



Basic Concepts of Machine Learning

Machine Learning Indonesia Meet Up

Risman Adnan

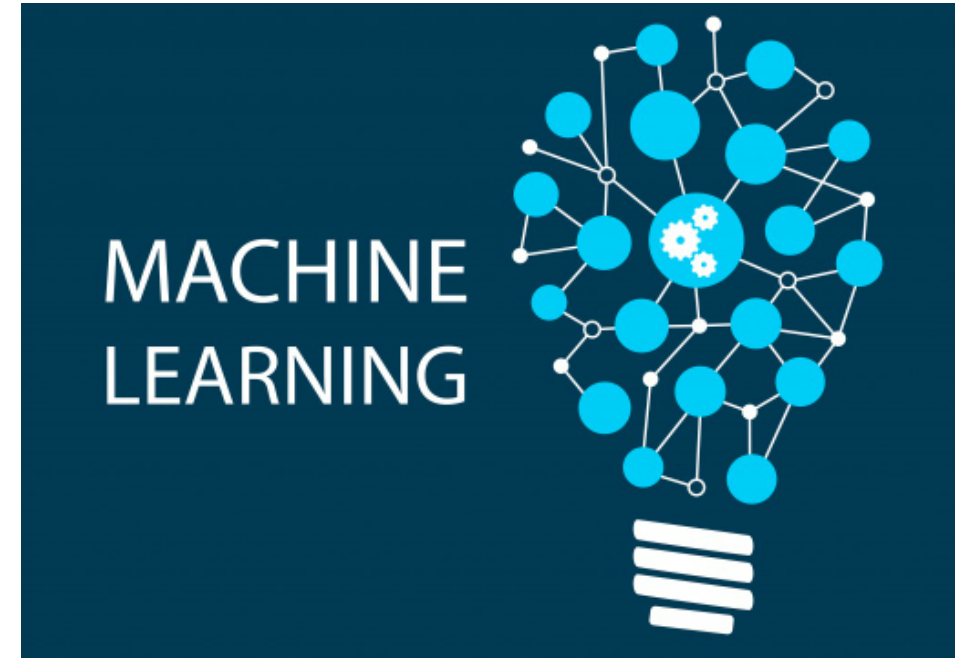
Samsung R&D Institute Indonesia

University of Indonesia



Outline

- The Learning Problem
- Machine Learning Landscape
- Simple Perceptron Model
- Deep Learning vs Machine Learning
- How to Get Start
- Q&A





The Learning Problem



The Learning Problem

The essence of ML:

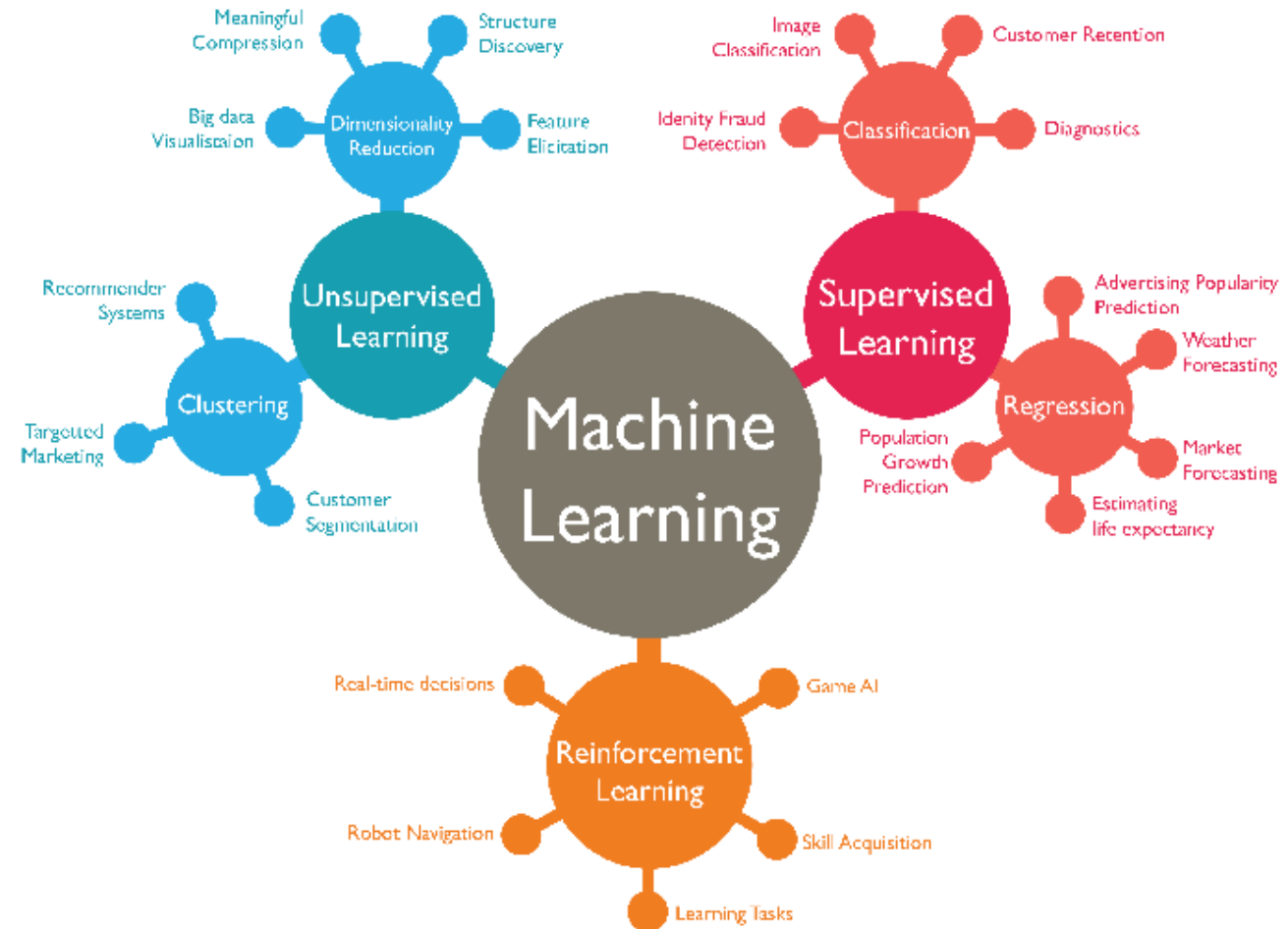
1. We have data
2. Patterns exist in data
3. We cant do math formula

Examples:

