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Intelligent Skincare Product Recommendation System

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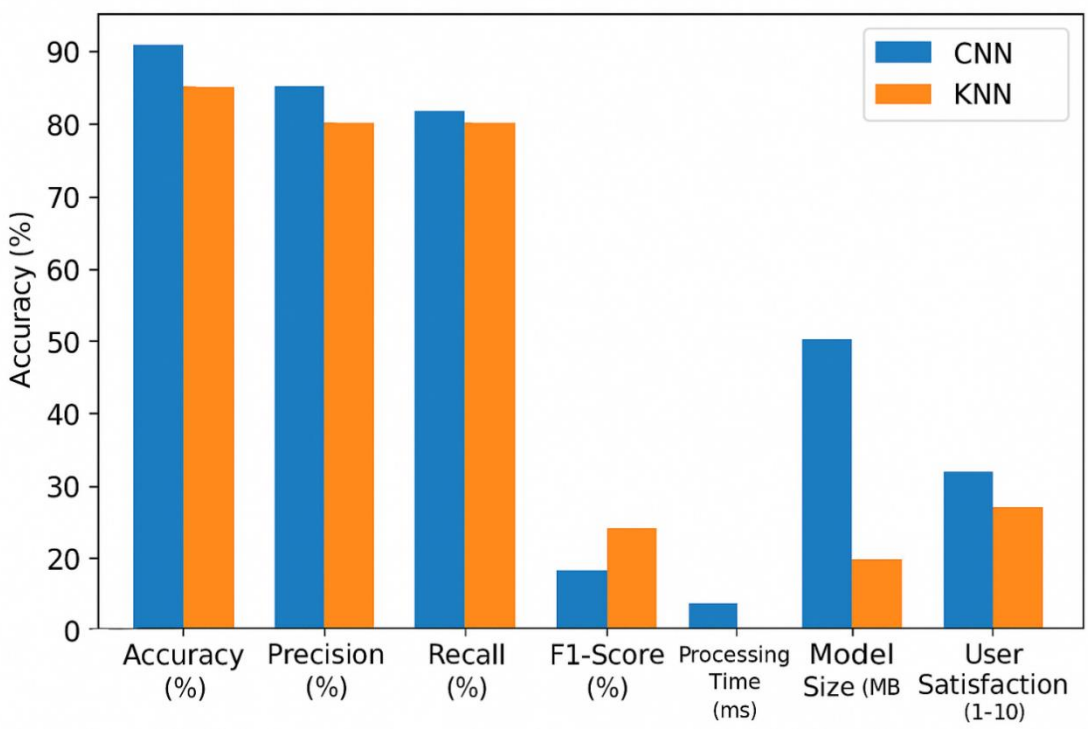
Abstract: The "**Intelligent Skincare Recommendation System"** is a mobile application developed using Flutter that leverages artificial intelligence to deliver personalized skincare solutions. The system enables users to either upload an image of their skin or manually input details such as skin type, texture, and common concerns including acne, dryness, or sensitivity. Through image processing and machine learning techniques, the application analyses the user's skin features and classifies their skin type. Utilizing the K-Nearest Neighbours (KNN) algorithm, the system generates tailored skincare product recommendations, routines, and guidance aligned with the user's specific needs. The integration of AI and dermatological insights helps users make informed product choices, minimizes trial-and-error in skincare selection, and promotes effective and data-driven skin health management.

1. INTRODUCTION

In recent years, skincare has become an essential aspect of personal health and well-being, with individuals increasingly seeking products that match their specific skin types and conditions. However, selecting suitable skincare products often involves extensive trial-and-error due to the lack of personalized recommendations and scientific guidance. This challenge highlights the need for an intelligent system that can analyse individual skin characteristics and provide data-driven skincare suggestions tailored to each user.

The **Intelligent Skincare Recommendation System** is designed to address this issue by combining **artificial intelligence (AI)**, **machine learning**, and **computer vision** to offer personalized skincare recommendations. Developed as a **mobile application using Flutter**, the system allows users to either upload a facial image or manually input details such as skin type, texture, and common issues including acne, dryness, oiliness, or sensitivity. The application employs **image processing techniques** to analyze skin features and utilizes the **K-Nearest Neighbours (KNN)** algorithm to classify skin types and generate customized product recommendations.

By integrating AI with dermatological knowledge, the system provides a scientific and efficient approach to skincare management. Its **user-friendly interface**, **real-time analysis**, and **personalized suggestions** make it suitable for a wide range of users seeking to improve their skincare routine. This intelligent system not only enhances user experience but also promotes informed decision-making, helping users achieve healthier skin through technology-driven insights.



