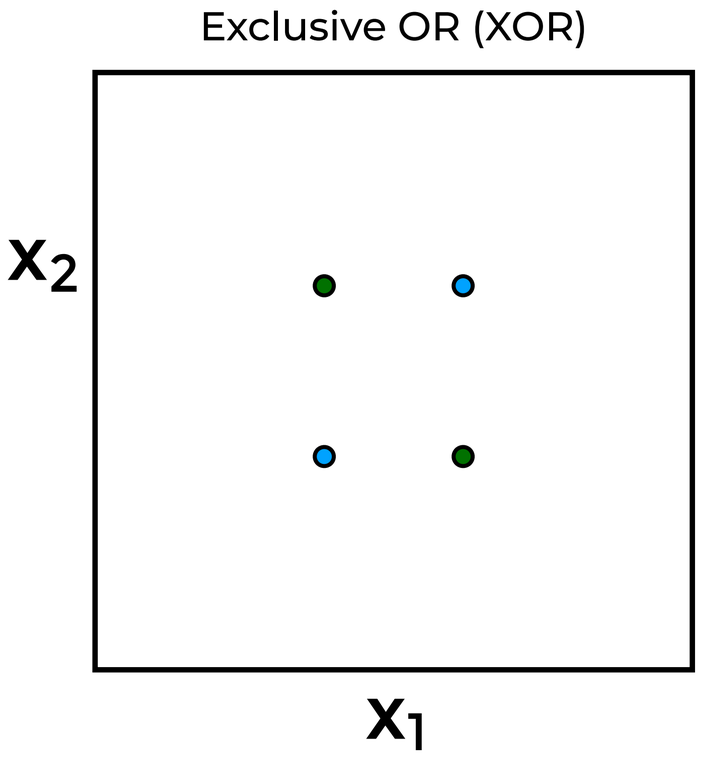
Machine Learning I
60629A

Summary
Neural Networks
— Week #5

What if data is not linearly separable?



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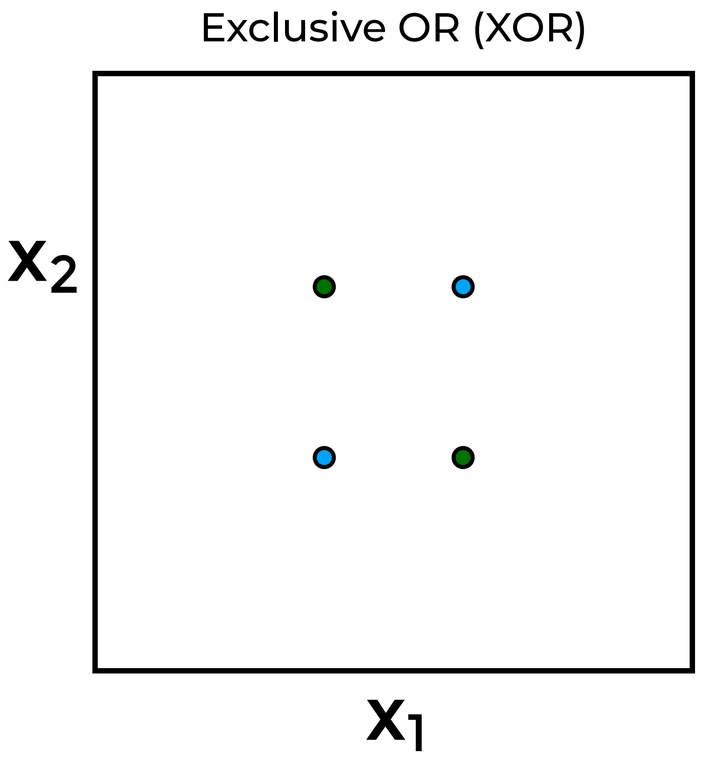
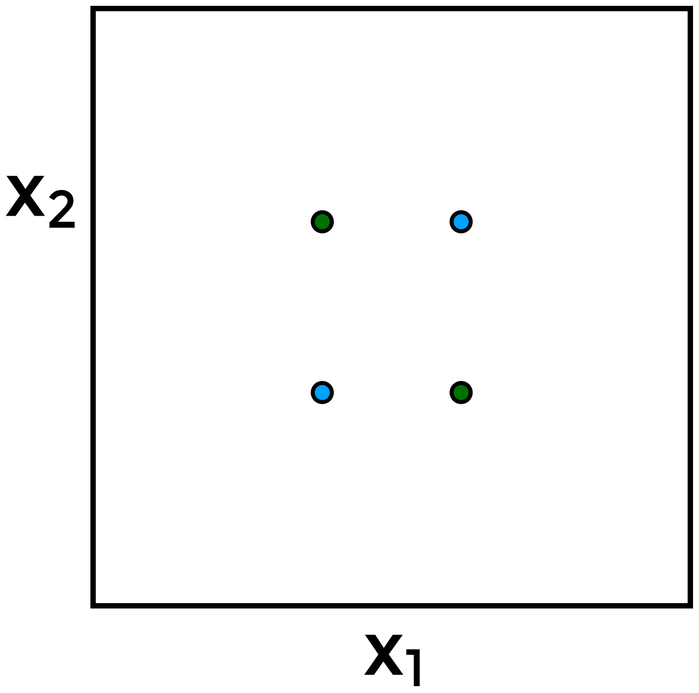


