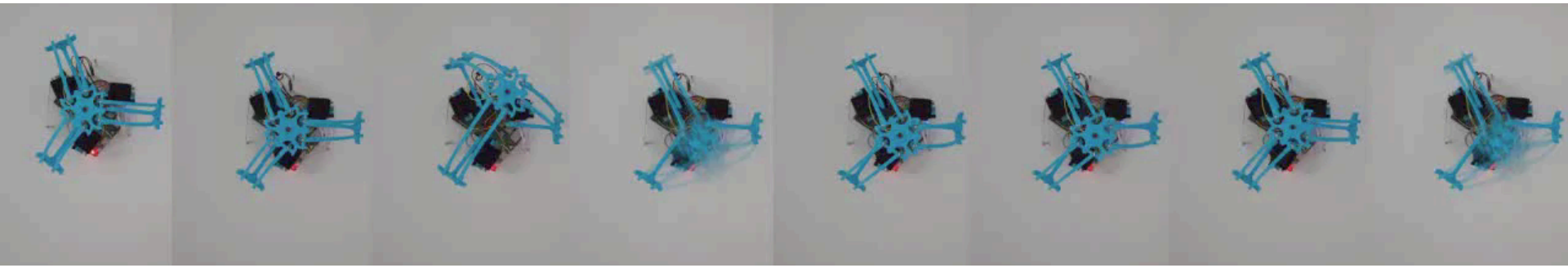
Introduction

Industrial AI Lab.

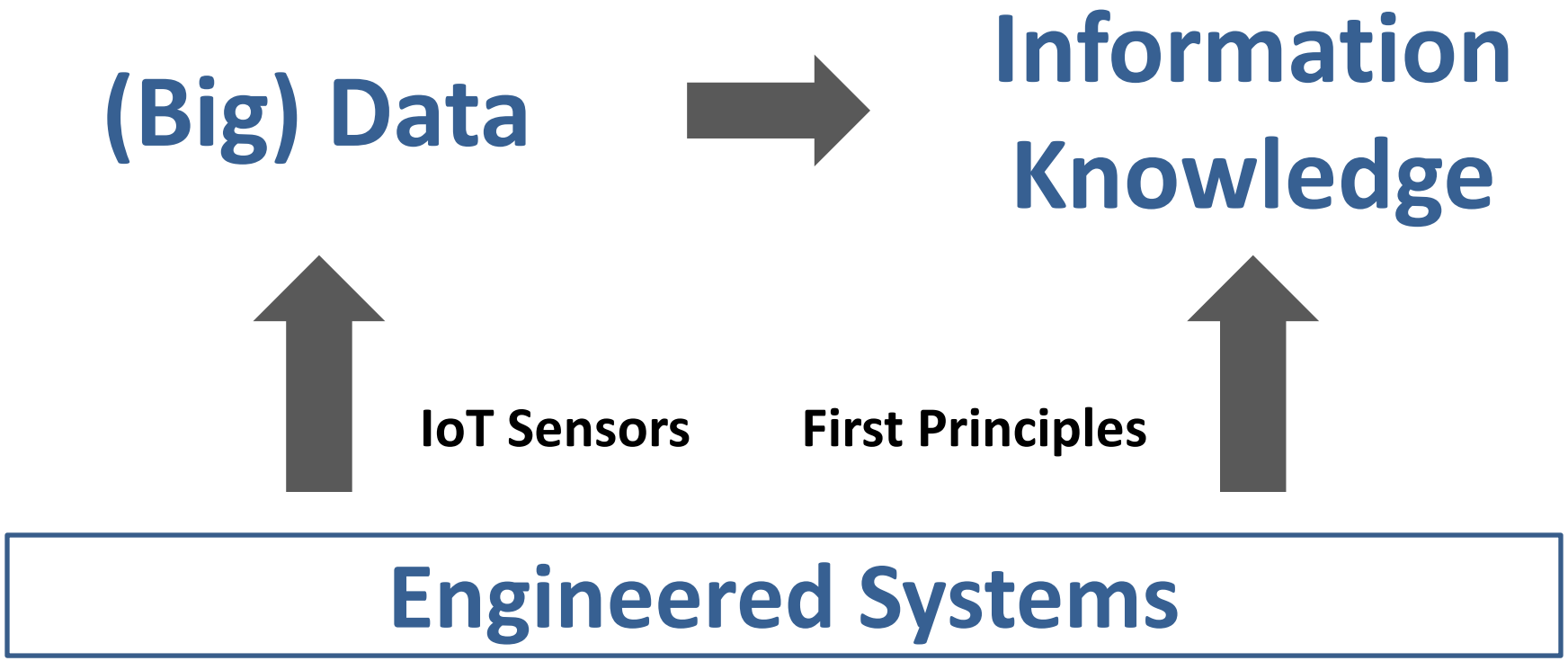
Introduction

- 2018 - present: POSTECH
  - Industrial AI Lab.
- 2013 - 2017: UNIST
  - iSystems Design Lab.
- 2010, Ph.D. from the University of Michigan, Ann Arbor
  - S. M. Wu Manufacturing Research Center
  - The Center of Intelligent Maintenance Systems (IMS)
- 2008, M.S. from the University of Michigan, Ann Arbor
- 2005, B.S. of Electrical Engineering from Seoul National University
- 2001, B.S. of Mechanical Engineering from Seoul National University




Data Science
Machine Learning/Deep Learning
Artificial Intelligence
Industrial AI

