

LUMEA - AI-Based Skin Disease Detection and 'Skincare Recommendation System

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Abstract—Skin health plays a crucial role in overall well-being, influencing both physical comfort and self-confidence. However, dermatological care remains inaccessible to many due to the shortage of specialists, high consultation costs, and delays in diagnosis. With the rapid evolution of Artificial Intelligence (AI) and Computer Vision, automated skin analysis systems have emerged as powerful tools for assisting both users and medical professionals

Skin health plays a crucial role in overall well-being, influencing both physical comfort and self-confidence. However, dermatological care remains inaccessible to many due to the shortage of specialists, high consultation costs, and delays in diagnosis. With the rapid evolution of Artificial Intelligence (AI) and Computer Vision, automated skin analysis systems have emerged as powerful tools for assisting both users and medical professionals

This integration of AI-driven diagnostics and climate-aware personalization bridges the gap between dermatology and accessibility, allowing individuals to receive guidance without the need for frequent clinic visits. The project ultimately aims to promote skin health awareness, encourage preventive care, and make intelligent skincare support available to everyone through an intuitive web interface.

I. INTRODUCTION

Dermatological diseases are among the most common health issues globally, yet timely diagnosis remains a challenge. Many users rely on self-diagnosis or random product use, leading to worsened conditions and allergic reactions. Traditional diagnosis requires in-person consultation, which is often time-consuming and geographically limited. Furthermore, most skincare recommendation systems lack personalization, ignoring crucial parameters such as skin type, environmental exposure, and medical history. The problem addressed in this project is the absence of an

accessible, intelligent, and adaptive skincare support system that can accurately analyze skin images, detect diseases, and provide context-aware skincare recommendations.

II. LITERATURE REVIEW

A. Overview of AI in Dermatology

Artificial Intelligence (AI) has transformed the landscape of dermatology by enabling early, automated, and highly accurate detection of skin conditions. Through the use of Deep Learning and Computer Vision, AI models can interpret minute variations in color, texture, and patterns in skin images, allowing for improved diagnostic precision. Convolutional Neural Networks (CNN) in particular have demonstrated remarkable success in image-based medical analysis, outperforming traditional manual methods in both accuracy and speed. AI applications in dermatology extend beyond diagnosis to include skin-type identification, tone analysis, and product recommendation. These systems often aim to personalize skincare routines and assist healthcare providers by offering data-driven insights. Moreover, the integration of external factors such as environmental conditions (UV exposure, humidity, pollution) into dermatological systems has opened new avenues for adaptive and context-aware recommendations. Despite these advancements, current research remains fragmented. Most existing solutions focus solely on disease detection or cosmetic recommendations without combining both into a unified framework. The following sections review notable works in this field, highlighting their methodologies, 3. Absence of Inclusive Skin Tone Mapping: Few systems achievements, and limitations that motivated the development of Lumea'.

B. Review of Existing Works

Machine Learning Framework for Accurate Skin Tone, Type, and Disease Detection

A recent study proposed a Machine Learning Framework capable of identifying skin tone, type, and common diseases through CNN-based image processing. The model integrated web scraping techniques to collect skincare information from reliable online sources, which were then processed using Natural Language Processing (NLP) for summarizing relevant advice. This hybrid system aimed to combine medical analysis with dynamic skincare recommendations.

C. AI-Based Smart Cosmetics Suggestion System

Another study introduced an AI-Based Smart Cosmetics Suggestion System, focusing on tailoring product recommendations based on skin type and real-time weather data. It integrated climate APIs to retrieve environmental parameters such as UV index, temperature, and humidity, using them to generate context-aware product suggestions. Deep learning algorithms were utilized to analyze user inputs and map skin conditions to compatible cosmetics.

D. Cosmetic Suggestion Based on Skin Condition Using Artificial Intelligence

A third related work focused on enhancing user safety by filtering out allergy-causing cosmetic ingredients using AI-based classification. The system applied CNN models to identify skin conditions and recommend suitable, low-risk cosmetic products. Additionally, it implemented a feedback mechanism, allowing users to rate the recommendations and improve system accuracy over time.