- Movie Rating
- Credit Approval
- Hand Written Recognition

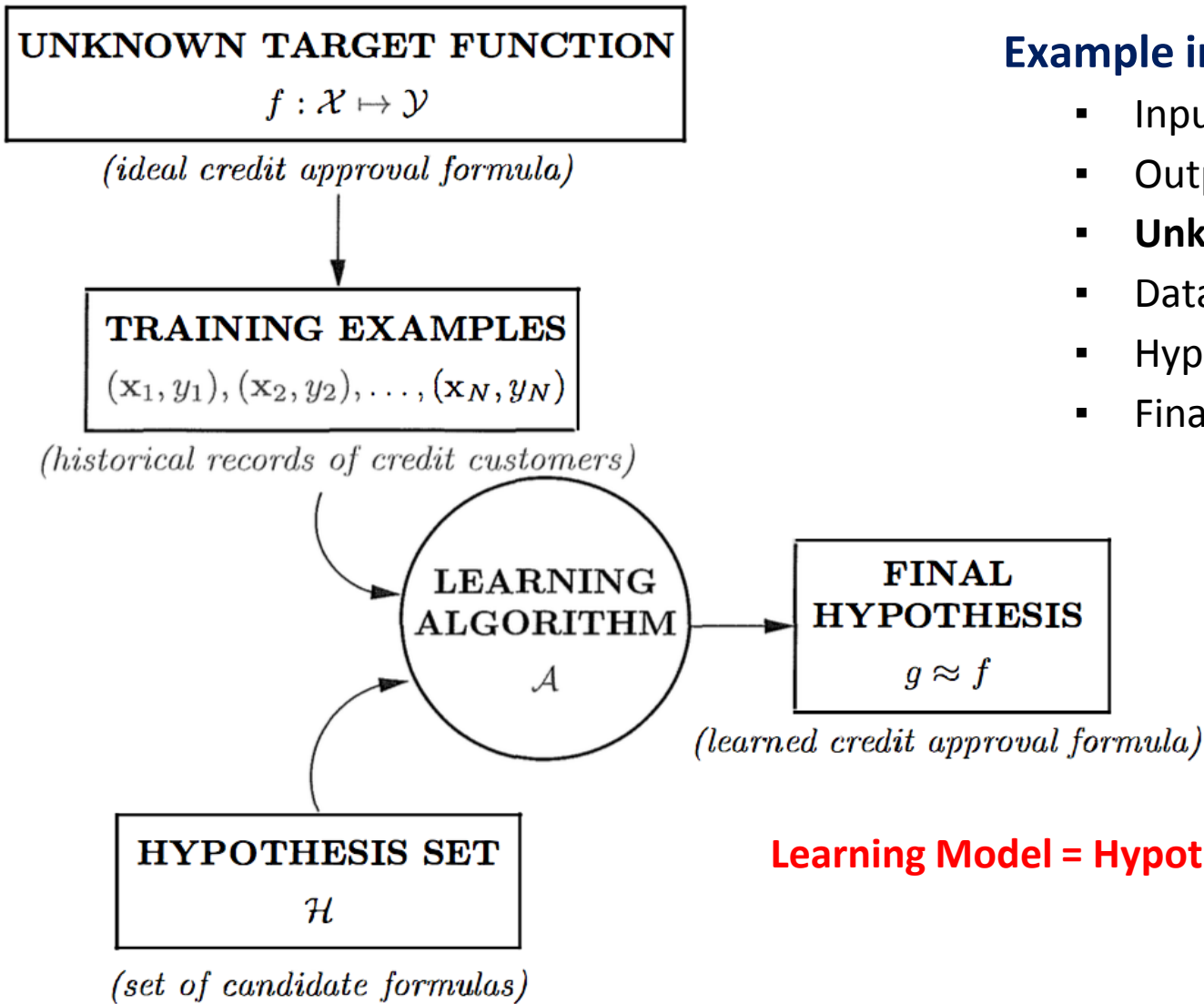
Domain Areas

- Movie Rating
- Credit Approval
- Hand written recognition





Components of Learning



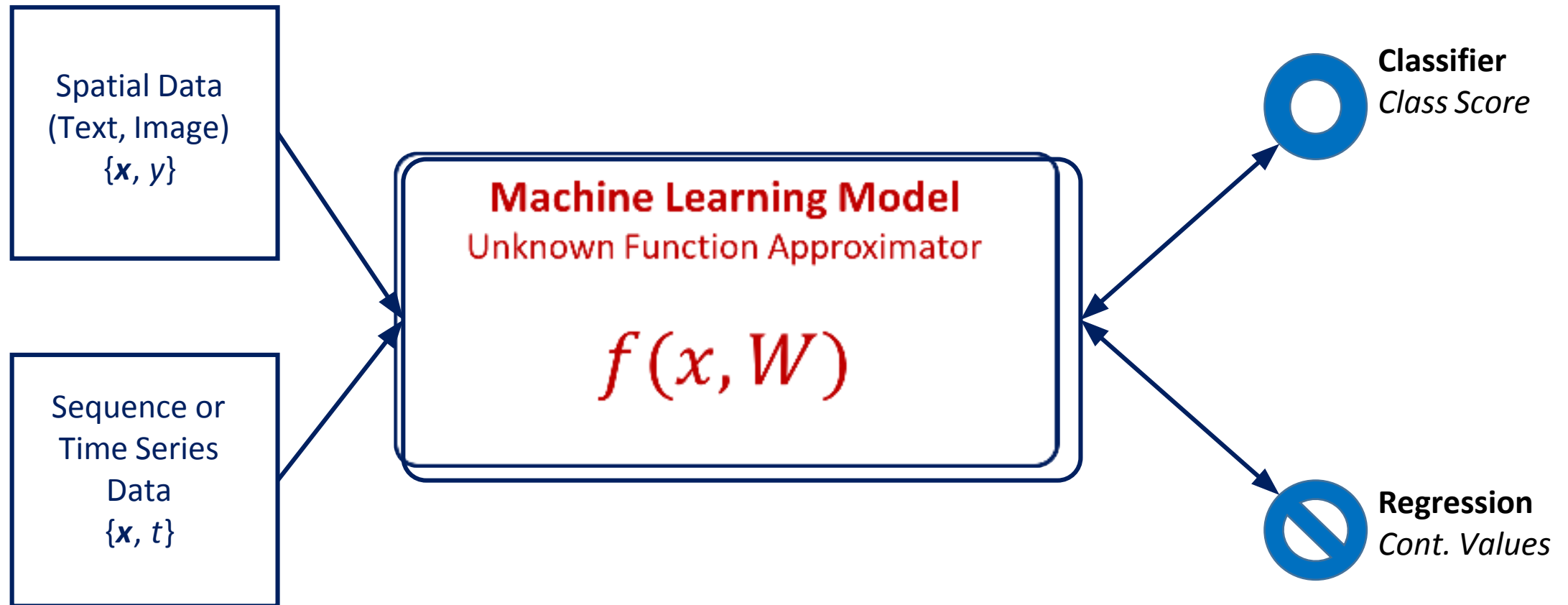
Example in Banking: Credit Card Approval

- Input : \mathbf{x} (*customer application*)
- Output : y (*good/bad customer*)
- **Unknown** Target Function $f : X \rightarrow Y$
- Dataset $\{\mathbf{x}, y\}$ (*customers record database*)
- Hypothesis Set: $H : X \rightarrow Y$
- Final Hypothesis g

Learning Model = Hypothesis Set + Learning Algorithm



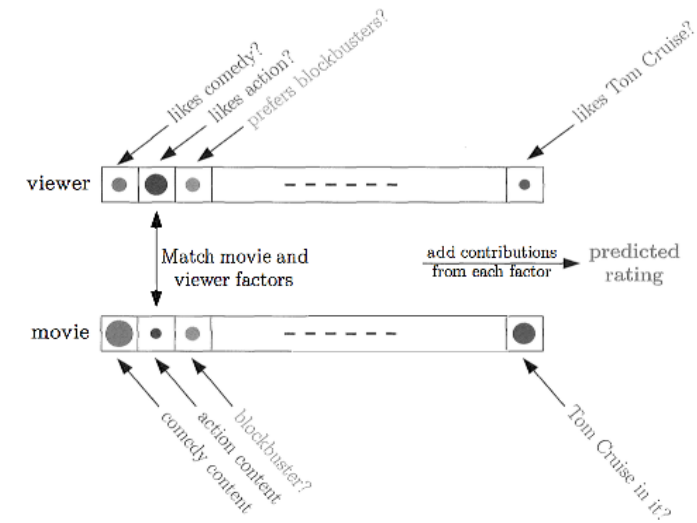
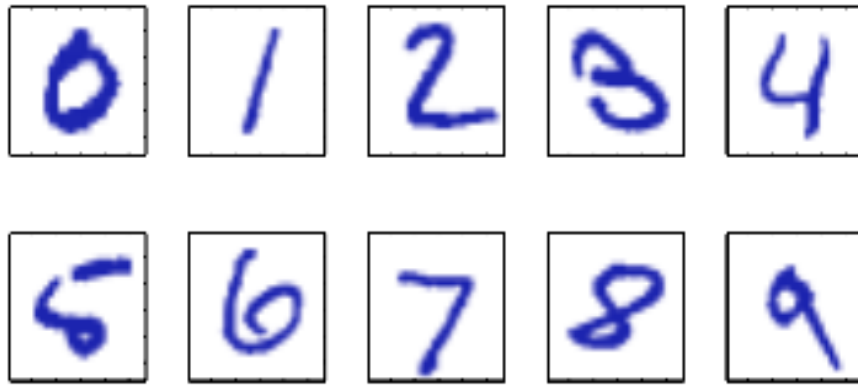
Machine Learning Model





Problem Examples

- **Problem:** Recognize Handwritten Digits
- **Problem:** Predict Viewer Rate Movie



Dataset

Rule Based

Classic
Machine
Learning

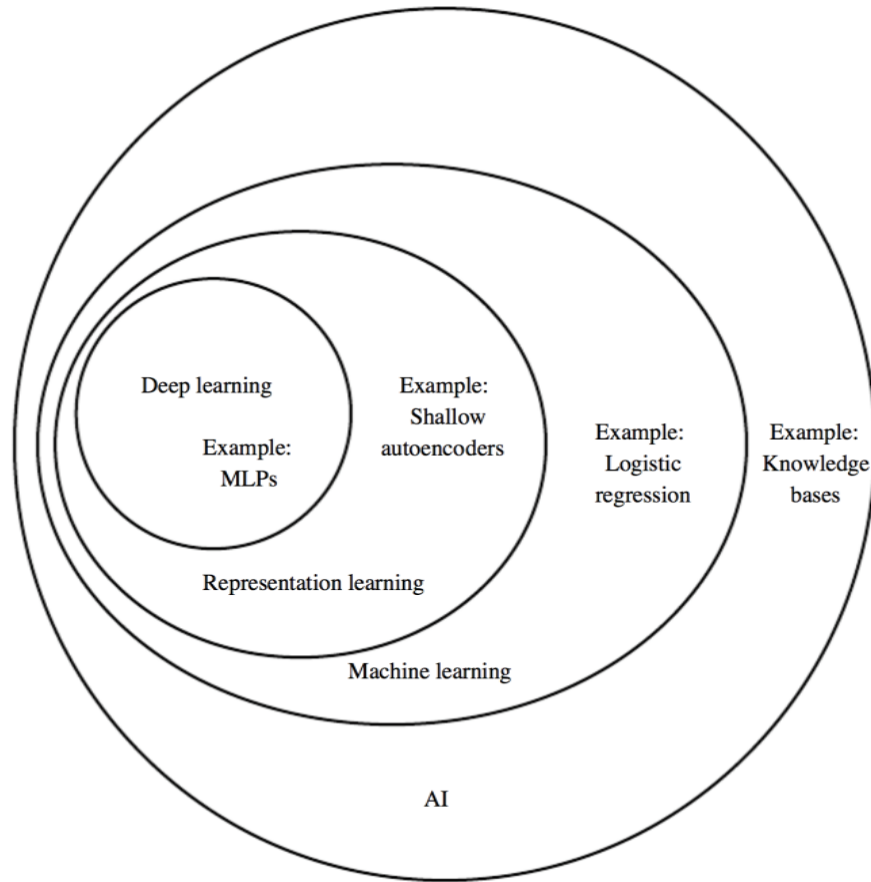
Representation
Learning



Machine Learning Landscape



Machine Learning Map



THEORY	TECHNIQUES		PARADIGMS
	MODELS	METHODS	
VC	Linear	Regularization	Supervised
Bias-Variance	Neural Networks	Validation	Unsupervised
Complexity	SVM	Aggregation	Reinforcement
Bayesian	Nearest Neighbors	Input Processing	Active
	RBF		Online
	Gaussian Processes		
	SVD		

Machine learning become a jungle of models, methods!



Main Paradigms

Automatic discovery of patterns in data through computer algorithms and the use of those patterns to take actions such as ***classifying*** or ***clustering*** the data into categories.

- **Supervised Learning:** Learning by labeled example
 - E.g. An email spam detector
 - We have (input, correct output), and we can predict (new input, predicted output)
 - Amazingly effective if you have lots of data
- **Unsupervised Learning:** Discovering Patterns
 - E.g. Data clustering
 - Instead of (input, correct output), we get (input, ?)
 - Difficult in practices but useful if we lack labeled data
- **Reinforcement Learning:** Feedback & Error
 - E.g. Learning to play chess
 - Instead of (input, correct output), we get (input, only some output, grade of this output)
 - Works well in some domains, becoming more important



