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Traffic Signs Detection and Classification Using ResNet

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Introduction

Traffic sign recognition is a critical component in modern autonomous driving systems and advanced driver-assistance systems (ADAS). The ability to accurately detect and classify traffic signs ensures safer driving by alerting drivers to important road information and assisting autonomous vehicles in decision-making processes. This project utilizes the Residual Network (ResNet) architecture to classify traffic signs from a publicly available dataset.

Problem Statement

The primary challenge addressed in this project is the automatic recognition and classification of traffic signs from images. This task involves several complexities, including:

- Variations in lighting conditions: Traffic signs must be recognized in different lighting environments, such as daylight, dusk, and nighttime.
- Occlusions: Signs can be partially obscured by objects like trees, vehicles, or other signs.
- Different perspectives: The angle and distance from which a sign is viewed can vary greatly. Accurate traffic sign classification is essential for reducing road accidents and enhancing the overall safety of driving environments.

Dataset Overview

The dataset used in this project is sourced from the German Traffic Sign Recognition Benchmark (GTSRB). It includes:

- Number of Classes: The dataset contains images of 43 different types of traffic signs.
- Number of Images: There are over 50,000 images in the dataset, with varying numbers of images per class.
- Preprocessing Steps: Data preprocessing is crucial for preparing the dataset for training. Steps include:
    - Normalization: Standardizing the pixel values to a common range to ensure uniformity.
    - Data Augmentation: Techniques such as rotation, scaling, and flipping are applied to increase the diversity of the training data and improve model robustness.

Methodology

I employed the ResNet architecture for this project. ResNet, short for Residual Network, is known for its deep layer representations and the introduction of residual connections, which help mitigate the vanishing gradient problem in deep neural networks. Key aspects of the methodology include:

- ResNet Architecture: ResNet-50, which consists of 50 layers, was chosen for its balance between depth and computational efficiency.
- Model Training: The model was trained using the TensorFlow framework. Key hyperparameters such as learning rate, batch size, and number of epochs were tuned through experimentation.
- Residual Connections: These connections allow gradients to flow more easily through the network during backpropagation, facilitating the training of deeper networks.

Implementation

The implementation of the project involved several key steps, demonstrated through the following code snippets:

- Data Loading: Importing the dataset and splitting it into training, validation, and test sets.
- Model Creation: Defining the ResNet architecture using TensorFlow.
- Training: Compiling and fitting the model on the training data.
- Evaluation: Assessing the model's performance on the test data.

Discussion

- Interpretation of Results: The results demonstrate the effectiveness of ResNet in classifying traffic signs with high accuracy. The model's performance indicates its potential for real-world applications in autonomous driving systems.

- Challenges: Several challenges were encountered during the project, including data imbalance, where some classes had significantly fewer examples than others, and the need for extensive computational resources for training.

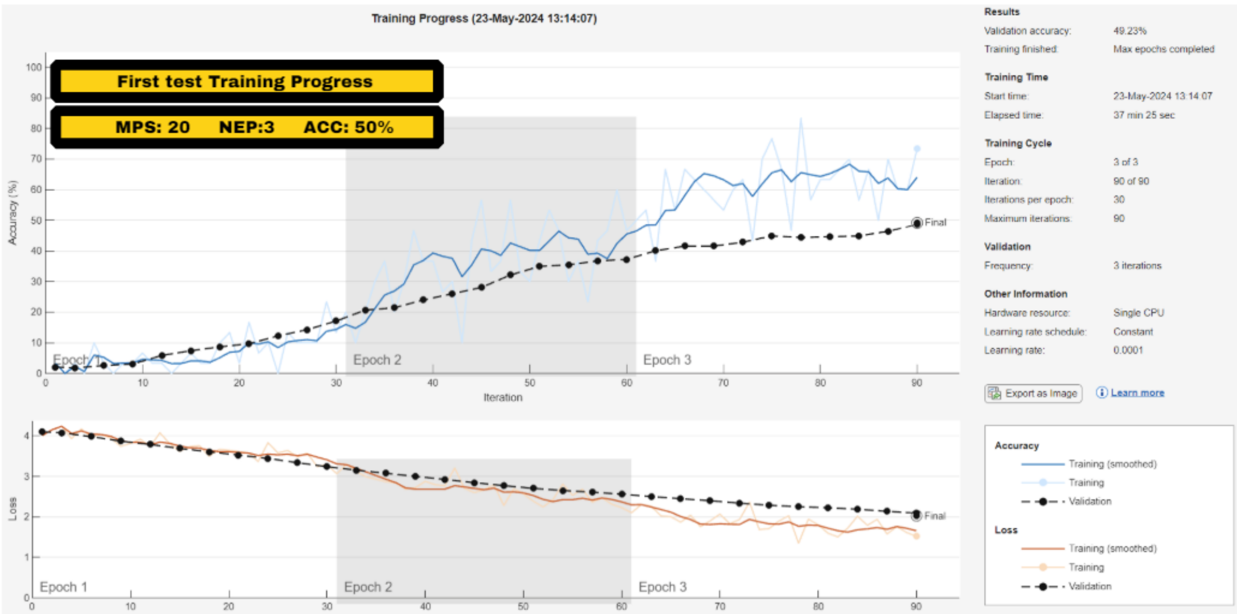
- Future Work: Future improvements could involve exploring ensemble methods to combine multiple models for better performance, increasing the dataset size with more diverse examples, and fine-tuning hyperparameters further.

