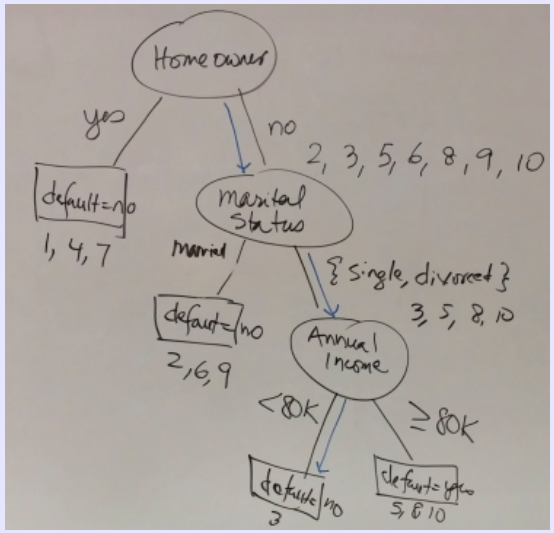
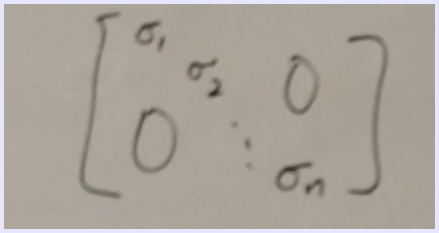
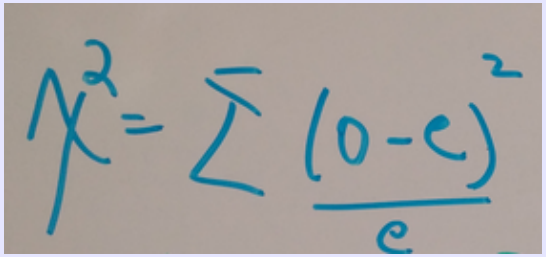
