ARTIFICIAL INTELLIGENCE

INTRODUCTION TO DEEP LEARNING

MUSTAFA ALDEMIR, INTEL TURKEY

ARTIFICIAL INTELLIGENCE

WHAT IS DEEP LEARNING GOOD FOR

DEEP LEARNING: EXAMPLES

"Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum."

Images
Computer vision, Image classification, Traffic sign detection, Pedestrian detection, localization…

Sound
Speech recognition, Natual Language Processing, Translation, Content captioning, speaker identification

Text
Natual Language Processing, text classification; web search, spam, email filtering

CLASSIFICATION

-> Label the image

Person

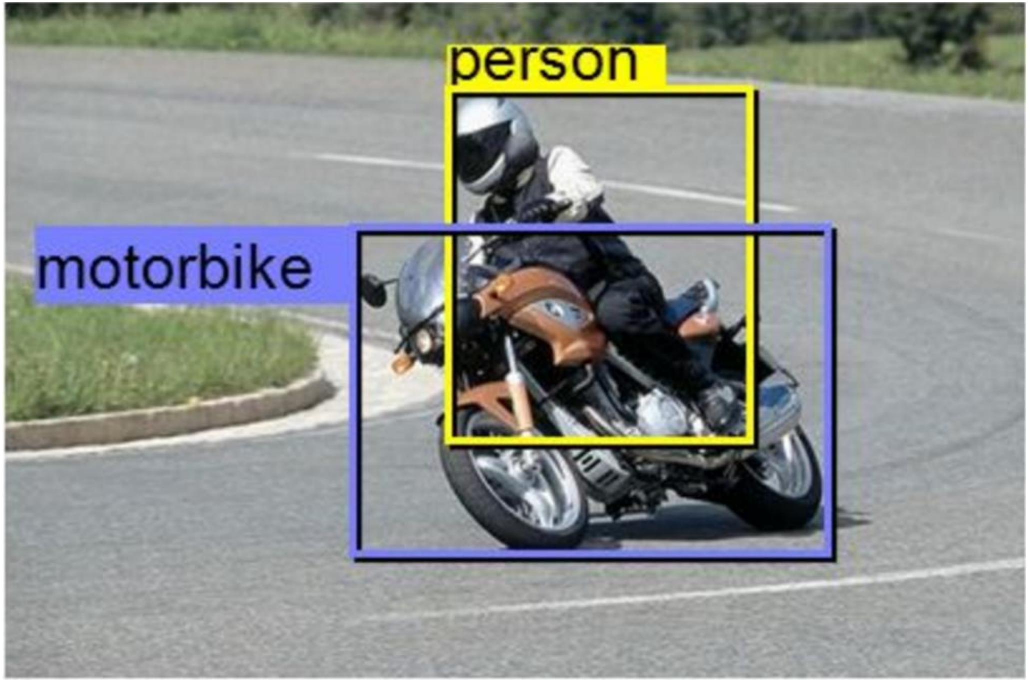
Motorcyclist

Bike

https://people.eecs.berkeley.edu/~jhoffman/talks/lsda-baylearn2014.pdf

DETECTION

-> Detect and label



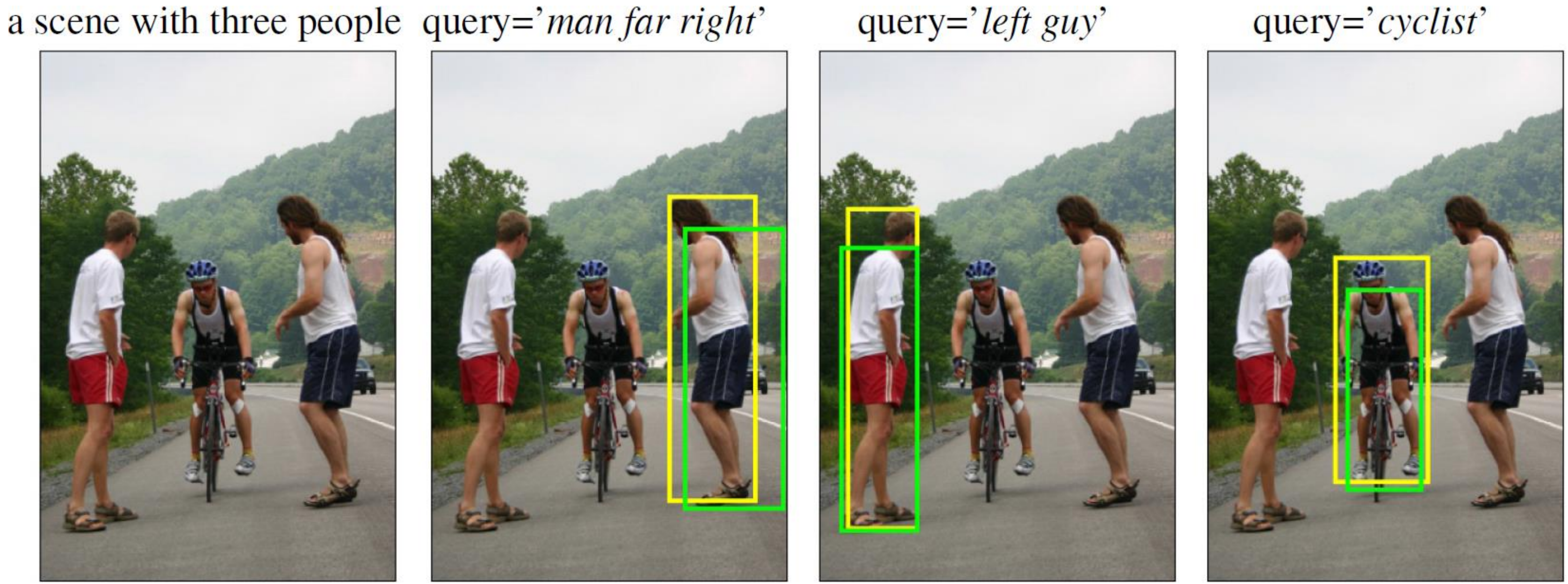
https://people.eecs.berkeley.edu/~jhoffman/talks/lsda-baylearn2014.pdf

SEMANTIC SEGMENTATION

-> Label every pixel

https://people.eecs.berkeley.edu/~jhoffman/talks/lsda-baylearn2014.pdf

NATURAL LANGUAGE OBJECT RETRIEVAL



http://arxiv.org/pdf/1511.04164v3.pdf

SPEECH RECOGNITION

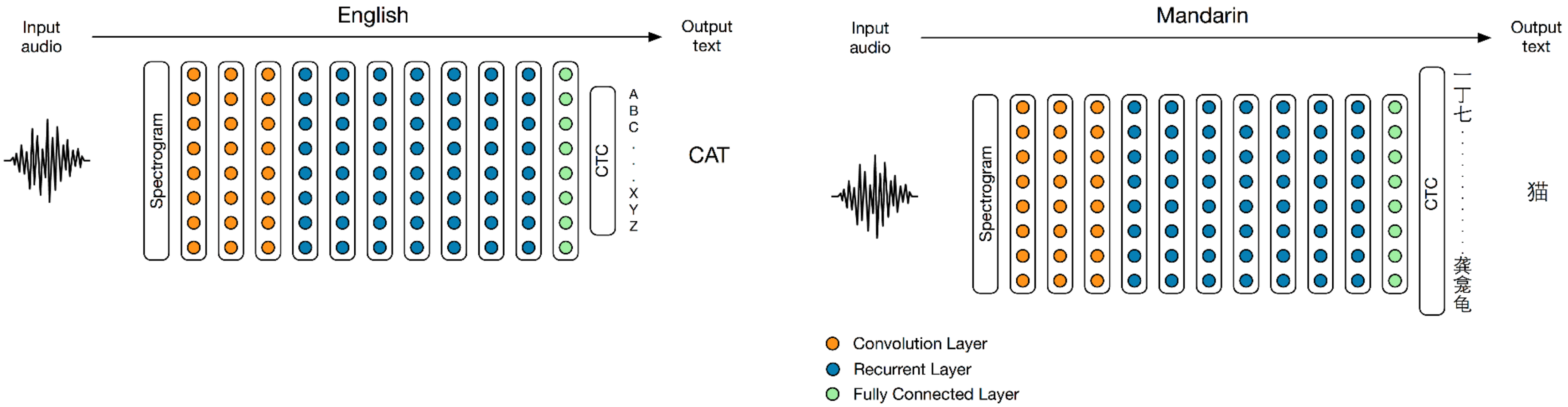


IMAGE / VIDEO CAPTIONING

Describes without errors	Describes with minor errors	Somewhat related to the image

A person riding a motorcycle on a dirt road.