Bar chart for KNN and CNN

2. Methodology:

2.1. Different Types of Methodologies for Skincare Recommendation

2.1.1. Image Processing-Based Approach

This approach utilizes **computer vision techniques** to analyse the user's skin image and identify key features such as texture, tone, and the presence of conditions like acne or dryness. The uploaded image is pre-processed through steps such as noise reduction, normalization, and segmentation to ensure accurate feature extraction. The processed image is then analysed using machine learning algorithms to classify the user's skin type. This method provides a data-driven and automated analysis, minimizing human bias and improving the precision of skincare recommendations.

2.1.2. Manual Input-Based Approach

In addition to automated analysis, the system also supports manual data entry, allowing users to input their skin details such as type (dry, oily, normal, or combination), texture, and common issues. This information serves as an alternative when an image cannot be uploaded or when users prefer to self-report their conditions. The entered data is processed by the recommendation engine, which uses the **K-Nearest Neighbours (KNN)** algorithm to suggest suitable skincare products and routines. This approach ensures accessibility and flexibility for all users, regardless of device camera quality or lighting conditions.

2.2. Technologies Used

2.2.1. Flutter Framework

Flutter is an open-source UI toolkit used to build the cross-platform mobile application for this system. It allows seamless development for both Android and iOS devices using a single codebase. Flutter's widget-based architecture ensures a responsive, user-friendly, and visually appealing interface, enabling smooth interaction between the user and the AI-based recommendation engine.

2.2.2. Machine Learning (K-Nearest Neighbours Algorithm)

The **KNN algorithm** is employed to generate personalized product recommendations. Based on the extracted features or manually entered parameters, the algorithm compares the user's data with existing labelled datasets to identify the most similar skin profiles. It then recommends products that have been effective for users with comparable skin conditions. This non-parametric, instance-based learning approach ensures simple yet effective classification and recommendation with minimal computational overhead.

2.2.3. Image Processing Techniques

Image processing plays a crucial role in the skin analysis workflow. The uploaded image undergoes several operations, including resizing, colour space conversion, and feature extraction, to identify key attributes such as smoothness, pigmentation, and the presence of blemishes. These extracted features are used as input parameters for the machine learning model to classify skin type and suggest suitable products.

2.2.4. Database and Backend Integration

The application maintains a database containing skincare product information, categorized by skin type, ingredients, and suitability. The backend system interacts with the machine learning model to retrieve the most relevant recommendations for the user. The integration ensures that data storage, retrieval, and recommendation generation occur efficiently in real-time.

2.2.5. Artificial Intelligence and Dermatological Knowledge Integration

The system's logic is enhanced through the integration of AI-driven insights and dermatological principles, ensuring that recommendations are not only data-driven but also clinically relevant. The AI model continuously improves as more user data is collected, refining the recommendation accuracy over time and ensuring a more intelligent and adaptive skincare advisor.

3. System Description:

3.1. Skin Image Acquisition

The system begins with capturing or uploading a user's skin image through the Flutter-based mobile app. The image is pre-processed to normalize lighting, remove noise, and standardize resolution, ensuring consistent quality for further analysis.

3.2. Image Processing and Feature Extraction

Once acquired, the image undergoes processing to detect and isolate the skin region. Techniques such as grayscale conversion, filtering, and edge detection are applied. From these processed images, textural and colour features are extracted using statistical methods like GLCM or histogram analysis, forming the dataset used for classification.

3.3. Skin Type Classification (KNN Algorithm)

The extracted features are input into a **K-Nearest Neighbours (KNN)** classifier trained on labelled datasets of various skin types—dry, oily, normal, and combination. Based on similarity measures, the algorithm predicts the user's skin type, forming the basis for personalized product recommendations.

3.4. Product Recommendation Engine

After classification, the system's recommendation engine matches the user's skin type and condition with suitable products stored in the database. Each recommendation includes product details, usage instructions, and tips for effective skincare. The process ensures that results are both personalized and data-driven.

