"From Fundamentals to Building Your Own Intelligent System"

AI & Machine Learning Bootcamp 2025

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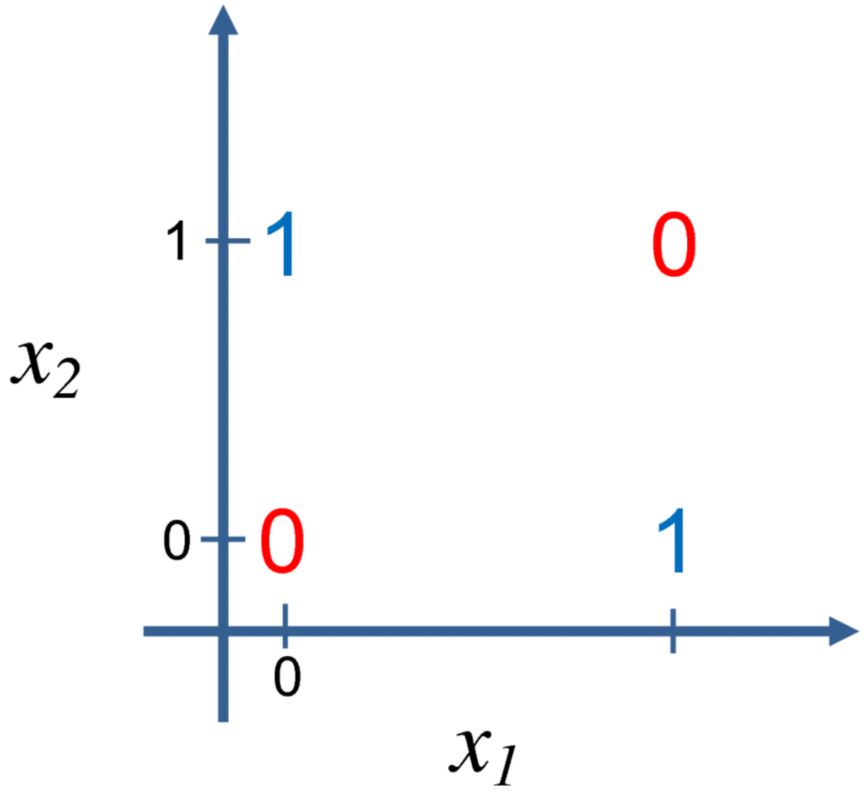
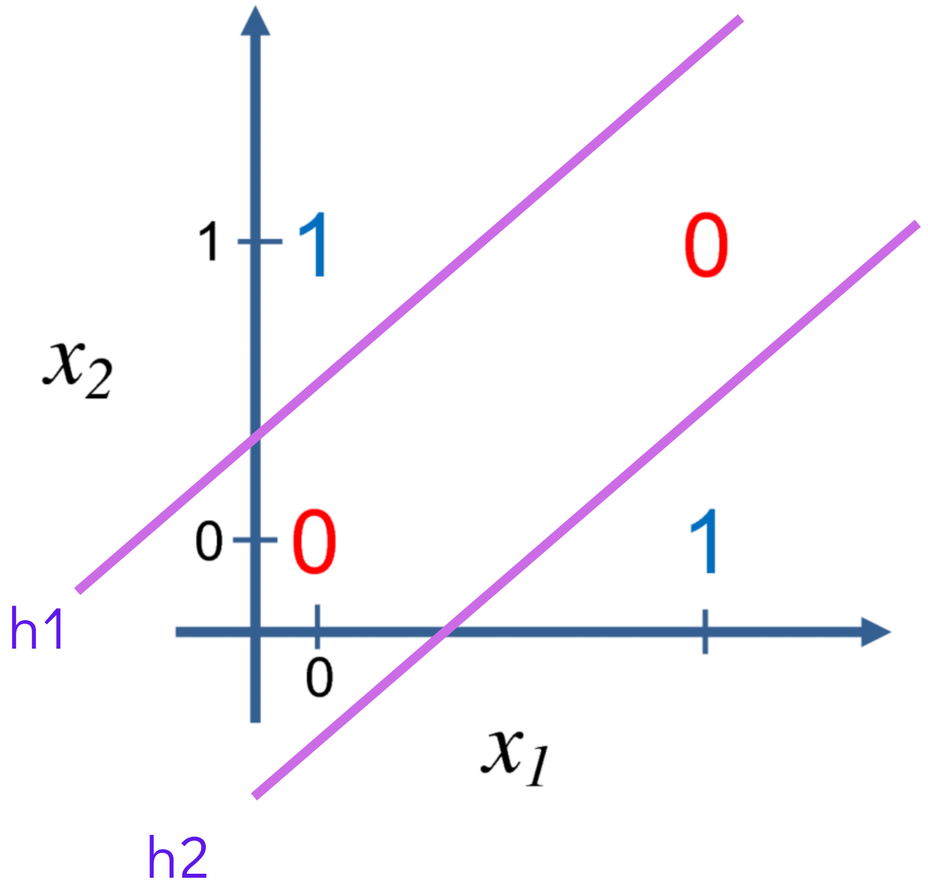
Logical Operation