Computer Vision Domain

Classification



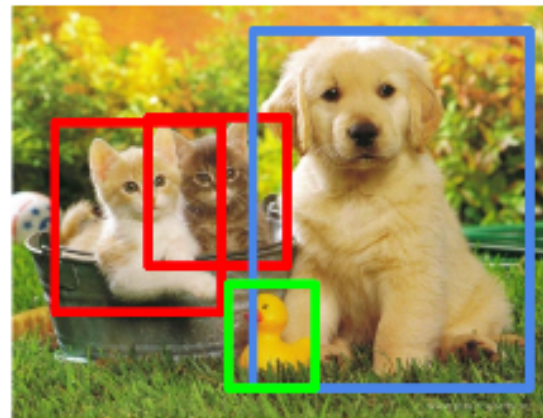
CAT

**Classification
+ Localization**



CAT

Object Detection



CAT, DOG, DUCK

**Instance
Segmentation**



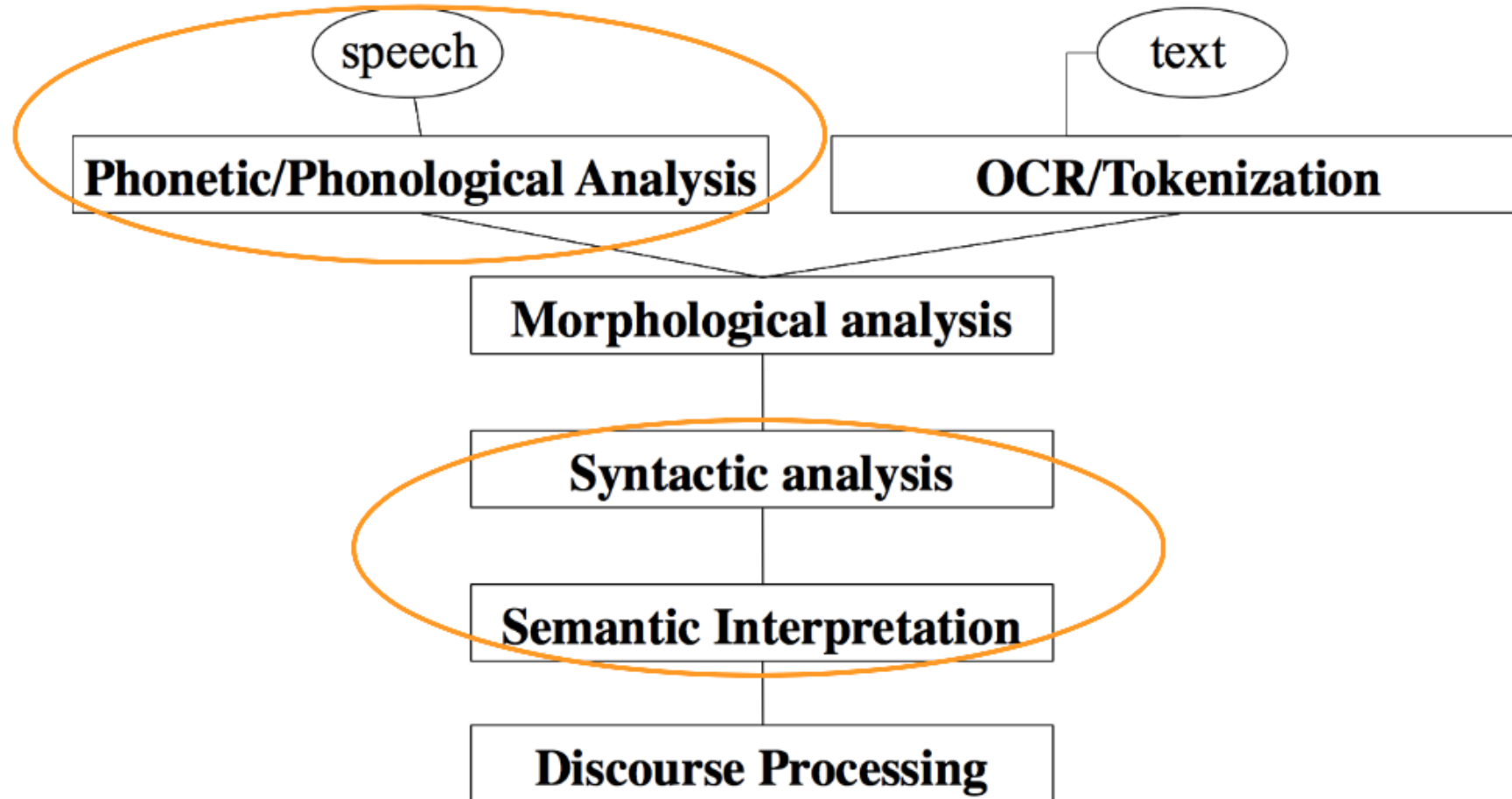
CAT, DOG, DUCK

Single object

Multiple objects



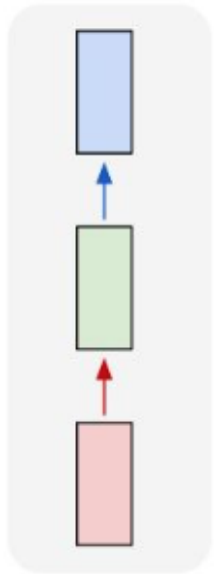
Natural Language Processing Domain





Sequence Labeling in NLP Domain

one to one



Basic

one to many

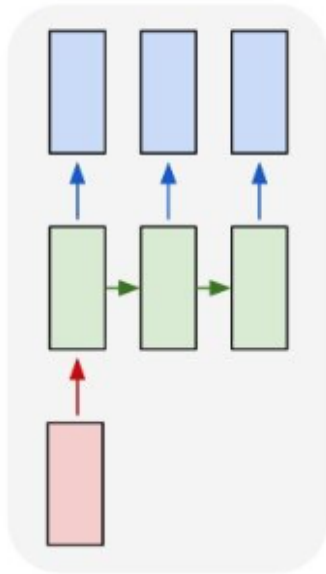
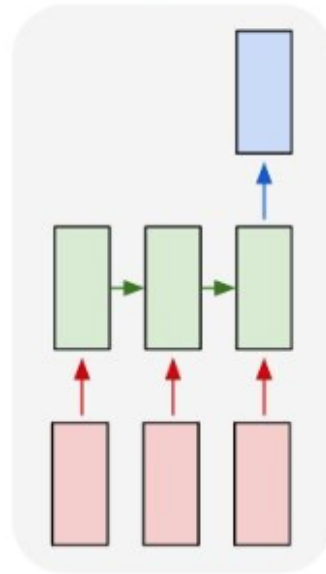


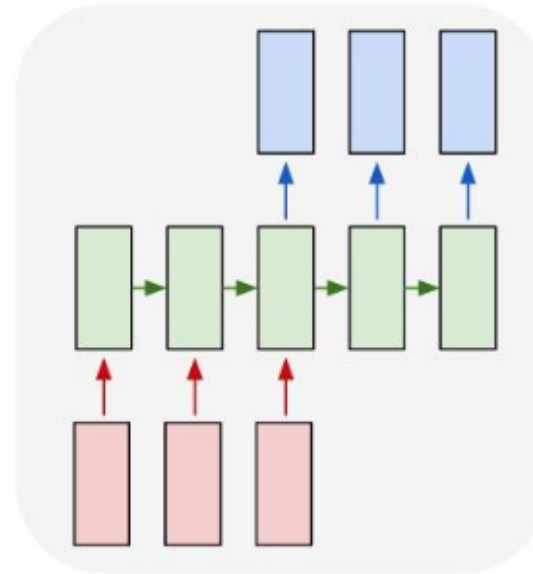
Image Captioning

many to one



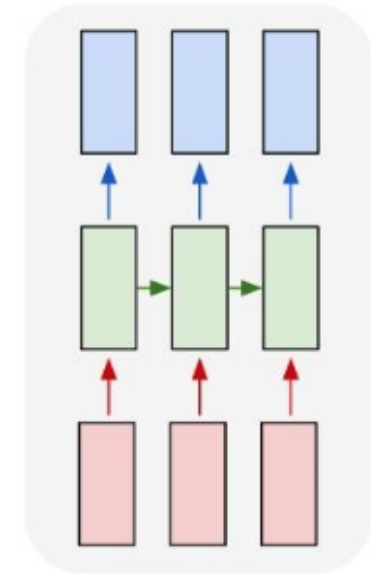
Sentiment Classification

many to many



Machine Translation

many to many

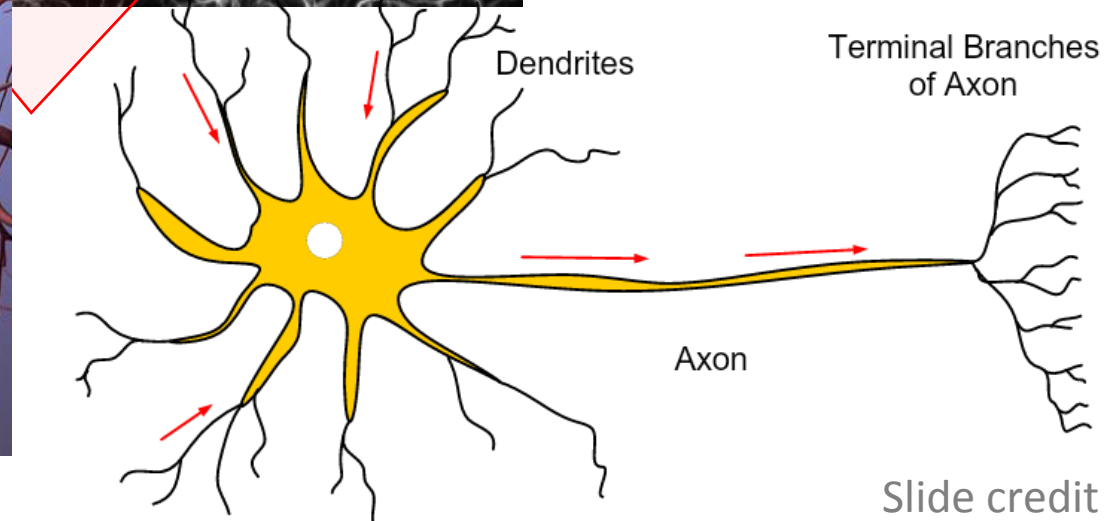
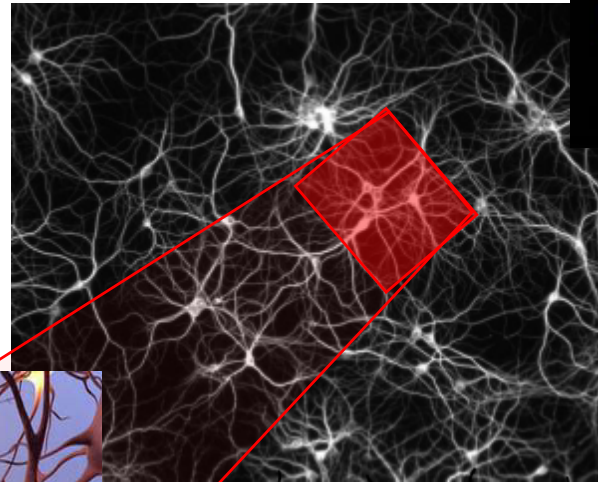


