Skin Tone Detection And Cosmetic Shade Recommender Using Deep Learning Approach

A RESEARCH PROJECT SUBMITTED TO

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STATISTICS

BY

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Abstract

When the customer is going to purchase a cosmetic product, the individual should be aware about which skin tone he has, because most of the cosmetic products like foundation, concealer etc. depends upon the skin tone of the individual. It is challenging task to identify the correct match of cosmetic shade for particular skin tone. To overcome this problem, Artificial Intelligence (AI) plays a significant role in identification of the suitable cosmetic shade. This research aims to accurately determining the skin tone and recommend the suitable product. To fulfill objectives of the study, the deep learning (DL) architectures like YOLOV8, YOLO11n are implemented. These models effectively predict skin tones with 84% and 82% accuracy respectively. In the recommendation part, the correct cosmetic shade for the predicted skin tone is suggested, along with the top 3 cosmetic brands for foundation and concealer. This recommendation process is based on the YOLOV8 trained model as it has high accuracy among another trained model.

Keywords : AI, DL, YOLO, Skin tone recognition, Cosmetic shade recommendation.

Introduction

Beauty and skincare are now an important part of everyone's life. In recent years, the skincare industry has made a lot of progress and advancements. However, choosing the right cosmetic shade that perfectly matches your skin tone is still a challenge. Traditional methods for identifying skin tones often depend on manual checks, which can be subjective and inconsistent. For example, people usually need advice from an expert to find the perfect match, but this is not always possible. To solve this problem, Artificial Intelligence (AI) can be used. AI is a powerful tool, and with the introduction of advanced deep learning models like YOLO (You Only Look Once), especially YOLOv8 and YOLO11n, it is now possible to create automated and accurate systems for detecting skin tones and recommending cosmetic shades. YOLO models are fast and efficient in analyzing images, making them perfect for this task. This study uses YOLOv8 and YOLO11n to accurately detect skin tones from images and recommend the best cosmetic shades. YOLOv8 is great for detecting and classifying different categories efficiently, while YOLO11n is specifically designed to classify images with high accuracy. These

models work together to predict skin tones with precision and provide users with personalized recommendations for makeup products.

The models are trained on a range of skin tone data collected from online sources. By using advanced AI techniques, this study removes the manual methods and gives users an easy and accurate way to choose the right cosmetic shade. This system not only simplifies the process but also brings technology closer to the beauty and skincare world.

Objectives

- To implement deep learning models for accurate skin tone detection from images.
- To classify and separate skin tones into various distinct types for deep analysis.
- To provide accurate recommendations for the best cosmetic shade match based on the classified skin tone.

Methodology

The methodology for cosmetic shade detection and recommendation focuses on developing a model that can accurately identify skin tones and suggest suitable cosmetic shades. The DL techniques are used for the purpose of image classification recognize variations in skin tones and it matches skin tones with the best cosmetic shades using set guidelines. Here are some several steps explaining the data collection, data processing, model selection, model training, model validation, cosmetic shade recommendation, performance evaluation.

Data Collection :

There is a requirement of various images of different skin tones for the study. The required data is collected from online platform like GitHub, Kaggle etc. The data is mainly categorized into 5 classes namely, Dark Mid-dark, medium, Fair, Very fair, each of them having near about 200 images. Specific datasets include:

Skin Tone Classification Dataset : This dataset contains images categorized into three classes: White, Brown, and Black, with each class having 500 images.

Skin Tone Detection Dataset : This dataset contains images categorized into four classes: Dark, Mid-dark, Light, Mid-light with eadch class having near about 1000 images.

Data Processing :

In this step, images that are not suitable for analysis are removed. This includes blurry images, those with shadows on the face, or images with excessive light or focus on face. Removing such images provide better accuracy during analysis. Also, images are resized to a consistent size.

Model Selection:

For the purpose of skin tone identification, image classification is useful. Deep learning models like YOLO architecture are chosen for this task. For analysis, the dataset was systematically divided into training, validation, and testing subsets

Model Training:

The models were trained using the processed images, with each image labelled to match the correct skin tone. During training, the model learns to recognize patterns and features in the images that correspond to different skin tones, improving its ability to classify them accurately.

