Demystifying AI

Neural Networks

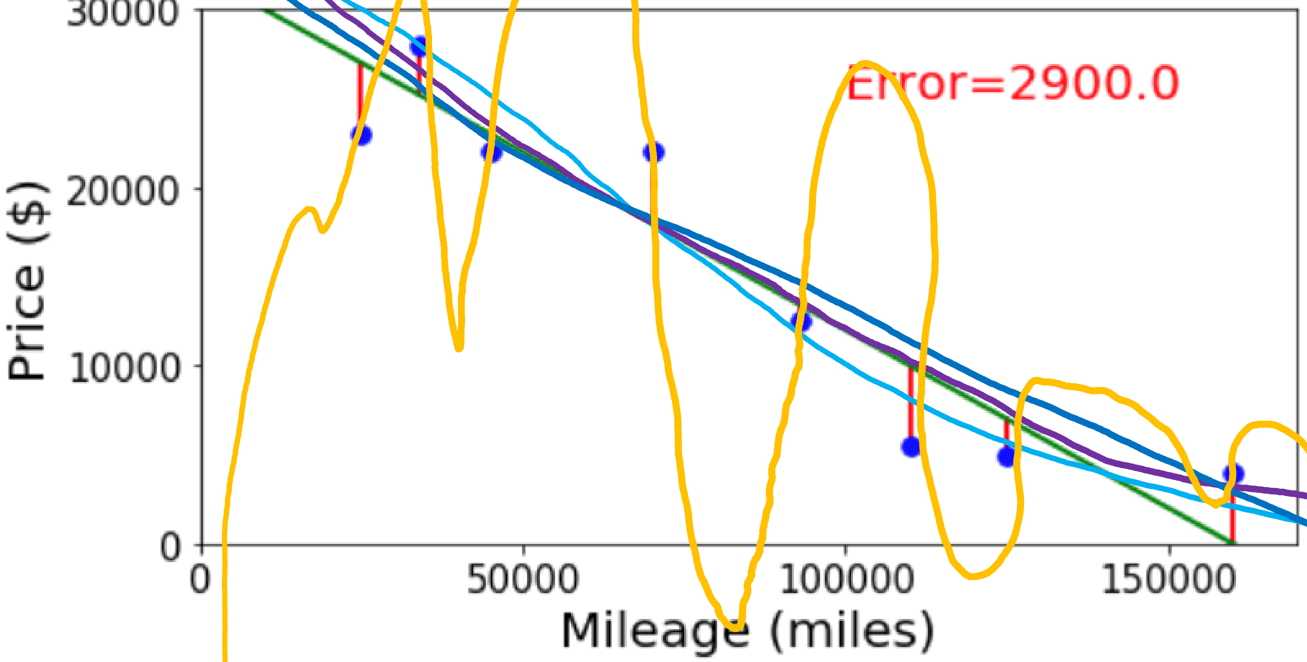
Instructor: Pat Virtue

Warm-up Exercise: Plotting Functions

Paper handout

Linear Regression

Selling my car example



Regression for Non-linear data

Paper handout

Linear Regression

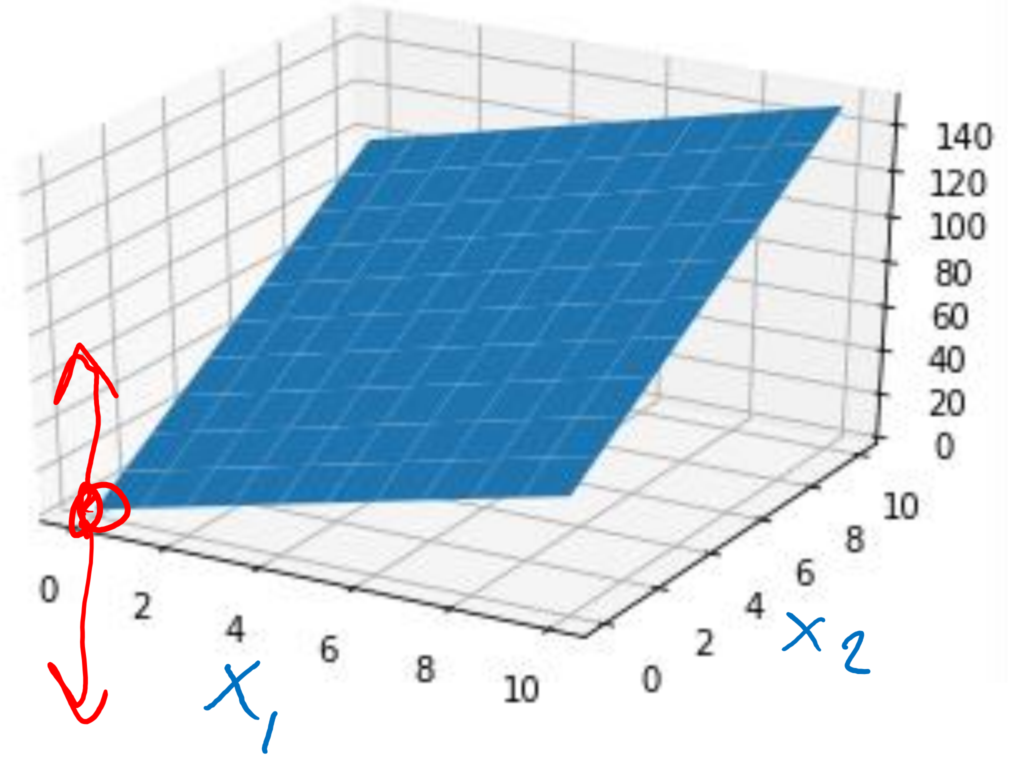
