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Personalized Skin Type Classification and Recommendations

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Abstract

This paper presents a novel AI-driven web-based system for personalized skincare solutions through automated skin type classification and tailored product recommendations. Leveraging deep learning techniques, specifically a pre-trained MobileNetV2 model, the system analyzes user-uploaded facial images to accurately classify skin types such as oily, dry, combination, and acne-prone. This classification enables the generation of customized skincare product suggestions from a curated database, addressing individual skin conditions with precision. The platform integrates user management features allowing both administrators and users to interact seamlessly, enhancing usability and content relevance through dynamic FAQ management. By combining computer vision with machine learning, the proposed approach overcomes traditional challenges in subjective skin assessment and inefficient product selection, providing an accessible, data-driven tool that empowers users to optimize their skincare routines. Experimental results demonstrate high classification accuracy and improved user satisfaction, highlighting the potential of AI to transform personal care through personalized recommendations. This work contributes to the intersection of healthcare and artificial intelligence by offering an efficient, scalable solution for individualized skin health management.

Keywords: Skin Type, MobileNetV2, Deep Learning, CNNs

I.INTRODUCTION

Skincare plays a crucial role in maintaining overall health and well-being, as the skin is the body's largest organ and primary defense against environmental hazards. Healthy skin not only contributes to physical protection but also impacts psychological confidence and social interactions. With the increasing awareness of personal care and the booming global skincare market, consumers are more invested than ever in finding products and routines that suit their unique skin types and conditions. However, the diversity of skin types—such as oily, dry, combination, sensitive, and acne-prone—requires personalized approaches to skincare. Each type demands specific products and care practices to address its distinct characteristics and challenges. For example, oily skin may benefit from oilcontrol cleansers and non-comedogenic moisturizers, while dry skin requires intense hydration and barrier repair. The complexity of skin biology and the variability among individuals make the selection of appropriate skincare products a nuanced task.

Traditionally, skin type determination has relied on manual assessments conducted by dermatologists or self-evaluation by consumers. Dermatological assessments, while accurate, are often inaccessible due to cost, time, or geographic limitations. Selfassessments, on the other hand, are subjective and prone to inaccuracies, as individuals may misinterpret their skin's needs or overlook subtle conditions. This leads many consumers to engage in trialand-error approaches, purchasing multiple products without guaranteed effectiveness. Such inefficiencies not only waste resources but can also exacerbate skin problems when incompatible products are used. Furthermore, skin conditions are dynamic and influenced by factors such as age, climate, diet, and stress, necessitating ongoing evaluation and adjustment of skincare routines. The absence of accessible, objective, and adaptive tools for skin assessment presents a significant challenge in personal skincare management.

The advent of artificial intelligence (AI) and machine learning (ML) technologies offers promising solutions to these challenges. AI-powered systems can analyze complex data patterns

and perform image recognition tasks with high precision, enabling objective and scalable skin assessments. By employing computer vision techniques, AI models can evaluate facial images to identify skin types, detect conditions like acne or hyperpigmentation, and assess skin texture and hydration levels. Deep learning architectures, such as convolutional neural networks (CNNs), have been particularly effective in image classification tasks, making them suitable for skin analysis applications. These technologies facilitate the transition from subjective, manual evaluations to automated, data-driven assessments that are accessible to a wider audience. Moreover, AI systems can continuously learn and adapt, allowing for personalized recommendations that evolve with the user's skin condition over time.

This paper presents a web-based AI-driven platform designed to provide personalized skincare solutions by classifying skin types from user-uploaded images and offering tailored product recommendations. The system utilizes a pre-trained MobileNetV2 model, a lightweight and efficient deep learning architecture optimized for mobile and web applications, to perform accurate skin type classification. Upon analyzing the uploaded image, the model categorizes the skin into types such as oily, dry, combination, or acne-prone. Based on this classification, the platform generates customized skincare product suggestions drawn from a curated database, ensuring that recommendations align with the user's specific skin needs. This approach addresses the limitations of traditional skincare assessments by providing an objective, rapid, and user-friendly tool that empowers individuals to make informed decisions about their skincare routines.

