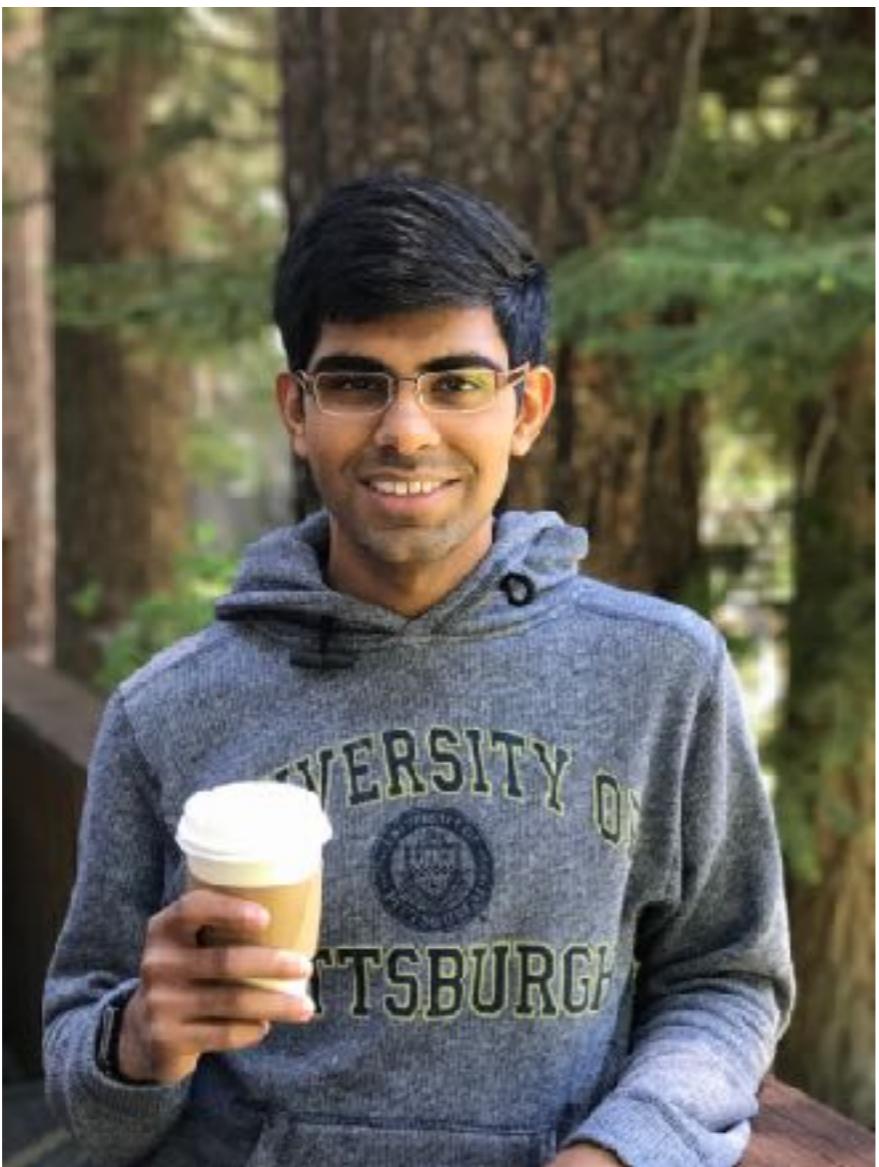


# Exploring Deep Learning

## Theory and Practice

Ritwik Gupta  
Machine Learning Researcher  
CMU SEI Emerging Technology Center

# About Me



Machine Learning Researcher  
CMU SEI



Data Science Intern  
Apple (AML)



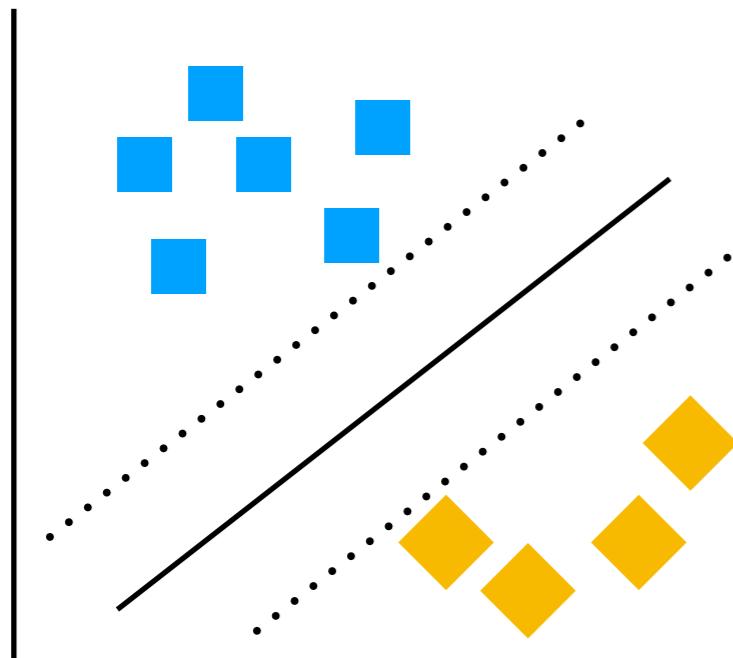
Data Science Intern  
Staples Innovation Lab



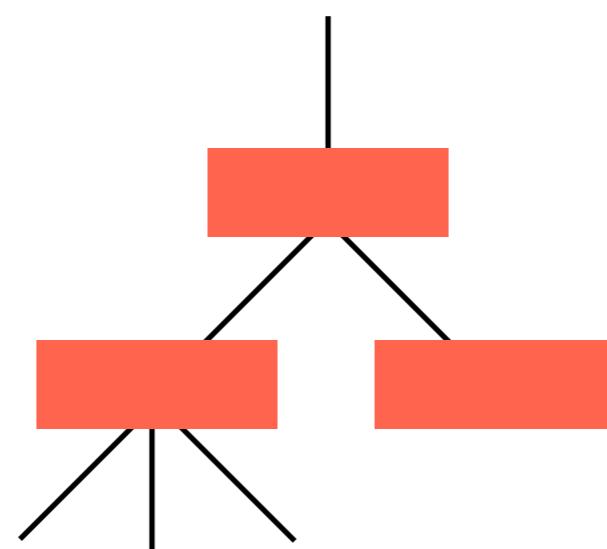
Data Science Intern  
Pitt DBMI

# Background

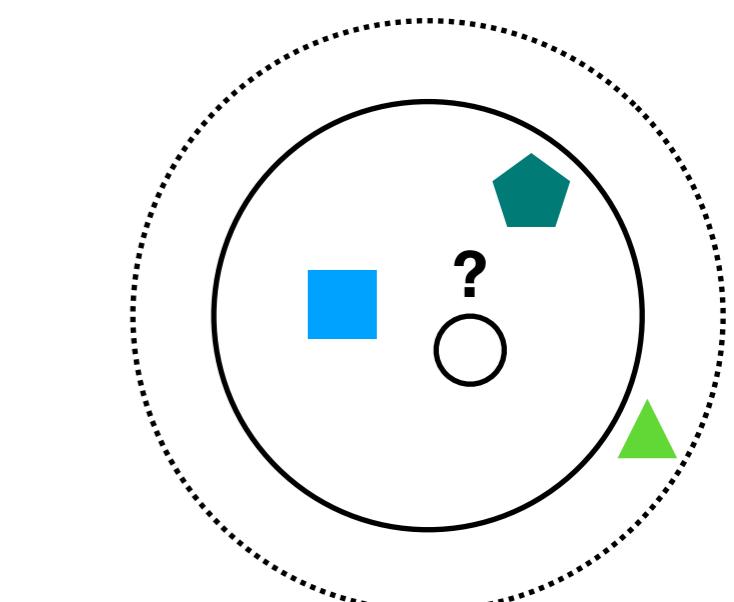
# Shallow Learning?



SVM



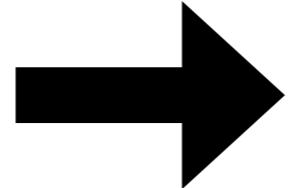
Decision Tree



k-Nearest Neighbors

(and many more)

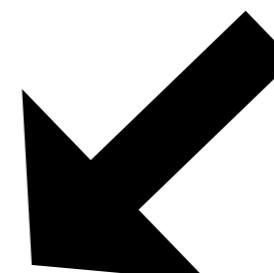
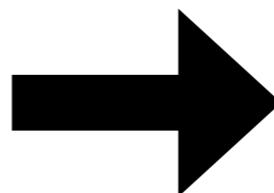
# Feature Representation



# Manual Feature Representation



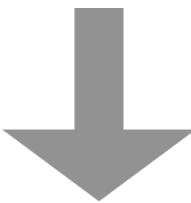
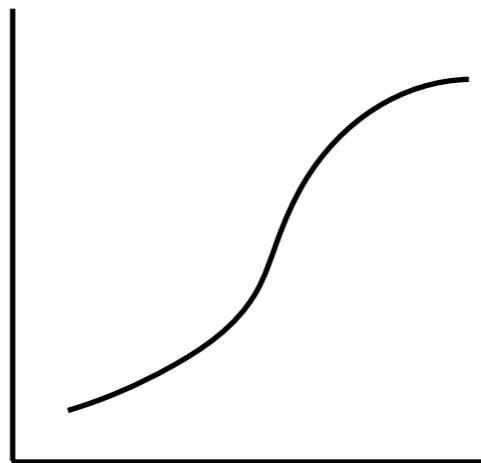
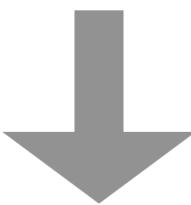
Eyes {1...N}



