

The hyperbolic tangent (tanh) activation function is another commonly used activation function in machine learning. It's similar to the sigmoid function but has an extended range from -1 to 1. The tanh function is defined as follows:

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

Here's a detailed breakdown of the hyperbolic tangent activation function:

1. Function Range:

- The tanh function squashes its input into the range of (-1, 1).
- As x approaches positive infinity, $\tanh(x)$ approaches 1.
- As x approaches negative infinity, $\tanh(x)$ approaches -1.
- At $x = 0$, $\tanh(0) = 0$.

2. Smoothness:

- Similar to the sigmoid function, the tanh function is smooth and continuously differentiable.

3. Zero-Centered Output:

- Unlike the sigmoid function, the tanh function is zero-centered, which can be advantageous for optimization in certain cases.

4. Derivative (for Backpropagation):

- The derivative of the tanh function with respect to its input x is given by:
$$\tanh'(x) = 1 - \tanh^2(x)$$
- This derivative is used in the backpropagation algorithm during the training of neural networks.

5. Similarity to Sigmoid:

- The tanh function is essentially a scaled version of the sigmoid function. It's mathematically related to the sigmoid as $\tanh(x) = 2 \cdot \sigma(2x) \downarrow$.

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- The tanh function is essentially a scaled version of the sigmoid function. It's mathematically related to the sigmoid as $\tanh(x) = 2 \cdot \sigma(2x) - 1$.

6. Zero-Centered Output:

- One of the advantages of tanh over sigmoid is that it has zero mean, which can help mitigate the vanishing gradient problem in certain cases.

7. Usage:

- The tanh activation function is often used in the hidden layers of neural networks. It can be particularly useful in situations where the data distribution is centered around zero.

In summary, the tanh activation function is similar to the sigmoid but has a different range, mapping inputs to values between -1 and 1. It is useful in situations where zero-centered outputs and a wider range are desired.
