

DermalScan – AI Facial Skin Aging Detection App



Infosys Springboard Virtual Internship Program

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Introduction

With the rapid advancement of computer vision and deep learning, automated facial analysis has become a significant area of research. Age estimation from facial images plays a crucial role in various domains including dermatology, skincare, security, personalized recommendations, and digital health applications. Traditional methods of assessing facial age often rely on manual observation, which can be subjective, inconsistent, and time-consuming.

To address these limitations, this project proposes an **AI-based Facial Age Detection System** capable of predicting the age category of an individual from a facial image. Using convolutional neural networks (CNNs), data augmentation, and a well-structured dataset, the system learns visually identifiable age-related features such as wrinkles, skin texture, and facial structure changes.

This project aims to deliver an efficient, scalable, and accurate model that supports real-world usage and showcases the practical application of deep learning in facial analysis. The developed system serves as a valuable contribution to the growing field of AI-driven dermatological and biometric solutions.

Problem Statement

This project will provide a fast, reliable, and scalable solution that can support dermatologists, skincare brands, and users by delivering objective age predictions with minimal human intervention. A web-based frontend will enable users to upload images and visualize aging signs with annotated bounding boxes and labels.

Objectives of the Project

- To design an AI system capable of detecting and localizing key facial features associated with aging.
- To classify age-related facial characteristics such as wrinkles, dark spots, puffy eyes, and clear skin using a trained Convolutional Neural Network (CNN).
- To train and evaluate a deep learning model to achieve robust and accurate facial feature classification.
- To develop an interactive web-based frontend that allows users to upload facial images and view the annotated results.
- To implement a backend processing pipeline that analyzes input images and returns predictions along with visual annotations.
- To enable export of annotated outputs and system logs for documentation, reporting, or further analysis.

Dataset Preparation and Preprocessing (Milestone-1)

1. Introduction

The objective of Milestone 1 is to prepare a clean, labelled, balanced, and preprocessed dataset for training a model that detects facial age-related skin features such as wrinkles, dark spots, puffy eyes, and clear skin.

This milestone ensures high-quality data for efficient model training in Milestone 2.

2. Dataset Setup

2.1 Folder Structure

```
project_root/
├── dataset/
├── splitteddataset/
│   ├── train/
│   └── validation/
└── test/
└── notebooks/
```

dataset – Main directory containing all project image data.

splittedset – Contains the dataset split into train/ and validation/ folders for model training and performance evaluation. Generated from the cleaned dataset.

notebooks – Contains Jupyter notebooks for data analysis, visualization, preprocessing, and model experimentation.

2.2 Class Definitions

Images were categorized into the following four classes:

- Clear Skin
- Wrinkles
- Dark Spots
- Puffy Eyes

Ambiguous or low-quality images were removed to maintain dataset purity.

3. Dataset Inspection and Class Distribution

A short script was used to verify:

- Images are correctly labelled
- Samples display properly

```
Import os
```

```
for c in classes:
```

```
    clfolder = os.path.join(datasetpath,c)
```

```
    imagename = os.listdir(clfolder)[0]
```

```
    imgagepath = os.path.join(clfolder,imganame)
```

```
    img = cv2.imread(imgagepath)
```

3.1 Class Distribution Plot

To check dataset balance, the number of images per class was counted and plotted.