Machine Learning and Deep Learning

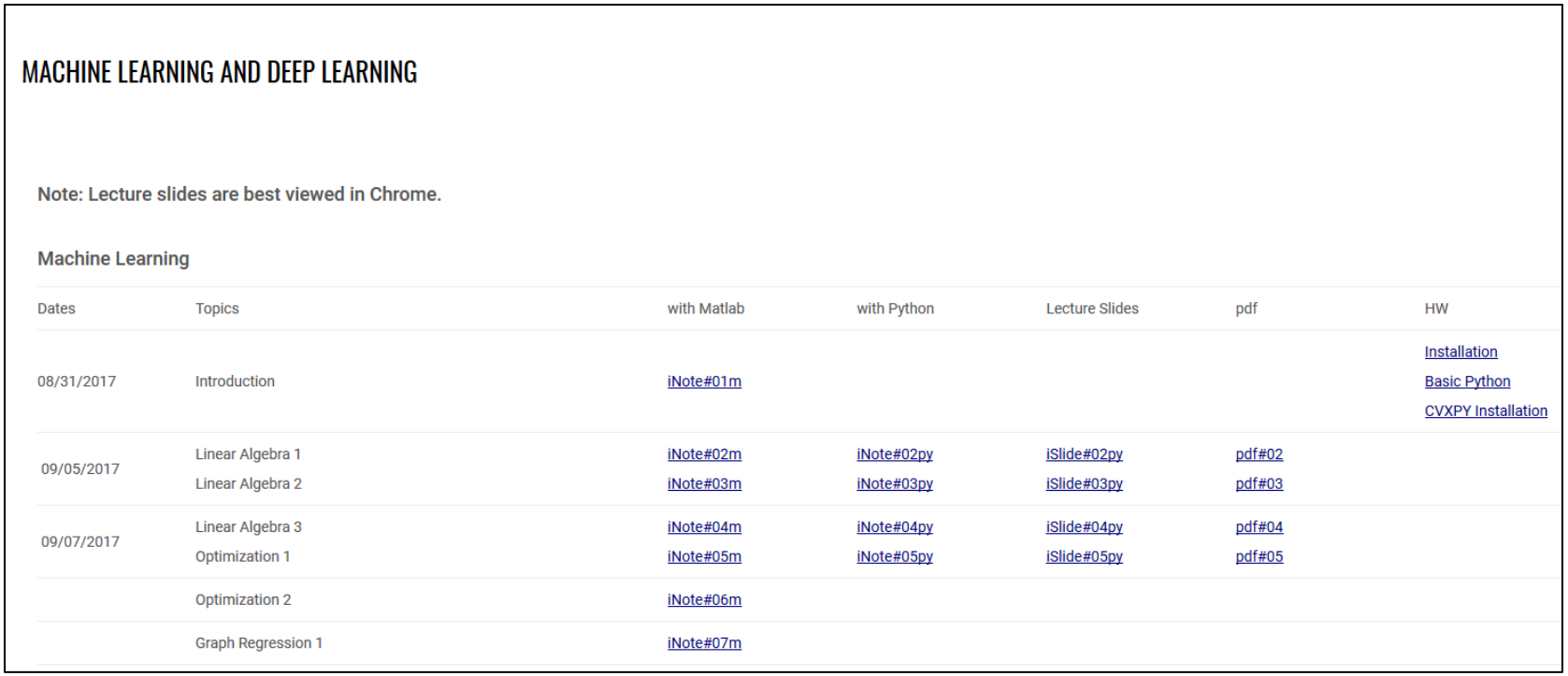


Course Info

- Machine learning
  - Linear algebra
  - Optimization
  - Statistical and probabilistic approaches
- Python in class and assignments
  - Used a lot
  - Provide all necessary .py codes for a class
- Evaluation
  - Two exams (30% + 35%)
  - Many assignments (25%)
  - Class participation (10%)

Lecture Materials

- All lecture materials are already available at
  - http://isystems.unist.ac.kr/teaching/machine-learning/
- Lecture video will be posted at YouTube (but in Korean)



MACHINE LEARNING AND DEEP LEARNING

Note: Lecture slides are best viewed in Chrome.

Machine Learning

Dates	Topics	with Matlab	with Python	Lecture Slides	pdf	HW
08/31/2017	Introduction	iNote#01m				Installation Basic Python CVXPY Installation
09/05/2017	Linear Algebra 1 Linear Algebra 2	iNote#02m iNote#03m	iNote#02py iNote#03py	iSlide#02py iSlide#03py	pdf#02 pdf#03	
09/07/2017	Linear Algebra 3 Optimization 1	iNote#04m iNote#05m	iNote#04py iNote#05py	iSlide#04py iSlide#05py	pdf#04 pdf#05	
	Optimization 2	iNote#06m				
	Graph Regression 1	iNote#07m				

What is Machine Learning

- Draw a meaningful conclusion, given a set of data (observation, measurement)

- In 1959, Arthur Samuel defined machine learning as a
  - "Field of study that gives computers the ability to learn without being explicitly programmed"

  - Often hand programming not possible
  - Solution? Get the computer to program itself, by showing it examples of the behavior we want! This is the *learning* approach of AI
  - Really, we write the structure of the program and the computer tunes many internal parameters

What is Machine Learning ?

- Many related terms:
  - Pattern recognition
  - Neural networks → Deep learning
  - Data mining
  - Adaptive control
  - Statistical modeling
  - Data analytics / data science
  - Artificial intelligence
  - Machine learning

