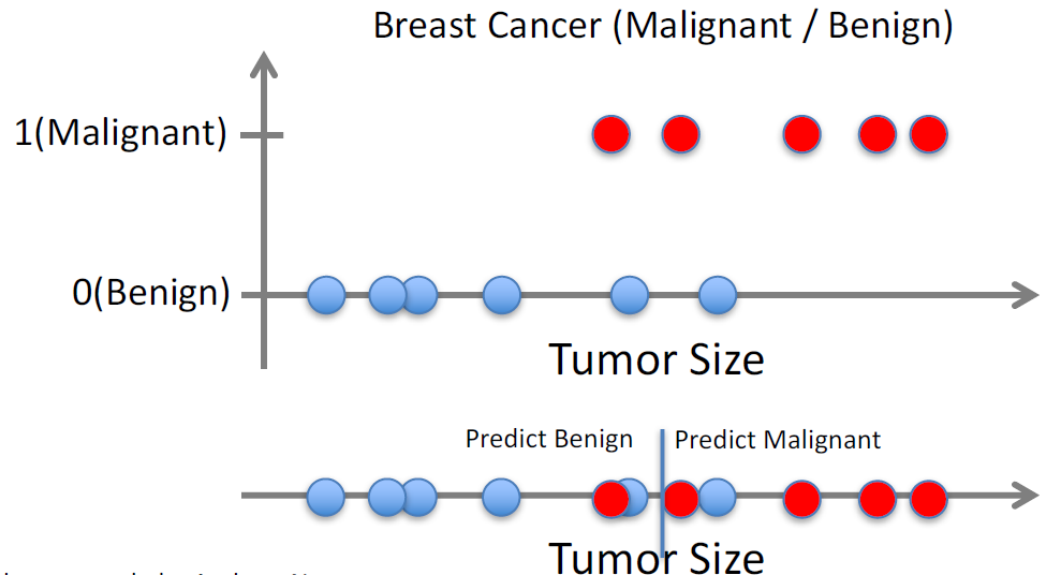


Supervised Learning: Regression and Classification

Given $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$, lean a function $f(x)$ to predict y given x, where y is real-valued data

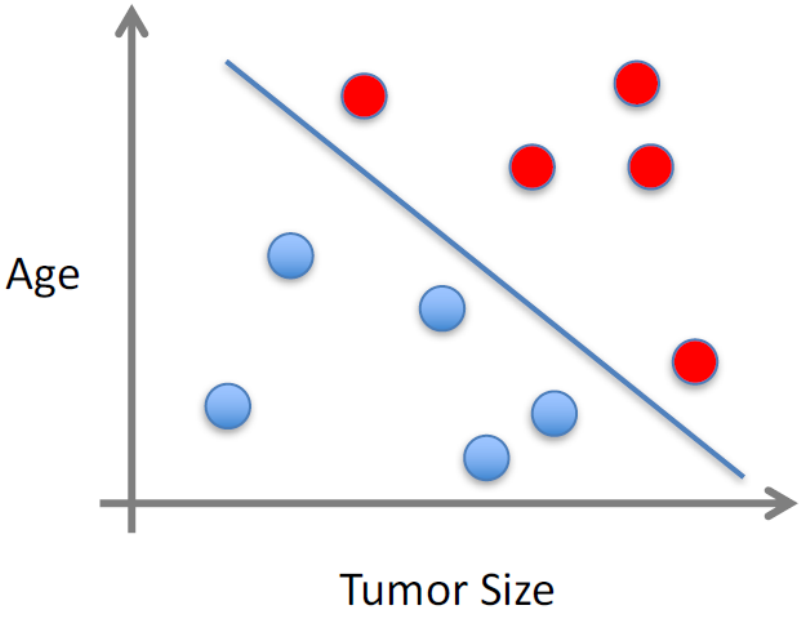


Given $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$, lean a function $f(x)$ to predict y given x, where y is categorical data



Supervised Learning: Classification (Multi Dimension)

