Deep Learning on CIFAR-10: 89% Accuracy Challenge - Final Report

Introduction

The CIFAR-10 dataset, known for its diversity, contains 60,000 color images spread across 10 categories. This project aimed to construct a custom CNN that achieves high classification accuracy efficiently. The target was to surpass 85% validation accuracy within 30 epochs. The final model achieved 89%.

Problem Statement

To design a custom convolutional neural network (CNN) from scratch that achieves a validation accuracy above 85% on the CIFAR-10 dataset within 30 training epochs, without relying on pre-trained models.

Dataset Overview

- Name: CIFAR-10
- Image Count: 60,000 (32x32 resolution)
- Categories: 10 distinct classes
- Training Samples: 50,000
- Test Samples: 10,000

Methodology

Data Preprocessing:

- Normalized images to [0,1] range.
- One-hot encoded labels.
- Split into 30k training and 20k validation samples.

Data Augmentation:

- Rotations, shifts, and horizontal flips.

Model Architecture:

- 4 Convolutional Blocks with Batch Normalization and LeakyReLU.
- MaxPooling layers.
- Dropout layers for regularization.
- Dense output layer with softmax.

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Training Strategy:

- Optimizer: Adam
- Loss: Categorical Crossentropy
- Learning Rate Scheduler: ReduceLROnPlateau
- Training limited to 30 epochs.

Results

- Final Validation Accuracy: 89%
- Test accuracy closely matched validation accuracy.
- Training was completed efficiently within the epoch limit.

Discussion

The project's success emphasizes how structured model tuning and data augmentation enable excellent performance. LeakyReLU activation boosted convergence speed by mitigating dead neuron issues, and dropout layers prevented overfitting.

Conclusion

A validation accuracy of 89% was attained without transfer learning. This showcases that with smart architecture, data preprocessing, and training strategies, competitive results are achievable even with basic CNNs.

Future Work

- Build deeper CNNs.
- Introduce modern augmentations like CutMix.
- Explore lightweight CNNs for mobile deployment.

References

- TensorFlow and Keras official documentation

- CIFAR-10 Dataset Documentation

- 'Deep Learning' by Ian Goodfellow et al.