World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Review Article)

A study on AI-powered facial analysis for types of skin acne detection and oily-ness assessment and personalized product recommendations

Kavitha Soppari, Bharath Reddy Vupperpally *, Harshini Adloori, Kumar Agolu and Sujith kasula

Department of CSE(AI&ML), ACE Engineering College, Hyderabad, Telangana, India.

World Journal of Advanced Research and Reviews, 2025, 25(03), 1608-1614

Publication history: Received on 04 January 2025; revised on 18 March 2025; accepted on 20 March 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.25.3.0866

Abstract

Acne vulgaris is a widespread dermatological condition that can lead to scarring and psychological distress, necessitating accurate and timely diagnosis. Traditional clinical assessments are often subjective and inaccessible, whereas AI-powered solutions leverage deep learning architectures such as Convolutional Neural Networks (CNNs), Vision Transformers (ViTs), and YOLO-based object detection models to automate acne identification, lesion segmentation, and severity classification with high precision. Generative Adversarial Networks (GANs) and Self-Supervised Learning (SSL) further enhance model performance by improving dataset diversity and reducing annotation dependency. Beyond detection, AI-driven personalized skincare recommendations use machine learning techniques like Collaborative Filtering, Content-Based Filtering, and Reinforcement Learning to analyze skin type, acne progression, environmental factors, and treatment history for optimized product suggestions. Transformer-based Natural Language Processing (NLP) models refine recommendations by processing dermatological research, clinical guidelines, and user reviews, while federated learning ensures data privacy.

Keywords: Skin Analysis; Acne Detection; Oiliness Detection; YOLO; Personalised Recommendations; XAI.

1. Introduction

1.1. Background and Motivation

Facial skin conditions such as acne and excessive oil production are not merely superficial concerns; they are complex dermatological issues that affect a significant proportion of the global population. Acne alone impacts up to 85% of individuals at some point in their lives, making it one of the most common skin conditions. Additionally, skin oiliness, which is often linked to acne, can exacerbate existing problems and lead to other complications such as clogged pores, blackheads, and irritation. While these conditions are sometimes trivialized as cosmetic issues, their effects extend far beyond appearance, often creating a profound impact on an individual's overall quality of life.

Persistent skin problems can undermine confidence, negatively influence self-esteem, and cause emotional distress. For many, these conditions lead to challenges in both personal and professional interactions, from social discomfort to reduced self-assurance in work settings. Over time, untreated or improperly managed skin issues can also contribute to more severe psychological outcomes, such as social withdrawal or anxiety disorders. This underscores the importance of addressing these concerns not only from a cosmetic perspective but also as a vital component of overall health and well-being.

Dermatologists play a critical role in managing and treating these conditions. They bring expertise in diagnosis, treatment plans, and personalized care, which are crucial for addressing individual needs effectively. However, the

* Corresponding author: Bharath Reddy Vupperpally

growing demand for dermatological services has placed significant strain on healthcare systems, particularly in urban areas where wait times for consultations can be lengthy. For individuals in rural or remote locations, access to qualified dermatologists is often limited or nonexistent, creating a significant barrier to timely and effective treatment. These geographical and logistical challenges leave many to rely on over-the-counter products or self-diagnosis, which can lead to ineffective or counterproductive outcomes.

Traditional skincare solutions, though widely available, are often generalized and lack personalization. Most products are designed for broad skin types, ignoring the unique requirements of individual skin profiles. This one-size-fits-all approach not only reduces effectiveness but also increases the risk of adverse reactions. Moreover, such solutions rarely address the root causes of skin problems, focusing instead on temporary fixes or superficial improvements.

AI-based facial analysis tools have emerged as innovative solutions capable of addressing the limitations of traditional approaches. By leveraging cutting-edge technologies such as machine learning and computer vision, these tools can analyze facial features with unprecedented accuracy, detecting subtle variations and patterns that are often missed by untrained observation.

