Face Mask Detection Using Deep Learning

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1. Introduction

Problem Statement
In public spaces, detecting whether individuals are wearing face masks properly is important for health and safety enforcement. Automating this process using deep learning reduces human error and makes enforcement scalable.

Objective
To build and compare deep learning models that can classify images of faces into:

- *With Mask*
- *Without Mask*
- *Mask Worn Incorrectly*

2. Dataset

Source

- *Kaggle: "Face Mask Detection" dataset*
- *2994 images per class,* ***cropped to show face and head region only***
- *Total images: ~8982 (before split)*

Preprocessing

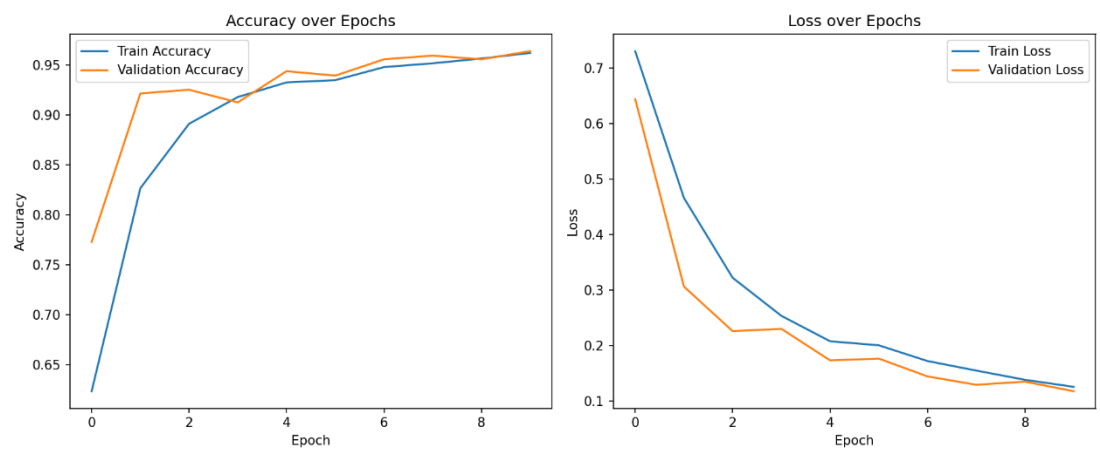
- *Resized to 224x224*
- *Normalized pixel values*
- *Data split:*
    - *70% training*
    - *15% validation*
    - *15% testing*

- *Sample Images from Each Class*

3. Models

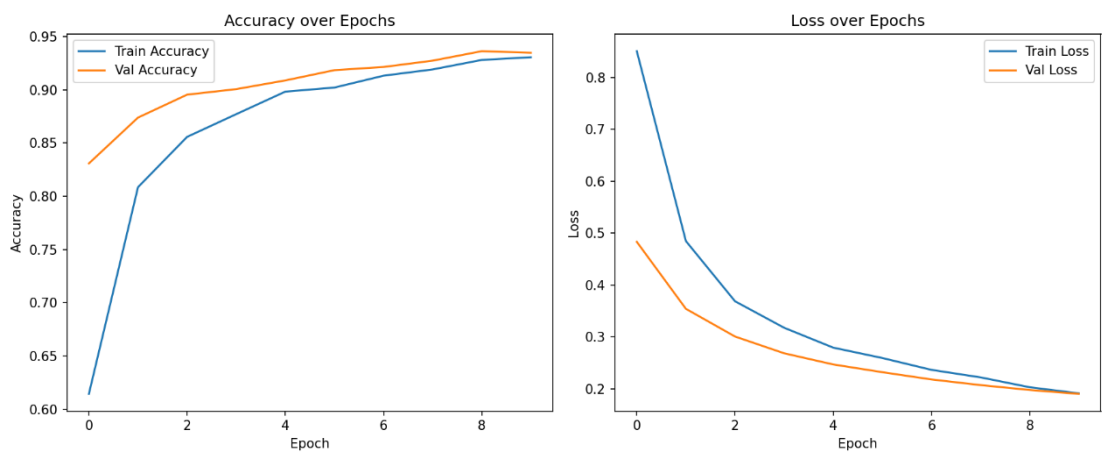
3.1 Custom CNN (Baseline)

