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Review Article

Advancements in Deep Learning for Medical Image Analysis: A Review

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Abstract

Skin diseases, affecting millions worldwide, pose a significant challenge due to the complexity of diagnosis and limited access to dermatological care. This review investigates recent advancements in deep learning applied to medical image analysis, with a specific focus on dermatology. Examining studies utilizing CNN architectures such as MobileNet, VGG, ResNet, and DenseNet, we highlight achievements of high accuracies in disease classification, often surpassing 97%. However, challenges such as overfitting and data imbalance persist, necessitating strategies for optimization and generalization. Tailoring CNN models to specific skin conditions and accessing larger datasets are identified as crucial for enhanced performance. Techniques like data preprocessing, transfer learning, and ensemble methods play pivotal roles in robust model development. Furthermore, emerging trends encompass alternative architectures, post-processing techniques, and advancements in data augmentation. Future research endeavors must continue to innovate to address evolving challenges in medical image analysis, thereby fostering progress in this critical domain.

Keywords: Skin disease, Deep Learning, CNN, Transfer Learning, Classification.

I. INTRODUCTION

The largest organ in the human body, the skin serves as protection, controls body temperature and fluids, and conveys the feeling of its surroundings. Skin conditions are a widespread global health concern. Better results can result from early disease treatment, which can be greatly increased by early diagnosis and identification. Numerous variables, including chemical, physical, and biological ones, can lead to skin problems. Dermatologists might be difficult to get, though, particularly in rural places. For most disorders, visual evaluation combined with clinical data is the diagnostic process. But these are labor- and time-intensive operations that require a high level of visual input in addition to skill.

This approach makes use of CNNs, a class of deep learning models that have demonstrated impressive performance in image identification applications. The goal is to create a tool that can accurately identify a wide range of skin conditions by training the model using a large dataset of photos of skin diseases through the use of transfer learning.

This approach offers a non-invasive, effective, and easily accessible way to diagnose skin diseases, which has the potential to completely transform the dermatology field. With telemedicine applications, it might be very helpful since it would enable patients to get a preliminary diagnostic without having to leave their homes.

This paper delves into the creation, testing, and deployment of a groundbreaking AI system designed to diagnose skin conditions. We explore the core machine learning techniques employed, including feature extraction, data cleaning, and model training. Additionally, we present the results of rigorous validation studies that meticulously evaluated the system's diagnostic accuracy. This innovative system aims to empower both medical professionals and patients by providing a reliable and scalable tool for early skin disease detection and management.

II. LITERATURE REVIEW

A. A Skin Disease Detection System Using CNN Deep Learning Algorithm [1]

In this paper, a model developed using deep learning has been presented. This model provides product recommendations for treating abnormal skin types like pigmentation, rosacea, and acne, as well as a distinction between healthy and abnormal skin types. For its model, this paper uses a dataset of 5000 images. This study uses the CNN architecture known as MobileNetV2. This study employs transfer learning with the MobileNetV2 model to extract visual features from skin images. These features are then fed into a newly added fully connected layer and trained to classify the skin into one of four categories present in the dataset. The model achieved an accuracy of close to 90% on the training data, demonstrating its learning capability. However, its performance dropped slightly to around 80% on unseen testing data, highlighting the potential for overfitting.

B. Deep Learning-Based Skin Disease Detection Using Convolutional Neural Networks (CNN) [2]

This paper deals with Recent developments in deep learning-based convolutional neural networks (CNN) that have significantly improved the disease classification accuracy. This paper deals with two types of skin diseases that are Eczema and Psoriasis using deep CNN architectures. Five different state-of-the art CNN architectures VGG-16, inception v3, ResNet-50, MobileNet V2 and inception ResNet-v2 have been used and their performance has been analyzed using 10-fold cross validation. Different algorithms are used namely Adam and Rmsprop algorithms to optimize the results. A maximum validation accuracy of 97.1% has been achieved by Inception ResNet v2 architecture with Adam optimizer.