- x can be multi-dimensional
  - Each dimension corresponds to an attribute



- Clump Thickness
- Uniformity of Cell Size
- Uniformity of Cell Shape

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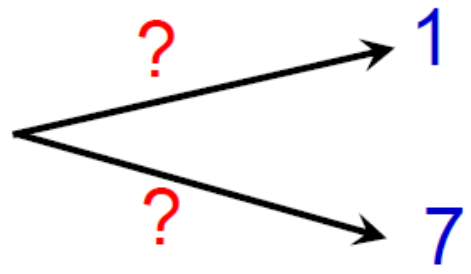
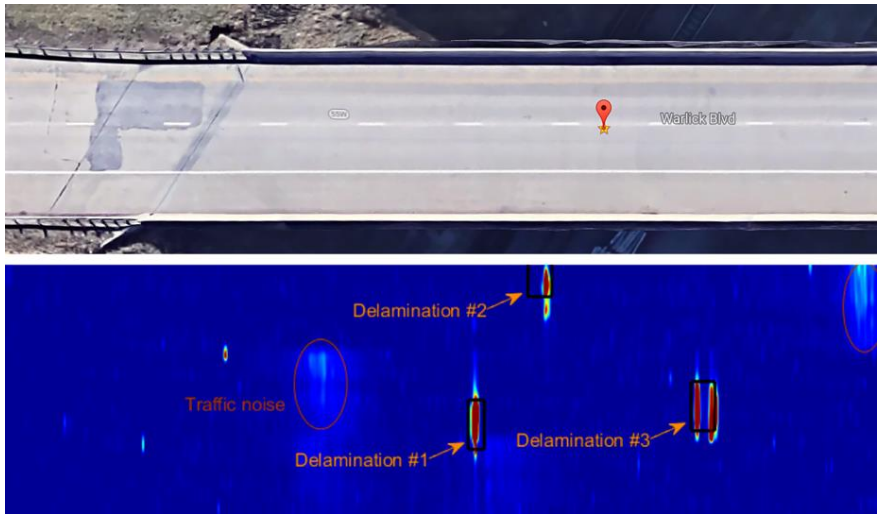


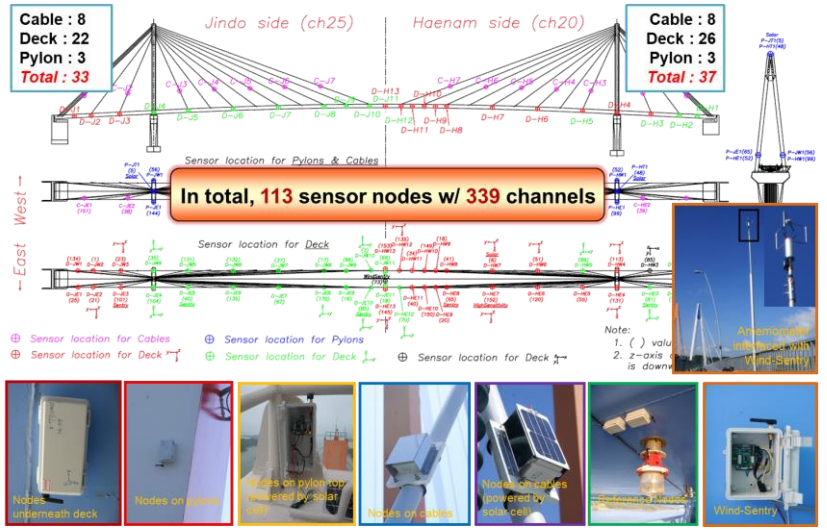
Example: Supervised Learning (Civil and Mechanical Engineering)