Conclusion

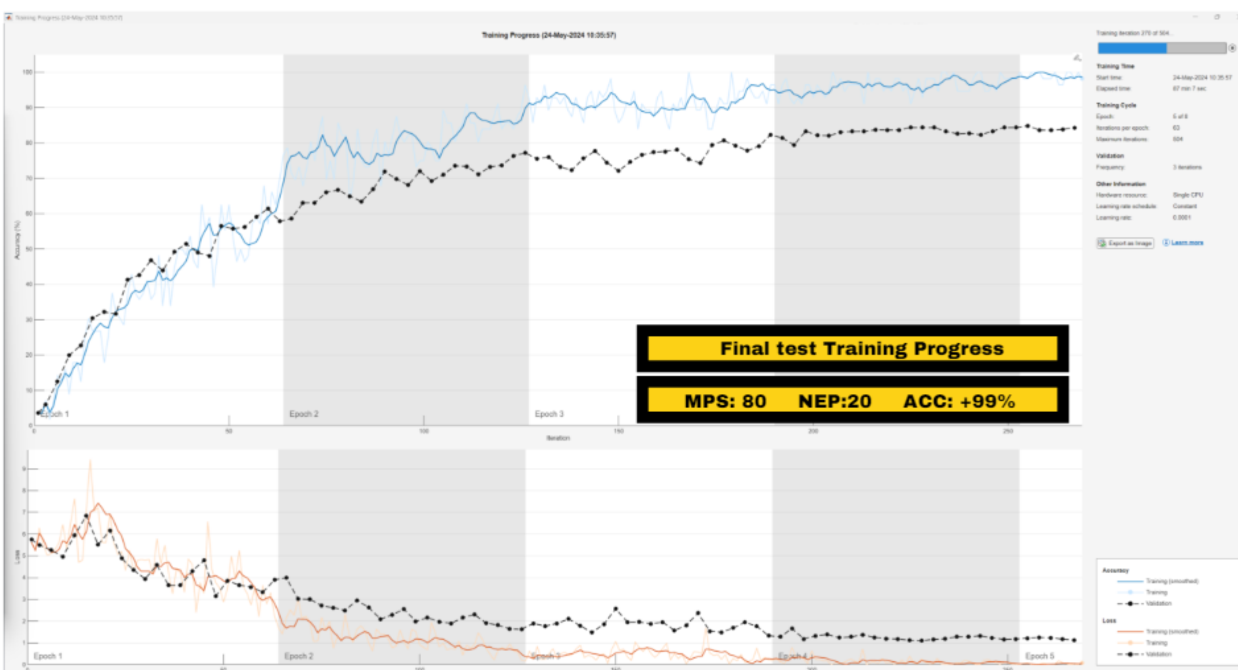
In conclusion, this project highlights the importance of traffic sign classification in enhancing road safety and supporting the development of intelligent transportation systems. The ResNet model demonstrated strong performance, indicating its potential for practical applications. Further research and development can continue to improve the accuracy and robustness of such models.

Experiments

First test Training Progress

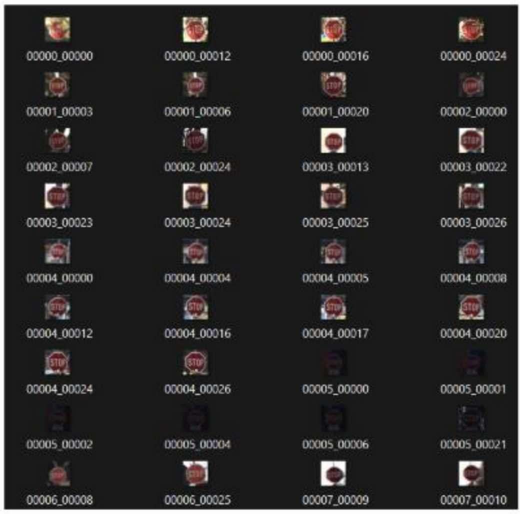


Final test Training Progress



Dataset Overview

Training Dataset



Testing Dataset