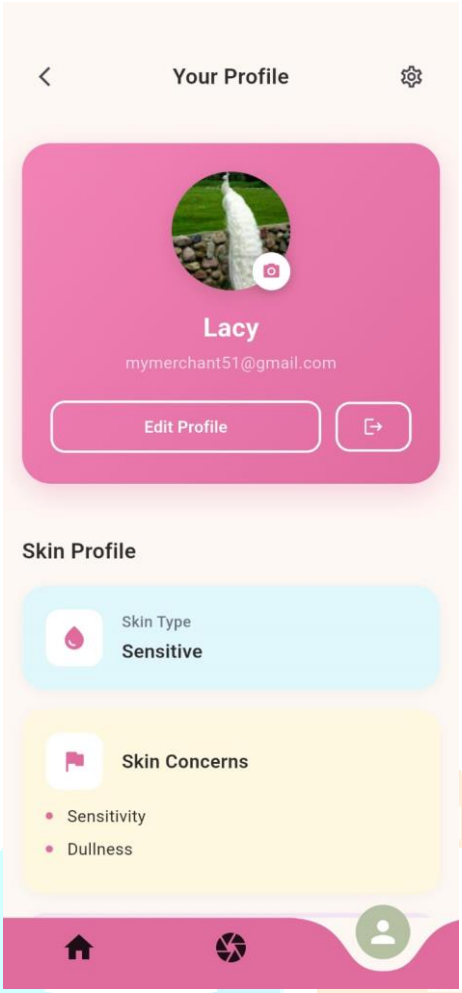
3.5. User Interface and Feedback Integration

The **Flutter-based interface** enables users to interact seamlessly—uploading images, viewing results, and receiving tailored recommendations. Over time, user feedback and preferences are stored to enhance the model's performance through continuous learning.

4. Results and Discussions

The implementation of the **Intelligent Skincare Recommendation System** using Flutter and machine learning technologies was successfully completed through several key stages. The system enables users to either upload facial images or manually input their skin-related details. The uploaded image is processed in real-time using computer vision techniques to extract relevant skin features such as texture, tone, and the presence of common issues like acne, dryness, or oiliness.

Following image analysis, the extracted features are classified using the **K-Nearest Neighbours (KNN)** algorithm to determine the user's specific skin type. Based on the classification results, the system provides personalized skincare recommendations, suggesting products that best suit the identified skin characteristics.


Your Profile
Lacy
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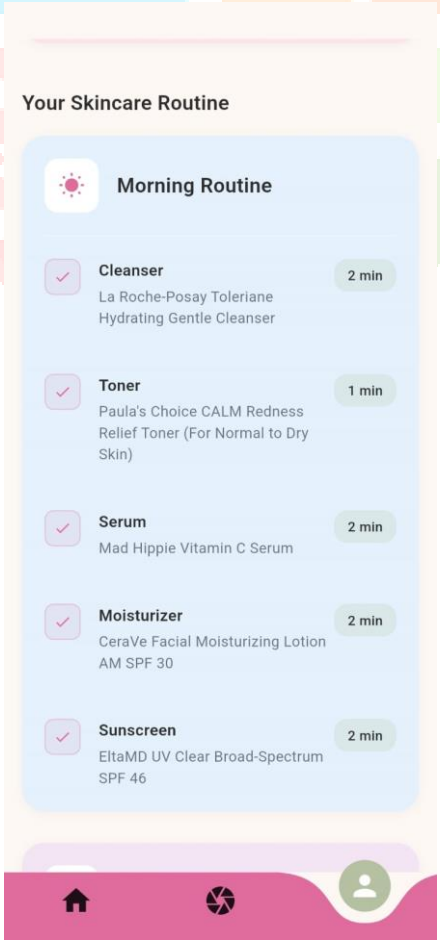
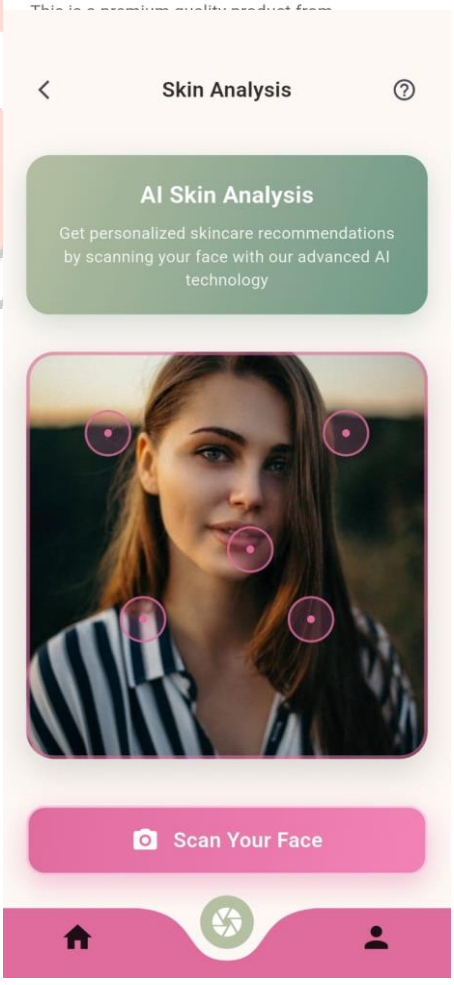
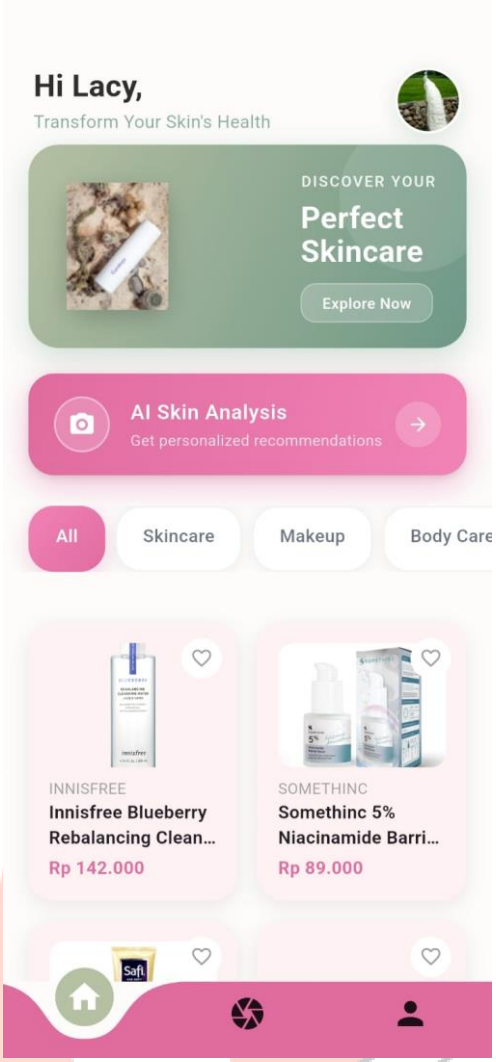
Edit Profile
Skin Profile
Skin Type
Sensitive
Skin Concerns
Sensitivity
Dullness


