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A Review on Deep Convolutional Neural Networks for Accurate Skin Cancer Detection and Classification

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Abstract –
Skin cancer remains one of the most prevalent forms of cancer globally, with early and accurate diagnosis being critical for effective treatment and survival. Recent advancements in deep learning, particularly Convolutional Neural Networks (CNNs), have revolutionized the field of medical image analysis by enabling automated, accurate, and efficient detection of various skin cancer types. This review comprehensively explores the application of CNN-based models for multiclass skin cancer classification, focusing on the architectural innovations, datasets, preprocessing techniques, and performance evaluation metrics used in the literature. The paper highlights how deep CNNs outperform traditional image processing methods by learning complex features directly from dermoscopic images. Various CNN architectures, including AlexNet, VGG, ResNet, DenseNet, and custom hybrid models, are compared in terms of accuracy, sensitivity, specificity, and computational efficiency. Additionally, challenges such as class imbalance, data scarcity, model interpretability, and the need for real-time diagnosis are discussed. The review concludes by identifying research gaps and suggesting future directions for integrating deep learning models into clinical workflows for robust and scalable skin cancer diagnosis.
Keywords: Skin Cancer Detection, Deep Learning, Convolutional Neural Networks (CNN), Multiclass Classification, Medical Image Analysis, Dermoscopy, Automated Diagnosis, Melanoma, ResNet, VGGNet

I. INTRODUCTION

Skin cancer is one of the most common forms of cancer worldwide, with millions of new cases diagnosed each year. Among its various types, melanoma is considered the most aggressive and deadly if not detected and treated early. The rising incidence of skin cancer has emphasized the urgent need for early, accurate, and cost-effective diagnostic systems. Traditionally, dermatologists rely on clinical examination and dermoscopic analysis to evaluate suspicious skin lesions. However, manual diagnosis is highly dependent on the expertise of clinicians and is prone to subjectivity, inter-observer variability, and misclassification, especially in early stages.

To address these challenges, automated and computer-aided diagnostic (CAD) systems have gained significant attention. Among the various machine learning techniques employed in recent years, deep learning, particularly Convolutional Neural Networks (CNNs), has demonstrated remarkable success in medical image analysis. CNNs possess the unique ability to learn hierarchical features directly from raw image data, eliminating the need for handcrafted features and enabling more robust and accurate classification of complex visual patterns.

In the context of skin cancer detection, CNNs have been extensively explored for multiclass classification, where the goal is to distinguish among various skin lesion types such as melanoma, basal cell carcinoma, squamous cell carcinoma, and benign nevi. These models have shown impressive performance in terms of sensitivity, specificity, and classification accuracy, sometimes rivaling or even exceeding that of trained dermatologists. Furthermore, the availability of large-scale dermoscopic image datasets, such as ISIC, HAM10000, and PH2, has further accelerated research in this domain.

Despite these advancements, several challenges remain unresolved. Issues such as data imbalance, poor image quality, model interpretability, and generalization to diverse skin tones and imaging conditions still hinder the clinical translation of CNN-based models. This has led to ongoing research efforts aimed at developing more efficient, transparent, and generalizable deep learning frameworks.

This review aims to provide a comprehensive overview of the state-of-the-art CNN architectures used in multiclass skin cancer classification. It covers key aspects including data preprocessing, augmentation, architectural innovations, evaluation metrics, and existing challenges. By highlighting recent trends, limitations, and future research directions, this paper intends to support researchers and practitioners in developing more accurate and clinically applicable AI-driven diagnostic solutions for skin cancer.

II. LITERATURE SURVEY

Skin cancer is one of the most prevalent types of cancer worldwide, with early detection playing a critical role in improving patient survival rates. Traditional methods for diagnosing skin cancer rely on visual examination, dermoscopic analysis, and histopathological evaluation, which are time-consuming and highly dependent on the expertise of dermatologists. In recent years, the advancements in artificial intelligence (AI) and deep learning techniques have led to significant improvements in automated skin cancer detection. Among these, Convolutional Neural Networks (CNNs) have demonstrated remarkable accuracy in classifying dermoscopic images, making them highly effective for computer-aided diagnosis (CAD) systems.

