

مكتتب 100%



عايز يتجوز: %20

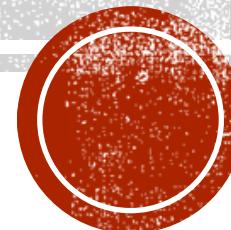
معوش فلوس: %30

فوت صلاة الفجر: %50



بسم الله الرحمن الرحيم

# BACKPROPAGATION



$$f(a, b, c) = a * b + c$$

$$\frac{f(x+h) - f(x)}{h}$$

$$f(a+h, b, c) = (a+h) * b + c$$

$$(f(a+h, b, c) - f(a, b, c)) / h$$

$$((a+h) * b + c - (a*b + c)) / h$$

$$(a*b + h*b + c - a*b - c) / h$$

$$df/da = h*b / h = b$$

Differentiating  $f$  with respect to  $a$

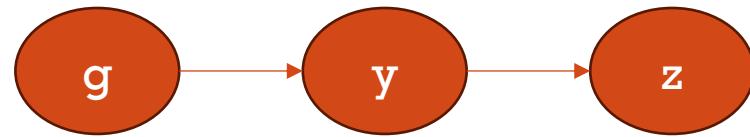


$$g = -2 * w_1$$

$$y = w_2 + g$$

$$z = y * w_3$$

$$z = \underbrace{(w_2 - 2 * w_1)}_{g} * w_3$$



Target = 10

w1 = 3

w2 = 4

w3 = 5

Predicted = Z =  $(4 - 2 * 3) * 5 = -10$

Loss =  $10 - (-10) = 20$

Backpropagation STARTS...



$$g = -2 * w_1$$



Target = 10

$$y = w_2 + g$$

Predicted = -10

$$z = y * w_3$$

Loss = 20

$$z = (w_2 + -2 * w_1) * w_3$$

w<sub>1</sub> = 3

w<sub>2</sub> = 4

w<sub>3</sub> = 5

**GOAL!!!**

$dz / dw_1$  Differentiate z with respect to w<sub>1</sub>

$dz / dw_2$  Differentiate z with respect to w<sub>2</sub>

$dz / dw_3$  Differentiate z with respect to w<sub>3</sub>

Chain Rule STARTS...



Car is 4 times faster than bicycle, and bicycle is 2 times faster as a man

→ So, Car is  $4 \times 2 = 8$  times faster than man

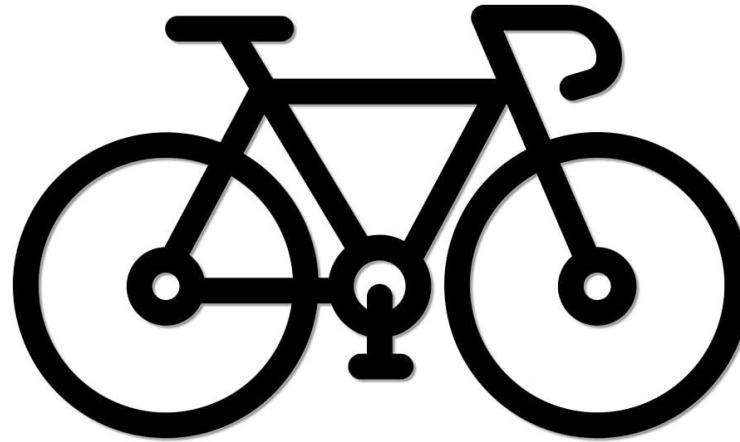
$$d\text{Car}/d\text{Bicycle} = 4, d\text{Bicycle}/d\text{Man} = 2$$

→ So,  $d\text{Car}/d\text{Man} = d\text{Car}/d\text{Bicycle} \times d\text{Bicycle}/d\text{Man} = 4 \times 2 = 8$

5km



10km



40km



## Chain Rule



$$g = -2 * w_1$$

$$y = w_2 + g$$

$$z = y * w_3$$

$$z = (w_2 + -2 * w_1) * w_3$$



Target = 10

Predicted = -10

Loss = 20

w1 = 3

w2 = 4

w3 = 5

$$\frac{dz}{dw_1} = \frac{dz}{dy} * \frac{dy}{dg} * \frac{dg}{dw_1}$$

$$\frac{dz}{dw_2} = \frac{dz}{dy} * \frac{dy}{dw_2}$$

$$\frac{dz}{dw_3} = y$$



$$g = -2 * w_1$$

$$y = w_2 + g$$

$$z = y * w_3$$

$$z = (w_2 + -2 * w_1) * w_3$$



Target = 10

Predicted = -10

Loss = 20

$w_1 = 3$

$w_2 = 4$

$w_3 = 5$

$$\rightarrow \frac{dz}{dw_1} = \frac{dz}{dy} * \frac{dy}{dg} * \frac{dg}{dw_1}$$

