Transfer Learning for Traffic Sign Recognition

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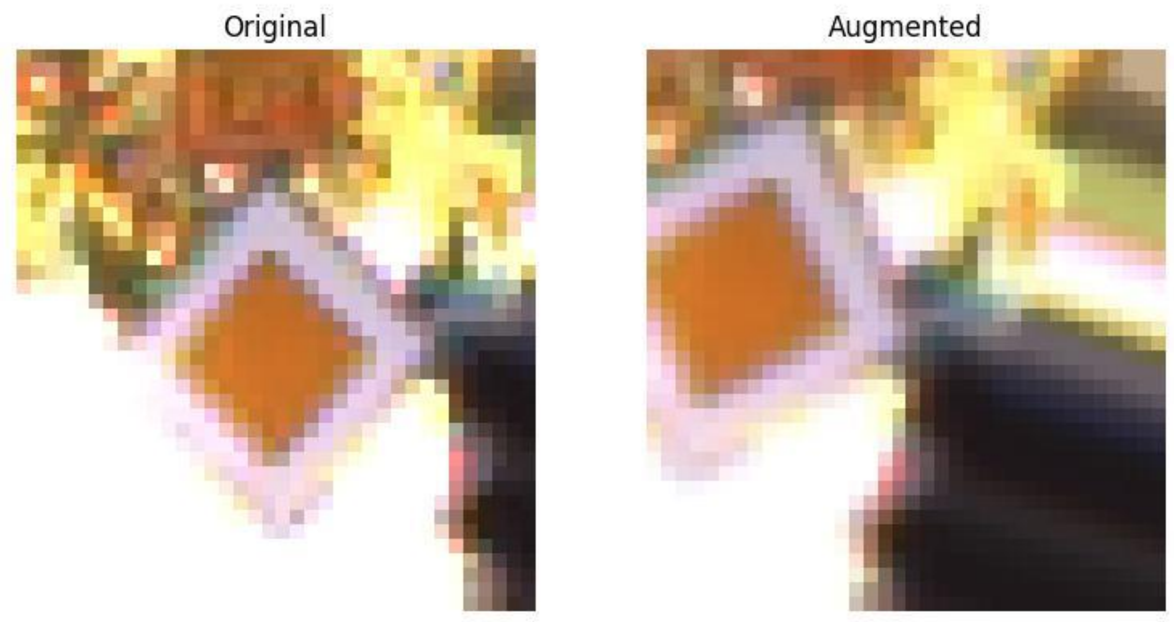
Introduction: Traffic sign recognition is crucial for road safety and efficient traffic management. There are many different road signs so being able to identify each one correctly is pivotal to road safety, so this requires a robust recognition model. This project explores the effectiveness of transfer learning, specifically utilizing the pre-trained model VGG16.

Objectives:

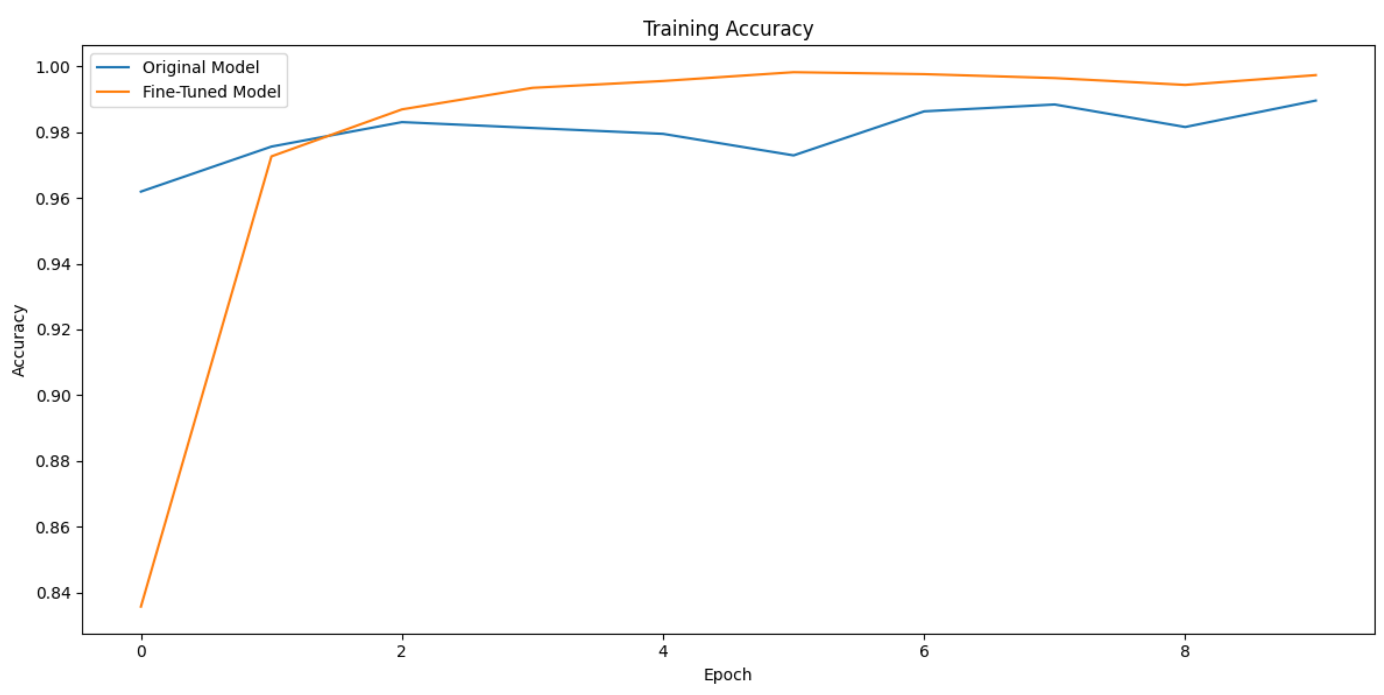
1.Implement Transfer Learning: Apply VGG16 for robust traffic sign recognition.
2.Enhance Dataset Understanding: Address challenges like class imbalances for better insights.
3.Optimize Model Performance: Fine-tune and use data augmentation for improved accuracy, especially in limited-sample classes.
4.Conduct In-Depth Analysis: Evaluate performance metrics, unraveling training and validation patterns.

