



INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A Systematic Review Of Machine Learning And Deep Learning Approaches For Skin Cancer Detection

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Abstract

Skin cancer detection using Machine Learning (ML) and Deep Learning (DL) techniques has emerged as a pivotal tool in early diagnosis, aiding in the reduction of mortality rates associated with skin malignancies. Traditional diagnostic methods, which rely heavily on dermatologists' expertise, can be complemented by automated systems to improve efficiency and accuracy. This paper reviews various ML and DL approaches employed in the detection of skin cancer, particularly melanoma, basal cell carcinoma (BCC), and squamous cell carcinoma (SCC). ML models such as Support Vector Machines (SVM), Random Forests (RF), and k-Nearest Neighbors (k-NN) have been applied to skin lesion image classification, relying on handcrafted features like texture, shape, and color. However, the advent of DL, particularly Convolutional Neural Networks (CNNs), has revolutionized the field by eliminating the need for manual feature extraction and enabling automatic learning from large datasets. DL techniques, including transfer learning using pre-trained networks like VGG, ResNet, and EfficientNet, have demonstrated superior performance, achieving accuracy rates comparable to or surpassing human dermatologists. The use of large datasets like ISIC and HAM10000 has facilitated model training, though challenges like data imbalance, model interpretability, and generalization across diverse populations remain. This paper also explores hybrid models that integrate ML and DL, enhancing the overall diagnostic power. Despite these advances, further research is needed to address the limitations of existing models, such as ensuring robustness and scalability in real-world applications. Ultimately, the integration of ML and DL in skin cancer detection holds the potential for significant advancements in dermatological healthcare, offering a promising tool for both clinical and remote diagnostics.

Introduction

Skin cancer is one of the most prevalent forms of cancer globally, with melanoma, basal cell carcinoma (BCC), and squamous cell carcinoma (SCC) being the most commonly diagnosed types. While melanoma is the deadliest, early detection of any form of skin cancer significantly improves treatment outcomes and patient survival rates. However, traditional methods of diagnosis, such as visual examination by dermatologists followed by biopsy, often face limitations related to accuracy, subjectivity, and the high volume of cases requiring analysis. These challenges emphasize the need for advanced computational tools capable of assisting in the early and accurate detection of skin cancer.

Over the past few years, **Machine Learning (ML)** and **Deep Learning (DL)** have gained substantial attention in the field of medical image analysis, particularly for skin cancer detection. **ML** methods, such as Support Vector Machines (SVM), Random Forests (RF), and k-Nearest Neighbors (k-NN), are commonly used to classify skin lesions based on manually extracted features, including texture, color, and shape. These methods rely heavily on human expertise for feature engineering, and while they have shown some success, they are limited by the quality of the extracted features and the need for domain-specific knowledge.

In contrast, **Deep Learning**—especially **Convolutional Neural Networks (CNNs)**—has revolutionized skin cancer detection by eliminating the need for manual feature extraction. CNNs automatically learn hierarchical features directly from raw image data, making them highly effective for complex image classification tasks. By leveraging large image datasets like the ISIC Archive or the HAM10000 dataset, DL models can be trained to recognize intricate patterns and subtle differences between benign and malignant lesions. Pre-trained models such as **VGG**, **ResNet**, and **EfficientNet** are often used in a process called **transfer learning**, where a model trained on large-scale datasets is fine-tuned to a specific task like skin cancer detection. This has resulted in significant improvements in the accuracy and robustness of these models.

The growing use of ML and DL techniques has shown promising results, with many models achieving performance comparable to or even surpassing that of experienced dermatologists. However, challenges remain, including issues related to **data imbalance**, where benign lesions often outnumber malignant ones, leading to potential biases in model predictions. Additionally, **interpretability** of DL models is still an ongoing concern, as these "black-box" models can make it difficult to understand the reasoning behind their predictions. Moreover, **generalization** across diverse patient populations, geographic regions, and skin types remains a challenge, as existing models may not perform equally well in all scenarios.