E. Interpretation

The comparative analysis demonstrates that existing research contributions have primarily addressed isolated aspects of AI in skincare—such as disease classification, cosmetic recommendation, or allergy prevention. However, none of these systems provide an integrated, adaptive, and clinically relevant framework capable of connecting dermatological analysis with environmental awareness and personalized care. The Lumea system ‘bridges these gaps by combining medical diagnostics, real-time data integration, and personalized skincare recommendations into a single, user-accessible web platform. This holistic approach distinguishes Lumea

as a next-generation AI-driven ‘dermatology solution.

F. Research Gaps and Limitations

The literature review reveals several critical research gaps:

1. Lack of Environmental Adaptation: None of the reviewed systems dynamically adjust recommendations based on UV index, humidity, or climate conditions.
2. Limited Medical and Clinical Validation: Many models use non-standard datasets, reducing diagnostic credibility.
3. Absence of Inclusive Skin Tone Mapping: Few systems employ medically accepted scales like the Fitzpatrick scale, resulting in bias.
4. Restricted User Interaction and Web Deployment: Several prototypes remain academic concepts without real-time accessibility.
5. No Unified Hybrid Model: Existing studies typically separate disease detection and recommendation systems instead of merging them for a complete skincare solution. Lumea directly addresses these limitations by integrating ‘CNN-based medical diagnosis, real-time environmental data, and personalized recommendations into one seamless, interactive platform.

III. SIGNIFICANCE OF THE STUDY

A. Importance of Early Detection

The paramount significance of the Lumea ‘project lies in its capability for early detection of skin diseases through immediate, AI-driven image analysis. Dermatological conditions, ranging from common afflictions like acne and eczema to severe malignancies such as melanoma, require timely diagnosis for effective treatment and improved patient outcomes. This system utilizes deep learning and computer vision techniques, specifically Convolutional Neural Networks (CNNs), to act as a crucial first line of defense. By rapidly identifying key visual indicators associated with various skin conditions from a user-submitted image, Lumea effectively overcomes the barriers of appointment waiting times and geographical distance. This rapid screening capability is especially vital for aggressive diseases like melanoma, where early identification is directly correlated with survival rates, positioning

the application as a critical tool for preliminary risk assessment and encouraging immediate clinical follow-up.

B. Personalized Skincare and Accessibility

The project introduces a significant advancement in personalization by moving beyond generic skincare advice. The system's methodology relies on deep learning to accurately identify a user's unique skin type and tone, which, combined with the detection of specific conditions, allows for truly tailored recommendations. Furthermore, Lumea addresses a substantial barrier in modern healthcare—accessibility. By facilitating clinic referrals and teleconsultations directly through the platform, the system dramatically lowers the geographical and economic hurdles associated with professional dermatological care. This feature is transformative for users in remote or underserved areas, ensuring that expert advice and necessary medical follow-up are within reach, thus democratizing access to specialized skin health management.

C. Environmental Awareness Integration

A core innovation of this study is the integration of real-time environmental awareness into the recommendation process. Traditional skincare advice often fails to account for external, dynamic stressors. Lumea resolves this by incorporating live data from the OpenWeatherMap API, including the UV index, humidity, and general climate conditions based on the user's location. For instance, a high UV index immediately triggers stronger sunscreen recommendations, while low humidity might necessitate a shift toward more occlusive moisturizers. This methodology ensures that the skincare regimen is not static but adaptive and contextually relevant, helping users proactively manage the daily impact of their local environment on skin health.

D. Societal and Clinical Relevance

From a societal perspective, Lumea offers a highly relevant solution by empowering individuals with immediate, expert-level skin health information, fostering a proactive approach to self-care. It acts as an effective digital primary screening tool, which can significantly reduce the clinical burden on primary healthcare physicians by filtering noncritical cases and prioritizing users requiring urgent attention. Clinically, the system provides a robust technological foundation for tele-

dermatology, enhancing the efficiency of remote consultations by providing the consulting physician with pre-screened image data and personalized environmental context. Ultimately, the project contributes to the broader field of digital health by demonstrating a scalable, integrated, and intelligent solution for skin health management.

IV. SYSTEM ARCHITECTURE

The Lumea' system is designed as a comprehensive AI-powered platform for personalized skincare, focusing on both early disease detection and tailored recommendations. The architecture is strategically divided into several interconnected modules: the user interface, the backend computational services, the core AI analysis component, and external data integrators. This structure ensures a robust, scalable, and climate-aware application capable of handling high-volume image processing and real-time data synthesis.

