Project Report: Image Classification on Oxford 102 Flower Dataset

1. Introduction

This project involves building a deep learning model to classify images of flowers from the **Oxford 102 Flower Dataset** into 102 distinct categories. Leveraging a pre-trained Convolutional Neural Network (CNN) with transfer learning and fine-tuning, the project aimed to achieve high accuracy despite the dataset's challenges, such as class imbalance and visual similarity across categories.

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2. Dataset Overview

Dataset Characteristics:

- **Total Classes:** 102 flower categories.
- **Images per Class:** Between 40 and 258 images, creating a total of over 8,000 images.
- **Key Challenges:**
    - **Intra-class variation:** Flowers within the same category vary significantly in appearance.
    - **Inter-class similarity:** Visually similar flowers exist across different categories, leading to potential misclassifications.

Filtered Dataset:

To simplify analysis, the top 10 flower categories with the highest image counts were identified:

- **Top Classes and Image Counts:**
    - Petunia: 258 images
    - Passionflower: 251 images
    - Wallflower: 196 images
    - Water Lily: 194 images
    - Nasturtium: 184 images
    - Rose: 171 images

- Plumeria: 166 images
- Foxglove: 162 images
- Cyclamen: 154 images
- Lotus: 137 images.

A subset of the dataset was created using these 10 classes, containing a total of 1,993 images.

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3. Model Architecture and Training Process

Architecture:

- **Base Model:** Pre-trained ResNet18.
- **Loss Function:** Cross-entropy loss for multi-class classification.
- **Optimization:** Did hyperparameter tunning achieving the best results with SGD optimizer with a learning rate of 0.01.

Training Configuration:

- **Epochs:** 5 epochs for faster execution.
- **Batch Size:** Best performance with 64 after hyperparameter tunning.
- **Data Augmentation:**
  - Random cropping and flipping for enhanced generalization.
  - Normalization for standardizing pixel values.

Training Strategy:

- Initially froze the pre-trained layers and trained only the custom head.
- Later unfroze the full model for fine-tuning using a reduced learning rate.

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4. Evaluation Results

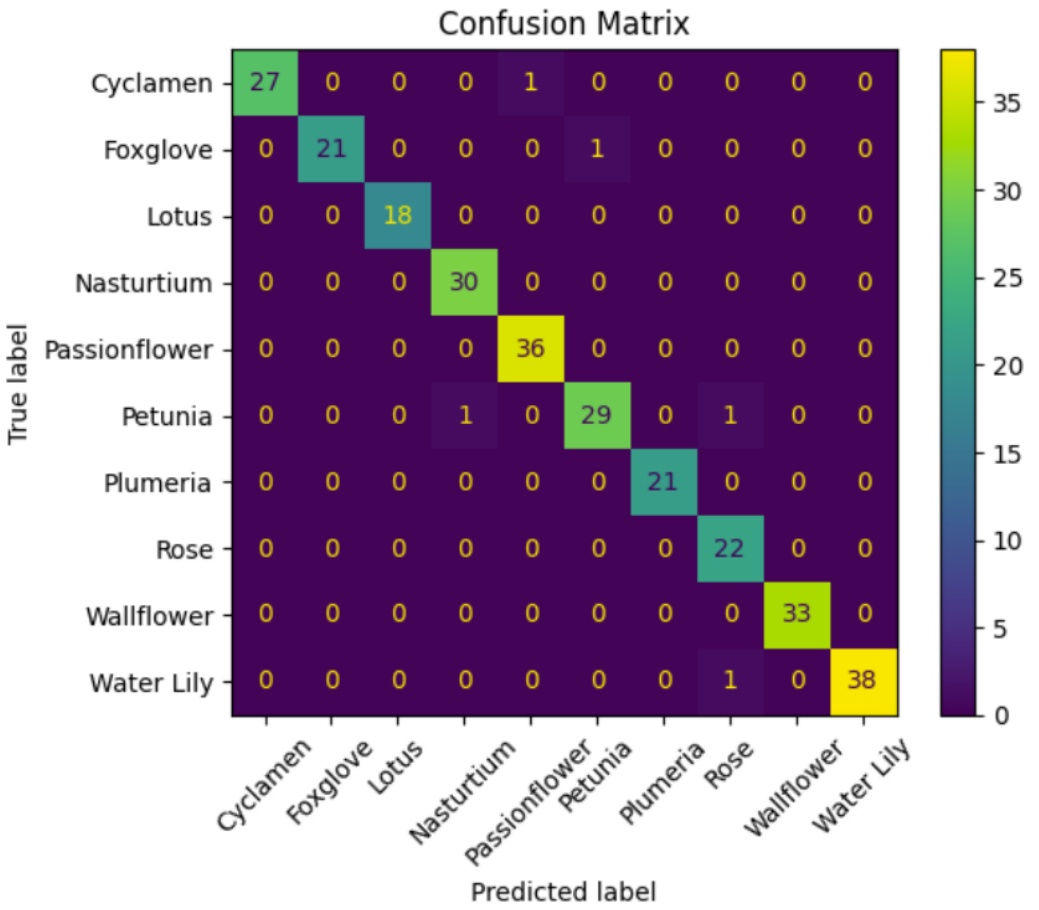
Metrics:

The model was evaluated using standard metrics:

- **Training Accuracy:** Achieved 98.21 %.

- **Validation Accuracy:** Achieved 98.21%.
- **Test Accuracy:** Achieved 98%.
- **Loss Curves:** Training and validation loss converged smoothly, indicating no overfitting.

Confusion Matrix Analysis:



The confusion matrix revealed:

High accuracy for distinct flower categories, showing just a very few misclassifications in categories like Petunia and Rose.

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5. Insights and Discussion

Observations:

1. **Performance:** The model performed well overall, with higher accuracy for classes with abundant data.
2. **Misclassifications:** Categories with visual similarities or lower representation were more challenging, leading to misclassifications.
3. **Generalization:** Effective data augmentation enhanced the model's robustness.

Key Challenges:

- **Class Imbalance:** Lower-represented classes, like Lotus, saw reduced performance.
- **Visual Similarity:** Classes like Rose and Foxglove were misclassified.