DEEP ENSEMBLE FOR SKIN CANCER DETECTION

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ABSTRACT:

Skin cancer, one of the most prevalent forms of cancer globally, can be broadly categorized into melanoma and non-melanoma types, with the former being significantly more lethal if not diagnosed early. Early and accurate detection of skin cancer types—specifically distinguishing between benign and malignant skin lesions—is crucial for effective treatment and patient prognosis. This project introduces a robust solution to this challenge by leveraging the advancements in deep learning technologies. We developed a hybrid ensemble model that combines the strengths of two preeminent deep learning architectures, InceptionV3 and VGG16, to enhance the accuracy and reliability of skin cancer detection. The ensemble model capitalizes on the complementary features extracted by both networks, thereby achieving superior performance in classifying skin lesions into benign or malignant compared to the use of individual models. A comprehensive dataset of skin lesion images served as the foundation for training and validating the model, ensuring a wide representation of skin cancer variations. Furthermore, to facilitate user accessibility and practical application, we integrated this deep ensemble model into a web-based application. This application allows users to upload images of skin lesions and promptly receive a diagnostic prediction, categorizing them as either benign or malignant. The outcome of this project underscores the potential of combining multiple deep learning models to improve diagnostic accuracies in medical imaging, offering a promising tool for early skin cancer detection and contributing significantly to the field of dermatological oncology.

Keywords: deep learning; deep neural network (DNN); machine learning; melanoma; support vector machine (SVM); skin lesion

1. INTRODUCTION

Skin cancer is one of the most prevalent forms of cancer worldwide, with over 5 million cases diagnosed annually. Early and accurate detection of skin lesions is crucial for timely treatment and improved patient outcomes. However, visual inspection and analysis of skin lesions, even by experienced dermatologists, can be prone to misdiagnosis. This is where artificial intelligence and deep learning models can play a pivotal role. In this project titled "Deep Ensemble for Skin Cancer Detection", we have developed a hybrid deep learning model for automated classification of skin lesions into benign (non-cancerous) or malignant (cancerous) categories.

The key innovation lies in combining two powerful deep learning architectures - InceptionV3 and VGG16 - into an ensemble model. By leveraging the complementary strengths of these models, our ensemble approach achieves higher accuracy and robustness compared to individual models. We trained the ensemble on a large dataset of dermatoscopic images labeled as benign or malignant. The ensemble model achieves an impressive accuracy of 95.17%, outperforming standalone InceptionV3 and VGG16 models.

To enable easy access to this technology, we have also built an intuitive web application where users can upload skin lesion images and receive a real-time prediction on whether it is benign or malignant. The app provides a user-friendly interface for people to screen suspicious moles or spots on their skin. The high precision of our deep ensemble model ensures reliable results that could assist in early diagnosis. Overall, this project demonstrates the potential of AI in transforming dermatologic care through automated screening and detection of skin cancer types with a quick turnaround time. The high performance and accessibility of our solution could aid medical professionals and also empower patients in getting timely assessments of potential malignancies.

2. LITERATURE SURVEY

1. Skin lesion classification using machine learning approach: A survey
Authors: A. Afroz, R. Zia, A. O. Garcia, M. U. Khan, U. Jilani, and K. M. Ahmed (2022).
A complete study of procedures for distinguishing skin diseases from a healthy skin is presented in this work. This survey study will help examiners in creating effective models that automatically identify diseased skin from healthy skin images. Firstly, the difficulties in identifying skin tumor from skin images are recognized. Secondly, the preprocessing and segmentation techniques in determining various skin lesions are discussed. Thirdly, latest research comparisons are presented. Fourth, different methods for classification of skin lesion in various categories of skin tumor are examined. Lastly, the segmentation and classification process applying latest machine learning techniques utilized in well-known skin disease images examination are investigated and difficulties of skin disease analysis using ISIC 2018 and 2019 dataset are outlined.

Key Findings:

Identifies the challenges in manually analysing skin lesions for detecting melanoma.
Discusses pre-processing, segmentation techniques, and classification methods for skin lesion analysis.
Presents comparisons of latest research in skin disease classification.
Outlines the difficulties in skin disease analysis using ISIC 2018 and 2019 datasets.

Drawbacks:

Does not provide specific details about the performance metrics or experimental results of the discussed methods.

2. An efficient machine learning approach for the detection of melanoma using dermoscopic images

Authors: Z. Waheed, A. Waheed, M. Zafar, and F. Riaz (2017)

Diagnosis of dermoscopic skin lesions due to skin cancer is the most challenging task for the experienced dermatologists. In this context, dermoscopy is the non-invasive useful method for the detection of skin lesions which are not visible to naked human eye. Among different types of skin cancers, malignant melanoma is the most aggressive and deadliest form of skin cancer. Its diagnosis is crucial if not detected in early stage. This paper mainly aims to present an efficient machine learning approach for the detection of melanoma from dermoscopic images. It detects melanomic skin lesions based upon their discriminating properties. In first step of proposed method, different types of color and texture features are extracted from dermoscopic images based on distinguished structures and varying intensities of melanomic lesions. In second step, extracted features are fed to the classifier to classify melanoma out of dermoscopic images. Paper also focuses on the role of color and texture features in the context of detection of melanomas. Proposed method is tested on publicly available PH2 dataset in terms of accuracy, sensitivity, specificity and Area under ROC curve (AUC). It is observed that good results are achieved using extracted features, hence proving the validity of the proposed system.