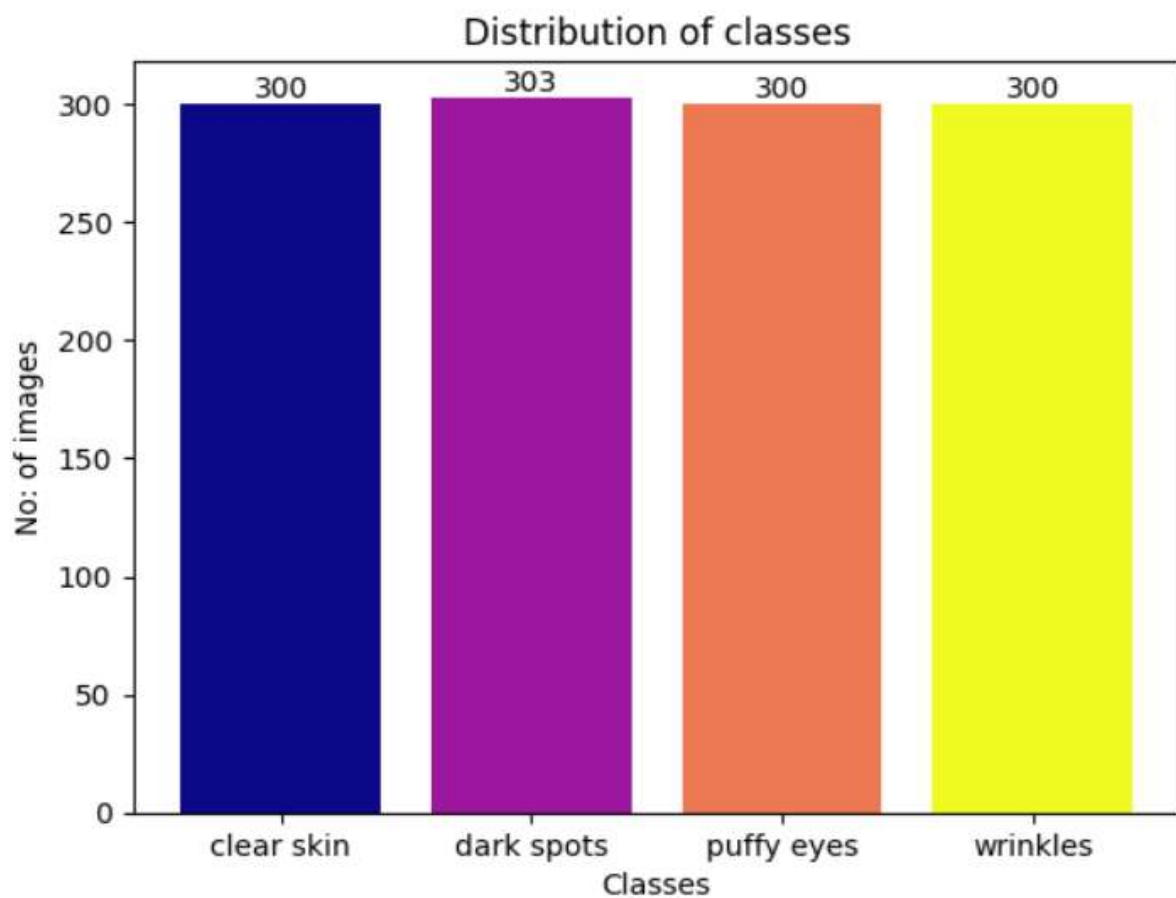


Figure 1: Distribution of images across 4 classes

4. Test-Train-Validation Split

The dataset was divided into three subsets using a 70:20:10 ratio, where 70% of the images were allocated for training, 20% for validation, and 10% for testing. All three subsets contain the same four classes: clear skin, wrinkles, dark spots, and puffy eyes.

- **Training Set (70%)**
Used to fit the model and learn the distinguishing features of each class.
- **Validation Set (20%)**
Used during training to tune hyperparameters and evaluate model performance on data the model has not seen before.
- **Test Set (10%)**
Used only after training is complete to measure the model's final performance and generalization ability on completely unseen data.

This three-way splitting strategy ensures that the model is trained effectively, validated during development, and rigorously evaluated after training, thereby improving its reliability and real-world applicability.

5. Image Preprocessing

5.1 Resize and Normalize

All images were resized to **224 × 224 pixels** for model compatibility. Pixel values were normalized by dividing each value by **255**, ensuring all inputs fall within the 0–1 range.

5.2 One-Hot Encoding

Labels were automatically converted into one hot encoding using `class_mode="categorical"`, allowing the model to handle multi class classification.

6. Data Augmentation Pipeline

Augmentation was applied only to training images to increase diversity while preserving class features. These transformations simulate natural changes that occur in facial photos without altering the underlying age-related features.

Transformations Used

- **Rotation ($\pm 20^\circ$)** – Simulates slight head tilts, helping the model remain accurate even when faces are not perfectly aligned.
- **Zoom (up to 20%)** – Mimics variations in camera distance, ensuring the model can detect age features such as wrinkles or dark spots even when the face appears closer or farther away.
- **Horizontal/Vertical Shifts (10%)** – Represents small changes in face positioning within the frame, preventing the model from becoming sensitive to fixed face alignment.