Hi Lacy,
Transform Your Skin's Health
SOMETHINC
Somethinc 5% Niacinamide Barrier Serum
Rp 89.000
Product Details


Your Skincare Routine
Morning Routine
Cleanser
La Roche-Posay Toleriane Hydrating Gentle Cleanser
2 min
Toner
Paula's Choice CALM Redness Relief Toner (For Normal to Dry Skin)
1 min
Serum
Mad Hippie Vitamin C Serum
2 min
Moisturizer
CeraVe Facial Moisturizing Lotion AM SPF 30
2 min
Sunscreen
EltaMD UV Clear Broad-Spectrum SPF 46
2 min


Skin Analysis
AI Skin Analysis
Get personalized skincare recommendations by scanning your face with our advanced AI technology
Scan Your Face



4.1. Future Work

While the current system effectively identifies skin types and suggests suitable products, future enhancements can make it even more comprehensive and adaptive. Upcoming versions could incorporate deep learning models such as **Convolutional Neural Networks (CNNs)** to further improve image analysis accuracy and handle more complex skin conditions.

Additionally, integrating a larger dermatology-backed dataset could help refine product recommendations based on diverse skin tones, environmental conditions, and age groups. The inclusion of **real-time** progress tracking, where users can monitor changes in their skin over time through periodic image uploads, would add significant value.

5. Conclusion

In summary, the Intelligent Skincare Recommendation System represents a significant advancement in the field of personalized skincare. By integrating artificial intelligence, machine learning, and computer vision, the system bridges the gap between technology and dermatological science to offer customized skincare solutions.

This innovative approach not only helps users make informed decisions about their skincare routines but also minimizes the trial-and-error process often associated with product selection. The system's ability to analyse facial features and provide tailored recommendations contributes to healthier skin management and improved user confidence.

However, it is important to recognize that while technology offers valuable support, professional dermatological consultation and user education remain vital for achieving optimal skincare results. Continued research, dataset expansion, and system refinement will further enhance the reliability and

inclusivity of this application, paving the way toward a future where intelligent skincare systems become an integral part of everyday health and wellness.

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