Video Classification



Simple Perceptron Model

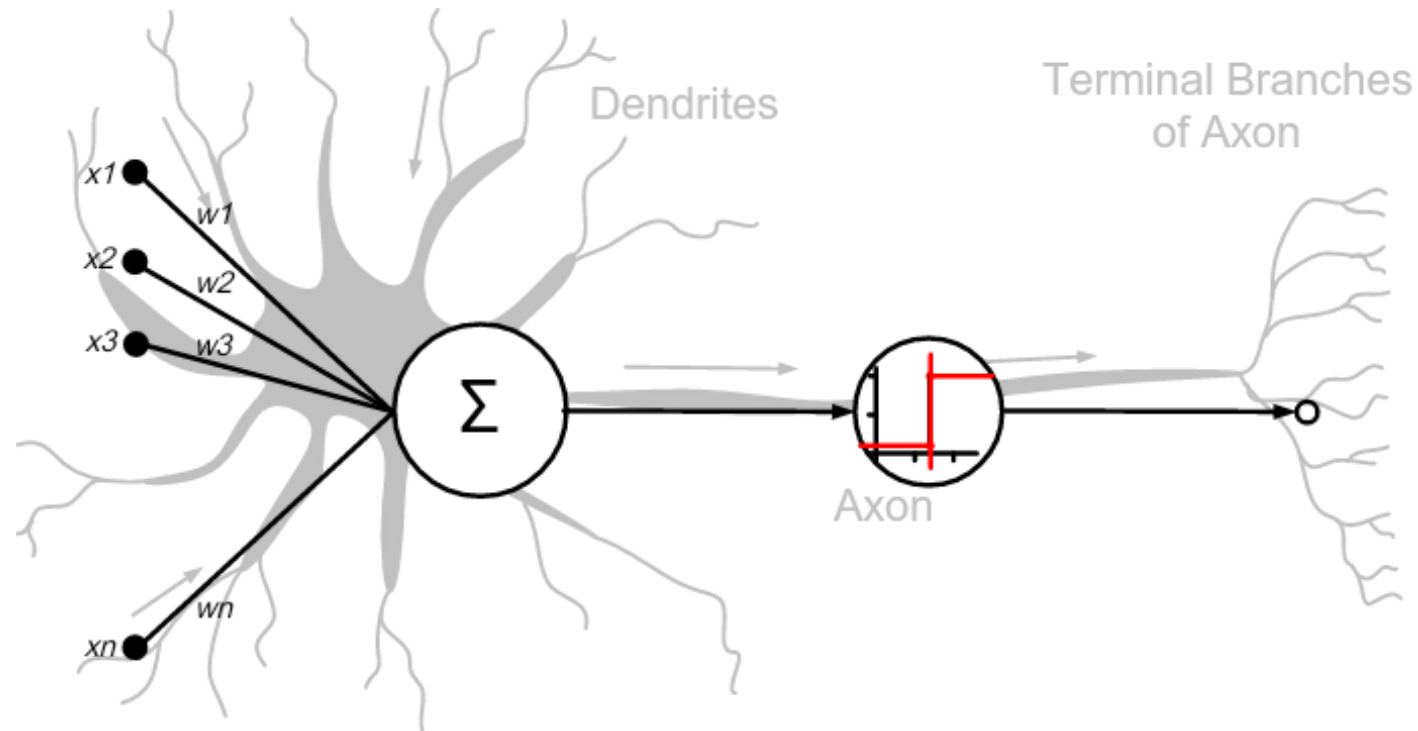
Perceptron Inspired by Biological Neurons



Slide credit : Geoffrey Hinton



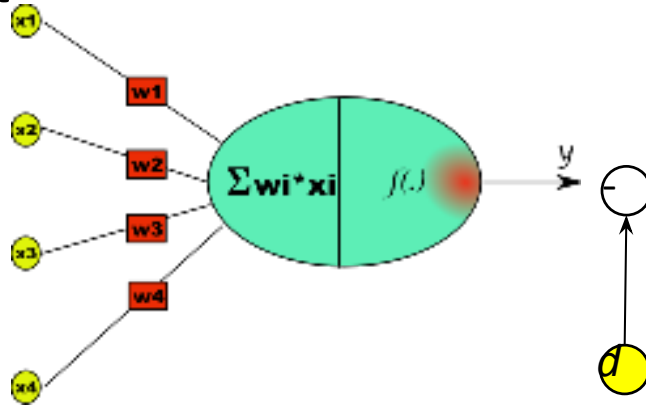
Perceptron in Artificial Neural Networks



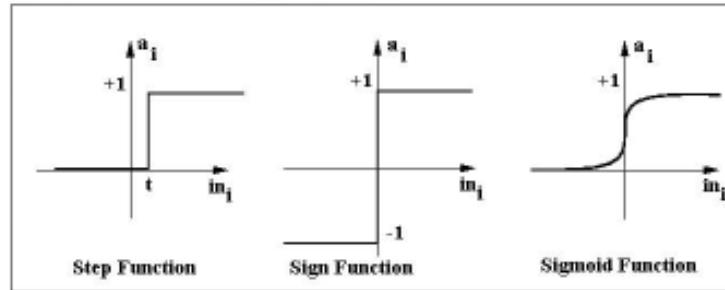


A Simple Model - Perceptron

Perceptron
:



Activation
functions:

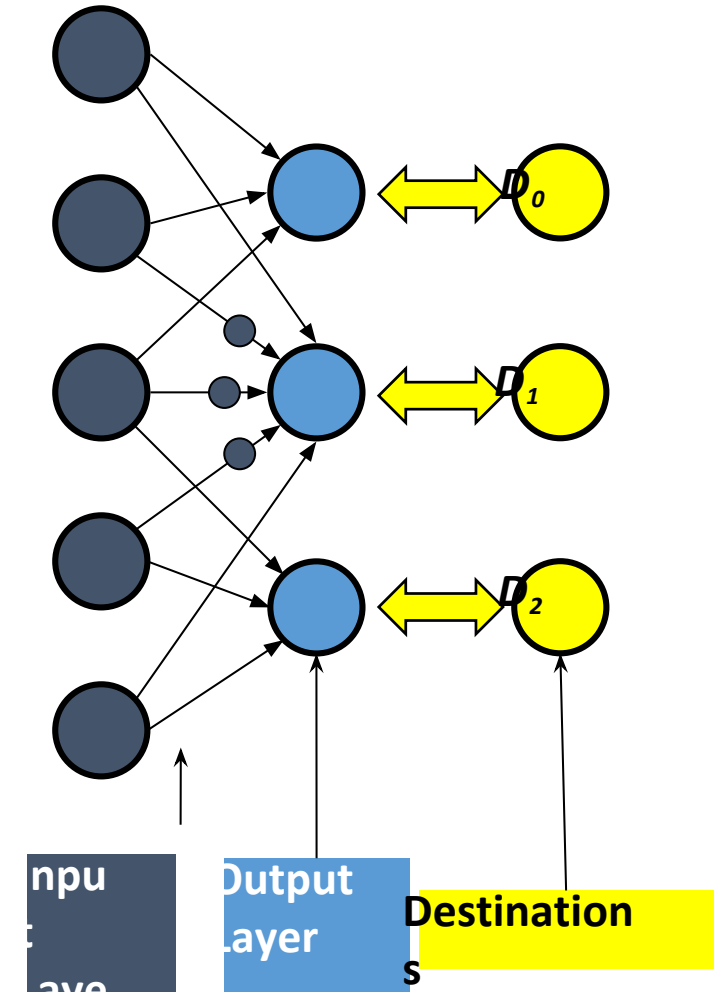


Learning:

$$y^{(t)} = f \left\{ \sum_i w_i^{(t)} x_i^{(t)} \right\}$$

Update

$$\begin{cases} \Delta w_i^{(t)} = \varepsilon (d^{(t)} - y^{(t)}) x_i^{(t)} \\ w_i^{(t+1)} = w_i^{(t)} + \Delta w_i^{(t)} \end{cases}$$



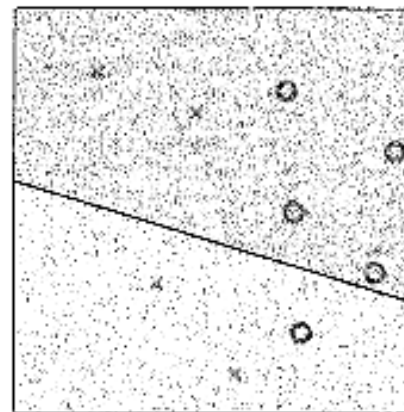


A Simple Hypothesis Set – The Perceptron

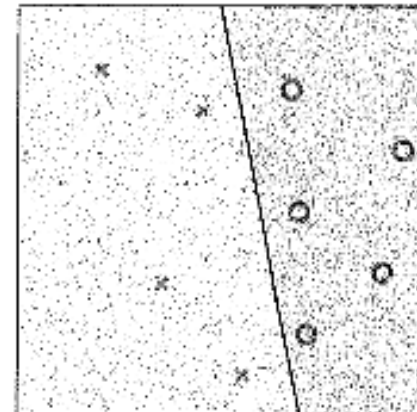
- For input $\mathbf{x} = (x_1, \dots, x_d)$ 'attributes for a customer'

Approve credit if $\sum_{i=1}^d w_i x_i > \text{threshold},$

Deny credit if $\sum_{i=1}^d w_i x_i < \text{threshold}.$



(a) Misclassified data



(b) Perfectly classified data

- This formula can be written more compact as

$$h(\mathbf{x}) = \text{sign} \left(\left(\sum_{i=1}^d w_i x_i \right) + b \right),$$

$$h(\mathbf{x}) = \text{sign}(\mathbf{w}^T \mathbf{x}).$$



Perceptron Learning Algorithm

- The perceptron implement:

$$h(\mathbf{x}) = \text{sign}(\mathbf{w}^T \mathbf{x}).$$

- Given the training set:

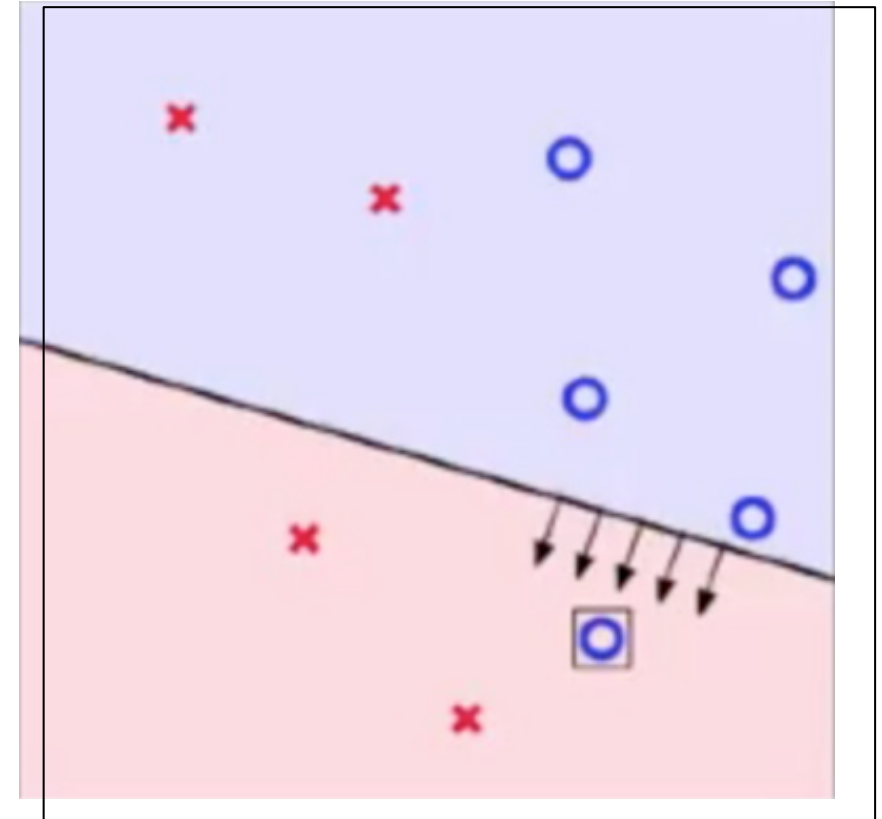
$$(\mathbf{x}_1, y_1) \cdots (\mathbf{x}_N, y_N)$$

- Pick a misclassified point:

$$(\mathbf{x}(t), y(t))$$

- And update the weight vector:

