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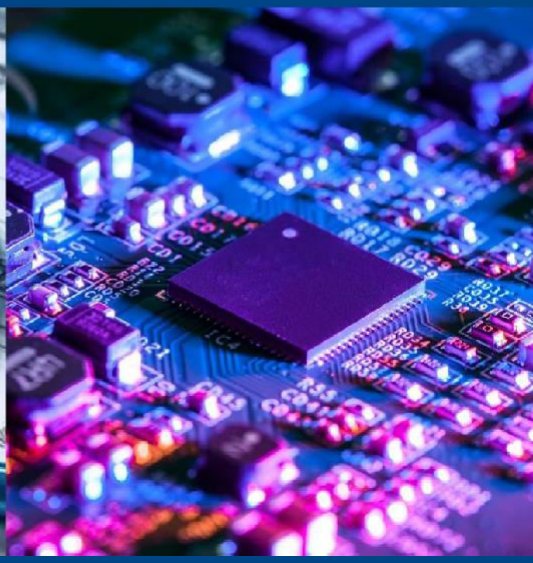

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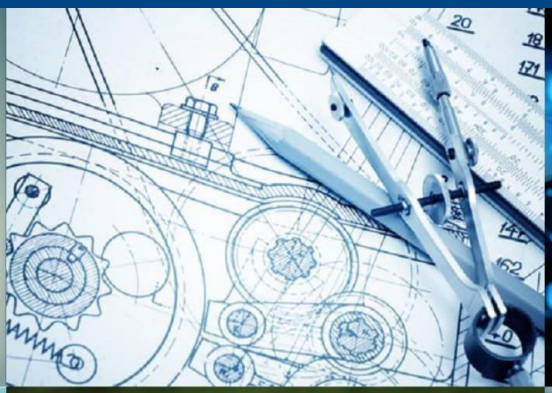

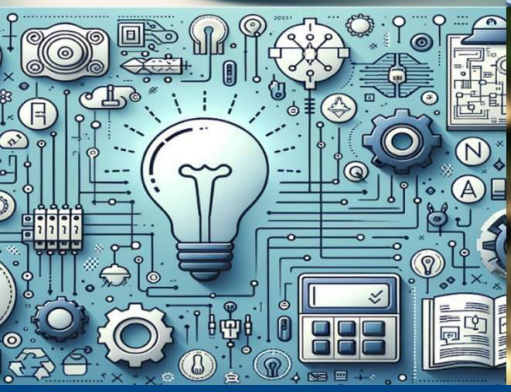

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E-Derma: Real-Time Facial Skin Analysis and Personalized Skincare Recommendation System

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ABSTRACT: Skin health plays a significant role in personal well-being and self-confidence, yet access to timely and personalized dermatological consultation remains limited for many individuals. Most existing digital skincare solutions depend on self-reported questionnaires or generic recommendations, which may not accurately reflect a user's true skin condition. To overcome these limitations, this project presents E-Derma, a real-time facial skin analysis and personalized skincare recommendation system. E-Derma analyzes facial images captured using standard camera devices to detect visible skin conditions such as acne, dryness, pigmentation, dullness, wrinkles, and redness. The system applies image preprocessing techniques to improve image quality and minimize the impact of lighting variations, after which extracted facial features are evaluated using a rule-based analysis framework that assigns confidence scores and severity levels to each detected condition. Based on the analysis results, E-Derma provides personalized skincare recommendations focused on ingredient-level guidance rather than brand-specific promotion, promoting transparency and informed decision-making. The system supports secure user registration and stores analysis results in a structured database, allowing users to track changes in their skin condition over time, while an administrative interface enables efficient data management, monitoring, and statistical analysis of system usage. Additionally, optional AI-generated explanations enhance user understanding by providing clear and contextual feedback regarding detected skin issues and recommended skincare ingredients. Designed as a non-invasive academic prototype, E-Derma demonstrates how intelligent image-based analysis can support accessible, scalable, and user-centric skincare assistance.

KEYWORDS: Facial Skin Analysis, Personalized Skincare, Image-Based Analysis, Rule-Based System

I. INTRODUCTION

1.1 Background and problem context

Recent advancements in intelligent computing have influenced the development of modern digital applications across various fields, including healthcare and personal assistance. Image-based analysis techniques now allow systems to extract useful information from visual data captured using common camera devices, creating new opportunities for personal health assessment. Skin health is an important factor in overall well-being, yet traditional skincare evaluation methods often rely on manual consultations, self-assessment, or generalized product recommendations. These approaches can be time-consuming, costly, and sometimes inaccurate due to the lack of objective analysis. Many individuals also face limited access to professional dermatological guidance. To address these challenges, the proposed **E-Derma** system provides real-time facial skin analysis using image-based evaluation. By examining facial images, the system identifies visible skin conditions and generates personalized skincare recommendations. This approach reduces user effort, improves assessment accuracy, and makes basic dermatological guidance more accessible and convenient.

