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Basics of Neural Network Programming

Vectorization

What is vectorization?

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

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

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

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

Non-vectorized:

```
z = 0
for i in range(n-x):
    z += w[i] * x[i]
z += b
```

Vectorized

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

$\left.\begin{array}{l} \rightarrow \text{GPU} \\ \rightarrow \text{CPU} \end{array}\right\}$ SIMD - single instruction multiple data.

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More vectorization examples

Neural network programming guideline

Whenever possible, avoid explicit for-loops.

Neural network programming guideline

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$$u = Av$$

$$u_i = \sum_{\substack{i \\ \uparrow}} \sum_{\substack{j \\ \uparrow}} A_{ij} v_j$$

```
u = np.zeros((n,1))
for i ...          ←
    for j ...      ←
        u[i] += A[i][j]*v[j]
```

```
u = np.dot(A,v)
```

Andrew Ng

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, ~~dw1 = 0, dw2 = 0~~, db = 0
for i = 1 to n:
    $z^{(i)} = w^T x^{(i)} + b$
    $a^{(i)} = \sigma(z^{(i)})$
    $J \mathrel{+}= -[y^{(i)} \log \hat{y}^{(i)} + (1 - y^{(i)}) \log(1 - \hat{y}^{(i)})]$
    $dz^{(i)} = a^{(i)}(1 - a^{(i)})$
    ~~$dw_1 \mathrel{+}= x_1^{(i)} dz^{(i)}$~~
    ~~$dw_2 \mathrel{+}= x_2^{(i)} dz^{(i)}$~~
    $db \mathrel{+}= dz^{(i)}$
J = J/m, ~~$dw_1 = dw_1/m$, $dw_2 = dw_2/m$~~, db = db/m
```

$dw = np.zeros((n\_x, 1))$

for $j = 1 \ldots n_x$

$dw_j \mathrel{+}= \ldots$

$n_x = 2$

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

$dw \mathrel{/}= m.$