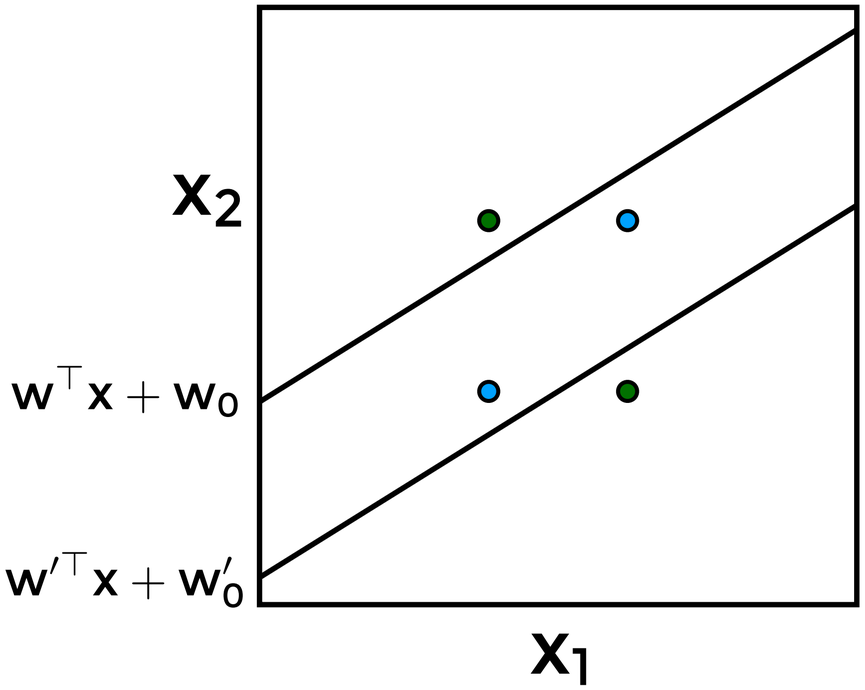
Use the joint decision of several linear classifier?

What if data is not linearly separable?

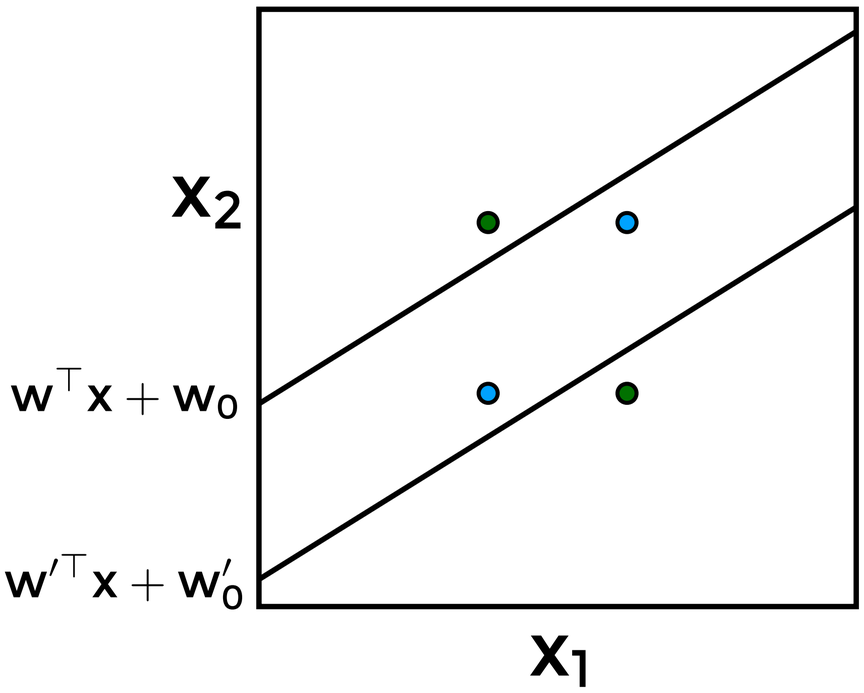
Exclusive OR (XOR)



Use the joint decision of several linear classifier?