- **Horizontal Flip** – Helps the model generalize to left/right orientation of facial features, since aging signs appear symmetrically.
- **Brightness Variation** – Accounts for different lighting conditions, ensuring age-related features are recognized in bright or dim environments.
- **Fill mode: Nearest** – Used to fill in newly created pixels during transformations while preserving important facial details.

These augmentations improve robustness by teaching the model to focus on age-indicative patterns rather than on fixed image positions, lighting, or orientation.

```
traingenerator = ImageDataGenerator(
    rescale=1./255,
    rotation_range=20,
    zoom_range=0.2,
    width_shift_range=0.1,
    height_shift_range=0.1,
    horizontal_flip=True,
    brightness_range=(0.9, 1.1),
    fill_mode="nearest")
```

7. Visualization of Output

7.1 Original Images

These images represent some sample images from the dataset before augmentation.



Figure 2: Sample Original Images from the Dataset

7.2 Augmented Images

These images demonstrate how augmentation transforms some sample images from the dataset.



Figure 3: Sample Augmented Images from the Dataset

8. Conclusion

Milestone 1 successfully produced a clean, structured, and enhanced dataset ready for model development. All required inspection, preprocessing, and augmentation tasks were completed. This forms the foundation for next module.

Model Training and Evaluation (Milestone -2)

1.Introduction

The objective of Milestone-2 is to train, evaluate, and select an optimal deep learning model for classifying facial age-related skin features using the dataset prepared in Milestone-1. This milestone focuses on transfer learning, comparative evaluation of multiple CNN architectures, and integration of the trained model into a face detection and prediction pipeline.

Although EfficientNetB0 was initially planned, multiple models were trained and evaluated, and ResNet50 was selected as the final model due to its superior accuracy and stable validation performance.

The first module in it focuses on training convolutional neural network models to classify facial skin aging characteristics into the following four categories:

- Clear Skin
- Wrinkles
- Dark Spots
- Puffy Eyes

Transfer learning was done using pretrained CNN architectures to leverage learned visual representations and adapt them to the facial aging classification task.

2. Models Evaluated

The following pretrained CNN architectures were trained and evaluated using the same dataset, preprocessing steps, and training strategy:

1. EfficientNetB0
2. EfficientNetB2
3. MobileNetV2
4. ResNet50

All models were trained using categorical cross-entropy loss and the Adam optimizer

3. Model Architecture (Final Selected Model – ResNet50)

ResNet50, pretrained on ImageNet, was selected due to its residual learning framework, which enables deeper networks to train effectively without degradation.

Architecture Overview:

- Pretrained ResNet50 as base model (top layers removed)
- Global Average Pooling layer
- Fully connected (Dense) layer
- Dropout layer for regularization

- Output layer with Softmax activation (4 classes)

4. Training Configuration

Parameter	Value
Input Image Size	224 × 224
Loss Function	Categorical Cross-Entropy
Optimizer	Adam
Initial Learning Rate	1e-4
Batch Size	16
Epochs (Phase-1 Training)	12
Epochs (Fine-Tuning)	20

5. Training Strategy

5.1 Phase-1 Training (Feature Extraction)

- All layers of the pretrained model were frozen
- Only the custom classification head was trained
- Objective: Learn task-specific facial aging features

5.2 Fine-Tuning Phase

- Upper layers of the base model were unfrozen
- Model retrained with a reduced learning rate
- Objective: Improve feature specialization and generalization

6. Validation Accuracy Comparison Across Models

To compare learning behaviour and stability, validation accuracy curves of all four models were analysed.

Only the **fine-tuning validation accuracy curves** were considered for comparison, since this phase determines the final generalization capability of each model.