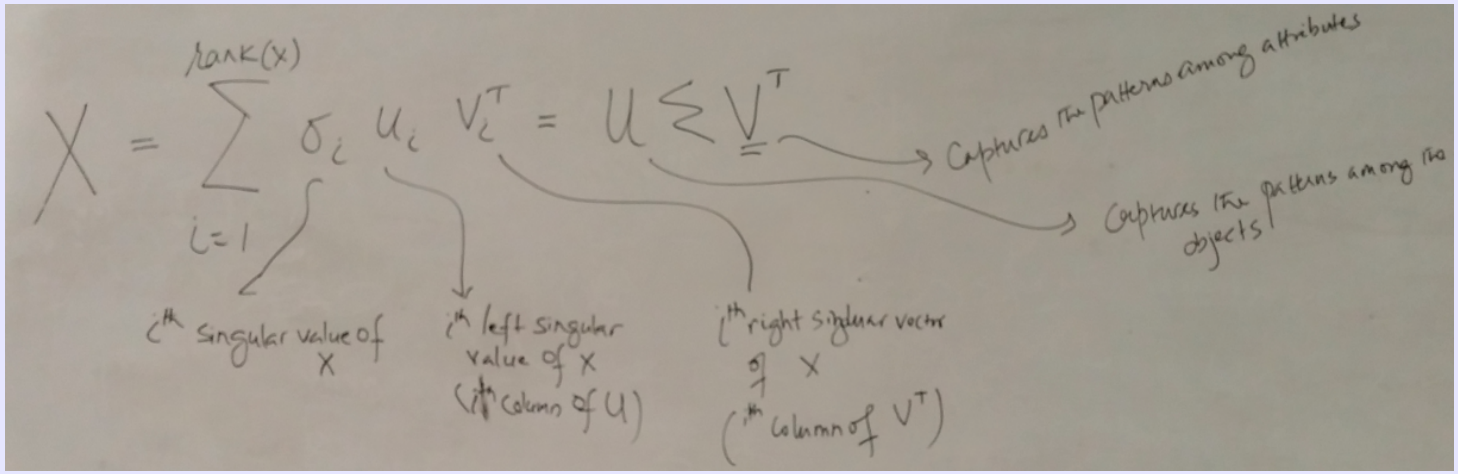
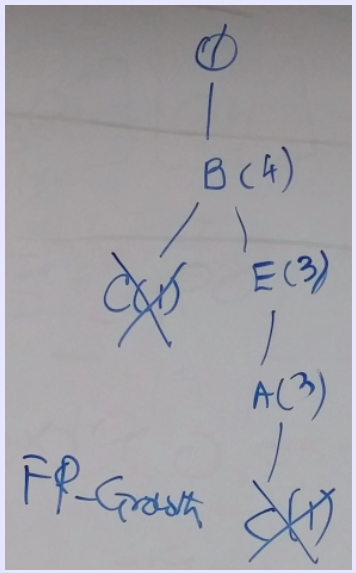
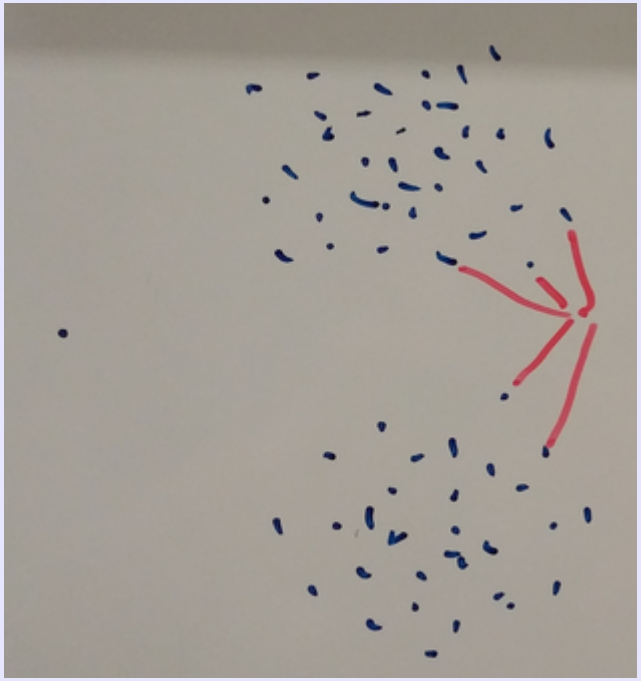