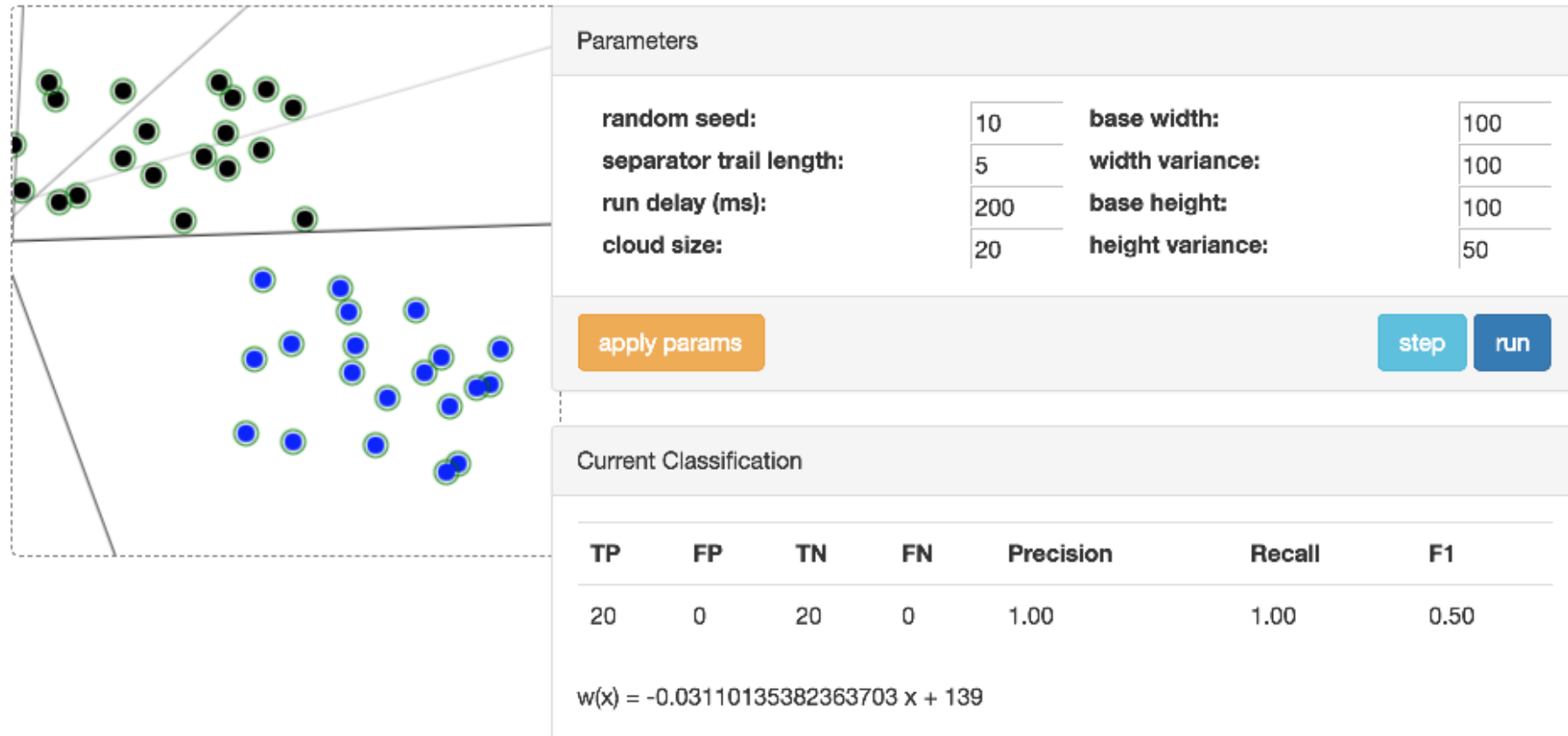
$$\mathbf{w}(t+1) = \mathbf{w}(t) + y(t)\mathbf{x}(t).$$





Simple Perceptron Demo

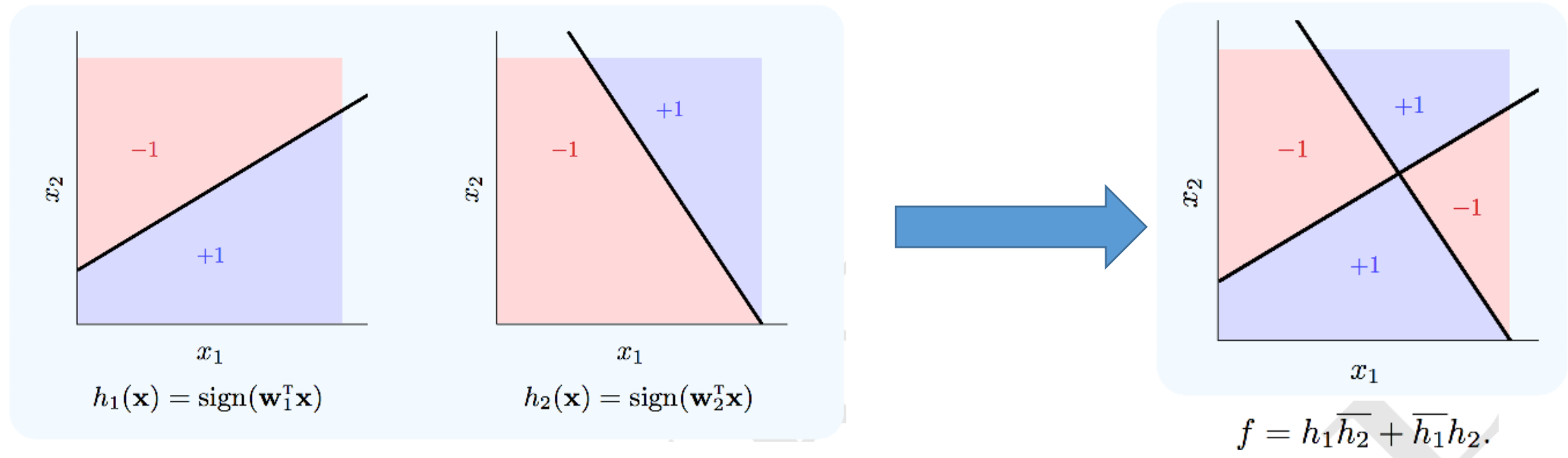
<http://ditam.github.io/demos/perceptron/perceptronDemo.html>





Combining Perceptron

- Can perceptron combined to perform more complex target function?
- Yes if we can write f using simple AND and OR operations:



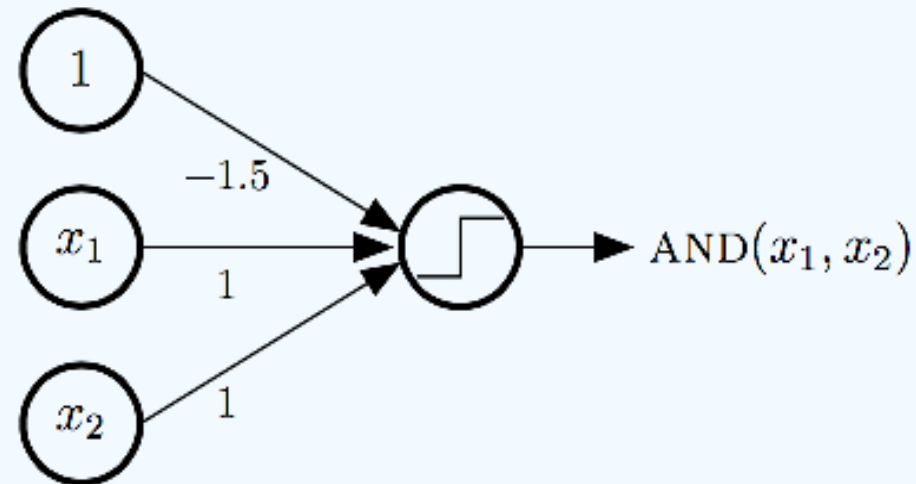
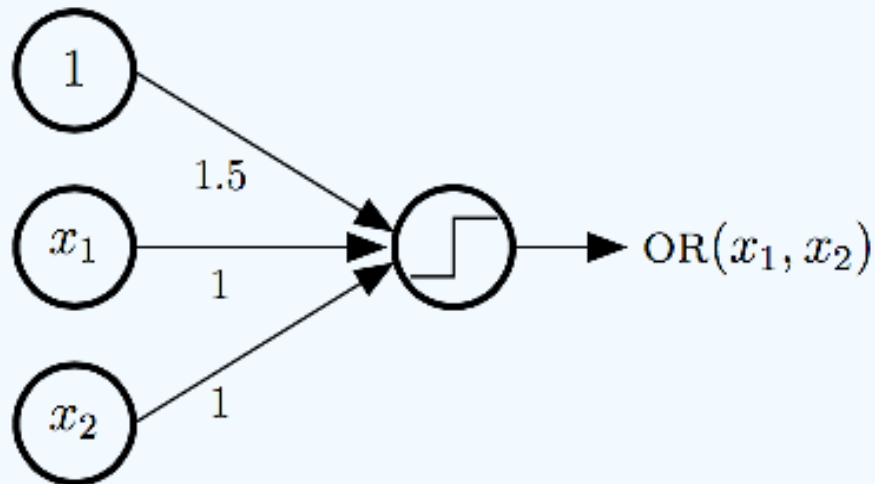
Note: Using standard Boolean notation (multiplication for AND, addition for OR, and overbar for negation)



Combining Perceptron

- Can perceptron implement AND and OR operation?

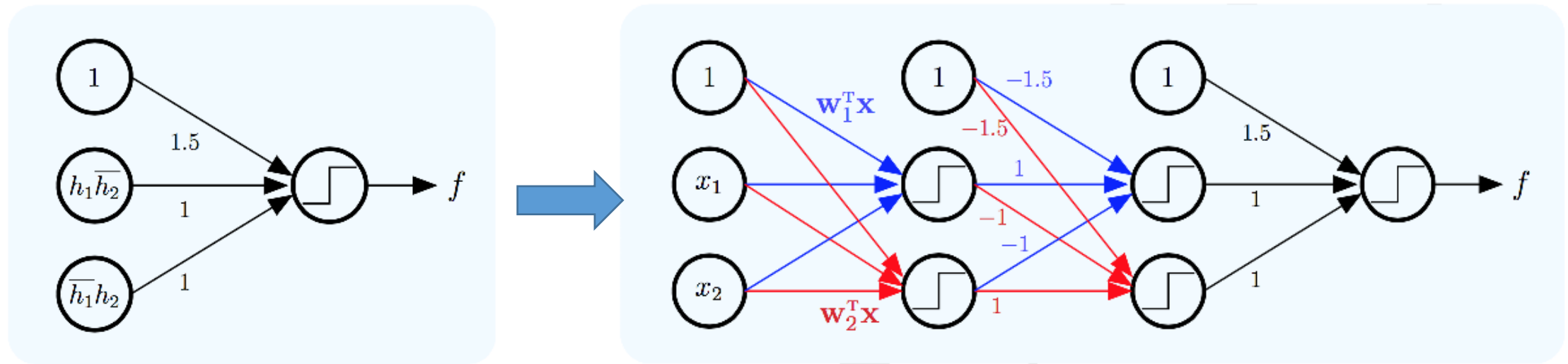
$$\begin{aligned}\text{OR}(x_1, x_2) &= \text{sign}(x_1 + x_2 + 1.5); \\ \text{AND}(x_1, x_2) &= \text{sign}(x_1 + x_2 - 1.5).\end{aligned}$$





