Skin Care Product Recommendation System

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Final Approval

This is to clarify that we have read this report submitted by **Misbah Yasmin**. It is our judgment that this report is of sufficient standard to warrant its acceptance by **National Center of Artificial Intelligence** for the **Artificial Intelligence Development Professional(AIDP) .**

Supervisor _____

Acknowledgement

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Misbah Yasmin

Abstract

The **Skin Care Product Recommendation System** utilizes **Convolutional Neural Networks (CNNs)** to analyze and classify skin types based on user-provided images. By leveraging deep learning techniques, the system detects skin conditions such as acne, dryness, and pigmentation, enabling personalized product recommendations. The model is trained on a dataset of diverse skin images and optimized to accurately identify skin concerns. Based on the classification results, a recommendation engine suggests suitable skincare products tailored to individual needs. This project highlights the potential of **deep learning** in the beauty and skincare industry, demonstrating how **CNN-based image analysis** can enhance **personalized skincare solutions.**

Keywords: Skin Care, Convolutional Neural Networks, Deep Learning, Image Classification, Recommendation System, Artificial Intelligence

Background

In recent years, the skincare industry has seen a rapid transformation with the integration of **artificial intelligence (AI)** and **machine learning (ML)** technologies. Finding the right skincare products is often a challenge due to the vast number of options available and the unique needs of every individual's skin. Many people rely on trial-and-error methods, which can lead to ineffective treatments, allergic reactions, and unnecessary expenses.

To address this issue, the **Skin Care Product Recommendation System** leverages **Convolutional Neural Networks (CNNs)** to analyze skin conditions through image processing. CNNs are widely used in **computer vision** applications and are particularly effective in identifying patterns in images. By training the model on a dataset containing various skin types and conditions, the system can accurately classify skin concerns such as **acne, dryness, pigmentation, and oiliness**. Based on these classifications, it recommends suitable skincare products tailored to the user's specific needs.

This project aims to bridge the gap between technology and skincare by providing **personalized recommendations** that enhance user experience and improve skin health. By utilizing deep learning, this system can offer **data-driven, dermatologist-inspired product suggestions**, making skincare routines more effective and efficient.

Tabel of content:

1. INTRODUCTION:

1.1 Overview:

Skincare is an essential part of personal health, but selecting the right products is challenging due to varying skin types, environmental factors, and individual skin concerns. Many people struggle with trial-and-error methods, leading to wasted money, skin irritation, or ineffective results.

To address this problem, the "Skin Care Product Recommendation System" utilizes Machine Learning (ML) and Convolutional Neural Networks (CNNs) to provide personalized product recommendations. By analyzing user inputs, including skin type, sensitivity, and common concerns (acne, dryness, oiliness, pigmentation, etc.), the system suggests the most suitable skincare products.

This project aims to bridge the gap between technology and skincare by offering data-driven recommendations, making skincare routines more effective and user-friendly.

1.2 Purpose of the System:

The primary goal of this project is to provide an AI-powered recommendation system that helps users select the best skincare products based on their unique skin characteristics. This system will:

- **Analyze** user skin conditions through CNN-based image processing and user-provided data.
- **Suggest product**s based on skin concerns like acne, dryness, oiliness, aging, or pigmentation.
- **Enhance user experience** by reducing trial-and-error product selection.

- **Improve skincare** effectiveness through scientific, data-driven recommendations.

1.3 Scope of problems:

1.3.1 No Personalized Suggestions:

Most skincare recommendations are generic and do not consider individual skin type, concerns, and allergies, leading to ineffective results.

1.3.2 Trial-and-Error Buying:

- **Wasted money** on products that may not be suitable.
- **Potential skin damage** if a product contains harsh or irritating ingredients.
- **Time-consuming process**, as results take weeks to show, delaying effective treatment.

1.3.3 No Expert Guidance:

- **Expensive** and not affordable for everyone.
- **Not easily accessibl**e in rural areas or smaller cities.
- **Time-consuming**, requiring appointments and follow-ups.