II.LITERATURE REVIEW

[1] Author: Hsiao-Hui Li, Yuan-Hsun Liao, Yen-Nun Huang, Po-Jen Cheng

Title: Based on Machine Learning for Personalized Skin Care Products

Recommendation Engine, Authors: HsiaoHui Li, Yuan-Hsun Liao, Yen-Nun Huang,

Po-Jen Cheng

This paper presents a machine learningbased recommendation engine aimed at personalizing facial skin care products based on an individual's unique skin condition. Utilizing advanced computer vision techniques, particularly the YOLOv4 object detection algorithm, the system analyzes facial images to detect key features like acne, wrinkles, and spots. By extracting and processing regions of interest (ROIs), the system applies a multilabel classification model to assess skin health and recommend suitable products. This intelligent platform seeks to alleviate the confusion faced by consumers when choosing from thousands of cosmetic products, while also preventing potential skin damage from unsuitable choices.[1]

[2] Author: Soundarya M, Sonasri Mu, Vasuppradha S, Sujitha B

Title: Predictive Analysis of Skin Type and Personalized Acid Recommendations for Effective Skin Care Using ResNet-50, Authors: Soundarya M, Sonasri Mu,

Vasuppradha S, Sujitha B

This paper introduces a deep learning approach using ResNet-50 to analyze skin types and provide personalized acid recommendations for skincare.

Recognizing the limitations of traditional CNNs, such as difficulty with long-range feature dependencies and data imbalance, the authors propose ResNet-50 for its superior accuracy and feature extraction capabilities. By classifying images into skin types like oily, dry, sensitive, etc., and recommending suitable acids (e.g., AHA, BHA, PHA), the system aims to deliver tailored skincare routines. Enhanced with image augmentation techniques like random vertical flipping, the model adapts to variations in skin tone, lighting, and conditions, offering a more accurate and effective skin analysis.[2]

[3] Author: Jinhee Lee, Huisu Yoon, Semin Kim, Chanhyeok Lee, Jongha Lee, Sangwook Yoo.

Title: Deep learning-based skin care product recommendation: A focus on cosmetic ingredient analysis and facial skin conditions, Authors: Jinhee Lee, MS; Huisu Yoon, PhD; Semin Kim, PhD;

Chanhyeok Lee, MS; Jongha Lee, MS; Sangwook Yoo, PhD.

This research introduces a deep learningbased system for recommending skincare products by analyzing both cosmetic ingredients and users' facial skin conditions. The method leverages a deep neural network to evaluate ingredient effectiveness and incorporates facial image-based AI models to assess the user's skin status. By integrating these components, the system delivers personalized and accurate product recommendations tailored to specific skin issues. Evaluation results confirm the model's effectiveness, making it a promising tool for enhancing the skincare selection process through AI-driven insights.[3]

[4] Author: Gyeongeun Lee, Xunfei Jiang, Natalie Parde Title:A Content-based Skincare Product Recommendation System, Authors:

Gyeongeun Lee, Xunfei Jiang, Natalie Parde This study presents a content-based skincare product recommendation system designed to provide personalized suggestions by analyzing users' skin types and the chemical ingredients of skincare products. Traditional recommendation methods often fail to address individual skin needs or require users to know specific product names. In contrast, this system enhances accessibility by allowing users to specify desired beauty outcomes, thus catering to those with limited skincare knowledge. By comparing ingredient similarities across products, the system returns customized recommendations from various product categories, ultimately improving product-user compatibility and satisfaction.[4]

