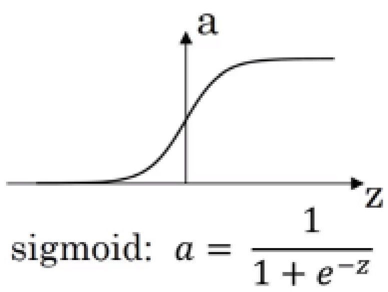
1 Activation functions in neural networks

1.1 Sigmoid / Logistic function



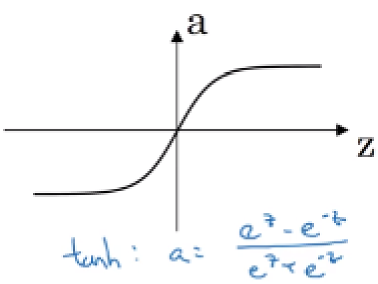
Description

- $g(z) = \sigma(z) = \frac{1}{1+e^{-z}}$; $g'(z) = g(z)\,(1 - g(z))$
- squashes numbers to range [0, 1]
  high values near 1, high negative values near 0
- has a nice interpretation of saturating the "firing rate" of a neuron

Problems

- saturated neurons "kill" the gradient
  high positive and high negative values generate ~0 gradients (flat slope)
- sigmoid outputs are not zero-centered (inneficient gradient updates)
- the exponential function is computationally expensive

1.2 Tanh



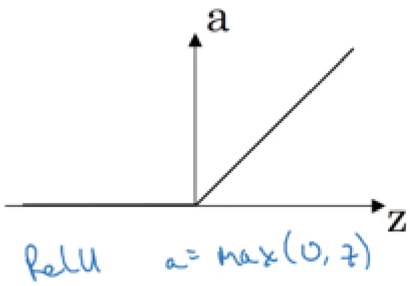
Description

- $g(z) = tanh(z) = \frac{e^z - e^{-z}}{e^z + e^{-z}}$; $g'(z) = 1 - g(z)^2$
- squashes numbers to range [-1, 1]
  high values near 1, high negative values near -1
- outputs are zero-centered

Problems

- saturated neurons "kill" the gradient

1.3 ReLU (REctified Linear Unit)



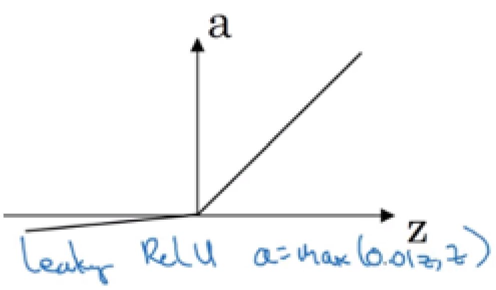
Description

- $g(z) = max(0, z)$; $g'(z) = 0$ if $z < 0$, $g'(z) = 1$ if $z > 0$
- does not saturate in the positive region
- very computationally efficient
- converges much faster than sigmoid/tanh in practice

Problems

- not zero-centered output
- saturated neurons in the negative region
- dead ReLUs will never activate and therefore will never update

1.4 Leaky ReLU



Description

- $g(z) = max(0.01z, z)$; $g'(z) = 0.01$ if $z < 0$, $g'(z) = 1$ if $z > 0$
- does not saturate
- computationally efficient
- converges faster than sigmoid/tanh in practice
- will not die

1.5 Softmax function

Description

- $g(z_j) = \frac{e^{z_j}}{\sum_{k=1}^{K} e^{z_k}}$ for $j = 1, 2, \ldots, K$
- used as the output activation function in a multiclass classification problem
- is a generalization of the logistic function
- squashes a K-dimensional vector z of arbitrary real values to an other K-dimensional vector of real values, where each entry is in the range [0, 1] and all entries sum up to 1