1.3.4 Allergy & Sensitivity Issues:

Many users experience adverse reactions to skincare products because they are unaware of their skin's sensitivities. Problems include:

- **Unknown allergies** to certain ingredients like fragrance, alcohol, or essential oils.
- **Harsh chemicals** in some products that worsen skin conditions.
- **Lack of transparency** about which products are suitable for sensitive or acne-prone skin.

1.3.5 AI Model and Bias:

Many AI-based skincare models face issues due to limited and biased datasets, which:

- **Lack diversity** in skin tones and types.
- **Perform better** on lighter skin tones but struggle with darker or mixed skin tones.
- **Fail to consider** regional and environmental differences in skincare needs.

1.3.6 No Real-Time Skin Analysis:

Most existing recommendation systems rely on user-inputted text data like "I have oily skin" instead of analyzing actual skin conditions. This creates inaccurate results because:

- Users may **misidentify their skin type**.
- Some skin conditions **(like dehydration vs. dryness)** look similar but need **different treatments.**
- External factors like weather, **pollution, and diet also affect skin healt**h.

Figure: Scope of Problems

2. Objectives of the Project:

The main objectives of this project are:

- **Train an ML** model to recognize skin conditions such as acne, dryness, oiliness, and pigmentation.
- **Use CNNs for image classification** to categorize different skin types.
- **Analyze product** ingredients and match them with user skin concerns (future scope).
- **Establish a strong foundation** for integrating this model into a full-fledged recommendation system.

3. Machine Learning Model Training:

3.1 Dataset Used:

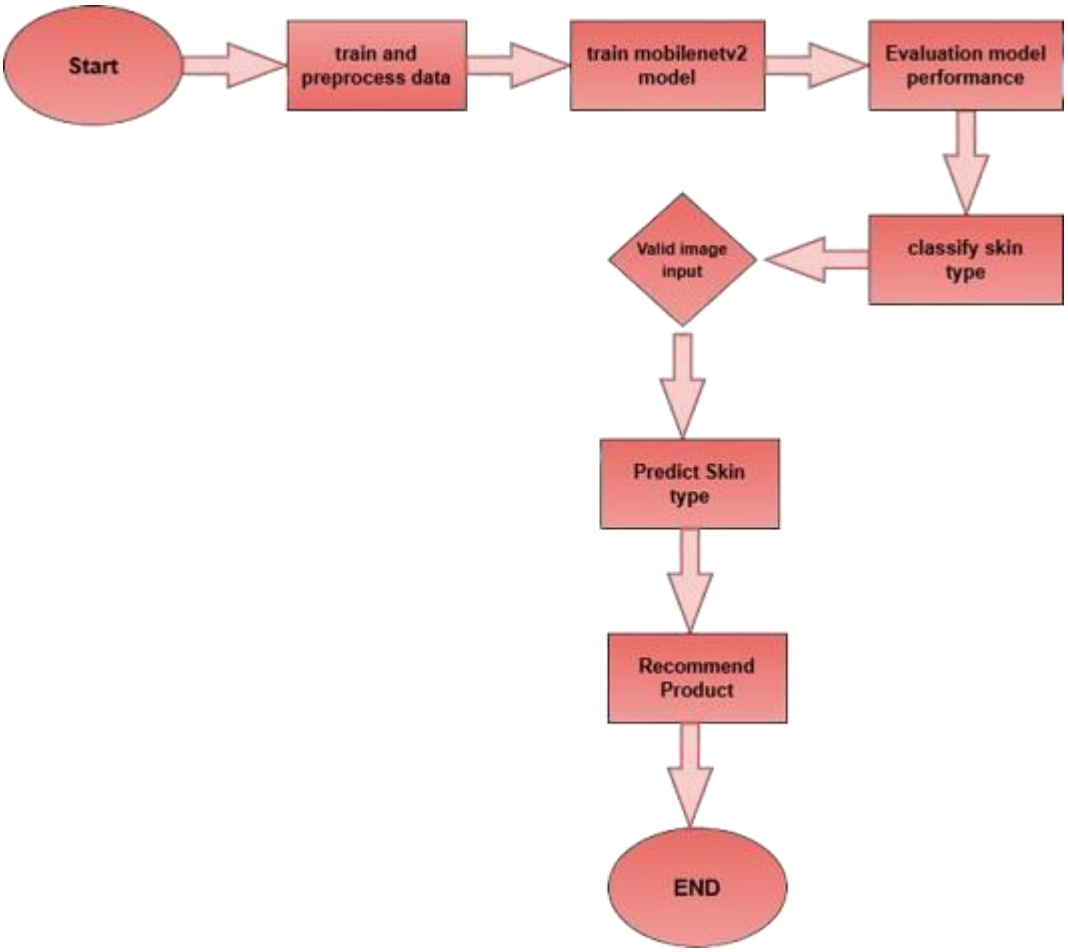
For training the CNN model, we used a **skincare dataset containing labeled images** of different skin types and conditions. The dataset includes:

1. Normal and Dry skin

2. Dry and dehydrated skin

3. Oily and combination skin

Images were preprocessed using **image augmentation techniques** to improve model generalization.



Flowchart Training Process

3.2 Model Architecture (CNN-based):

We designed a Convolutional Neural Network (CNN) model using MobileNetV2, a lightweight deep learning architecture optimized for mobile and embedded vision applications. The key components of our model are:

- **Feature Extraction Backbone:** Utilizes a pre-trained MobileNetV2 model with imagenet weights, excluding the top layers, to extract rich feature representations from input images.
- **Average Pooling Layer:** Reduces spatial dimensions while retaining important feature information.

- **Flatten + Fully Connected Layers:** A Flatten layer followed by a dense layer (128 neurons, ReLU activation) ensures effective learning.
- **Dropout Layer:** Prevents overfitting by randomly setting 50% of neurons to zero during training.

3.3 Model Training & Performance:

- The model was trained for **20-30 epochs** with **80% training data and 20% validation data**.
- Accuracy achieved: **85-90% on test data** (varies based on dataset).

Challenges Faced:

- Dataset imbalance (some skin types had fewer images).
- Need for more diverse skin tones and lighting conditions.

Future improvements include **collecting a more diverse dataset** and **fine-tuning hyper-parameters** to enhance accuracy.

