Day-5: 27 June 2023

1980-90

"Let G be any continuous non-constant function from $\mathbb{R}$ to $\mathbb{R}$. Then $\Sigma^n(G)$ is uniformly dense on compacta in $C(\mathbb{R}^n)$."

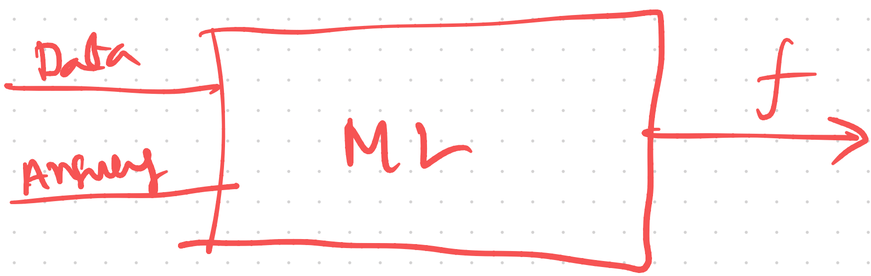
$$\equiv$$

"$\Sigma^n(G)$ networks are capable of arbitrarily accurate approximation to any real-valued continuous function over a compact set"

"Universal Approximation Theorem"

Break down the goal into tasks

- Understand terminology in ML
- Mathematical foundation of ML
  - Mathematical Definitions
  - Universal Approximation Theorem
- Mathematical Model of Artificial Neural Network(ANN)
  - Feed Forward
  - Backward Propagation
  - Activation and loss functions
- Implement algorithm for ANN in python
- Problem-1: Binary Classifier
- Introduction to python packages
- Problem-2: Digit Recognition
- Problem-3: Solving a Differential Equation



Computers vs Human Brain

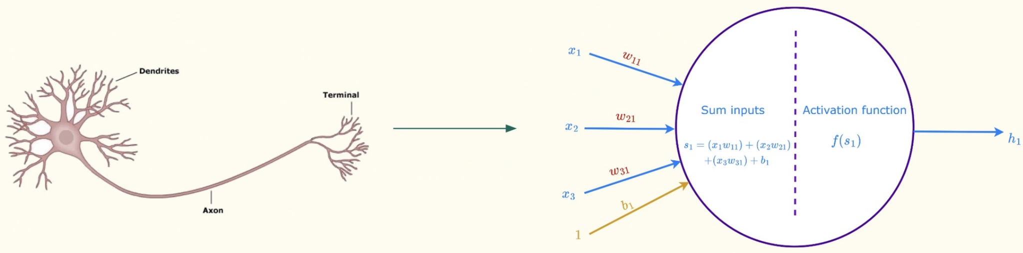
$$24321578392311 \times 6578413655462 + \frac{52345\sqrt{95665742124}}{\sqrt{1+\frac{57551872}{301785}}}$$

