



December 6, 2025

Learning Goal

Trace how input data flows through a neural network to produce a prediction.

This slide establishes the learning objective for this topic

Key Concept (1/2)

Forward propagation is the process of computing a network's output given an input. Data flows forward from input layer through hidden layers to the output layer - hence the name.

At each layer, we perform two operations: 1. **Linear transformation**: Multiply inputs by weights and add bias ($z = Wx + b$) 2. **Non-linear activation**: Apply activation function ($a = f(z)$)

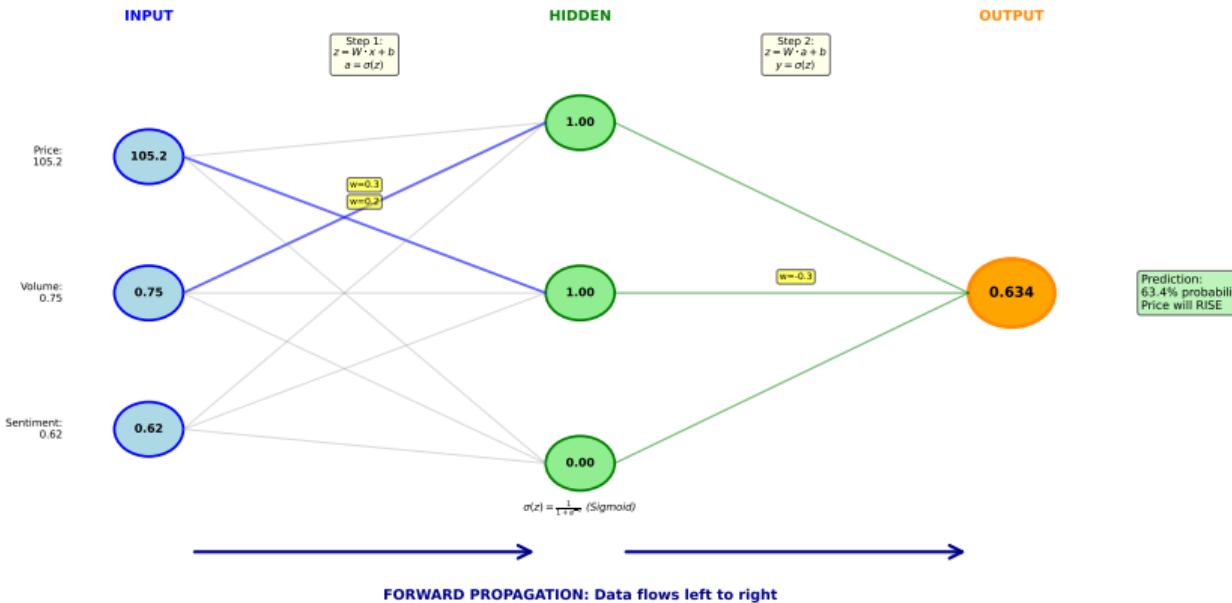
Understanding this concept is crucial for neural network fundamentals

Key Concept (2/2)

The output of one layer becomes the input to the next. When data reaches the output layer, we have our prediction. During training, we compare this prediction to the true value to calculate error.
For a trading application, forward propagation answers: "Given today's market data, what does the network predict about tomorrow's price?"

Understanding this concept is crucial for neural network fundamentals

Forward Propagation: Making a Prediction



Visual representations help solidify abstract concepts

Hidden layer computation:

$$\begin{aligned} z^{[1]} &= W^{[1]}x + b^{[1]} \\ a^{[1]} &= \sigma(z^{[1]}) \end{aligned}$$

Output layer computation:

$$\begin{aligned} z^{[2]} &= W^{[2]}a^{[1]} + b^{[2]} \\ \hat{y} &= \sigma(z^{[2]}) \end{aligned}$$

Where: - x = input features - $W^{[l]}$ = weight matrix for layer l - $b^{[l]}$ = bias vector for layer l - $z^{[l]}$ = pre-activation values - $a^{[l]}$ = activation values (layer output) - \hat{y} = predicted output

Mathematical formalization provides precision

Imagine a relay race where each runner transforms the baton before passing it:

1. **Start:** Raw market data (price = 105.2, volume = 0.75, sentiment = 0.62)
 2. **Hidden layer:** Each neuron "weighs" this data, adds its perspective, and outputs a transformed signal
 3. **Output layer:** The final neuron combines all hidden signals into a single prediction
 4. **Finish:** Probability of price increase (e.g., 74.2%)
- The weights determine how much each neuron "listens" to each input. Training adjusts these weights to improve predictions.

Intuitive explanations bridge theory and practice

Practice Problem 1

Problem 1

A network has 2 inputs, 2 hidden neurons, and 1 output. Given:
- Input: $x = [1.0, 0.5]$
- Hidden weights: $W1 = [[0.2, 0.4], [0.6, 0.3]]$
- Hidden bias: $b1 = [0.1, -0.1]$
Calculate $z1$ (pre-activation for hidden layer).

Solution

For hidden neuron 1:

$$z_1^{[1]} = 0.2(1.0) + 0.4(0.5) + 0.1 = 0.2 + 0.2 + 0.1 = 0.5$$

For hidden neuron 2:

$$z_2^{[1]} = 0.6(1.0) + 0.3(0.5) + (-0.1) = 0.6 + 0.15 - 0.1 = 0.65$$

$$z1 = [0.5, 0.65]$$

Practice problems reinforce understanding

Practice Problem 2

Problem 2

Continuing from Problem 1, apply sigmoid activation to get a_1 (hidden layer output).

Solution

$$a_1^{[1]} = \sigma(0.5) = \frac{1}{1 + e^{-0.5}} = \frac{1}{1 + 0.607} = 0.622$$

$$a_2^{[1]} = \sigma(0.65) = \frac{1}{1 + e^{-0.65}} = \frac{1}{1 + 0.522} = 0.657$$

$$a_1 = [0.622, 0.657]$$

Practice problems reinforce understanding

- Forward propagation computes output from input layer to output layer
- Each layer: linear transformation ($Wx + b$) then activation (f)
- All neurons in a layer compute in parallel
- The final output is the network's prediction
- No learning happens during forward propagation - just computation

These key points summarize the essential learnings