II. LITERATURE REVIEW

Existing research in automated image analysis highlights the effectiveness of visual feature extraction techniques for recognizing patterns in facial and medical images. These techniques have been applied to detect visible skin conditions such as acne, dryness, and pigmentation by analyzing texture, color, and brightness variations. Several skincare recommendation systems have been developed in previous studies; however, many rely primarily on user questionnaires or predefined generic rules instead of actual facial image analysis. Even systems that use images often provide limited personalization or focus on brand-oriented suggestions. The **E-Derma** project addresses these limitations by combining real-time facial image evaluation with rule-based interpretation and ingredient-level recommendations, resulting in a more transparent and user-focused approach.

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III. EXISTING SYSTEM

Most existing skincare and dermatology-related systems rely on manual consultations or simple online questionnaires, where users describe their skin concerns through text-based inputs. This approach often results in generalized or inaccurate assessments due to the absence of objective evaluation. Additionally, many traditional skincare applications do not support real-time image-based analysis and are unable to visually examine skin conditions such as acne, dryness, or pigmentation. The lack of automated facial assessment and personalized ingredient-level recommendations reduces the overall effectiveness and reliability of these systems.

IV. PROPOSED SYSTEM

The proposed system, **E-Derma**, is designed to perform automated facial skin analysis using images captured through standard camera devices. Users can upload or capture a facial image, which is then processed to examine visible skin characteristics and identify common skin conditions such as acne, dryness, and pigmentation. The system evaluates these features in real time to generate meaningful analysis results.

Key features of the proposed system include:

- Automated detection of facial skin conditions
- Real-time image-based skin analysis
- Personalized skincare recommendations based on detected skin conditions
- Ingredient-level guidance to improve transparency and user understanding
- Suggestions for nearby dermatologists based on user location

By integrating image-based evaluation with rule-based decision logic, E-Derma provides a fast, user-friendly, and accessible solution for preliminary skincare guidance. The system reduces reliance on manual consultation while enhancing user convenience and decision accuracy.

V. SYSTEM ARCHITECTURE

To ensure modularity, scalability, and easy maintenance, the **E-Derma Skin Analysis System** is designed using a layered architecture, as illustrated in the diagram. The workflow is divided into clearly defined layers, where each layer performs a specific function, from user interaction to skincare recommendation and dermatologist suggestion.

Phase 1: Presentation Layer

The presentation layer consists of the **Web Client**, which includes Registration, Login, and Profile pages. Users enter personal details such as name, contact number, city, and skin type. After logging in, users can upload or capture a facial image, view their profile, and access previous analysis results. This layer handles data input and result display.

Phase 2: Application Layer

The application layer is implemented using a **FastAPI backend** that manages authentication, profile handling, and request processing. Facial image submissions are received through the /analyze endpoint, validated, and forwarded to the image processing module. This layer also handles database operations for storing user information and analysis history. An optional AI refinement step may be used.

Image Processing Module

The image processing module performs preprocessing tasks such as image resizing and feature extraction to enhance image quality and maintain consistency. These steps reduce noise and extract relevant features required for accurate skin analysis.

Phase 3: Analysis and Recommendation Layer

In this layer, the **Skin Analysis Engine** uses heuristic rule-based logic to detect common skin conditions such as acne, dryness, and pigmentation. Based on the detected conditions, ingredient-level skincare recommendations are generated. Finally, the system suggests the nearest dermatologist using the user's location information.

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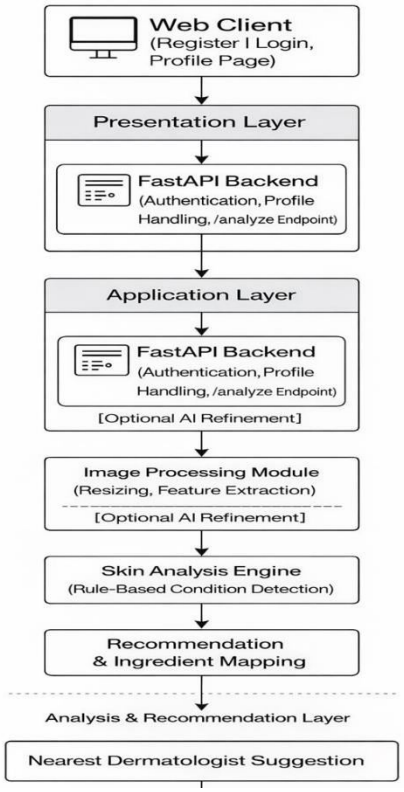

VI. METHODOLOGY

The methodology of the **E-Derma Skin Analysis System**, as illustrated in the above figure, describes the step-by-step process used to analyze facial skin conditions and generate personalized skincare recommendations.