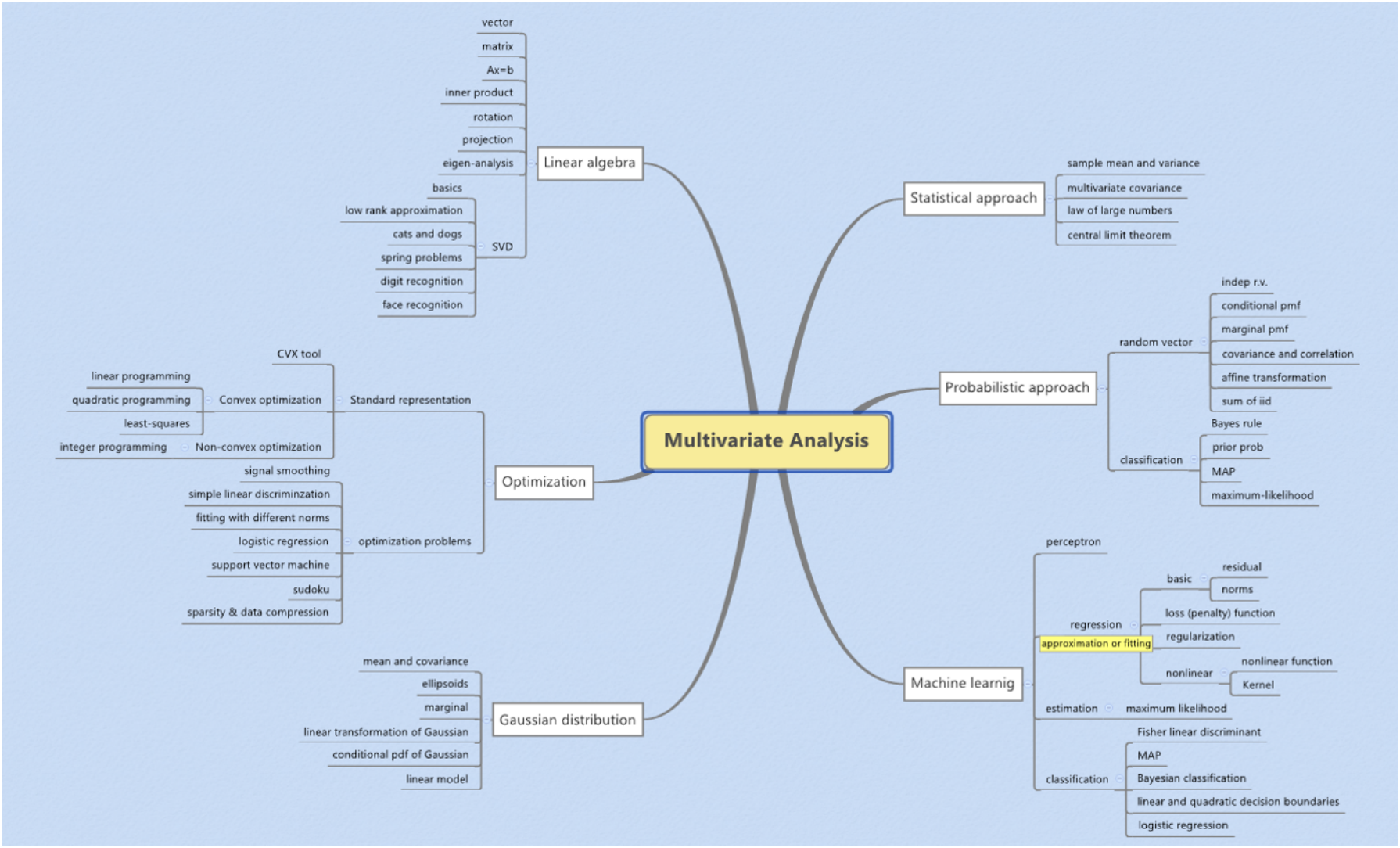
Learning: Views from Different Fields

- Engineering
  - Signal processing, system identification, adaptive and optimal control, information theory, robotics, …
- Computer science
  - Artificial intelligence, computer vision, …
- Statistics
  - Learning theory, data mining, learning and inference from data, …
- Cognitive science and psychology
  - Perception, movement control, reinforcement learning, mathematical psychology, …
- Economics
  - Decision theory, game theory, operational research, …

Course Roadmap

- Supervised Learning
  - Regression
    - Linear, Nonlinear (kernel), Ridge (L_2 norm regularization), Lasso (L_1 norm regularization)
  - Classification
    - Perceptron, SVM, Logistic regression, Bayesian classifier
- Unsupervised Learning
  - Clustering
    - k-means, Gaussian Mixture Model (GMM)
  - Dimension reduction
    - Principal Component Analysis (PCA)
- Probabilistic Machine Learning
  - Parameter estimation (MLE and MAP)

Course Roadmap



Required Mathematical Tools

- Linear algebra
  - Vector and Matrix
  - $Ax = b$
  - Projection
  - Eigen analysis
- Optimization
  - Least squares
  - Convex optimization (cvx or cvxpy)
- Statistics
  - Law of large numbers, central limit theorem
  - Correlation
  - Monte Carlo simulation
- Probability
  - Random variable, Gaussian density distribution, conditional probability
  - maximum likelihood (MLE), maximum a posterior (MAP), Bayesian thinking

Deep Learning

- Deep Learning will not be covered in this course

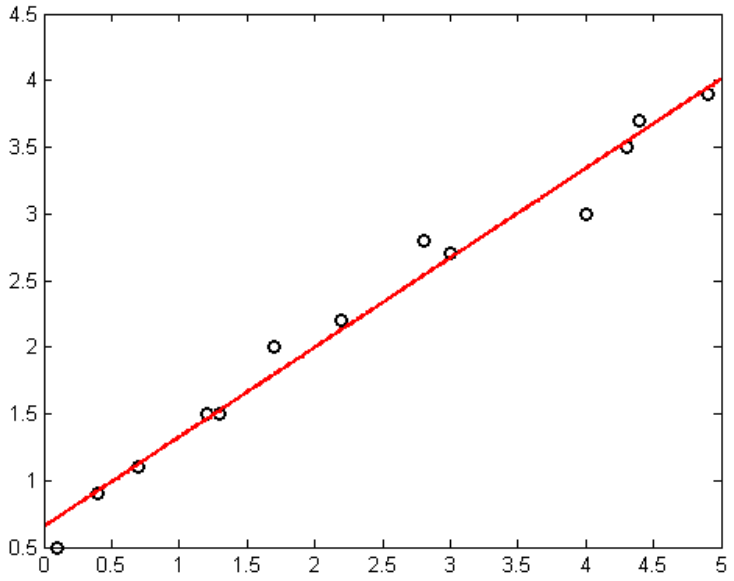
- I plan to open a new graduate course for deep learning next semester (2018 Fall)

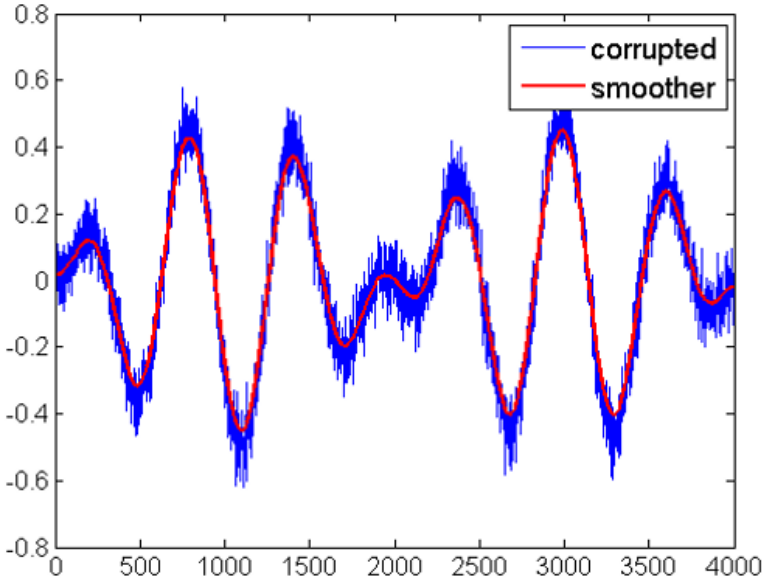
- For those who are eager to learn about deep learning,
  - http://isystems.unist.ac.kr/teaching/machine-learning/
  - Short course tutorials
  - Installation and TensorFlow

What Will We Cover?