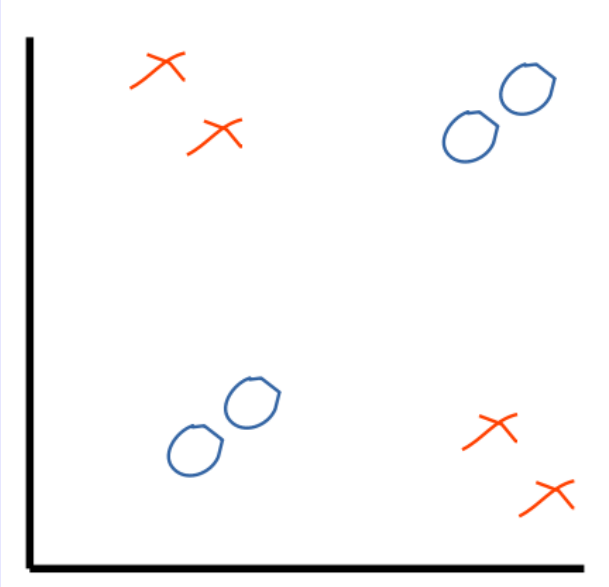


CS 422: Data Mining
Vijay K. Gurbani, Ph.D.,
Illinois Institute of Technology

Lecture: **Introduction to Artificial Neural Networks**

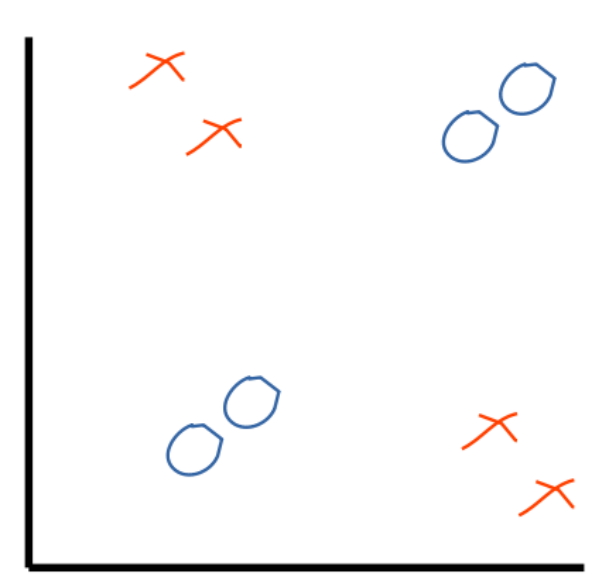
Introduction

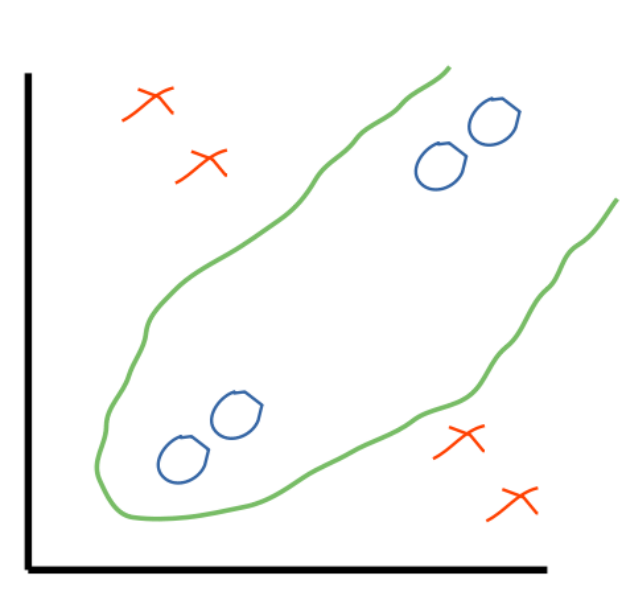
- Hidden layers are needed if the data must be separated using a non-linear boundary.

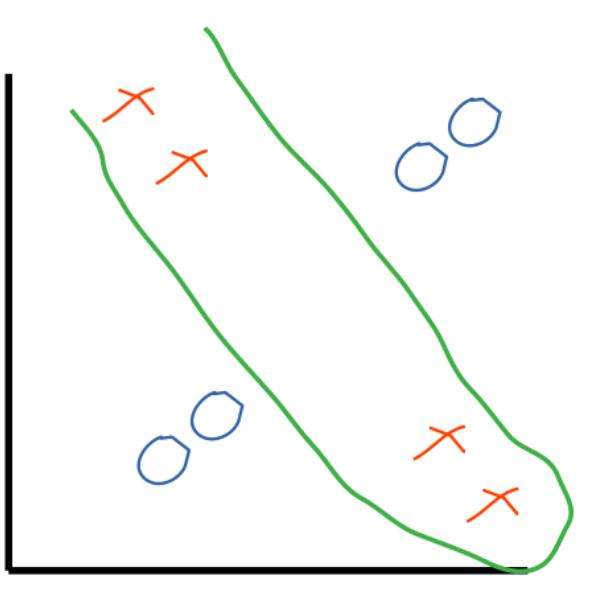


Introduction

- Hidden layers are needed if the data must be separated using a non-linear boundary.

