

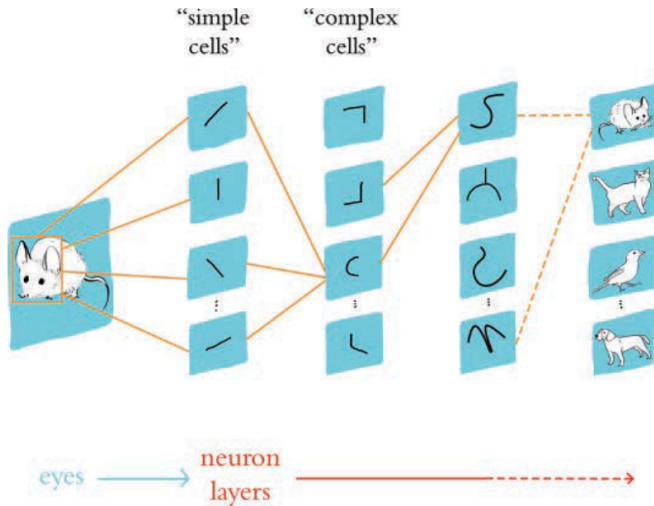
Deep Networks

CS 4277 Deep Learning

Kennesaw State University

Biological Vision

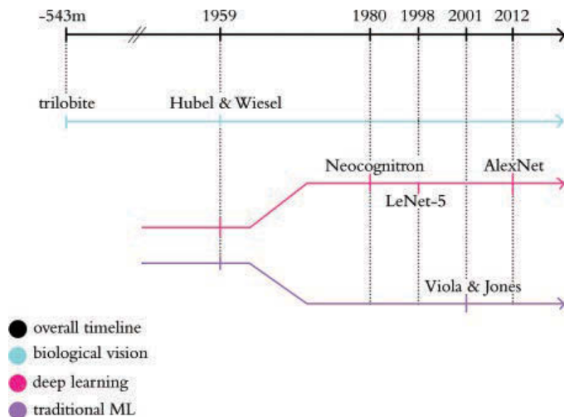
In the 1950s, Hubel and Wiesel at Johns Hopkins, experimenting on cats, discovered the hierarchical nature of neurons in the visual cortex.



1

Machine Vision

In 1980 Kunihiro Fukushima proposed the *Neocognitron* architecture explicitly based on neuron layers in biological vision.



2

It took the success of LeCun and Bengio's *LeNet-5*, and later Krizhevsky and Stuskever's *AlexNet* to realize the full potential of a deeply layered machine vision model and firmly establish the supremacy of Deep Learning for machine vision.

Composing Shallow Networks

Recall a single input/output shallow network:

$$h_d = a(\theta_{d0} + \theta_{d1}x)$$

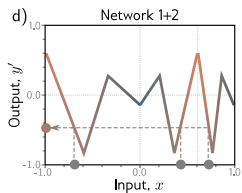
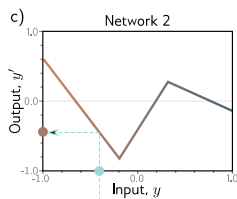
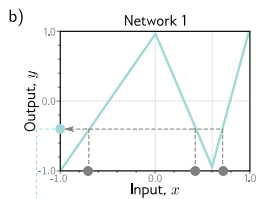
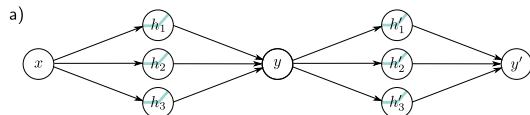
$$y = \phi_0 + \sum_{d=1}^D \phi_d h_d$$

You could concatenate this with another shallow network with the same architecture that takes the first network's output as its input:

$$h'_d = a(\theta'_{d0} + \theta'_{d1}y)$$

$$y = \phi'_0 + \sum_{d=1}^D \phi'_d h'_d$$

Composed Shallow Networks



Composed Shallow Networks Formulation

4.2

Deep Neural Networks

4.3

Hyperparameters

4.3.1

Linear Algebra Interlude: Matrices

Boom!

Matrix Network Notation

4.4

General Matrix Formulation

4.4.1

Capacity of Shallow vs. Deep Neural Networks

4.5.1, 4.5.2

Depth and Width Efficiency

4.5.3

Large Structured Inputs

4.5.4

Training and Generalization

4.5.5