

04. Neuron Decision Maker

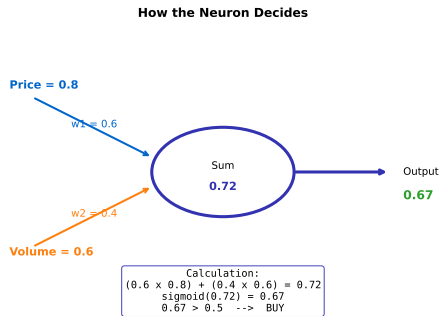
Neural Networks - From Brain to Business

See how a single neuron makes buy/sell decisions using a threshold.

A single neuron acts as a **decision maker** by comparing its output to a **threshold**. For binary classification with sigmoid activation: - Output < 0.5 : Predict Class 1 (BUY) - Output ≥ 0.5 : Predict Class 0 (SELL)

The neuron computes a weighted combination of inputs, transforms it through the sigmoid function, and produces a probability. The threshold converts this probability into a discrete decision.

In trading terms: if the neuron outputs 0.67 (67% confidence in price increase), the decision is BUY. If it outputs 0.33 (33% confidence), the decision is SELL.
The position of the decision boundary in feature space corresponds to where the neuron output equals exactly 0.5 - the point of maximum uncertainty.



Neuron computation:

$$z = w_1x_1 + w_2x_2 + b$$

$$\hat{y} = \sigma(z) = \frac{1}{1 + e^{-z}}$$

Decision rule:

$$\text{Decision} = \begin{cases} \text{BUY} & \text{if } \hat{y} > 0.5 \\ \text{SELL} & \text{if } \hat{y} \leq 0.5 \end{cases}$$

Boundary condition ($\hat{y} = 0.5$):

$$z = 0 \implies w_1x_1 + w_2x_2 + b = 0$$

Think of the neuron as a judge weighing evidence:

1. **Gather evidence:** Each input (price, volume) provides information 2. **Weight importance:** Some evidence matters more (larger weights) 3. **Combine and evaluate:** Sum weighted evidence, adjust by bias 4. **Confidence level:** Sigmoid converts to 0-100% confidence 5. **Make decision:** If confidence \geq 50%, rule in favor (BUY)

The weights encode what the neuron has learned about which inputs matter and how much.

Practice Problem 1

Problem 1

A neuron has weights $w_1 = 0.6$ (for price), $w_2 = 0.4$ (for volume), and bias $b = -0.3$. Given price = 0.8 and volume = 0.5, what is the decision?

Solution

Step 1: Weighted sum

$$\begin{aligned} z &= 0.6(0.8) + 0.4(0.5) + (-0.3) \\ z &= 0.48 + 0.20 - 0.30 = 0.38 \end{aligned}$$

Step 2: Sigmoid activation

$$\hat{y} = \frac{1}{1 + e^{-0.38}} = \frac{1}{1 + 0.684} = 0.594$$

Step 3: Decision Since $0.594 > 0.5$: **Decision: BUY** (59.4% confidence in price increase)

Problem 2

Using the same neuron, what values of (price, volume) lie exactly on the decision boundary?

Solution

On the boundary, $z = 0$:

$$0.6 \cdot \text{price} + 0.4 \cdot \text{volume} - 0.3 = 0$$

Solving for volume:

$$\text{volume} = \frac{0.3 - 0.6 \cdot \text{price}}{0.4}$$

$$\text{volume} = 0.75 - 1.5 \cdot \text{price}$$

Example points on the boundary: - price = 0.0: volume = 0.75 - price = 0.5: volume = 0.0 - price = 0.3: volume = 0.3
These points all yield 50% confidence (maximum uncertainty).

- A neuron outputs a probability via sigmoid activation
- Default threshold of 0.5 converts probability to binary decision
- The decision boundary is where output = 0.5 ($z = 0$)
- Threshold can be adjusted based on risk tolerance
- Single neuron = single linear decision boundary