2	0.5	1	0	1	0	0
---	-----	---	---	---	---	---

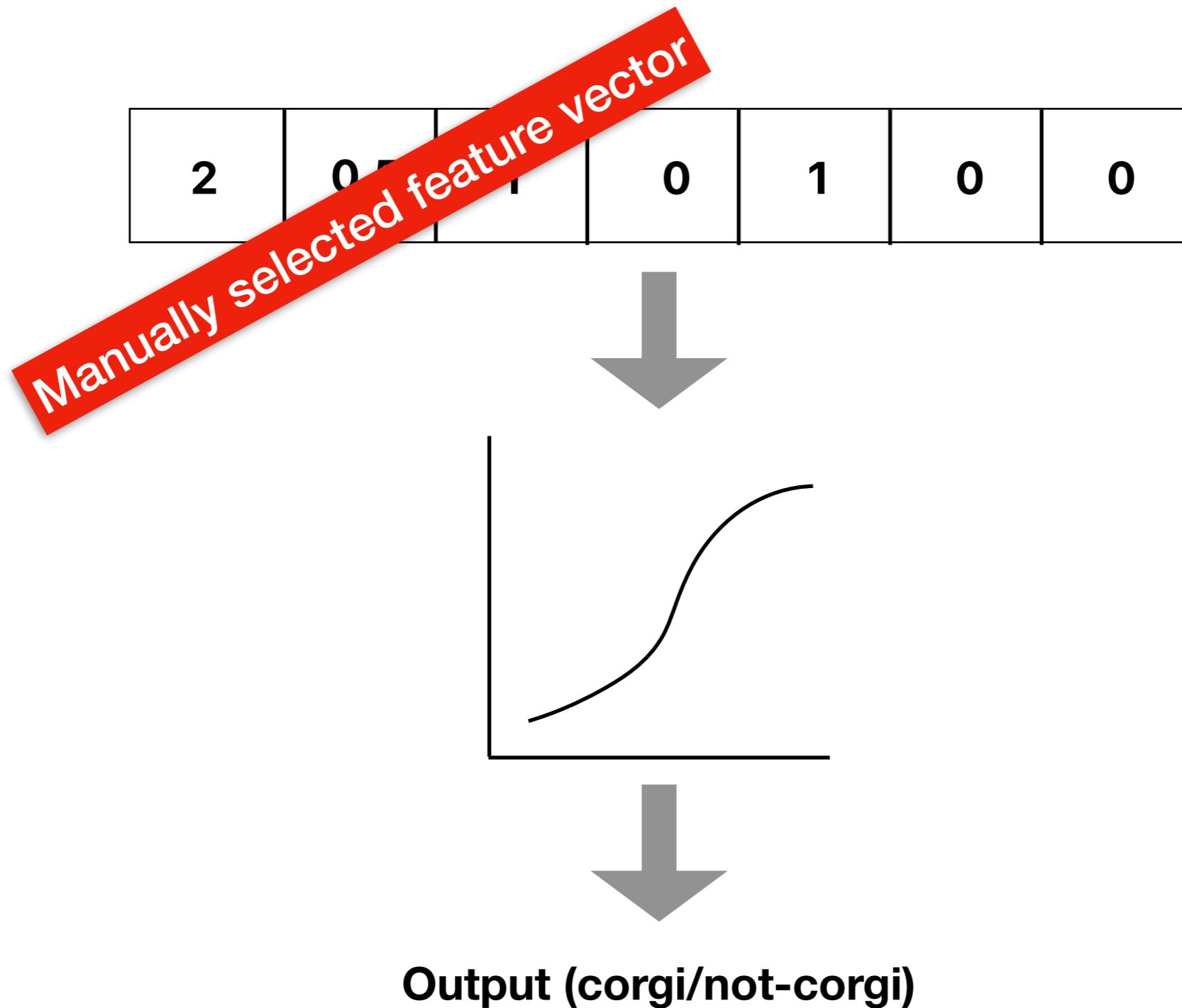
# Shallow Models

2	0.5	1	0	1	0	0
---	-----	---	---	---	---	---

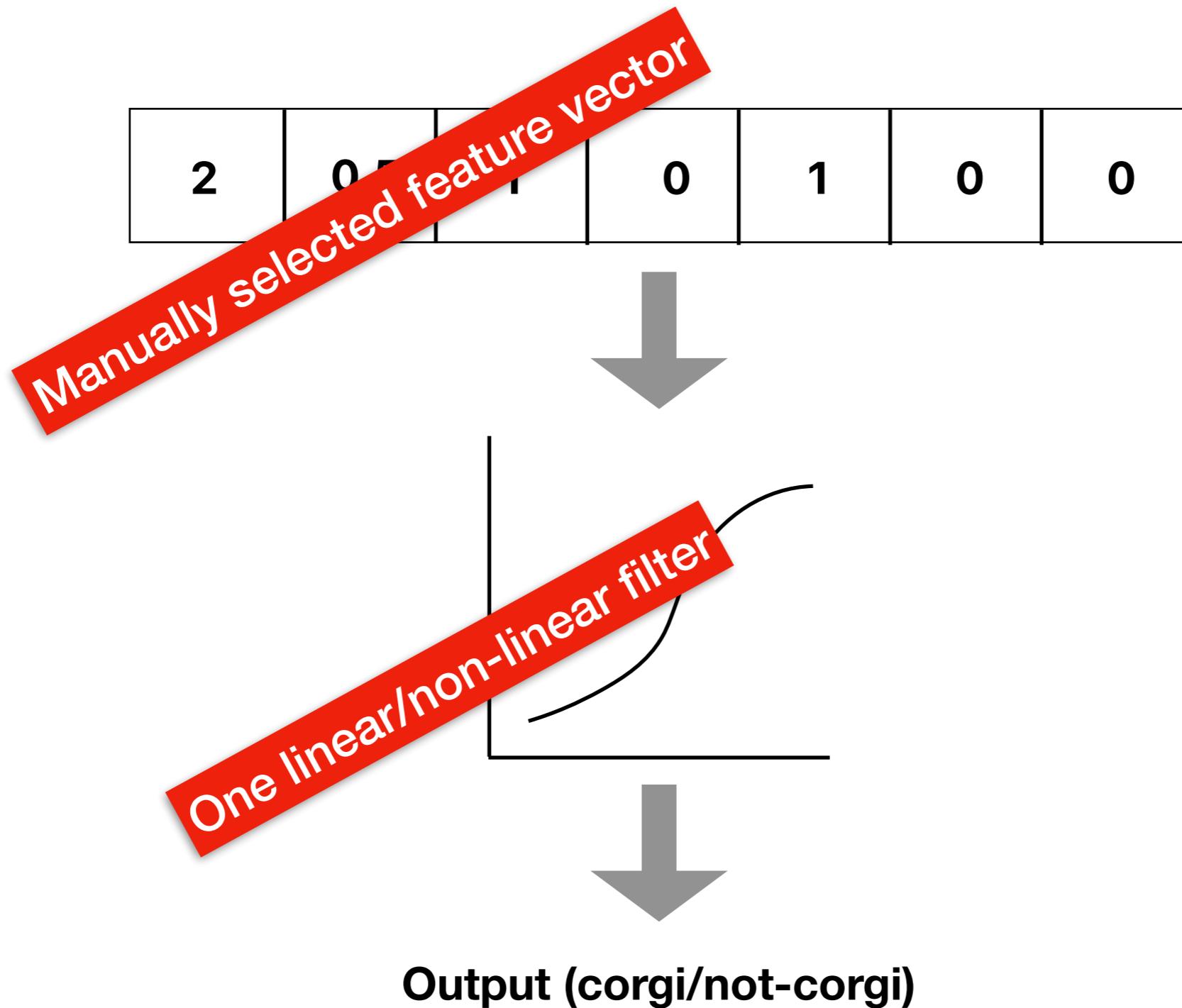


**Output (corgi/not-corgi)**

# Shallow Models



# Shallow Models



# Shallow Models (are great)



# Shallow Learning is Still Hot

Astrophysics > Instrumentation and Methods for Astrophysics

## Support Vector Machine classification of strong gravitational lenses

P. Hartley, R. Flamary, N. Jackson, A. S. Tagore, R. B. Metcalf

(Submitted on 24 May 2017 (v1), last revised 7 Jul 2017 (this version, v2))

Computer Science > Computer Vision and Pattern Recognition

## Scalable Nearest Neighbor Search based on kNN Graph

Wan-Lei Zhao, Jie Yang, Cheng-Hao Deng

(Submitted on 30 Jan 2017 (v1), last revised 3 Feb 2017 (this version, v2))

Statistics > Machine Learning

## Improved Clustering with Augmented k-means

J. Andrew Howe

(Submitted on 22 May 2017)

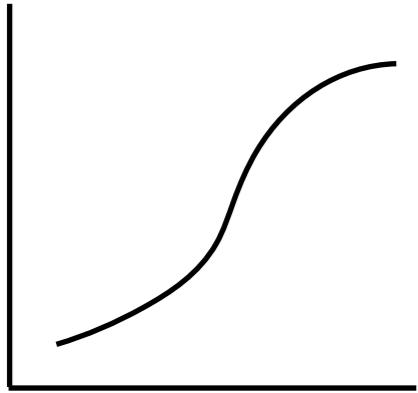
Computer Science > Learning

## Deep Forest: Towards An Alternative to Deep Neural Networks

Zhi-Hua Zhou, Ji Feng

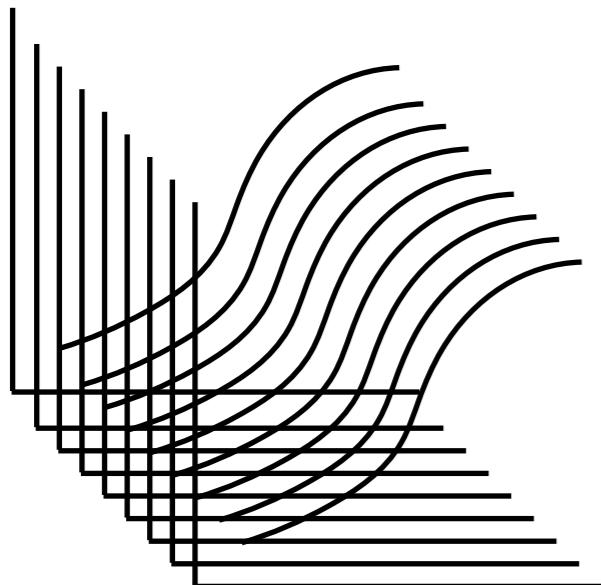
(Submitted on 28 Feb 2017 (v1), last revised 31 May 2017 (this version, v2))