Two dogs play in the grass.

A skateboarder does a trick on a ramp.

A group of young people playing a game of frisbee.

Two hockey players are fighting over the puck.

A little girl in a pink hat is blowing bubbles.

ARTIFICIAL INTELLIGENCE

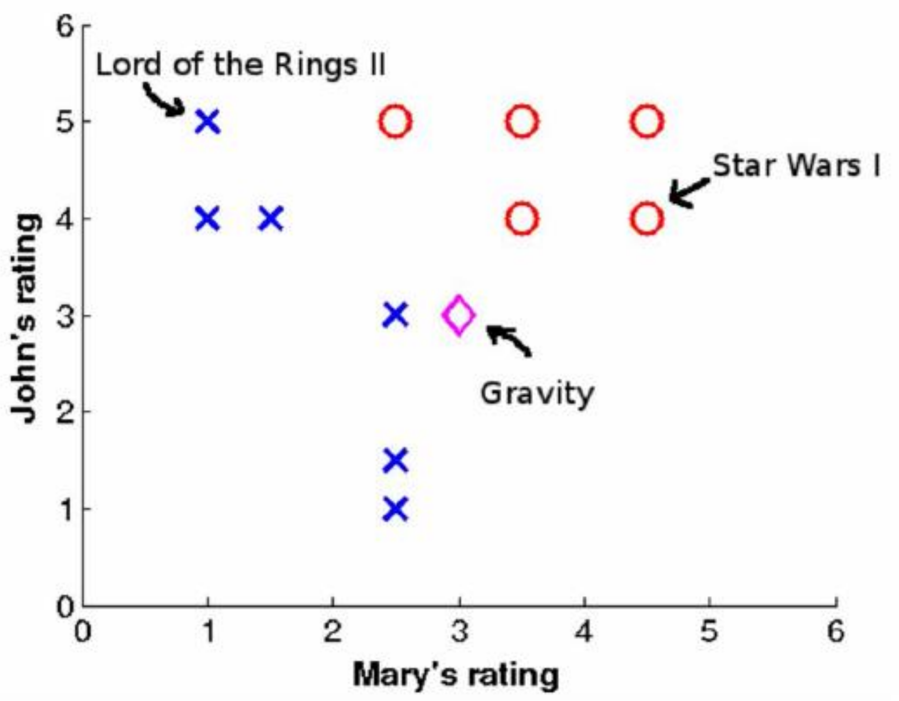
NEURAL NETWORKS

Will Nancy like Gravity?

Let's ask close friends Mary and John, who already watched it and rated between 1-5.

NETFLIX

Movie	Mary's Rating	John's Rating	Does Nancy like?
Lord of the Rings 2	1	5	No
…	…	…	…
Star Wars 1	4.5	4	Yes
Gravity	3	3	?


Lord of the Rings II
Star Wars I
Gravity
John's rating
Mary's rating
0
1
2
3
4
5
6

A decision function can be as simple as weighted linear combination of friends:

$$h_{\theta,b} = \theta_1 x_1 + \theta_2 x_2 + b$$

$$h_{\theta,b} = \theta^T x + b$$

- Labels: “I like it” -> 1 “I don’t like it” -> 0
- Inputs: Mary’s rating, John’s rating

ACTIVATION FUNCTION

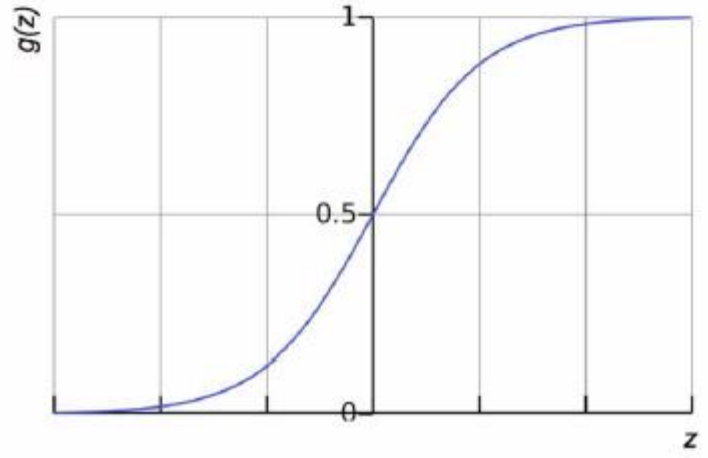
This function has a problem. Its values are unbounded.

We want its output to be in the range of 0 and 1.

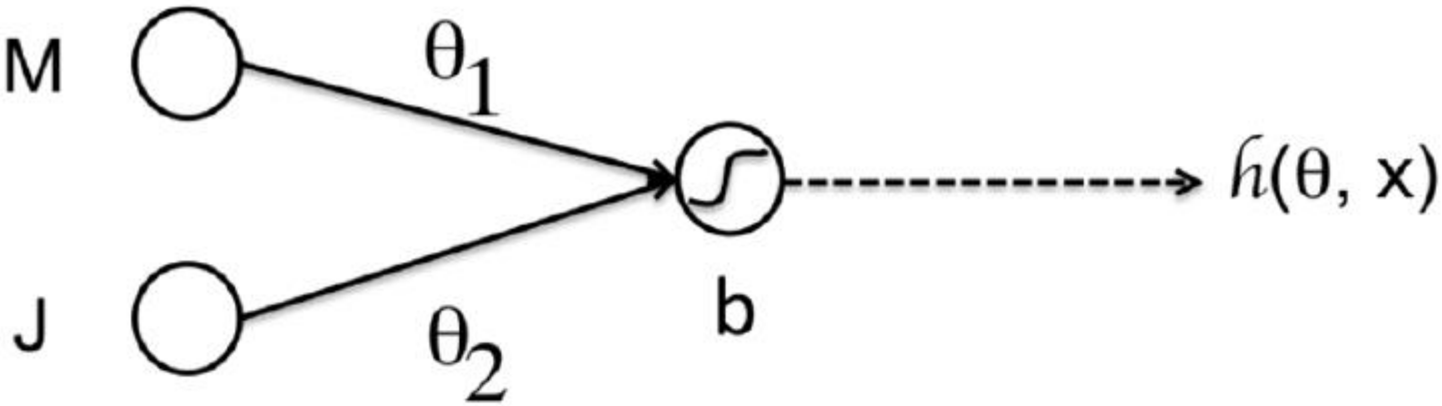
$$h_{\theta,b} = g(\theta^T x + b),$$

where $g(z)$ is sigmoid function.

$$g(z) = \frac{1}{1 + exp(-z)}$$



ANOTHER WAY OF REPRESENTING THE MODEL



LEARN FROM DATA

We will use the past data to learn θ, b to approximate y. In particular, we want to obtain θ, b such that:

$h_{\theta,b}\left(x^{(1)}\right) \approx y^{(1)}$ where $x^{(1)}$ is my friend's ratings for 1st movie.

$h_{\theta,b}\left(x^{(2)}\right) \approx y^{(2)}$ where $x^{(2)}$ is my friend's ratings for 2nd movie.

...

$h_{\theta,b}\left(x^{(m)}\right) \approx y^{(m)}$ where $x^{(m)}$ is my friend's ratings for mth movie.