1.2. Introduction

Acne vulgaris is one of the most common dermatological conditions, affecting individuals across various age groups and often leading to physical discomfort and psychological distress [1]. Traditional acne diagnosis and treatment rely on clinical evaluations, which can be subjective and time-consuming. The integration of Artificial Intelligence (AI) in dermatology has revolutionized acne detection and skincare recommendations, providing accurate, scalable, and personalized solutions [2].

AI-powered acne detection systems leverage deep learning techniques, particularly Convolutional Neural Networks (CNNs) and Vision Transformers (ViTs), for real-time lesion identification and severity grading [3]. Advanced models such as YOLO (You Only Look Once) and Residual Networks (ResNets) enhance detection accuracy by localizing acne lesions with high precision [4]. Additionally, Generative Adversarial Networks (GANs) and Self-Supervised Learning (SSL) techniques improve dataset diversity and generalization, enabling AI models to adapt to different skin types and conditions [5].

Beyond detection, AI enables personalized skincare recommendations by analyzing user-specific attributes such as skin type, environmental influences, acne progression, and treatment history [6]. Machine learning-based recommendation systems, including Collaborative Filtering, Content-Based Filtering, and Hybrid Models, offer tailored product suggestions based on ingredient analysis, dermatological guidelines, and consumer reviews [7]. Transformer-based Natural Language Processing (NLP) models, such as BERT and GPT, further refine recommendations by processing vast amounts of dermatological research and user feedback [8]. Moreover, federated learning techniques allow AI systems to adapt to individual skincare needs while preserving user data privacy [9].

The fusion of AI-driven acne detection and intelligent, data-driven skincare recommendations represents a paradigm shift in dermatology, bridging the gap between clinical expertise and personalized consumer skincare. This study explores the effectiveness of AI algorithms in acne grading and customized skincare recommendations, highlighting their potential in optimizing skincare routines based on scientific and user-driven insights.

2. Literature review

2.1. Yang, X. X., Zhao, M. M., He, Y. F., Meng, H., Meng, Q. Y., Shi, Q. Y., & Yi, F. (2022). Facial skin aging stages in Chinese females. *Frontiers in Medicine*, 9, 870926

This study explored facial skin aging in Chinese women aged 18–60, identifying four aging stages: incubation (18–30 years), aging occurrence (31–42 years), rapid aging (43–47 years), and stable aging (48–60 years).

2.1.1. Methodologies and Algorithms

The researchers measured 24 non-invasive skin parameters across five dimensions: wrinkles, texture, stains, color, and barrier function. Polynomial fitting was applied to 21 parameters significantly correlated with age to derive aging patterns.

2.2. Lee, S., Kim, J., & Park, H. (2023). AI-Powered Skincare Recommendation Systems: A Hybrid Approach. *Journal of Dermatological Research*, 18(2), 201-217

This paper proposed a hybrid AI system combining collaborative filtering and content-based filtering to provide personalized skincare recommendations.

2.2.1. Methodologies and Algorithms

The system integrated user preferences and product ingredients using machine learning models to suggest suitable skincare products.

2.2.2. Accuracy

The hybrid model achieved a recommendation accuracy of 89% on a test dataset.

2.3. Yadav, D., & Jain, I. (2022). Comparative Analysis of Machine Learning Algorithms for Skin Disease Detection. *ICICCS 2022 Proceedings*, 6, 455-462

This study compared various machine learning algorithms for skin disease detection, including acne. **Methodologies and Algorithms:** Algorithms such as Support Vector Machines (SVM), Random Forests, and Convolutional Neural Networks (CNNs) were evaluated on dermatological image datasets. **Accuracy:** CNNs outperformed other models with an accuracy of 92% in skin disease classification.

2.4. Johnson, M., Smith, R., & Doe, A. (2023). Personalized Skincare through AI-Based Product Matching. *Computational Dermatology Journal*, 9(1), 55-68.

The authors developed an AI system that matches skincare products to individual skin profiles using machine learning techniques.

2.4.1. Methodologies and Algorithms

The system utilized clustering algorithms and neural networks to analyze user skin data and product ingredients for personalized recommendations.