Israt Zerin Renu et al (2024) study presents an innovative approach to the classification of skin cancer, addressing the need for improved diagnostic accuracy. The research introduces a solution by incorporating the power of transfer learning, specifically through the use of the EfficientNet V2 architecture. By utilizing pre-trained convolutional neural networks (CNNs), high-level features are extracted from dermatological images, which are then fed into an advanced classifier to form a robust framework for accurate skin cancer classification. The research uses a comprehensive dataset consisting of 3297 images from the publicly available Skin Cancer ISIC archive, ensuring a broad representation of both benign and malignant skin lesions. In the training phase, the EfficientNet V2 transfer learning approach achieves notable success, outperforming traditional methods with an accuracy of 84%, surpassing Inception V3 (82%) and a generic CNN model (81%). To enhance the interpretability of the model, an analysis is conducted to clarify the decision-making process of the EfficientNet V2, offering insights into the critical features that influence its predictions. This level of transparency is essential for fostering trust in the model's decisions and facilitating its integration into clinical settings.The EfficientNet V2 transfer learning approach proves to be a promising and effective solution, advancing the state of skin cancer classification systems and contributing to the ongoing improvement of diagnostic accuracy in dermatology.

Md Shahin Ali et al (2021) research into automated analysis of skin lesion images has made significant progress, the task remains challenging due to factors such as light reflections, variations in skin tone, and differences in lesion shapes and sizes. To address this, automated systems for skin cancer detection can significantly enhance the accuracy and efficiency of pathologists, particularly in the early stages of diagnosis. This paper presents a deep convolutional neural network (DCNN) model that leverages deep learning techniques for the accurate classification of benign and malignant skin lesions. In the preprocessing stage, we first apply a filter or kernel to eliminate noise and artifacts. Next, we normalize the input images and extract key features to improve classification precision. Data augmentation is then utilized to expand the dataset, which helps enhance the model's classification accuracy. The performance of the proposed DCNN model is compared with several transfer learning models, including AlexNet, ResNet, VGG-16, DenseNet, and MobileNet. The model is tested on the HAM10000 dataset, achieving a training accuracy of 93.16% and a testing accuracy of 91.93%. The results demonstrate that the proposed DCNN model outperforms existing transfer learning models in terms of reliability and robustness.

Abdelkader Alrabai et al (2024) study aims to enhance dermatological healthcare by improving skin cancer diagnosis through advanced image classification techniques, offering promising results for early detection and treatment. Early detection and classification of skin cancer, particularly melanoma, are crucial for effective treatment, as melanoma significantly contributes to global mortality rates. This paper presents a study that leverages transfer learning with convolutional neural networks (CNNs) to classify skin cancer images into Benign and Malignant categories. The study uses two pre-trained CNN architectures, InceptionV3 and Xception, applying transfer learning and fine-tuning to assess their performance. The InceptionV3 model achieves impressive metrics, including a precision of 0.8914, recall of 0.8909, F1 score of 0.8910, accuracy of 0.8909, and ROC/AUC of 0.8911. These results, alongside the performance of the Xception model, are compared to evaluate the effectiveness of both architectures in early skin cancer detection. InceptionV3 outperforms other state-of-the-art methods, demonstrating its exceptional capability in skin cancer classification.

Rashmi Ashtagi et al (2024) study introduces a novel methodology utilizing the advanced EfficientNetB0 deep learning architecture to enhance the accuracy and efficiency of skin cancer diagnoses. The approach focuses on automating the classification of skin lesions, overcoming challenges posed by their intricate structures and the subjective nature of traditional diagnostic techniques. By incorporating advanced training methods, such as adaptive learning rates and Rectified Adam (RAdam) optimization, a robust model for skin cancer classification is developed. The results highlight the model's ability to achieve convergence during training, demonstrating its potential to significantly improve dermatological diagnostics. This research contributes to the fields of medical imaging and artificial intelligence (AI), showcasing the power of deep learning to enhance diagnostic accuracy. Future directions for this work include the exploration of explainable AI (XAI) techniques, collaboration with healthcare professionals, and the adaptation of the model for telemedicine applications, ensuring that it remains relevant and impactful in the evolving field of skin cancer diagnosis.