X	Y	OR	AND	XOR
0	0	0	0	0
0	1	1	0	1
1	0	1	0	1
1	1	1	1	0



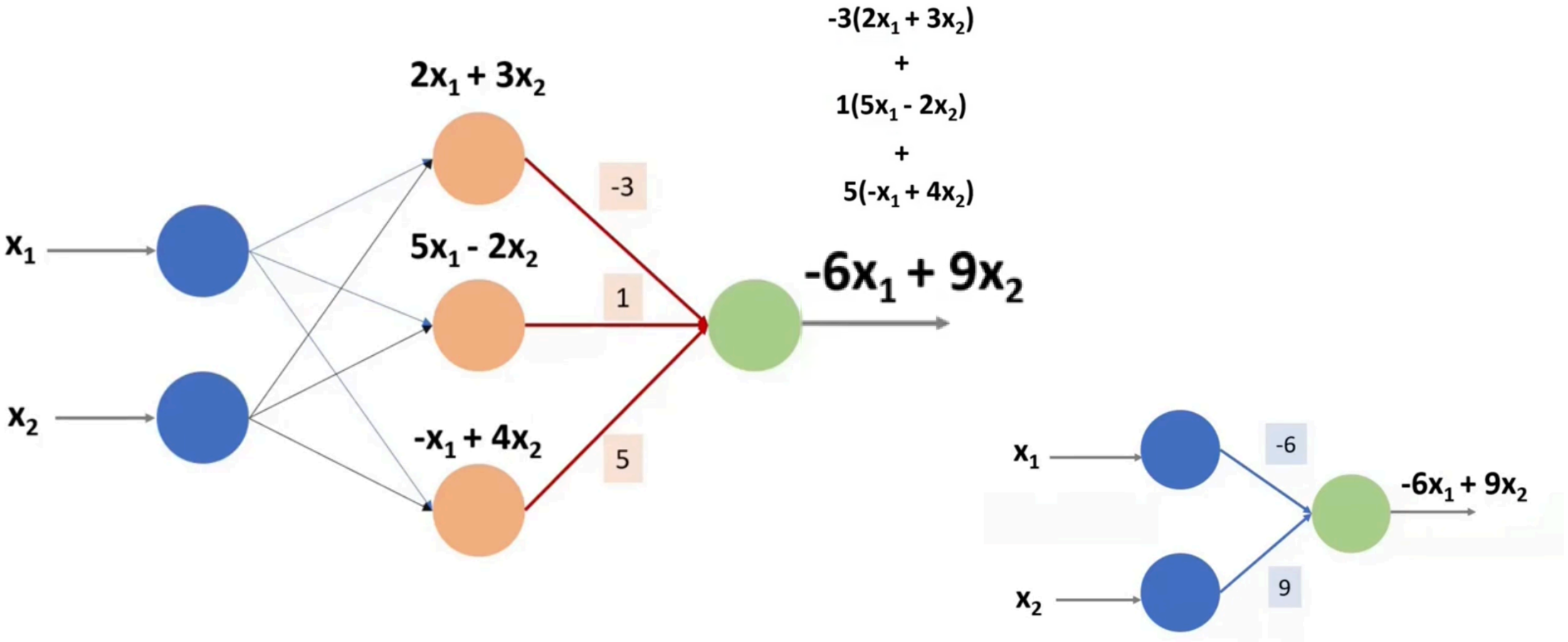
XOR


1
1
0
x_2
0
0
1
h1
0
x_1
h2

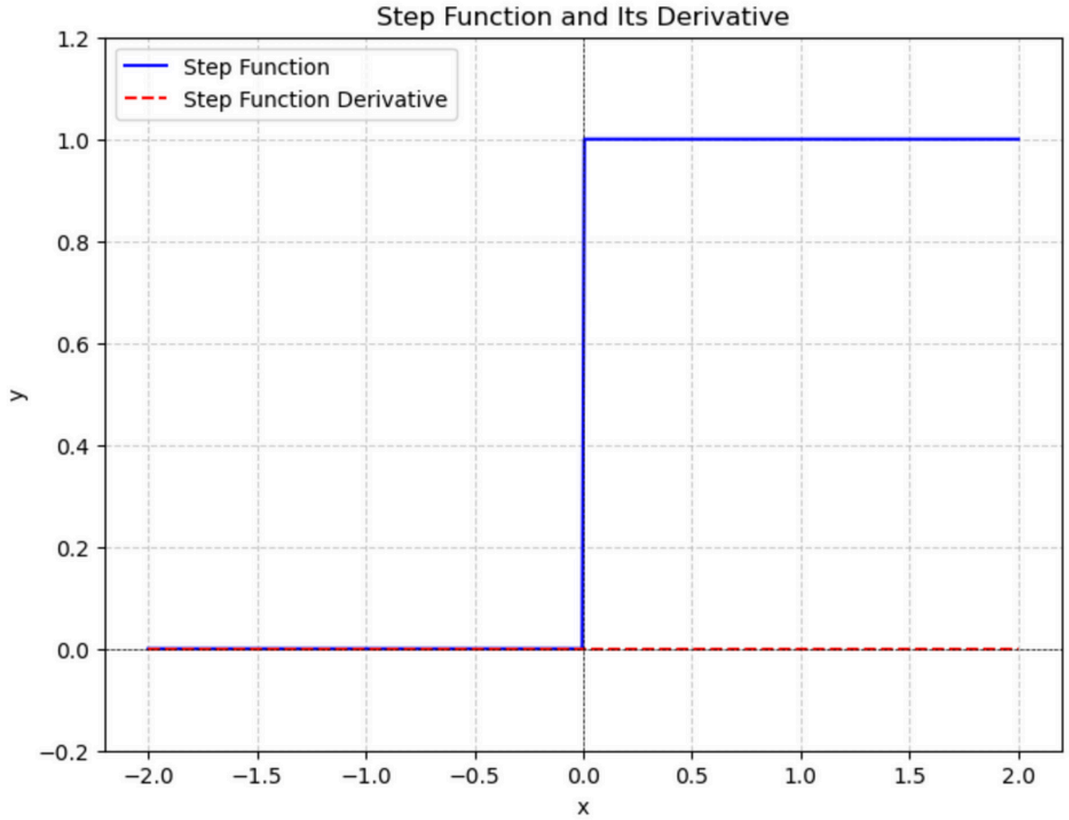
Activation Functions

Why

- To add non-linearity



