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Basics of Neural Network Programming Vectorization

What is vectorization?

$$z = \underline{w^T x} + b$$

Non-vectorized:

$$z = 0$$

for i in $\text{range}(n-x)$:

$$z += w[i] * x[i]$$

$$z += b$$

$$w = \begin{bmatrix} \vdots \\ \vdots \\ \vdots \end{bmatrix} \quad x = \begin{bmatrix} \vdots \\ \vdots \\ \vdots \end{bmatrix}$$

$$w \in \mathbb{R}^{n_x}$$

$$x \in \mathbb{R}^{n_x}$$

Vectorized

$$z = \underbrace{\text{np.dot}(w, x)}_{w^T x} + b$$

\Rightarrow GPU } SIMD - single instruction
 \Rightarrow CPU } multiple data.



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More vectorization examples

Neural network programming guideline

Whenever possible, avoid explicit for-loops.

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$$u = Av$$

$$u_i = \sum_j A_{ij} v_j$$

$$u = \text{np.zeros}(n, 1)$$

for i ...

for j ...

$$u[i] += A[i][j] * v[j]$$

$$u = \text{np.dot}(A, v)$$

Vectors and matrix valued functions

Say you need to apply the exponential operation on every element of a matrix/vector.

$$v = \begin{bmatrix} v_1 \\ \vdots \\ v_n \end{bmatrix} \rightarrow u = \begin{bmatrix} e^{v_1} \\ e^{v_2} \\ \vdots \\ e^{v_n} \end{bmatrix}$$

```
→ u = np.zeros((n,1))  
→ for i in range(n):  
    → u[i]=math.exp(v[i])
```

```
import numpy as np  
u = np.exp(v)  
  
np.log(v)  
np.abs(v)  
np.maximum(v, 0)  
v**2  
1/v
```

Logistic regression derivatives

$$J = 0, \quad \boxed{\cancel{dw_1 = 0, dw_2 = 0}}, \quad db = 0$$

$$dw = np.zeros((n-x, 1))$$

→ for i = 1 to n:

$$z^{(i)} = w^T x^{(i)} + b$$

$$a^{(i)} = \sigma(z^{(i)})$$

$$J_{\pm} = -[y^{(i)} \log \hat{y}^{(i)} + (1 - y^{(i)}) \log(1 - \hat{y}^{(i)})]$$

$$dz^{(i)} = a^{(i)}(1 - a^{(i)})$$

$$\boxed{\cancel{dw_1 += x_1^{(i)} dz^{(i)}}}$$

$$\boxed{\cancel{dw_2 += x_2^{(i)} dz^{(i)}}}$$

$$\boxed{\cancel{db += dz^{(i)}}}$$

$$n_x = 2$$

$$dw += x^{(i)} dz^{(i)}$$

$$J \equiv J/m, \quad \boxed{\cancel{dw_1 = dw_1/m, dw_2 = dw_2/m, db = db/m}}$$

$$dw /= m.$$