22-8-25

LAB-5

Aim: To study different activation functions used in neural networks.

Objective:

- To explore commonly used activation functions.
- To analyze their mathematical behavior and impact on learning.
- To understand the importance of non linearity in deep neural networks.

Pseudo Code:

1. Define different activation functions:
   Sigmoid, Tanh, ReLU, Leaky ReLU, Softmax
2. Input a range of values.
3. Apply each activation function to the Input
4. Observe the Outputs Curve
5. Compare function based on range, gradient

Observation:

Sigmoid: Smooth, maps values.
Tanh: Similar to sigmoid.

Formula:

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

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

3) ReLu = (Rectified Linear Unit)

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

4) Leaky ReLU

$$f(n) = \begin{cases} a & n > 0 \\ an & n \leq 0 \end{cases}$$

5) Softmax:

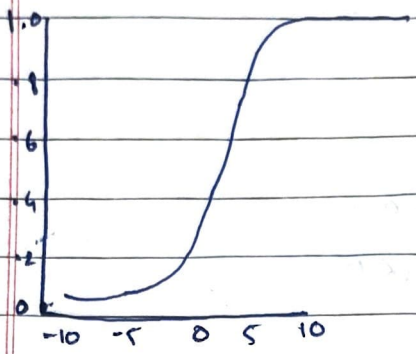
$$f(x_i) = \frac{e^{x_i}}{\sum_{j=1}^{n} e^{x_j}}$$

Observation Table:

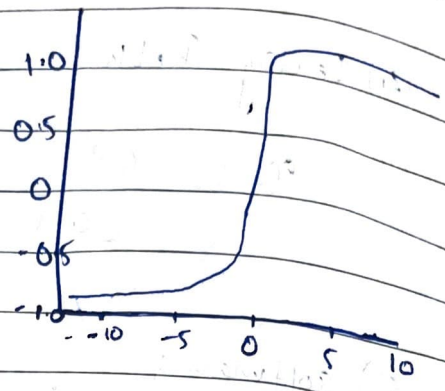
	Activation fn	Output Range	Advantage	Usecase
1)	Sigmoid	(0,1)	Smooth, probabilistic Output	Binary classification
2)	Tanh	(-1,1)	Centered around 0, better than sigmoid.	Hidden layer (Older networks).
3)	ReLU	$(0, \infty)$	Fast, Reduce computation time.	Hidden layer (Modern CNN/ ANN).
4)	Leaky ReLU	$(-\infty, \infty)$	Fixes ReLU (dying) issues	Deep Hidden layer
5)	Softmax	(0,7), sum=1	Give probability Distribution	Output layer for multi-class

Graphs:

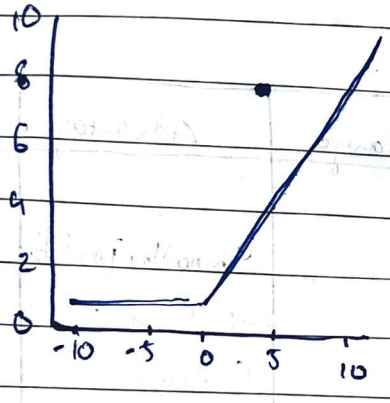
Sigmoid:



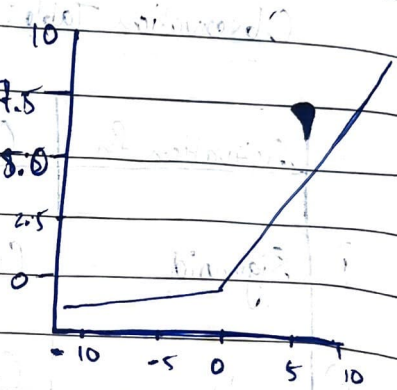
Tanh



ReLU



Leaky ReLU



- ReLU and Leaky ReLU are most effective in hidden layer.
- Sigmoid and Tanh are rarely used today due to vanishing gradient.
- Softmax for multiclass classification problems.

Result:

Studied different activation functions & their roles

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Code | Notebook | Python 3 (ipykernel)

[8]:
```
import numpy as np
import tensorflow as tf
from tensorflow.keras import layers, models
import pandas as pd

activation_functions = [
    'relu', 'sigmoid', 'tanh', 'softplus', 'softsign',
    'elu', 'selu', 'gelu', 'exponential'
]

np.random.seed(42)
x_input = np.linspace(-5, 5, 100).reshape(-1, 1)

results = {
    'Activation Function': [],
    'Output Range': []
}

for act in activation_functions:
    model = models.Sequential([
        layers.Input(shape=(1,)),
        layers.Dense(1, activation=act)
    ])
    y_output = model.predict(x_input, verbose=0)
    y_min, y_max = np.min(y_output), np.max(y_output)
    results['Activation Function'].append(act)
    results['Output Range'].append(f"[{y_min:.3f}, {y_max:.3f}]")
```

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Code | Notebook | Python 3 (ipykernel)

```
    ])
    y_output = model.predict(x_input, verbose=0)
    y_min, y_max = np.min(y_output), np.max(y_output)
    results['Activation Function'].append(act)
    results['Output Range'].append(f"[{y_min:.3f}, {y_max:.3f}]")

results_df = pd.DataFrame(results)

for i in range(0, len(results_df), 3):
    print(results_df.iloc[i:i+3])
    print("-"*40)

results_df.to_csv("activation_function_observation.csv", index=False)
```

```
  Activation Function     Output Range
0                relu   [0.000, 7.692]
1             sigmoid   [0.445, 0.555]
2                tanh  [-1.000, 1.000]
----------------------------------------
  Activation Function     Output Range
3            softplus   [0.032, 3.455]
4            softsign  [-0.748, 0.748]
5                 elu  [-0.748, 1.380]
----------------------------------------
  Activation Function     Output Range
6                selu  [-1.748, 5.462]
7                gelu  [-0.170, 1.495]
8         exponential  [0.058, 17.189]
----------------------------------------
```

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