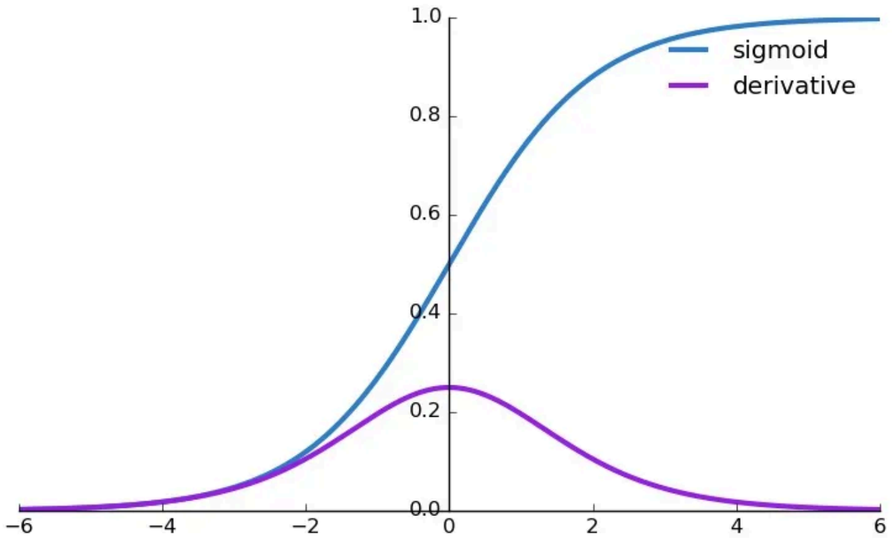
Step function



$$f(x) = \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{if } x \geq 0 \end{cases}$$

- Non-linearity ✓
- Differentiability ✗
- Zero-centeredness ✗
- Computational efficiency ✓