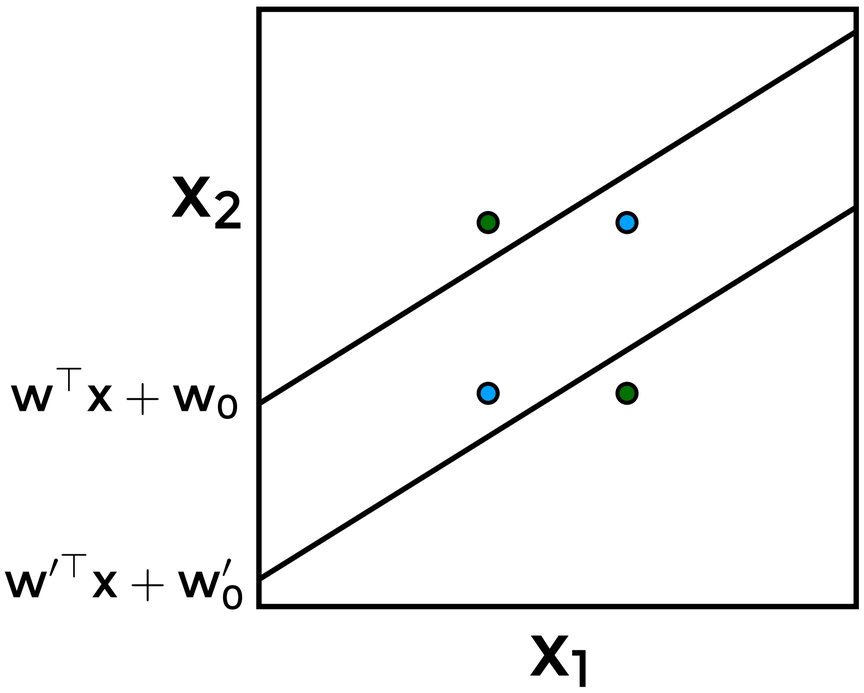
Combining models



$$f(x): \begin{cases} (w^\top x + w_0) > 0 \implies \\ (w^\top x + w_0) < 0 \implies \end{cases}$$

$$f'(x): \begin{cases} (w'^\top x + w'_0) > 0 \implies \\ (w'^\top x + w'_0) < 0 \implies \end{cases}$$

Combining models



$f(x)$: $(w^\top x + w_0) > 0 \implies$ ●
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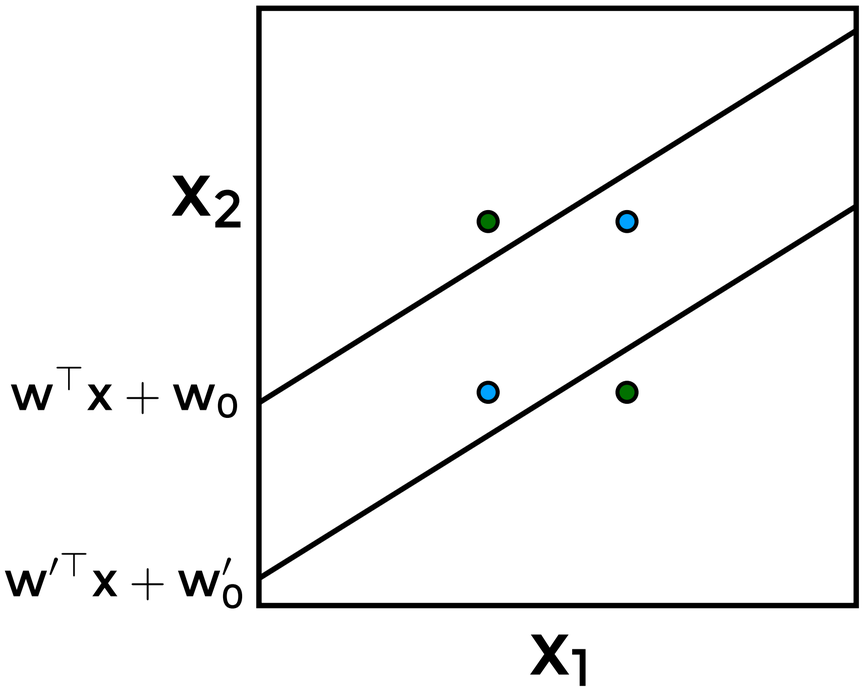

