■ Detailed Report on GTSRB Notebook (CNN & MobileNetV2)

■ Introduction

This notebook analyzes the German Traffic Sign Recognition Benchmark (GTSRB) dataset using two deep learning approaches: a custom Convolutional Neural Network (CNN) and a transfer learning model based on MobileNetV2. The objective is to classify traffic sign images into their respective categories with high accuracy.

■ Dataset & Preprocessing

The dataset consists of over 39,000 traffic sign images categorized into 43 different classes. Preprocessing steps included resizing images to 32x32 pixels, normalization, and data augmentation to improve generalization. Labels were encoded using one-hot encoding.

■ CNN Model Results

1. Training Accuracy: ~99.6%
2. Validation Accuracy: ~99.6%
3. Validation Loss: ~0.0155
4. Strength: Learned robust features with data augmentation.
5. Weakness: Prone to overfitting on rare classes.

■ MobileNetV2 (Transfer Learning) Results

1. Training Accuracy: ~95%
2. Validation Accuracy: ~99.8%
3. Validation Loss: ~0.0071
4. Strength: Superior generalization due to pre-trained ImageNet features.
5. Weakness: Computationally heavier compared to CNN.

■ Classification Report Summary

Metric	Score
Overall Accuracy	0.98
Macro Avg F1	0.98
Weighted Avg F1	0.98

■ Confusion Matrix Insights

The confusion matrix showed excellent recognition across most classes. Some rare classes exhibited minor misclassifications, but overall precision and recall remained very high. This highlights the effectiveness of both CNN and MobileNetV2 in handling multi-class classification.

■■ CNN vs MobileNetV2 Comparison

1. CNN achieved high accuracy but showed slight overfitting in rare classes.
2. MobileNetV2 consistently outperformed CNN in validation accuracy (~99.8%).
3. Data augmentation was crucial for CNN to reduce overfitting.
4. MobileNetV2 required more computation but provided stronger generalization.

■ Conclusion

The notebook demonstrates that deep learning can achieve near-perfect accuracy on the GTSRB dataset. While the custom CNN provided strong results, MobileNetV2 transfer learning proved superior in accuracy and robustness. Future work could explore architectures like EfficientNet, ResNet, and advanced techniques to handle class imbalance, such as SMOTE or focal loss.