# Deep Learning



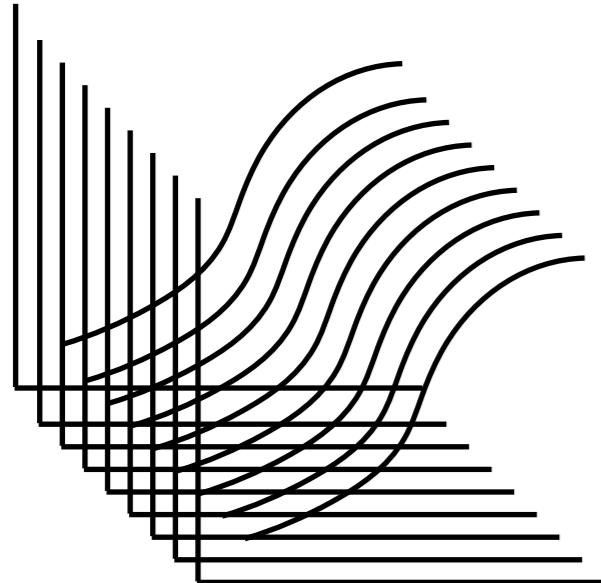
**Multiple non-linearities**

# Deep Learning

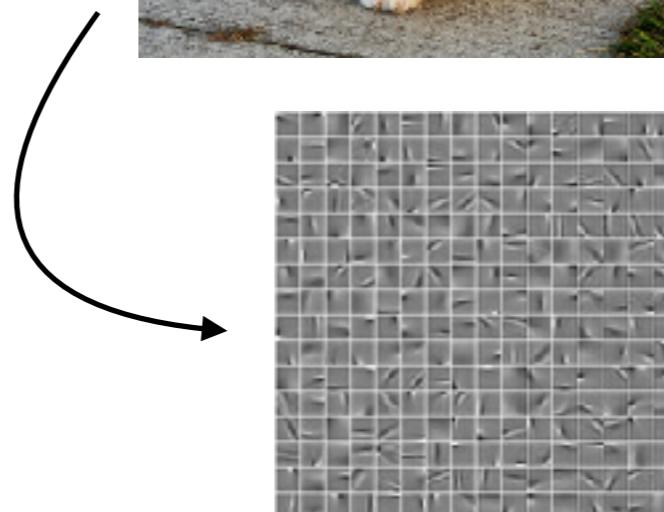


**Multiple non-linearities**

# Deep Learning

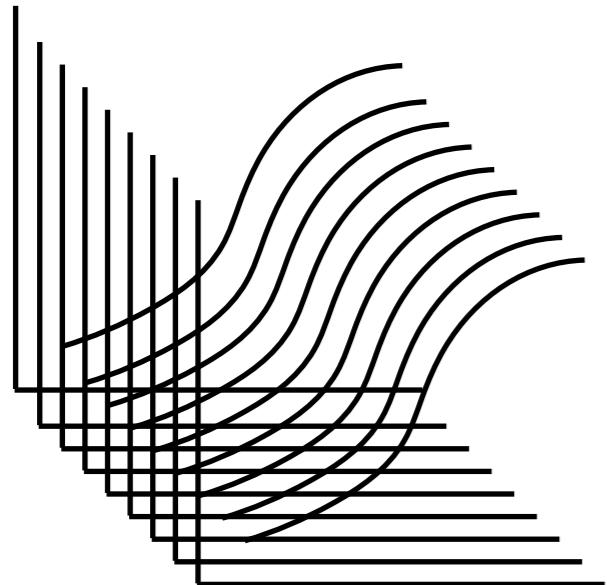


**Multiple non-linearities**

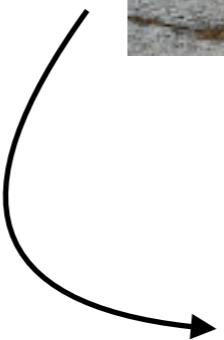


**Representation Learning**

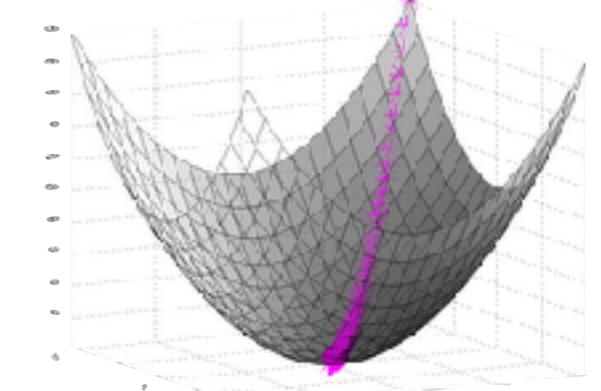