Combining Perceptron

- We can visualize $f = h_1 \overline{h_2} + \overline{h_1} h_2$ as the following:

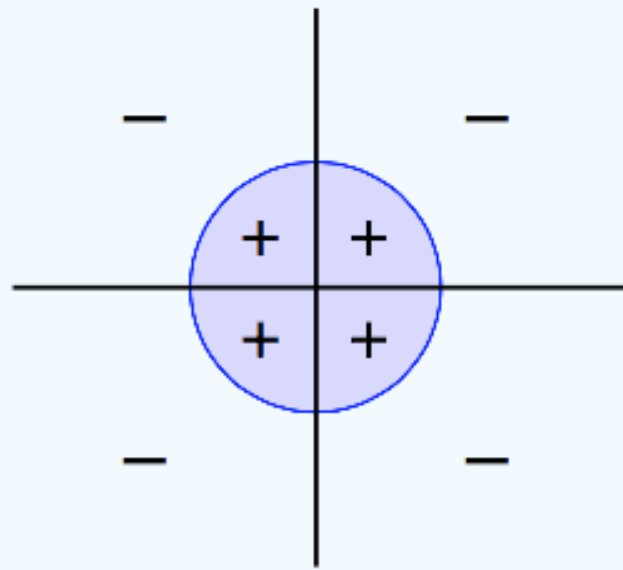


- Key Insight:** More layers of nodes are used between input and output to implement more complex target function f . We called Multi-Layer Perceptron. Additional layers are called *hidden layers*.

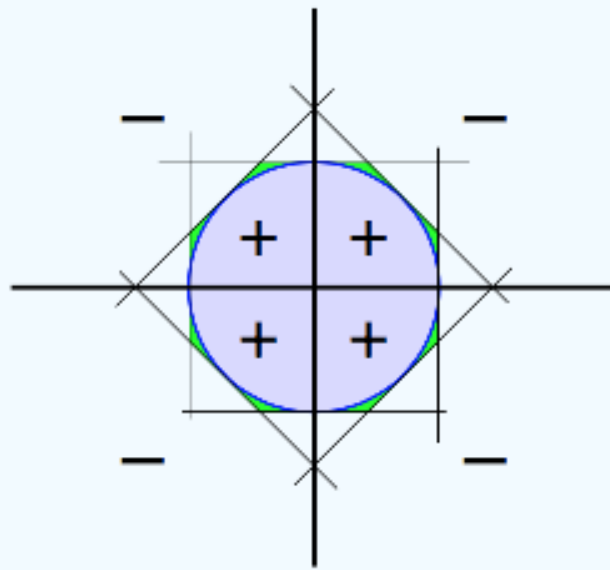


A Powerful Model

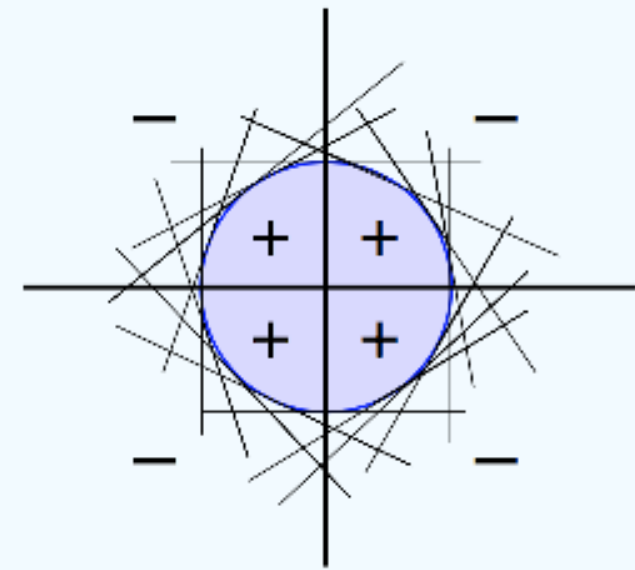
- If f can be decomposed into perceptrons using an OR of ANDs, then it can be implemented by a 3-layer perceptron. If f is not strictly decomposable into perceptrons, but the decision boundary is smooth, then a 3-layer perceptron can come arbitrarily close to implementing f . **Visual Proof:**



Target



8 perceptrons



16 perceptrons



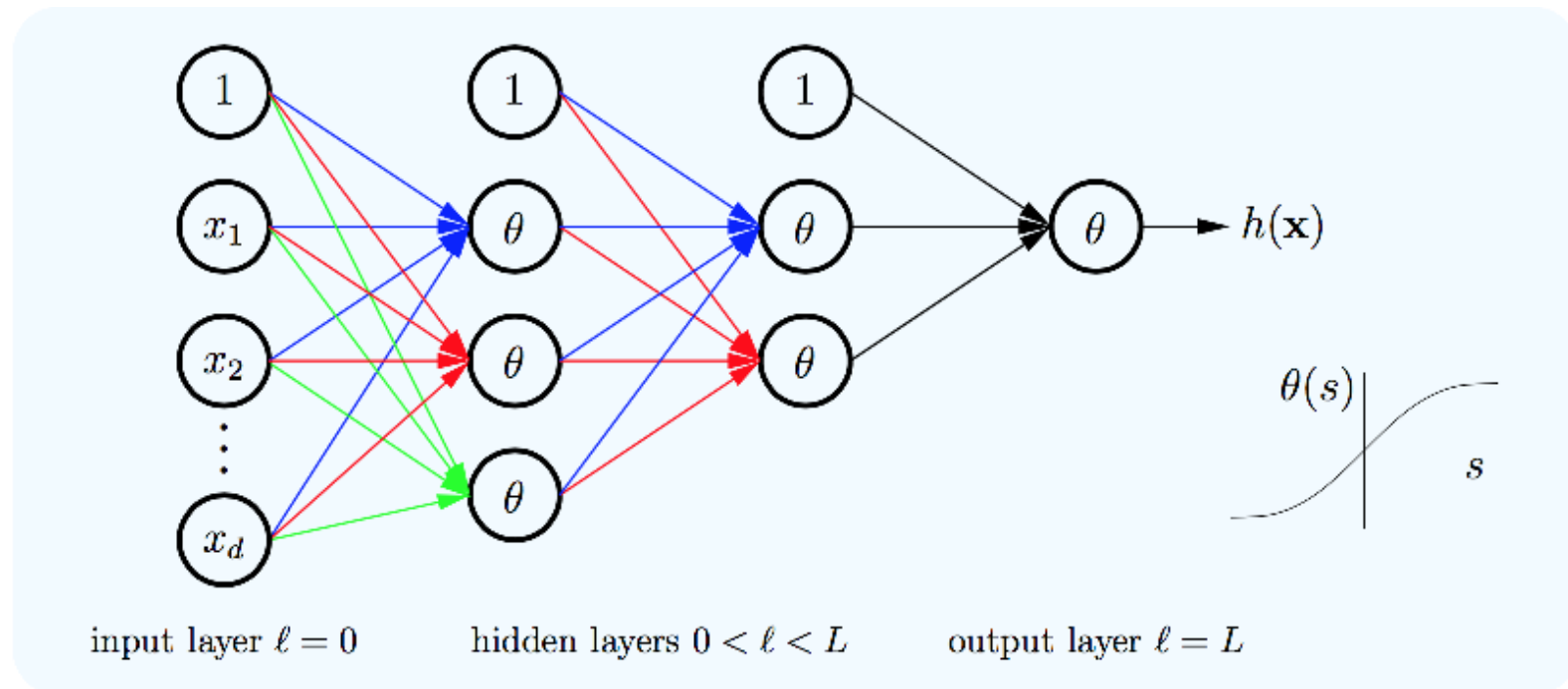
Deep Learning vs Machine Learning



Multi Layer Perceptron

Architecture:

- **Input Layer**
- **Hidden Layers**
- **Output Layer**
- One Direction Flow

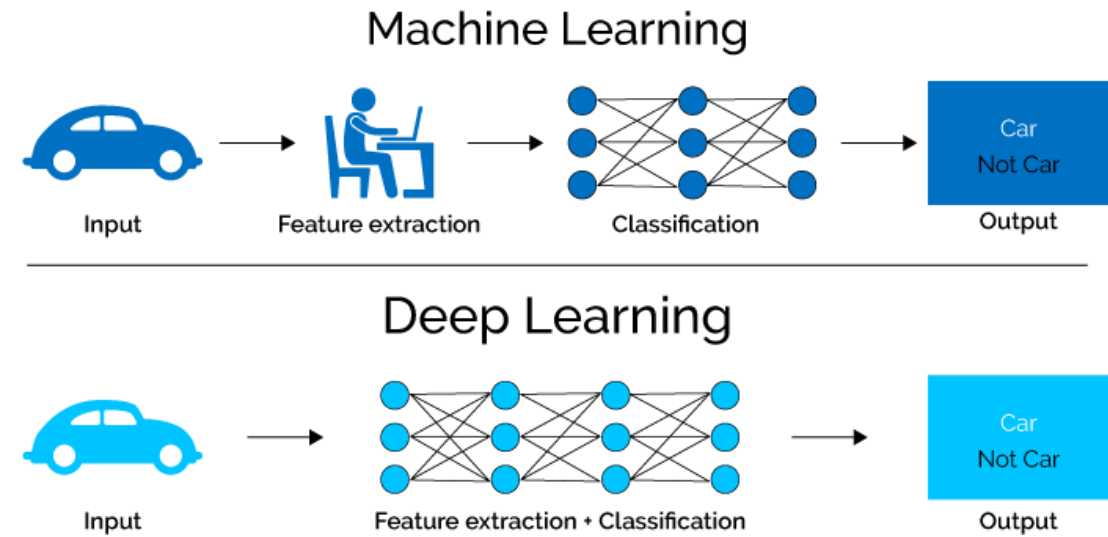
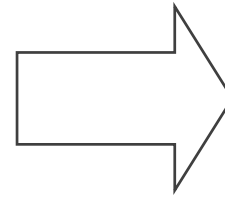
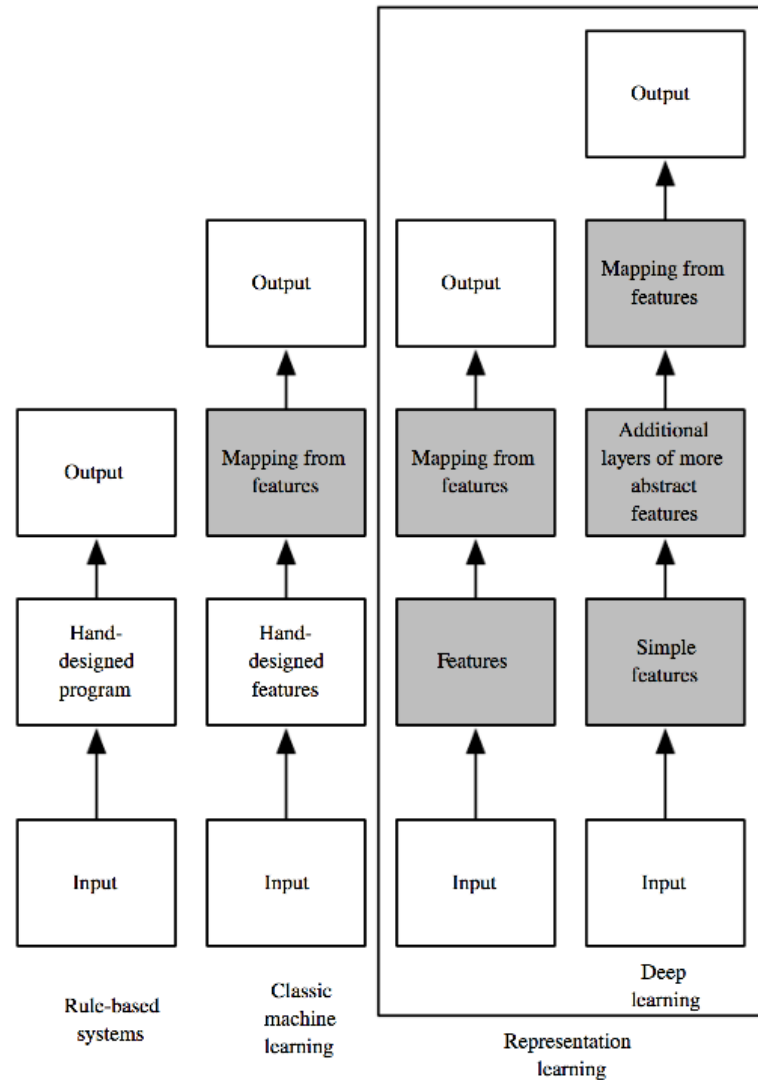