COST FUNCTION

To find values of θ and b we can minimize the following ***cost function***:

$$J(\theta, b) = \left(h_{\theta,b}\left(x^{(1)}\right) - y^{(1)}\right)^2 + \left(h_{\theta,b}\left(x^{(2)}\right) - y^{(2)}\right)^2 + \ \dots + \left(h_{\theta,b}\left(x^{(m)}\right) - y^{(m)}\right)^2$$

$$J(\theta, b) = \sum_{i=1}^{m} \left(h_{\theta,b}\left(x^{(i)}\right) - y^{(i)}\right)^2$$

BACKPROPOGATION

TODO!

STOCHASTIC GRADIENT DESCENT

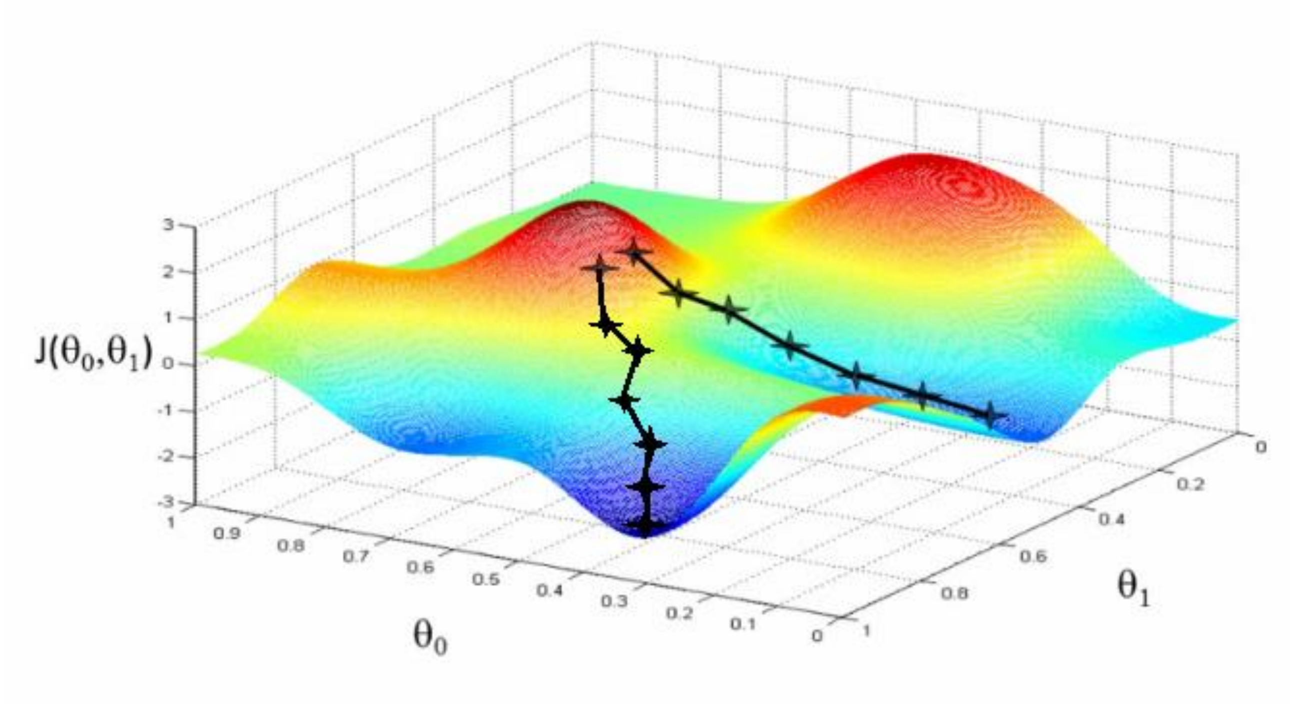
Use Stochastic Gradient Descent (SGD):

$$\theta_1 = \theta_1 - \alpha\Delta\theta_1$$

$$\theta_2 = \theta_2 - \alpha\Delta\theta_2$$

$$b = b - \alpha\Delta b$$

STOCHASTIC GRADIENT DESCENT



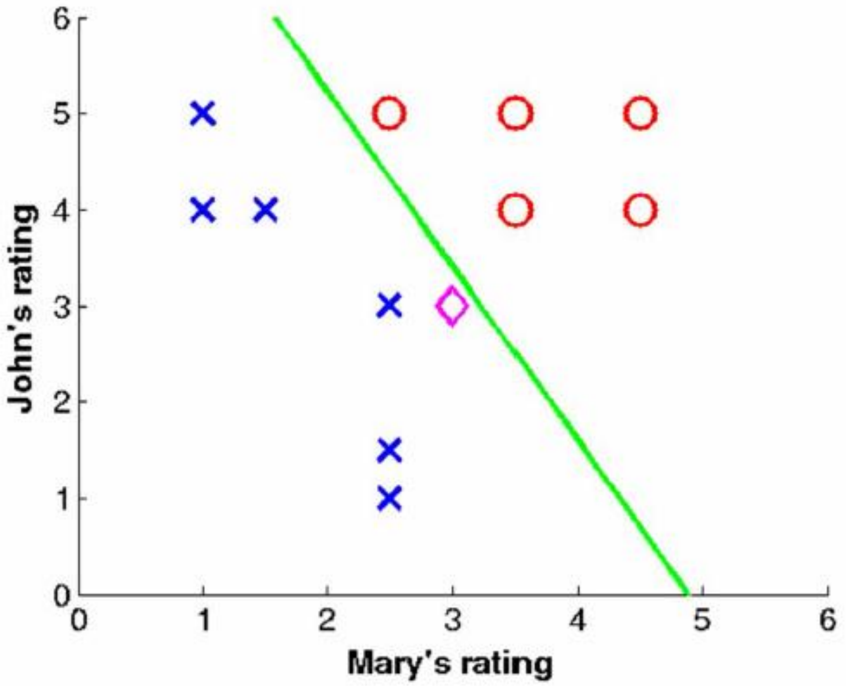
STEPS

1. Initialize the parameters θ and b at random
2. Pick a random example $\{x^{(i)}, y^{(i)}\}$
3. Compute the partial derivatives of θ_1, θ_2, b
4. Update parameters using:

$$\theta_1 = \theta_1 - \alpha\Delta\theta_1$$
$$\theta_2 = \theta_2 - \alpha\Delta\theta_2$$
$$b = b - \alpha\Delta b$$

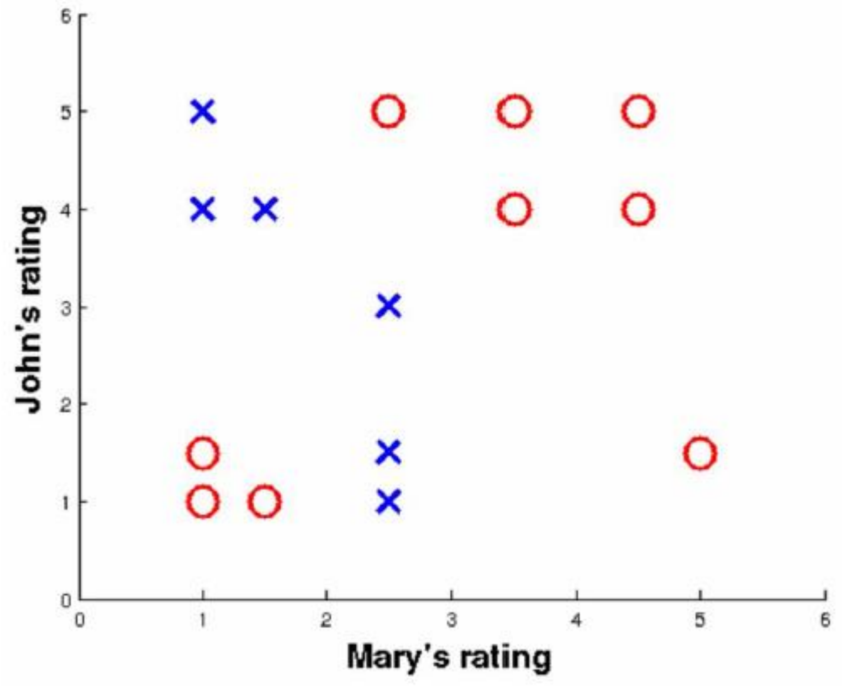
Stop it when parameters don't change much, or after a certain number of iterations.