Despite these challenges, ML and DL techniques have the potential to significantly improve the accuracy, speed, and accessibility of skin cancer detection, especially in resource-limited settings or in situations where access to experienced dermatologists is scarce. These technologies also hold the promise of assisting dermatologists in making more informed and confident diagnostic decisions, ultimately leading to better patient outcomes. With continued advancements in technology, data collection, and model interpretability, the integration of ML and DL into clinical practice could become a cornerstone in the fight against skin cancer.

Literature Work

The increasing prevalence of skin cancer over the past decade has highlighted the critical need for timely detection [1]. Given the skin's role as the body's largest organ, skin cancer is a significant concern. Computer-aided diagnostic techniques offer promising avenues for rapid and non-invasive detection.

Machine learning, particularly deep learning, has emerged as a powerful tool for early cancer diagnosis, overcoming limitations associated with manual methods. Deep learning, inspired by the human brain, has revolutionized machine learning with artificial neural networks [2].

Researchers have evaluated the accuracy of these computer-aided techniques using databases like ScienceDirect, SpringerLink, and IEEE [2]. Studies have explored various approaches, including skin lesion segmentation and classification. For instance, one study [3] utilized an implantation manifold and SqueezeNet on the PH2 dataset, achieving a 92.18% accuracy in melanoma identification. Another study [4] employed VGG-SegNet on the ISIC2016 database for skin melanoma region extraction.

Combining human and artificial intelligence has also shown promise. A study [5] demonstrated 82.95% multiclass accuracy by integrating diagnoses from German dermatologists and a convolutional neural network (CNN). The InSiNet deep learning technique [6] achieved high accuracy (94.59%, 91.89%, and 90.549%) on ISIC 2018, 2019, and 2020 datasets, respectively, for benign and malignant tumor detection.

Deep learning methods, such as region-based CNNs and fuzzy k-means clustering, have been applied to early-stage melanoma classification [7]. These methods, tested on ISIC-2017, PH2, and ISBI-2016 datasets, achieved accuracies of 95.40%, 93.1%, and 95.6%, respectively, outperforming existing techniques.

Convolutional neural networks (CNNs) have proven superior in image and feature recognition, with successful applications in medical imaging [8]. Deep learning-based systems are now aiding in cancer prognosis, treatment, and follow-up.

The Lesion-classifier, using pixel-by-pixel classification, achieved 95% accuracy on ISIC 2017 and PH2 datasets for melanoma and non-melanoma classification [9].

In the below table we are showcasing the works performed by various authors and datasets, data types, techniques used and number of classes.

Reference Number	Dataset	Dataset	Number of classes
[10]	300	HAM10000	5
[11]	1323	HAM10000	2
[12]	1280	ISIC-2016	2
[13]	2000	ISIC-2017	2
[14]	1280	PH ²	2
[15]	2000	ISBI2017	7
[16]	48,373	DermNet, ISIC Archive, Dermofit image library	2
[17]	7470	HAM10000	2
Proposed	3753	Image Net	8
Proposed	16,170	HAM10000	2
Proposed	1000	ISIC	2
Proposed	6705	HAM10000	7
Proposed	279	Image Net	7
Proposed	10015	HAM10000	2
Proposed	10015	HAM10000	2

Table 1: Comparison with other mechanisms

Research going on skin cancer Detection

The pursuit of effective skin cancer detection has propelled a dynamic field of research, where technological innovation converges with medical expertise. Here's a more detailed exploration of the ongoing endeavors:

1. The Ascendancy of Artificial Intelligence:

Deep Learning's Diagnostic Prowess:

Convolutional neural networks (CNNs) have emerged as powerful tools for analyzing dermoscopic images, which provide magnified views of skin lesions. These AI models are trained on vast datasets of images, enabling them to discern subtle patterns and features indicative of malignancy.

Researchers are dedicated to refining these algorithms, focusing on enhancing their accuracy, minimizing false positives, and optimizing their efficiency. This involves continuous development of new AI architectures and the curation of extensive, diverse datasets.

Mobile Health Applications:

The development of smartphone-based applications for skin cancer self-screening is a burgeoning area. These apps leverage AI to analyze images captured by smartphone cameras, potentially enabling early detection in remote or underserved populations.

2. Advancements in Imaging Technologies:

Beyond Dermoscopy:

Researchers are investigating advanced imaging modalities, such as optical coherence tomography (OCT) and multispectral imaging, to provide deeper insights into skin lesion morphology.

