Machine Learning Methods and their Sensor and IOT Applications

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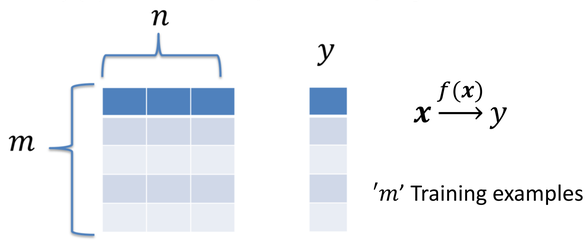
MACHINE LEARNING PARADIGMS

- **Supervised Learning**
  - Ground Truth or True Label for the data is known
  - Ground Truth is used in training an algorithm
- **Unsupervised Learning**
  - Datasets do not have any associated labels
  - Unsupervised model's goal is to derive hidden structure in the data
- Training Dataset is represented as table of values and labels
  - Each training data can be represented in a pair

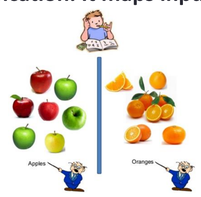
$$(x^{(1)}, y^{(1)}), (x^{(2)}, y^{(2)}) \ \ldots \ (x^{(m)}, y^{(m)})$$

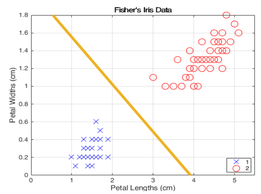
  - Machine learning model learns a hypothesis function $f(x)$ which maps input x to output y



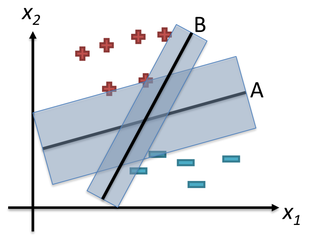
SUPERVISED LEARNING ALGORITHMS (EXAMPLES)

- **Logistic Regression** and **Perceptron** learning are methods for classification. It maps input to discrete outcomes

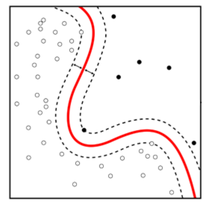




- The **Support Vector Machine (SVM)** algorithm is used for binary classification. It obtains the best decision boundary (hyperplane)
  - The objective function is convex and finds a global minimum.
  - The Kernel trick allows us to find a non-linear decision boundary



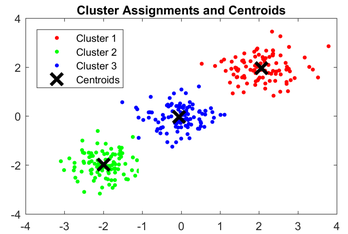
Linear Decision Boundary

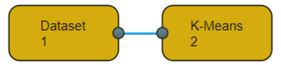


Use of kernel trick to find a non-linear decision boundary

UNSUPERVISED LEARNING ALGORITHMS & SOFTWARE

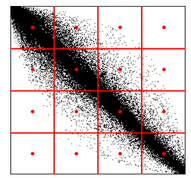
- **Clustering** determines a structure or pattern in a collection of unlabeled data
  - **K-means** iterative algorithm clusters data into K groups of equal variances



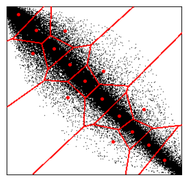


Online J-DSP HTML5 tool to run K-means algorithm

- **Vector Quantization** learns codebook vectors (centroids) for representing data



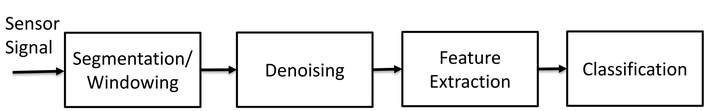
Uniform Quantization of 2-dimensional data



Vector Quantization of 2-dimensional data

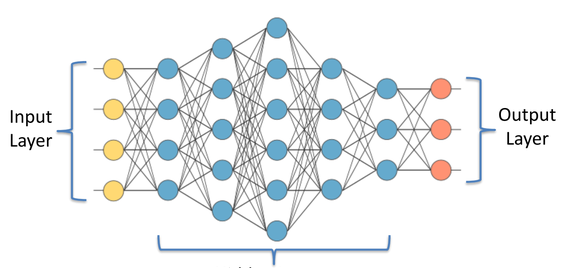
BASIC SIGNAL PROCESSING FRAMEWORK

- Basic signal processing framework includes windowing, followed by noise removal and feature extraction stage
- Extracted features are trained in the classification stage by a machine learning algorithm



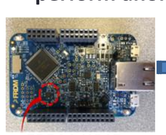
DEEP LEARNING – ARTIFICIAL NEURAL NETWORKS

- **Artificial Neural network** consists of many layers of neurons
  - Each layer learns a concept different from the previous layers
  - The term "deep learning" refers to several layers used to learn multiple levels of abstraction

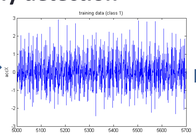


USE OF ACCELEROMETER SENSOR IN IOT APPLICATIONS

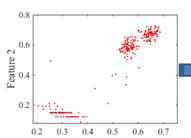
- Machine learning algorithm is implemented on an embedded sensor platform
- Accelerometer sensor data is used for training a machine learning model to perform anomaly detection



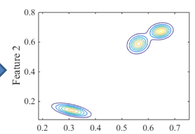
FRDM-K64F Accelerometer Sensor



Raw Sensor Data from the Accelerometer



Feature Extraction



Statistical Model by Machine Learning

ACKNOWLEDGEMENTS

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REFERENCE

[1] U. Shanthamallu, A. Spanias, C. Tepedelenlioglu, M. Stanley, "A Brief Survey of Machine Learning Methods and their Sensor and IoT Applications," *IEEE IISA 2017*, Larnaca, August 2017.

[2] A. Dixit, S. Katoch, P. Spanias, M. Banavar, H. Song, A. Spanias, "Development of Signal Processing Online Labs using HTML5 and Mobile platforms," *IEEE FIE 2017*, Indianapolis, October , 2017.