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Basics of Neural Network Programming

Vectorization

What is vectorization?

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

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

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

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

Non-vectorized:

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

z += b
```

Vectorized

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

→ GPU
→ CPU

} SIMD - single instruction multiple data.

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More vectorization examples

Neural network programming guideline

Whenever possible, avoid explicit for-loops.

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$u = Av$

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

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

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

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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
```

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Logistic regression derivatives

J = 0, ~~dw1 = 0, dw2 = 0~~, db = 0

dw = np.zeros((n_x, 1))

for i = 1 to n:

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

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

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

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

for j=1…n_x
$\mathrm{d}w_j$ += …

$\cancel{\mathrm{d}w_1 \mathrel{+}= x_1^{(i)} \mathrm{dz}^{(i)}}$

$\cancel{\mathrm{d}w_2 \mathrel{+}= x_2^{(i)} \mathrm{dz}^{(i)}}$

$n_x = 2$

$\mathrm{d}w \mathrel{+}= x^{(i)} \mathrm{d}z^{(i)}$

$\mathrm{db} \mathrel{+}= \mathrm{dz}^{(i)}$

J = J/m, ~~$\mathrm{d}w_1 = \mathrm{d}w_1/m$, $\mathrm{d}w_2 = \mathrm{d}w_2/m$~~, db = db/m

dw /= m.

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