Data Fitting or Approximation (Regression)

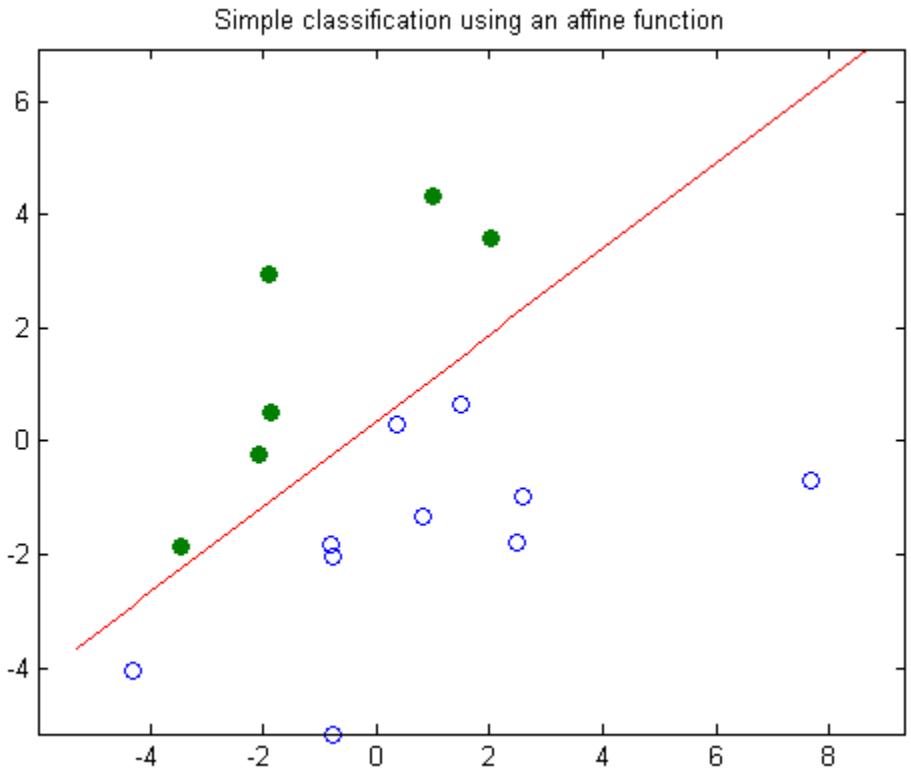
- Statistical process for estimating the relationships among variables





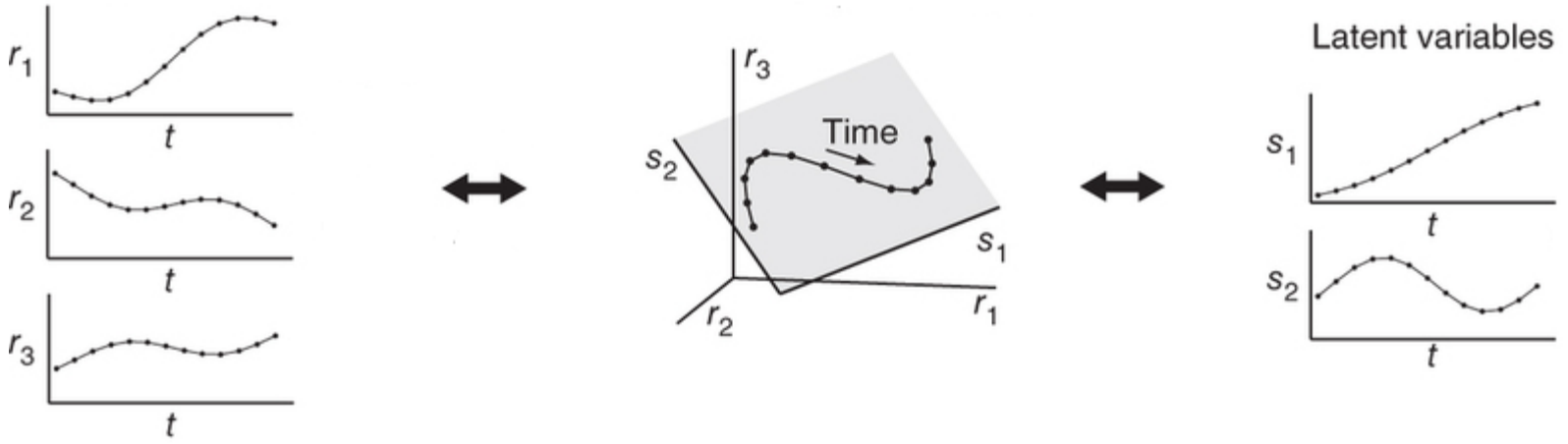
Classification

- The problem of identifying to which of a set of categories (sub-populations) a new observation belongs, on the basis of a training set of data containing observations (or instances) whose category membership is known



Dimension Reduction

- Multiple Sensors + Principal Components
- the process of reducing the number of random variables under consideration, and can be divided into feature selection and feature extraction.

