A Gentle Introduction to Deep Learning

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Outline

- Learning Goals
- Deep Learning Intuition
- Commonly Used Activations
- Summary

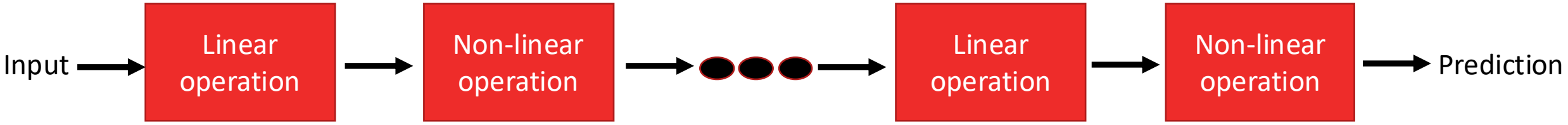
Learning Goals

- Get an intuitive feel for how the majority of deep learning methods work

- Get familiar with different activation functions used in deep learning

Deep Learning Intuition

- Alternated stack of linear and non-linear operations
- Non-linear operations that come immediately after a linear operation are called “activations”
- The activation at the end of the network determines if the model is a regression or classification network
- You can have two consecutive non-linear operations
- Two consecutive linear operations often do not make sense



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Deep Learning Intuition

C = A × B → Equivalent linear operation

$$Y = A \times B \times X$$

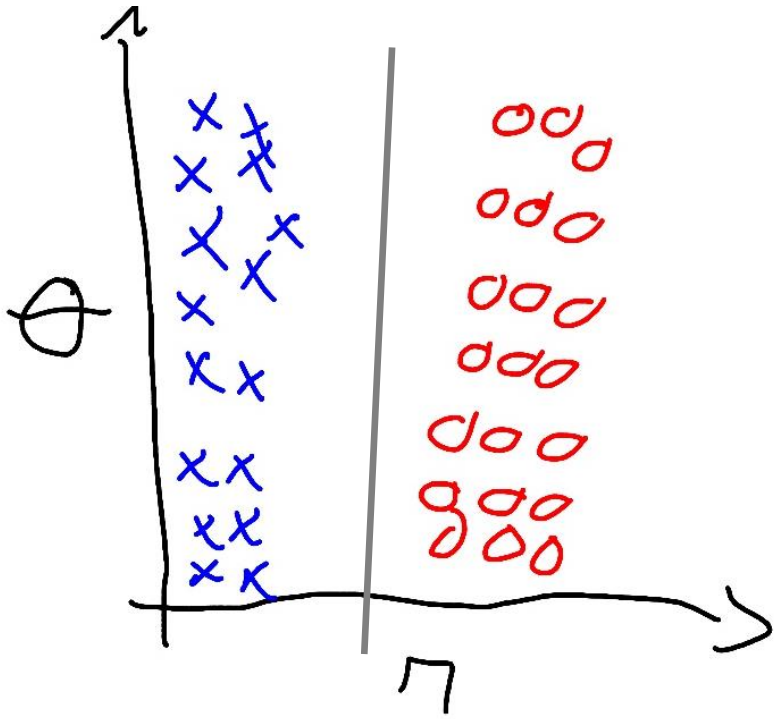
X → Input

Y → Output

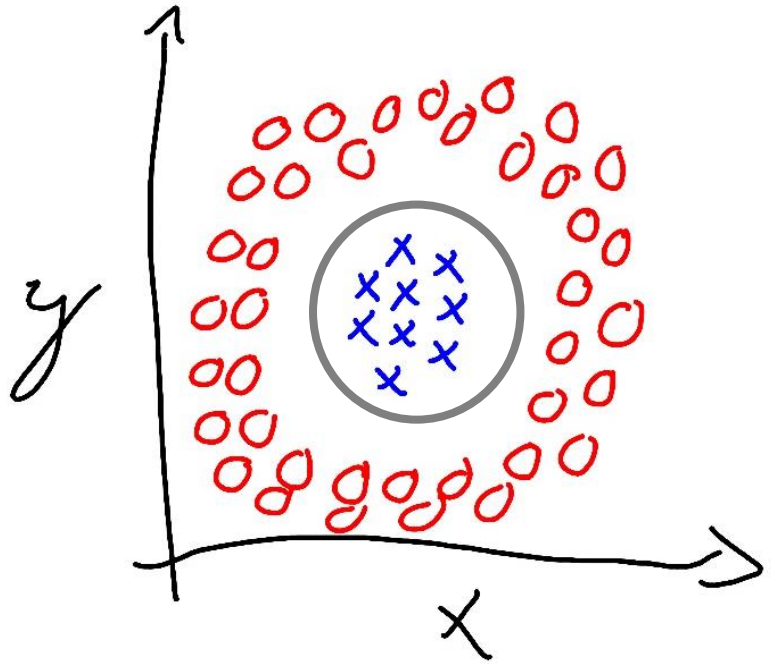
A → Linear Operation

B → Linear Operation

Deep Learning Intuition



Linear model



Non-linear models allow you to get more complex decision boundaries.