[5] Author: Ruchika Chouhan, Snehlata Barde

Title:A Review on Cosmetic Product Recommendation Using Deep Learning, Authors: Ruchika Chouhan, Snehlata Barde,This paper presents a comprehensive review of cosmetic product recommendation systems that leverage deep learning techniques to offer personalized skincare and makeup suggestions. Given the challenges users face while shopping for cosmetics online— due to variations in skin tone, type, and sensitivity—the authors explore several models such as face recognition, tag recommendation, and convolutional neural networks. The study analyzes how user preferences, skin concerns, and product attributes are processed to enhance recommendation accuracy, thereby facilitating better online shopping experiences tailored to individual skincare needs.[5]

[6] Author: Kasidit Saraphon, Supansa Chaising, Nyi Nyein Aung, Wanus Srimaharaj

Title: Regularized Pyramid Convolutional Layers for Human Skin Type Assessment, Authors: Kasidit Saraphon, Supansa Chaising, Nyi Nyein Aung, Wanus

Srimaharaj,

This research proposes a novel approach for human skin type assessment by employing Regularized Pyramid Convolutional Layers (PCL) to capture complex skin attributes across multiple scales. Traditional models struggle with the nonlinear relationships between skin texture, tone, and elasticity. The study utilizes the Fitzpatrick17k dataset, enhancing classification accuracy by preprocessing clinical images and applying a multi-scale convolutional strategy. Results show a significant improvement in skin type classification performance, emphasizing the method's applicability in dermatological image analysis and its broader impact on personalized skincare and medical diagnosis.

[7] Author: Permanki Guthu Rithesh Pakkala, Akhila Thejaswi R, Bellipady Shamantha Rai, Prakhyath Rai, C Pooja Shetty, Aishwarya S

Title: Data-Driven Beauty: Unleashing the Power of Deep Learning in Skincare, Authors: Permanki Guthu Rithesh Pakkala,

Akhila Thejaswi R, Bellipady Shamantha Rai, Prakhyath Rai, C Pooja Shetty, Aishwarya S This study introduces a novel, data-driven skincare recommendation system that utilizes advanced deep learning techniques—Gray-Level Co-occurrence Matrix (GLCM) for texture extraction and Graph Neural Networks (GNNs) for accurate skin type classification. By treating different facial regions as nodes in a graph, the GNN captures spatial relationships more effectively than CNNs or RNNs.

The proposed model achieved 90% accuracy, simplifying skincare product selection while improving user satisfaction.
This approach transforms the way consumers choose products, offering tailored skincare solutions through automated personal skin analysis.[7]

[8] Author: Jianghong Ran, Guolong Dong

Title: Automatic Measurement of Comprehensive Skin Types Based on
Image Processing and Deep Learning, Authors: Jianghong Ran, Guolong Dong, Fan Yi, Li Li, Yue Wu(Affiliations: Key Laboratory of Cosmetic and Institute of Cosmetic Regulatory Science, Beijing Technology and Business University, China), This study proposes an advanced method for skin type classification using an improved Inception-v3 deep learning model, enhanced with transfer learning. The method leverages multimodal data including physiological signals, questionnaire responses, and multi-lightsource facial images to classify skin into 16 types based on the Baumann Skin Type Indicator (BSTI). By outperforming traditional methods, the model achieves high accuracy across the four BSTI dimensions—dry/oily, sensitive/resistant, pigmented/nonpigmented, and wrinkled/tight. This research provides a more objective and scalable approach to skin type assessment, enabling more personalized and precise skincare solutions.[8]

[9] Author: Hyeon Ki Jeong, Christine Park, Ricardo Henao, Meenal Kheterpal Title: Deep Learning in Dermatology: A Systematic Review of Current Approaches, Outcomes, and Limitations Authors: Hyeon Ki Jeong, Christine Park, Ricardo Henao,
Meenal Kheterpal
This systematic review explores the evolving role of deep learning, particularly convolutional neural networks (CNNs), in dermatology. It evaluates current methodologies, the diversity of image datasets, and the performance metrics used across various studies. The review highlights the challenges in clinical implementation due to inconsistent data quality, varying model architectures, and regulatory hurdles. It also outlines the potential of AI as clinical decision-support tools, emphasizing the need for standardized practices and robust validation to ensure safe and effective integration into dermatological care.[9]