A. Image Upload and Preprocessing

The system's operational sequence is initiated by the user's interaction with the frontend, where they upload a skin or facial image. The image can be captured live via the device's camera or selected from the gallery. Upon submission, it immediately undergoes mandatory preprocessing using the OpenCV library. This step standardizes the visual data before it reaches the AI model, mitigating inconsistencies from varying user inputs. The preprocessing routine includes resizing the image to conform to the model's input requirements, applying filtering to remove noise and enhance feature prominence, and normalization to adjust pixel values, thereby ensuring reliable model performance across different lighting conditions.

B. Skin Analysis with CNN

The core intelligence of the Lumea' system resides in its Skin Analysis with CNN module, hosted within the Flask API. The system utilizes advanced Convolutional Neural Networks (CNNs), such as MobileNet or ResNet, trained extensively on diverse public dermatology datasets. Once the preprocessed image is received, the model executes a dual-classification

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Phase 1: Completed Architecture

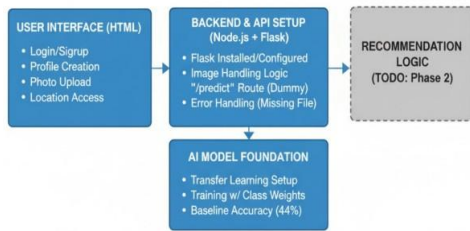


Fig. 1. Phase 1 Completed Architecture

task: identifying the user’s skin type (dry, oily, combination) and skin tone, while simultaneously performing Skin Condition Identification. This identification covers a range of dermatological issues, including acne, eczema, melanoma, fungal infections, psoriasis, and pigmentation irregularities. The CNN’s efficiency allows nearreal-time diagnostic results, providing actionable insights directly to the user.

C. Environmental Data Integration

To ensure that personalized recommendations are adaptive rather than static, the system incorporates a real-time data feed via the OpenWeatherMap API. Based on the user’s location, either auto-detected or manually entered, the system fetches critical environmental parameters, including the UV Index, Humidity, and Temperature. This approach allows the recommendation engine to optimize skincare guidance according to local climatic conditions, ensuring practical and contextually relevant advice.

D. Frontend and Backend Design

The system employs a clear separation of concerns using a modern technology stack. The Frontend is implemented in HTML, CSS, and JavaScript, providing a responsive interface for secure login/signup, profile creation, image upload, and displaying diagnostic insights along with product recommendations. The Backend, built with Node.js, manages the system workflow, handles user sessions, and orchestrates communication with both the CNN model and external APIs. The Flask API serves the deep learning model, acting as a bridge between backend logic and computational intelligence.

E. Product Recommendation Engine

The Product Recommendation Engine synthesizes

biological insights from the CNN model with environmental data to generate a personalized skincare routine. Recommendations are tailored based on detected skin type, identified conditions, and environmental parameters such as UV index and humidity. The engine further filters product suggestions according to dermatological safety and regional availability, ultimately delivering a comprehensive Personalized Skincare Routine along with direct e-commerce product links.

F. System Workflow

The end-to-end workflow begins with user image submission, followed by preprocessing and three parallel tasks: Skin Type Detection, Skin Tone Detection, and Skin Condition Identification. These results converge in the Generate Personalized Routine module, where environmental data is integrated to refine recommendations. A final filtering step ensures that only dermatologist-approved and regionally available products are presented to the user.

G. Block Diagram and Data Flow

The methodology is captured in the Data Flow Diagram (DFD), illustrating the sequential and concurrent operations of the system. After image submission, data flows simultaneously through the three core detection modules. Outputs converge in the Generate Personalized Routine module, merged with real-time environmental inputs. Two final filtering steps—Dermatologist Approval and Regional Availability—ensure the delivered Personalized Skincare Routine and Product Suggestions are precise, contextaware, and actionable.

V. METHODOLOGY

A. Lumea: Phase 1 Project Methodology

This chapter outlines the methodology, system architecture, and implementation status for Phase 1 of the Lumea’ project—an AI-based Skin Disease Detection and Skincare Recommendation System. The primary objective of this phase was to establish a fully functional framework integrating the frontend interface, backend services, core deep learning model, and environmental data pipelines, thereby laying the foundation for deployment, clinical validation, and future system enhancements.

