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Artificial Intelligence in Dermatology: Promises, Pitfalls, and Practical Realities

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Abstract

Artificial intelligence (AI) is rapidly transforming dermatology, enhancing diagnostic accuracy, clinical efficiency, and patient care. Using machine learning and deep neural networks, particularly convolutional neural networks, AI demonstrates expert-level performance in classifying skin lesions such as melanoma, etc. Beyond image analysis, emerging multimodal approaches integrate clinical, histopathological, and genomic data, enabling improved diagnosis, prognostication, and personalized treatment strategies. AI also supports teledermatology, expanding access to care.

However, challenges remain, including biases from underrepresented skin types, variability in image quality, and the need for regulatory validation and real-world studies. Ethical concerns, such as data privacy and over-reliance on AI, must also be addressed.

Future developments include automated severity scoring, longitudinal lesion monitoring, and integration with advanced technologies like 3D imaging and large language models. Collaborative, dermatologist-led development and robust regulatory frameworks will be essential for safe and effective clinical integration.

Key words: Artificial Intelligence, Dermatology, Machine Learning, Skin Diseases

Introduction

Artificial intelligence (AI) has rapidly emerged as a transformative force in dermatology, gaining increasing attention for its potential to enhance diagnostic precision, streamline clinical workflows, and reshape the future of skin disease management.

AI harnesses machine learning and deep neural networks to analyze dermatological images, facilitating the early detection of conditions such as skin cancer and psoriasis. Given that dermatology is fundamentally a visual specialty, it offers an ideal framework for image-based learning and pattern recognition, making it particularly well-suited for AI-driven applications.[1] A notable consideration is that many AI dermatology models are primarily trained on light-skinned populations, which may modestly limit their performance in darker phototypes common in Nepal and South Asia.

Technological Foundations

Convolutional neural networks (CNNs), a specialized class of artificial neural networks that dominate image processing i.e. finding patterns in images like edges, colors and shape etc., form the backbone of most artificial intelligence applications in dermatology.[2] Trained on large datasets, they enable the detection of distinctive visual patterns in dermoscopic and clinical images. Building on this, emerging multimodal models integrate diverse data types, including clinical images, patient history, and genomic information, to support more comprehensive diagnostic decision-making. Furthermore, recent advances are moving beyond traditional binary classification toward more versatile, generalizable models capable of performing a range of clinically relevant tasks.[3] AI dermatology

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systems often rely on cloud-based processing, which enables high computational performance but requires stable internet connectivity, whereas lightweight, on-device (local) models are increasingly being developed to enable offline use in low-bandwidth or resource-limited settings.[4]

Core Applications

The application of artificial intelligence in dermatology primarily involves machine-based systems' ability to classify skin lesions accurately. Initially applied to differentiate malignant from non-malignant lesions, AI has demonstrated particular strength in skin lesion classification, achieving expert-level accuracy in distinguishing melanoma from benign conditions, as well as in the detection of squamous cell carcinoma and basal cell carcinoma. Overall, AI-based models have shown robust performance in tumor detection, with reported average accuracy, sensitivity, and specificity of approximately 90%, 87%, and 91%, respectively.[5]

AI has also shown promise in assessing disease severity, with a 2025 meta-analysis indicating an overall accuracy of approximately 81%, rising to as high as 96% in certain conditions such as psoriasis.[6] Deep learning has shown strong potential in differentiating inflammatory skin diseases as well. For instance, an AI dermatology assistant (AIDDA) using the EfficientNet B4 CNN algorithm classified healthy skin, psoriasis, eczema, and atopic dermatitis with 95.8% accuracy (sensitivity 94.4%, specificity 97.2%) based on clinical images.[7]

Artificial intelligence has also been applied in ulcer assessment through imaging, enabling objective evaluation of wound size, tissue characteristics, healing progression, and infection risk.[8]

Machine learning models, particularly those employing supervised approaches, have demonstrated robust predictive performance (with AUC frequently exceeding 0.8) across a wide range of dermatological outcomes. These include predicting treatment response, assessing surgical complexity, estimating the risk of chronic ulcers in venous eczema, and evaluating the malignancy risk of skin lesions.[9]

AI in dermatology, especially in dermatopathology, shows high diagnostic value, using deep learning on digitized histopathology slides to accurately classify lesions like melanomas and naevi, enhancing diagnostic precision.[10] Artificial intelligence in dermatology is expanding beyond image analysis to incorporate gene expression profiling and genomic data, enabling molecular classification, prognostication, and personalized treatment strategies. AI-driven analysis of gene expression data using machine learning models (e.g., support vector machines) can identify robust multi-gene biomarkers, achieving high diagnostic accuracy and enabling precise differentiation of psoriasis from clinically similar inflammatory skin diseases.[11,12]

Teledermatology, augmented with AI-driven diagnostic and triage tools, has the potential to extend dermatologic care to underserved and remote populations while improving workflow efficiency and diagnostic accuracy.[13] In countries like Nepal, where dermatologists are concentrated in urban centers, AI-augmented teledermatology could help triage patients in remote districts. For example, a community health worker could photograph a suspicious lesion, and an AI model could flag high-risk cases for specialist review. However, without locally validated models and reliable internet access, this remains aspirational.

Challenges and Limitations

Biases due to underrepresented skin tones limit the generalizability of AI models, while factors such as image artifacts, inconsistent quality, and image noise can compromise algorithm performance. Additional challenges include limited explainability, the need for regulatory validation, and the lack of prospective real-world trials. Ethical concerns regarding data privacy and the potential over-reliance on AI further underscore the need for careful implementation.[12]

Dermatology, grounded largely in subjective interpretation, is inherently prone to diagnostic variability, an element that can undermine accuracy and presents a notable challenge for the advancement of AI-driven learning systems. Developing diverse registries across a wide range of diseases, along with collaboration between national and international registries, is essential for comprehensive dermatologic data coverage. Additionally, the cost and practical viability of developing AI-based devices and applications remain important considerations in the implementation of AI in dermatology.

Regulatory gap — no AI dermatology tool has yet received full approval in Nepal or most low-income countries.

Future Directions

AI can automate disease severity scoring, enable longitudinal monitoring of skin lesions, and support non-specialists through diagnostic decision-support tools.[2] Integration of AI with advanced modalities such as 3D imaging and large language models holds promise for enabling more precise, data-driven, and personalized dermatologic care.[14]

The future of AI in dermatology depends on dermatologist-led, equitable development to ensure safe and ethical adoption. With the potential to enhance diagnostic accuracy, accessibility, and efficiency, AI can significantly improve patient care. Establishing robust regulatory frameworks and standardized approval pathways, similar to those in radiology, will be essential to ensure the reliability and clinical integration of AI-based tools.

For AI use to be practical in public hospitals in Nepal, tools must be low-cost, offline-capable, and integrated into existing workflows — not reliant on expensive cloud computing.

Conclusion

The evolving landscape of AI in dermatology highlights both its transformative potential and the need for cautious implementation. Collaborative efforts between clinicians and technologists are essential to ensure responsible development, with AI positioned as a supportive tool that enhances, rather than replaces, clinical expertise. The goal is not automation, but augmentation — helping clinicians see more, miss less, and reach patients who currently have no access at all.

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