OCT, for instance, offers high-resolution cross-sectional images of skin tissue, revealing subsurface structures that may be indicative of malignancy.

Standardization and Refinement:

Efforts are underway to standardize dermoscopy protocols and image acquisition techniques, ensuring consistency and reliability across clinical settings.

3. Emphasis on Early Detection and Risk Stratification:

Risk Assessment Tools:

Researchers are developing sophisticated tools to assess an individual's risk of developing skin cancer, considering factors such as genetic predisposition, sun exposure history, and phenotypic characteristics.

Preventative Measures:

Alongside detection, research emphasizes preventative strategies, including public health campaigns promoting sun safety and the development of novel sunscreen formulations.

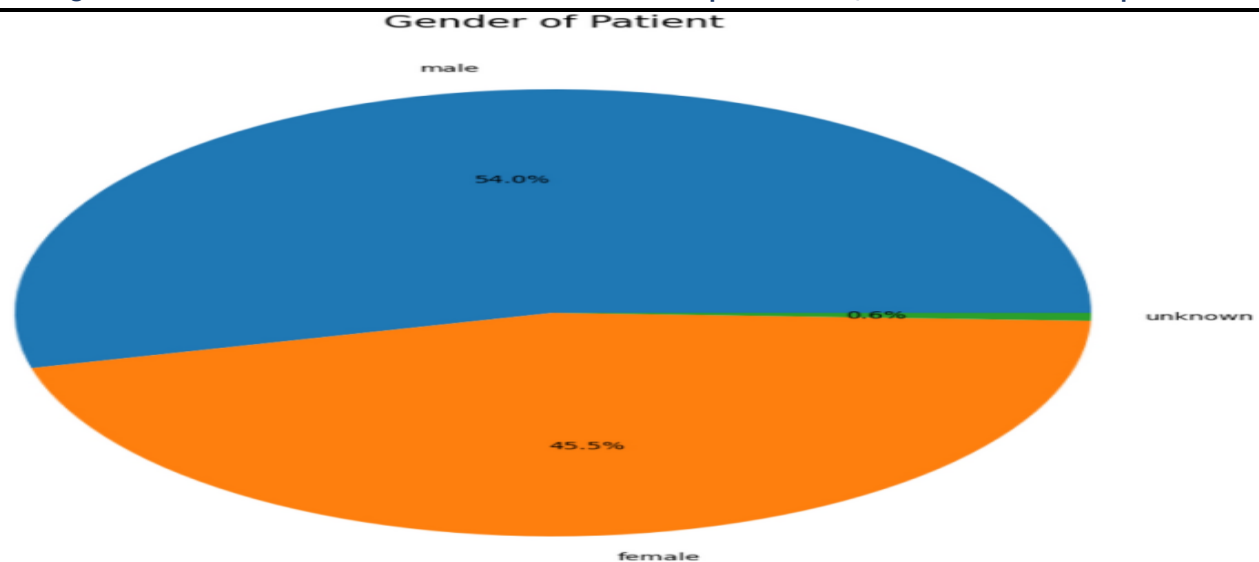


Figure 1: Gender of Patient

4. Key Research Goals:

Improving Diagnostic Accuracy:

The paramount objective is to enhance the sensitivity and specificity of skin cancer detection, minimizing the need for unnecessary biopsies.

Enhancing Accessibility:

Researchers aim to democratize access to skin cancer screening through the development of user-friendly technologies, such as mobile applications.

Personalized Medicine:

The application of genomics and proteomics to understand the molecular underpinnings of skin cancer is paving the way for personalized treatment strategies.

In essence, the field of skin cancer detection is characterized by a multidisciplinary approach, integrating artificial intelligence, advanced imaging, and clinical expertise to improve patient outcomes.

Existing Works

The field of skin cancer detection is witnessing a surge in research activity, primarily driven by the advancements in artificial intelligence and imaging technologies. Here's a breakdown of the key research areas:

1. Deep Learning and Convolutional Neural Networks (CNNs):

Image Analysis:

A significant portion of research is dedicated to developing CNN-based algorithms for analyzing dermoscopic images. These algorithms are trained on large datasets to identify patterns and features indicative of skin cancer.

