1 Vector multiplication

Values are generally represented as x and weights as θ. These are sepparated into two vectors.

values = $\begin{bmatrix} x_1 & x_2 & \cdots & x_n \end{bmatrix}$

weights = $\begin{bmatrix} \theta_1 \\ \theta_2 \\ \cdots \\ \theta_n \end{bmatrix}$

When multiplied together these two vectors will take the following shapes.

(1,n) $\times$ (n, 1) = (1, 1)

After the multiplication the result will be a 1×1 vector, in practice a scalar value. A more concrete example of performing a multiplication.

$\mathrm{v}_1 = \begin{bmatrix} 2 & 3 & 7 & 1 \end{bmatrix}$

$\mathrm{v}_2 = \begin{bmatrix} 0.2 \\ 0.6 \\ 0.7 \\ 0.1 \end{bmatrix}$

$2 \times 0.2 + 3 \times 0.6 + 7 \times 0.7 + 1 \times 0.1 = 7.1999999999999993$

$v_1 \times v_2 = 7.1999999999999993$

```
import numpy as np
v1 = np.array([2, 3, 7, 1])
v2 = np.array([0.2, 0.6, 0.7, 0.1])
np.matmul(v1, v2)
```

2 Matrix and vector multiplication

$$\mathrm{M}_1 = \begin{bmatrix} 2 & 3 & 7 & 1 \\ 4 & 2 & 1 & 9 \end{bmatrix}$$

$$\mathrm{v}_2 = \begin{bmatrix} 0.2 \\ 0.6 \\ 0.7 \\ 0.1 \end{bmatrix}$$

$$(2,4) \times (4,1) = (2,1)$$

$$M_1 \times v_2 = \begin{bmatrix} 7.2 \\ 3.6 \end{bmatrix}$$

```python
import numpy as np
v2 = np.array([0.2, 0.6, 0.7, 0.1])
m1 = np.array([[2, 3, 7, 1],[4, 2, 1, 9]])
np.matmul(m1, v2)
```

3 Matrix multiplication

$$\mathrm{M}_1 = \begin{bmatrix} 2 & 3 & 7 & 1 \\ 4 & 2 & 1 & 9 \end{bmatrix}$$

$$\mathrm{M}_2 = \begin{bmatrix} 0.2 & 0.4 \\ 0.6 & 0.3 \\ 0.7 & 0.2 \\ 0.1 & 0.3 \end{bmatrix}$$

$$(2,4) \times (4,2) = (2,2)$$

$$M_1 \times M_2 = \begin{bmatrix} 7.2 & 3.4 \\ 3.6 & 5.1 \end{bmatrix}$$

```python
import numpy as np
m1 = np.array([[2, 3, 7, 1],[4, 2, 1, 9]])
m2 = np.array([[0.2, 0.4], [0.6, 0.3],[0.7, 0.2], [0.1, 0.3]])
np.matmul(m1, m2)
```

4 Tranpose

Sometimes the roation of the matrix is wrong. In these cases you can use something called *transpose* in order to flip the matrix dimensions. Transpoing of a matrix is generally notated with an uppercase T in superset.

M^T is the matrix M tranposed. Lets assume that the matrix M had the dimensions $(15, 200)$. Then M^T will have the dimensions $(200, 15)$. From the previous examples we have looked at, assume we instead defined M_1 and M_2 as following.

$M_1 = \begin{bmatrix} 2 & 3 & 7 & 1 \\ 4 & 2 & 1 & 9 \end{bmatrix}$

$M_2 = \begin{bmatrix} 0.2 & 0.6 & 0.7 & 0.1 \\ 0.4 & 0.3 & 0.2 & 0.3 \end{bmatrix}$

Now, we cannot multiply M_1 and M_2 since they have the dimensions $(2, 4)$ and $(2, 4)$. However, if we transpose one of them we can. Which one we tranpose will effect the output of the multiplication.

$M_2^T = \begin{bmatrix} 0.2 & 0.4 \\ 0.6 & 0.3 \\ 0.7 & 0.2 \\ 0.1 & 0.3 \end{bmatrix}$

$M_1 \times M_2^T = \begin{bmatrix} 7.2 & 3.4 \\ 3.6 & 5.1 \end{bmatrix}$

If we instead transpose M_1 before we multiply we get the following result.

$M_1^T \times M_2 = \begin{bmatrix} 2.0 & 2.4 & 2.2 & 1.4 \\ 1.4 & 2.4 & 2.5 & 0.9 \\ 1.8 & 4.5 & 5.1 & 1.0 \\ 3.8 & 3.3 & 2.5 & 2.8 \end{bmatrix}$

Note how the the dimensions also change since we now are using the following dimensions. $(4, 2) \times (2, 4) = (4, 4)$.