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1. Evaluate each model

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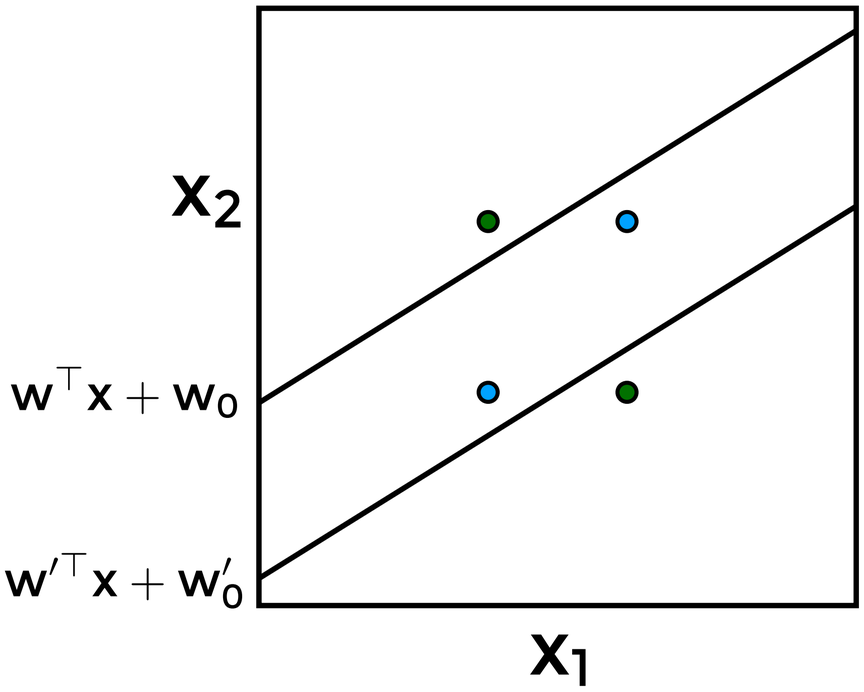
2. Combine the output of models

Combining models



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1. Evaluate each model

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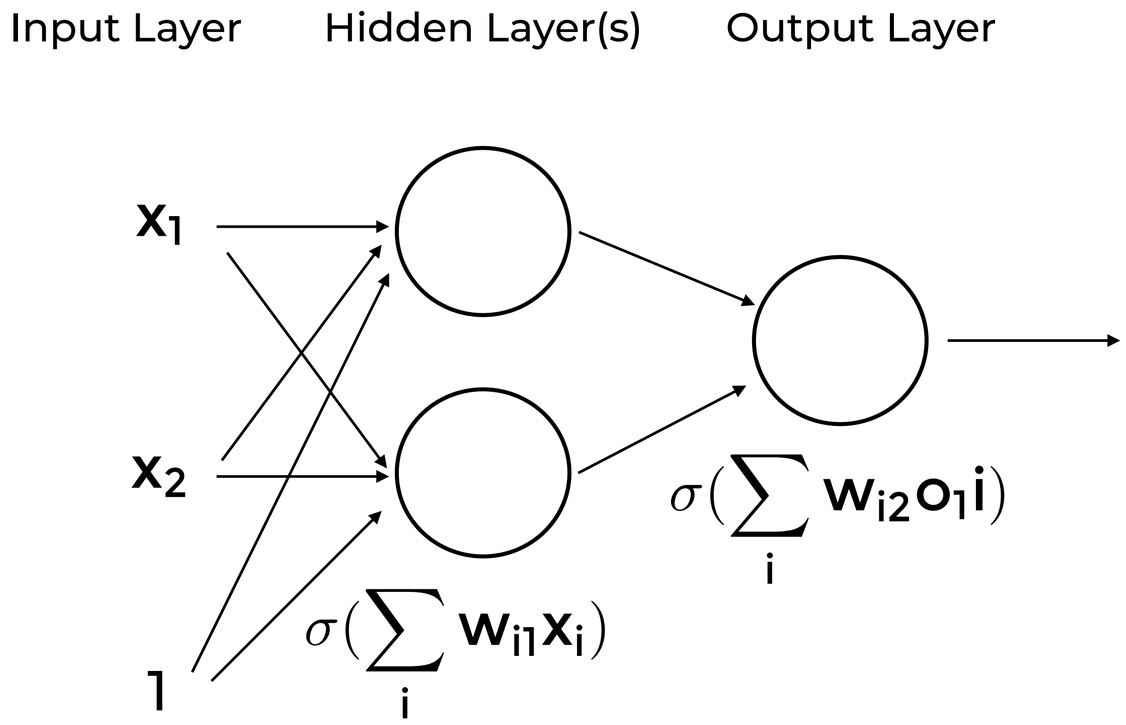
2. Combine the output of models

$$f''(x) = \text{threshold}(w''^\top \begin{bmatrix} f(x) \\ f'(x) \end{bmatrix} + w''_0)$$