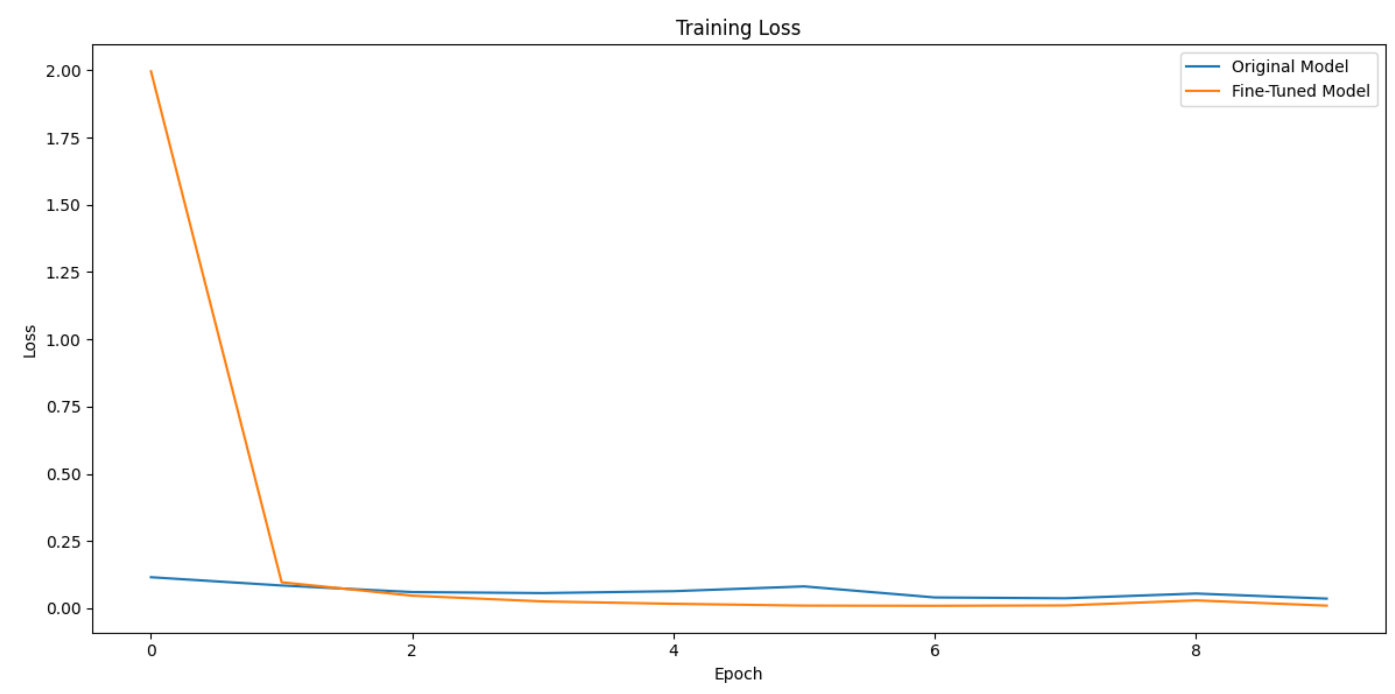
Data Preprocessing & Data Augmentation: To ensure compatibility with the VGG16 model, all traffic sign images were resized to the standard input size of 224x224 pixels. Additionally, pixel values were normalized to the range [0, 1]. This preprocessing step ensures uniformity and facilitates stable model training.

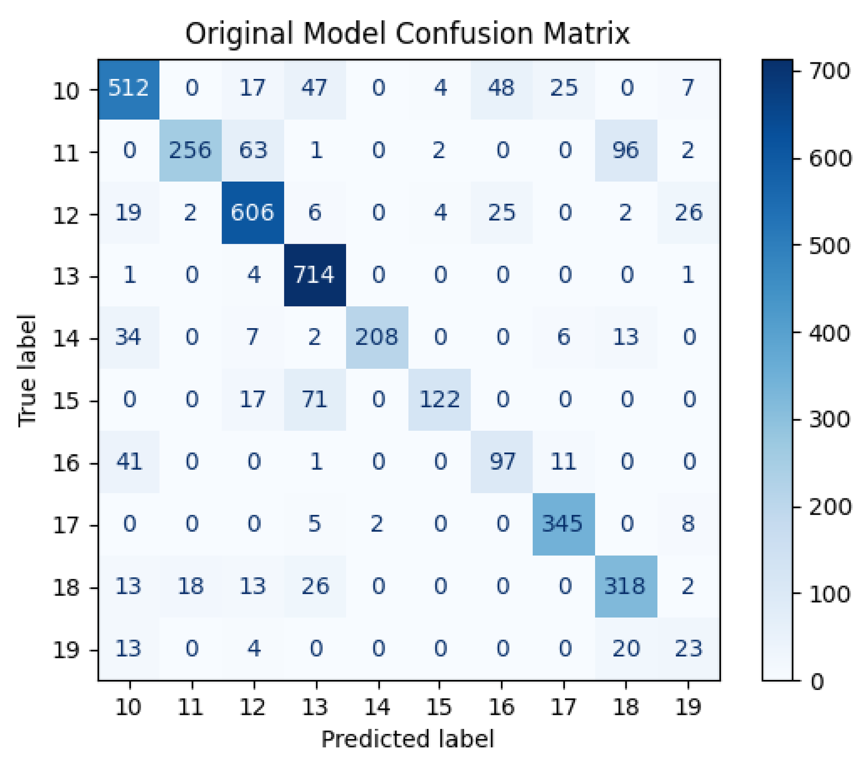
To enhance the model's ability to generalize, an ImageDataGenerator from Keras was employed for data augmentation. This involves applying random transformations to the original images, generating augmented samples for model training to increase the size of the minority classes which were present in the dataset.