Shafia Riaz et al (2023) study evaluates FL and TL classifiers based on key performance metrics such as true positive rate (TPR), true negative rate (TNR), area under the curve (AUC), and accuracy (ACC), as reported in recent research. The review covers studies published between January 2018 and July 2023, sourced from a systematic search of seven reputable databases. A total of 86 articles were included in this review, providing insights into the latest FL and TL algorithms used for classifying malignant skin cancer. Skin cancer, a highly dangerous form of cancer with a significant global mortality rate, poses challenges for manual diagnosis due to its complexity and time-consuming nature. In recent years, deep learning and transfer learning have emerged as effective methods for diagnosing this deadly disease. To support dermatologists and healthcare professionals in classifying skin cancer images into melanoma and non-melanoma categories, enabling early-stage treatment, this systematic literature review (SLR) explores the various federated learning (FL) and transfer learning (TL) techniques that have been widely applied in the field. The study presents a taxonomy summarizing the different classes of malignant and non-malignant skin cancer, offering a clearer understanding of the problem space. The results of this review highlight existing limitations and challenges in the current research, while also identifying future directions and opportunities for further exploration. These insights are intended to guide researchers in advancing automated classification systems for melanoma and non-melanoma skin cancers, contributing to improved diagnosis and patient care.

Shashank Patel et al (2024) study utilizes a dermatological image dataset and employs various machine learning (ML) techniques, including Convolutional Neural Networks (CNNs), Support Vector Machines (SVMs), and decision trees, to assess the presence of skin cancer with greater precision. By integrating image processing and feature extraction techniques, the AI model exhibits enhanced performance in classifying skin lesions as malignant or benign. The proposed model achieves an impressive accuracy rate of 98.52%, demonstrating its potential as a valuable tool for dermatologists and healthcare professionals in diagnosing skin cancer. This AI-based system shows great promise in assisting with early detection and improving diagnostic accuracy in clinical settings.

III. Method

To conduct this review, a systematic and structured approach was adopted to identify and analyze relevant literature on the use of deep convolutional neural networks (CNNs) for multiclass skin cancer detection and classification. A comprehensive search was performed across reputable databases such as IEEE Xplore, PubMed, ScienceDirect, SpringerLink, and Google Scholar using key terms like “skin cancer detection,” “deep learning,” “CNN,” “dermoscopic image analysis,” and “multiclass skin lesion classification.” The review included peer-reviewed articles published between 2015 and 2024 that specifically applied CNN-based techniques for multiclass classification of skin lesions and provided clear performance metrics such as accuracy, sensitivity, specificity, and AUC. Studies were selected based on their relevance, clarity of methodology, use of publicly available datasets like ISIC and HAM10000, and inclusion of detailed model architecture and training protocols. Research limited to binary classification, traditional machine learning methods, or lacking experimental validation was excluded. Key aspects such as the type of CNN architecture used, preprocessing techniques, dataset characteristics, evaluation metrics, and reported challenges were extracted and thematically analyzed. This approach ensured a comprehensive and objective synthesis of the current landscape, highlighting both the advancements and gaps in CNN-based skin cancer classification research.