Feed-forward neural network



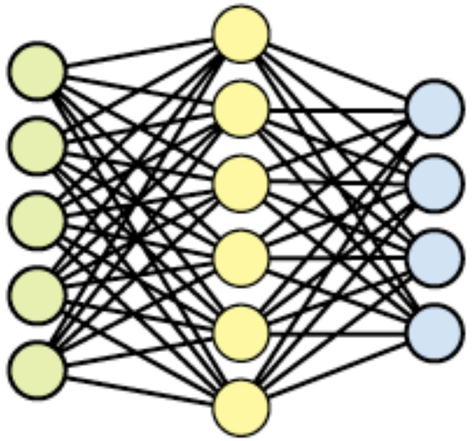
- Each arrow denotes a connection
  - A signal associated with a weight
- Each node is the weighted sum of its input followed by a non-linear activation
- Connections go left to right
  - No connections within a layer
  - No backward connections (recurrent)

Gradient descent

- No closed-form formula
- Repeat the following steps (for t=0,1,2,... until convergence):
  1. Calculate a gradient ∇w_{ij}^{t}
  2. Apply the update $w_{ij}^{t+1} = w_{ij}^{t} - \alpha \nabla w_{ij}^{t}$
- Stochastic gradient descent
  - One example at a time
- Batch gradient descent
  - All examples at a time

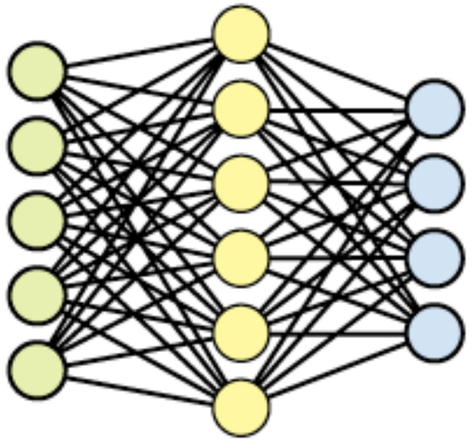
From Neural Networks to **Deep** Neural Networks