# Deep Learning



**Multiple non-linearities**

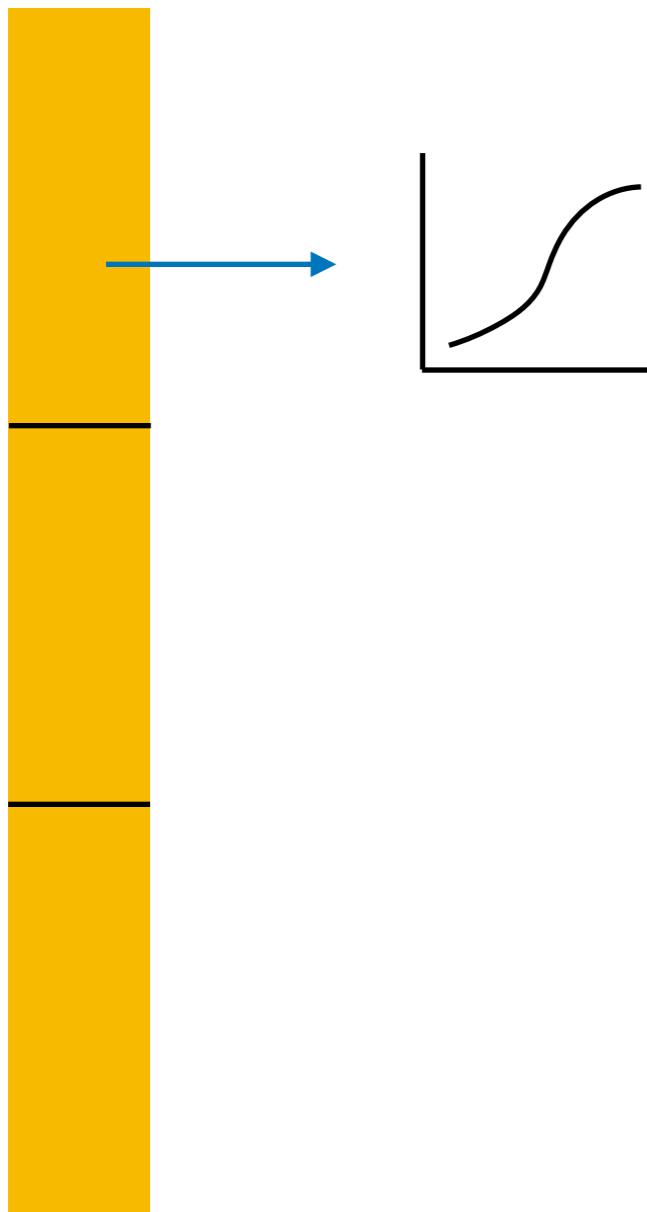


**Representation Learning**



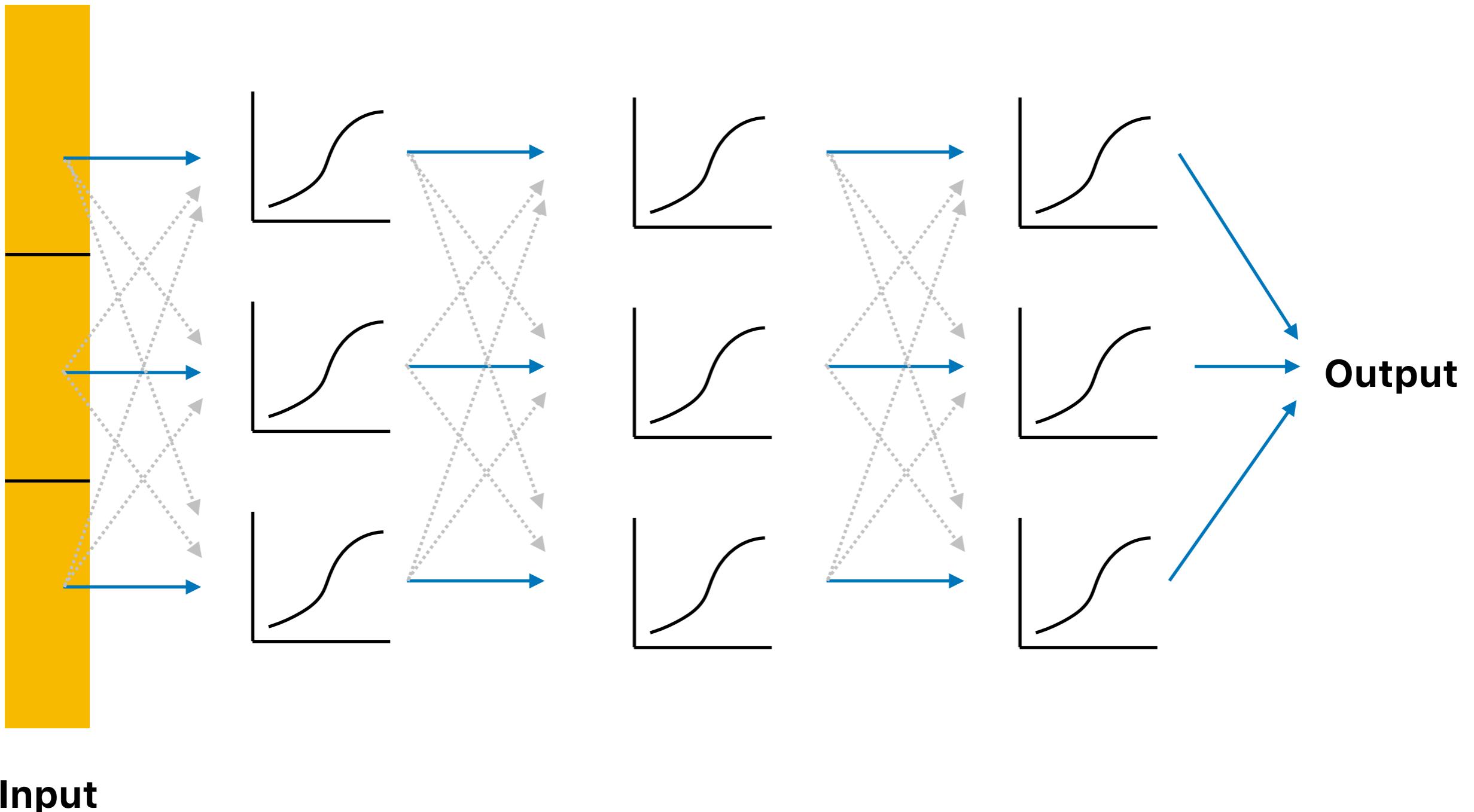
**Gradient Descent**

# Deep Learning

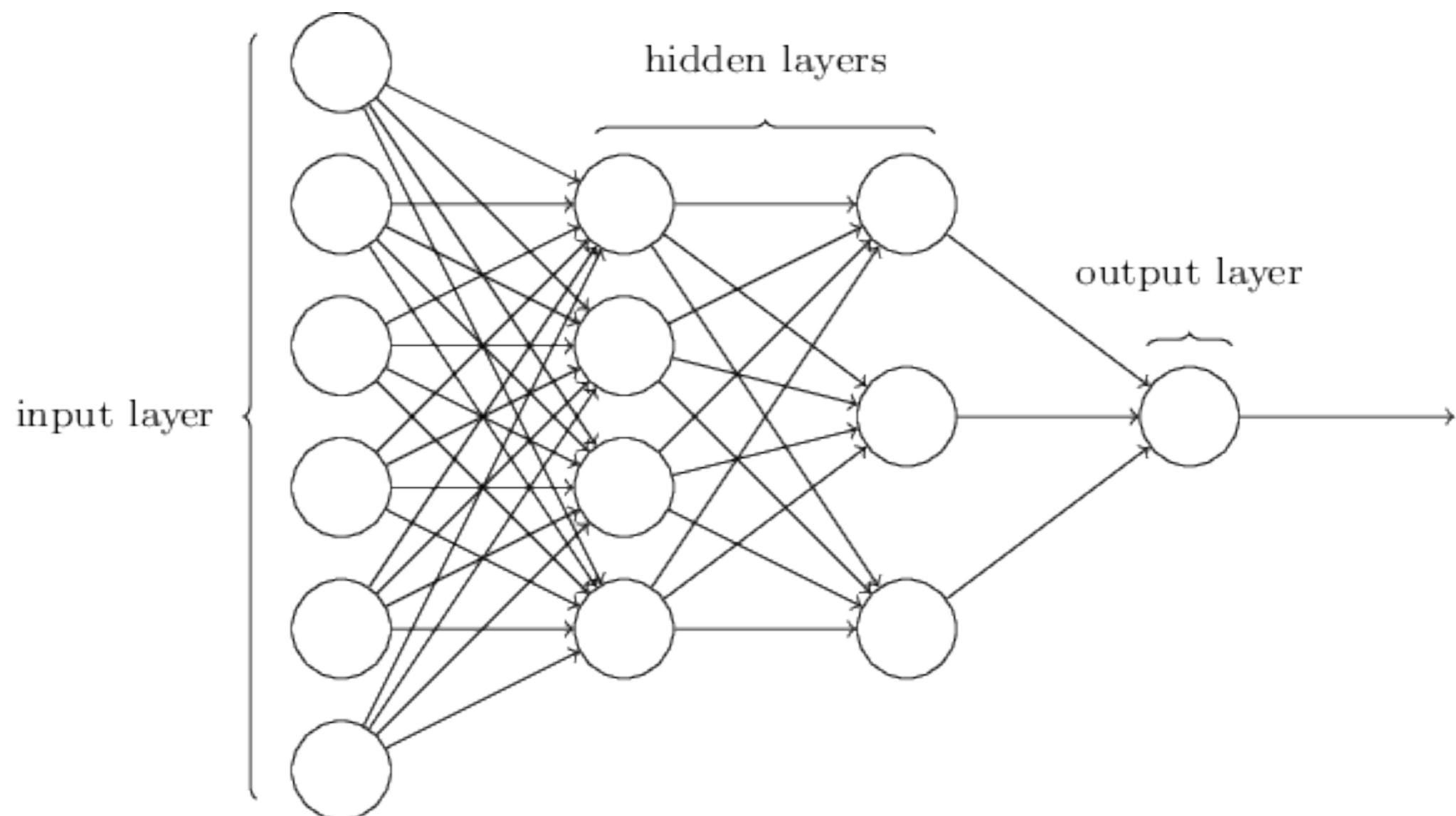


**Input**

# Deep Learning

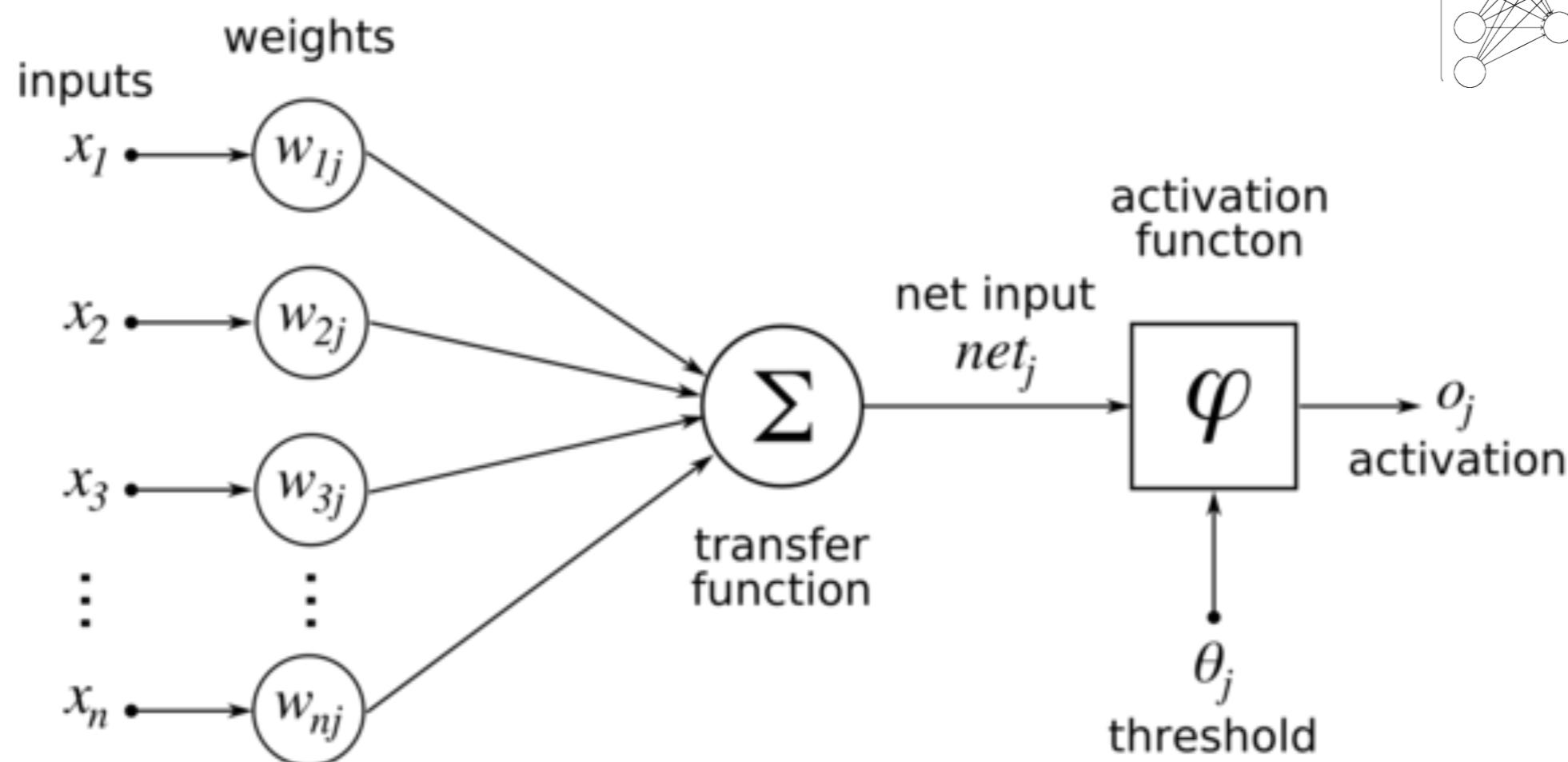


# Neural Networks

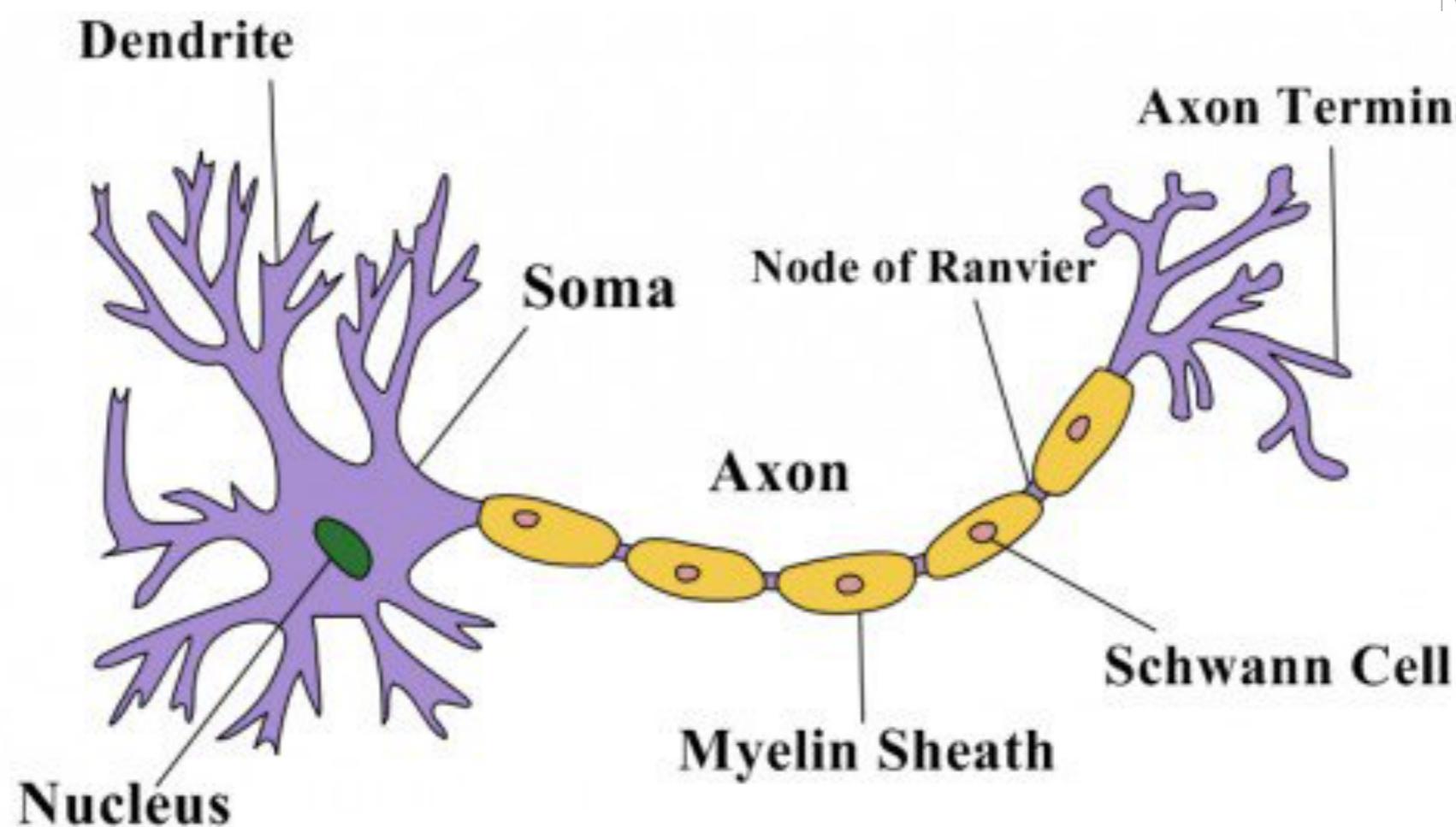


(This specific fully connected architecture is also known as a multi-layer perceptron)