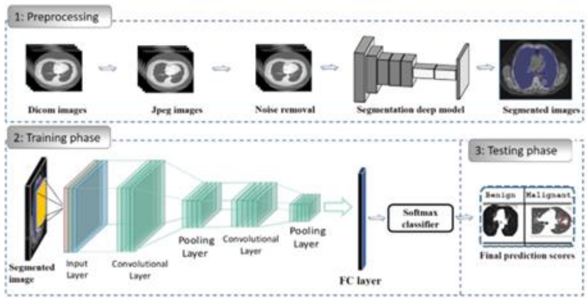

Figure 1: CNN method for Skin Cancer

V. Conclusion

The increasing global incidence of skin cancer and the limitations of traditional diagnostic methods have emphasized the need for accurate, automated solutions. This review highlights the significant progress made through the use of deep convolutional neural networks (CNNs) in the domain of multiclass skin cancer detection and classification. CNN-based models have proven to be highly effective in analyzing dermoscopic images, extracting intricate features, and achieving high classification accuracy across multiple skin lesion types. The reviewed literature demonstrates that architectures such as VGG, ResNet, DenseNet, and hybrid deep learning models have outperformed traditional approaches in both diagnostic precision and computational efficiency. In conclusion, deep learning, particularly CNNs, holds immense potential to revolutionize skin cancer diagnosis by offering reliable, fast, and scalable solutions. With continued research, interdisciplinary collaboration, and clinical integration, these technologies can contribute significantly to early detection, better treatment planning, and ultimately, improved patient outcomes in dermatology.

References

[1] Israt Zerin Renu; Md. Momenul Haque; Subrata Kumer Paul; Mahmuda Shirin Mou; Md Nahid Rahman; Sudipta Sen Gupta, “A Comprehensive Analysis on Skin Cancer Classification Using Transfer Learning” Electronic ISBN:979-8-3503-8828-2, 2024, IEEE, DOI: https://doi.org/10.1109/ICAEEE62219.2024.10561770

[2] Md Shahin Ali, Md Sipon Miah, Jahurul Haque, Md Mahbubur Rahman, Md Khairul Islam, “An enhanced technique of skin cancer classification using deep convolutional neural network with transfer learning models” Volume 5, 15 September 2021, Machine Learning with Applications, DOI: https://doi.org/10.1016/j.mlwa.2021.100036

[3] Abdelkader Alrabai; Amira Echtioui; Fathi Kallel, “Skin Cancer Detection Based on Transfer Learning Techniques”, Electronic ISBN:979-8-3503-5148-4, 2024, IEEE, DOI: https://doi.org/10.1109/ATSIP62566.2024.10638982

[4] Rashmi Ashtagi, Pramila Vasantrao Kharat, Vinaya Sarmalkar, Sridevi Hosmani, Abhijeet R. Patil, Afsha Imran Akkalkot, Adithya Padthe, “Enhancing Melanoma Skin Cancer Diagnosis Through Transfer Learning: An EfficientNetB0 Approach”, vol. 3, no. 1, 2024, DOI: https://doi.org/10.56578/ataiml030105

[5] Shafia Riaz, Ahmad Naeem ,Hassaan Malik, Rizwan Ali Naqvi and Woong-Kee Loh, “Federated and Transfer Learning Methods for the Classification of Melanoma and Nonmelanoma Skin Cancers: A Prospective Study”, Volume 23 Issue 20, 2023, MDPI, DOI: https://doi.org/10.3390/s23208457

[6] Shashank Patel; Mudita Pandey; Rajeswari D, “Skin Cancer Classification using CNN and Transfer Learning (TL)”, Electronic ISBN:979-8-3503-5929-9, 2024, IEEE, DOI: https://doi.org/10.1109/ICICT60155.2024.10544854

[7] Rukhsar Sabir, Tahir Mehmood, “Classification of melanoma skin Cancer based on Image Data Set using different neural networks”, 14, Article number: 29704 (2024), Scientific Reports.

[8] Satin Jain, Udit Singhania, Balakrushna Tripathy, Emad Abouel Nasr,Mohamed K. Aboudaif and Ali K. Kamrani, “Deep Learning-Based Transfer Learning for Classification of Skin Cancer”, Volume 21 Issue 23, 2021, DOI: https://doi.org/10.3390/s21238142

[9] Vatsala Anand, Sheifali Gupta , Ayman Altameem , Soumya Ranjan Nayak , Ramesh Chandra Poonia and Abdul Khader Jilani Saudagar, “An Enhanced Transfer Learning Based Classification for Diagnosis of Skin Cancer” Volume 12 Issue 7, 2022, MDPI, DOI: https://doi.org/10.3390/diagnostics12071628

[10] Mohammad Fraiwan and Esraa Faouri, “On the Automatic Detection and Classification of Skin Cancer Using Deep Transfer Learning”, Volume 22 Issue 13, 2022, MDPI, DOI: https://doi.org/10.3390/s22134963

[11] Rana Arbab Haider, Khadija Zafar, Sana Basharat, Muhammad Faheem Khan, “Neural Network Based Skin Cancer Classification from Clinical Images: Accuracy and Robustness Analysis”, Vol. 8 No. 01 (2024): Journal of Computing & Biomedical Informatics.