**[10] Author: B. Lokesh
Anjali Devarakonda, G. Srinivas, Nitish Kumar Naik**

Title: Intelligent Facial Skin Care Recommendation System, Authors: B.
Lokesh (Assistant Professor, MGIT), Anjali Devarakonda (UG Student, MGIT), G. Srinivas (UG Student, MGIT), Nitish
Kumar Naik (UG Student, MGIT) This study presents an intelligent webbased system that leverages Convolutional Neural Networks (CNN) to classify facial skin types and provide personalized skincare recommendations. By allowing users to upload facial images, the system analyzes skin characteristics such as dryness, oiliness, sensitivity, and specific conditions like moles and red spots. It combines a user-friendly interface with a powerful backend for real-time processing, offering tailored product suggestions based on individual skin profiles and preferences. The work highlights how machine learning can significantly improve personal skincare routines, with future plans to incorporate chatbots and an expanded product database.[10]

III. METHODOLOGY

The methodology for developing an AIdriven, web-based personalized skincare recommendation system is structured into several key stages, leveraging deep learning—specifically, the MobileNetV2 architecture—and integrating user-friendly web functionalities. The process encompasses data acquisition, image preprocessing, model training and optimization, system integration, and product recommendation.

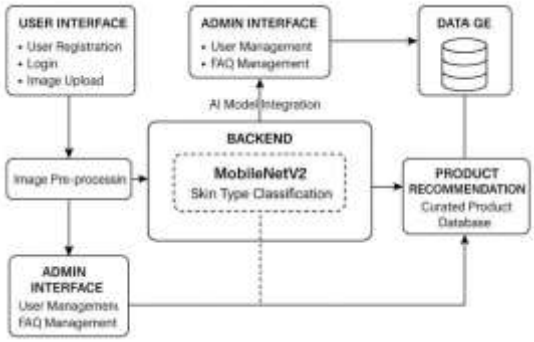


Fig 1. Proposed Methodology

3.1 Data Acquisition and Preparation

The foundation of the AI-driven skincare recommendation system is a robust and diverse dataset of facial images, each labeled according to skin type categories such as oily, dry, combination, and acneprone. To ensure the model's generalizability and effectiveness, images are collected from publicly available dermatological datasets as well as usercontributed photos, if permitted. The dataset is curated to include a wide range of demographic variables—such as age, gender, ethnicity, and lighting conditions— to minimize bias and enhance the model's ability to perform well across different user groups. This diversity is critical for building a system that can deliver accurate skin type classification for a global audience. **3.2 Image Pre-processing**

Before feeding the images into the deep learning model, a series of pre-processing steps are applied to standardize and enhance the data. Each image is resized to a consistent dimension (typically 224x224 pixels) to match the input requirements of the MobileNetV2 architecture. Pixel values are normalized to a standard range, which helps accelerate model convergence and stability during training. Additionally, data augmentation techniques—such as rotation, flipping, and color jittering—are employed to artificially expand the dataset, reduce overfitting, and improve the model's robustness to real-world variations in image capture.

3.3 Model Development

The core of the system's intelligence lies in the use of the MobileNetV2 deep learning architecture, chosen for its balance of high accuracy and computational efficiency. The model is initialized with weights pretrained on large image datasets like ImageNet, leveraging transfer learning to benefit from existing feature representations. The final layers of MobileNetV2 are fine-tuned using the curated skin type dataset, allowing the network to specialize in distinguishing subtle differences between skin types. The model's output layer uses a softmax activation function to assign probabilities to each skin type class, enabling precise and reliable classification from user-uploaded images.

