Report on Training a Fully Connected Feedforward Neural Network (FCFNN) for Approximating a Polynomial Function

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Session :2020-21
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August 28, 2025

1 Introduction

The purpose of this experiment is to design and train a Fully Connected Feedforward Neural Network (FCFNN) to approximate the polynomial function:

$$f(x) = 5x^2 + 10x - 2$$

This exercise demonstrates the capability of neural networks to approximate nonlinear functions using supervised learning.

2 Methodology

2.1 Dataset Preparation

- Input values x were randomly sampled from a uniform distribution in the range $[-20, 20]$.
- Corresponding target values were computed using the polynomial function $f(x)$.
- Both inputs and outputs were normalized to the range $[-1, 1]$ for stable training.
- The dataset was divided into 90% training, 5% validation, and 5% testing.

2.2 Neural Network Architecture

A sequential FCFNN was implemented using TensorFlow/Keras:

- Input layer: 1 neuron (for x).
- Two hidden layers: each with 64 neurons, ReLU activation.
- Output layer: 1 neuron (for regression output).

2.3 Training Setup

- Optimizer: Adam with learning rate 1×10^{-3}.
- Loss function: Mean Squared Error (MSE).
- Metric: R^2 score.
- Training duration: 20 epochs.

3 Results and Observations

3.1 Training Curves

Figure 1 shows the training and validation loss (MSE) across epochs. Both curves decreased smoothly, indicating successful learning. The R^2 score also converged close to 1, showing strong predictive performance.

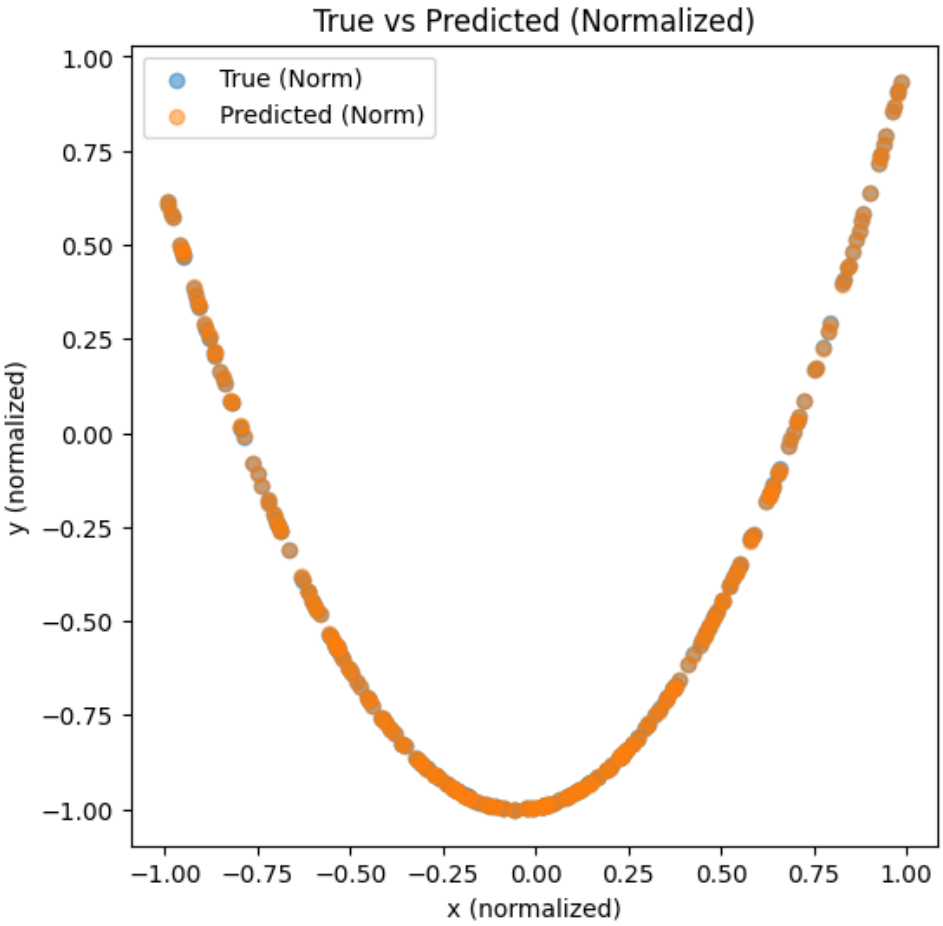

Figure 1: Training and validation loss over epochs.

3.2 Model Predictions

The trained network was evaluated on the test set. Figure 2 compares the true polynomial curve against the predicted outputs. The predicted values closely match the original

function, verifying that the FCFNN successfully approximated the quadratic polynomial.

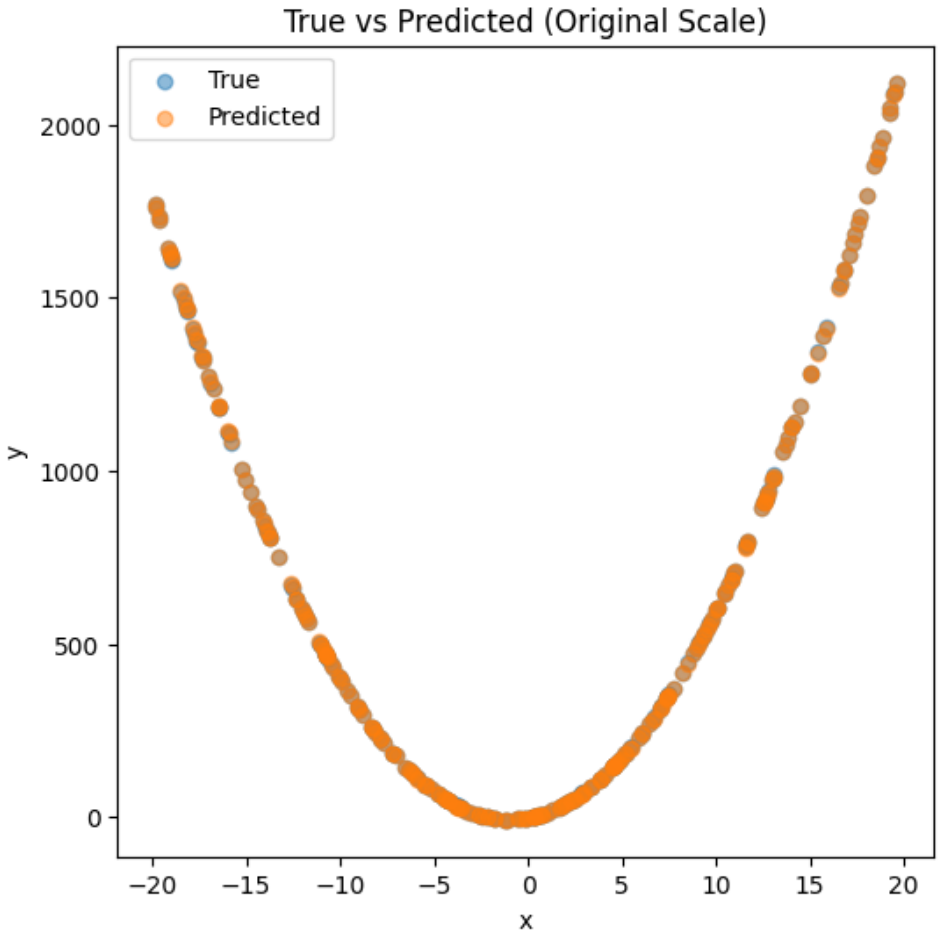

Figure 2: True function vs predicted function.

4 Conclusion

The experiment demonstrated that a simple FCFNN can approximate nonlinear functions such as a quadratic polynomial with high accuracy. Normalization and proper dataset splitting were crucial for stable training. The results confirm the universal approximation capability of feedforward neural networks.