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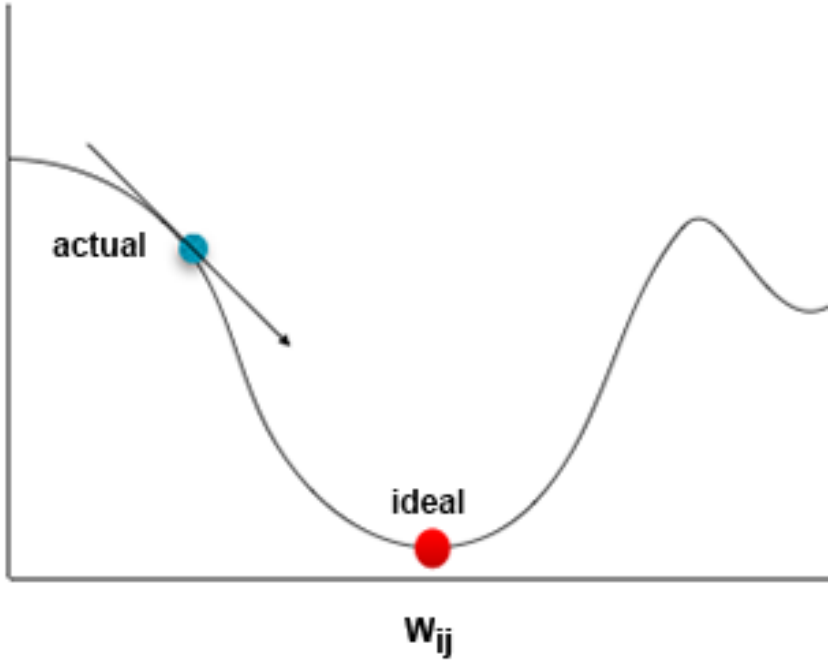
Deep Learning Intuition

1. Data
2. Model
3. Cost function or loss or objective

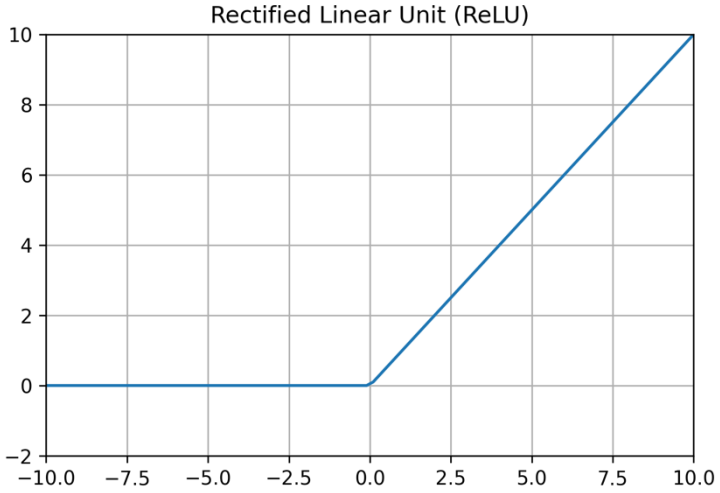
Fit the model to the data by minimizing your cost function.