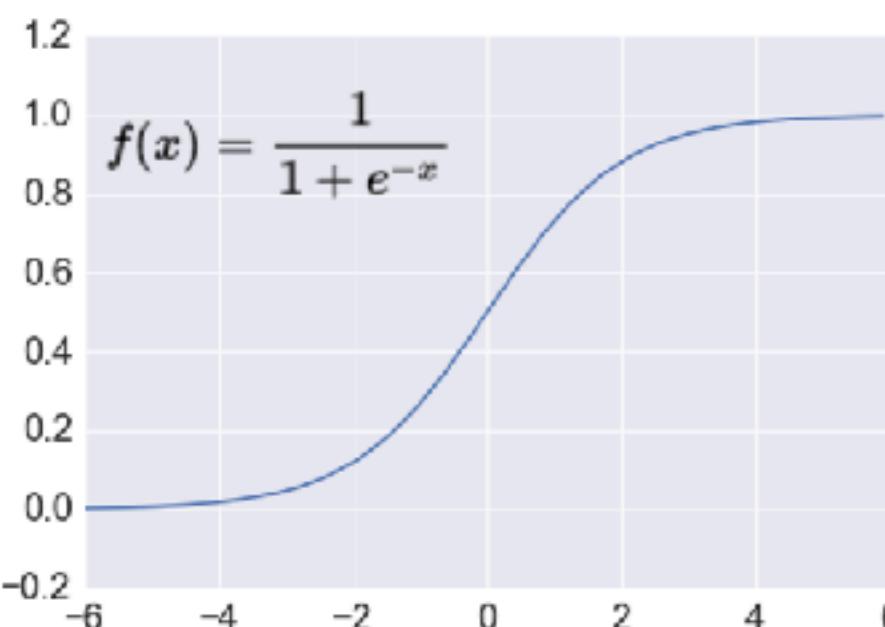
# Neural Networks



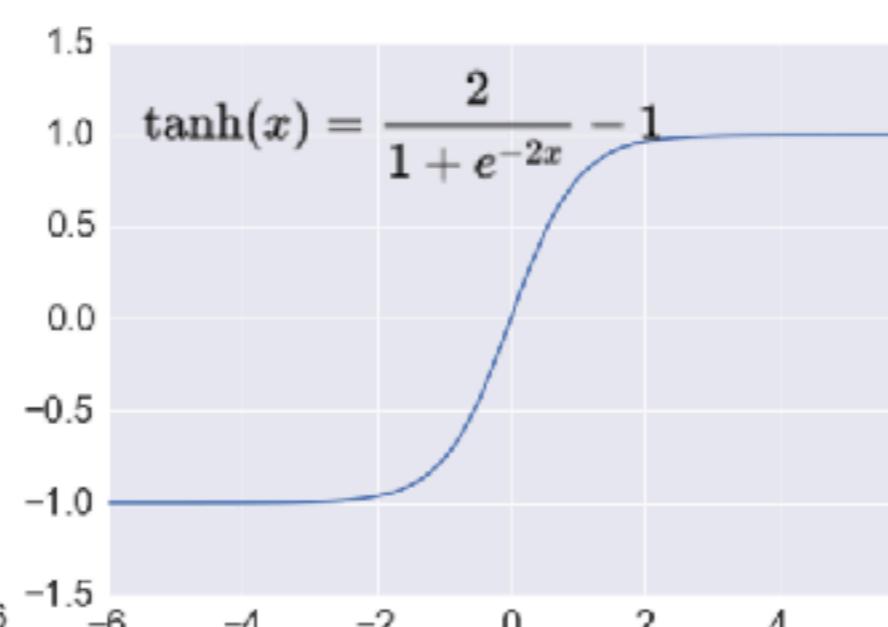
# Neural Networks



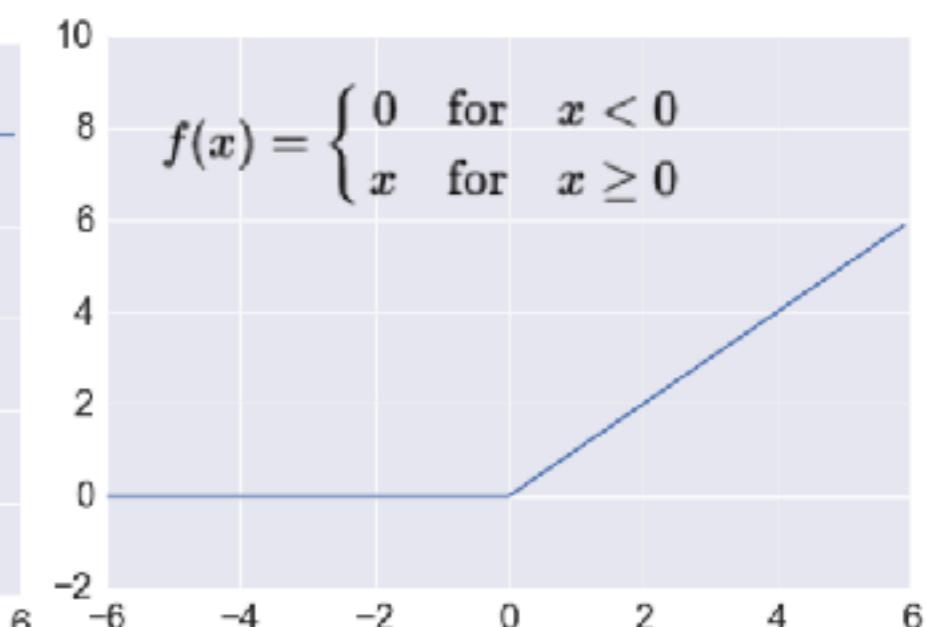
# Activations



Sigmoid



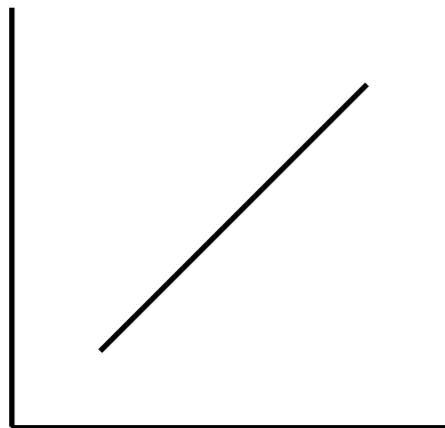
tanh (derived from sigmoid)



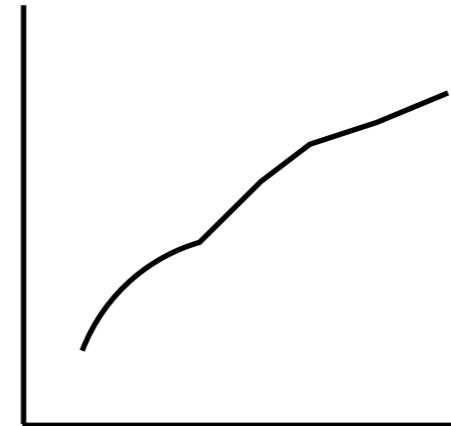
ReLU  
(rectified linear unit)

# Effectiveness

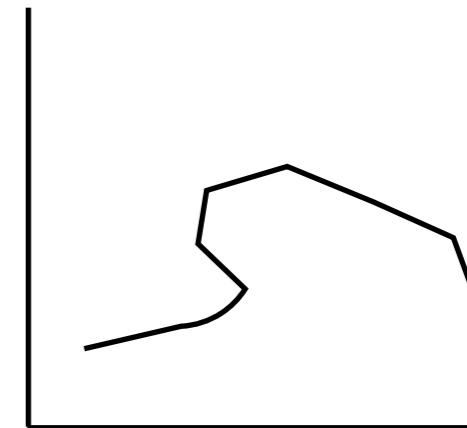
- Neural networks can approximate **any** continuous function, given enough layers.
- Have to solve for proper values for parameters: **NP-Complete**