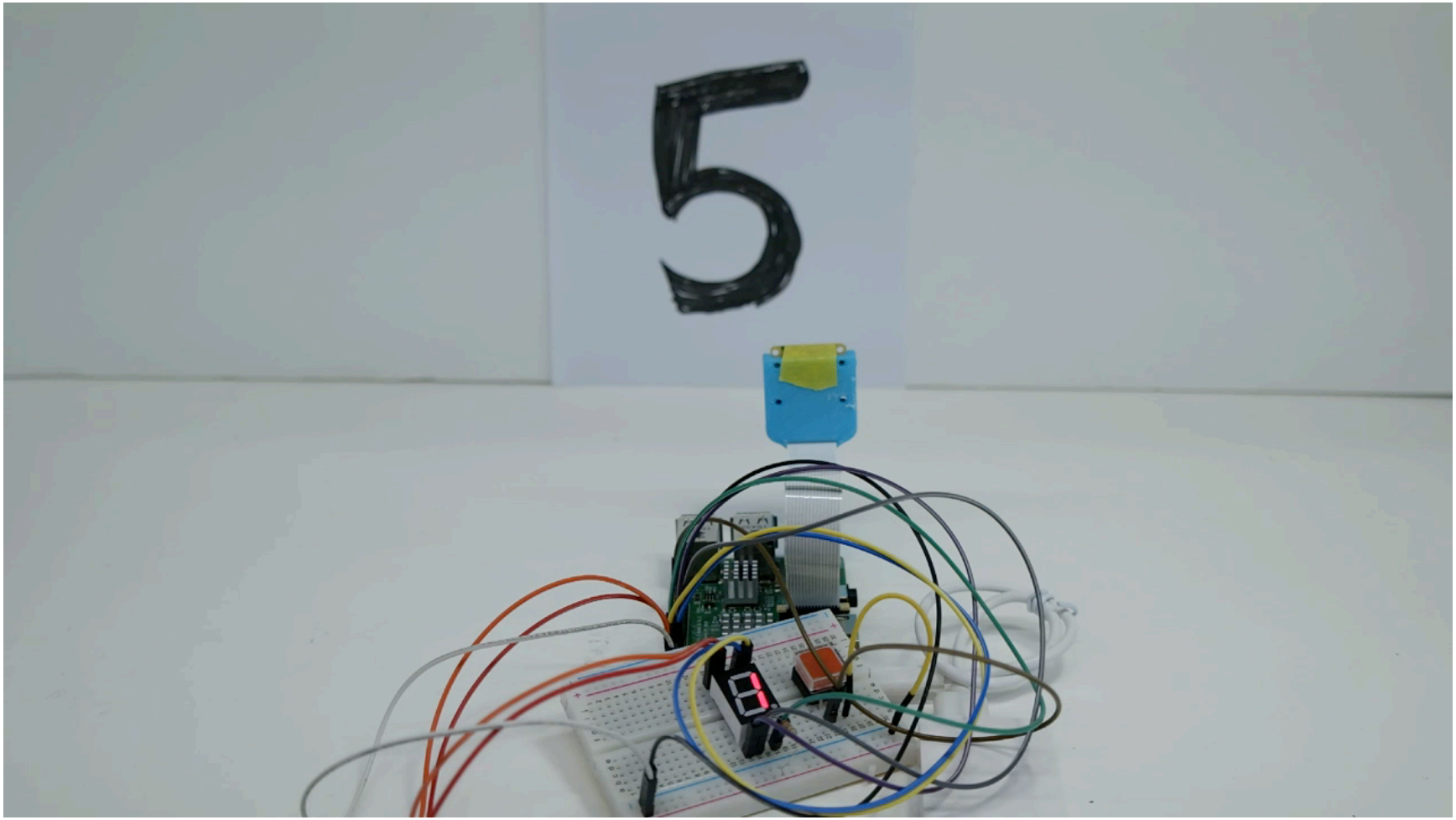


Industrial AI lab at POSTECH

- Vision
  - AI for mechanical engineering
  - AI for industrial applications
  - AI for manufacturing

- Some research activities in our lab

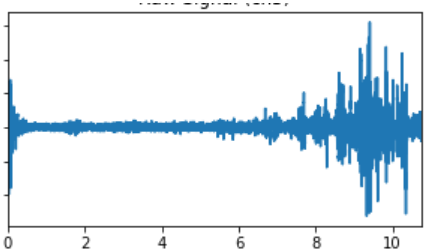
Deep Learning of Things (DoT)



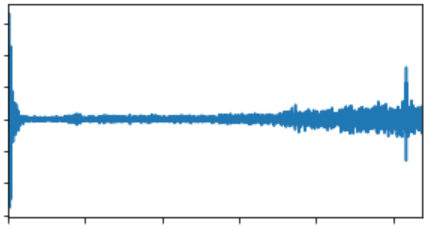
Sound Signal Classification

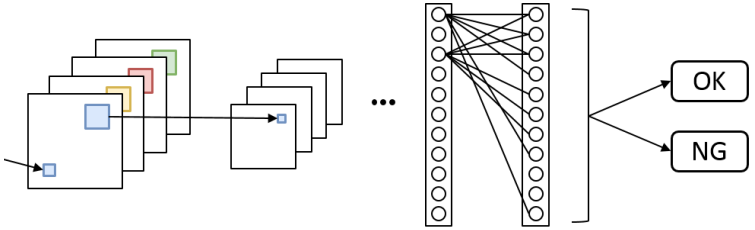
- Inspecting a rotating fan
  - Sampling frequency: 51.2 kHz
  - Duration: 8 sec ~ 9 sec