Deep Neural Networks = Many Hidden Layers MLP

Hidden Layers Represent Features Calm Down !

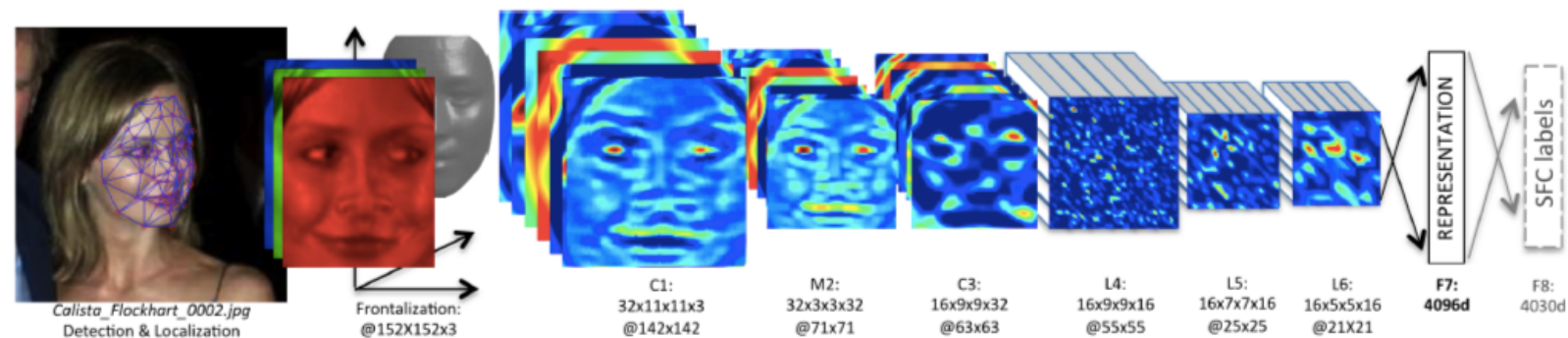
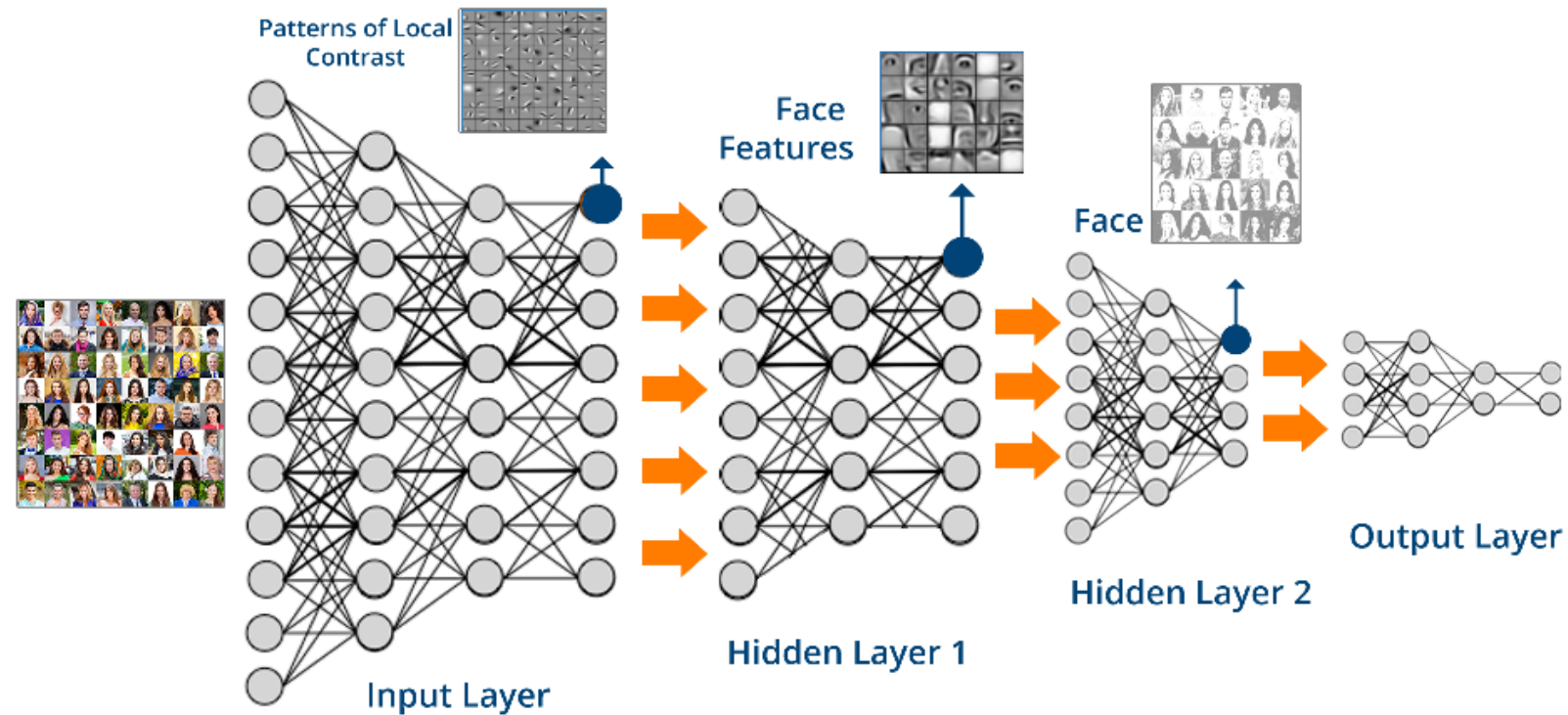