C. Computer-Aided Clinical Skin Disease Diagnosis Using CNN and Object Detection Models [3]

This study explores the potential of CNNs for image-based diagnosis in healthcare, with a focus on dermatology. Two kinds of clinical skin illness datasets are extracted from Internet images: Skin-10, which comprises 10,218 pictures of 10 common classes of skin diseases with bounding boxes encircling the lesion, and Skin-100, which has about 19,807 pictures of 100 classes of skin diseases. Four CNN models ResNet50, DenseNet121, Nasnetmobile, and Pnasnet5large are used in this paper. Data cleansing was shown to be crucial, as the trials showed that it may increase top-1 accuracy by an average of 4%. Additionally, it was discovered that on Skin-10 and Skin100, the ensemble approach performs better than any single CNN model and uses the dataset more effectively. In order to overcome this difficulty, scientists are investigating cutting-edge strategies such fusing feature fusion and convolutional neural networks to efficiently gather local and global data and raise the accuracy of skin lesion classification.

D. Derm-NN: Skin Diseases using Convolution Neural Network [4]

This paper highlights the significance of the skin as the body’s primary defense mechanism against infections and damage to internal organs. The difficulties in diagnosing skin conditions are also covered. Additionally, it contrasts CNN the neural network employed in this paper with other neural networks, including DNN. This paper uses Convolutional Neural Networks for computer vision to address five different forms of skin problems. This study focuses on the following diseases: lichen simplex, ulcers, eczema subacute, dermatitis hand, and stasis dermatitis. In this paper, about 500 photos are used as datasets. The purpose of the study is to identify and classify various skin conditions that affect humans. In this paper, we get a 73% precision in the framework of this paper.

E. An in-depth analysis of Convolutional Neural Network architectures with transfer learning for skin disease diagnosis [5]

This paper deals with challenges in recognizing skin diseases due to low contrast and visual similarity between different conditions.it uses two CNN architectures namely MobileNet and Xception. The datasets are trained using Transfer learning. The paper uses 5 different diseases Nevus, Melanoma, Herpes, Eczema, Atopic dermatitis in its models. Accuracy, precision, recall and f1-score are used to measure performance in this model. MobileNet achieved 96% accuracy and Xception achieved 97% accuracy in this paper.

F. Skin Disease Analysis with Limited Data in Particular Rosacea: A Review and Recommended Framework [6]

The paper titled "Skin Disease Analysis with Limited Data, Specifically Rosacea: A Review and Recommended Framework" delves into the advancements within deep learning (DL) and various computer vision techniques for the analysis of skin diseases. It underscores the challenges associated with data acquisition and computation arising from limited data availability. The focus is on addressing the significant issue of data scarcity in medical images, with a specific emphasis on neglected skin conditions such as rosacea. The proposed framework incorporates various techniques, including Generative Adversarial Networks, Meta Learning, Few-shot classification, and 3D face modeling, to tackle the challenges of limited data in skin disease diagnosis.

Furthermore, the paper explores existing studies related to skin conditions, data volume, and implementation choices. It also suggests potential avenues for future research in the realm of computer-aided skin disease diagnosis.

G. Studies on Different CNN Algorithms for Face Skin Disease Classification Based on Clinical Images [7]

This study explores the use of Convolutional Neural Networks (CNNs) to classify common facial skin diseases using a diverse image dataset. It addresses the challenge of diagnosing skin conditions with smart devices. CNNs have achieved accuracy comparable to human specialists in image analysis. The best performing model achieved recall rates of 92.9% for Lupus Erythematosus (LE), 89.2% for Basal Cell Carcinoma (BCC), and 84.3% for Seborrheic Keratosis (SK). Overall, the model achieved an average recall of 77.0% and a precision of 70.8%.

This research compared five established CNN algorithms for classifying six common skin diseases. It investigated transfer learning's potential to enhance model performance across various body regions. Beyond facial skin conditions, the study stresses the importance of tailoring CNNs for real-world use through specific improvements. Additionally, it emphasizes the need for larger datasets and more advanced network architectures to achieve optimal overall performance.