Model Validation:

After training, the models were tested on a different set of images that were not used during training. This helps to check how well the model performs on new, unseen data and ensures it can make accurate predictions in real-world situations. The model's accuracy and ability to generalize are measured during this step.

Cosmetic Shade Recommendation:

The cosmetic shade recommendation method firstly displays a table with cosmetic brands and their corresponding shade codes / names. Based on the identified skin tone, it suggests a range of suitable shades of each brand for that skin tone. This helps users to find the most appropriate cosmetic shade that match their skin tone.

Performance Evaluation:

This step involves checking how well the model’s predictions match the actual results. Various performance metrics, such as accuracy, precision, recall, and F1 score, are used to measure the model's effectiveness. These metrics help to determine if the model is making correct predictions and if it performs well. The goal is to make sure that the model gives accurate results.

Literature Review

Skin tone detection and cosmetic shade recommendation are gaining popularity in the beauty industry. Advanced techniques like machine learning are being used to improve these processes. Different models and architectures, such as YOLO, CNN, VGG16, DenseNet, EfficientNet, AlexNet, MobileNet etc. are chosen based on the level of accuracy needed for skin tone detection and product recommendations. These methods help in suggesting the cosmetic shade for users.

Study introduces an AI-based system that helps people choose the best cosmetic products, such as makeup, skincare, and haircare, based on their unique skin conditions. Using advanced deep learning models like CNN (88% accuracy), VGGNet (92% accuracy), and DenseNet (96% accuracy), the system analyzes skin images uploaded by users to detect issues like dryness, oiliness, or redness. It then recommends the most suitable products tailored to the user's skin needs.[1].

A study tackled the problem of poor lighting in photos for beauty product recommendations by using a MobileNet-v2 model to identify good and bad lighting. They created a synthetic dataset with different skin tones and lighting conditions, reducing the need for lots of real photos. This method improved accuracy in shade recommendations and provided real-time feedback to users.[2].

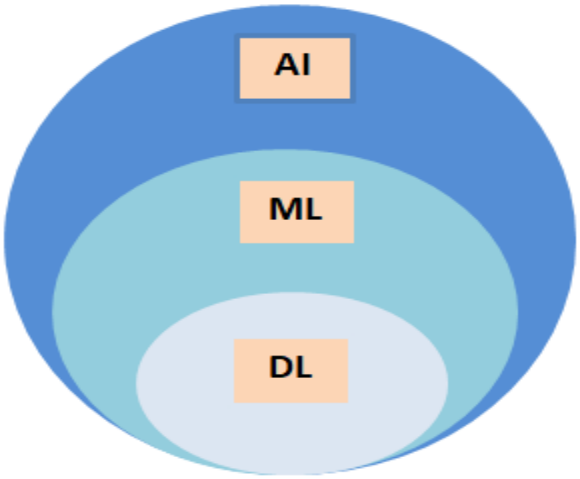
Research focuses on improving how computer vision can detect skin tones to recommend the best foundation shade, brand, and product for users. The proposed method was found to be fast, lightweight, and effective but had limitations. It struggled with very dark skin tones and lacked a well-designed dataset for validation.[3].

Introduces a neural network model for skin color detection, aiming to identify skin and non-skin pixels in images. The model, trained on skin samples from various groups, achieved over 90% detection accuracy. It performs well in complex lighting and backgrounds.[4].

Analysis

Deep Learning(DL) :

DL is a part of Machine Learning (ML), which itself is a subset of AI. AI refers to techniques that enable computers to mimic human behavior. DL architectures, inspired by the structure and functioning of the human brain, are used for complex tasks within ML. DL algorithms analyze data using a logical structure to make conclusions like humans. To achieve this, deep learning uses a multi-layered structure of algorithms called neural networks. The design of the neural network is based on the structure of the human brain. Just as we use our brains to identify patterns and classify different types of information, we can teach neural networks to perform the same tasks on data. Neural network layers act like filters, processing data from simple to complex to improve accuracy. Similar to the human brain, they compare new information with known patterns. Neural networks enable us to perform many tasks, such as clustering, classification or regression.



This study involves the implementation of advanced architectures such as YOLOv8 and YOLO11n models, known for their efficiency and accuracy in image analysis tasks.