NETFLIX



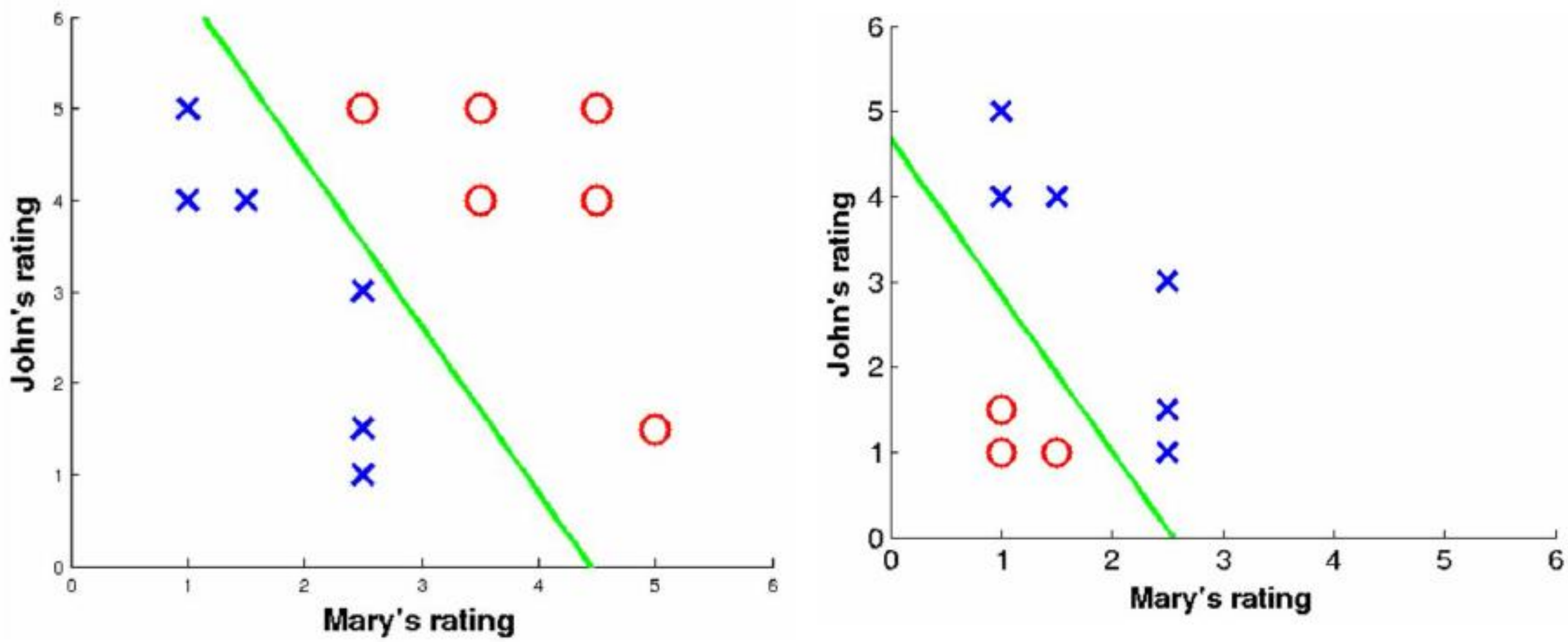
Gravity movie is slightly on the “don’t watch” side.

With this data set, it seems like ”not watching it” makes more sense.



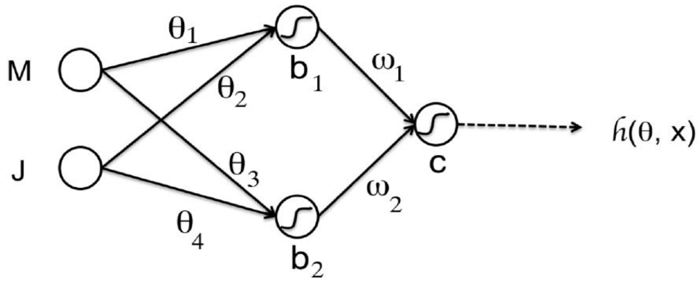
Nancy likes some of the movies both Mary and John rated poorly.

How can I have a linear decision boundary separate these?