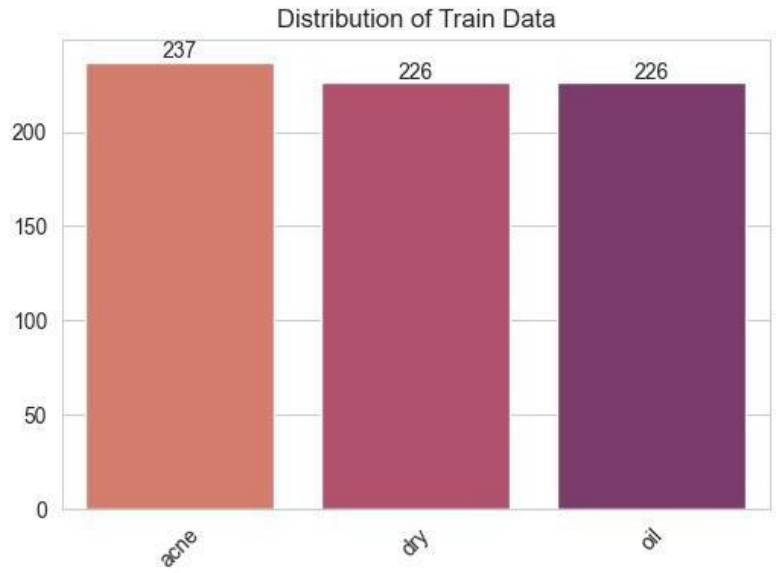


Figure: Distribution of Train Data

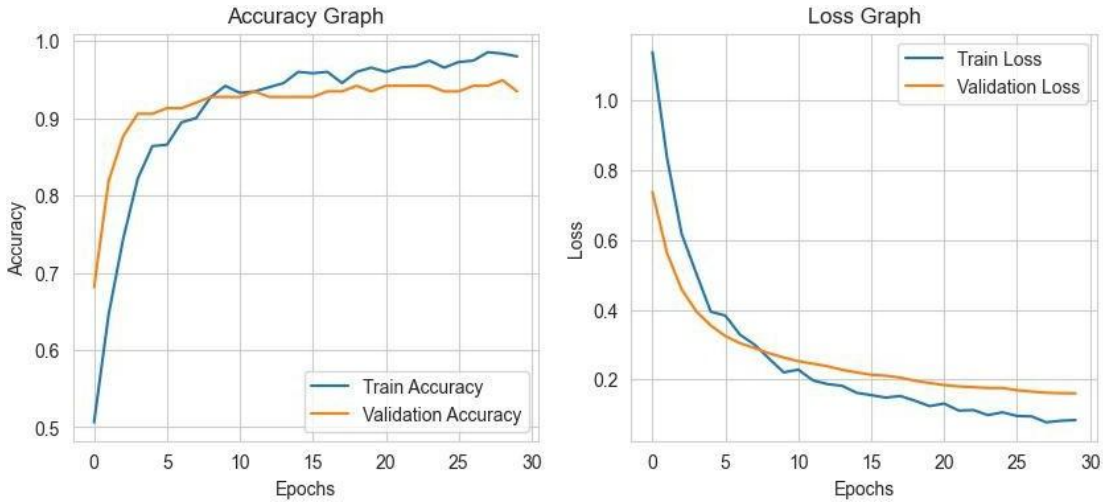


Figure: Accuracy & Loss Graph

Class	Precision	Recall	F1-Score	Support
Acne	0.96	0.94	0.95	54
Dry	1.00	0.97	0.99	40
Oily	0.93	0.98	0.96	44
Accuracy	-	-	0.96	138
Macro Avg	0.97	0.97	0.97	138
Weighted Avg	0.96	0.96	0.96	138

