

## **Architecture & Code Modifications**

### **Code Modification:**

1. Final Activation Function
  - Softmax is now used in these 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.