Step 1: User Input
The process begins when the user registers or logs into the system and enters basic details such as name, contact number, city, and skin type. The user then captures a facial image using the device camera or uploads an image from the gallery.

Step 2: Image Acquisition
The submitted facial image is collected by the system and temporarily stored. This image serves as the primary input for the skin analysis process and is forwarded for further processing.

Step 3: Image Preprocessing
Image preprocessing is performed using OpenCV techniques to enhance image quality and consistency. This includes resizing the image to a standard resolution, converting color spaces, and reducing noise to remove unwanted visual distortions.

Step 4: Feature Extraction
From the preprocessed image, important visual features such as brightness, chroma (color saturation), and skin texture or sharpness are extracted. These features represent key indicators of visible skin characteristics.

Step 5: Skin Analysis Engine
The refined features are analyzed using a heuristic rule-based skin analysis engine. The system detects common skin conditions such as acne, dryness, pigmentation, and dullness, and determines their severity levels.

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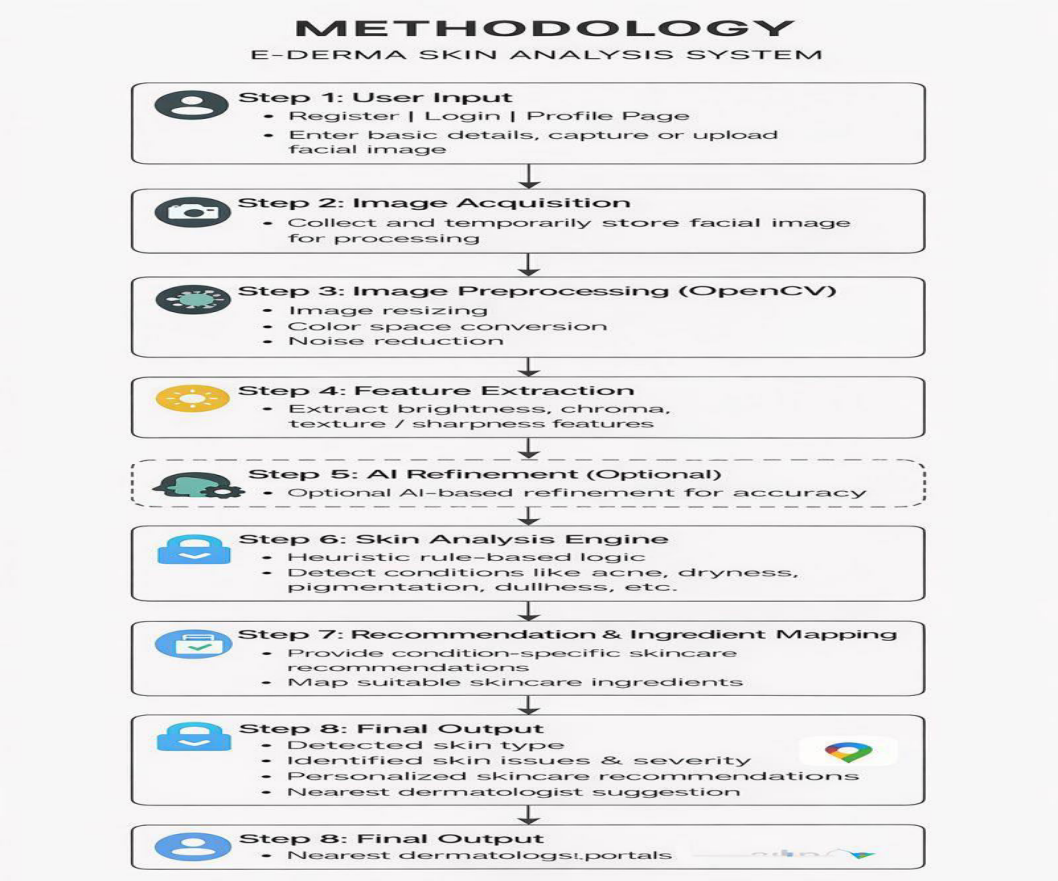
Step 6: Recommendation and Ingredient Mapping

Based on the detected skin conditions, suitable skincare ingredients are mapped, and relevant product guidance is generated. Recommendations focus on ingredient-level suitability rather than brand-specific promotion.