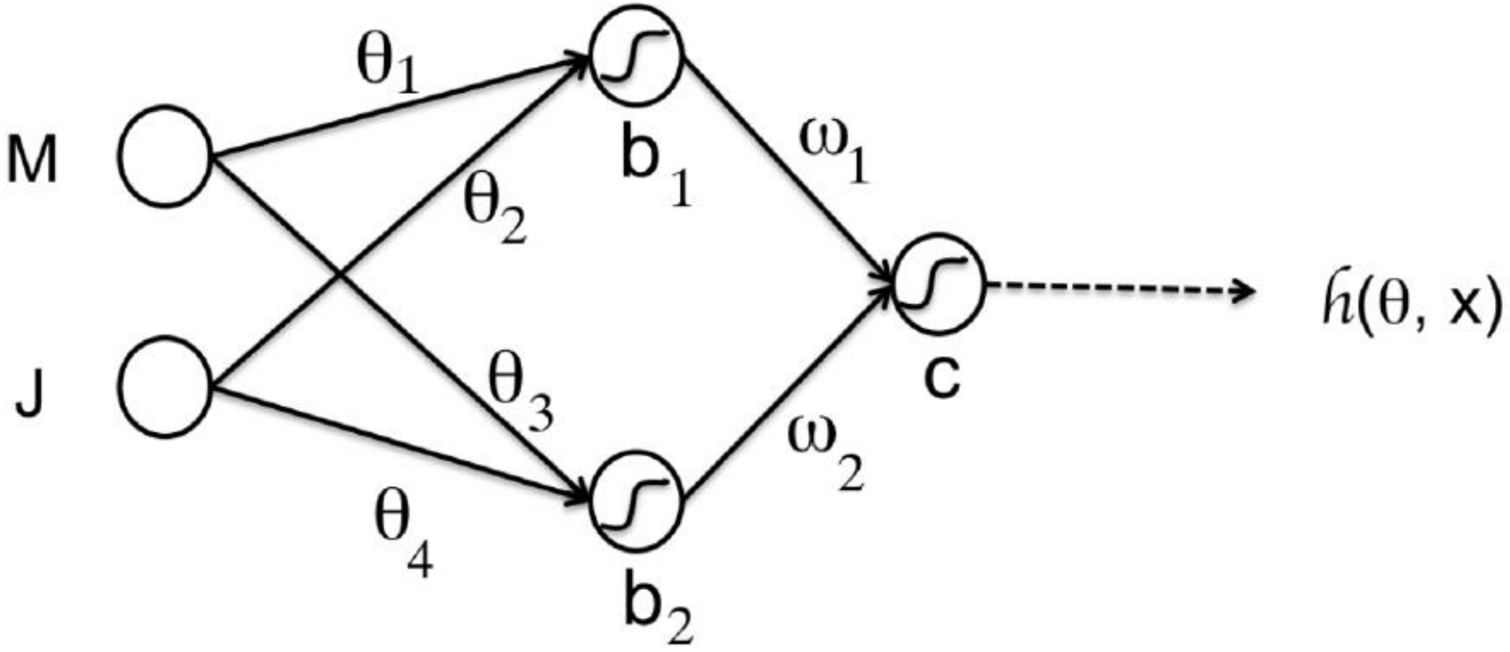

John's rating
Mary's rating
John's rating
Mary's rating

NETFLIX

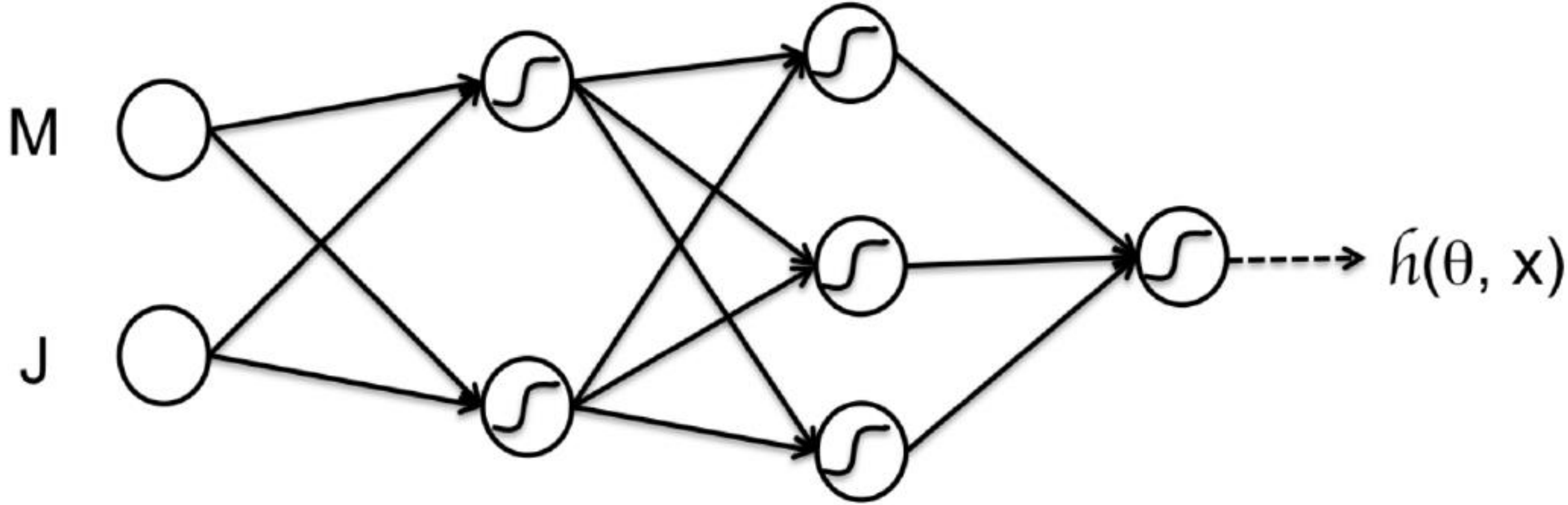
Movie	Output by decision function *h1*	Output by decision function *h2*	Does Nancy like?
Lord of the Rings 2	$h_1(x^{(1)})$	$h_2(x^{(1)})$	No
…	…	…	…
Star Wars 1	$h_1(x^{(n)})$	$h_2(x^{(n)})$	Yes
Gravity	$h_1(x^{(n+1)})$	$h_2(x^{(n+1)})$	?



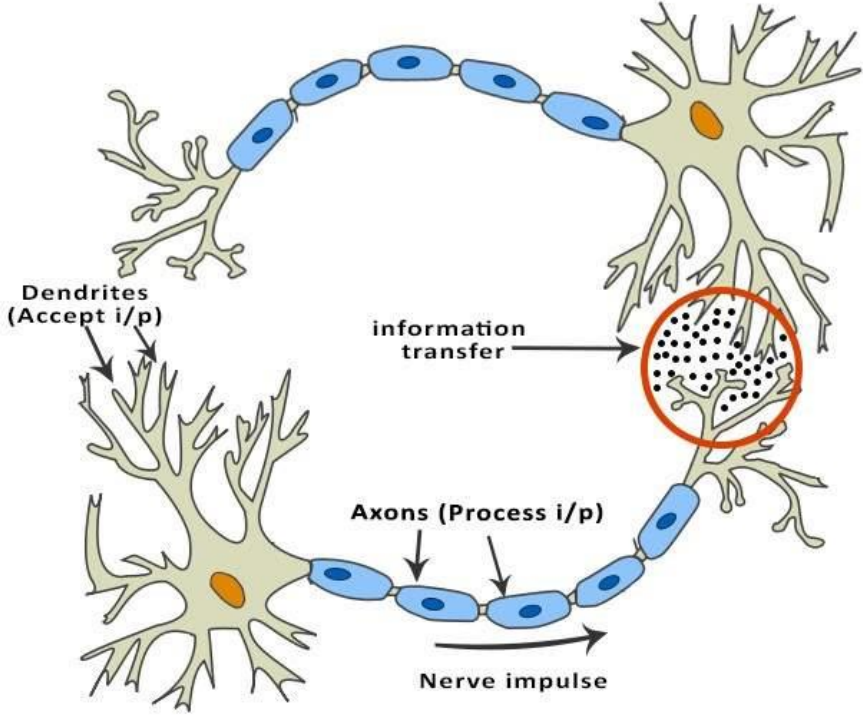
THIS IS THE NEURAL NETWORK



A DEEPER NEURAL NETWORK

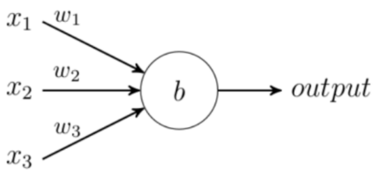


INSPIRED BY HUMAN BRAIN



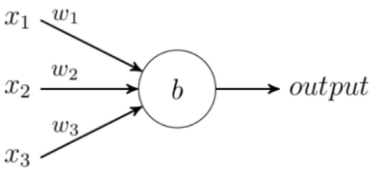
DEEP LEARNING: BASIC STRUCTURE

BASIC SINGLE NEURON

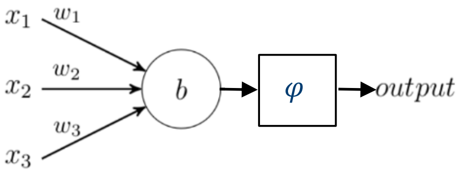


DEEP LEARNING: BASIC STRUCTURE

BASIC SINGLE NEURON



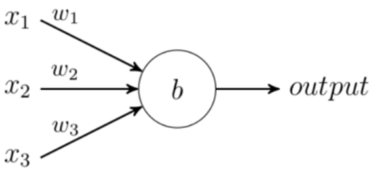
SINGLE NEURON WITH ACTIVATION



$\varphi \longrightarrow$ Activation function

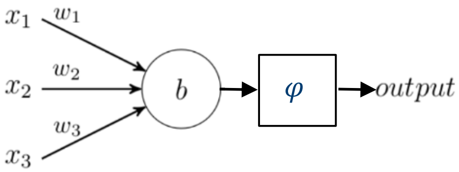
DEEP LEARNING: BASIC STRUCTURE

BASIC SINGLE NEURON



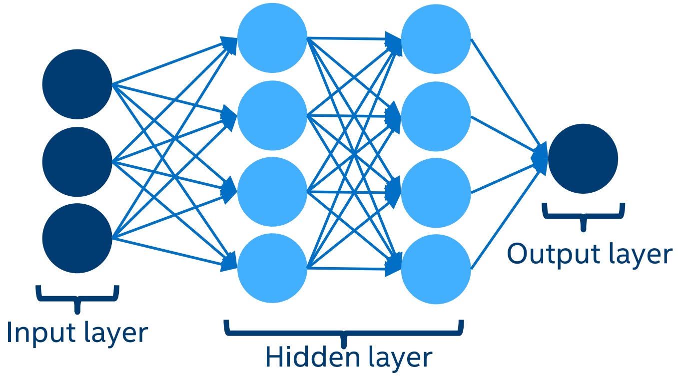
$$u_n = \sum_{j=1}^{m} w_{nj} x_j$$

SINGLE NEURON WITH ACTIVATION



$\varphi \rightarrow$ Activation function

BASIC STRUCTURE WITH TWO HIDDEN LAYERS



ARTIFICIAL INTELLIGENCE

SUMMARY

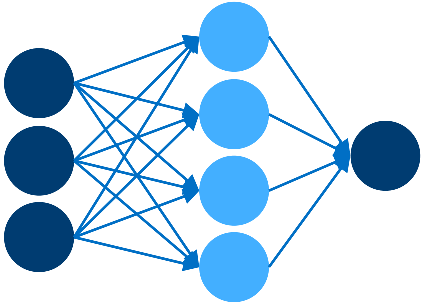
KEYWORDS

- Training / Testing percentage
- Overfitting – Underfitting
- Topology
- Training Algorithms
- Learning Rate
- Batch Size