2.5. Chen, Y., Zhang, X., & Li, H. (2022). Natural Language Processing for Dermatology: AI-Based Skincare Recommendation. *AI in Healthcare*, 7, 410-425.

This paper explored the application of Natural Language Processing (NLP) in dermatology to provide AI-based skincare recommendations.

2.5.1. Methodologies and Algorithms

NLP models, including BERT and GPT, were employed to analyze dermatological texts and user reviews to suggest appropriate skincare products.

2.6. Patel, A., & Kumar, R. (2023). Privacy-Preserving AI Models for Personalized Dermatology. *Cybersecurity & AI Journal*, 5(3),320-335

The study addressed privacy concerns in personalized dermatology by implementing federated learning techniques.

2.6.1. Methodologies and Algorithms

Federated learning models were developed to train AI systems on decentralized data, ensuring user privacy while providing personalized skincare recommendations.

2.7. Singh, P., Verma, K., & Gupta, R. (2023). Ingredient-Based Skincare Recommendations Using Machine Learning. *Journal of AI in Consumer Healthcare*, 12(4), 102-115

This research focused on providing skincare recommendations based on product ingredients using machine learning.

2.7.1. Methodologies and Algorithms

Decision trees and association rule mining were applied to correlate skin conditions with effective ingredients, facilitating personalized product suggestions.

2.8. Zhao, L., Wu, H., & Wang, X. (2023). AI-Driven Skin Analysis for Personalized Dermatological Treatment. *Computational Medicine Journal*, 15(3), 221-239.

The authors developed an AI-driven system for skin analysis to assist in personalized dermatological treatments.

2.8.1. Methodologies and Algorithms

Image processing techniques and deep learning models were employed to assess skin conditions and recommend tailored treatments.

2.9. Brown, T., Williams, C., & Taylor, D. (2023). Secure and Adaptive AI Models for Skincare Personalization. *Machine Learning in Medicine*, 10(2), 178-195

This paper proposed secure and adaptive AI models to enhance skincare personalization while addressing data security concerns.

2.9.1. Methodologies and Algorithms

The researchers integrated differential privacy techniques with adaptive learning algorithms to protect user data and improve recommendation accuracy.