- *Built from scratch using Conv → ReLU → Pooling → Dense layers*
- *Simple and effective for learning structure*
- *Trained for 10 epochs*
- *Accuracy ~96%*



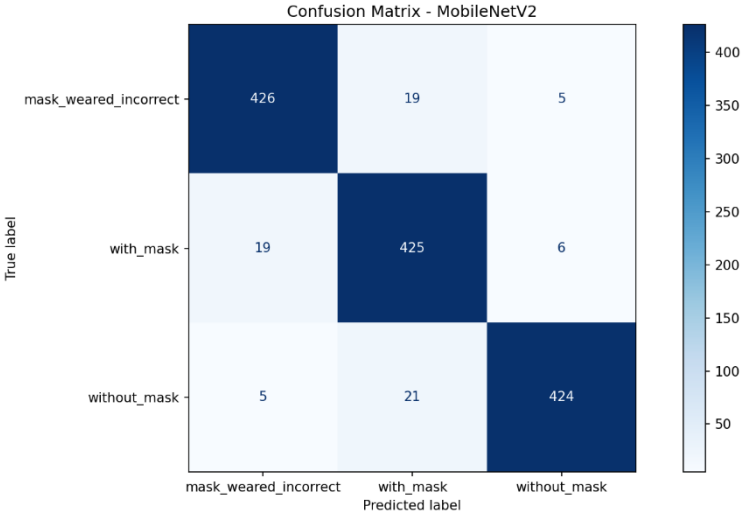
3.2 MobileNetV2 (Transfer Learning)

- *Pretrained on ImageNet*
- *Used as a frozen feature extractor with a new classifier*
- *Quick to train (~19.5 mins), stable, and high accuracy*



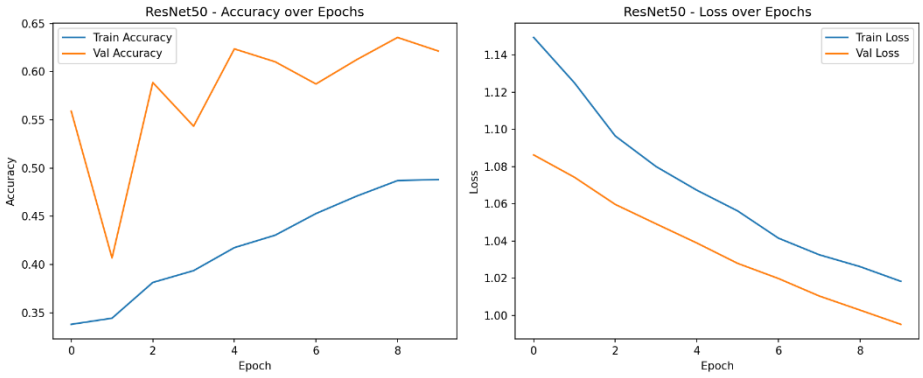
📊 Classification Report:

	precision	recall	f1-score	support
mask_weared_incorrect	0.95	0.95	0.95	450
with_mask	0.91	0.94	0.93	450
without_mask	0.97	0.94	0.96	450
accuracy			0.94	1350
macro avg	0.95	0.94	0.94	1350
weighted avg	0.95	0.94	0.94	1350

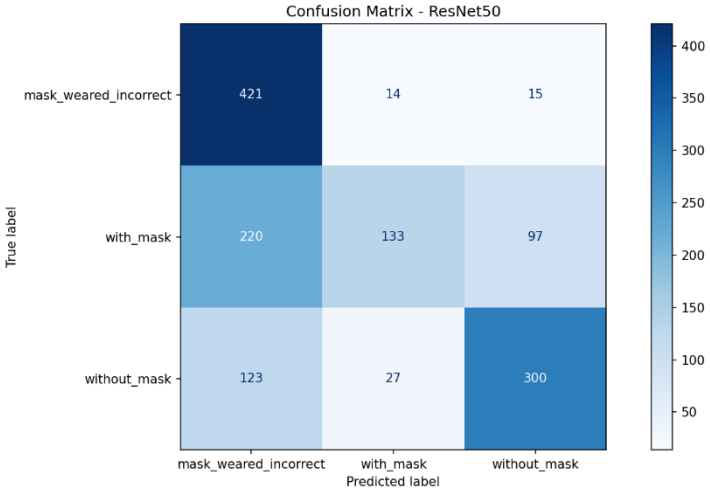


3.3 **ResNet50**

- *Deep residual model with skip connections*
- *Used as a frozen feature extractor*
- *Moderate performance*
- *Training time: ~54 minutes*
- *Not selected for final deployment*

