Tree Leaf Recognition with Transfer Learning

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Abstract

This project applies transfer learning to fine-grained tree species recognition using the Leafsnap dataset (185 species). Leveraging a pre-trained ResNet50 with a lightweight classifier head, we achieve 91.2% top-1 accuracy and 98.1% top-5 accuracy in just 38 minutes of training, achieving a 38× speedup over typical end-to-end CNNs. Results confirm that transfer learning makes deep learning accessible to practitioners with minimal resources and time.Tree-Leaf-Recognition-with-Transfer-Learning.docx

Introduction

Fine-grained visual categorization remains challenging due to low inter-class variance among species. Training deep CNNs from scratch is impractical for most users. This project uses transfer learning, proposing a ResNet50 feature extractor with only the final classification layer trained for tree leaf recognition, thereby dramatically reducing computational requirements and expertise barriers.Tree-Leaf-Recognition-with-Transfer-Learning.docx

Dataset

- Leafsnap Dataset (Kumar et al., 2012): 30,866 images, 185 tree species (lab + field conditions), roughly balanced distribution.
- Split: 80% train, 10% validation, 10% test.
- Images resized, center-cropped, and normalized. Data augmentation (flips, rotation, crops, color jitter) applied.Tree-Leaf-Recognition-with-Transfer-Learning.docx

Methods

- Backbone: ResNet50 (pre-trained, convolutional layers frozen).
- Only final classifier (2048→185) is trained (~185K parameters).
- Optimizer: Adam (lr=0.0001, weight decay=0.0001).
- Batch size: 64, epochs: up to 50 (with early stopping).
- Training uses RTX 3060 GPU.Tree-Leaf-Recognition-with-Transfer-Learning.docx

Results

Split	Top-1 Accuracy	Top-5 Accuracy	Loss
Training	93.1%	98.9%	0.213
Validation	91.2%	98.1%	0.346

- Training time: 38.5 minutes (25 epochs).Tree-Leaf-Recognition-with-Transfer-Learning.docx
- Inference: ~100ms/image on GPU.

- Model outperforms or matches prior works in accuracy and speed.

Discussion

- Error analysis: Misclassifications mainly between species within the same genus or visually similar families, especially in field images.
- Transfer learning allows rapid convergence, eliminates heavy regularization, and requires limited tuning.
- Accessible for domain experts, not just ML specialists.Tree-Leaf-Recognition-with-Transfer-Learning.docx

Future Work

- Two-stage fine-tuning (unfreeze final ResNet block).
- Model ensembling and integration of attention mechanisms.
- Lightweight mobile deployment (TF Lite).
- Dataset refinement and augmentation.Tree-Leaf-Recognition-with-Transfer-Learning.docx

Conclusion

Transfer learning with ResNet50 delivers fast, highly accurate tree species recognition, enabling domain experts to deploy reliable models for ecological and biodiversity research without massive computational investment. Top-5 accuracy above 98% indicates strong reliability for real-world use-cases.Tree-Leaf-Recognition-with-Transfer-Learning.docx

References

1. Kumar et al., ECCV 2012.
2. Barr et al., Ecological Informatics 2017.
3. He et al., CVPR 2016.
4. Galbally et al., Stanford CS230.
5. Yosinski et al., NIPS 2014.
6. Koenig & Patel, Stanford CS229.Tree-Leaf-Recognition-with-Transfer-Learning.docx

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