B. System Architecture and Technology Stack

The Lumea system employs a modular client-server architecture designed for high-throughput image processing, real-time environmental data integration, and AI-driven personalized recommendation generation. The architecture consists of interconnected components that manage the user journey from image upload to personalized product suggestions. The frontend, developed using HTML, CSS, and JavaScript, provides a responsive interface for user actions including profile creation, secure login, image submission, and the visualization of diagnostic insights along with recommended skincare products. The backend, implemented in Node.js, orchestrates workflow management, handles authentication and session control, and communicates with both the AI model hosted via Flask and external environmental data sources such as the OpenWeatherMap API. The AI model itself, leveraging MobileNetV2 and ResNet architectures, performs the core dermatological analysis, while environmental integration ensures recommendations are contextually relevant to real-time UV, humidity, and climate conditions.

Component	Technology	Role
Frontend Web Interface	HTML, CSS, JavaScript	Handles image upload, profile management, displays diagnostic insights and product recommendations, ensuring a responsive and intuitive user experience.
Backend Management	Node.js	Manages user input, authentication, session management, workflow orchestration, and communication with both the AI model API and external environmental data sources.
AI Model Serving	Flask API	Hosts the Convolutional Neural Network (CNN) model, processes image data, and returns predictions to the backend in real time.
AI Model	MobileNetV2 / ResNet	Performs skin type, tone, and condition classification, detecting dermatological conditions such as acne, eczema, psoriasis, fungal infections, and melanoma.
Environmental Data	OpenWeatherMap API	Retrieves real-time UV index, humidity, and temperature to support context-aware skincare recommendations.

C. Image Upload, Preprocessing, and Core Analysis

Users interact with the HTML frontend to upload facial or skin images. Once submitted, these images are processed through a rigorous preprocessing pipeline using OpenCV to standardize visual input and ensure high-quality feature extraction. The preprocessing steps include resizing images to conform with CNN input specifications, filtering to remove noise and highlight key features, normalization to adjust pixel values consistently across varying lighting conditions, and data

augmentation techniques during training to improve model robustness and generalization. The processed images are then forwarded to the Flask API hosting the core AI model. The CNN models, specifically MobileNetV2 and ResNet, execute dual-classification tasks. They first determine the user's skin type and tone, aligned with medically recognized scales, and concurrently detect common dermatological conditions such as acne, eczema, psoriasis, pigmentation irregularities, fungal infections, and melanoma. This analysis transforms raw image data into actionable dermatological insights, facilitating early detection and personalized skincare guidance.

D. Deep Learning Training Strategy

The AI model was trained using a structured methodology. Transfer learning with MobileNetV2 forms the foundation, enabling efficient extraction of high-dimensional image features. Training preprocessing mirrors the live system pipeline, including resizing, normalization, and data augmentation. Fine-tuning occurs in two stages: initially training only the added classification layers, followed by selective adjustment of base layers to optimize accuracy. Class weights were applied to address data imbalances across skin types and conditions. The model achieved a baseline classification accuracy of 44%, with ongoing improvements focused on expanding the dataset, incorporating additional augmentation techniques, and optimizing hyperparameters for better generalization. % CNN and Transfer Learning description

E. Data Integration and Recommendation Engine

Lumea integrates environmental data dynamically through the OpenWeatherMap API. User location is obtained either through geolocation services or manual entry, allowing retrieval of real-time UV index, humidity, and temperature. This information ensures that all recommendations are climate-aware and contextually relevant. The product recommendation engine synthesizes AI-derived diagnostic results with environmental data to provide personalized skincare advice. Skin type and detected conditions are matched to suitable products while factoring in environmental risk, such as high UV index triggering stronger sunscreen recommendations. Recommendations are tailored to user safety, including allergy-safe options, and incorporate ethical AI considerations with feedback

loops to enhance inclusivity and continuous system improvement.

VI. RESULTS AND DISCUSSION

A. System Interface Overview

The results section provides a visual and functional overview of the Lumea system's interface, demonstrating the completion of key frontend and user interaction modules. The implemented interface is a user-centric web application built with React.js, designed to make dermatological support accessible from anywhere via mobile or web.