Collapse classification



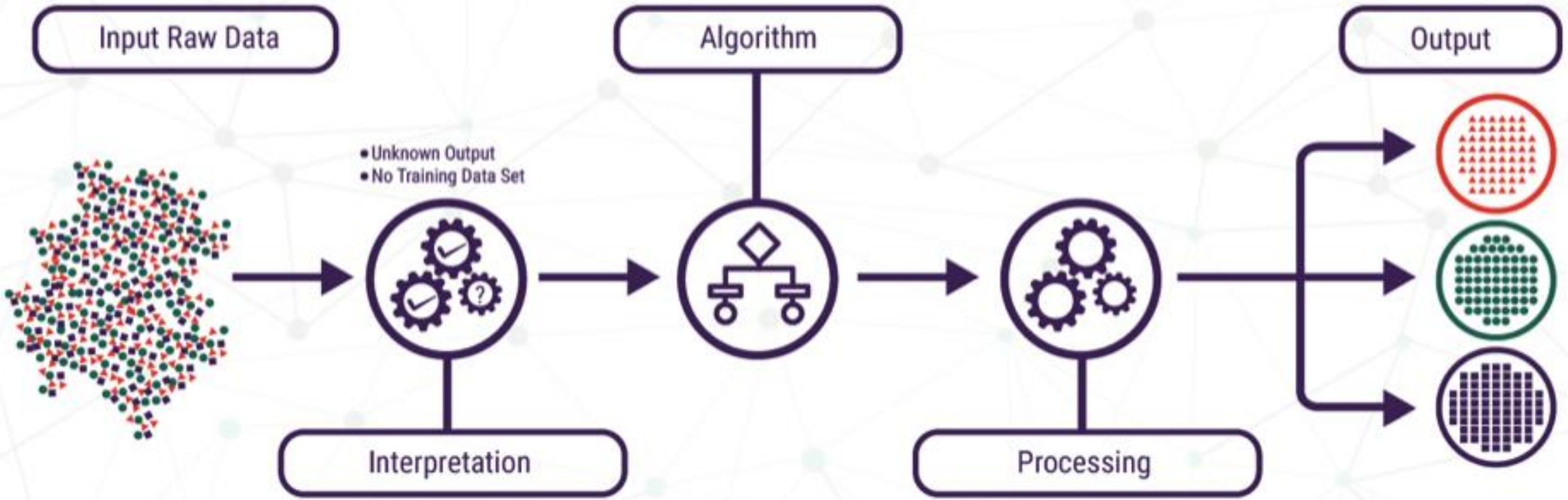
Delamination detection

Pipeline inspection

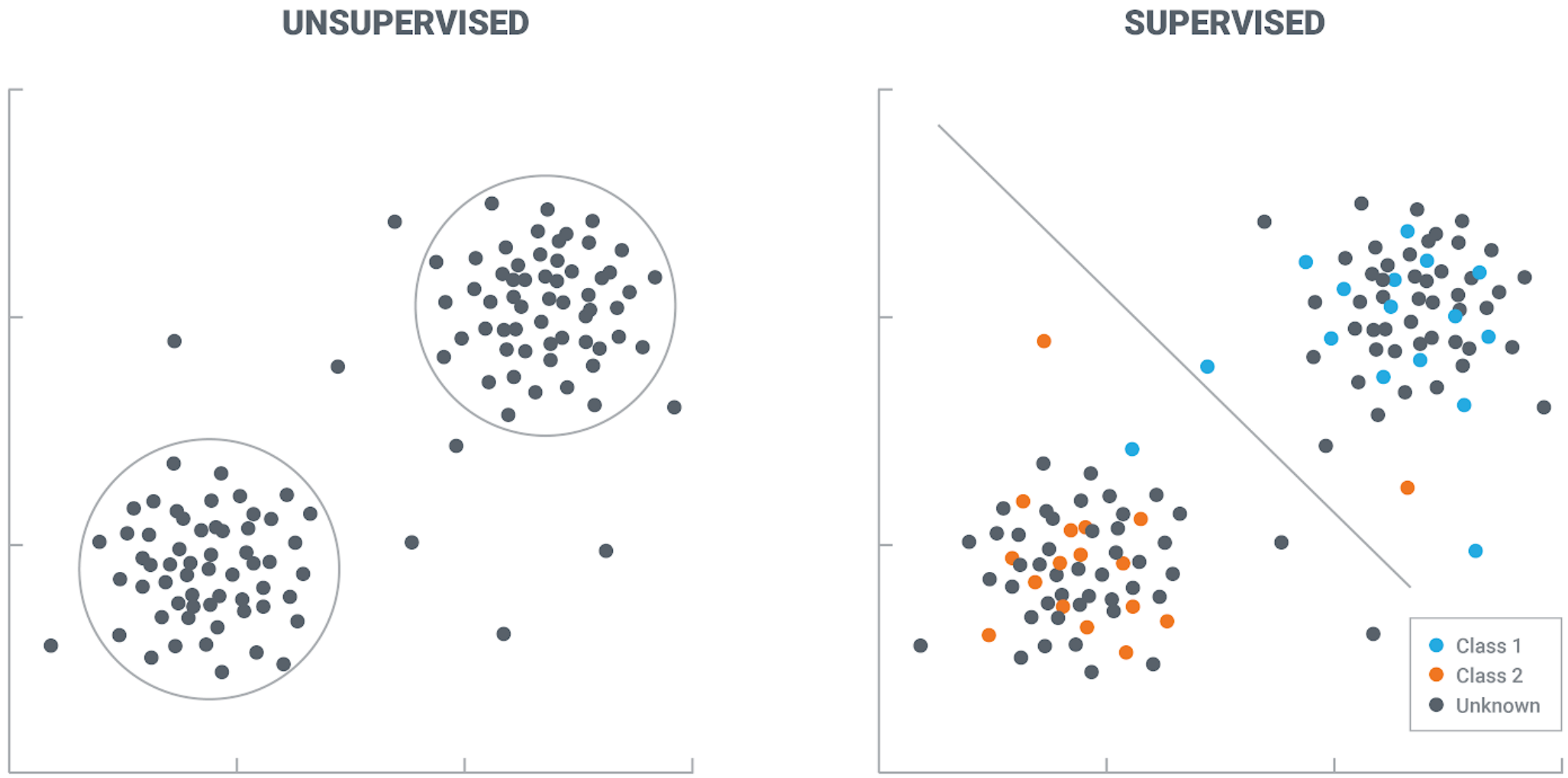


Wirless