A neural Network

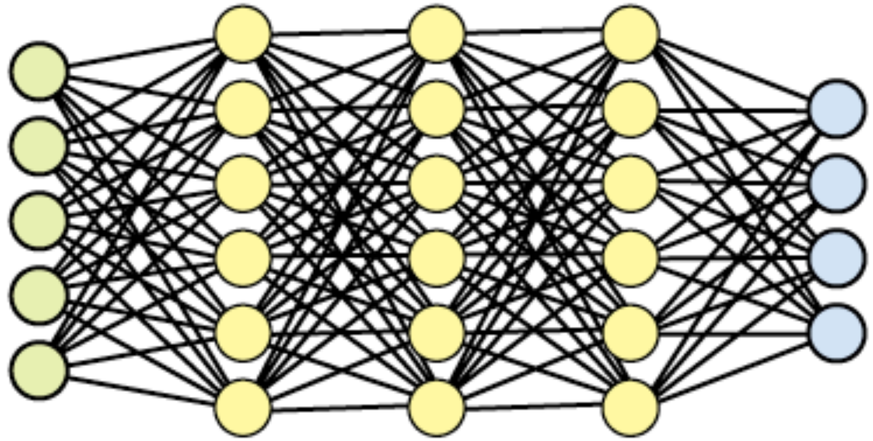


From Neural Networks to **Deep Neural Networks**

A neural Network

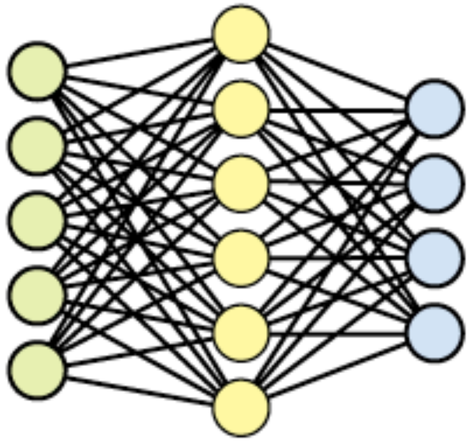


A deep neural Network

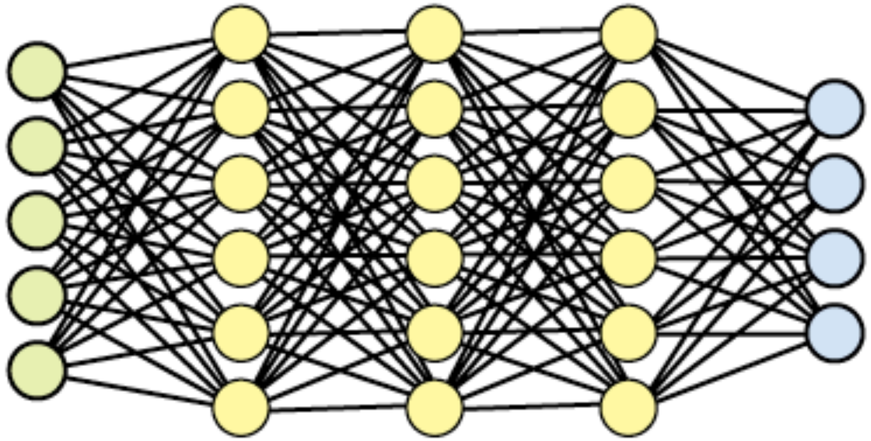


From Neural Networks to Deep Neural Networks

A neural Network



A deep neural Network

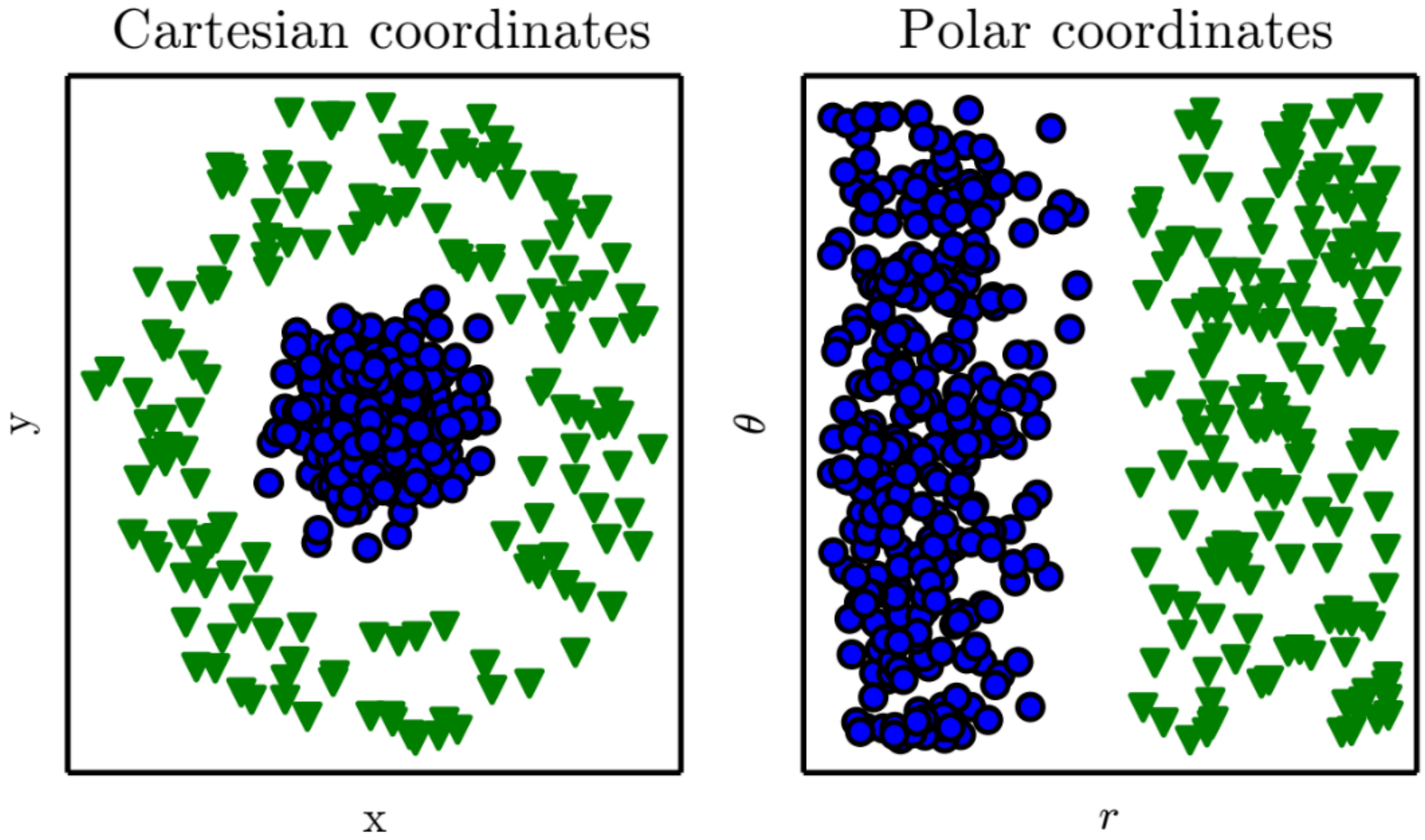


Modern deep learning provides a powerful framework for supervised learning.
By adding more layers and more units within a layer, a deep network can represent functions of increasing complexity.

Deep Learning — Part II, p.163
http://www.deeplearningbook.org/contents/part_practical.html

Another View of deep learning

- **Representations are important**



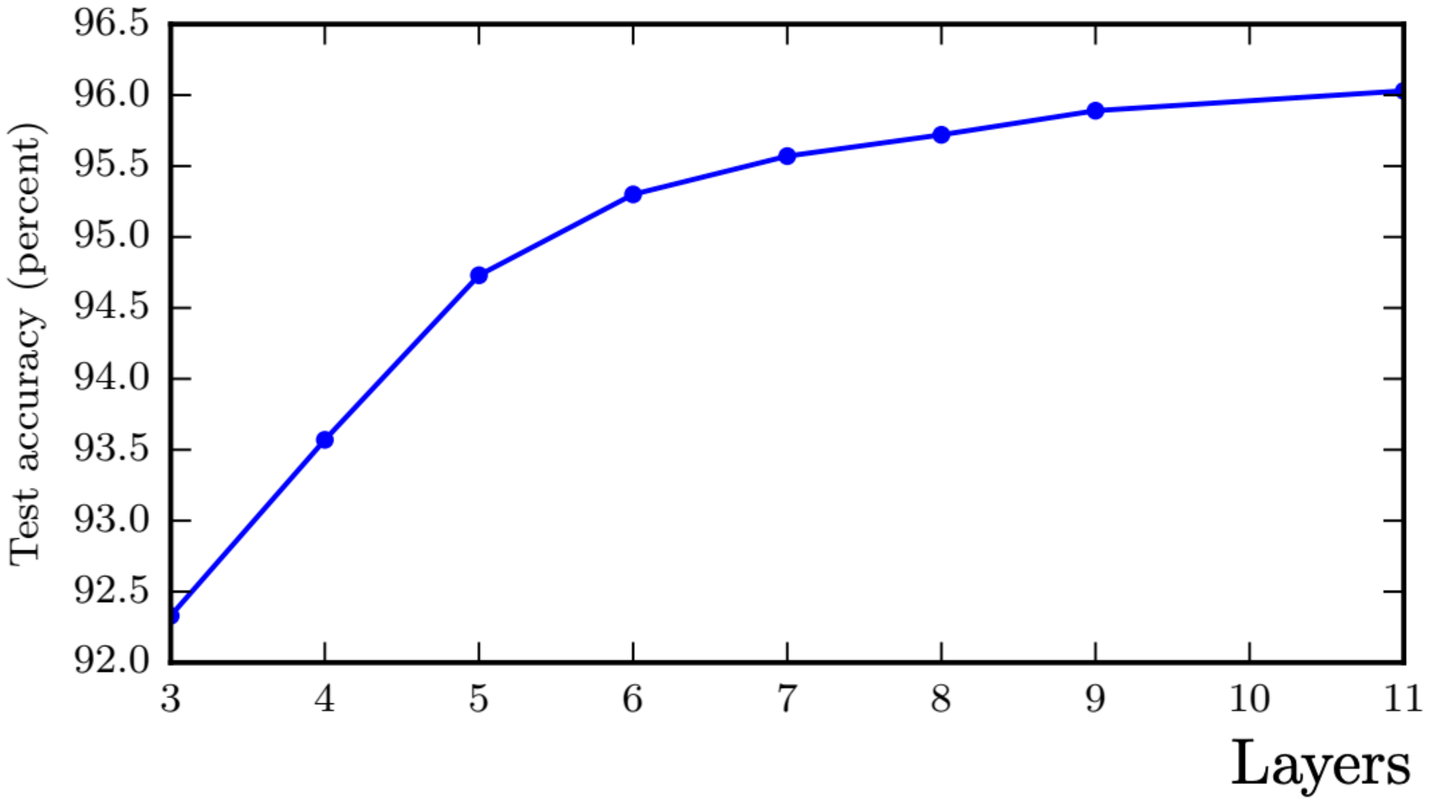
[From: Honglak Lee (and Graham Taylor)]

