VIT | Vidyalankar Institute of Technology
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Deep Learning 2024-25

Assignment 2

Design an AI-powered industrial monitoring system that predicts potential equipment failures based on sensor data. The system takes two critical inputs:

- **$x_1 = 1$:** Represents temperature deviation from normal operating levels.
- **$x_2 = -1$:** Represents pressure drop below standard thresholds.

The neural network uses the following parameters:

- **Weight vector (w):** [1, -2, -1, 1] – Reflecting the sensitivity of the system to temperature, pressure, vibration, and fluid levels.
- **Bias (b):** [1, 0] – A baseline adjustment to account for system offsets.

Task 1: Model Behavior with Different Activation Functions

Your goal is to understand how the system reacts to these sensor readings by applying different activation functions to the output layer:

1. **Sigmoid:** Models probability and smooth transitions between failure and normal operation.
2. **ReLU (Rectified Linear Unit):** Allows linear responses for positive values, ignoring negative signals.
3. **Tanh:** Centers outputs around zero, highlighting positive or negative deviations.
4. **Step Function:** Provides a hard threshold for immediate binary decision-making (failure or no failure).

Calculate the output (z) and apply each activation function. How does the system's prediction vary with each function?

Task 2: Decision Boundary and Sensitivity

Imagine the system operates in environments where small changes in sensor inputs (e.g., slight temperature increase or pressure drop) can lead to different predictions.

- **How sensitive is the model to these small input variations under each activation function?**
- **Which activation function would create sharp decision boundaries (immediate action for failure)?**
- **Which one allows for gradual alerts and warnings before critical failure occurs?**

Task 3: Choosing the Optimal Activation Function

The system must be configured based on operational requirements:

- **For safety-critical environments (e.g., nuclear plants),** sharp binary decisions are necessary.
- **For systems requiring adaptive control (e.g., HVAC or fluid monitoring),** smooth responses to sensor data are preferred.

Which activation function is best suited for:

- **Sharp binary alerts** – preventing false negatives in critical situations.
- **Smooth control systems** – maintaining equipment stability with subtle adjustments.

Explain your reasoning with calculations, simulations, or visual interpretations of how the model output shifts with different activation functions.