1) *Key Interface Screens and Functionality:* The following interface screenshots and their core functionalities confirm the successful implementation of the system's foundational structure: Lumea Dashboard: The main landing page is an AI-Powered Path to Healthier Skin, which instantly detects skin conditions and offers personalized, climate-adaptive skincare routines. It provides the entry points for analysis and directs users to the login/signup process. User Authentication: Secure login and signup modules have been implemented, allowing users to register or access accounts seamlessly, ensuring only authorized access. The signup page includes an option to "Continue with Google". Profile Creation: A user-friendly profile interface was developed to input personal details (Full Name, Age, Gender) and specify Skin Concerns (e.g., acne, redness, pigmentation) for personalized skincare analysis. AI Skin Analysis Start: This is the central hub for the system. It presents the core value propositions: Personalized Skincare Routine and Skin Condition Detection. Crucially, it includes the Upload Photo and Take Photo features, along with a prominent button for Location Access to enable climate-adaptive recommendations. Sample Disease Detection: A sample result screen illustrates the system's diagnostic capability, showing a High Probability of Melanoma with a simulated AI Confidence: 92.5%. It includes an Immediate Action Advised warning and outlines Next Steps Specialist Referral. It also incorporates a risk profile based on the ABCDE criteria (Asymmetry, Border, Color, Diameter) and lists Local Health Impact Risk (UV Index, Air Quality). Sample Health Score and Routine: This screen provides a personalized summary, welcoming the user back ("Welcome back, Emily!"). It displays an overall

skin health score (88% - Excellent),

the latest Primary Concern (Acne and Increased Oiliness), and the Today's Lumea Skincare Routine (AM/PM steps). It prominently features Local Skin Impact data for the user's location (e.g., New York, NY) detailing the UV Index (High) and Humidity (35% Dry). The successful implementation of these components indicates that the frontend is complete and connected, providing a secure and interactive platform for users, which is essential for the system's objective of bridging the accessibility gap for dermatological analysis.

B. Dashboard Screens

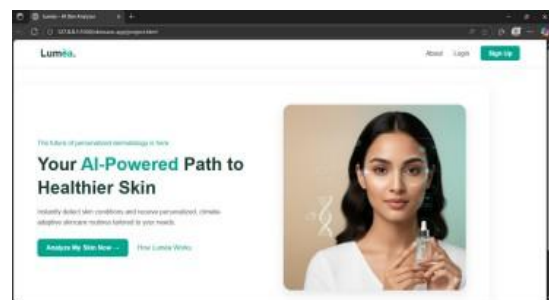


Fig. 2. Lumea Dashboard

C. Login and Signup Pages

The Lumea Login Page serves as the secure entry point to the AI-based skincare and disease detection system. It was designed to authenticate existing users, ensuring that only registered individuals can access their personalized dashboards and skincare insights. Built using React.js, the page combines a clean and minimal design with essential functionality for a smooth user experience. It typically includes fields for entering an email and password, along with options like "Forgot Password" for easy recovery and a link to the Sign-Up page for new users. The design prioritizes accessibility and responsiveness, allowing users to log in seamlessly from both desktop and mobile devices. From a technical perspective, when a user enters their credentials, the frontend communicates with the backend—managed by Node.js and Flask—to verify the details stored in the system's secure database. Upon successful authentication, the user is directed to their personalized dashboard where they can upload skin images, view analysis reports, and receive product recommendations. The login system was implemented to maintain data privacy and account protection, which is vital since the platform handles sensitive skin images and health-

related information. Overall, the Lumea Login Page provides a trustworthy and user-friendly gateway into the AI-powered skincare platform.

The Sign-Up Page in Lumea is designed to onboard new users by collecting the basic information required to create a personal account. This page focuses on simplicity and inclusivity, ensuring that first-time users can register quickly and begin using the platform’s features. The interface allows users to input their name, email, password, and demographic details such as age and gender, which are later used to