Linear



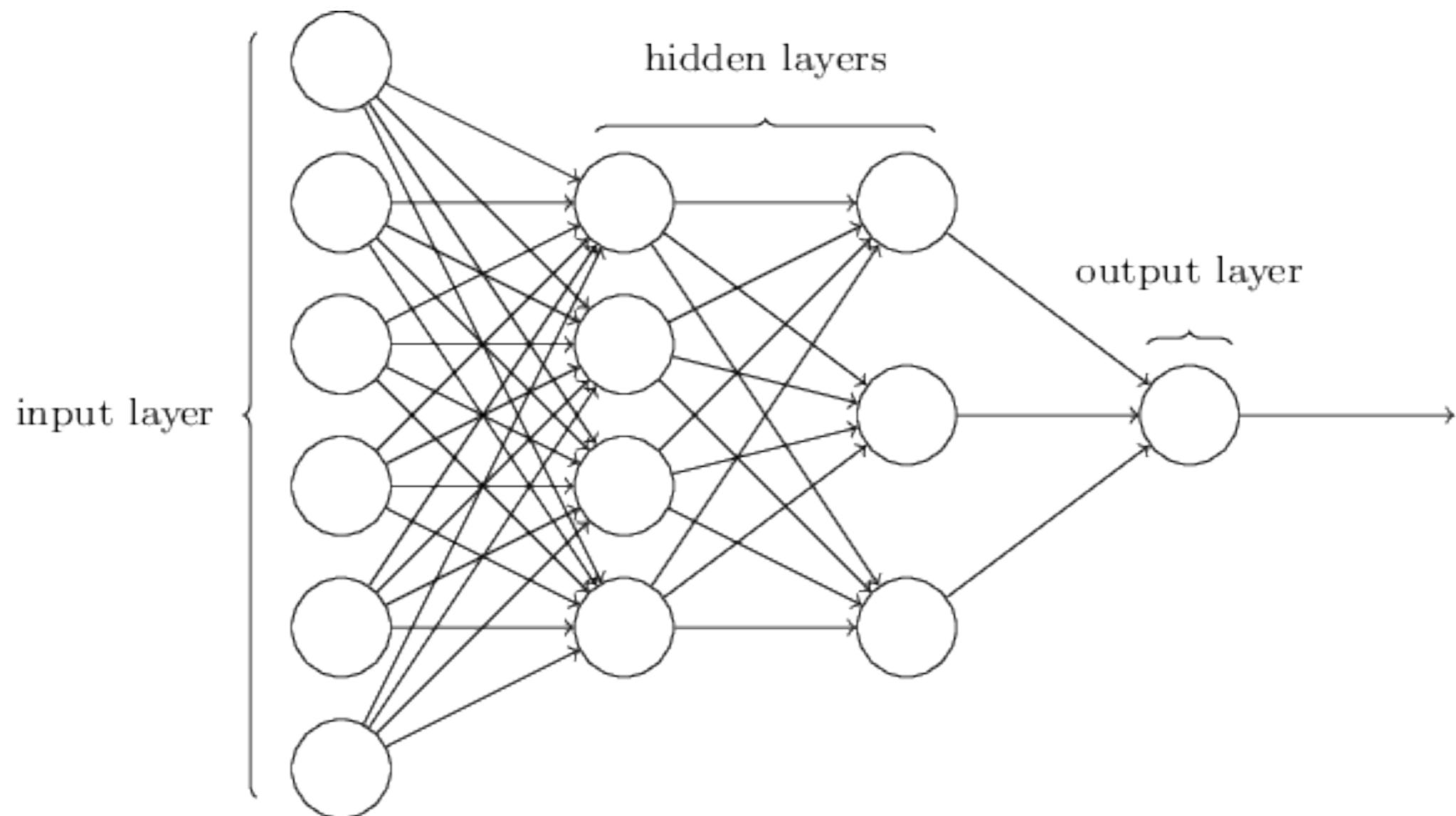
Linear + Sigmoid



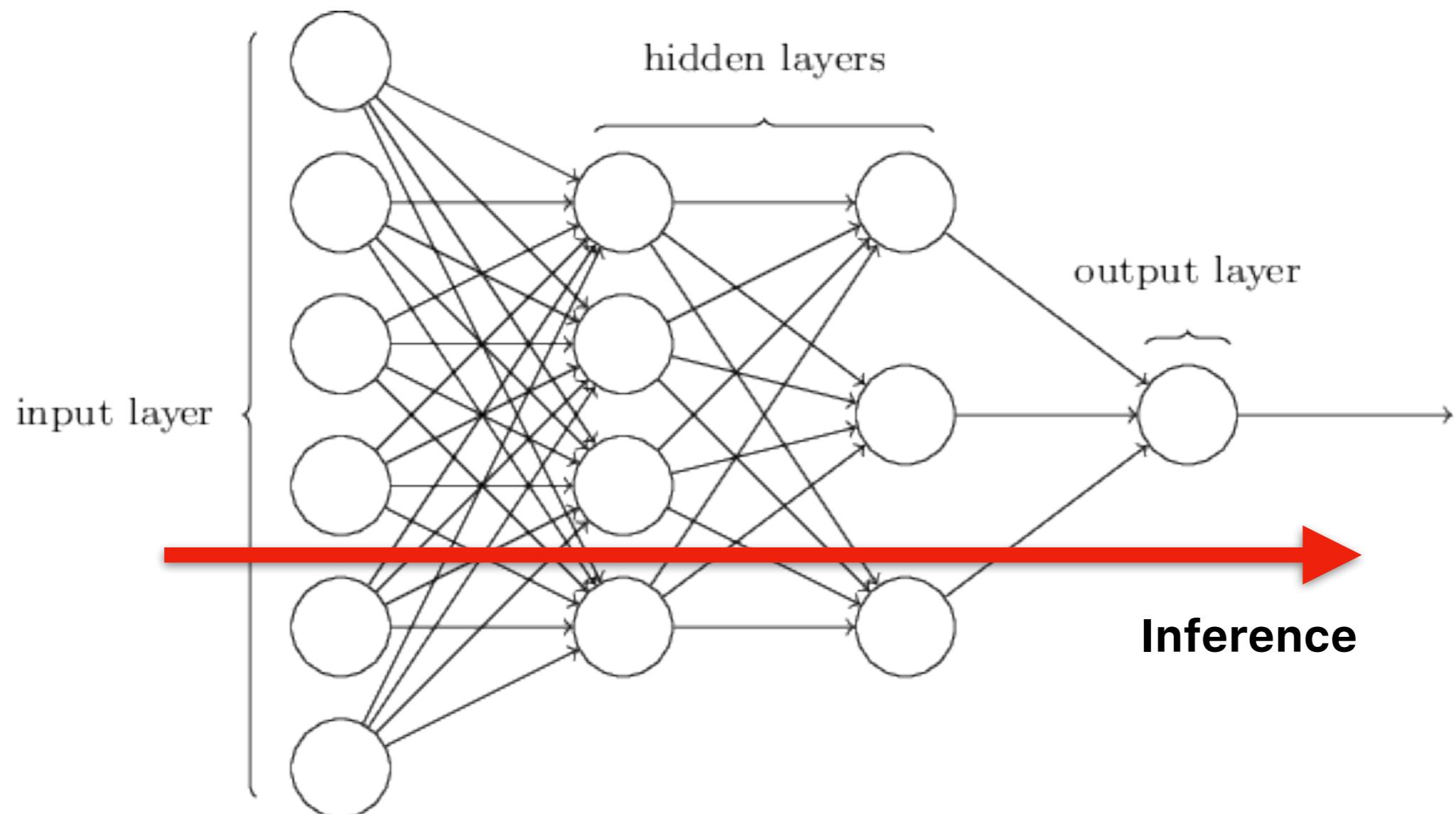
Linear + Sigmoid +  
Linear

(not accurate, just a representation)