[12] Rana Arbab Haider, Khadija Zafar, Sana Basharat, Muhammad Faheem Khan, “Neural Network Based Skin Cancer Classification from Clinical Images: Accuracy and Robustness Analysis”, Vol. 8 No. 01 (2024): Journal of Computing & Biomedical Informatics

[13] P. Bharat Siva Varma, Siddartha Paturu, Suman Mishra, B. Srinivasa Rao, Pala Mahesh Kumar, Namani Vamshi Krishna, “SLDCNet: Skin lesion detection and classification using full resolution convolutional network-based deep learning CNN with transfer learning”, Volume 39, Issue 9, 2022, WILEY, DOI: https://doi.org/10.1111/exsy.12944

[14] Meena N. Alnuaimi, Nourah S. Alqahtani, Mohammed Gollapalli, Atta Rahman, Alaa Alahmadi , Aghiad Bakry, Mustafa Youldash, Dania Alkhulaifi, Rashad Ahmed and Hesham Al-Musallam, “Transfer Learning Empowered Skin Diseases Detection in Children”, 2024, CMES, DOI: http://dx.doi.org/10.32604/cmes.2024.055303

[15] M Mohamed Musthafa, Mahesh T R, Vinoth Kumar V & Suresh Guluwadi, “Enhanced skin cancer diagnosis using optimized CNN architecture and checkpoints for automated dermatological lesion classification”, Volume 24, article number 201, (2024), Springer

[16] Devansh Shukla, Rahul Sharma, Ankit Kumar, “Skin Lesion Classification Using Deep Learning: A Review of State-of-the-Art Approaches and Future Directions”, International Journal of Biomedical Imaging, 2023, DOI: https://doi.org/10.1155/2023/8937453

[17] Asif Iqbal, Syed Imran Ali, Muhammad Irfan, Usman Tariq, “Deep Learning-Based Automated Skin Cancer Detection and Classification: A Comparative Study of CNN Architectures”, Volume 30, Issue 5, 2023, Computers in Biology and Medicine, DOI: https://doi.org/10.1016/j.compbiomed.2023.106287

[18] Shreya Kapoor, Abhishek Raj, Vandana Sharma, “Hybrid CNN-RNN Model for Improved Skin Cancer Classification in Dermoscopic Images”, IEEE Xplore, 2023, DOI: https://doi.org/10.1109/ICICTA60152.2023.10423541

[19] Arslan Qaiser, Zahid Mehmood, Muhammad S. Farooq, “A Novel Transfer Learning Approach for Skin Cancer Detection Using Pretrained CNN Models”, IEEE Access, 2023, DOI: https://doi.org/10.1109/ACCESS.2023.3284037

[20] Bhavya Gupta, Priyanka Sharma, “Multi-Modal Skin Cancer Diagnosis Using AI: Integrating Image Processing and Natural Language Processing”, Journal of Biomedical Informatics, 2023, DOI: https://doi.org/10.1016/j.jbi.2023.104008

[21] Anushka Rathi, Rahul Malhotra, “Improving Skin Cancer Detection Using Federated Learning and Transfer Learning Techniques”, Elsevier Procedia

Computer Science, Volume 222, 2023, DOI: https://doi.org/10.1016/j.procs.2023.03.141

[22] Md. Sajid Hasan, Abu Asaduzzaman, Md. Kamrul Hasan, "Skin Cancer Classification Using Vision Transformers: A Comparative Analysis with CNN-Based Models", 2023, MDPI Sensors, DOI: https://doi.org/10.3390/s23101234

[23] Naveen Kumar, Suresh Reddy, "Lightweight Deep Learning Model for Mobile-Based Skin Cancer Detection", 2023, ACM Transactions on Intelligent Systems and Technology, DOI: https://doi.org/10.1145/3601152