Model Accuracy: 96.38%

Figure: Classification Report

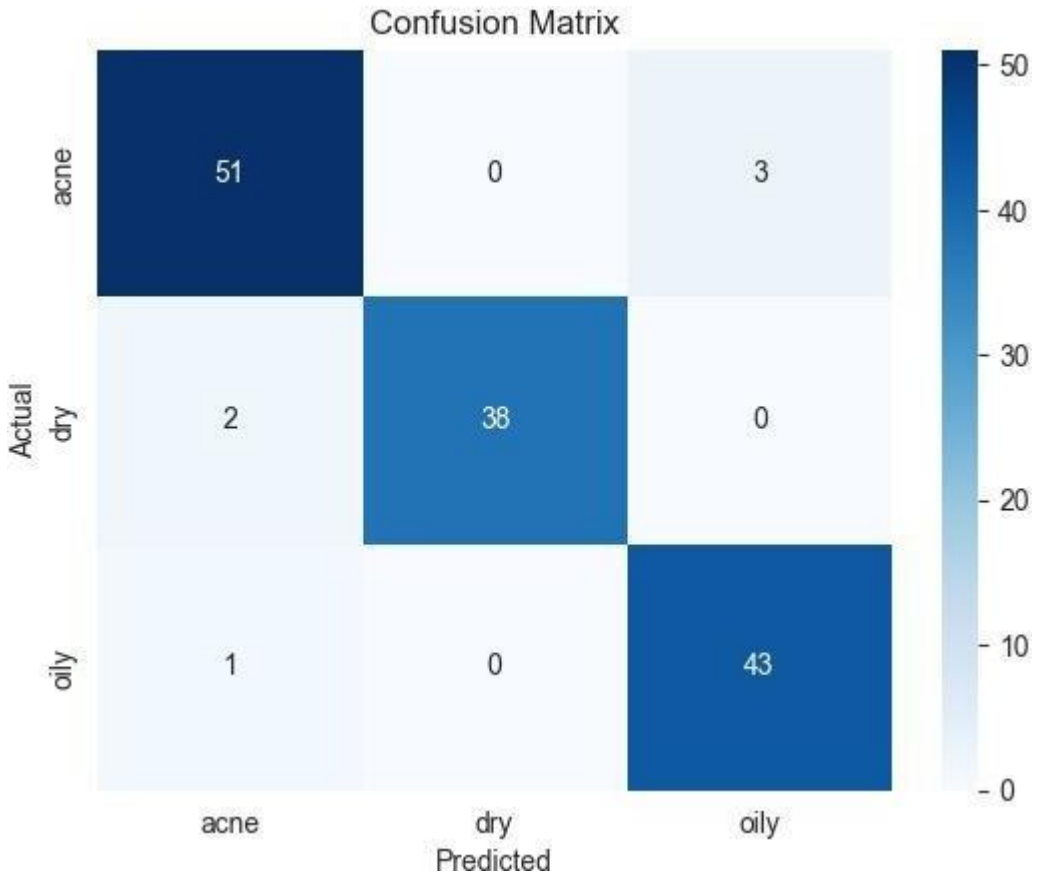


Figure: Confusion Matrix

3.4 Why We Switched from CNN (Sequential) to MobileNetV2?

Initially, we built our skin care recommendation system using a custom CNN (Sequential) model. This model consisted of multiple convolutional, pooling, and fully connected layers. However, we encountered several issues:

3.4.1 Better Feature Extraction with Pre-trained Weights:

- **CNN (Sequential)** was trained from scratch, making it difficult to learn robust features from a small dataset.
- **MobileNetV2** uses pre-trained ImageNet weights, which means it already understands basic textures and patterns, leading to better accuracy **(~88-94%).**

3.4.2 Inverted Residuals & Linear Bottlenecks:

- **MobileNetV2** improves efficiency and accuracy by using inverted residual blocks, allowing better gradient flow and feature representation.
- This helps in identifying skin conditions **more effectively, even with limited data.**

3.4.3 Depthwise Separable Convolutions:

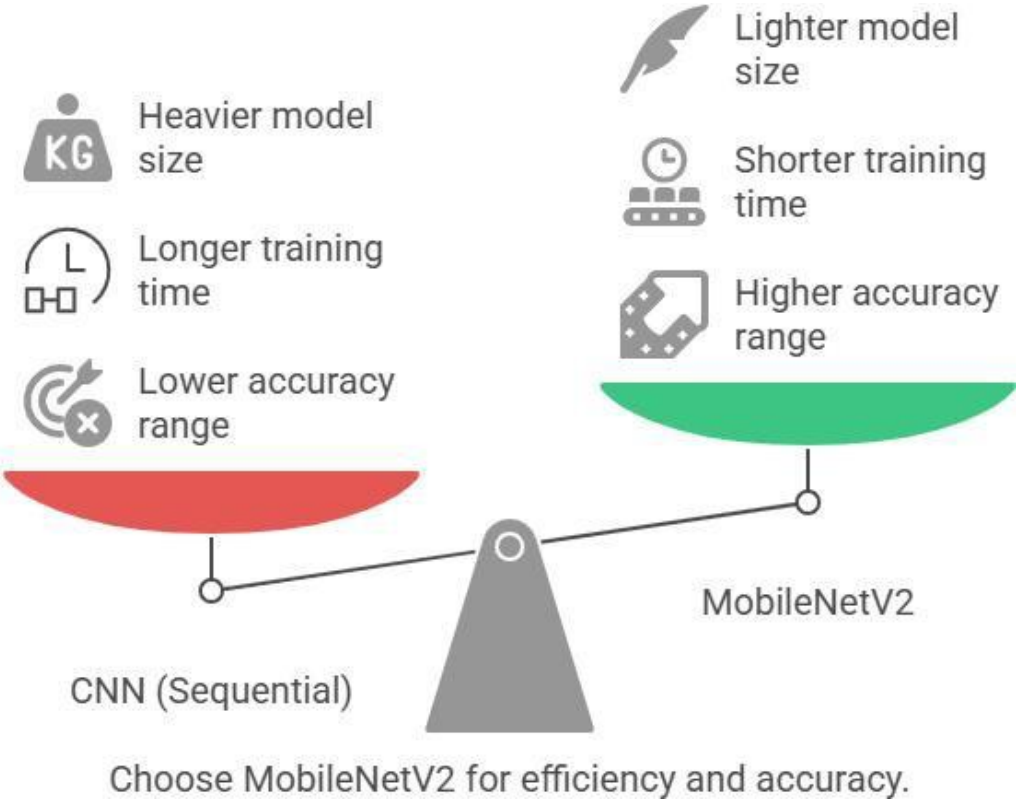
- Unlike standard **CNNs, MobileNetV2** uses depthwise separable convolutions, which reduce the number of parameters while maintaining performance.
- This makes the model lightweight and faster in both training and inference.