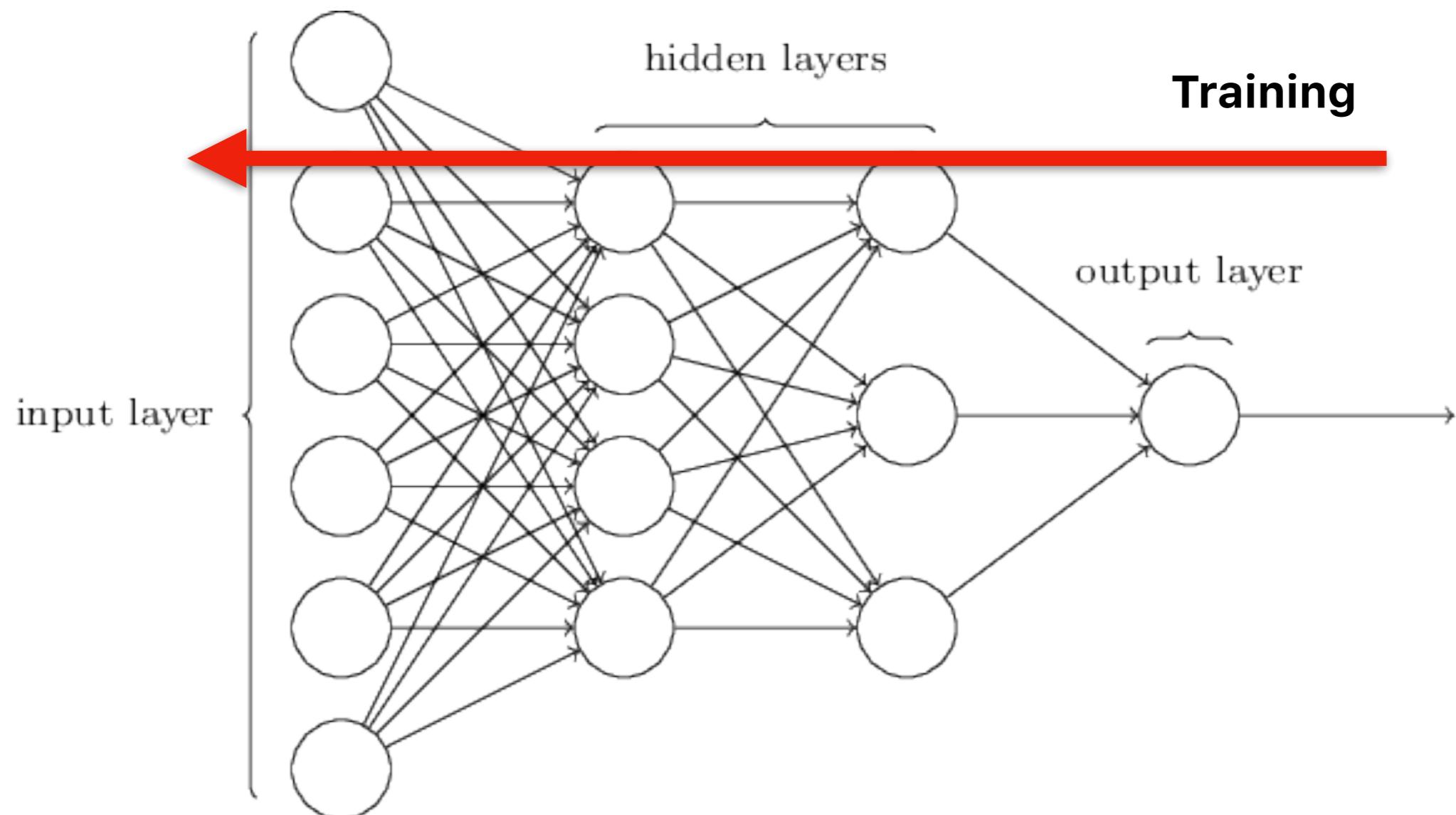
# Training



# Training

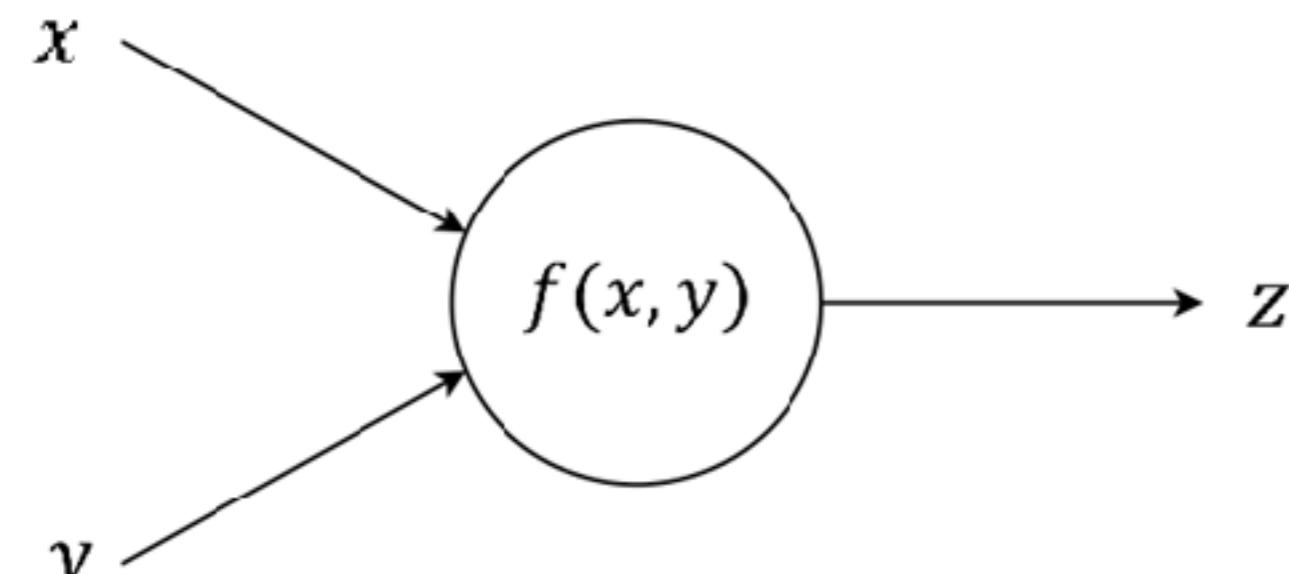


# Training

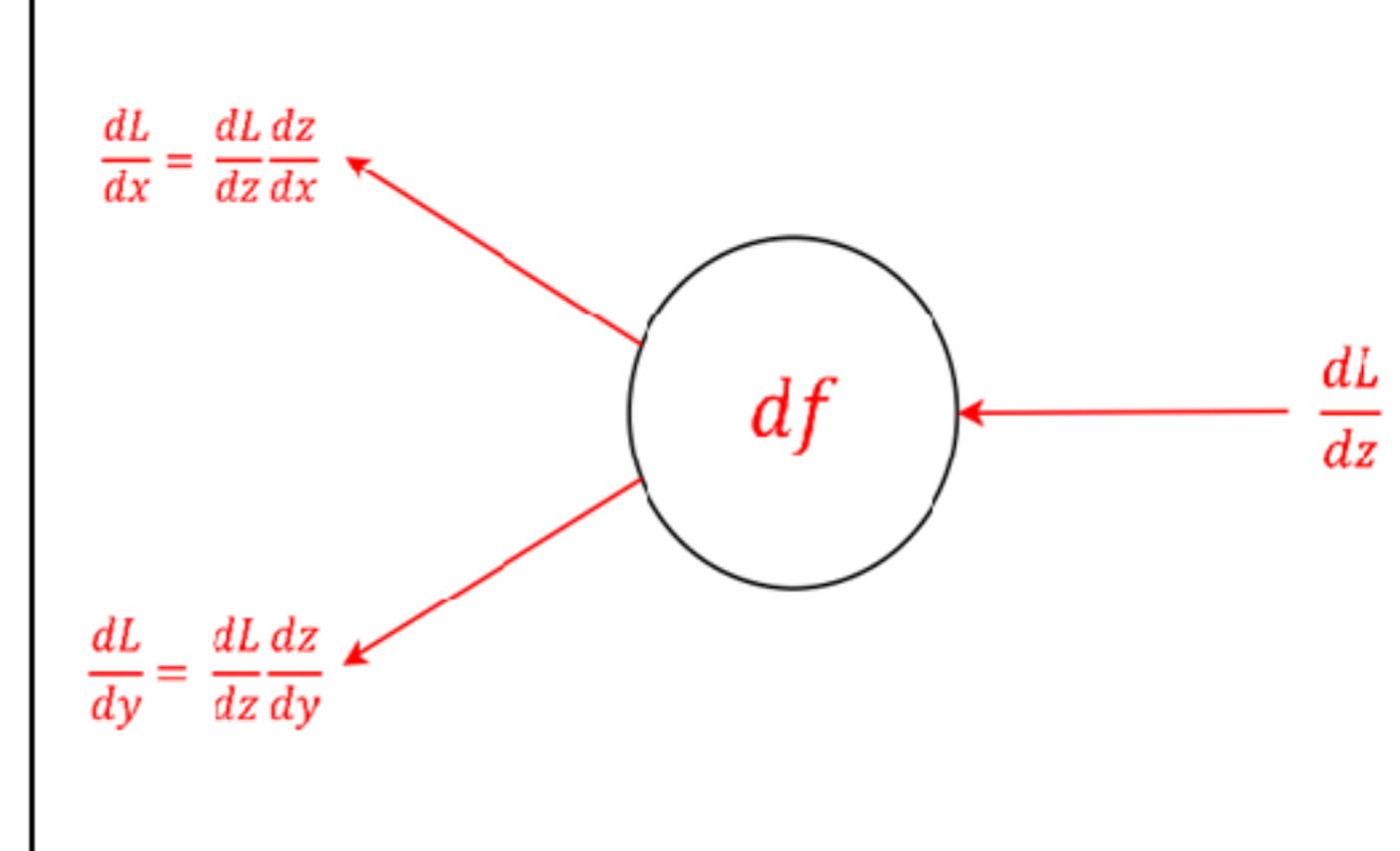


# Training

Forwardpass

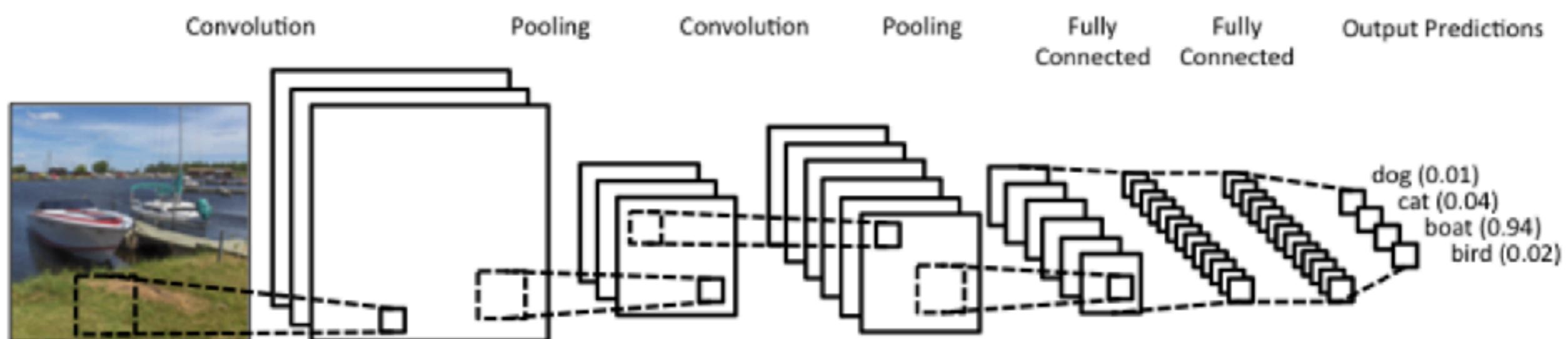


Backwardpass



# Convolutional Neural Networks

# CNNs



# Convolution

1	1	1	0	0
0	1	1	1	0
0	0	1	1	1
0	0	1	1	0
0	1	1	0	0

Input

1	0	1
0	1	0
1	0	1

Kernel

# Convolution

1 <small>x1</small>	1 <small>x0</small>	1 <small>x1</small>	0	0
0 <small>x0</small>	1 <small>x1</small>	1 <small>x0</small>	1	0
0 <small>x1</small>	0 <small>x0</small>	1 <small>x1</small>	1	1
0	0	1	1	0
0	1	1	0	0

Image

4		

Convolved  
Feature

# Convolution

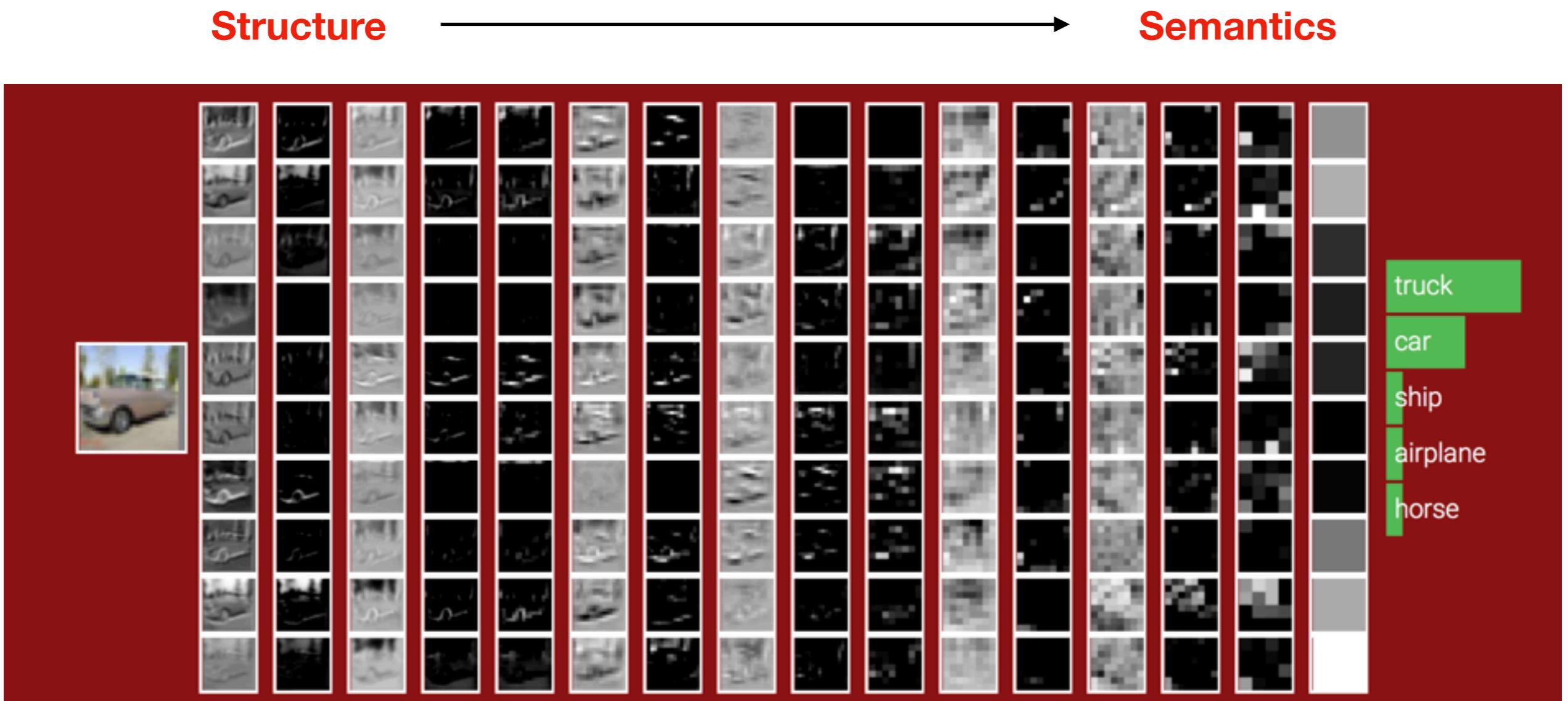
1 <small>x1</small>	1 <small>x0</small>	1 <small>x1</small>	0	0
0 <small>x0</small>	1 <small>x1</small>	1 <small>x0</small>	1	0
0 <small>x1</small>	0 <small>x0</small>	1 <small>x1</small>	1	1
0	0	1	1	0
0	1	1	0	0