$$\frac{dg}{dw_1} = -2$$



$$\begin{aligned} & (f(x+h) - f(x)) / h \\ & (g(w_1+h) - g(w_1)) / h \\ & (-2*(w_1+h) + 2*w_1) / h \\ & (-2*\cancel{w_1} - 2*h + 2*\cancel{w_1}) / h \\ & -2*h / h = -2 \end{aligned}$$

$$\frac{f(x+h) - f(x)}{h}$$



$$g = -2 * w_1$$

$$y = w_2 + g$$

$$z = y * w_3$$

$$z = (w_2 + -2 * w_1) * w_3$$



Target = 10

Predicted = -10

Loss = 20

$w_1 = 3$

$w_2 = 4$

$w_3 = 5$

$$\rightarrow \frac{dz}{dw_1} = \frac{dz}{dy} * \frac{dy}{dg} * \frac{dg}{dw_1}$$

$$\frac{dg}{dw_1} = -2$$

$$\frac{dy}{dg} = 1$$

$$\begin{aligned} & \frac{(f(x+h) - f(x))}{h} \\ & \frac{(y(g+h) - y(g))}{h} \\ & \frac{(w_2 + (g+h) - (w_2+g))}{h} \\ & \frac{(w_2 + g + h - w_2 - g)}{h} \\ & h/h = 1 \end{aligned}$$

$$\frac{f(x+h) - f(x)}{h}$$



$$g = -2 * w_1$$

$$y = w_2 + g$$

$$z = y * w_3$$

$$z = (w_2 + -2 * w_1) * w_3$$



Target = 10

Predicted = -10

Loss = 20

$w_1 = 3$

$w_2 = 4$

$w_3 = 5$

$$\rightarrow \frac{dz}{dw_1} = \frac{dz}{dy} * \frac{dy}{dg} * \frac{dg}{dw_1}$$

$$\frac{dg}{dw_1} = -2$$

$$\frac{dy}{dg} = 1$$

$$\frac{dz}{dy} = w_3$$

$$\begin{aligned} & \frac{(f(x+h) - f(x))}{h} \\ & \frac{(z(y+h) - z(y))}{h} \\ & \frac{((y+h)*w_3 - y*w_3)}{h} \\ & \frac{(y*w_3 + h*w_3 - y*w_3)}{h} \\ & h*w_3 / h = w_3 \end{aligned}$$

$$\frac{f(x+h) - f(x)}{h}$$



$$g = -2 * w_1$$

$$y = w_2 + g$$

$$z = y * w_3$$

$$z = (w_2 + -2 * w_1) * w_3$$

$$\frac{dg}{dw_1} = -2$$

$$\frac{dy}{dg} = 1$$

$$\frac{dz}{dy} = w_3 = 5$$



Target = 10

Predicted = -10

Loss = 20

$w_1 = 3$

$w_2 = 4$

$w_3 = 5$

→  $\frac{dz}{dw_1} = \frac{dz}{dy} * \frac{dy}{dg} * \frac{dg}{dw_1} = -2 * 1 * 5 = -10$

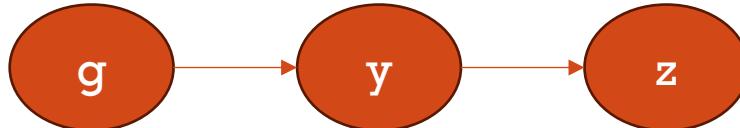


$$g = -2 * w_1$$

$$y = w_2 + g$$

$$z = y * w_3$$

$$z = (w_2 + -2 * w_1) * w_3$$



Target = 10

Predicted = -10

Loss = 20

w<sub>1</sub> = 3

w<sub>2</sub> = 4

w<sub>3</sub> = 5

$$\frac{dz}{dw_1} = \frac{dz}{dy} * \frac{dy}{dg} * \frac{dg}{dw_1} = -10$$

$$\frac{dz}{dw_2} = \frac{dz}{dy} * \frac{dy}{dw_2} = w_3 * 1 = w_3 = 5$$

$$\frac{dz}{dw_3} = y = w_2 + g = w_2 - 2 * w_1 = 4 - 2 * 3 = -2$$



# NEXT... Gradient Descent