3.4 Model Optimization

To further enhance classification performance and ensure the model's reliability in diverse scenarios, several optimization strategies are implemented. Techniques such as batch normalization and global average pooling are incorporated to stabilize the training process and reduce the risk of overfitting. Where applicable, attention mechanisms—like Squeeze-andExcitation blocks—are added to help the model focus on the most relevant features within the images. Multi-scale feature aggregation may also be used to capture both fine and broad skin characteristics, ensuring that the system can accurately identify skin types even in challenging or varied image conditions.

3.5 System Integration and Web Application

Once the model is trained and optimized, it is integrated into a user-friendly web application that serves as the primary interface for both administrators and endusers. The backend hosts the deep learning model as a service, processing uploaded images and returning skin type predictions in real time. The application features distinct interfaces: administrators can manage user accounts, update frequently asked questions (FAQs), and oversee system performance, while users can register, log in, upload images, and receive personalized skincare recommendations. This seamless integration ensures that advanced AI capabilities are accessible through an intuitive and responsive web platform.

3.6 Personalized Product Recommendation

After the user's skin type is identified, the system leverages a curated database of skincare products to generate tailored recommendations. The recommendation engine matches products to the predicted skin type while considering factors such as product ingredients, user preferences, and potential sensitivities. This ensures that users receive not only accurate but also safe and relevant suggestions for their skincare routines. The recommendations are presented alongside educational content and FAQs, empowering users to make informed choices and optimize their skin health.

3.7 Evaluation and Validation

To ensure the reliability and effectiveness of the system, comprehensive evaluation is conducted using standard performance metrics such as accuracy, precision, recall, and F1-score on a reserved validation dataset. The system is further refined through continuous monitoring of user feedback and system logs, allowing for iterative improvements in both the classification model and the recommendation logic. This ongoing validation process ensures that the platform remains accurate, user-centric, and adaptable to evolving user needs and technological advancements.

IV. TECHNOLOGIES USED

4.1 Deep Learning Frameworks and MobileNetV2 Architecture:

The core technology for skin type classification in this system is deep learning, specifically utilizing the MobileNetV2 architecture. MobileNetV2 is a lightweight convolutional neural network (CNN) designed for efficient image classification on devices with limited computational resources. It incorporates depthwise separable convolutions, inverted residual blocks, and global average pooling to capture intricate patterns in skin images while maintaining high computational efficiency. The final classification is performed using a softmax activation layer, which outputs the probability of each skin type class. Transfer learning is applied by initializing the model with pre-trained weights, allowing for faster convergence and improved accuracy when trained on the facial skin dataset.

4.2 Image Processing and Data Augmentation Tools

To ensure robust model performance, image processing libraries such as OpenCV and PIL (Python Imaging Library) are used for pre-processing tasks. These include resizing images to the required 224x224 pixels, normalizing pixel values, and applying data augmentation techniques like rotation, flipping, and color adjustments. Such augmentation increases dataset diversity and helps the model generalize better to real-world variations in lighting, skin tone, and image quality.

4.3 Backend and Model Deployment: The trained MobileNetV2 model is deployed as a backend service, typically using frameworks like TensorFlow or PyTorch for model inference. For webbased deployment, TensorFlow Lite or ONNX can be used to optimize the model for fast, real-time predictions. The backend handles user requests, processes uploaded images, and returns classification results and recommendations efficiently, ensuring a seamless user experience.

4.4 Web Application Technologies: The user interface and system management features are implemented using modern web development technologies. Frontend frameworks such as React, Angular, or Vue.js provide a responsive and interactive user experience. The backend server is commonly built with Node.js, Django, or Flask, which manage user authentication, image uploads, and communication with the AI model. Secure storage solutions and RESTful APIs facilitate smooth integration between the user interface and the deep learning backend.

4.5 Database Management Systems:

A relational or NoSQL database (such as MySQL, PostgreSQL, or MongoDB) is used to store user information, image metadata, and the curated skincare product database. This enables efficient querying and retrieval of personalized product recommendations based on the predicted skin type and user preferences.

