

## **Architecture & Code Modifications**

### **Code Modification:**

1. Final Activation Function
  - Softmax is now used in the output layer.
  - This replaces the binary sigmoid activation previously used.
2. Hidden Layer Activation
  - ReLU (Rectified Linear Unit) is applied in all hidden layers.
    - i. Prevents vanishing gradient problems.
    - ii. Improves training speed and stability in deeper networks.
3. Output Layer
  - Configured with 5 neurons to represent the 5 target classes.
  - Softmax activation ensures multiclass probability outputs.
4. Loss Function
  - Implemented explicit cross-entropy loss for multiclass classification.
  - This replaces the binary error calculation used before.
5. Label Handling
  - Labels are now class indices (0–4).
  - During backpropagation, labels are converted into one-hot encoding to properly compute gradient
6. Prediction Logic
  - Predictions are made using argmax to select the class with the highest probability.

The network has been successfully modified from a binary classifier to a multiclass classifier.

### **Network Structure:**

1. Input Layer: 10 features (10 neurons)
2. Hidden Layer:
  - Layer 1: 64 neurons, ReLU activation
  - Layer 2: 32 neurons, ReLU activation
  - Layer 3: 16 neurons, ReLU activation
3. Output Layer:
  - 5 neurons (corresponding to 5 classes)

- Softmax activation to produce a probability distribution across the classes

## **Results and Analysis:**

- Test Accuracy: 39.31%. This indicates the model correctly predicted the class for roughly 4 out of 10 test samples.
- Class 0 & 3: Strong recall, indicating the model often predicts these classes when they are present.
- Class 2: Very poor precision and recall, the model struggles to identify this class correctly.
- Class 4: High precision but low recall, the model is cautious and only predicts this class when it's confident.
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- Precision: 0.4204
- Recall: 0.3931
- F1 Score: 0.3720
- Confusion Matrix
  - Class 0 and Class 3 show strong diagonal values.
  - Class 2 is frequently misclassified as Class 0 and Class 3.
  - Class 1 and Class 4 have significant confusion with Class 3.

## **Conclusion**

The assignment successfully demonstrated the transition from binary to multiclass classification using a neural network. While the model achieved moderate accuracy and showed strengths in certain classes, challenges such as misclassification and poor performance on specific classes highlight the need for further refinement.

Overall Performance:

- Test Accuracy: 39.31% , the model correctly classified ~4 out of 10 samples.
- Weighted Precision: 0.4204, Weighted Recall: 0.3931, Weighted F1 Score: 0.3720.

- These metrics indicate moderate performance, above random guessing (20% for 5 classes)

With targeted improvements in data handling, architecture design, and optimization strategies, the model's performance can be significantly enhanced for future multi-class classification tasks.