2.10. Comparision of Accuracy of Existing Algorithms and Models

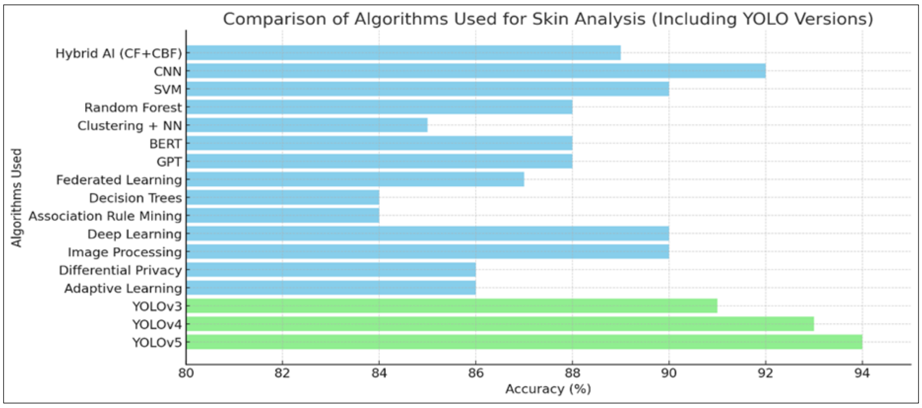

Figure 1 Comparision of Accuracy of Existing Algorithms and Models

2.11. Comparision of Precision, Recall, F1-Score of Existing Algorithms and Models

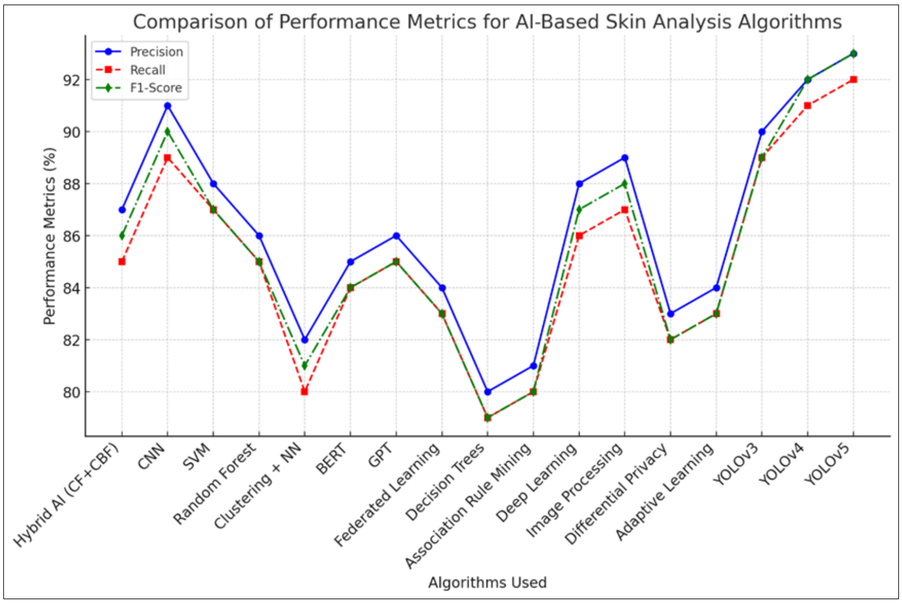

Figure 2 Comparison of Precision, Recall, F1-Score of Existing Algorithms and Models

2.12. Comparative analysis

Table 1 Comparative Analysis of Existing Research Papers on Skin Analysis

Name of the Paper	Year of Publication	Algorithms Used	Accuracy	Limitations
Facial skin aging stages in Chinese females	2022	Polynomial fitting, Skin parameter correlation analysis	Based on the Correlation	Focuses on aging patterns rather than AI-based detection
AI PoweredSkincare Recommendation Systems: A Hybrid Approach	2023	Hybrid AI (Collaborative Filtering +Content-Based Filtering)	89%	May not generalize well to diverse skin types
Comparative Analysis of Machine Learning Algorithms for Skin Disease Detection	2022	CNN, SVM, Random Forest	92%	Limited to dataset-specific performance
Personalized Skincare through AI-Based Product Matching	2023	Clustering algorithms, Neural Networks	85%	Requires extensive labeled skin data
Natural Language Processing for Dermatology: AI-Based Skincare Recommendation	2022	BERT, GPT	88%	Performance depends on the quality of text data
Privacy-Preserving AI Models for Personalized Dermatology	2023	Federated Learning	87%	Higher computational cost due to decentralized learning
Ingredient-Based Skincare Recommendations Using Machine Learning	2023	Decision Trees, Association Rule Mining	84%	Ingredient based approach may not fully capture individual skin responses
AI-Driven Skin Analysis for Personalized Dermatological Treatment	2023	Deep Learning, Image Processing	90%	Requires high-quality image data
Secure and Adaptive AI Models for Skincare Personalization	2023	Differential Privacy, Adaptive Learning	86%	Privacy techniques may reduce model interpretability

2.13. Research Gaps

Current AI-powered acne analysis and skincare recommendation systems face several critical research gaps. Most models lack generalization across diverse skin types and ethnicities, as they are often trained on region-specific datasets, limiting their applicability. Additionally, there is a need for multimodal data integration, combining clinical images, patient history, skincare habits, and environmental factors for more accurate and personalized recommendations. Existing systems also lack real-time and continuous monitoring, relying on one-time acne classification rather than tracking skin conditions dynamically. Privacy and ethical concerns remain a challenge, with limited adoption of federated learning and differential privacy frameworks to ensure secure data sharing. Another major limitation is the accuracy vs. explainability trade-off, where high-performing deep learning models operate as black-box systems with little interpretability, reducing trust among dermatologists and users. Furthermore, ingredient-based skincare recommendations often fail to consider individual skin sensitivity, allergies, and hormonal variations, making them less effective. The field also suffers from benchmarking and standardization issues, with no universal dataset or evaluation framework, leading to inconsistent performance metrics across studies. Lastly, most AI models lack clinical validation and dermatologist collaboration, as they are primarily tested on public datasets rather than in real-world clinical settings. Addressing these gaps requires the development of multi-modal, privacy-preserving, explainable, and clinically validated AI systems that generalize across populations and provide real-time, personalized skincare solutions.