Training: Leveraging the pre-trained VGG16 model, a custom classification head was integrated for traffic sign recognition. The model, compiled with Adam optimizer and categorical crossentropy loss, underwent training on an augmented dataset. During fine-tuning, specific layers were selectively unfrozen for improved dataset adaptation. Training dynamics exhibited clear trends: the original model maintained high accuracy with consistent low loss, while the fine-tuned model showcased gradual accuracy improvement and a sharp reduction in training loss. This highlights the fine-tuned model's adaptability and refinement throughout the training process.



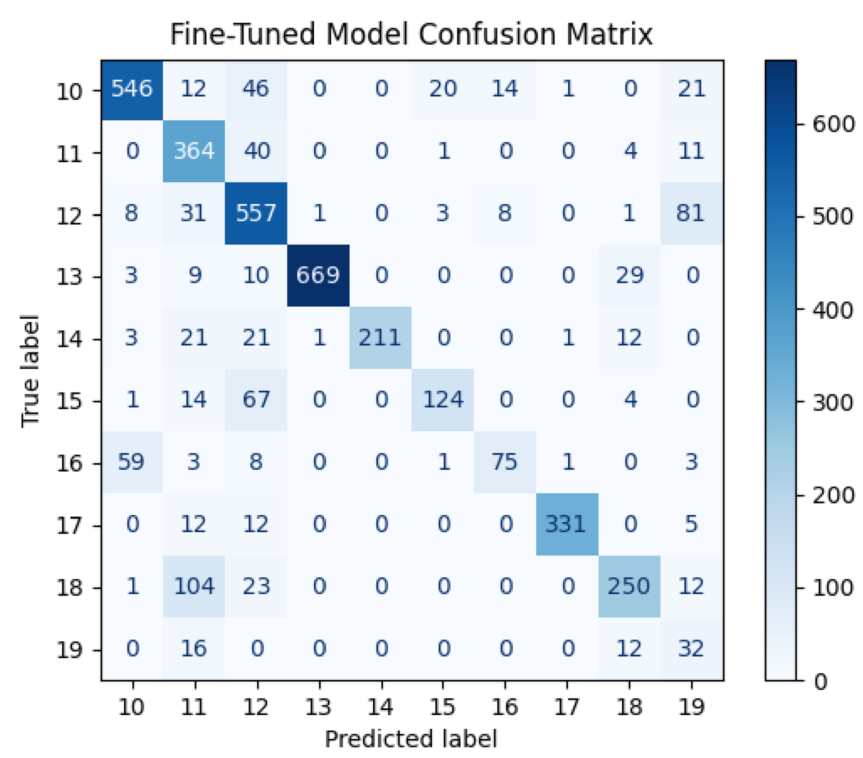




Test Set Performance:

Original Model:
- **Test Accuracy:** 81.45%
- **Test Loss:** 0.6962

Fine-Tuned Model:
- **Test Accuracy:** 80.38%
- **Test Loss:** 0.6663



Results & Conclusion: This study centers on developing a robust traffic sign classifier through deep learning. Rigorous data preprocessing, including curation and augmentation, ensured model resilience. Fine-tuning a pre-trained VGG16 model for the specific task showcased test set accuracies of approximately 81.5% for the original model and 80.4% for the fine-tuned model. This underscores the importance of refining models for real-world applications, contributing to the advancement of intelligent systems for safer driving. Despite challenges with class 19 as shown in the confusion matrices, both models exhibited commendable performance across other classes. A prediction image underscores the models' proficiency in identifying road signs, with the fine-tuned model displaying slightly higher confidence in its prediction.