Implementation:

Programming languages: Python is used in your project for image classification, which is a type of deep learning. It has powerful libraries like TensorFlow and Keras that help in building and training models to recognize and classify images.

Development Tools:

The tools used for the project include Jupyter Notebook, Visual Studio (VS) Code, and Google Colab. These tools help in coding, testing, and running deep learning models efficiently.

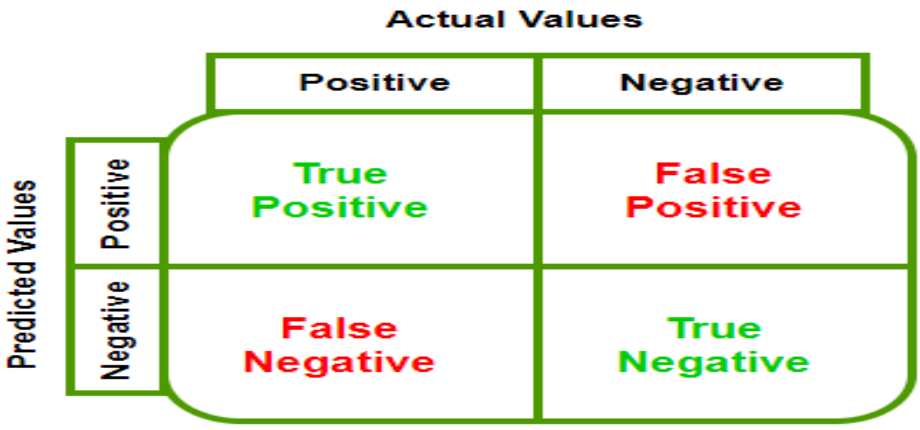
YOLO Model :

YOLO (You Only Look Once) is a popular deep learning model used for classification and object detection. It detects objects in images or videos by dividing the input into a grid, making it very fast and efficient. Particularly in object detection problem it identifies and locates multiple objects in an image. While in classification problem it assigns a label to detected objects.

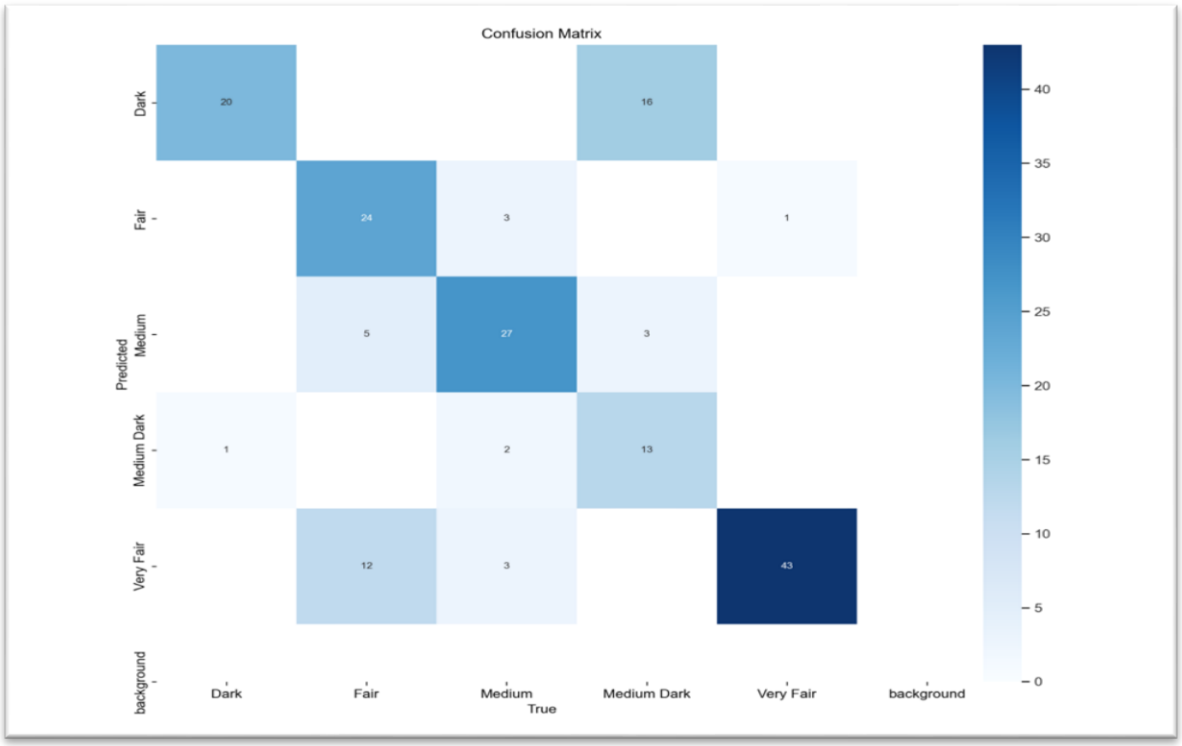
YOLOV8 : It is a versatile model used for both object detection and image classification. In classification tasks, it well assigns a class label to the entire image, making it suitable for applications that don't require object locations. Its speed, accuracy, and adaptability to custom datasets make it a powerful tool for modern image processing tasks.