Researchers are focusing on improving the accuracy and robustness of these models, particularly in distinguishing between benign and malignant lesions.

Automated Diagnosis Systems:

Studies are exploring the integration of AI into automated diagnostic systems, aiming to assist dermatologists in making more accurate and timely diagnoses.

Research also focuses on creating mobile applications that utilise smartphone cameras and AI, to allow for at home screening.

2. Advanced Imaging Technologies:

Optical Coherence Tomography (OCT):

OCT is being investigated for its ability to provide high-resolution, cross-sectional images of skin tissue, enabling the visualization of subsurface structures.

Research aims to determine the effectiveness of OCT in detecting early-stage skin cancers that may be difficult to identify with traditional dermoscopy.

Multispectral Imaging:

This technology captures images of skin lesions at multiple wavelengths, providing additional information about tissue composition and vascularity.

Researchers are exploring the potential of multispectral imaging to improve the accuracy of skin cancer detection.

3. Data and Datasets:

ISIC Archive:

The International Skin Imaging Collaboration (ISIC) Archive plays a vital role in providing standardized datasets for training and evaluating AI algorithms.

Ongoing research focuses on expanding these datasets and improving their quality to enhance the performance of AI models.

Data Augmentation:

Researchers are using data augmentation techniques to increase the size and diversity of training datasets, which helps to improve the generalizability of AI models.

4. Clinical Integration:

Clinical Trials:

Clinical trials are being conducted to evaluate the effectiveness of AI-based diagnostic systems in real-world clinical settings.

These trials aim to assess the impact of AI on diagnostic accuracy, patient outcomes, and clinical workflow.

Telemedicine:

Research is exploring the use of telemedicine and AI to provide skin cancer screening and diagnosis in remote or underserved areas.

In essence, the current research landscape is highly dynamic, with a focus on leveraging technology to improve the accuracy, accessibility, and efficiency of skin cancer detection.

Conclusion

The overarching conclusion regarding current research in skin cancer detection points to a transformative era, driven by the convergence of artificial intelligence and advanced imaging technologies. The collective effort focuses on moving beyond traditional visual inspection, aiming for earlier, more precise, and widely accessible diagnoses. Deep learning, especially convolutional neural networks, has emerged as a powerful tool for analyzing dermoscopic images, promising to surpass human capabilities in identifying subtle cancerous patterns. Alongside this, technologies like optical coherence tomography and multispectral imaging are providing deeper insights into skin lesion morphology, enabling the detection of cancers at their nascent stages. The development of mobile applications and telemedicine platforms further democratizes access to screening, potentially benefiting underserved populations. Ultimately, the synthesis of these technological advancements with clinical expertise is poised to significantly improve patient outcomes, reduce unnecessary biopsies, and usher in a future where skin cancer is detected and managed with unprecedented efficiency and accuracy.

References

- [1] Vaishnavi K., Ramadas M.A., Chanalya N., Manoj A., Nair J.J. Deep learning approaches for detection of COVID-19 using chest X-ray images; Proceedings of the 2021 Fourth International Conference on Electrical, Computer and Communication Technologies (ICECCT); Piscataway, NJ, USA. 15–17 September 2021. [Google Scholar]
- [2] Duc N.T., Lee Y.-M., Park J.H., Lee B. An ensemble deep learning for automatic prediction of papillary thyroid carcinoma using fine needle aspiration cytology. *Expert Syst. Appl.* 2022;188:115927. doi: 10.1016/j.eswa.2021.115927. [DOI] [Google Scholar]
- [3] Kassem M.A., Hosny K.M., Damaševičius R., Eltoukhy M.M. Machine learning and deep learning methods for skin lesion classification and Diagnosis: A systematic review. *Diagnostics*. 2021;11:1390. doi: 10.3390/diagnostics11081390. [DOI] [PMC free article] [PubMed] [Google Scholar]
- [4] Abayomi-Alli O.O., Damasevicius R., Misra S., Maskeliunas R., Abayomi-Alli A. Malignant skin melanoma detection using image augmentation by oversampling in nonlinear lower-dimensional embedding manifold. *Turk. J. Electr. Eng. Comput. Sci.* 2021;29:2600–2614. doi: 10.3906/elk-2101-133. [DOI] [Google Scholar]
- [5] Kadry S., Taniar D., Damaševičius R., Rajinikanth V., Lawal I.A. Extraction of abnormal skin lesion from dermoscopy image using VGG-SegNet; Proceedings of the 2021 Seventh International Conference on Bio Signals, Images, and Instrumentation (ICBSII); Chennai, India. 25 March 2021. [Google Scholar]
- [6] Hekler A., Utikal J.S., Enk A.H., Hauschild A., Weichenthal M., Maron R.C., Berking C., Haferkamp S., Klode J., Schadendorf D., et al. Superior skin cancer classification by the combination of human and artificial intelligence. *Eur. J. Cancer*. 2019;120:114–121. doi: 10.1016/j.ejca.2019.07.019. [DOI] [PubMed] [Google Scholar]