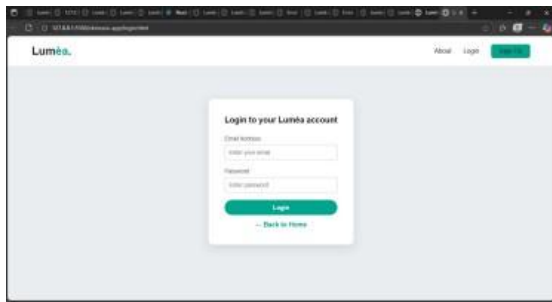


Fig. 3. Lumea Login Page

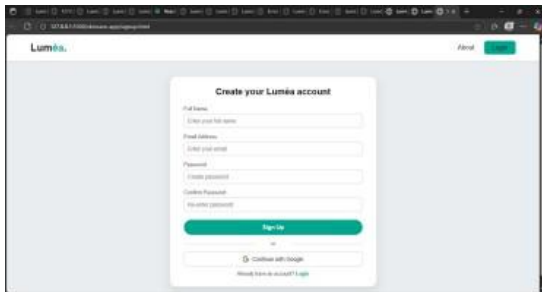


Fig. 4. Lumea SignUp

personalize skincare analysis and recommendations. After the details are entered, the system validates the data—checking for unique email IDs and strong passwords—to ensure security and accuracy before account creation. Once registration is complete, the backend stores the user data securely and provides access to the Profile Creation page, where users can add further details and upload images for analysis. The sign-up process also integrates with the authentication system, ensuring a seamless transition between registration and login. The page is designed with a modern, responsive layout, using visual consistency that matches the overall Lumea theme seen in the dashboard and login interfaces. In essence, the Sign-Up Page acts as the starting point of a personalized skincare journey, enabling users to access AI-driven skin detection and tailored recommendations with ease and security.

D. Profile Creation

The Profile Creation Page in Lumea plays a key role in personalizing the user experience within the AI-based skincare and disease detection platform. After logging in or signing up, users are guided to this page to complete their personal details, which help the system deliver customized skincare analysis and product recommendations. The interface is designed to be simple, clean, and user-friendly, encouraging users to enter accurate information without any complexity. Typically, the page includes input fields for name, age, gender, skin concerns, and location, which together form the foundation for individualized analysis.

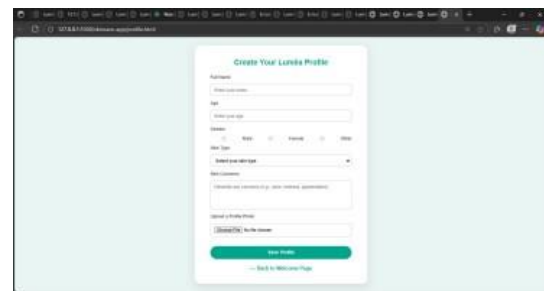


Fig. 5. Lumea Create Profile

E. Image upload and Disease detection

The Image Upload Page in Lumea is one of the most important features of the system, as it serves as the starting point for the AI-based skin analysis process. Through this interface, users can easily upload an image of their skin or face using either the device’s camera or gallery. The page is designed using React.js, ensuring a smooth, responsive, and user-friendly experience across all devices. Once an image is uploaded, it undergoes preprocessing using OpenCV in the backend. This preprocessing step includes resizing the image to a standard dimension, filtering out noise, and normalizing pixel values to prepare it for accurate analysis by the deep learning model.



Fig. 6. Lumea Upload Image

The Disease Detection Module of Lumea is where the system’s AI capabilities truly come ‘ to life. After the image is uploaded and preprocessed, it is analyzed using a Con- volutional Neural Network (CNN) model—specifically Mo- bileNetV2, which has been fine-tuned through transfer learning for dermatological image classification. The model identifies key visual features in the image and classifies skin conditions such as acne, eczema, pigmentation, psoriasis, or fungal infec- tions. Alongside disease classification, the system also detects skin type and tone, providing a holistic understanding of the user’s skin health.

F. Health Score Analysis

The Health Score Analysis in Lumea provides users with a simple yet informative summary of their overall skin health



Fig. 7. Lum’ea Disease Detection

based on AI-driven analysis. After the disease detection process, the system generates a numerical or percentage-based health score that reflects the condition of the user’s skin. This score is calculated using various parameters, including the severity of detected skin conditions, the clarity and texture of the skin, and the presence of any abnormalities such as acne, pigmentation, or dryness. By converting complex AI predictions into an easy-to-understand score, Lumea ensures that users can quickly assess their skin’s health status without needing technical or medical expertise. The health score is displayed on the user dashboard in a visually engaging format—often through graphs, bars, or circular indicators—to help users track improvements over time. If the score is low, the system may indicate potential skin concerns and suggest steps for improvement, such as hydration, sun protection, or dermatologist consultation. Conversely, a higher score reflects healthy skin with minimal detected issues. The feature also interacts with the environmental data integration module, considering external factors like UV index and

humidity that may influence skin health. Technically, the health score is derived from the CNN model’s confidence levels and prediction metrics, combined with data from the user’s profile and environmental APIs. This integrated approach ensures that the score is both accurate and personalized, offering actionable insights rather than just diagnostic output. Overall, the Health Score Analysis acts as a comprehensive wellness indicator, helping users monitor their skin condition understand AI-based results intuitively, and make informed decisions about skincare routines and lifestyle adjustments.