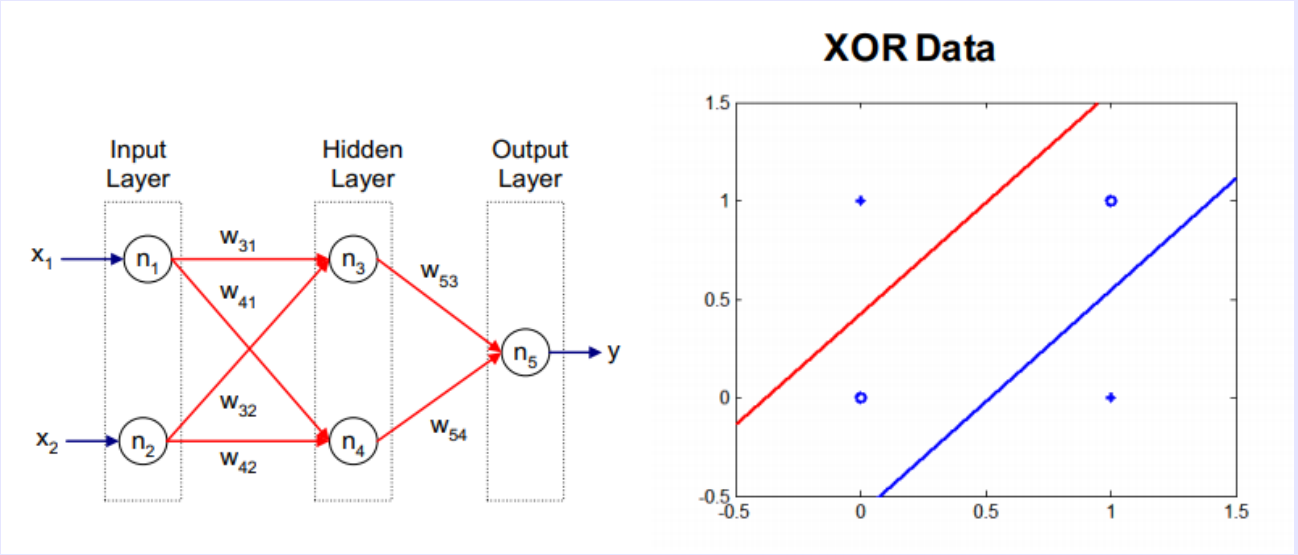






Introduction

- Major difference between ANN and Perceptron is inclusion of hidden layers.
  - Consider the solution to the XOR problem in a FFNN:

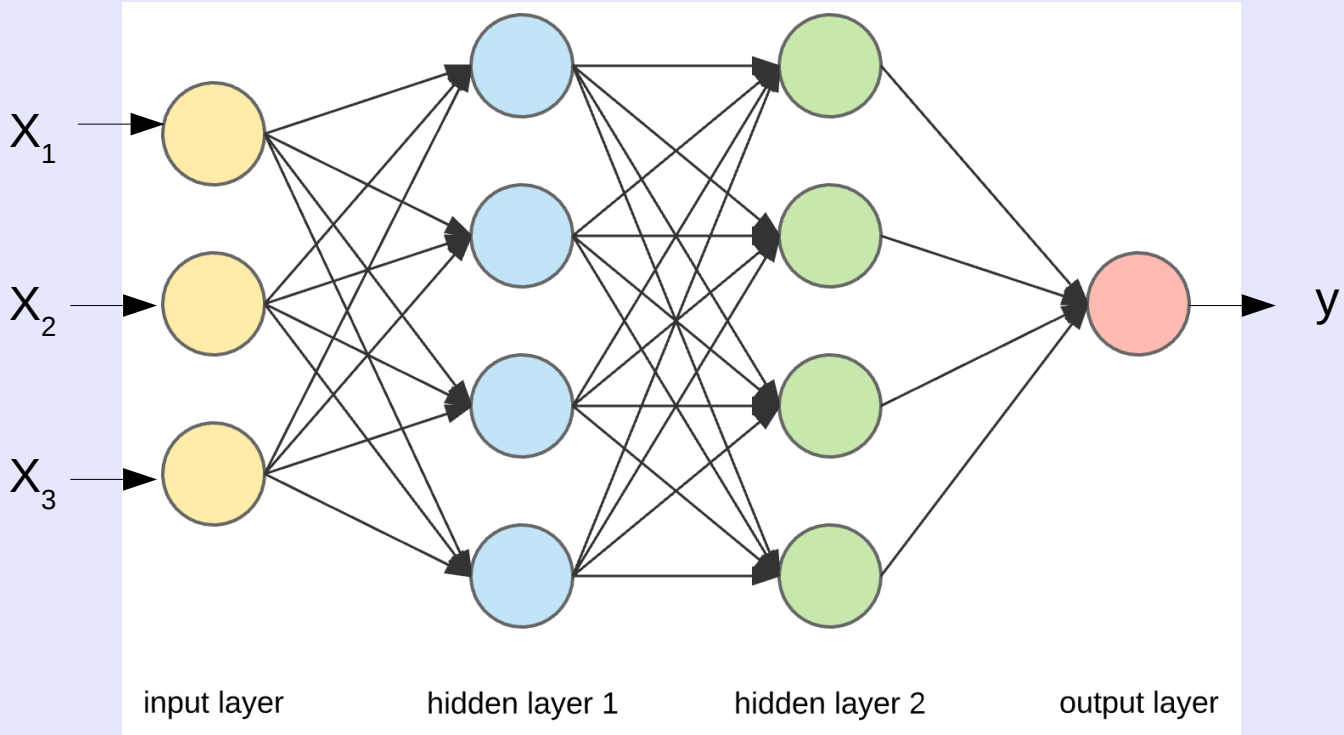


Introduction

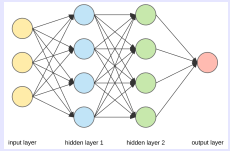
- Major difference between ANN and Perceptron is inclusion of *hidden layers*.
  - Universal Approximation Theorem for Neural Networks: A FFNN with a single hidden layer containing an arbitrary number of neurons can **approximate** any **continuous** function on compact subsets of $\mathbb{R}^n$(Cybenko 1989).
  - The theorem was also proved for arbitrary number of *hidden layers*, each containing a limited number of neurons (Lu et al. 2017).
  - Hidden layers can represent arbitrary complex decision boundaries.

Introduction

- Generalizes the concept of a single-neuron perceptron to the more complex architecture of nodes capable of learning non-linear decision boundaries.

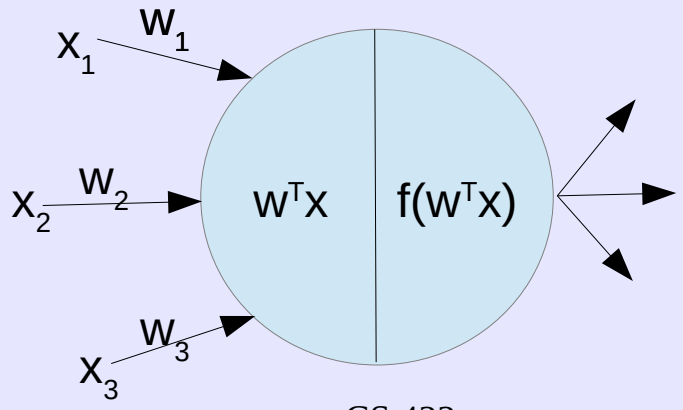


Introduction

- Three kinds of neural networks:
  - Feed forward neural networks 
    - General neural networks for classification, regression, etc.
  - Convolutional neural networks
    - Excel at image recognition.
  - Recurrent neural networks
    - Excel at language tasks.

Introduction

- Hidden nodes learn *latent* representation (features useful for class boundaries).
- First hidden layer captures simpler features (since it receives the predictors as input).
- Subsequent hidden layers hone into specific patterns of the data to extract features.
- So, what does a neuron do?



f(.) is an activation function.
You have seen this before …
…