- [7] Reis H.C., Turk V., Khoshelham K., Kaya S. InSiNet: A deep convolutional approach to skin cancer detection and segmentation. *Med. Biol. Eng. Comput.* 2022;7:1–20. doi: 10.1007/s11517-021-02473-0. [DOI] [PubMed] [Google Scholar]
- [8] Nawaz M., Mehmood Z., Nazir T., Naqvi R.A., Rehman A., Iqbal M., Saba T. Skin cancer detection from dermoscopic images using deep learning and fuzzy k-means clustering. *Microsc. Res. Tech.* 2022;85:339–351. doi: 10.1002/jemt.23908. [DOI] [PubMed] [Google Scholar]
- [9] Humayun M., Sujatha R., Almuayqil S.N., Jhanjhi N.Z. A Transfer Learning Approach with a Convolutional Neural Network for the Classification of Lung Carcinoma. *Healthcare.* 2022;10:1058. doi: 10.3390/healthcare10061058. [DOI] [PMC free article] [PubMed] [Google Scholar]
- [10] Adegun A.A., Viriri S. Deep learning-based system for automatic melanoma detection. *IEEE Access.* 2019;8:7160–7172. doi: 10.1109/ACCESS.2019.2962812. [DOI] [Google Scholar]
- [11] Hekler A., Utikal J.S., Enk A.H., Hauschild A., Weichenthal M., Maron R.C., Berking C., Haferkamp S., Klode J., Schadendorf D., et al. Superior skin cancer classification by the combination of human and artificial intelligence. *Eur. J. Cancer.* 2019;120:114–121. doi: 10.1016/j.ejca.2019.07.019. [DOI] [PubMed] [Google Scholar]
- [12] Lopez A.R., Giro-i-Nieto X., Burdick J., Marques O. Skin lesion classification from dermoscopic images using deep learning techniques; Proceedings of the 2017 13th IASTED International Conference on Biomedical Engineering (BioMed); Innsbruck, Austria. 20 February 2017. [Google Scholar]
- [13] Harangi B. Skin lesion classification with ensembles of deep convolutional neural networks. *J. Biomed. Inform.* 2018;86:25–32. doi: 10.1016/j.jbi.2018.08.006. [DOI] [PubMed] [Google Scholar]
- [14] Kim C.-I., Hwang S.-M., Park E.-B., Won C.-H., Lee J.-H. Computer-Aided Diagnosis Algorithm for Classification of Malignant Melanoma Using Deep Neural Networks. *Sensors.* 2021;21:5551. doi: 10.3390/s21165551. [DOI] [PMC free article] [PubMed] [Google Scholar]
- [15] Alnowami M. Very Deep Convolutional Networks for Skin Lesion Classification. *J. King Abdulaziz Univ. Eng. Sci.* 2019;30:43–54. [Google Scholar]
- [16] Ameri A. A deep learning approach to skin cancer detection in dermoscopy images. *J. Biomed. Phys. Eng.* 2020;10:801. doi: 10.31661/jbpe.v0i0.2004-1107. [DOI] [PMC free article] [PubMed] [Google Scholar]
- [17] Sae-Lim W., Wettayaprasit W., Aiyarak P. Convolutional neural networks using MobileNet for skin lesion classification; Proceedings of the 2019 16th International Joint Conference on Computer Science and Software Engineering (JCSSE); Chonburi, Thailand. 10 July 2019.