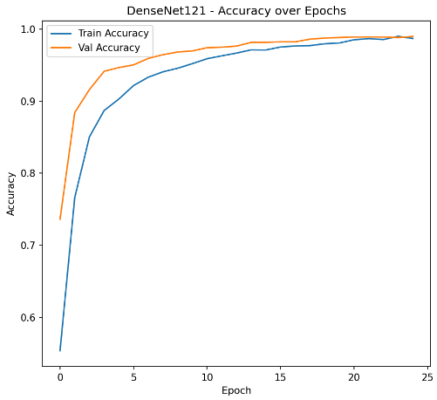


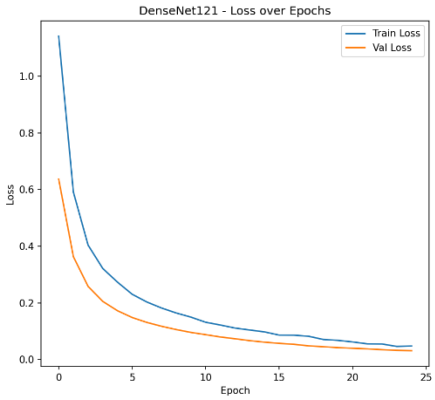
mask_weared_incorrect	0.55	0.94	0.69	450
with_mask	0.76	0.30	0.43	450
without_mask	0.73	0.67	0.70	450
without_mask	0.73	0.67	0.70	450
accuracy			0.63	1350
macro avg	0.68	0.63	0.61	1350
weighted avg	0.68	0.63	0.61	1350



3.4 DenseNet121 (Best Model)

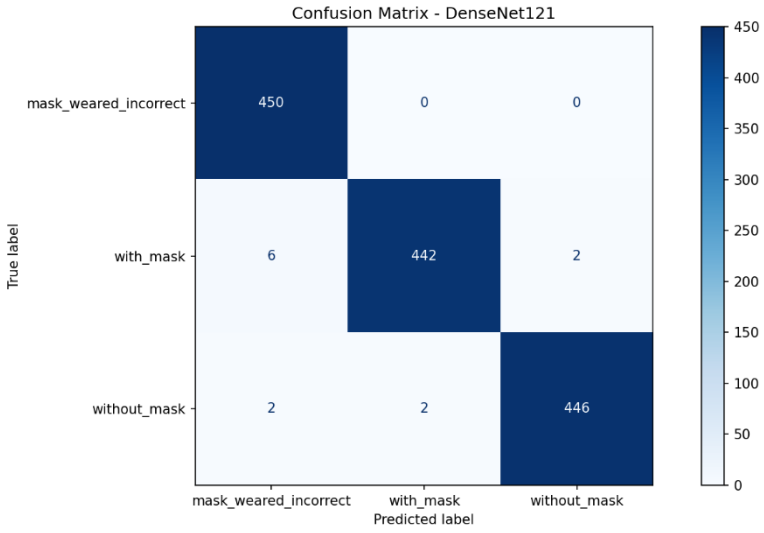
- *Pretrained on ImageNet*
- *Fine-tuned final 30 layers*
- *Dense connections improved feature reuse*
- *Best performance overall*
- *Training time: ~2.5 hours*