Step 7: Final Output

The final results are presented to the user in a clear and understandable format. The output includes detected skin type, identified skin issues with severity levels, personalized skincare recommendations, and suggestions for the nearest dermatologist when required.



VII. DESIGN AND IMPLEMENTATION

7.1 Architectural Design

The **E-Derma Skin Analysis System** follows a layered architectural design to enhance modularity, scalability, and maintainability. The system is organized into three logical layers: **Presentation Layer**, **Application Processing Layer**, and **Analysis and Recommendation Layer**, which interact through well-defined interfaces to ensure smooth data flow.

The **Presentation Layer** provides a web-based interface that supports user registration, login, and profile management. Users enter personal details such as name, contact number, city, and skin type, and upload or capture facial images for analysis. This layer is responsible only for data input and result display.

The **Application Processing Layer** acts as the middleware and is implemented using a **FastAPI backend**. It handles authentication, request validation, image handling, and communication with processing modules, ensuring that images are properly formatted and forwarded for analysis.

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The **Analysis and Recommendation Layer** perform skin evaluation using OpenCV-based preprocessing and feature extraction. A heuristic rule-based engine detects skin conditions such as acne, dryness, pigmentation, and dullness, and generates ingredient-level skincare recommendations along with nearby dermatologist suggestions.

7.2 Implementation Details

The **E-Derma Skin Analysis System** is implemented using **Python**, chosen for its strong support in image processing and backend development. The system follows a modular design to ensure scalability and ease of maintenance.

Facial images captured or uploaded through the web interface are processed using **OpenCV**. Preprocessing includes image resizing, color space conversion, and noise reduction to ensure consistent input quality and reliable feature extraction.

Skin analysis is performed using a **heuristic rule-based approach**, where visual features such as brightness, texture, and color variations are analyzed to detect common skin conditions including acne, dryness, pigmentation, and dullness.

Based on the detected conditions, suitable skincare ingredients and product recommendations are generated. The system also integrates location-based services to suggest nearby dermatologists, and the final results are displayed through the user interface.

VIII. OUTCOME OF RESEARCH

This research successfully demonstrates the development of an automated facial skin analysis and skincare recommendation system. The implemented **E-Derma** system analyzes user-uploaded facial images to identify visible skin conditions such as acne, dryness, pigmentation, dullness, wrinkles, and redness. The results confirm that OpenCV-based image preprocessing combined with heuristic rule-based analysis can provide reliable real-time outputs without requiring expensive hardware or complex infrastructure. An important outcome of this work is the successful implementation of a complete end-to-end pipeline, starting from secure user registration and image input to ingredient-level recommendations, product links, and dermatologist location suggestions. The system also stores analysis results in a structured database, enabling history tracking and analytics. Overall, the project demonstrates that intelligent image-based systems can improve accessibility to basic dermatological guidance and support users in making informed skincare decisions.

IX. RESULTS AND DISCUSSION

The E-Derma system was implemented and evaluated through functional testing using real user inputs and facial images. The results show that the system can accurately process images and detect common skin conditions including acne, dryness, pigmentation, dullness, wrinkles, and redness. OpenCV-based preprocessing improved analysis consistency by reducing noise and normalizing image features, while the heuristic rule-based engine effectively mapped extracted visual metrics to predefined skin condition categories. The system generates clear and interpretable outputs, including detected skin type, issue confidence scores, severity levels, and ingredient-based skincare recommendations. Integration of location-based dermatologist suggestions further enhances practical usability by encouraging professional consultation when necessary. Although performance may vary under poor lighting or low image quality, the results confirm that E-Derma is a cost-effective and practical solution for preliminary skin analysis and personalized skincare guidance.

X. FUTURE WORK

While the E-Derma system meets its primary objectives, several enhancements can be explored in future work. Deep learning–based skin analysis models may be integrated to improve detection accuracy for complex conditions such as fine wrinkles, severe acne, and uneven skin texture. Expanding the dataset with diverse skin tones, lighting environments, and age groups can further enhance robustness. Future versions may support real-time video-based analysis and long-term skin progress tracking using stored analysis history. Additionally, deeper integration with professional dermatologist consultation platforms and advanced recommendation engines can further improve the system's real-world applicability and user experience.

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XI. CONCLUSION

This project successfully presents **E-Derma**, a real-time facial skin analysis and personalized skincare recommendation system. By combining image processing techniques with rule-based decision logic and optional AI refinement, the system delivers quick and accessible insights into skin health. Ingredient-level recommendations enhance transparency and user trust, while dermatologist location suggestions bridge the gap between automated analysis and professional care. Overall, the project demonstrates the effective application of intelligent image-based analysis in healthcare-related domains and highlights the potential of AI-driven systems in improving personal skincare awareness and accessibility.

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