Johns Hopkins Engineering

Applied Machine Learning for Mechanical Engineers

Machine Learning Fundamentals, Part 1, A

JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

Overview of Machine Learning in General

- By the end of this lecture you will be able to:
  - Describe problems that machine learning addresses
  - Describe how machine learning works in general
  - Describe training and testing data
  - Describe supervised and unsupervised machine learning

Overview of Machine Learning in General

- Problems
  - Estimation problems
  - Recognition problems
  - Feature extraction problems
  - Acceleration

Overview of Machine Learning in General

- Estimation Problems
  - Estimate materials' strength using materials' properties
  - Estimate housing prices in a region
  - Estimate state of damage in wind turbine blades
  - Estimate damage condition of rotating machinery
  - Earthquake prediction

Overview of Machine Learning in General

- Recognition Problems
  - Identify a particular type of cracks on the surface of materials
  - Identify facial expressions
  - Identify certain species by scrapping tweets or flicker photos
  - Identify faces or location of eyes in a picture

Overview of Machine Learning in General

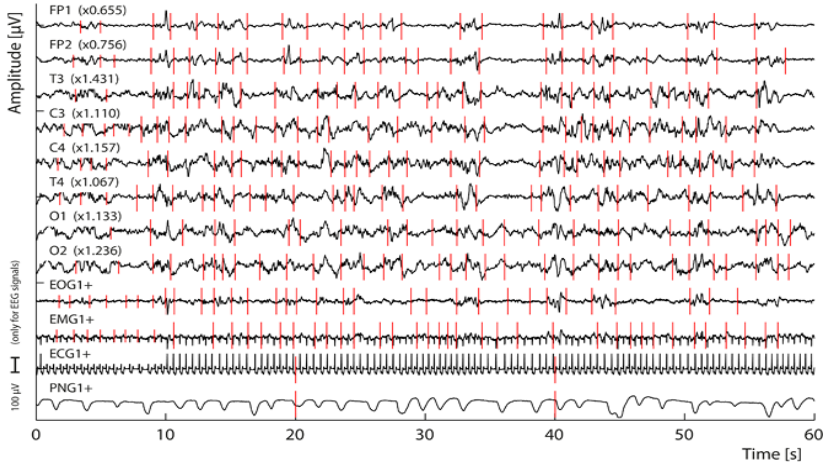
- Feature Extraction
  - Reconstruction of turbulent flows with machine learning
  - Bearing fault diagnosis based on feature extraction
  - Machine learning based feature extraction for quality control in a production line

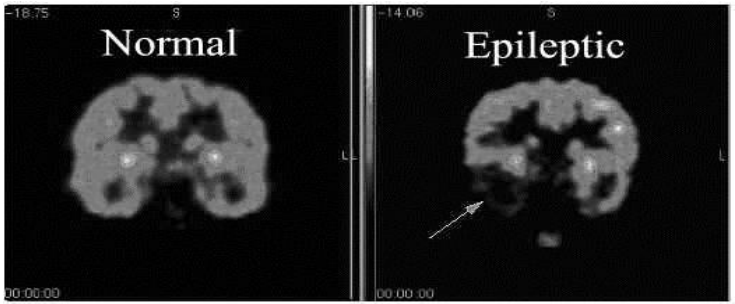
Overview of Machine Learning in General

- Acceleration
  - Accelerated non-destructive materials characterizations
  - Accelerated Materials Design of Lithium Superionic Conductors by Machine Learning
  - Adaptive machine learning framework to accelerate molecular dynamics

Overview of Machine Learning in General

- Epileptic or not?
  - Physician: 65% accurate
  - Machine: 97% accurate
    - Analysis of EEG (electroencephalogram) records in an epileptic patient using wavelet transform (Adeli el al. 2003, Neuroscience Methods)





http://bio.felk.cvut.cz/biocmsms/uploads/images/eeg/segmentation-adaptive-and-constant.png
http://www.chm.bris.ac.uk/webprojects2002/wrigglesworth/epilepsy.jpg

Overview of Machine Learning in General

- Machine Learning in General
  - Mimic the way human brain learns and respond.
    - Requires data to learn (training data)
    - Requires data to evaluate the learning (testing or evaluation data)

http://insights.ingredientsnetwork.com/wp-content/uploads/2015/04/Brain-image.jpg

Overview of Machine Learning in General

- Machine Learning in General

  - Mimic the way human brain learns and respond.
    - Learn patterns
    - Learn difference
    - Learn characteristics, attributes, measures, or features

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Overview of Machine Learning in General

- Machine Learning in General
  - Mimic the way human brain learns and respond.

Overview of Machine Learning in General

- Machine Learning in General
  - Mimic the way human brain learns and respond.

$\boldsymbol{X}_{1,1}$ $\boldsymbol{X}_{1,2}$ $\boldsymbol{X}_{1,10}$

Category 1

$\boldsymbol{X}_{2,2}$ $\boldsymbol{X}_{2,2}$ $\boldsymbol{X}_{2,10}$

Category 2

Training data

$$\boldsymbol{X}_{i,j} = \left[X_{i,j,1}, X_{i,j,2}, \dots, X_{i,j,N}\right]$$

Testing data
Category 1 or 2?

http://clipartix.com/wp-content/uploads/2016/05/Smiley-face-happy-smiling-face-clip-art-at-vector-clip-art-2.jpg
https://media-exp2.licdn.com/mpr/mpr/AAEAAQAAAAAAAAidAAAAJDNlZmJhM2Q3LWU4ZmEtNDE0NS1iYjgzLWU5N2YwZDg0MmJmMw.png
https://i.pinimg.com/originals/a0/46/79/a0467907a7d9d41b786f8743b221e4a.png
https://qdbr.daf.qld.gov.au/dogs
https://archive.cnx.org/resources/6f2e4fa162a-ac3db3b-b19c198-aedd72-6d9e5cf-eb/pitch_signal.jpg
https://d3jkudlc7u70kh.cloudfront.net/cat-facts.jpg

Overview of Machine Learning in General

- Machine Learning in General
  - Data
    - Training
    - Evaluating (or testing) data (accuracy/error)
  - Train a student with course materials and hundreds of sample problems (study day and night and go over materials multiple times!)
  - Evaluate the “trained” student with a dozens of evaluating problems and compare student answers to the correct answers (final score!)

Overview of Machine Learning in General

- Machine Learning in General
  - Supervised machine learning for supervised problems
    - data (whether training or testing) has two parts, input data and output data
    - Example: student needs to mathematically estimate the compressive strength of materials (can be compared with actual results from lab experiment)
  - Unsupervised machine learning for unsupervised problems:
    - data (whether training or testing) has only input data and no output data
    - Example: student needs to describe the characteristics of damage on a metal surface (might have an infinite way of describing the damage, no true answer but one can judge how relevant the description is to damage in general)

Overview of Machine Learning in General

- Machine Learning in General
  - Classifiers for classification problems
    - Output/s is/are in form of categories, classes, or integers
    - Example: classification of cracks in materials
  - Regressors for regression problems
    - Output/s is/are in form of real values
    - Example: estimation of housing prices in future

Overview of Machine Learning in General

- In this lecture, you learned about:
  - Problems that machine learning addresses
  - How machine learning works in general
  - Training and testing data
  - Supervised and unsupervised machine learning
- In the next lecture, we will talk about training and testing data in machine learning