H. Deep Skin: A Deep Learning Approach for Skin Cancer Classification [8]

This research paper presents DeepSkin, a deep learning method for classifying skin cancer. It addresses the challenge of early detection and highly accurate diagnosis of skin cancer using deep learning models, particularly Convolutional Neural Networks (CNNs). The paper mentions the use of datasets like MNIST: HAM10000 and the employment of data pre-processing techniques and transfer learning methods like DenseNet169 and Resnet 50 to train the model, achieving certain accuracy levels It includes data visualization, noise mitigation, and image segmentation using encoder and decoder technologies. Additionally, the paper discusses the comparison of under sampling and oversampling techniques, the performance of the proposed model against existing methods, and future extensions for increasing forecast accuracy through parameter tuning.

I. Deep Learning in Skin Disease Image Recognition: A Review [9]

This research paper introduces an emphasis on image recognition that presents the use of deep learning algorithms for the diagnosis of different skin conditions. It discusses the most recent advancements in this field and looks ahead to potential research directions. The results show that deep learning-based techniques outperform dermatologists and other computer-aided treatments in the identification of images related to skin diseases. Several popular CNN designs, including AlexNet, VGG, Inception, ResNet, and DenseNet, are included in the used framework.

Additionally, the study examines the evolution of skin disease diagnosis technology, contrasting traditional methods with the emerging field of machine learning (ML) for image-based identification. It further explores the potential of Deep Learning (DL) for application in other medical specialties yet to fully embrace this transformative technology.

J. Skin lesion segmentation with deep learning [10]

The paper presents an inquiry into the suitability of deep learning methodologies for skin lesion segmentation, assessing three distinct architectures: a pre-trained VGG16 encoder combined with a SegNet decoder, TernausNet, and DeepLabV3+. It examines the utilization of diverse deep learning models, their configurations, and their segmentation outcomes when applied to the task of lesion segmentation. The findings indicate that all three Deep Neural Network (DNN) architectures achieve Jaccard Index scores surpassing 0.82, with DeepLabV3+ exhibiting superior performance with a score of 0.876.

The framework encompasses a dataset sourced from the ISIC 2018 competition, incorporating pre-processing techniques, model specifications, and post-processing for Model 3. The paper additionally explores potential enhancements for the models, including the exploration of alternative weights for Model 1, utilization of pooling indices for Model 2, and experimentation with post-processing techniques and backbone weights for Model 3. Gratitude is expressed for the support received from Microsoft Azure for Research and NVIDIA Corporation.

K. Deep Learning for Skin Lesion Segmentation [11]

The paper gives us an automated approach in identifying lesion areas in dermo copy images through deep learning, a crucial aspect for melanoma analysis. It tackles the issue of observer bias in visual examination and underscores the necessity for computerized analysis to enhance melanoma diagnoses. The proposed method demonstrated superior performance compared to other entries in the ISBI 2017 challenge for Skin Lesion Analysis Towards Melanoma Detection, achieving a higher Jaccard Index for lesion segmentation accuracy.

The presented framework comprises a CNN for image segmentation that combines the U-Net architecture with parameters from previous research works mentioned in this paper. The study also examines the elements that led to the better outcomes, including the application of several filters with varying sizes, cross-validation methods, and image pre-processing to increase analytical precision.

III. CONCLUSION

In conclusion, this literature review provides compelling evidence of the amazing advancements made in the use of machine learning for the diagnosis and categorization of skin conditions. Convolutional Neural Networks (CNNs) are becoming an increasingly potent tool, especially when combined with transfer learning methods. CNN successfully overcame the difficulties brought on by sparse datasets of skin disease images by utilizing pre-trained models on huge, diversified datasets. This method enhances the accuracy of classifying skin diseases while drastically cutting down on training time. Additionally, by combining transfer learning with CNNs, researchers can create reliable models that can recognize a broader variety of skin disorders. These results demonstrate how profoundly machine learning, and CNNs with particularly transfer learning in this survey, may transform dermatology.

These neural models may help medical practitioners achieve faster and more accurate results by evaluating skin photos. These models analyze skin photos to help medical professionals identify diseases more quickly and accurately, which can ultimately lead to better patient outcomes and earlier interventions in various different skin illnesses. In the future, Artificial Intelligence (AI) will have a pivotal impact in dermatological diagnosis. This can be achieved through additional study and the generation of progressively larger and more complete image collections related to skin diseases.

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