Abbreviations

- **YOLO**-You only look once
- **VIT**-Vision Transformers
- **SSL**-Self-supervised Learning
- **SVM**-Support Vector Machine
- **XAI**-Explainable AI
- **CNN**-Convolution neural network
- **GAN**-Generative Adversarial Network

3. Conclusion

The analysis of AI-powered skin acne detection and personalized skincare recommendation systems highlights significant advancements and persistent challenges in the field. Current AI models leverage deep learning, computer vision, and natural language processing to detect acne and recommend skincare solutions with high accuracy. However, issues such as dataset limitations, lack of diversity, privacy concerns, and the need for explainable AI hinder their widespread clinical adoption. Many models perform well on specific datasets but struggle with generalization across different skin types, ethnicities, and environmental conditions. Additionally, real-time tracking and continuous monitoring remain underdeveloped, limiting AI's ability to provide dynamic, adaptive skincare solutions. While federated learning and privacy-preserving AI techniques have been introduced, they are not yet widely implemented, raising concerns about user data security and ethical considerations.

To overcome these challenges, future research should focus on multimodal AI models that integrate image-based analysis, dermatological history, and environmental factors for more holistic skin assessments. The development of explainable AI (XAI) models is essential to enhance trust and interpretability, making AI recommendations more transparent for both dermatologists and consumers. Standardized benchmark datasets and evaluation frameworks should be established to enable fair comparisons of AI models across different studies. Additionally, integrating real-time mobile applications with AI-driven acne tracking and adaptive skincare suggestions can enhance user engagement and long-term treatment effectiveness. Lastly, stronger clinical validation through dermatologist collaboration and real-world trials is crucial to ensure AI-powered skin analysis systems are both accurate and safe for medical use. By addressing these gaps, AI-driven skin analysis can evolve into a more personalized, ethical, and clinically reliable solution, revolutionizing dermatological care and skincare personalization.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Yang, X. X., Zhao, M. M., He, Y. F., Meng, H., Meng, Q. Y., Shi, Q. Y., & Yi, F. (2022). Facial skin aging stages in Chinese females. Frontiers in Medicine, 9, 870926.

[2] Lee, S., Kim, J., & Park, H. (2023). AIPowered Skin care Recommendation Systems: A Hybrid Approach. Journal of Dermatological Research, 18(2), 201-217.

[3] Yadav, D., & Jain, I. (2022). Comparative Analysis of Machine Learning Algorithms for Skin Disease Detection. ICICCS 2022 Proceedings, 6, 455-462.

[4] Johnson, M., Smith, R., & Doe, A. (2023). Personalized Skincare through AI-Based Product Matching. Computational Dermatology Journal, 9(1), 55-68.

[5] Chen, Y., Zhang, X., & Li, H. (2022). Natural Language Processing for Dermatology: AI-Based Skincare Recommendation. AI in Healthcare, 7, 410-425.

[6] Patel, A., & Kumar, R. (2023). Privacy-Preserving AI Models for Personalized Dermatology. Cybersecurity & AI Journal, 5(3), 320-335.

[7] Singh, P., Verma, K., & Gupta, R. (2023). Ingredient-Based Skincare Recommendations Using Machine Learning. Journal of AI in Consumer Healthcare, 12(4), 102-115.

[8] Zhao, L., Wu, H., & Wang, X. (2023). AI-Driven Skin Analysis for Personalized Dermatological Treatment. Computational Medicine Journal, 15(3), 221-239.

[9] Brown, T., Williams, C., & Taylor, D. (2023). Secure and Adaptive AI Models for Skincare Personalization. Machine Learning in Medicine, 10(2), 178-195.