  - NG sound

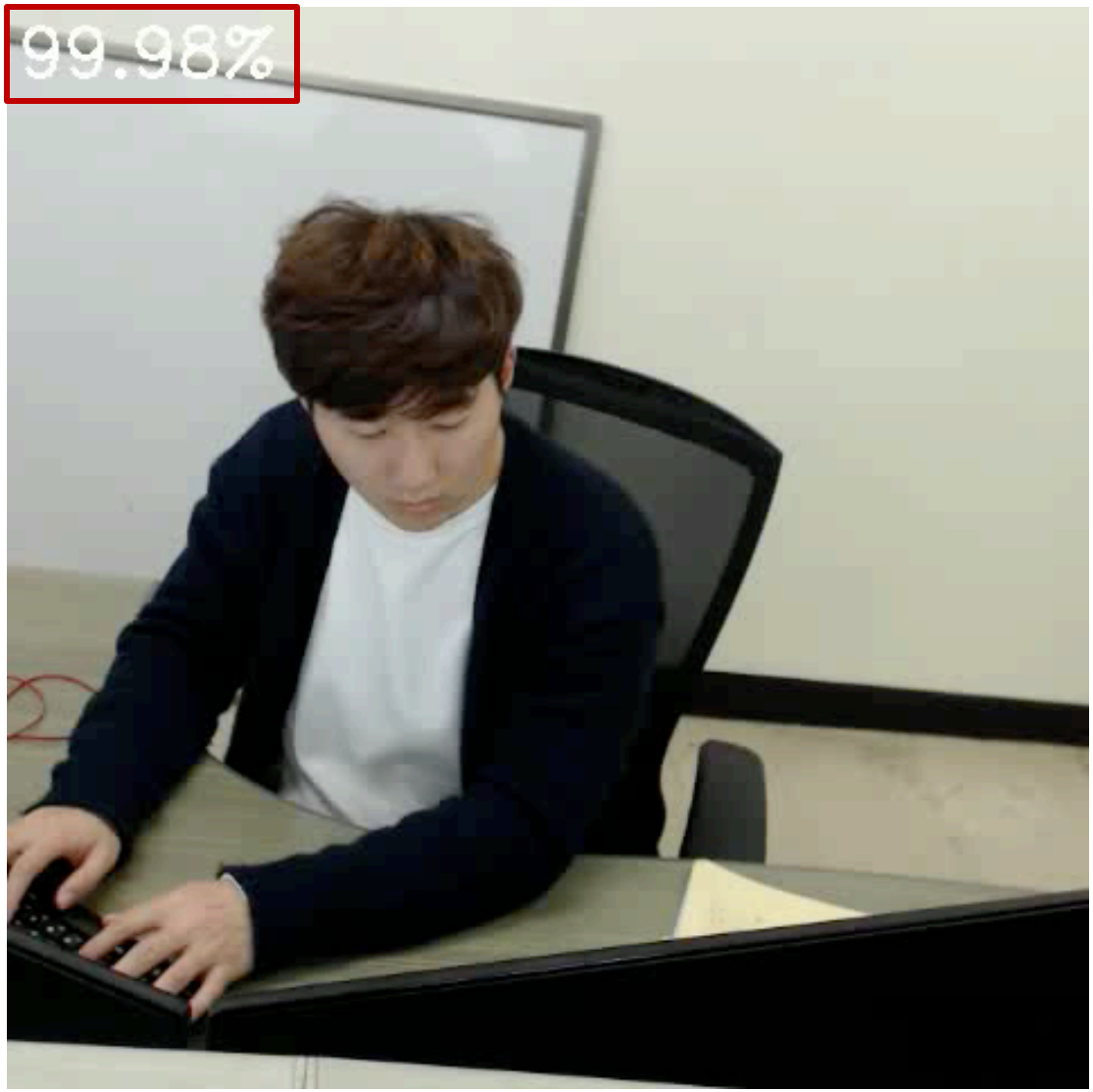


  - OK sound

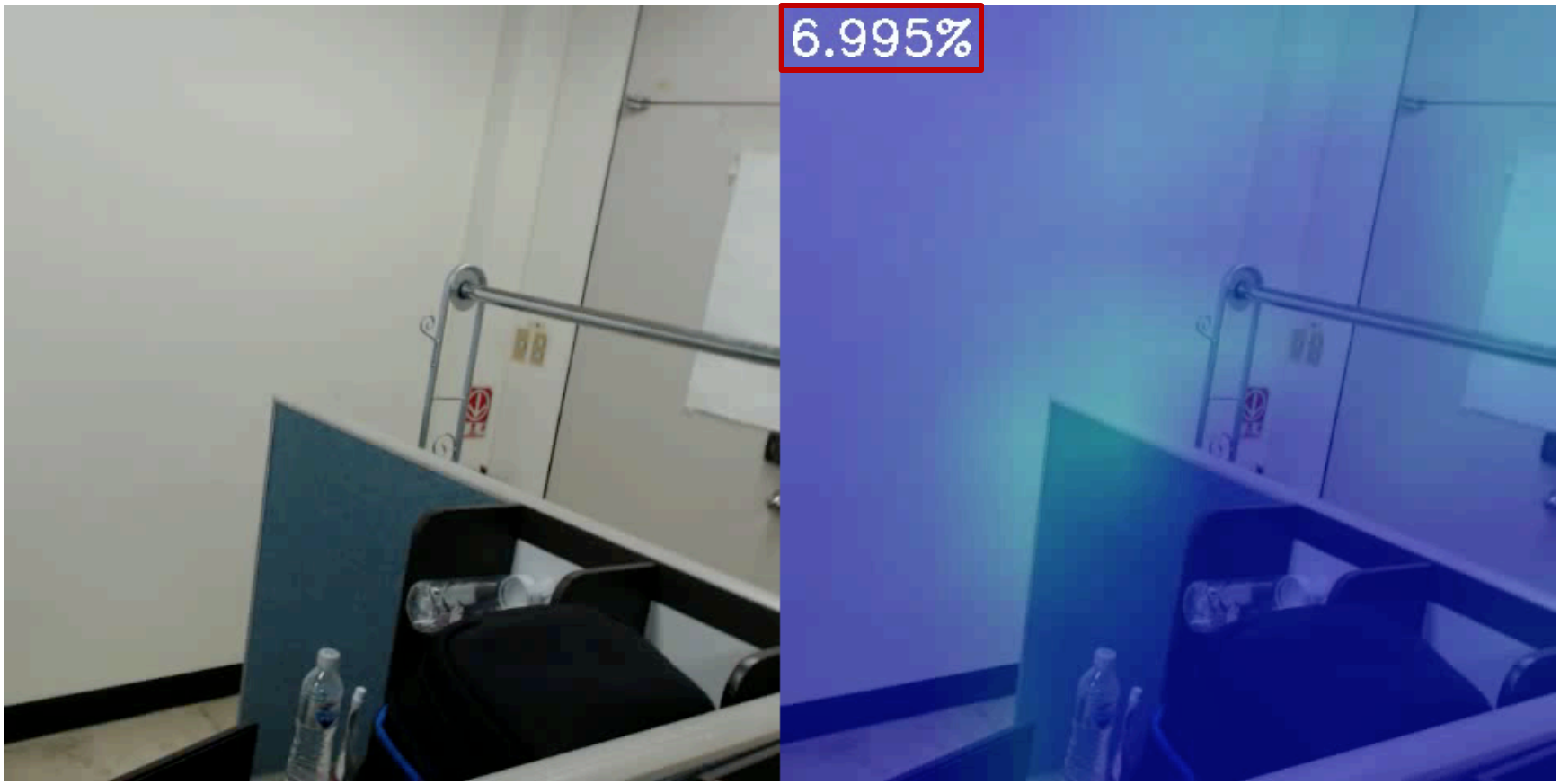




Real-time Human Detection



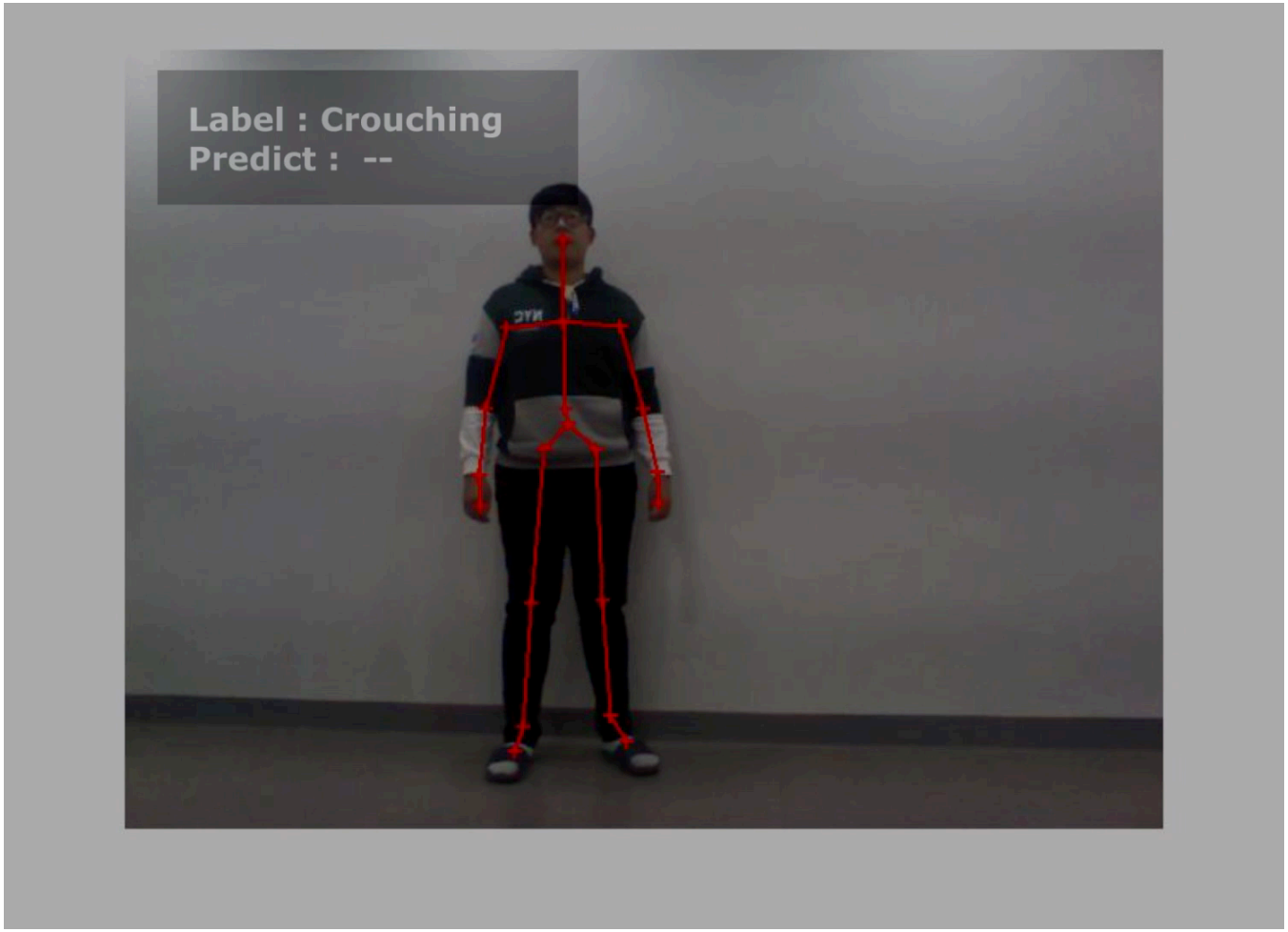
Visualizing and Understanding Convolutional Networks



Privacy-preserving Human Detection

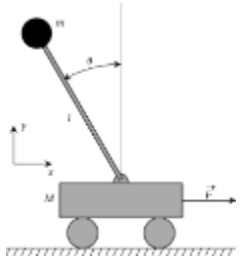
Artistic Style Transfer

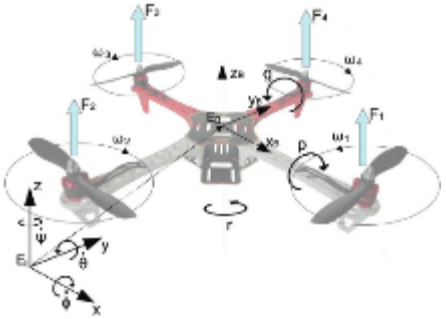
Human Motion Recognition

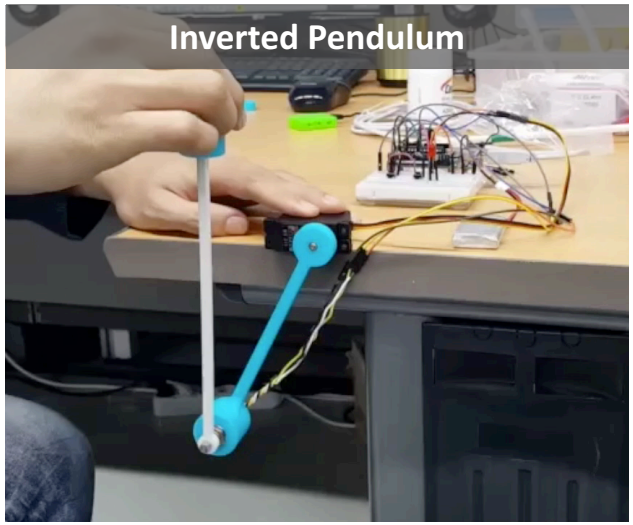


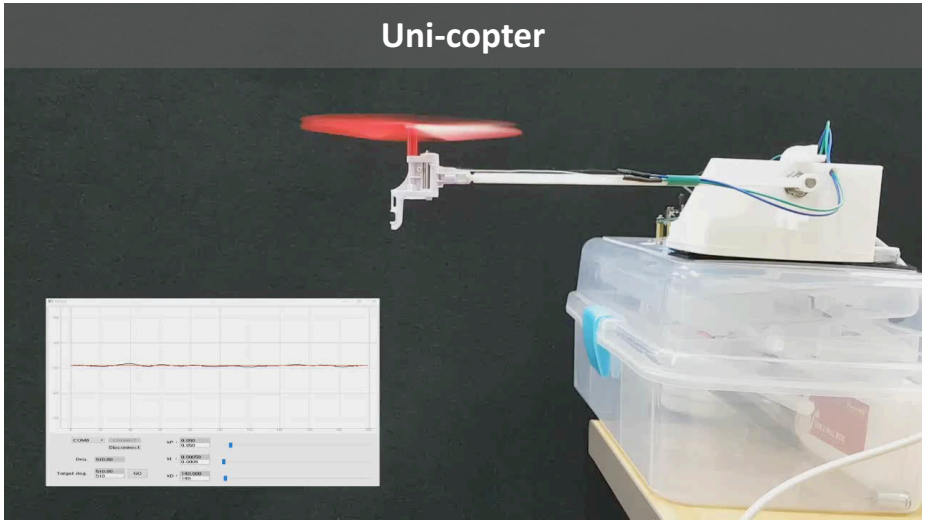
Make it Stable (Robust)