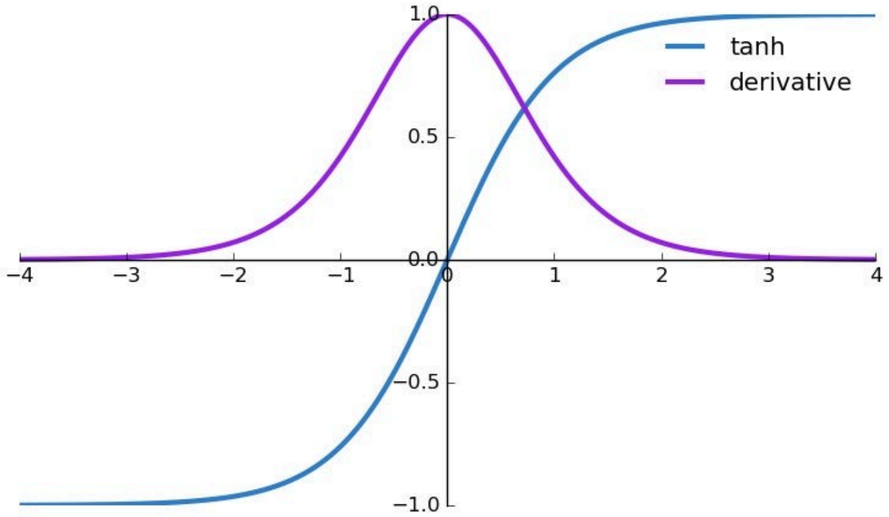
Sigmoid (Logistic)



$$f(x) = \frac{1}{1 + e^{-x}}$$

- Non-linearity ✅
- Differentiability ✅
- Zero-centeredness ❌
- Computational efficiency ⚠️

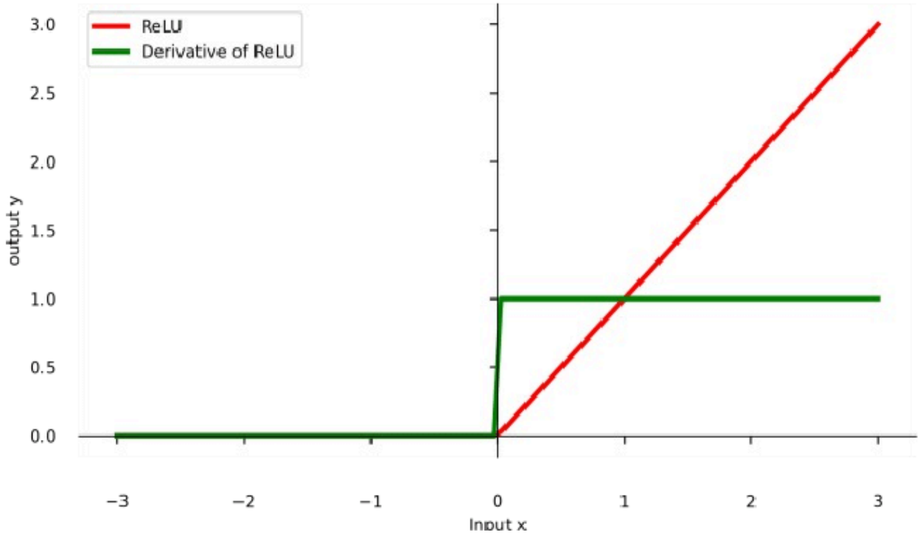
tanh



$$f(x) = \tanh(x) = \frac{2}{1 + e^{-2x}} - 1$$

- Non-linearity ✅
- Differentiability ✅
- Zero-centeredness ✅
- Computational efficiency ⚠️

Rectified Linear Unit (ReLU)



$$f(x) = \max(0, x)$$

- Non-linearity ✅
- Differentiability ⚠️ (not at 0)
- Zero-centeredness ❌
- Computational efficiency ✅

Summary

Activation Function	Non-linearity	Differentiability	Zero-centeredness	Computational Efficiency	Saturation Effects
Step	✓	✗	✗	✓	✓
Sigmoid	✓	✓	✗	⚠	✗
Tanh	✓	✓	✓	⚠	✗
ReLU	✓	⚠ (not at 0)	✗	✓	✗

Cheat Sheet

Problem Type	Last-layer Output Nodes	Hidden-layer activation	Last-layer activation	Loss function
Binary classification	1	RELU (first choice), Tanh (for RNNs)	Sigmoid	Binary Crossentropy
Multi-class, single-label classification	Number of classes		Softmax	Categorical Crossentropy
Multi-class, multi-label classification	Number of classes		Sigmoid (one for each class)	Binary Crossentropy
Regression to arbitrary values	1		None	MSE
Regression to values between 0 and 1	1		Sigmoid	MSE/Binary Crossentropy