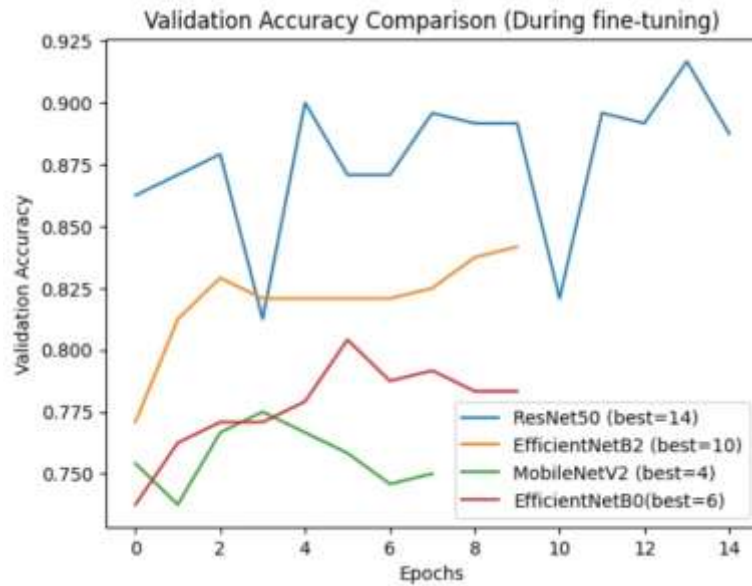


Figure 4: Validation Accuracy Curves of Evaluated CNN Models

7. Quantitative Performance Comparison

A comparative analysis was performed using training accuracy, validation accuracy, and validation loss.

	Model	Total Epochs	Best Epoch	Train Acc	Val Acc	Val Loss
0	ResNet50	15	14	96.199524	91.666669	0.304088
1	EfficientNetB2	10	10	88.123518	84.166664	0.442586
2	MobileNetV2	8	4	75.415677	77.499998	0.587149
3	EfficientNetB0	10	6	76.603323	80.416667	0.789934

Figure 5: Performance Comparison of Evaluated Models

8. Model Selection Justification

Based on the comparative analysis, **ResNet50 was selected as the final model** for deployment.

Reasons for Selection:

- Achieved the **highest validation accuracy** among all evaluated models.
- Displayed relatively stable validation accuracy curves despite minor fluctuations.
- Lower validation loss, indicating better generalization.
- Residual connections enabled effective learning of facial texture patterns such as wrinkles and dark spots.

Although EfficientNet and MobileNet architectures performed competitively, ResNet50 demonstrated superior consistency and robustness, making it the most suitable choice for this application.

9. Final Model Evaluation

Metric	Value
Training Accuracy	96.19
Validation Accuracy	91.67
Test Accuracy	89.26

The ResNet50 model shows strong and consistent performance across training, validation, and test datasets. The **training accuracy of 96.19%** indicates effective learning of facial aging features, while the **validation accuracy of 91.67%** confirms good generalization and satisfies the milestone requirement of achieving at least 90% validation accuracy.

The **test accuracy of 89.26%**, slightly lower than validation accuracy, reflects realistic performance on completely unseen data and suggests minimal overfitting. Overall, these results demonstrate that the selected model is reliable and suitable for real-world facial aging analysis.

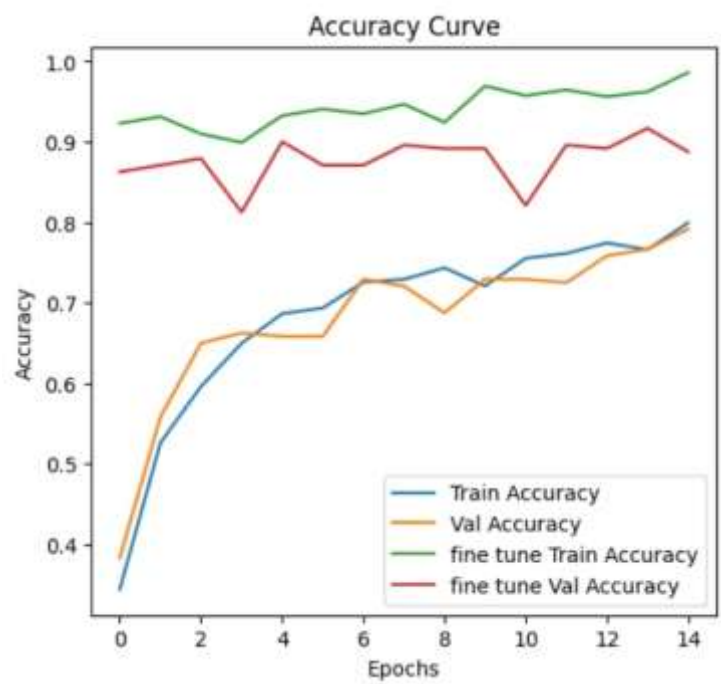


Figure 6: Training vs Validation Accuracy Curve (ResNet50)