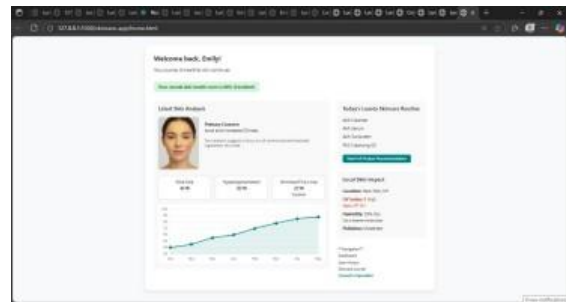


Fig. 8. Lum’ea Health Score

VII. CONCLUSION

The Lumea project successfully developed an AI-based skin disease detection and skincare recommendation system that combines the power of deep learning, computer vision, and web-based interaction. By integrating a MobileNetV2 CNN model with Flask and Node.js backends and a React.js frontend, the system effectively demonstrates how artificial intelligence can assist in dermatological analysis and personalized skincare. Users can securely log in, create profiles, upload skin images, and receive condition-based recommendations along with a health score. The model achieved a baseline accuracy of 44%, proving its capability to detect and classify different skin types and diseases. Furthermore, the integration of real-time environmental data such as UV index and humidity enhanced the practicality of skincare suggestions, making Lumea adaptive and user-centered. Overall, the project fulfilled its primary objectives by developing a functional prototype that bridges technology and skincare awareness, promoting accessible and preventive dermatological care While the current version of Lumea lays a strong foundation, there remains significant scope for future enhancement. The foremost priority is to improve model accuracy by expanding the dataset to

include a wider variety of skin tones, lighting conditions, and disease categories. Incorporating medical-grade dermatology datasets and fine-tuning the CNN architecture could greatly enhance diagnostic precision. Additionally, implementing explainable AI (XAI) methods would help users and dermatologists understand the reasoning behind each prediction, improving trust and transparency. Future versions can also include real-time camera-based skin scanning using mobile applications, enabling instant feedback and health monitoring. Integration with teledermatology services could allow users to directly consult dermatologists through the platform. Furthermore, the product recommendation system could be expanded to include personalized e-commerce suggestions based on skin analysis, preferences, and regional availability. Adding multilingual support and accessibility features would make Lumea more inclusive for global users. In essence, the future development of Lumea aims to transform it from a prototype into a comprehensive AI-driven dermatological assistant, capable of providing reliable, ethical, and user-friendly skin health support for people worldwide.

Efficient Convolutional Neural Networks for Mobile Vision Applications,” arXiv preprint arXiv:1704.04861, 2017.

- [5] Kingma, D. P., and Ba, J., “Adam: A Method for Stochastic Optimization,” arXiv preprint arXiv:1412.6980, 2014
- [6] A. Esteva et al., “Dermatologist-level classification of skin cancer with deep neural networks,” *Nature*, vol. 542, no. 7639, pp. 115–118, 2017. (Accessed 2025).
- [7] S. Han et al., “Classification of clinical images for benign and malignant cutaneous tumors using deep learning,” *Journal of Investigative Dermatology*.

BIBLIOGRAPHY

- [1] Lakshana Kugaraj, D. M. G. T. Dassanayake, and Karthiga Rajendran, “A Machine Learning Framework for Accurate Skin Tone, Type, and Disease Detection with Web Scraping and NLP for Dermatological Insights,” *Proceedings of the International Conference on Innovative Trends in Research (ICITR)*, 2024.
- [2] Bhavana D. E., Gopalkrishna C., Ravi Kumar, Harisha S., and Kaushik M., “Artificial Intelligence-based Smart Cosmetics Suggestion System based on Skin Condition,” *Proceedings of the International Conference on Advances in Information Technology (ICAIT)*, 2024.
- [3] A. Kavitha, R. Rathiya, T. Rajkumar, S. Abinaya, M. Britney Sandra, and M. Rajasri, “Cosmetic Suggestion Based on Skin Condition Using Artificial Intelligence,” *Proceedings of the International Conference on Engineering, Applied Sciences and Research (ICEARS)*, 2023.
- [4] Howard, A. G., Zhu, M., Chen, B., Kalenichenko, D., Wang, W., Weyand, T., Andreetto, M., and Adam, H., “MobileNets: