

Lecture 1: Introduction

Dr.-Ing. Sudchai Boonto, Assistant Professor

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Department of Control System and Instrument Engineering, KMUTT

Introduction

Neural Networks

Neural Networks have been used in Control Community for long time in many areas:

- Chemical engineering
- Robotics
- Neuroscience
- Electrical engineering
- etc

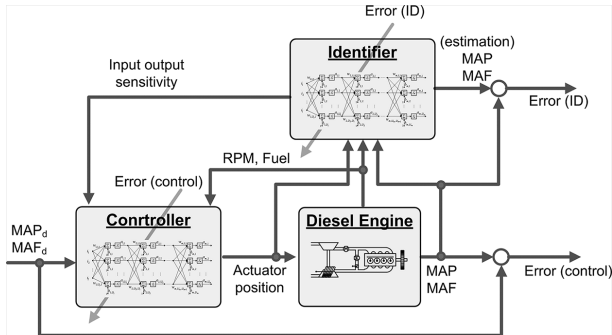


Neural Networks cont.

Artificial Neural Network (ANN) :

- Using in the general control problems but with ANN modeling the process and/or the controller
- Develop a mapping function for the current state of a process into suitable control actions through experience

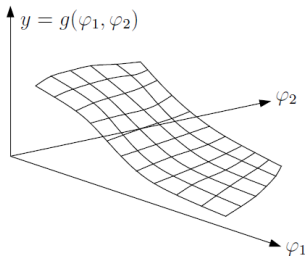
Actually we are using ANN in control applications for more than 30 years.



Neural Networks cont.

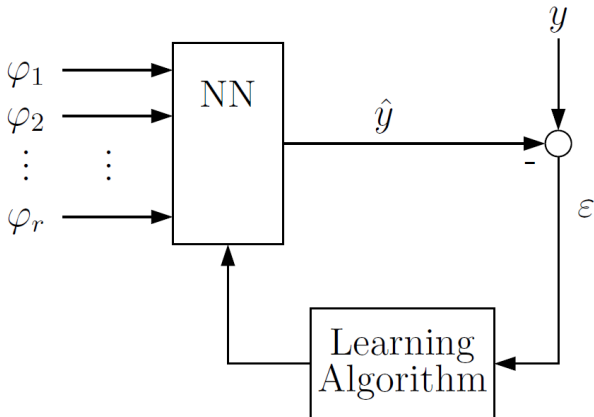
- The common application of neural networks is the solution of classification problem (e.g. pattern recognition)
- In control applications, neural networks are mainly used to approximate nonlinear functions. Consider a continuous, nonlinear function $g : \mathbb{R}^r \rightarrow \mathbb{R}$

$$y = g(\varphi_1, \varphi_2, \dots, \varphi_r)$$



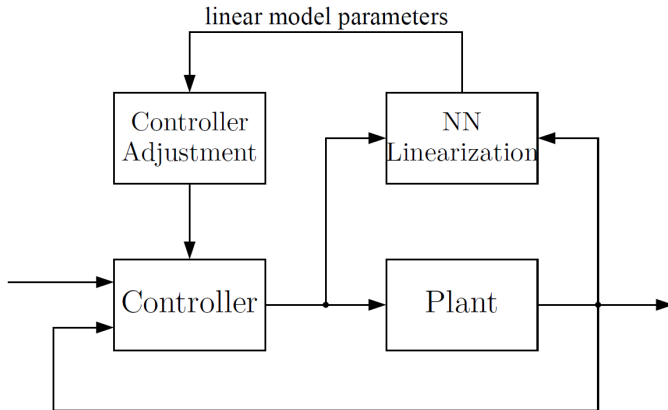
By assuming that at a number of points in the r -dimensional input space the values of g are known. A problem we will consider in this situation is that of finding an approximation of g that is as close as possible to the known values at the given points.

Neural Networks cont.



This process is referred to as *training* of a neural network.

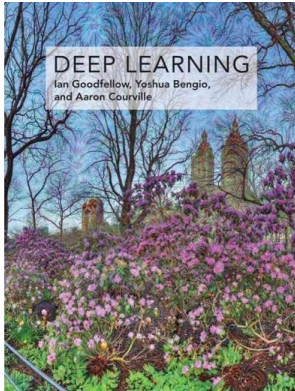
Neural Networks cont.



Pole placement design, minimum variance control (MVC) and predictive control.

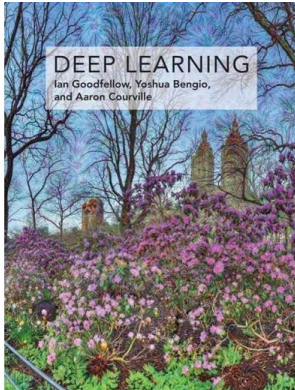
Deep Learning

What is Deep Learning ?

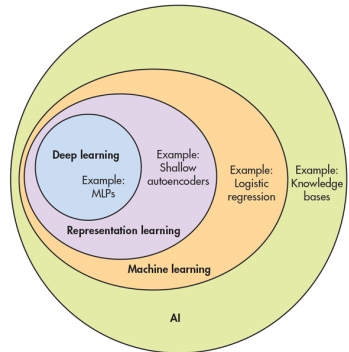


- The sexiest book in Deep Learning world

Deep Learning

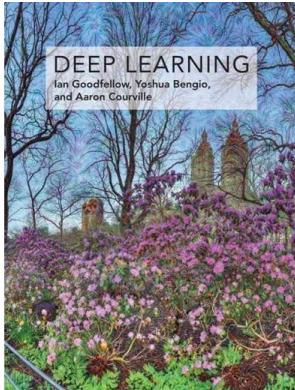


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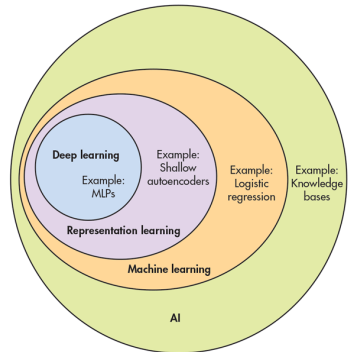
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Deep Learning



- The sexiest book in Deep Learning world

What is Deep Learning ?



Where is control?

Neural Networks for Control

Tradition:

- The process industries use controllers ranging from **PID** controllers to **Model Predictive Controllers (MPC)**
- Classical controller design process
 - Analysis the process dynamics and develop mathematical models
 - Construct a control law that meets certain design criteria

Learning Approach:

- Interact with the process and incrementally improve control behaviour
 - instead of suing a time consuming design process, the controller learns the process behaviour by interacting directly with the process.
 - It can be applied to a wide range of different process types: linear and nonlinear systems; deterministic and stochastic systems; SISO and MIMO
 - Anyways, model identification and controller learning are performed simultaneously

Grading

Scientists See Promise in Deep-Learning Programs

By JOHN MARKOFF NOV. 23, 2012



A voice recognition program translated a speech given by Richard F. Rashid, Microsoft's top scientist, into Mandarin Chinese. Hao Zhang/The New York Times



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The Keyword

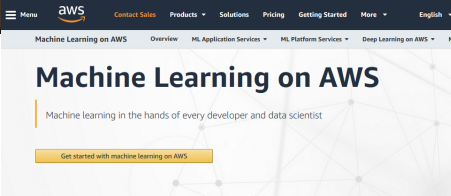
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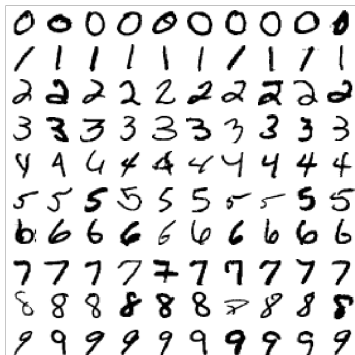
Machine Learning on AWS

Machine learning in the hands of every developer and data scientist

[Get started with machine learning on AWS](#)

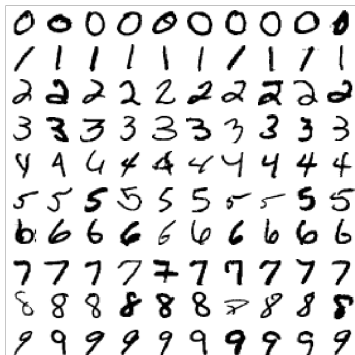
Why Machine Learning is needed

Write a Program to recognize the digit. This is hard to do manually!



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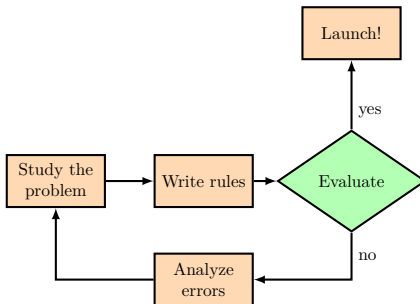


Machine Learning solution:

- Assume you have a database (training data) of number and non-number
- Automatically "learn" this function from data

Why Machine Learning is needed

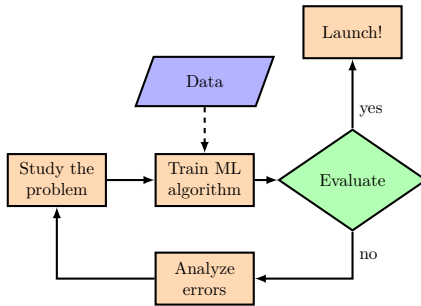
The traditional approach



- The problem may not trivial, your program will likely become a long list of complex rules.
- It is hard to maintain.

Why Machine Learning is needed

The Machine Learning approach



- Machine Learning techniques automatically learn. The program is much shorter.
- It is easier to maintain.

Why Machine Learning is needed

The Machine Learning approach is great for:

- Problems for which existing solutions require a lot of hand-tuning or long lists of rules: one Machine Learning algorithm can often simplify code and perform better.
- Complex problems for which there is no good solution at all using a traditional approach: the best Machine Learning techniques can find a solution.
- Fluctuating environments: a Machine Learning system can adapt to new data.
- Getting insights about complex problems and large amounts of data.

Grading

We will learn

- **Machine Learning**
 - Basic Machine Learning
 - Classification
 - Training model
 - Support Vector Machines
 - Decision Trees
 - Ensemble Learning and Random Forests
 - Dimensionality Reduction
- **Neural Network and Deep Learning**
 - TensorFlow
 - Introduction to Artificial Neural Networks
 - Training Deep Neural Nets
 - Convolutional Neural Networks
 - Recurrent Neural Networks
 - Autoencoders
 - Reinforcement Learning

How to get A

- I hope you can contribute something for the community.
- Showing that you can finish an assignment.
- Familiar with one of Machine Learning models such as TensorFlow, CNTK etc.

Reference

1. Aurélien, Géron, "*Hands-On Machine Learning with Scikit-Learn & TensorFlow*", O'reilly, 2017
2. S.P.K. Spielberg, R. B. Gopaluni, P. D. Loewen, "Deep Reinforcement Learning Approaches for Process Control", 2017 6th International Symposium on Advanced control of Industrial Processes (AdCONIP), May 28-31, 2017, Taipei, Taiwan