Deep Learning Intuition

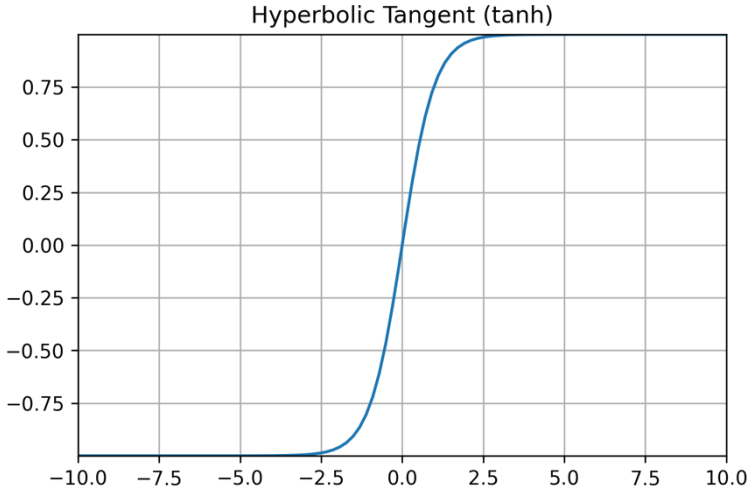
- Gradient descent optimization of the cost function
    - Linear and non-linear operations need to be differentiable
- Compute the gradient across the training set (the whole set or mini-batches)
- Update the model weights by giving a step in the opposite direction (i.e., minimize the cost)
- Compute the average cost function in the train and validation sets after each epoch



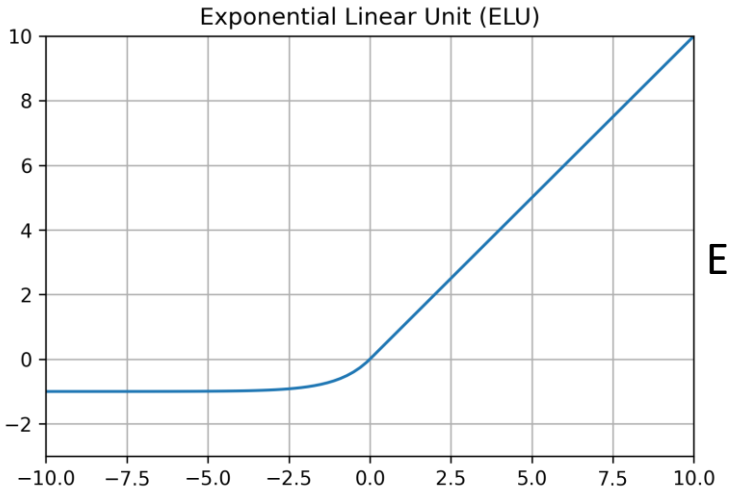
Activations



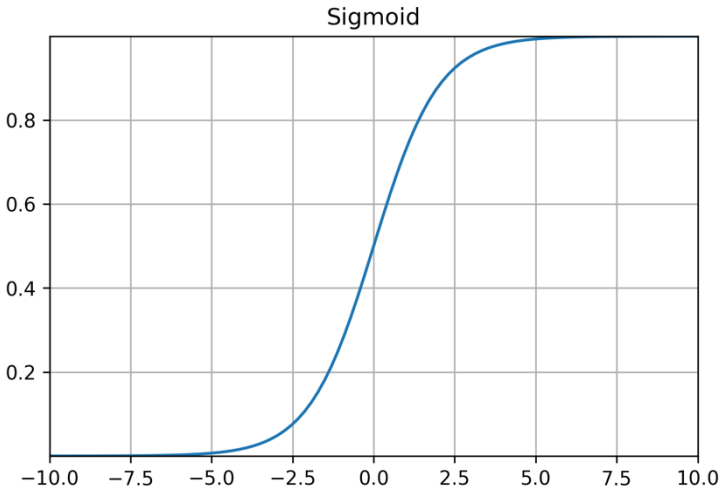
$$\text{ReLU}(x) = \begin{cases} x & x \geq 0 \\ 0 & x < 0 \end{cases}$$



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



$$\text{ELU}(x) = \begin{cases} x & x \geq 0 \\ \alpha(e^{x} - 1) & x < 0 \end{cases}$$



