Computer Vision & Pattern Recognition [B]

Mid-term Report

Submitted by:

Rahatul Ashekin Ashik

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Submitted to:

Dr. Debajyoti Karmaker

Associate Professor

Faculty of Science & Technology

Activation Function

The activation function decides whether a neuron should be activated or not by calculating the weighted sum and further adding bias to it. The purpose of the activation function is to introduce non-linearity into the output of a neuron.

There are six types of activation function about which we will discuss the advantage and disadvantage. These are – Step, Sigmoid, TanH, ReLU, PReLU, EReLU.

STEP

The step function maps any input greater than or equal to 0 to 1, and any input less than 0 to 0. This mathematical function produces binary output 0 or 1. Formula of this function is given below-

$$f(x) = \{ 0 \; if \; x < 0; \; 1 \; if \; x >= 0 \}$$

Advantage:

1. Simple and easy to understand
2. Binary output can be useful for certain applications, such as binary classification

Disadvantage:

1. Not continuous, making it unsuitable for gradient-based optimization
2. Output is not smooth, making it hard to use for regression tasks

SIGMOID

The sigmoid function maps any input to a value between 0 and 1. It is commonly used for binary classification tasks, where the output is a probability of belonging to a certain class. Formula of this function is given below-

$$f(x) = 1 / (1 + exp(-x))$$

Advantage:

1. Outputs values between 0 and 1, which can be interpreted as probabilities
2. Relatively simple and easy to compute
3. Differentiable, making it suitable for gradient-based optimization

Disadvantage:

1. Suffers from the vanishing gradient problem, which can make training slow and difficult
2. Prone to saturation when inputs are large, which can cause gradient vanishing and slow convergence

TANH

The hyperbolic tangent (tanh) activation function is a non-linear activation function maps the input to an output between -1 and 1, which makes it zero-centered and better suited for certain types of problems than the sigmoid function. Formula of this function is given below-

$$f(x) = (exp(x) - exp(-x)) / (exp(x) + exp(-x))$$

Advantage:

1. Outputs values between -1 and 1, which can be useful in certain applications
2. Differentiable, making it suitable for gradient-based optimization
3. Zero-centered, which can make optimization easier

Disadvantage:

1. Also suffers from the vanishing gradient problem, which can make training slow and difficult
2. Prone to saturation when inputs are large, which can cause gradient vanishing and slow convergence

RELU

The Rectified Linear Unit function returns the input value if it is positive, and 0 if it is negative. It is a popular choice for many neural networks because it is computationally efficient and has been shown to perform well in many applications. Formula of this function is given below-

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

Advantage:

1. Computationally efficient
2. Does not suffer from the vanishing gradient problem
3. Sparse activation, which can help with overfitting
4. Fast convergence in most cases

Disadvantage:

1. Not zero-centered, which can make optimization harder
2. Can cause dead neurons (ReLU neurons output zero for any input less than or equal to zero), which can lead to reduced network capacity and slow convergence

PRELU

The Parametric Rectified Linear Unit function is a variation of ReLU that introduces a learnable parameter to allow negative input values to have a small gradient instead of 0.

This allows the network to learn a small negative slope for negative inputs and has been shown to improve the performance of some deep learning models. Formula of this function is given below-

$$f(x) = \{ x \; if \; x > 0; \; alpha * x \; if \; x <= 0 \}$$

Advantage:

1. Can prevent dead neurons
2. Faster convergence compared to ReLU in some cases
3. Sparse activation, which can help with overfitting

Disadvantage:

1. More complex than ReLU
2. More difficult to compute compared to ReLU
3. Requires additional parameters to be learned during training

ERELU

The Exponential Linear Unit function is a modified version of ReLU that returns the input value if it is positive and an exponential function of the input if it is negative. It is designed to address the dying ReLU problem and has been shown to perform well in some deep learning models. Formula of this function is given below-

$$f(x) = \{ x \; if \; x > 0; \; a * (exp(x) - 1) \; if \; x <= 0 \}$$

Advantage:

1. Can prevent dead neurons
2. Faster convergence compared to ReLU in some cases

Disadvantage:

1. More complex than ReLU
2. More difficult to compute compared to ReLU
3. Output is not zero-centered, which can make optimization harder