Computers	vs	Human Brain
Easy		Difficult

Computers vs Human Brain

Computers	vs	Human Brain
Difficult		Easy

Biological Neuron vs Artificial Neuron

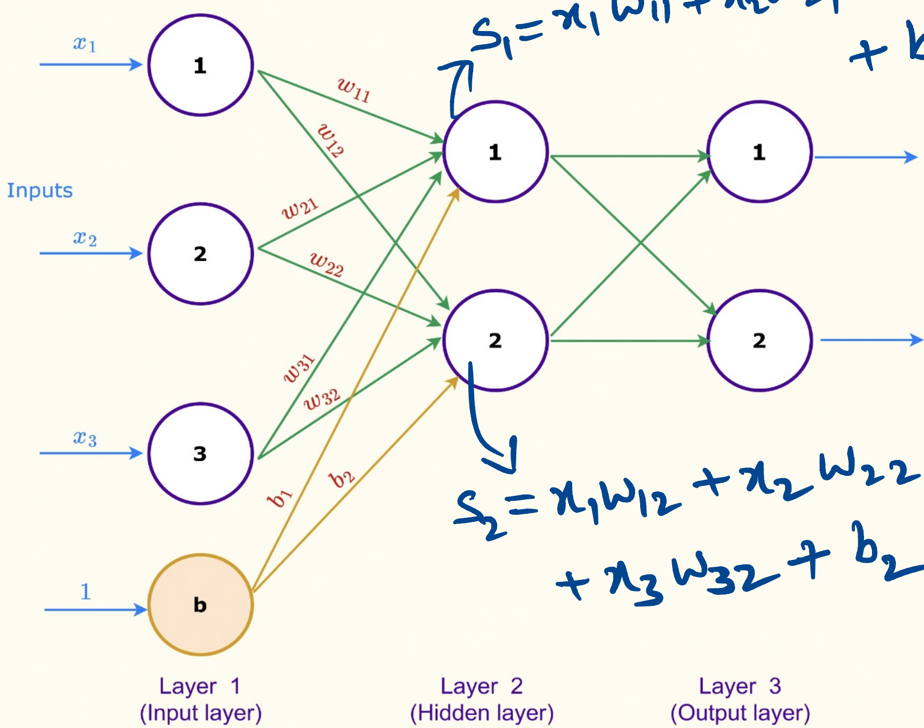


Biological Neuron

Artificial Neuron

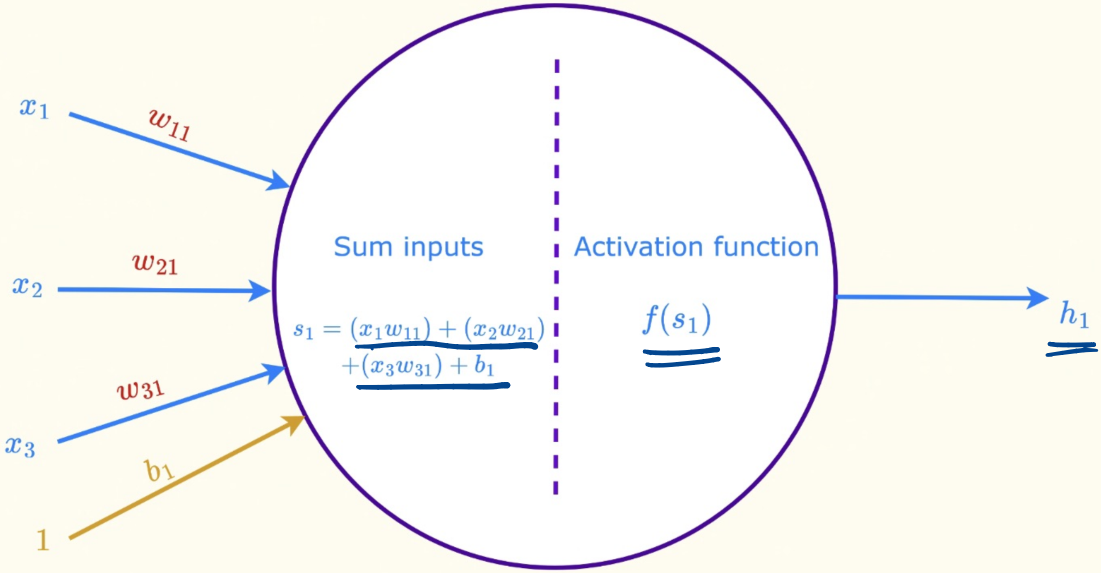
Input Feedforward

$$S_1 = x_1 w_{11} + x_2 w_{21} + x_3 w_{31} + b_1$$



$$S_2 = x_1 w_{12} + x_2 w_{22} + x_3 w_{32} + b_2$$

Activation function (Sigmoid) $f(x) = \frac{1}{1+e^{-x}}$



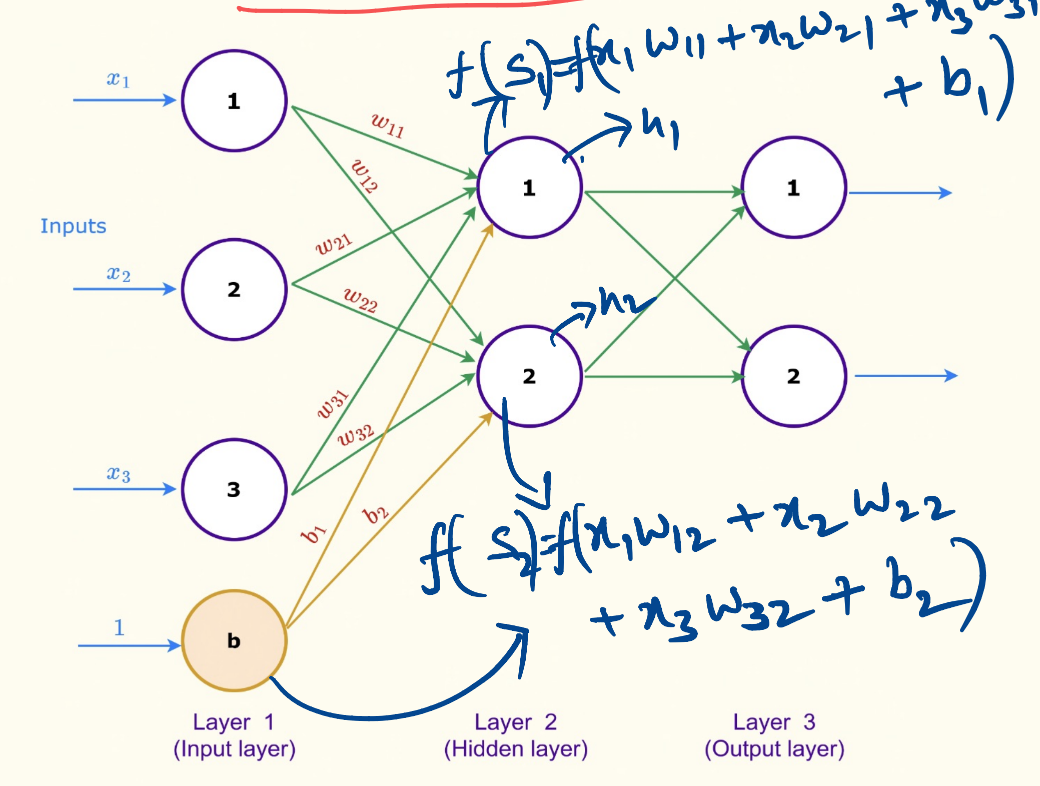
$$S_1 = x_1 w_{11} + x_2 w_{21} + x_3 w_{31} + b_1$$

$$S_2 = x_1 w_{12} + x_2 w_{22} + x_3 w_{32} + b_2$$

$$\begin{bmatrix} S_1 \\ S_2 \end{bmatrix} = \begin{bmatrix} w_{11} & w_{21} & w_{31} \\ w_{12} & w_{22} & w_{32} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$$

Biological Neuron Artificial Neuron

Input Feedforward



$$h_1 = f(S_1) = f(x_1 w_{11} + x_2 w_{21} + x_3 w_{31} + b_1)$$

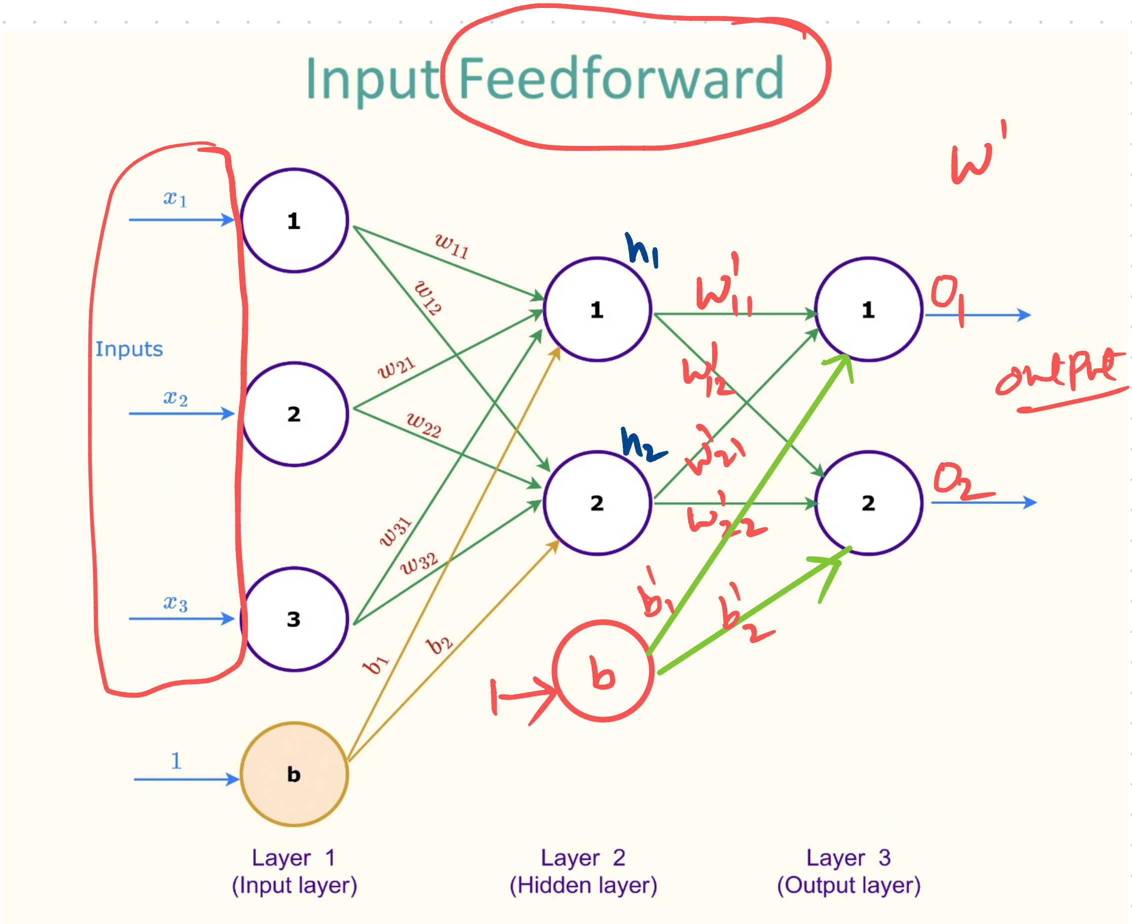
$$h_2 = f(S_2) = f(x_1 w_{12} + x_2 w_{22} + x_3 w_{32} + b_2)$$

$$
\begin{bmatrix} s_1 \\ s_2 \end{bmatrix} = \underset{W}{\begin{bmatrix} w_{11} & w_{21} & w_{31} \\ w_{12} & w_{22} & w_{32} \end{bmatrix}} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}
$$

$$
\boxed{S_H = W_{IH} \cdot X_I + B_I}
$$

$$
\boxed{\begin{aligned} h_1 &= f(s_1) \\ h_2 &= f(s_2) \end{aligned}}
$$

$$
\boxed{H_{hidden} = f(S_H)}
$$



$$H_{hidden} = \begin{bmatrix} h_1 \\ h_2 \end{bmatrix}$$

$$O_1 = f(h_1 w'_{11} + h_2 w'_{21} + b'_1)$$

$$O_2 = f(h_1 w'_{12} + h_2 w'_{22} + b'_2)$$

$$\begin{pmatrix} o_1 \\ o_2 \end{pmatrix} = f\left(\begin{bmatrix} w'_{11} & w'_{21} \\ w'_{12} & w'_{22} \end{bmatrix} \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} + \begin{bmatrix} b'_1 \\ b'_2 \end{bmatrix} \right)$$

$$\boxed{O = f\left(W_{HO} H_{hidden} + B_H\right)}$$

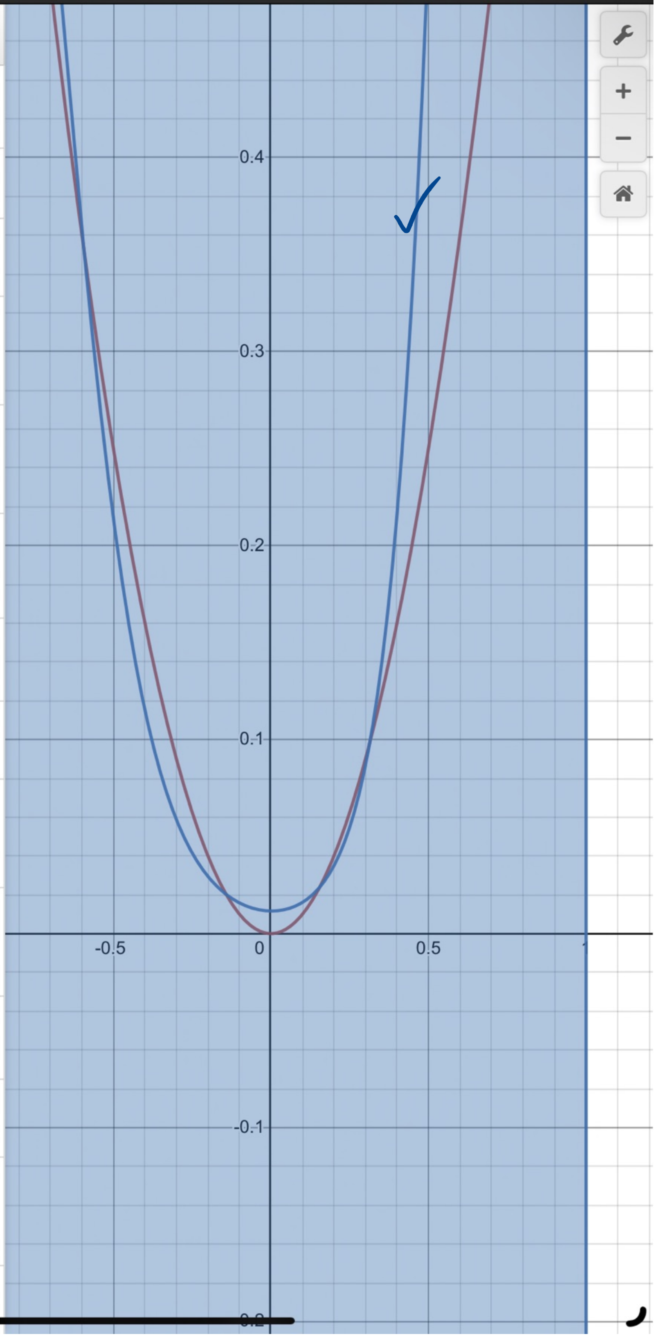
Start Page

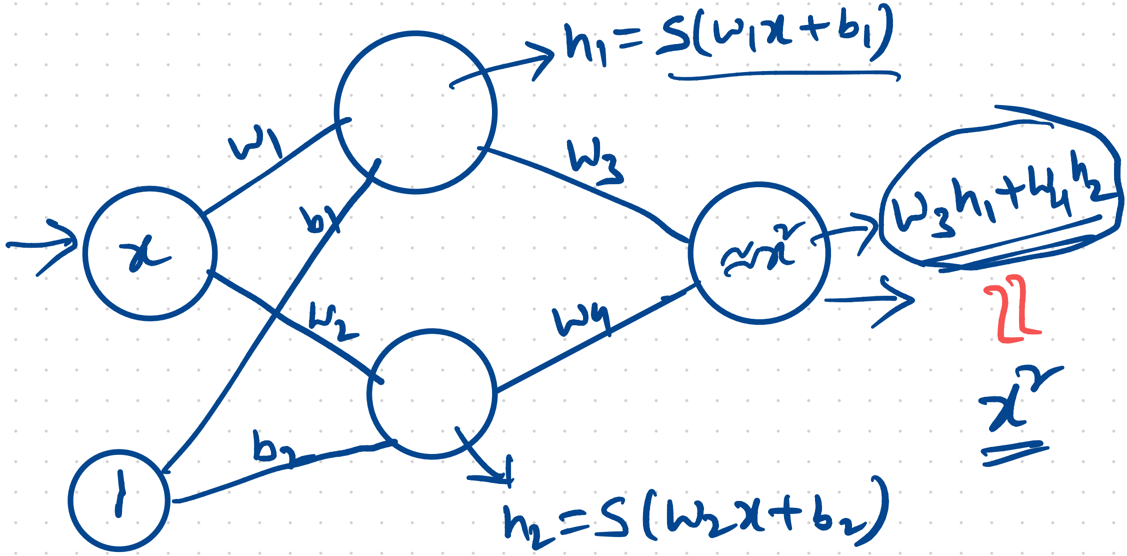
ANN_function_approx

ANN_function_approx Save desmos Satyaprasad

1. $f(x) = x^2$
2. $-1 \le x \le 1$
3. $f_1(x) = w_1 x + b_1$
4. $w_1 = 9.6$ (slider: −10 to 20)
5. $b_1 = -6.5$ (slider: −10 to 10)
6. $s(x) = \frac{1}{1+e^{-x}}$
7. $h_1(x) = s(f_1(x))$
8. $f_2(x) = w_2 x + b_2$
9. $w_2 = -7.4$ (slider: −10 to 10)
10. $b_2 = -5$ (slider: −10 to 10)
11. $h_2(x) = s(f_2(x))$
12. $N(x) = w_3 h_1(x) + w_4 h_2(x)$
13. $w_3 = 3.3$ (slider: −10 to 10)

$= 1$





$w_1 = 9.6$	$w_3 = 3.3$
$w_2 = -7.4$	$w_4 = 1$
$b_1 = -6.5$	
$b_2 = -5$	

4   2

I — H   H — O

"$\min(E(x))$" ~