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

https://keras.io/api/layers/activations/

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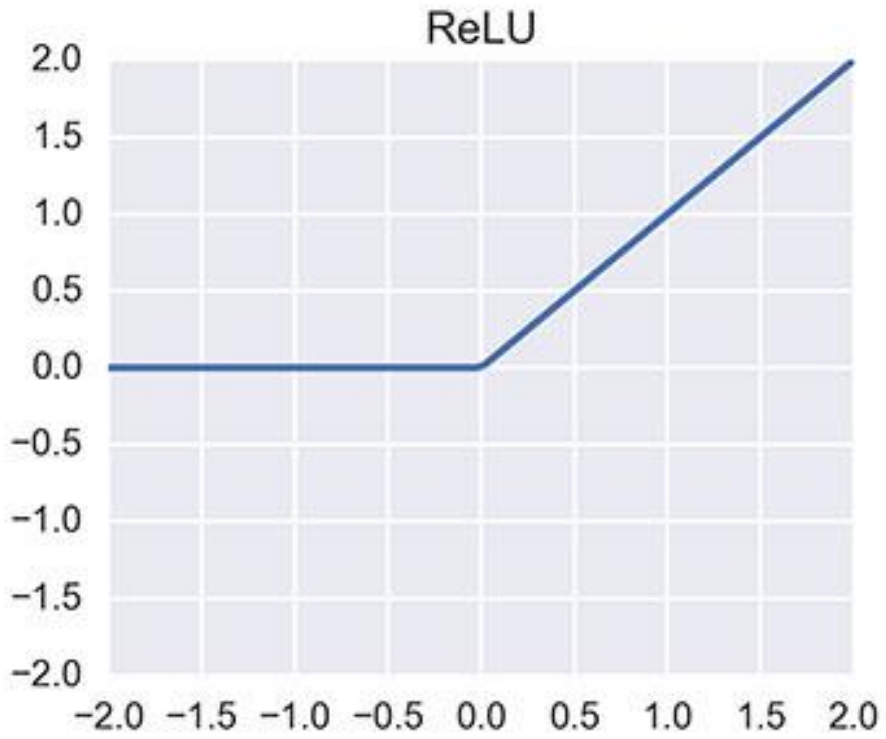
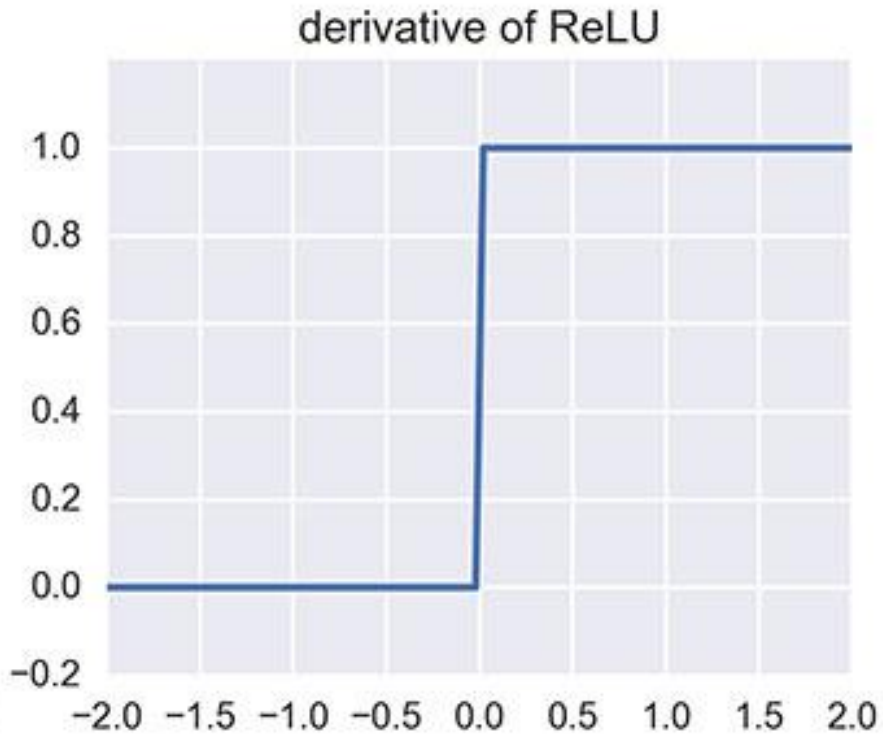
Activations - ReLU





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

$$\frac{dReLU(x)}{dx} = \begin{cases} 1 & x > 0 \\ 0 & x < 0 \end{cases}$$

Activations - Softmax

$$softmax(\vec{z}) = \frac{e^{z_i}}{\sum_{j=1}^{K} e^{z_j}}$$

- Softmax converts a real vector to a vector of categorical probabilities.
- The elements of the output vector are in range (0, 1) and sum to 1.
- Softmax is often used as the activation for the last layer of a classification network -> results are interpreted as a probability distribution.

Summary

- Deep learning models alternate between differentiable linear and non-linear operations
- Deep learning models are fit (i.e., trained) to the data by minimizing a cost function using gradient descent methods
- There are many potential non-linear operations
- ReLUs are commonly used due to their computational simplicity and simple derivative

Thank you!

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