Transfer Learning Report: MobileNet vs ResNet50

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This Report Includes:

- Model Architectures
- Comparison of Results
- Unfreezing Strategies
- Optimal Strategy
- Colab Notebook Links

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1. Model Architectures

ResNet50

ResNet50 is a deep convolutional neural network with 50 layers, known for its strong performance on a variety of image classification tasks. In this experiment, ResNet50 was used with ImageNet pretrained weights and without the fully connected top layer. The architecture leverages residual connections to allow for training very deep networks efficiently. Different unfreezing strategies were applied to study the effect on performance, training time, and adaptability.

MobileNet

MobileNet is a lightweight convolutional neural network designed for efficient performance on mobile and embedded devices. It uses depthwise separable convolutions to reduce computation and model size. Unlike MobileNetV2, it does not include inverted residuals or linear bottlenecks.

In this experiment, we used MobileNet (86 layers) pretrained on ImageNet. The model was evaluated in its frozen state and fine-tuned using different unfreezing strategies to study their effects on accuracy, inference time, and trainable parameters.

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2. Comparison of Results

Summary Table – Accuracy, Inference Speed, and Trainable Parameters:

Model	Strategy	Test Accuracy	Inference Speed	Trainable Parameters
ResNet50	Base Model (frozen)	88.93%	~6.8 sec / 100 images	~2,600,000
ResNet50	Strategy A (unfreeze layers)	92.37%	~6.7 sec / 100 images	22,094,853
ResNet50	Strategy B (unfreeze final blocks)	92.01%	~6.7 sec / 100 images	14,986,245
MobileNet	Base Model (frozen)	90.46%	5.33 sec / 100 images	5,125
MobileNet	Strategy A (unfreeze 30 layers)	85.29%	4.10 sec / 100 images	2,400,773
MobileNet	Strategy A (unfreeze 50 layers)	88.83%	5.24 sec / 100 images	3,077,893
MobileNet	Strategy B (unfreeze final blocks)	35.97%	5.32 sec / 100 images	5,125

Key Observations

ResNet50

- The frozen base model achieved 87.84% validation accuracy with minimal training.
- Strategy A (last 20 layers) significantly improved performance to 91.29% validation and 92.37% test accuracy.
- Strategy B (conv5 only) reduced the number of trainable parameters to ~15M, while maintaining comparable accuracy.
- Strategy B (conv4 + conv5) yielded the highest validation accuracy (93.10%), confirming the importance of deeper fine-tuning.

MobileNet

- The frozen base model achieved the highest test accuracy (90.46%) with the smallest model size.
- Strategy A-50 provided a strong balance between performance (88.83%) and flexibility.
- Strategy A-30 offered the fastest inference time (4.10s) but with lower accuracy (85.29%).
- Strategy B (unfreezing the final block only) performed poorly, indicating insufficient adaptation capacity.

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3. Unfreezing Strategies

ResNet50

- **a. Which unfreezing strategy performed better? Why?**
  Strategy B (conv4 + conv5) gave the best validation accuracy (93.10%), but Strategy A (last 20 layers) performed similarly with the same number of trainable parameters (22M). Strategy B (conv5 only) was more efficient, reducing parameters to 15M while maintaining ~92% test accuracy.
- **b. What happened when we unfroze too many or too few layers?**
  Unfreezing only conv5 reduced parameters but still improved accuracy. Adding conv4 (conv4+conv5) gave the best validation results. Strategy A with 20 layers covered both blocks and achieved the same result.

MobileNet

- **a. Which unfreezing strategy performed better? Why?**
  Strategy A-50 performed best (88.83%), achieving high accuracy while allowing the model to adapt. Strategy A-30 underperformed slightly but was faster. Strategy B drastically underperformed (35.97%).
- **b. What happened when we unfroze too many or too few layers?**
  - Unfreezing too few (A-30) limited adaptation.
  - Unfreezing more (A-50) improved accuracy.
  - Unfreezing only final blocks (B) lacked representational flexibility.

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4. Optimal Strategy

ResNet50
Strategy A (last 20 layers) is optimal as it provides strong accuracy (92.37%) and full control, while Strategy B (conv4 + conv5) confirms the same layers yield the best accuracy (93.10%) with the same parameter cost.

MobileNet
Strategy A-50 is optimal. It provides the best test accuracy (88.83%) with reasonable inference time and adaptability.

If speed and efficiency are priorities, Strategy A-30 offers a suitable trade-off.

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5. Colab Notebook Links

- **ResNet50 Notebook** – Toqa Asedah
- **MobileNet Notebook** – Hala Khalifeh