health monitoring

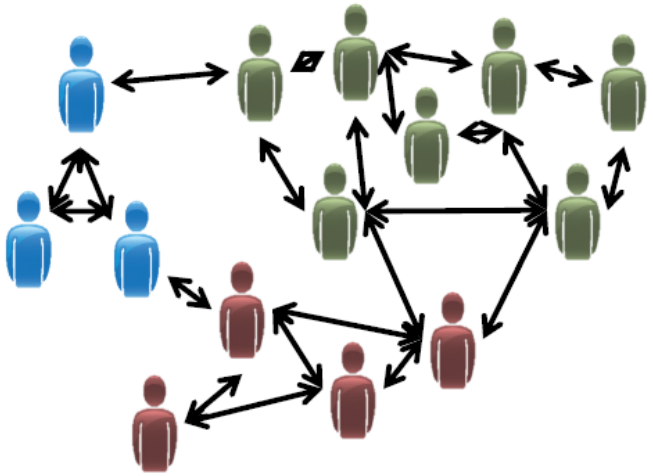
Unsupervised Learning



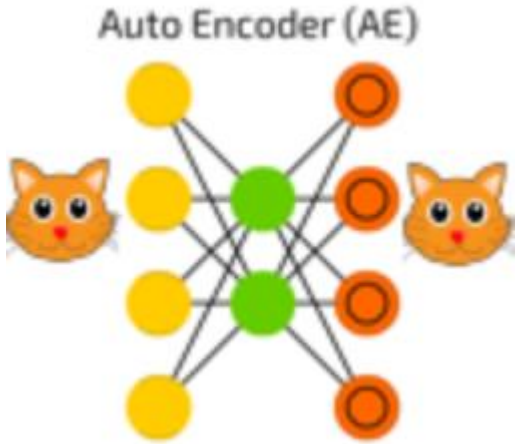
Unsupervised Learning Vs Supervised Learning