HANDWRITING EXAMPLE

MNIST DATASET
28x28 Pixels

Input layer | Hidden layer | Output layer



= 28x28 pixels
= 784 units

= 100 units
(variable)

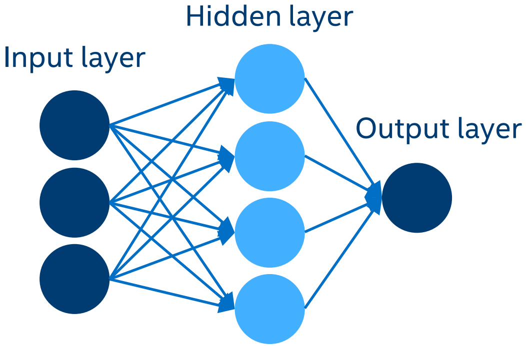
= 10 units (0 – 9)

TOTAL PARAMETERS

$W_{\text{input} \rightarrow \text{hidden}}$	784 x 100
b_{hidden}	100
$W_{\text{hidden} \rightarrow \text{output}}$	100 x 10
B_{output}	10

$$u_n = \sum_{j=1}^{m} w_{nj} x_j$$

TRAINING

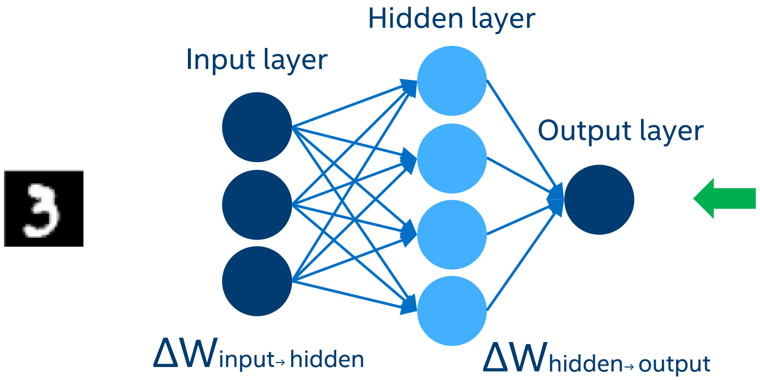


1) Initialize weights
2) Forward pass
3) Calculate cost
4) Backward pass
5) Update weights

Output	Ground Truth
0.2	0.0
0.0	0.0
0.5	1
0.0	0.0
0.1	0.0
0.4	0.0
0.2	0.0
0.0	0.0
0.1	0.0
0.0	0.0

Cost function =
C(output, truth)

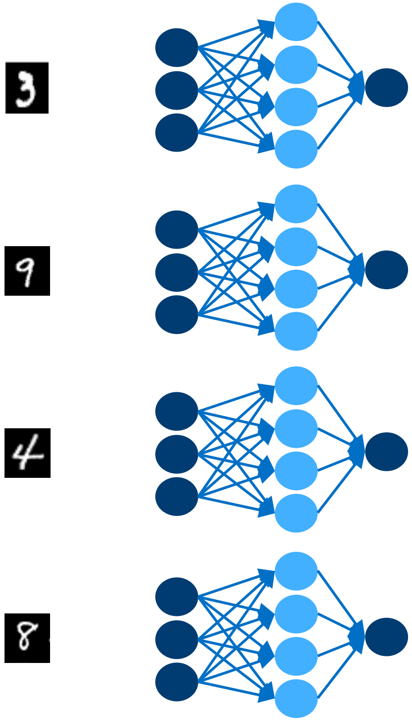
TRAINING: BACKPROPAGATION

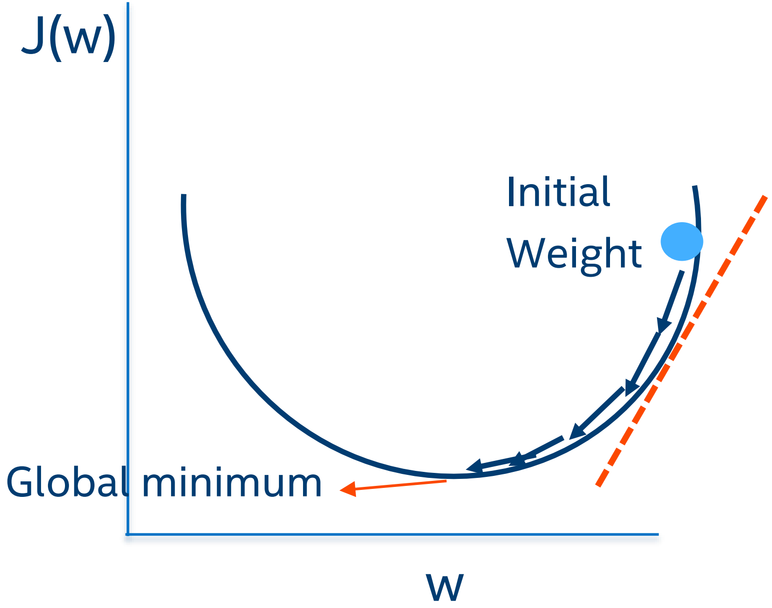


Cost function =

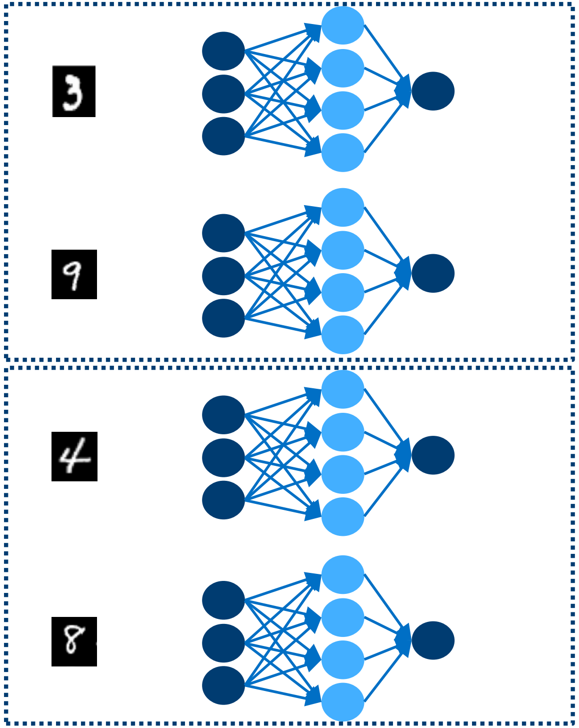
C(output, truth)

TRAINING: STOCHASTIC GRADIENT DESCENT





TRAINING: STOCHASTIC GRADIENT DESCENT



INTEL® DEEP LEARNING SDK EXAMPLE:

Learning rate: 0.01
Bacth size: 54
Epochs: 10

CLASSICAL MACHINE LEARNING VS DEEP LEARNING

CLASSIC ML

Using optimized functions or algorithms to extract insights from data

Training Data*

Algorithms

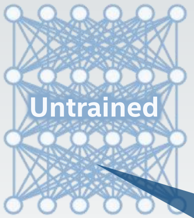
- Random Forest
- Support Vector Machines
- Regression
- Naïve Bayes
- Hidden Markov
- K-Means Clustering
- Ensemble Methods
- More…

Inference, Clustering, or Classification

New Data*

DEEP LEARNING

Using massive labeled data sets to train deep (neural) graphs that can make inferences about new data



CNN, RNN, RBM..