YOLO11n : This model is designed for fast and efficient image classification. It assigns one class label to the whole image, which is useful for tasks where identifying the type of image is enough without needing to locate or outline objects in it.

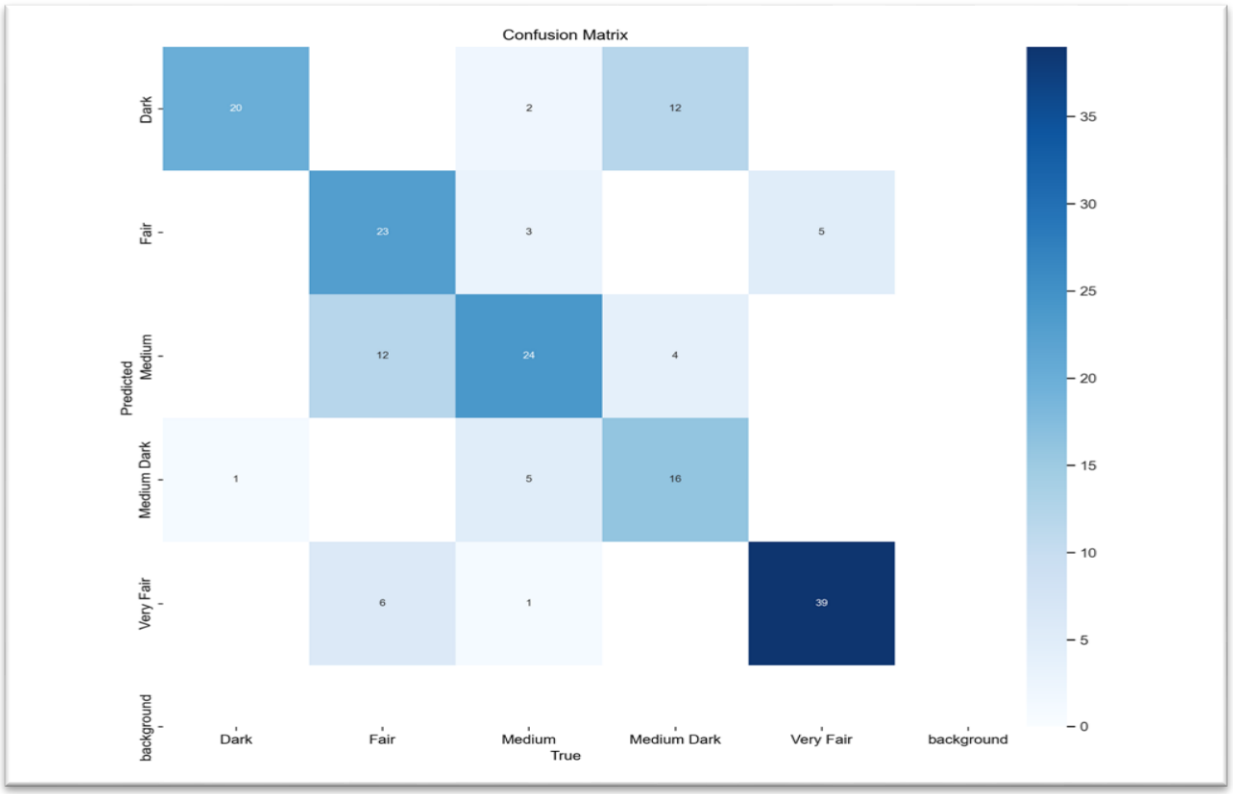
Confusion Matrix: It is a two-dimensional matrix used in classification experiments to evaluate the performance of a model by showing the number of correctly and wrongly classified data.



YOLOV8



YOLO11n



Classification Report :

A classification report provides a detailed summary of how well a deep learning model performed on a classification task. It includes 5 main columns and (N+3) rows.

Columns: The columns are Class Name, Precision, Recall, F1-Score, and Support.

Rows: There are N rows for each class in the dataset with three additional rows for accuracy, macro average, and weighted average.

Precision : Out of all the positive predicted, how many are truly positive.

Recall : Out of the total positive, how many are predicted positive.

F1 score : Harmonic mean of precision and recall

Support : Simply counts how many entries belong to each specific class in the actual labels, not the predictions.

YOLOV8

Classification Report:

	precision	recall	f1-score	support
Dark	0.97	1.00	0.99	38
Fair	0.73	0.75	0.74	59
Medium	0.72	0.89	0.80	65
Medium Dark	0.94	0.78	0.85	64
Very Fair	0.90	0.84	0.87	88
accuracy			0.84	314
macro avg	0.86	0.85	0.85	314
weighted avg	0.85	0.84	0.84	314

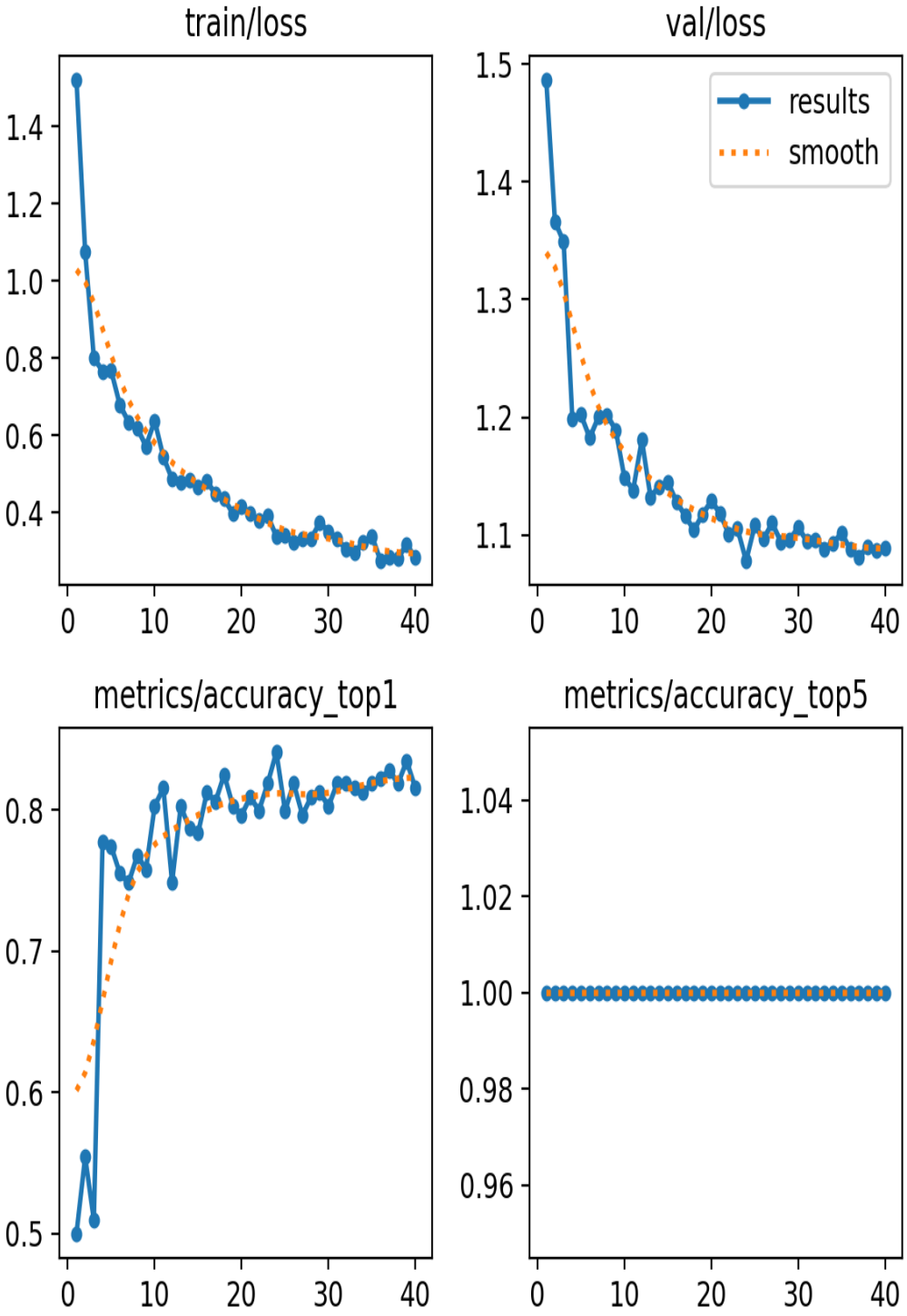
YOLO11n

Classification Report:

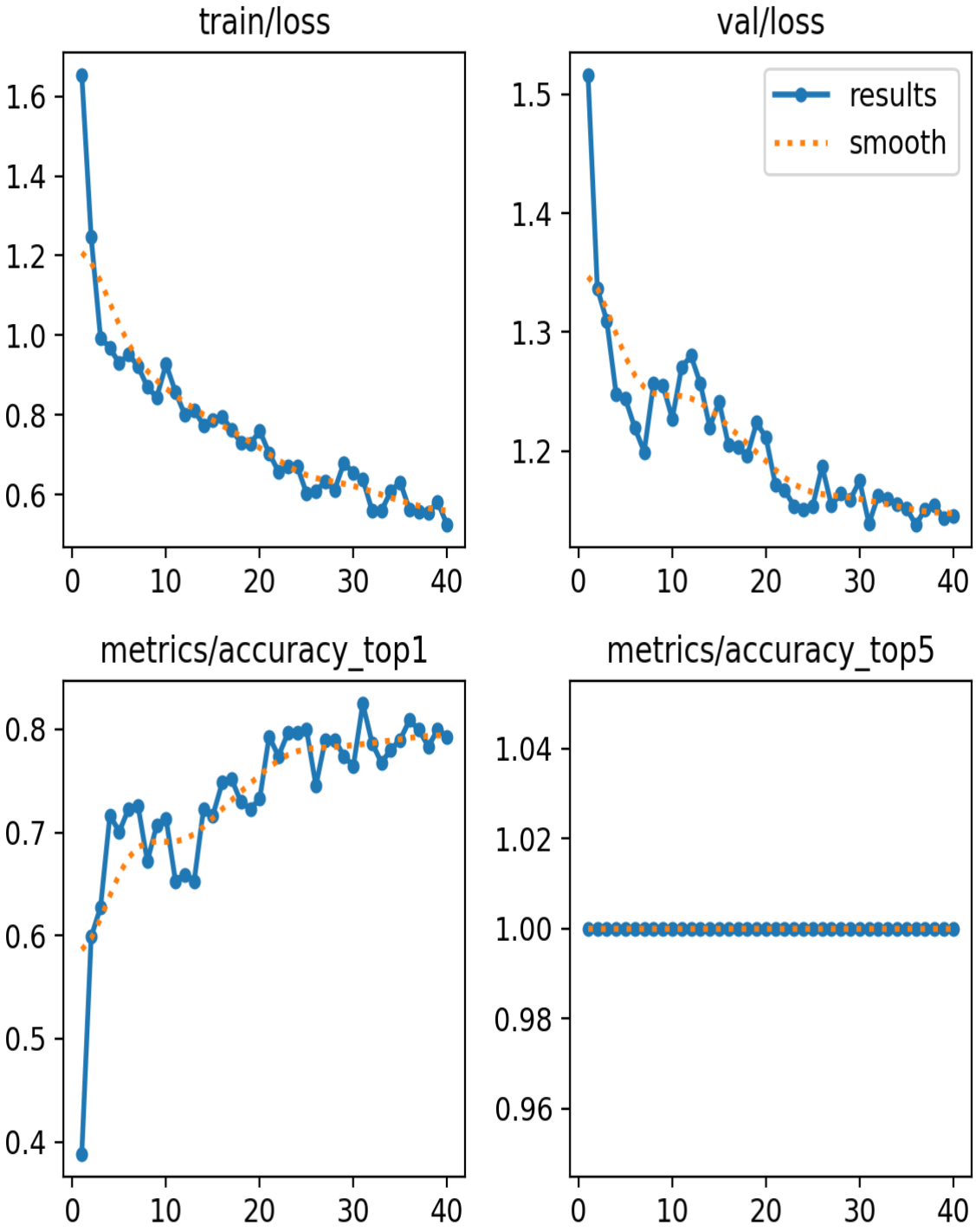
	precision	recall	f1-score	support
Dark	1.00	0.90	0.95	42
Fair	0.85	0.66	0.74	76
Medium	0.86	0.72	0.78	78
Medium Dark	0.69	0.98	0.81	45
Very Fair	0.80	0.96	0.87	73
accuracy			0.82	314
macro avg	0.84	0.84	0.83	314
weighted avg	0.84	0.82	0.82	314

Train-Validation Plots :

YOLOV8



YOLO11n


train/loss
val/loss
results
smooth
metrics/accuracy_top1
metrics/accuracy_top5

Conclusion :

From this study we can analyze that the YOLOv8 model achieved an overall accuracy of 84%, while the YOLO11n model achieved 82% accuracy. These results highlight the effectiveness of both models in skin tone classification, with YOLOv8 showing slightly better performance.

From the train –validation loss plot we conclude that, for YOLOV8 model, the training as well as validation loss decreases as the model is trained on large epochs. Similarly for YLO11n , the train- validation loss decreases. It indicates that there is improvement in learning.

From the train –validation accuracy plot we conclude that, for YOLOV8 model, the training as well as validation accuracy increases as the model is trained on large epochs. Similarly for YLO11n , the train- validation accuracy increases. This indicates that the model performs well.

Recommendation of cosmetic shade:

For the cosmetic shade recommendation, the YOLOv8 model was used as it showed higher accuracy compared to YOLO11n. After saving the trained YOLOv8 model, foundation shade names or codes for popular cosmetic brands like L'Oréal Paris, Maybelline New York, and Sugar were linked with predicted skin tones. When an image is processed, the model predicts the skin tone and identifies the matching shade ranges from these brands, providing accurate cosmetic shade recommendations.

The given image path is processed to display the skin tone and the recommended shades for each brand.

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Predicted Skin Tone: Medium Dark

Recommended L'oreal Paris Shades for Medium Dark: [520, 525, 530, 535]

Recommended Maybelline Shades for Medium Dark: [140, 145, 150, 155]

Recommended Sugar Shades for Medium Dark: [48, 50, 52, 55, 57]

From this shade range, select one shade lighter than your skin tone.
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Brand	Shade Code
L'oreal Paris	520
L'oreal Paris	525
L'oreal Paris	530
L'oreal Paris	535
Maybelline	140
Maybelline	145
Maybelline	150
Maybelline	155
Sugar	48
Sugar	50
Sugar	52
Sugar	55
Sugar	57

Limitations :

Here are the limitations of this study,

- Small Dataset : There is availability of limited dataset, which limits the model's ability to generalize effectively.
- Low-Quality Images : Some images in the dataset are of poor quality, like blur images, affecting the model's accuracy.
- Limited Models Implemented : Only a few models have been used, which reduces the scope for discovering better-performing approaches.
- Challenges with Various Skin Tones : The model may not perform well across all skin tones, particularly in extreme lighting conditions.

Future Scope :

- Implementing this study on a larger dataset will possibly improve accuracy, as it will allow the model to learn from more diverse examples.
- Additionally, exploring other models that were not implemented in this study could provide better results, as different algorithms may handle skin tone recognition and cosmetic shade recommendations more effectively.
- The project could also be expanded to support real-time detection and recommendations in live video or retail store applications, making it more practical and accessible for users.
- By including these models into a recommender system, it would be possible to provide personalized cosmetic suggestions based on individual skin tones, enhancing the user experience.
- Ongoing improvements in data collection, model tuning, and user experience can help build a more accurate, user-friendly system that serves a wider audience.

Reference :

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