Transfer Learning and Fine-Tuning for Image Classification

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1 Introduction

Transfer learning leverages knowledge from large-scale datasets to improve performance on smaller, task-specific datasets. In this work, transfer learning and fine-tuning strategies are applied to two image classification problems: Facial Expression Recognition (FER) and DeepWeeds classification.

2 Datasets

2.1 Facial Expression Recognition

The FER dataset consists of facial images categorized into seven emotional classes: angry, disgust, fear, happy, neutral, sad, and surprise.

2.2 DeepWeeds

The DeepWeeds dataset contains outdoor images of various weed species captured under real-world conditions, making classification challenging due to background complexity and lighting variation.

3 Pre-trained Model Selection

3.1 FER Model

MobileNetV2, pre-trained on ImageNet, was selected due to its lightweight architecture and suitability for small datasets with fine-grained features such as facial expressions.

3.2 DeepWeeds Model

ResNet50 was selected for DeepWeeds due to its deep residual architecture, which is effective for learning complex visual patterns in natural outdoor scenes.

4 Data Augmentation

Data augmentation techniques including random horizontal flipping, rotation, color jittering, and resizing were applied to improve generalization and reduce overfitting.

5 Fine-Tuning Strategies

Two strategies were explored:

- **Partial Fine-Tuning**: Freezing the backbone and training only the classifier layers.

- **Full Fine-Tuning**: Training all layers of the network.

6 Evaluation Metrics

Model performance was evaluated using accuracy, precision, recall, F1-score, and confusion matrices.

7 Results and Discussion

For FER, partial fine-tuning yielded better generalization due to the limited dataset size. For DeepWeeds, ResNet50 achieved strong performance by effectively learning complex spatial features.

8 Conclusion

This study demonstrates that transfer learning significantly improves performance for both datasets. Appropriate model selection and fine-tuning strategies are crucial and should be adapted to dataset characteristics.