**Ne
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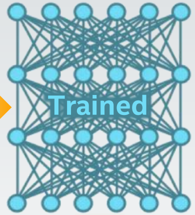
Dat
a**



Step 1: Training

Hours to Days in Cloud

Use massive labeled dataset (e.g. 10M tagged images) to iteratively adjust weighting of neural network connections

Step 2: Inference

Real-Time at Edge/Cloud

Form inference about new input data (e.g. a photo) using trained neural network

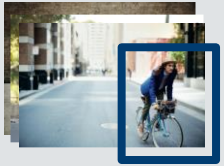
*Note: not all classic machine learning functions require training

DEEP LEARNING STEPS

STEP 1: TRAINING

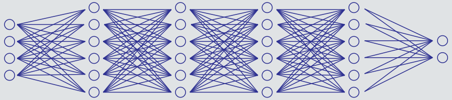
(In Data Center – Over Hours/Days/Weeks)

Lots of labeled input data



Person

Create "Deep neural net" math model



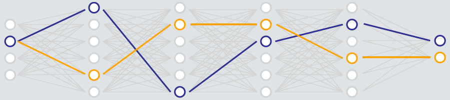
Output: Trained Model

Trained Model

STEP 2: INFERENCE

(End point or Data Center - Instantaneous)

New input from camera and sensors



Trained neural network model

97% person
2% traffic light

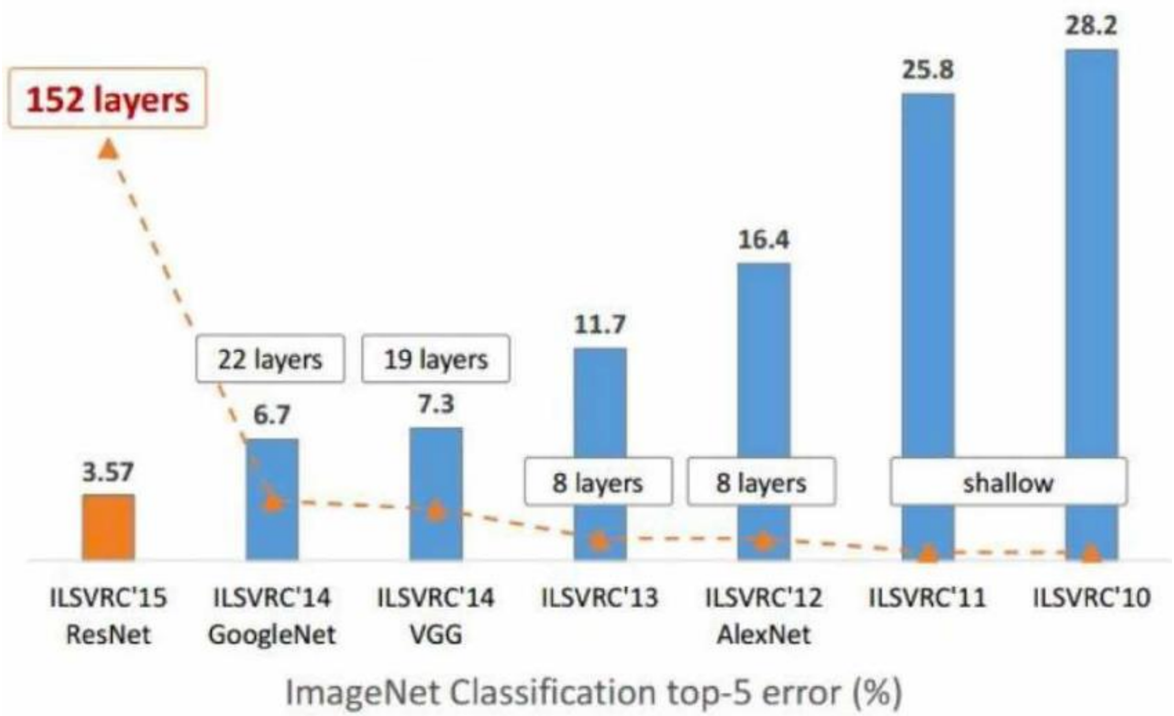
Output: Classification

ARTIFICIAL INTELLIGENCE

CONVOLUTIONAL NEURAL NETWORKS (CNN)

TODO

Evolution of Depth



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RECURRENT NEURAL NETWORKS (RNN)

TODO

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GENERATIVE ADVERSARIAL NETWORKS (GAN)

TODO

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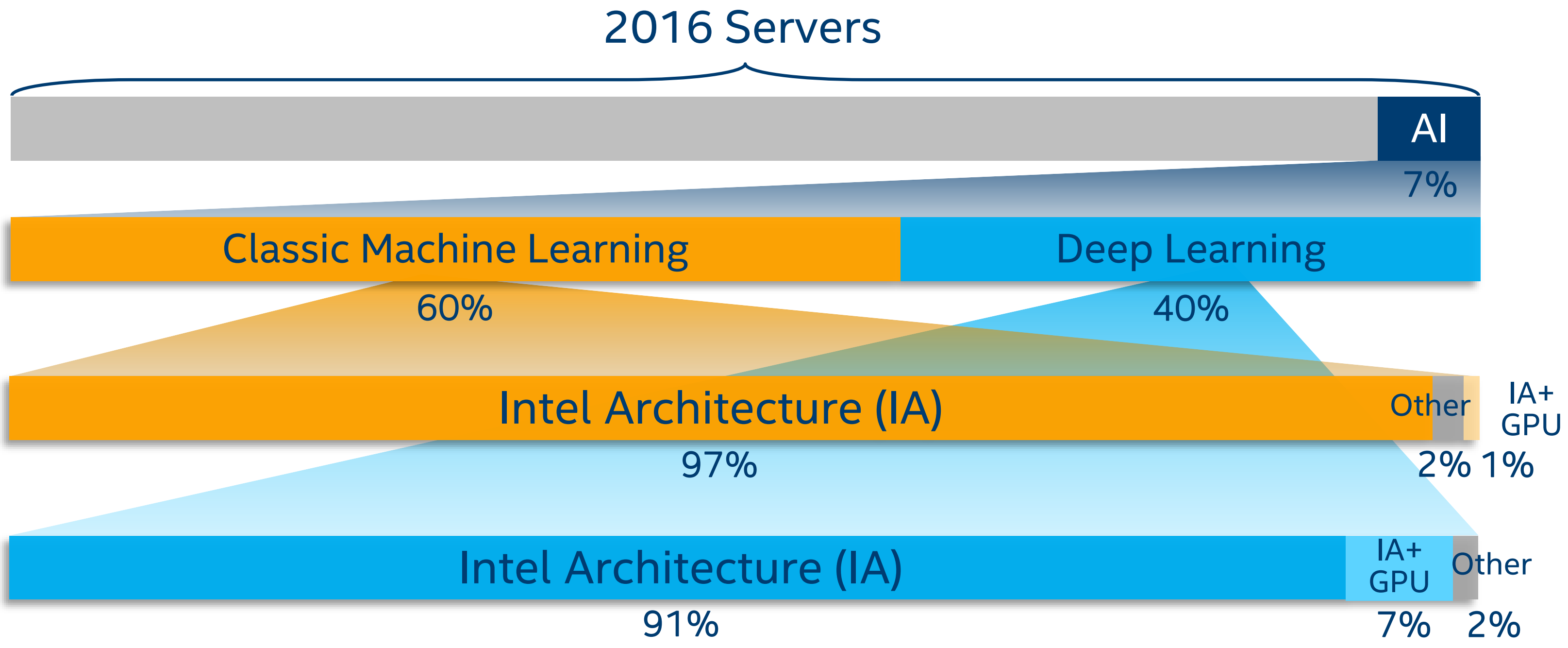
INTEL® AI PORTFOLIO

AI IS THE FASTEST GROWING DATA CENTER WORKLOAD



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Gain access to the latest libraries, frameworks, tools and technologies from Intel to accelerate your AI project.