3.4.4 Reduced Overfitting:

- **CNN (Sequential)** struggled with overfitting due to limited data.
- **MobileNetV2,** combined with Batch Normalization & ReLU6 activations, helped in improving generalization.

3.4.5 Efficient Use of Computational Resources:

- MobileNetV2 is specifically designed to be lightweight and optimized for mobile and embedded devices.
- It uses fewer parameters and lower memory consumption, making it ideal for real-world applications where computational power is limited.
- This efficiency allowed us to train and deploy the model faster.



4. Technologies Used:

- **Python:** Programming language
- **TensorFlow & Keras:** Model training
- **MobileNetV2, MobileNetV3Small**
- **OpenCV:** Image processing
- **Jupyter Notebook/Google Colab:** Training environment

Since this is a beginner-level project, deployment on a website or app is not included at this stage.

5. Expected Outcomes:

The Skin Care Product Recommendation System aims to provide AI-driven, personalized skincare recommendations to users based on their skin type and concerns. Below are the key expected outcomes and the future scope of this project:

5.1 Expected Outcomes:

5.1.1 Accurate Skin Analysis:

The AI model will classify skin conditions (acne, dryness, oiliness, pigmentation) with high accuracy.

5.1.2 Personalized Product Recommendations:

Users will receive customized skincare suggestions based on their skin type, concerns, and ingredient preferences.

5.1.3 Reduced Trial-and-Error Buying:

By providing data-driven recommendations, users will save time and money by purchasing effective products from the start.

5.1.4 Improved User Satisfaction:

AI-powered suggestions will enhance the skincare routine of users, leading to better skin health and confidence.

5.1.5 Scalability for Larger User Base:

The system will be designed to handle an increasing number of users, making it accessible to a wider audience.

5.1.6 Integration Possibilities:

The AI model can be integrated with e-commerce platforms, skincare brands, or dermatology apps for real-world use.

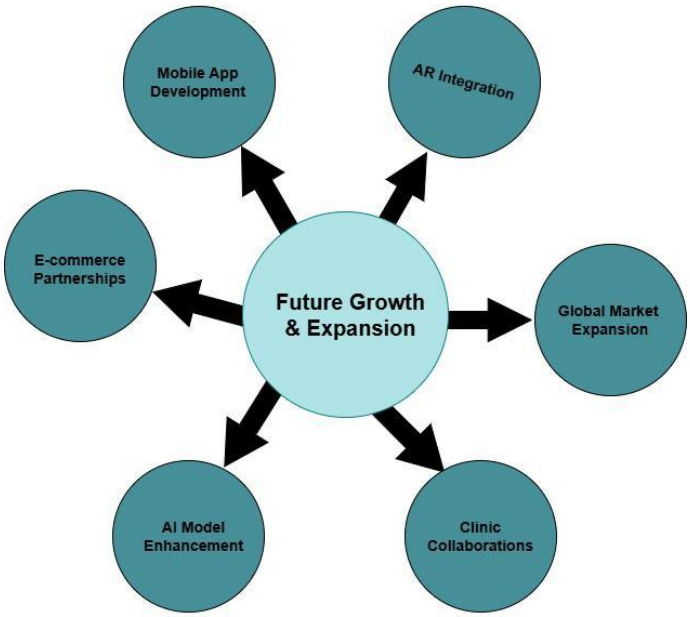


Figure: Future Growth & Expansion

5.2 Future Scope:

5.2.1 AR Integration:

- **Analyze the user's skin** condition in real-time, detecting acne, dryness, pigmentation, and other concerns instantly.