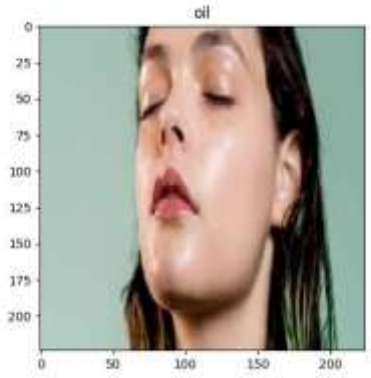
4.6 Product Recommendation Engine: The recommendation engine is developed using rule-based algorithms or machine learning models that match skincare products to the user's predicted skin type. It considers product ingredients, compatibility, and user feedback to provide safe and relevant suggestions. The engine is integrated into the backend to deliver personalized recommendations instantly after skin type classification.

4.7Administrative and User Management Tools:

The platform includes administrative tools for managing registered users, updating FAQs, and monitoring system performance. These tools are typically implemented as part of the web application, with secure authentication and role-based access controls to ensure data privacy and system integrity These integrated technologies collectively enable a robust, efficient, and user-friendly AI-driven skincare recommendation system, leveraging stateof-the-art deep learning and modern web development practices for real-world deployment.

V RESULT AND DISCUSSION.

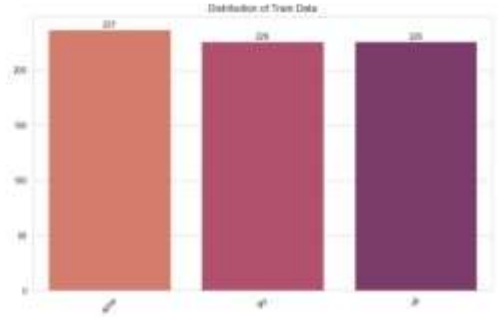
SKIN TYPE RESULT PAGE

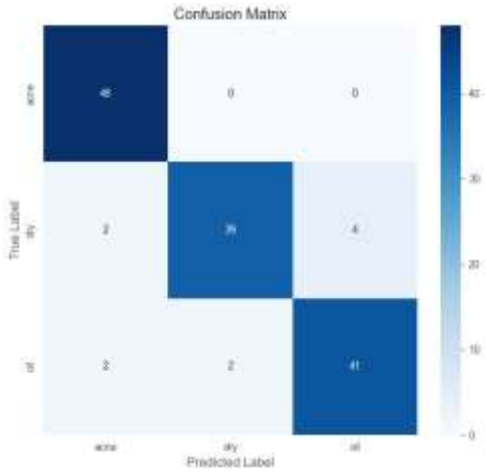


This is showing skin type.

Product Recommendation Result

Recommended product list is displaying here.





	precision	recall	f1-score	support
0	0.92	1.00	0.96	48
1	0.95	0.87	0.91	45
2	0.91	0.91	0.91	45
accuracy			0.93	138
macro avg	0.93	0.93	0.93	138
weighted avg	0.93	0.93	0.93	138

The skin type classification model was trained over 30 epochs, achieving a final validation accuracy of approximately 92.75%. Evaluation on the test set yielded an overall accuracy of 93%, with precision, recall, and F1-scores consistently above 0.90 across all three classes. This indicates that the model performs well in accurately identifying different skin types, demonstrating strong predictive capability and balanced performance across categories.

VI. CONCLUSION

In conclusion, the proposed AI-driven skincare recommendation system effectively leverages deep learning techniques, particularly the MobileNetV2 architecture, to accurately classify skin types from user-uploaded images and provide personalized product recommendations. By automating the traditionally subjective and error-prone process of skin assessment, this web-based platform makes expert-level skincare guidance accessible, efficient, and userfriendly. The integration of advanced image analysis, robust backend infrastructure, and dynamic user interfaces ensures a seamless experience for both users and administrators, while the personalized recommendation engine enhances the relevance and effectiveness of suggested skincare routines. Overall, this system demonstrates the transformative potential of artificial intelligence in personal care, empowering individuals to make informed decisions and optimize their skin health with confidence.

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