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INTEL AI PORTFOLIO

EXPERIENCES

TOOLS
- Intel® Deep Learning SDK
- Intel® Computer Vision SDK
- Movidius Neural Compute Stick
- saffron TECHNOLOGY an intel company
- E2E Tool
- Associative Memory Base

FRAMEWORKS
- Apache Spark MLlib BigDL
- TensorFlow
- mxnet
- theano
- neon
- torch
- Caffe

LIBRARIES
- python Intel Dist
- Intel® DAAL
- Intel® Nervana™ Graph*
- Intel® MKL
- MKL-DNN
- Intel® MLSL
- Movidius MvTensor Library

HARDWARE
- Compute: intel ATOM inside, intel QUARK inside, intel CORE i7 inside, intel XEON inside, intel XEON PHI inside, intel ARRIA 10 inside, Lake Crest*
- Memory & Storage
- Networking
- Visual Intelligence: intel REALSENSE TECHNOLOGY, Movidius an intel company

UNLEASH FULL POTENTIAL

*Coming 2017

LIBRARIES, FRAMEWORKS & TOOLS

	Intel® Math Kernel Library: Intel® MKL	Intel® Math Kernel Library: MKL-DNN	Intel® MLSL	Intel® Data Analytics Acceleration Library (DAAL)	Intel® Distribution	Open Source Frameworks	Intel Deep Learning SDK	Intel® Computer Vision SDK
High Level Overview	Computation primitives; high performance math primitives granting low level of control	Computation primitives; free open source DNN functions for high-velocity integration with deep learning frameworks	Communication primitives; building blocks to scale deep learning framework performance over a cluster	Broad data analytics acceleration object oriented library supporting distributed ML at the algorithm level	Most popular and fastest growing language for machine learning	Toolkits driven by academia and industry for training machine learning algorithms	Accelerate deep learning model design, training and deployment	Toolkit to develop & deploying vision-oriented solutions that harness the full performance of Intel CPUs and SOC accelerators
Primary Audience	Consumed by developers of higher level libraries and Applications	Consumed by developers of the next generation of deep learning frameworks	Deep learning framework developers and optimizers	Wider Data Analytics and ML audience, Algorithm level development for all stages of data analytics	Application Developers and Data Scientists	Machine Learning App Developers, Researchers and Data Scientists.	Application Developers and Data Scientists	Developers who create vision-oriented solutions
Example Usage	Framework developers call matrix multiplication, convolution functions	New framework with functions developers call for max CPU performance	Framework developer calls functions to distribute Caffe training compute across an Intel® Xeon Phi™ cluster	Call distributed alternating least squares algorithm for a recommendation system	Call scikit-learn k-means function for credit card fraud detection	Script and train a convolution neural network for image recognition	Deep Learning training and model creation, with optimization for deployment on constrained end device	Use deep learning to do pedestrian detection

Find out more at http://software.intel.com/ai

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Advancing Python Performance Closer to Native Speeds

python™

For developers using the most popular and fastest growing programming language for AI

Easy, Out-of-the-box Access to High Performance Python

- Prebuilt, optimized for numerical computing, data analytics, HPC
- Drop in replacement for your existing Python (no code changes required)

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- Data analytics with pyDAAL, enhanced thread scheduling with TBB, Jupyter* Notebook interface, Numba, Cython
- Scale easily with optimized MPI4Py and Jupyter notebooks

Faster Access to Latest Optimizations for Intel Architecture

- Distribution and individual optimized packages available through conda and Anaconda Cloud
- Optimizations upstreamed back to main Python trunk

software.intel.com/intel-distribution-for-python

INTEL® MKL-DNN

Math Kernel Library for Deep Neural Networks

For developers of deep learning frameworks featuring optimized performance on Intel hardware

Distribution Details

- Open Source
- Apache 2.0 License
- Common DNN APIs across all Intel hardware.
- Rapid release cycles, iterated with the DL community, to best support industry framework integration.
- Highly vectorized & threaded for maximal performance, based on the popular Intel® MKL library.

BETA Now Available!

github.com/01org/mkl-dnn

Direct 2D Convolution	Local response normalization (LRN)	Rectified linear unit neuron activation (ReLU)	Maximum pooling	Inner product

INTEL® MACHINE LEARNING SCALIING LIBRARY (MLSL)

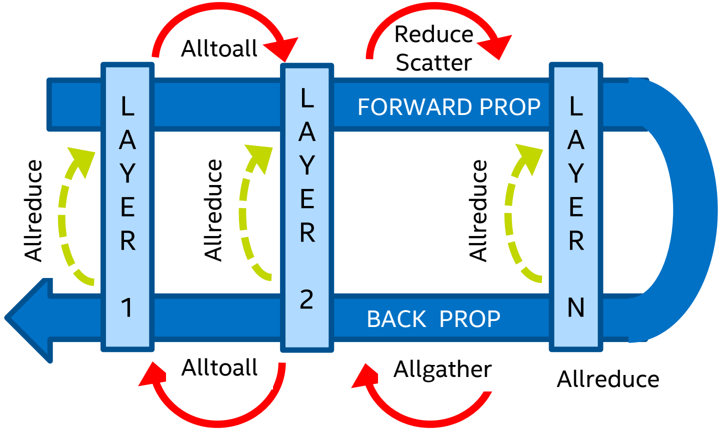
Scaling Deep Learning to 32 Nodes and Beyond

BETA Now Available!

For maximum deep learning scale-out performance on Intel® architecture

Deep learning abstraction of message-passing implementation

- Built on top of MPI; allows other communication libraries to be used as well
- Optimized to drive scalability of communication patterns
- Works across various interconnects: Intel® Omni-Path Architecture, InfiniBand, and Ethernet
- Common API to support Deep Learning frameworks (Caffe, Theano, Torch etc.)



github.com/01org/MLSL/releases

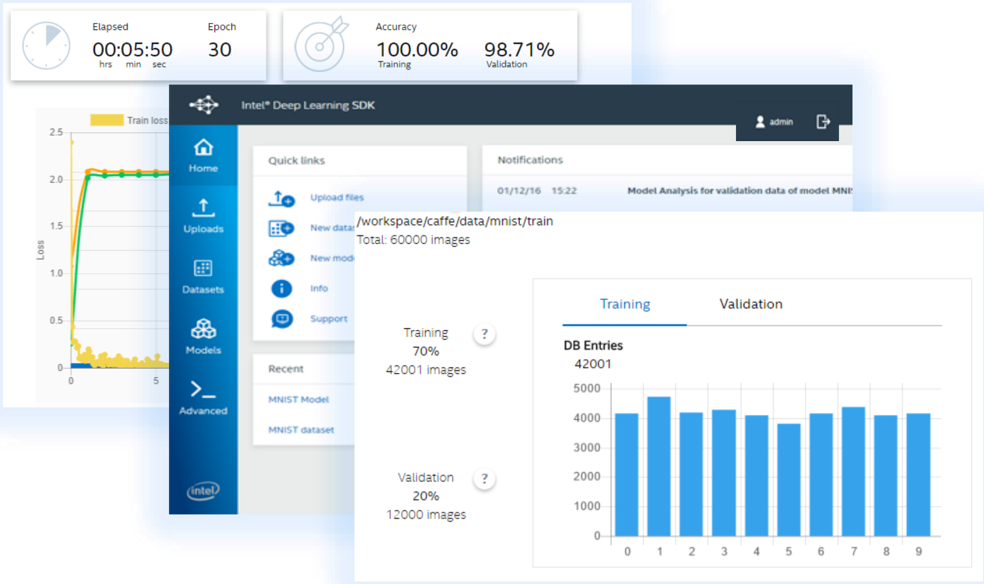
INTEL® DEEP LEARNING SDK

Accelerate Deep Learning Development

BETA
Available Now

For developers looking to accelerate deep learning model design, training & deployment

- **FREE** for data scientists and software developers to develop, train & deploy deep learning
- **Simplify installation** of Intel optimized frameworks and libraries
- **Increase productivity** through simple and highly-visual interface
- **Enhance deployment** through model compression and normalization
- **Facilitate integration** with full software stack via inference engine



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WHAT NEXT?

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Q&A

Software

STUDENT DEVELOPER PROGRAM