**STA 141C - Big Data & High Performance Statistical Computing** **Spring 2022**

# Lecture 14: Neural Networks

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**Disclaimer**: *My notes may contain errors, distribution outside this class is allowed only with the permission of the Instructor.*

## Announcement

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## Last time

- Gradient descent

## Today

- Neural Networks
- Stochastic gradient descent

## 1 Introduction

Artificial neural networks (ANNs), usually simply called neural networks (NNs), are computing systems inspired by the biological neural networks that constitute animal brains.

In mathematics, A Neural Network is a function which is generally comprised of

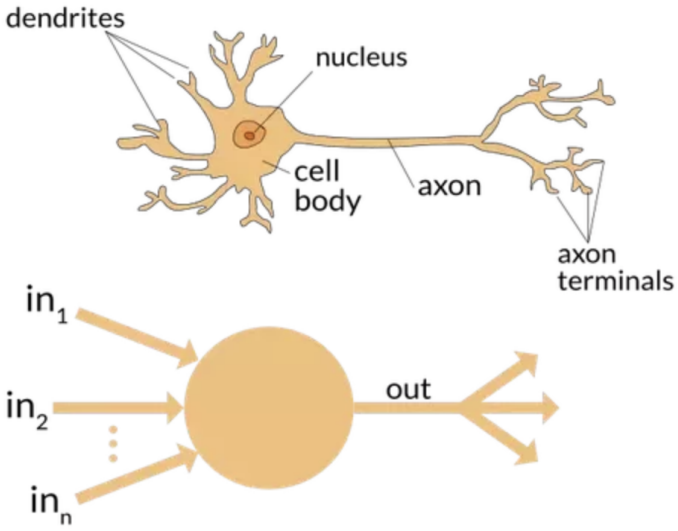
- Neurons: which pass input values through functions and output the result
- Weights: which carry values between neurons

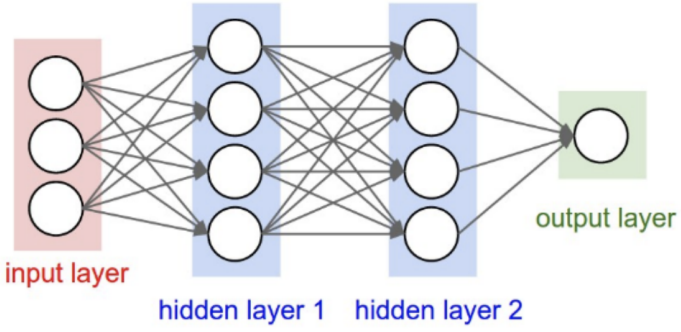
Neurons are grouped into three layers:

- Input layer: $d$ features $x_1, \ldots, x_d$
- Hidden layer (s)
- Output layer: $h(x)$

For a $N$-layer neural network, it consists $N-1$ hidden layer and the output layer.

A bit of history of NNs:


dendrites
nucleus
cell body
axon
axon terminals
in1
in2
inn
out


input layer
hidden layer 1
hidden layer 2
output layer

- In 1943, neurophysiologist Warren McCulloch and mathematician Walter Pitts wrote a paper on how neurons might work. In order to describe how neurons in the brain might work, they modeled a simple neural network using electrical circuits.
- In 1949, Donald Hebb wrote The Organization of Behavior, a work which pointed out the fact that neural pathways are strengthened each time they are used
- As computers became more advanced in the 1950's, it was finally possible to simulate a hypothetical neural network
- In 1959, Bernard Widrow and Marcian Hoff of Stanford developed models called "ADALINE" and "MADALINE." ADALINE was developed to recognize binary patterns so that if it was reading streaming bits from a phone line, it could predict the next bit. MADALINE was the first neural network applied to a real world problem, using an adaptive filter that eliminates echoes on phone lines.

## 2 Formal definition