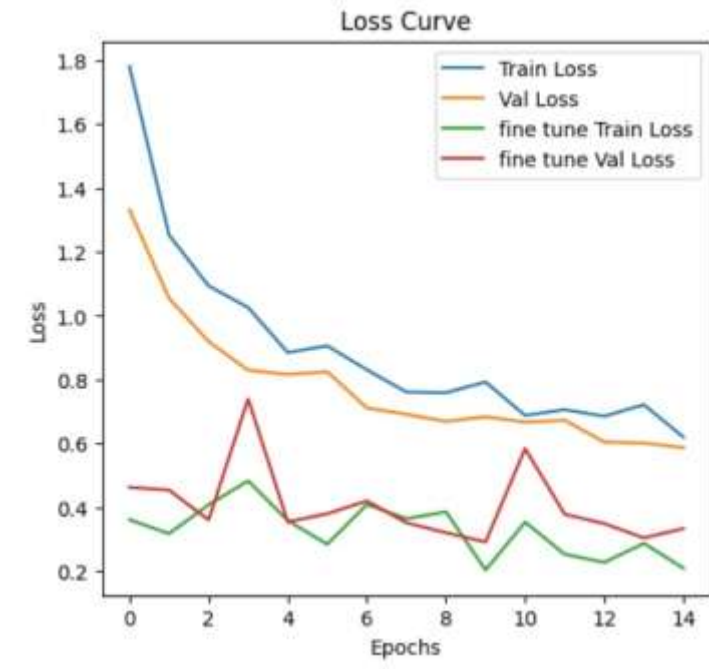


Figure 7: Training vs Validation Loss Curve (ResNet50)

10. Model Saving

The final trained ResNet50 model was saved for reuse in the prediction pipeline.

- resnet_best_model.h5

11. Face Detection

- OpenCV Haar Cascade classifier was used for frontal face detection
- Images were converted to grayscale
- Detected faces were cropped and resized to model input dimensions

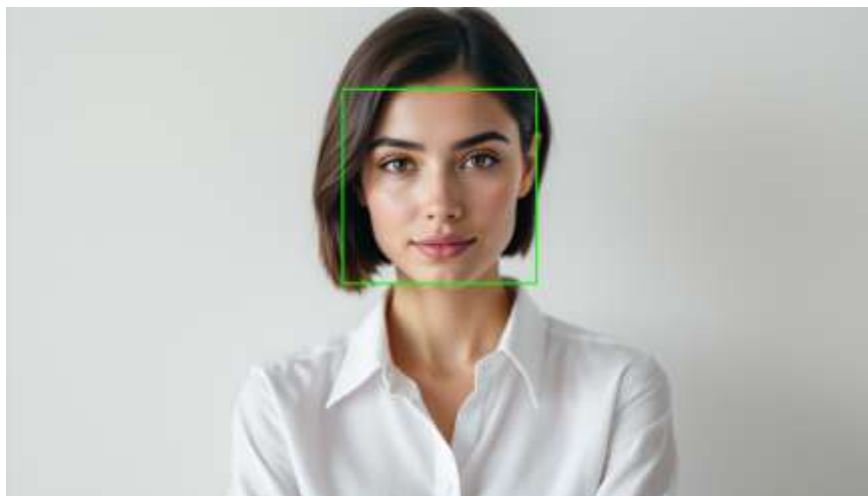


Figure 8: Face Detection Using Haar Cascade

12. Prediction Pipeline

Steps involved:

1. Detect face from input image
2. Crop and preprocess face region
3. Predict class probabilities using trained model
4. Identify dominant class
5. Display confidence percentages and estimated age

13. Visualization of Output

Each detected face displays:

- Bounding box
- Predicted skin aging class
- Confidence percentage
- Estimated age (derived from dominant class)



Figure 9: Facial Aging Prediction Output

15. Conclusion

Milestone-2 successfully implemented, evaluated, and selected a deep learning model for facial skin aging classification. Through comparative analysis of multiple CNN architectures, ResNet50 emerged as the most reliable and accurate model. The integration of face detection with prediction completes the core AI pipeline and prepares the system for deployment and frontend integration in the next milestone.