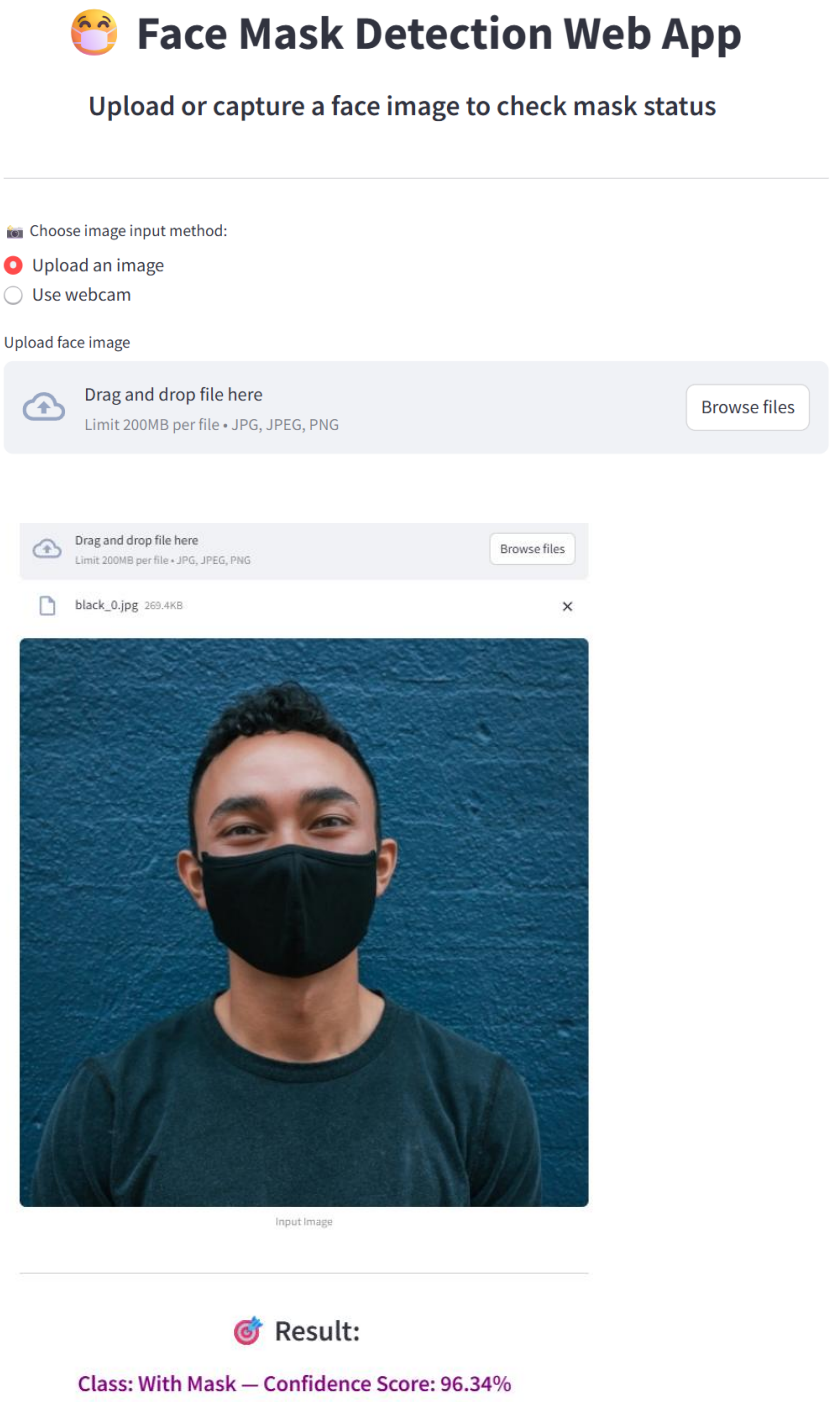
Classification Report:

	precision	recall	f1-score	support
mask_weared_incorrect	0.98	1.00	0.99	450
with_mask	1.00	0.98	0.99	450
without_mask	1.00	0.99	0.99	450
accuracy			0.99	1350
macro avg	0.99	0.99	0.99	1350
weighted avg	0.99	0.99	0.99	1350



4. Web Application

- *Built with Python + Streamlit*
- *Allows image upload or webcam capture*
- *Runs prediction using best model (DenseNet121)*
- *Displays result and confidence score*
- *UI:*



5. Conclusion

- *Custom CNN provided a solid baseline*
- *MobileNetV2: fast and reliable for low-resource settings*
- *DenseNet121: best overall accuracy and generalization*
- *Transfer learning is powerful even with limited data*
- *Successfully deployed in a working web application*