- Control: PID
- From open-loop to closed-loop systems

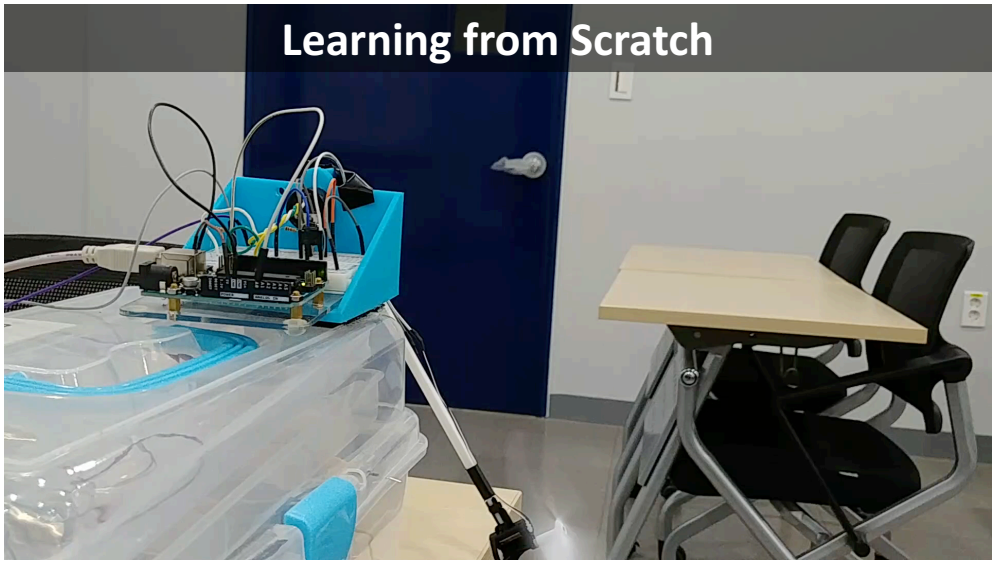




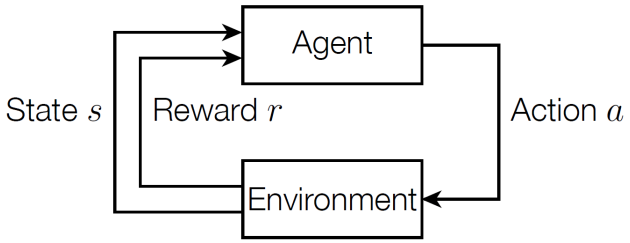


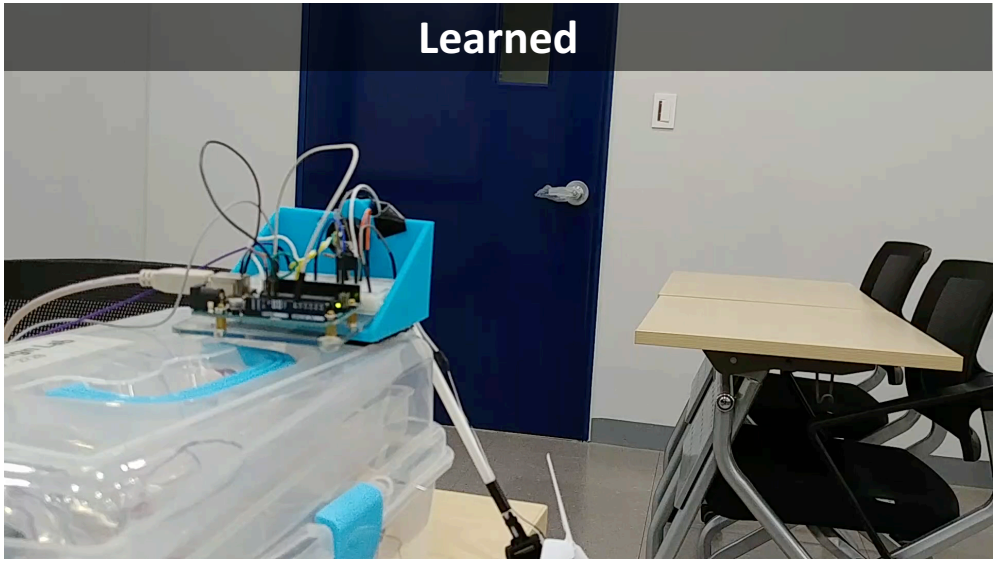


Reinforcement Learning on Unicopter



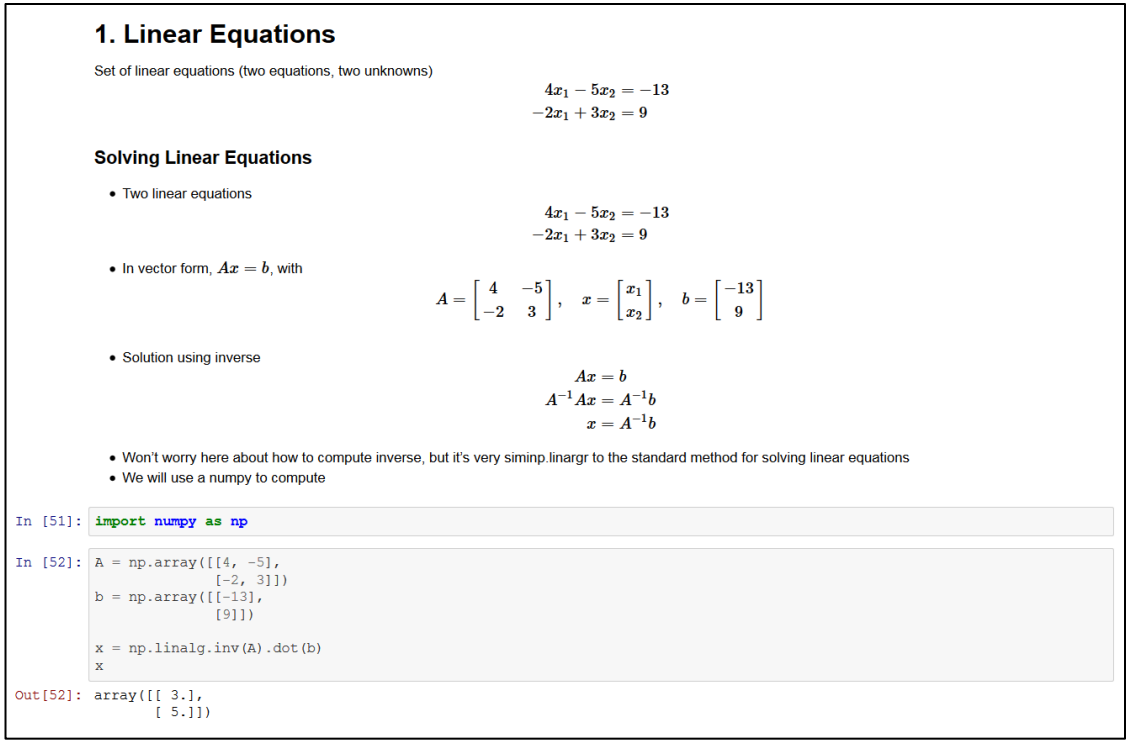
AlphaGo Zero





Make-up Class

- 02/26 (next Monday)
  - TA will discuss
    - python installation, ipython notebook, basic python, CVXPY



1. Linear Equations

Set of linear equations (two equations, two unknowns)

$$4x_1 - 5x_2 = -13$$
$$-2x_1 + 3x_2 = 9$$

Solving Linear Equations

- Two linear equations

$$4x_1 - 5x_2 = -13$$
$$-2x_1 + 3x_2 = 9$$

- In vector form, $Ax = b$, with

$$A = \begin{bmatrix} 4 & -5 \\ -2 & 3 \end{bmatrix}, \quad x = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}, \quad b = \begin{bmatrix} -13 \\ 9 \end{bmatrix}$$

- Solution using inverse

$$Ax = b$$
$$A^{-1}Ax = A^{-1}b$$
$$x = A^{-1}b$$

- Won't worry here about how to compute inverse, but it's very siminp.linargr to the standard method for solving linear equations
- We will use a numpy to compute

```
In [51]: import numpy as np

In [52]: A = np.array([[4, -5],
                       [-2, 3]])
         b = np.array([[-13],
                       [9]])

         x = np.linalg.inv(A).dot(b)
         x

Out[52]: array([[ 3.],
                [ 5.]])
```

- 03/21

- 04/02 (not sure yet)