Basics of Neural Network Programming

Vectorization

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What is vectorization?

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

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

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

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

Non-vectorized:

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

z += b
```

Vectorized

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

→ 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

$J = 0$, $\boxed{\cancel{dw1 = 0, \; dw2 = 0}}$, $db = 0$

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

→ for i = 1 to n:

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

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

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

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

for $j = 1 \ldots n_x$

$dw_j \mathrel{+}= \ldots$

$$\boxed{\cancel{dw_1 \mathrel{+}= x_1^{(i)} dz^{(i)}} \\ \cancel{dw_2 \mathrel{+}= x_2^{(i)} dz^{(i)}}}$$

$n_x = 2$

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

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

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

$dw \mathrel{/}= m.$

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