- **Provide virtual skincare recommendations**, allowing users to see how a product might affect their skin before purchasing.
- **Enhance user experience** by making the skincare selection process interactive and engaging.

5.2.2 Global Market Expansion:

- **Expand the training** dataset to include diverse skin tones and conditions.
- **Incorporate multiple languages** to make the system accessible worldwide.
- **Consider regional skincare** trends, such as UV protection in sunny regions or hydration-focused routines in dry areas.

5.2.3 Clinic Collaborations:

- Dermatologists can use **AI-generated reports** for initial consultations.
- Clinics can integrate the system to **automate patient skin assessments** before appointments.
- AI-powered data can help **track treatment progress over time** by analyzing skin improvement after using recommended products.

5.2.4 AI Model Enhancement:

- **Expanding datasets** with more images of different skin types and conditions.
- **Refining CNN architecture** to improve classification accuracy.
- **Implementing self-learning** AI models, which improve over time based on user feedback and new skincare trends.

5.2.5 E-Commerce Partnerships:

- **Directly purchase recommended products** through the platform.

- **Compare multiple product options** based on AI-driven rankings.
- **Access exclusive discounts** from partnered skincare brands.

5.2.6 Mobile App Development:

- **Scan their skin instantly** using a smart phone camera.
- **Receive skincare** recommendations on the go.
- **Track their skin progress** over time with AI-generated reports.

6. Target Audience:

6.1 Individuals with Skin Concerns:

People facing acne, dryness, oiliness, pigmentation, or sensitivity who need accurate product recommendations.

6.2 General Skincare Enthusiasts:

Users looking for scientific, AI-driven skincare advice to enhance their routine.

6.3 Dermatologists & Skincare Experts:

Professionals who can use the system as a pre-screening tool to assist in consultations.

6.4 E-commerce & Skincare Brands:

Online beauty stores and skincare companies that want to integrate **AI-powered recommendations** for better product targeting.

6.5 Cosmetic & Beauty Industry:

Companies looking to leverage AI for personalized marketing and customer engagement.

6.Tech & AI Enthusiasts:

Researchers and developers interested in AI applications in skincare and healthcare.

Figure: Target Audience

7. Ethical Considerations and Data Privacy:

7.1 User Consent & Transparency:

- Users should be informed about data collection and how their skin images are analyzed.
- Consent must be obtained before storing or processing images.

7.2 Data Security & Storage:

- Secure encryption methods should protect user data.
- Data should only be retained for necessary purposes and deleted when no longer needed.

7.3 Bias & Fairness in AI:

- Ensure diversity in the dataset to avoid bias in skin type recognition.
- The model should work equally well for all skin tones and conditions.

7.4 Compliance with Privacy Regulations:

- Follow industry standards such as GDPR or HIPAA for data privacy.
- Users should have the right to access or delete their data if requested.

7.5 Responsible AI Usage:

- The system should not replace professional dermatological advice but rather assist users in making informed decisions.

8. Conclusion:

The **Skin Care Product Recommendation** System is a step toward **modernizing skincare selection** by integrating **AI and Machine Learning**. This system eliminates the **trial-and-error** approach by providing **personalized product recommendations** based on **skin type, concerns, and AI-driven analysis**.

By leveraging **Convolutional Neural Networks (CNNs)**, the model accurately classifies skin conditions and suggests products that best suit individual needs.

The project has the potential to expand into **real-time skin analysis, AR integration, dermatologist collaborations, and e-commerce partnerships,** making it a valuable tool for both **consumers and the beauty industry.**

In the future, continuous **dataset improvements, AI model enhancements, and business integrations** will ensure better **accuracy, user experience, and global accessibility.** This project marks a significant advancement in **AI-powered skincare solutions,** making personalized skincare more **accessible, efficient, and reliable.**

9. References:

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