With N-D inputs

1D

$$\hat{y} = w x_1 + b$$

2D

$$\hat{y} = w_1 x_1 + w_2 x_2 + \underline{b}$$



ND

$$\hat{y} = \left(\sum_{i=1}^{N} w_i x_i \right) + b$$

Linear Regression

With N-D inputs

1-D linear function

$y = w_1 x_1 + b$

2-D linear function

$y = w_1 x_1 + w_2 x_2 + b$

3-D linear function

$y = w_1 x_1 + w_2 x_2 + w_2 x_2 + b$

N-D linear function

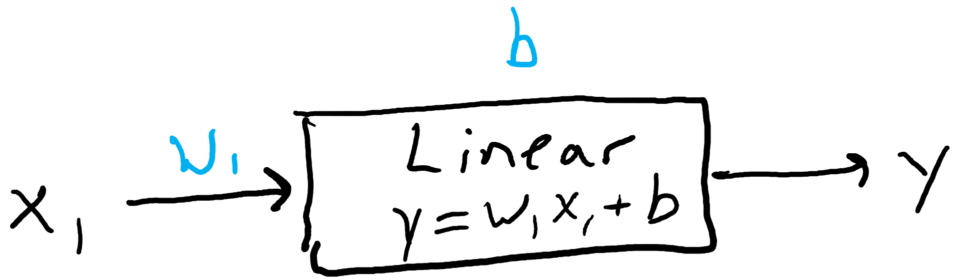
$y = \sum_{i=1}^{N} w_i x_i + b$

Network Diagrams

Linear functions

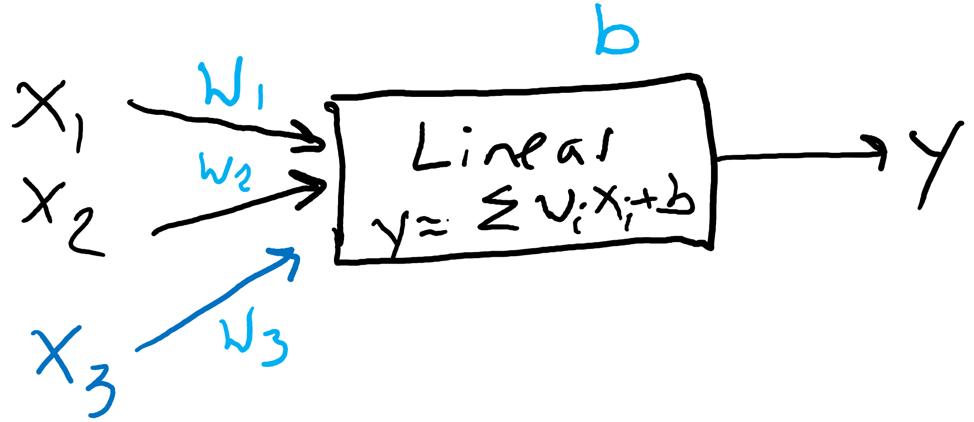
1-D linear function

$y = w_1 x_1 + b$



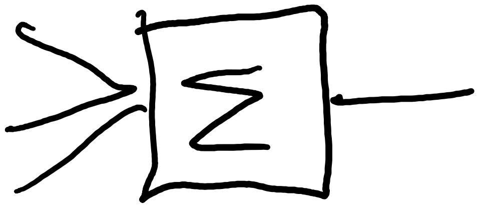
2-D linear function

$y = w_1 x_1 + w_2 x_2 + b$



3-D linear function

$y = w_1 x_1 + w_2 x_2 + w_2 x_2 + b$

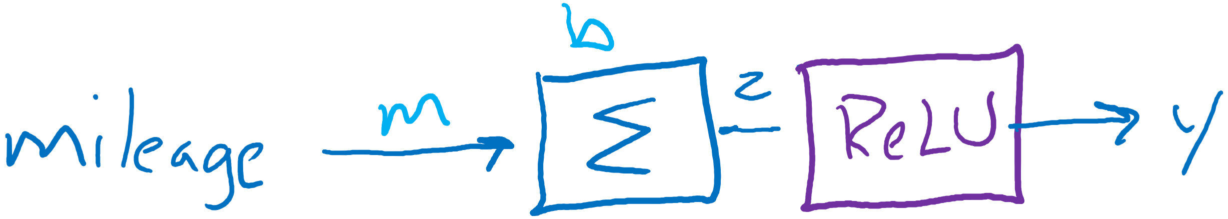


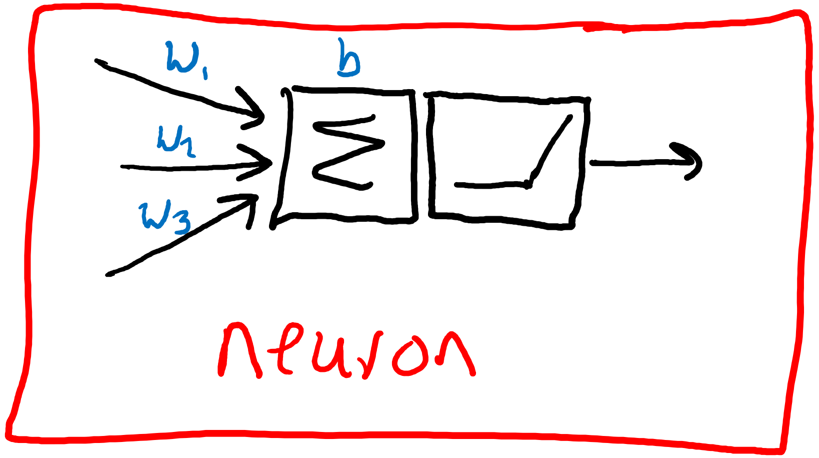
N-D linear function

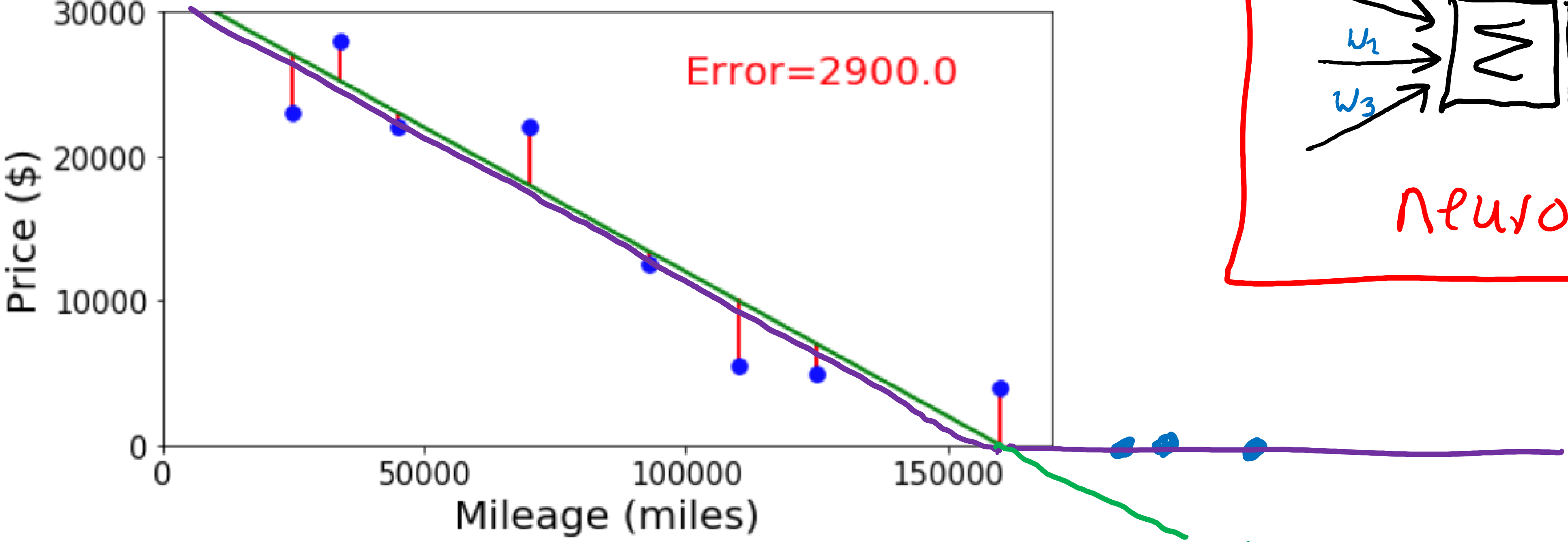
$y = \sum_{i=1}^{N} w_i x_i + b$

Linear Regression

Selling my car example







$$z = mx + b$$

$$a = \max(0, z)$$

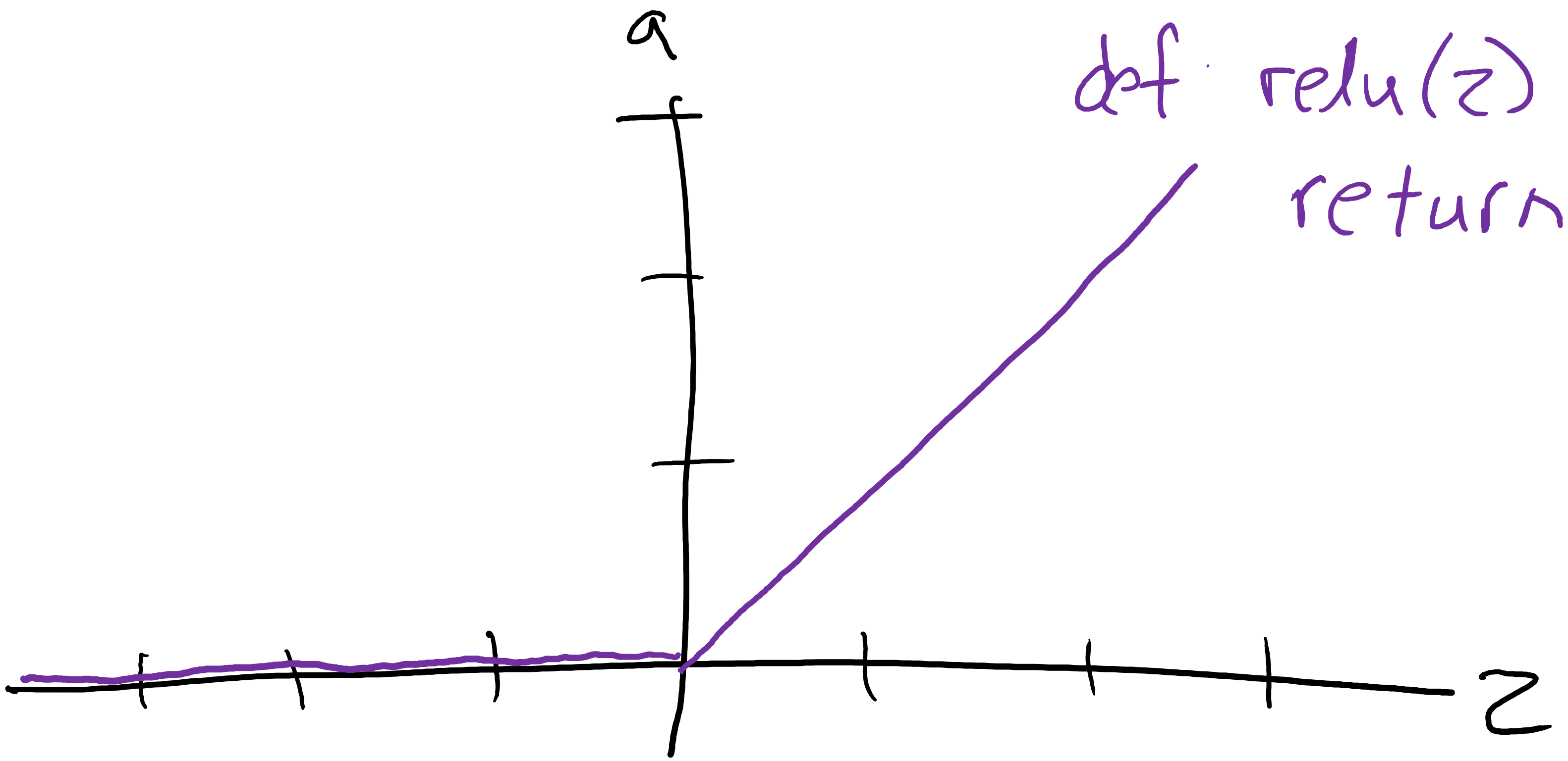
$$a = \mathrm{ReLU}(z)$$

Linear plus ReLU

Rectified linear unit

$$a = \mathrm{ReLU}(z) = \begin{cases} 0 & \text{if } z < 0 \\ z & \text{otherwise} \end{cases}$$

```
def relu(z)
    return max(0,z)
```



Plotting Functions

Connecting functions

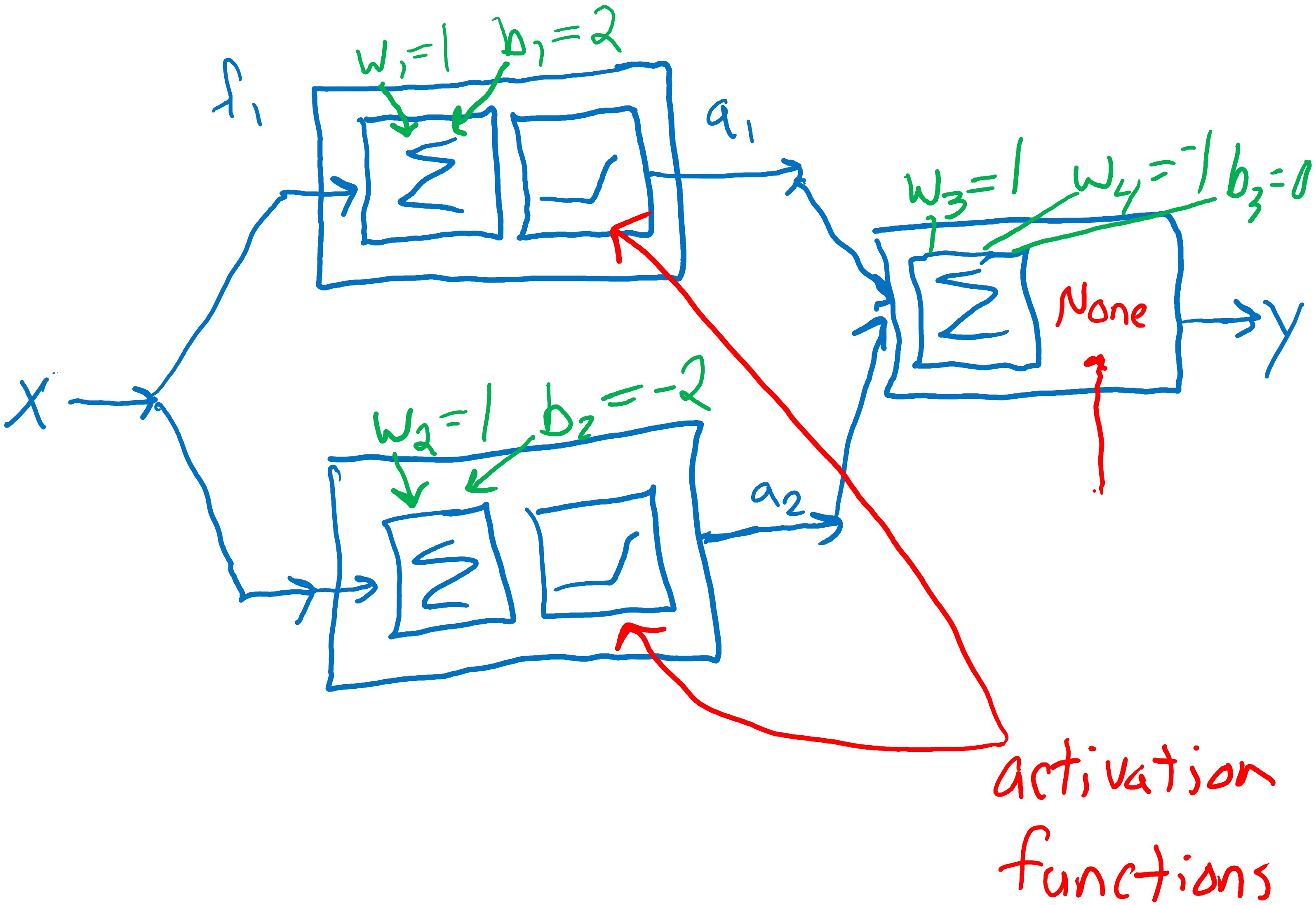
Plot the function $f_3(x)$ vs x

$a_1 = f_1(x) = \max(0, 1x + 2)$

$a_2 = f_2(x) = \max(0, 1x - 2)$

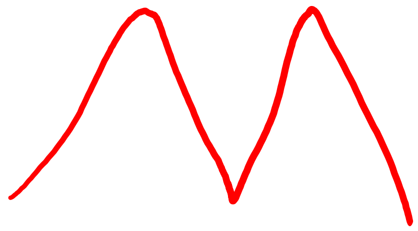
$y = f_3(x) = f_1(x) - f_2(x)$

$1 \cdot a_1 + (-1) a_2 + 0$



Neural Networks

https://www.cs.cmu.edu/~15181/tfp



Setup:

- Switch to the regression dataset that looks like the letter M
- Set the learning rate to 0.003

Steps:

- Set up your architecture: add as many hidden layers and neurons per layer as you like
- Click the play button
- Observe the resulting fit and loss (mean squared error)
- Repeat to try to use as few neurons a possible and still get a good fit

Three-neuron network

Connecting functions

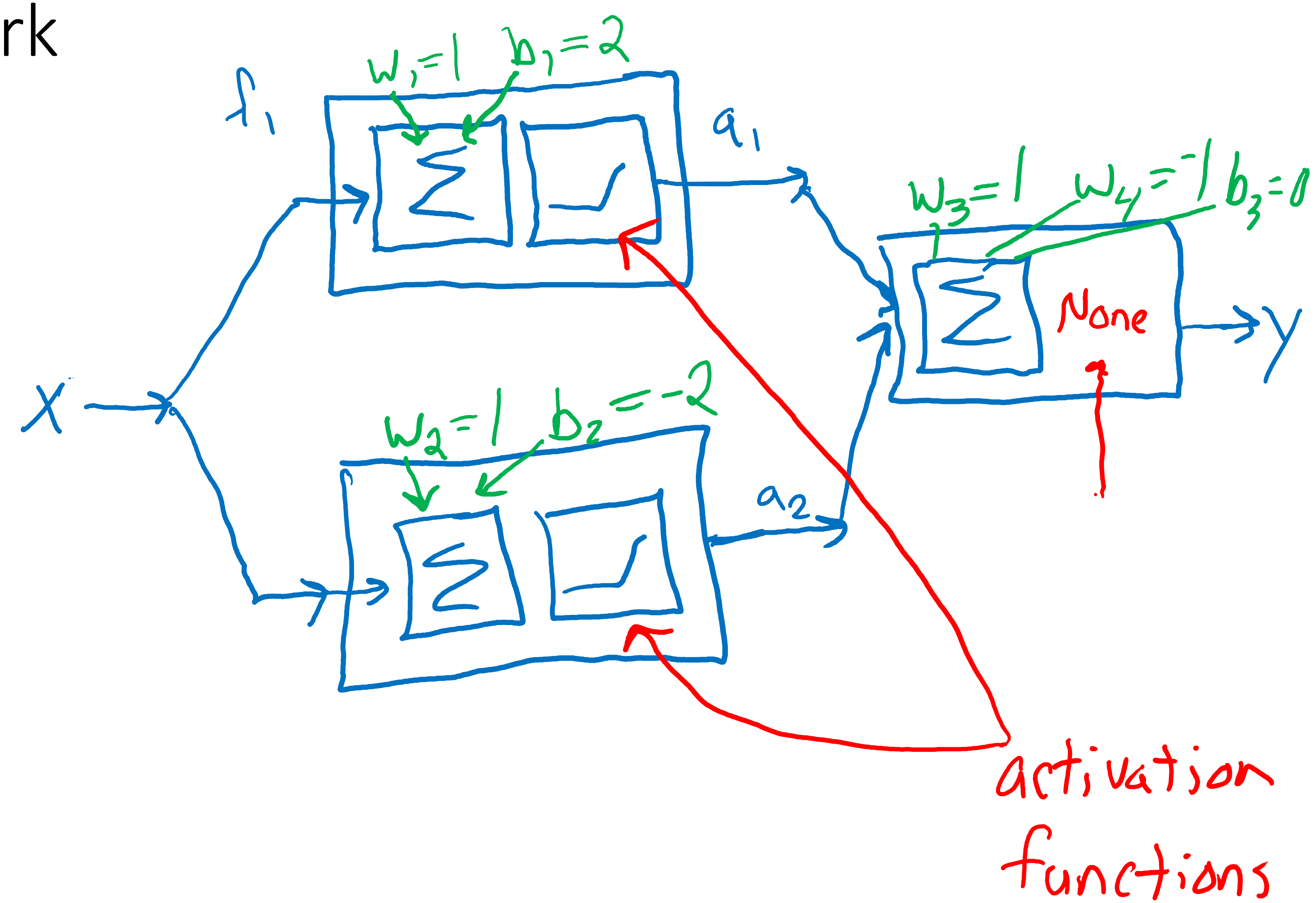
Plot the function $f_3(x)$ vs x

$a_1 = f_1(x) = \max(0, 1x + 2)$

$a_2 = f_2(x) = \max(0, 1x - 2)$

$y = f_3(x) = f_1(x) - f_2(x)$

$1 \cdot a_1 + (-1) a_2 + 0$



Three-neuron network

Connecting functions

Plot the function $f_3(x)$ vs x

$f_1(x) = \max(0, 1x + 2)$

$f_2(x) = \max(0, 1x - 2)$

$f_3(x) = f_1(x) - f_2(x)$