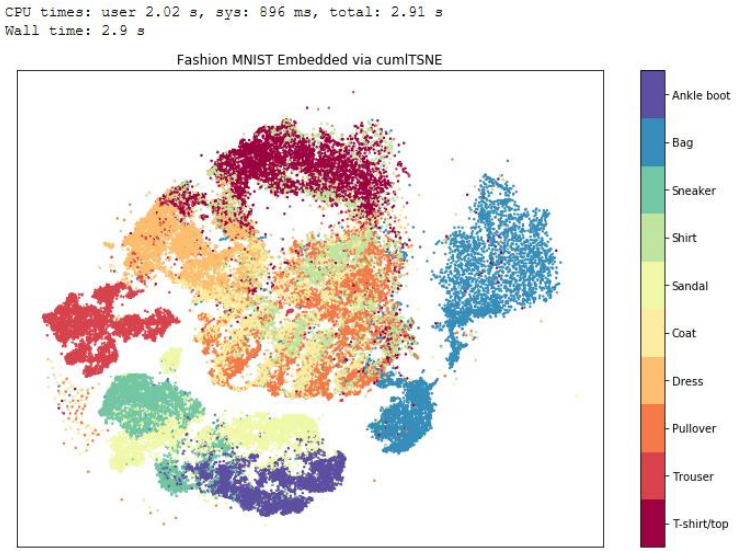
Example: Unsupervised Learning



Social Network

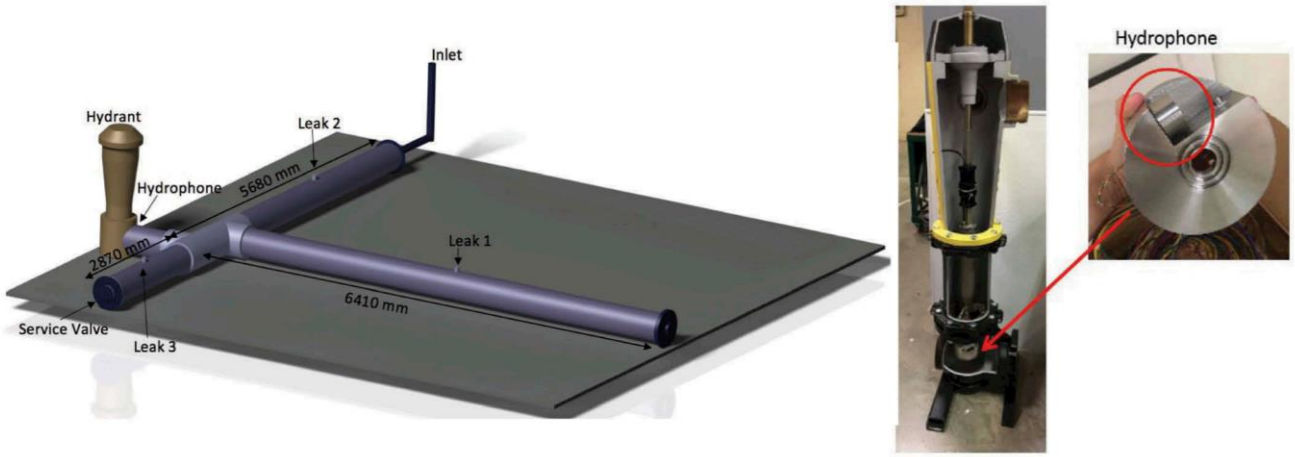


Autoencoder

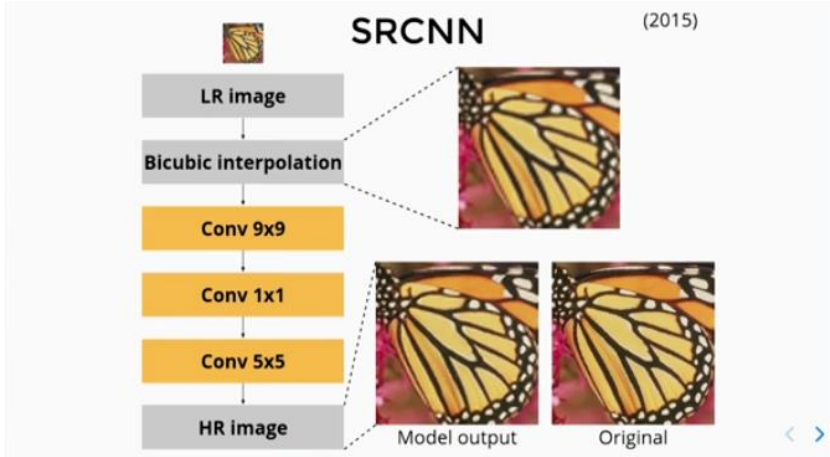


Visualization (t-SNE)

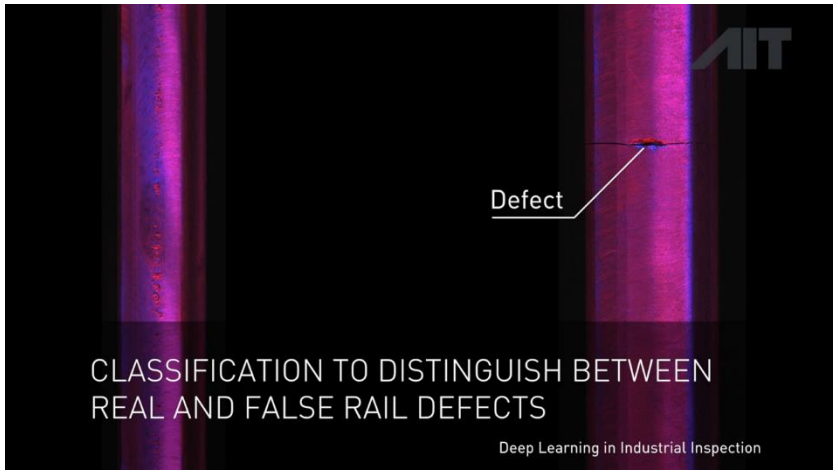
Example: Unsupervised Learning (Civil and Mechanical Engineering)



Leak detection (Cody et al, 2018) – Dr. Narasimhan's lab



Super-resolution application



AIT Deep Learning in industrial inspection