Hyperparameters

1. Model specific
   - Activation functions (output & hidden), Network size
2. Optimisation Objective
   - Regularization, Early-stopping, Dropout
3. Optimization procedure
   - Momentum, Adaptive learning rates

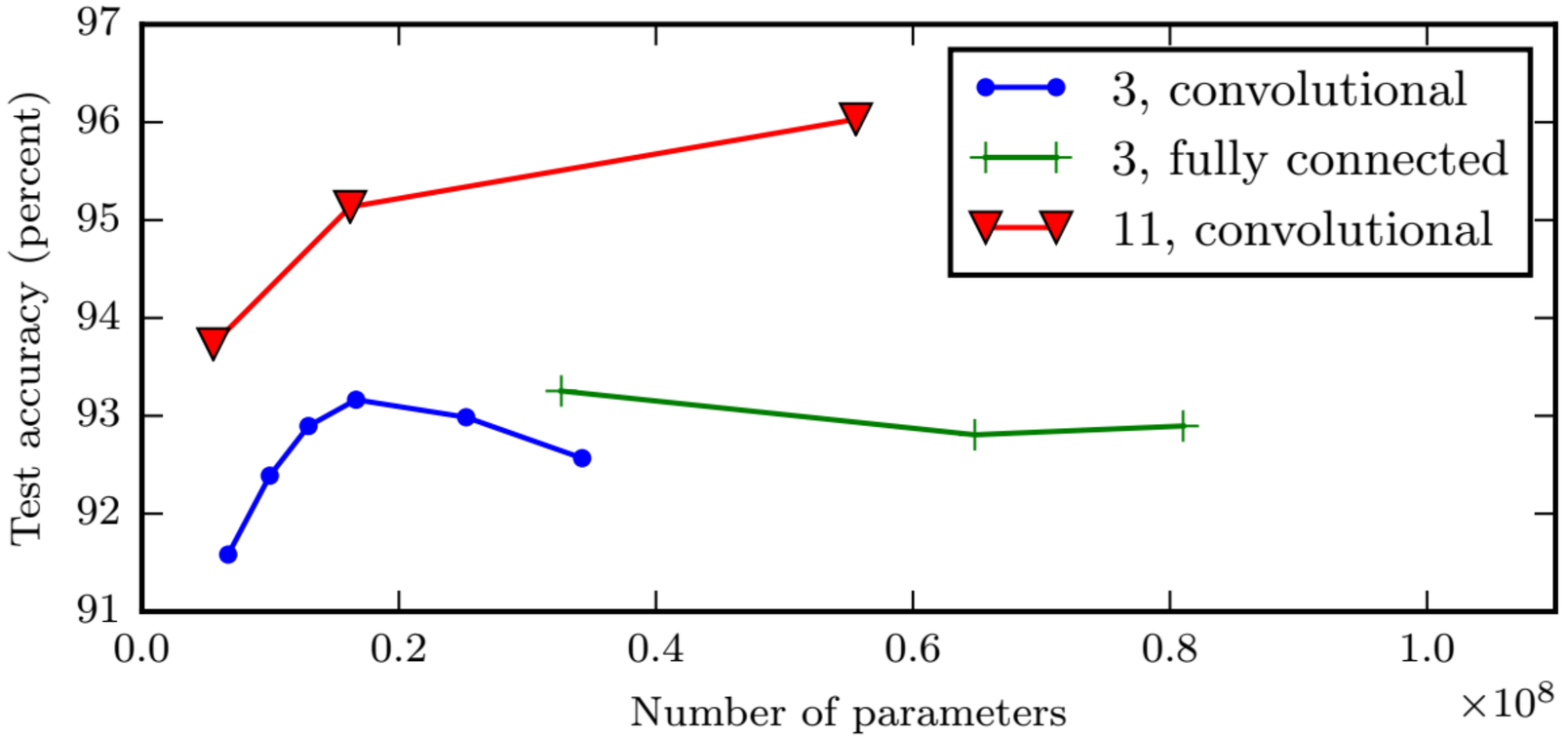
Wide or Deep?

Wide or Deep?



[Figure 6.6, Deep Learning, book]

Wide or Deep?



[Figure 6.7, Deep Learning, book]