Deep Representation Learning



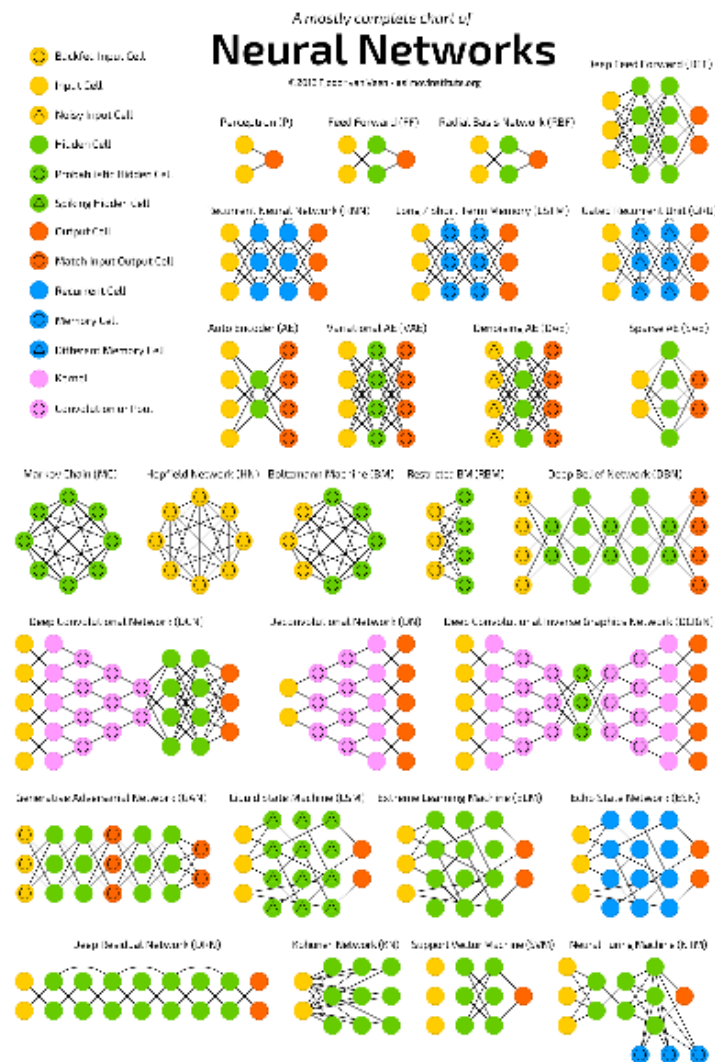


Example: Deep Learning

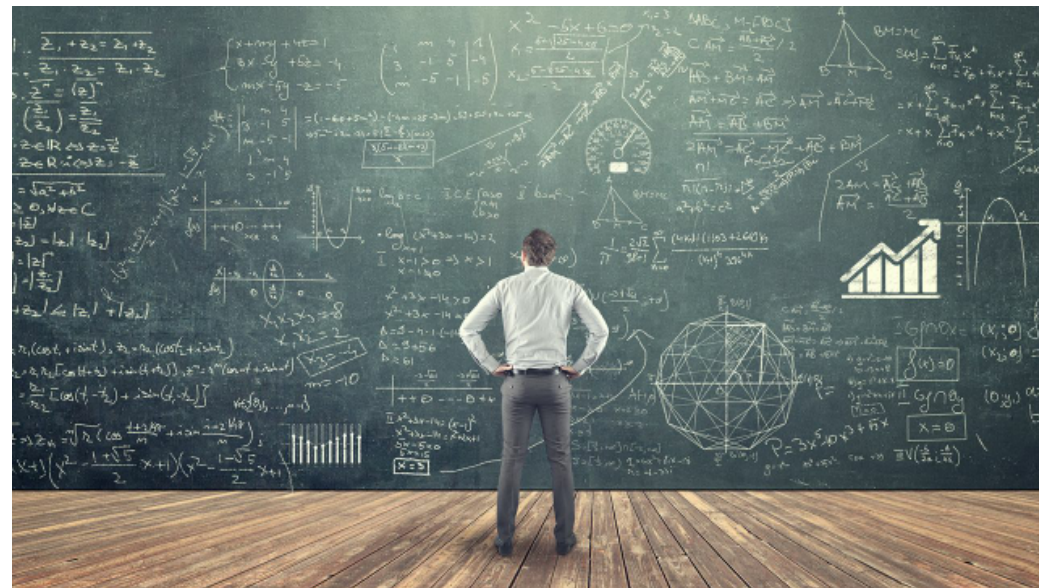




Deep Learning Landscape



**But....
Don't Skip Math!**



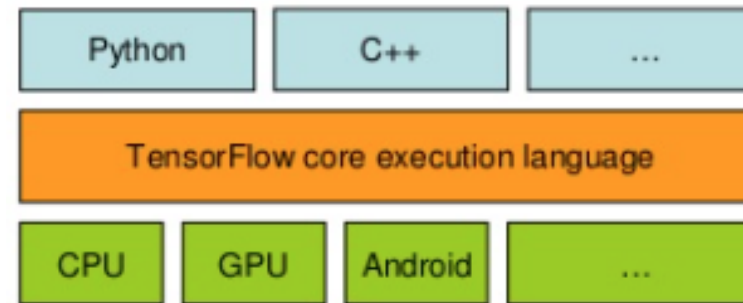


How to Get Started

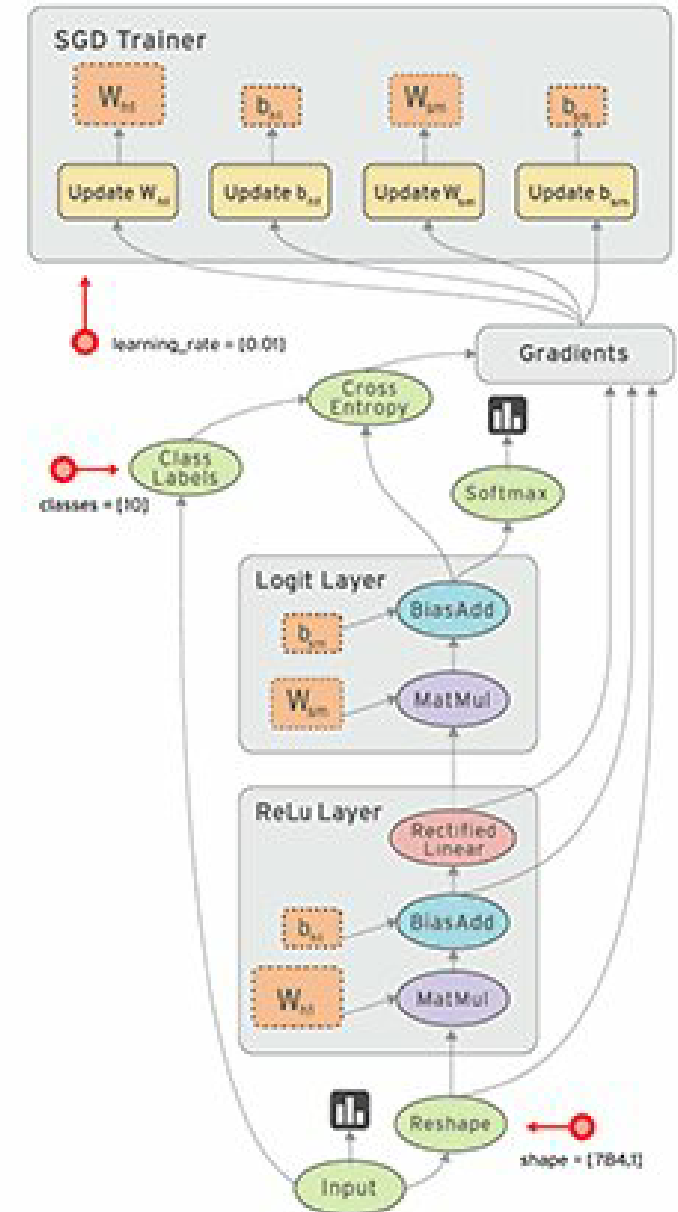


I Love Tensorflow

- **Tensor**
 - **Definition:** An array with more than two axes
 - Arbitrary dimensionality array
- **Directed Graph**
 - Used describes computation
 - **Node:** Instantiation of an operation
- **Operation**
 - An abstract computation
 - Have attributes
- **Kernel**
 - Particular implementation of an operation
 - Run on a type of device (e.g. CPU, GPU)
- **Variable**
 - Special operation to persistent mutable tensor
- **Session**
 - Created to interact with TensorFlow system



[Download at www.tensorflow.org](http://www.tensorflow.org)





But Many Frameworks

Additional: Keras

	Caffe	Torch	Theano	TensorFlow
Language	C++, Python	Lua	Python	Python
Pretrained	Yes ++	Yes ++	Yes (Lasagne)	Inception
Multi-GPU: Data parallel	Yes	Yes <code>cunn. DataParallelTable</code>	Yes <code>platoon</code>	Yes
Multi-GPU: Model parallel	No	Yes <code>fbcunn.ModelParallel</code>	Experimental	Yes (best)
Readable source code	Yes (C++)	Yes (Lua)	No	No
Good at RNN	No	Mediocre	Yes	Yes (best)



TensorFlow – Pros & Cons

- (+) Python + Numpy (Anaconda)
- (+) Computational graph abstraction, like Theano; great for RNNs
- (+) Much faster compile times than Theano
- (+) Slightly more convenient than raw Theano?
- (+) TensorBoard for visualization and Tensorflow Lite for Mobile
- (+) Data AND model parallelism; best of all frameworks
- (+/-) Distributed models, but not open-source yet
- (-) Slower than other frameworks right now
- (-) Much “fatter” than Torch; more magic
- (-) Not many pre-trained models



Use GPU Cloud Please

- **CPU is too slow! Please use GPU instance.**
- **You can use both Azure and Amazon EC2**
- **Azure GPU instance is available in South Central US Region.**

Data Science Virtual Machine for Linux (Ubuntu)

The Data Science Virtual Machine for Linux is an Ubuntu-based virtual machine image that makes it easy to get started with deep learning on AWS. It includes TensorFlow, MXNet, Caffe, Caffe2, PyTorch, Keras, Theano, and Torch and built, installed, and configured so they are ready to run immediately. The NVIDIA driver, CUDA, and cuDNN are also included. All frameworks use the GPU versions but work on the CPU as well. Many sample Jupyter notebooks are included.

The Data Science Virtual Machine for Linux also contains popular tools for data science and development as follows, including:

- Microsoft R Server 6.1 with Microsoft R Open 3.5.3
- Amazon EMR 5.7 and 5.8
- JupyterHub with sample notebooks
- [Kudu for Hadoop](#) for querying Hadoop data using SQL
- Spark Local 2.1.0 with Mesos and Scala Jupyter kernels
- Single node local Hadoop (HDFS, Yarn)
- AWS Command Line Interface
- Visual Studio Code, IntelliJ IDEA, PyCharm, and Atom
- JupyterLab, a next-generation interactive computing environment
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- JupyterLab, a next-generation interactive computing environment











You can view a full list of installed tools for the Linux edition [here](#).

Connect to the RStudio graphical desktop on the VM using RStudio. This virtual machine image lets you jump start deep learning, machine learning, or data science by including popular tools that are pre-installed and configured. Deep learning frameworks include CNTK, TensorFlow, MXNet, Caffe, Caffe2, PyTorch, Keras, Theano, and Torch. Many languages are supported.

Select a deployment mode:

Resource Manager

Create

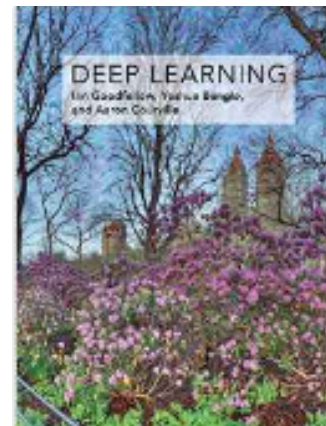
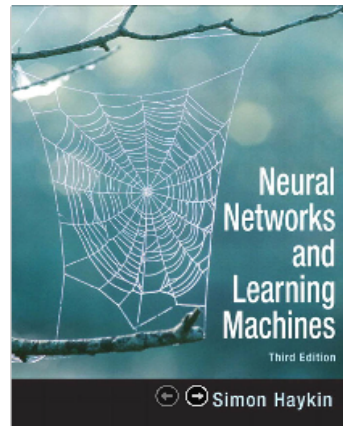
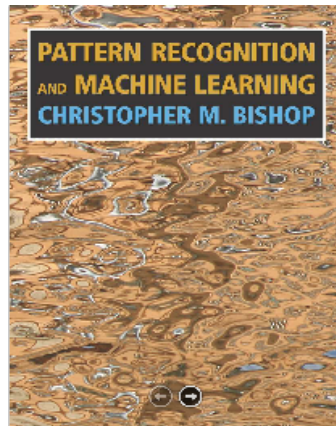
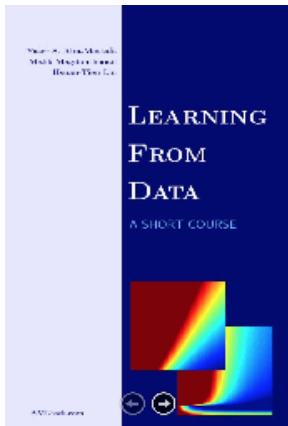
NC6 Standard		★	NC12 Standard		★
6	vCPUs		12	vCPUs	
56	GB		112	GB	
	8 Data disks			16 Data disks	
	8x500 Max IOPS			16x500 Max IOPS	
	380 GB Local SSD			680 GB Local SSD	
	1x K80 Graphics			2x K80 Graphics	
	Load balancing			Load balancing	
10,976,083.20			21,952,166.40		
IDR/MONTH (ESTIMATED)			IDR/MONTH (ESTIMATED)		

For Amazon EC2 GPU Guide, please look here: <https://aws.amazon.com/ec2/elastic-gpus/>



Additional Reading Materials

- Neural Networks and Deep Learning, **Michael Nielsen**
- Learning from Data, **Yaser S. Abu-Mostafa**
- Pattern Recognition and Machine Learning, **Christopher Bishop**
- Neural Networks and Learning Machines, **Simon Haykin**
- Neural Networks, Coursera, **Geoff Hinton**
- Convolutional Neural Networks, Stanford CS231s, **Fei-Fei Li**
- Deep Learning, **Ian Goodfellow, Yoshua Bengio, Aaron Courville**





Q&A

See you in next meet up