Image

4		

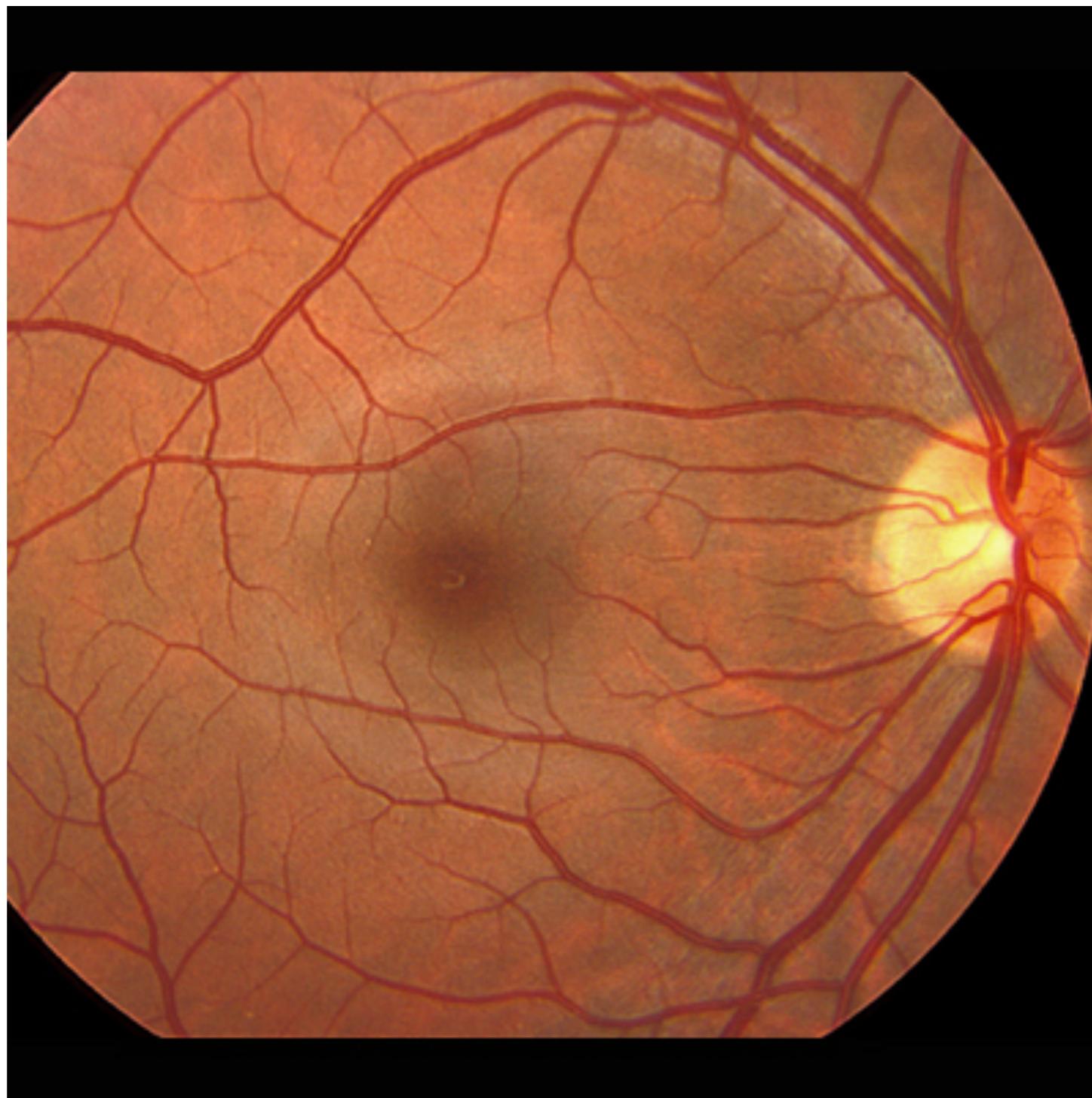
Convolved  
Feature

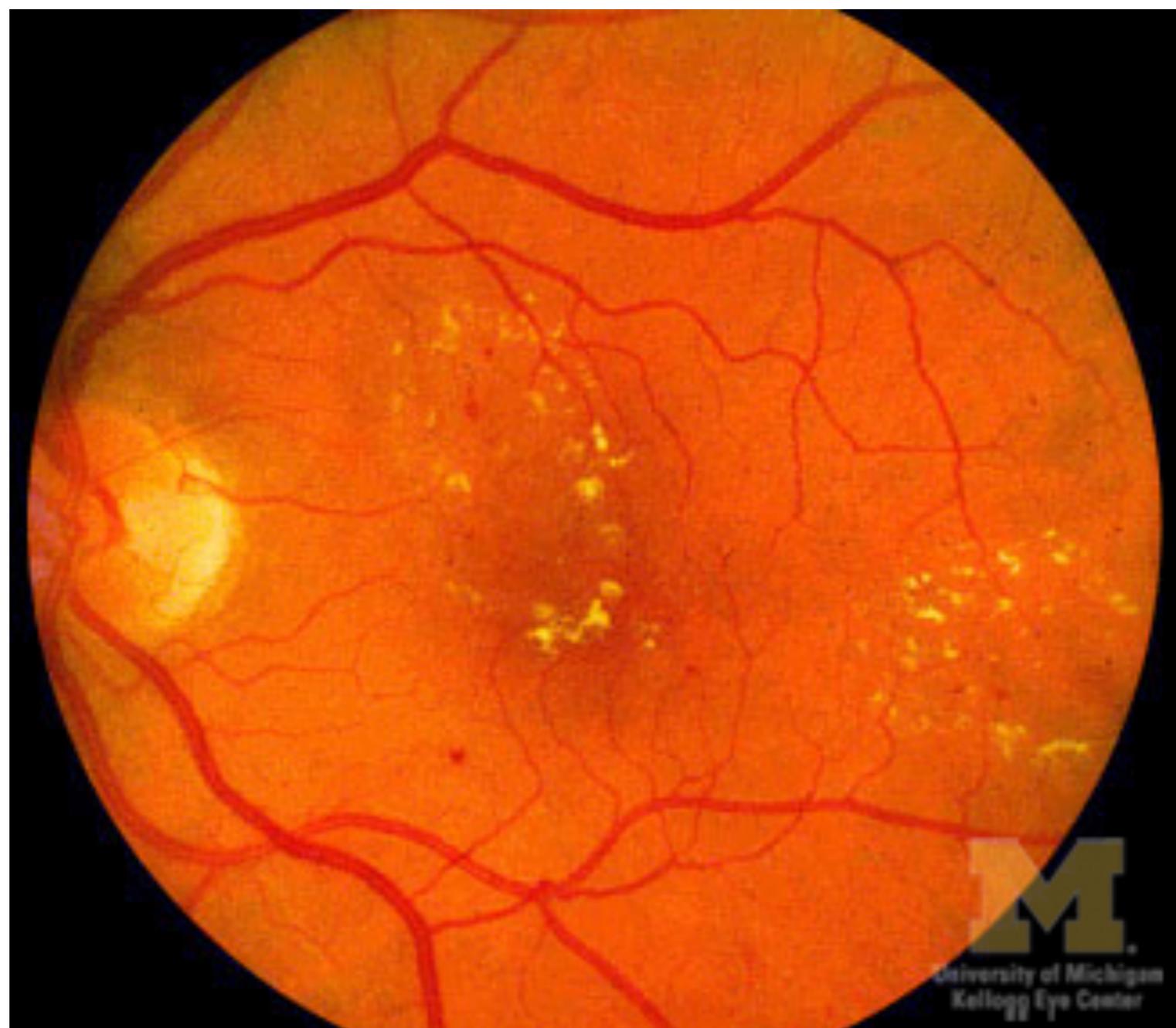
# CNN Representation Learning



CS231n Demo







**M**  
University of Michigan  
Kellogg Eye Center

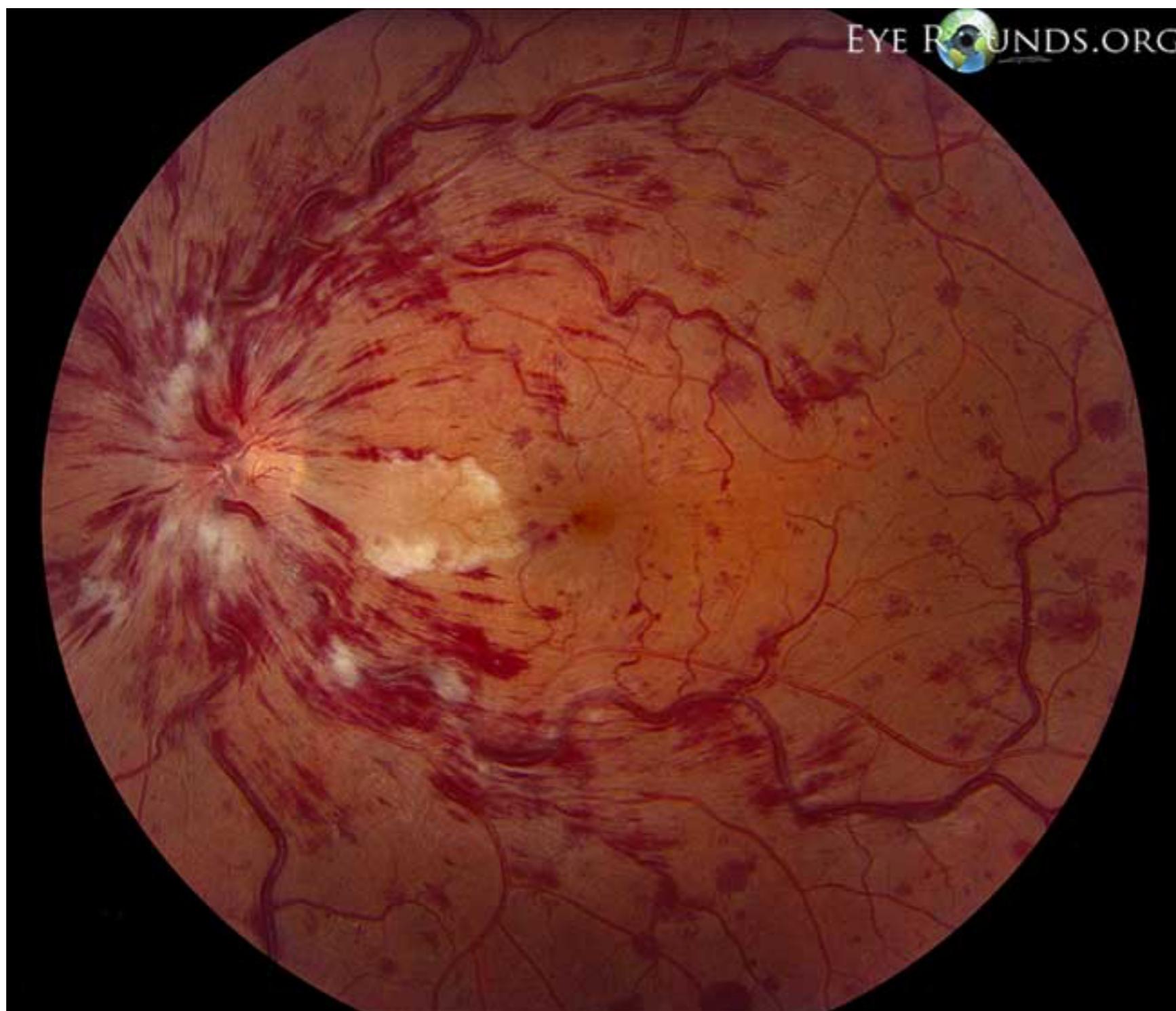


EYE ROUNDS.ORG

# What about this?



# What about this?



EYE ROUNDS.ORG

# CNNs + Medical Images = ❤



## Google Research Blog

The latest news from Research at Google

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### Deep Learning for Detection of Diabetic Eye Disease

Tuesday, November 29, 2016

Posted by Lily Peng MD PhD, Product Manager and Varun Gulshan PhD, Research Engineer