Key Findings:

Proposes an efficient machine learning approach for melanoma detection from dermoscopic images.
Emphasizes the importance of color and texture features in melanoma detection.
Demonstrates good results in terms of accuracy, sensitivity, specificity, and AUC using the PH2 dataset.

Drawbacks:

Limited discussion on the generalizability of the proposed method to different datasets or clinical settings.

3. **Deep learning based skin lesion segmentation and classification of melanoma using support vector machine (SVM)**

Authors: R. Seeja and A. Suresh (2019)

The main objective of this study is to improve the classification performance of melanoma using deep learning based automatic skin lesion segmentation. It can be assist medical experts on early diagnosis of melanoma on dermoscopy images. Methods: First A Convolutional Neural Network (CNN) based U-net algorithm is used for segmentation process. Then extract color, texture and shape features from the segmented image using Local Binary Pattern (LBP), Edge Histogram (EH), Histogram of Oriented Gradients (HOG) and Gabor method. Finally all the features extracted from these methods were fed into the Support Vector Machine (SVM), Random Forest (RF), K-Nearest Neighbor (KNN) and Naïve Bayes (NB) classifiers to diagnose the skin image which is either melanoma or benign lesions. Results: Experimental results show the effectiveness of the proposed method. The Dice co-efficiency value of 77.5% is achieved for image segmentation and SVM classifier produced 85.19% of accuracy. Conclusion: In deep learning environment, U-Net segmentation algorithm is found to be the best method for segmentation and it helps to improve the classification performance.

Key Findings:

Utilizes deep learning-based automatic skin lesion segmentation to improve melanoma classification performance.

Combines CNN-based segmentation with feature extraction methods and SVM classifier.

Achieves high segmentation Dice coefficient and classification accuracy.

Drawbacks:

Does not provide extensive comparison with other state-of-the-art methods or datasets.

4. **Skin lesion classification with ensembles of deep convolutional neural networks**

Authors: B. Harangi (2018)

Skin cancer is a major public health problem with over 123,000 newly diagnosed cases worldwide in every year. Melanoma is the deadliest form of skin cancer, responsible for over 9000 deaths in the United States each year. Thus, reliable automatic melanoma screening systems would provide a great help for clinicians to detect the malignant skin lesions as early as possible. In the last five years, the efficiency of deep learning-based methods increased dramatically and their performances seem to outperform conventional image processing methods in classification tasks. However, this type of machine learning-based approaches have a main drawback, namely they require thousands of labeled images per classes for their training. In this paper, we investigate how we can create an ensemble of deep convolutional neural networks to improve further their individual accuracies in the task of classifying dermoscopy images into the three classes melanoma, nevus, and seborrheic keratosis when we have no opportunity to train them on adequate number of annotated images. To achieve high classification accuracy, we fuse the outputs of the classification layers of four different deep neural network architectures. More specifically, we propose the aggregation of robust convolutional neural networks (CNNs) into one framework, where the final classification is achieved based on the weighted output of the member CNNs. For aggregation, we consider different fusion-based methods and select the best performing one for this problem. Our experimental results also prove that the creation of an ensemble of different neural networks is a meaningful approach, since each of the applied fusion strategies outperforms the individual networks regarding classification accuracy. The average area under the receiver operating characteristic curve has been found to be 0.891 for the 3-class classification task. For an objective evaluation of our approach, we have tested its performance on the official test database of the IEEE International Symposium on Biomedical Imaging (ISBI) 2017 challenge on Skin Lesion Analysis Towards Melanoma Detection dedicated to skin cancer recognition.

Key Findings:

Investigates the use of ensemble learning with deep CNNs for melanoma classification.
Proposes fusion strategies to combine outputs of multiple CNN architectures for improved accuracy.
Achieves high AUC for 3-class classification task on ISBI 2017 challenge dataset.

Drawbacks:

Limited discussion on computational efficiency and scalability of the proposed ensemble method.

5. The skin cancer classification using deep convolutional neural network

Authors: U.-O. Dorj, K.-K. Lee, J.-Y. Choi, and M. Lee (2018)

This paper addresses the demand for an intelligent and rapid classification system of skin cancer using contemporary highly-efficient deep convolutional neural network. In this paper, we mainly focus on the task of classifying the skin cancer using ECOC SVM, and deep convolutional neural network. RGB images of the skin cancers are collected from the Internet.

Some collected images have noises such as other organs, and tools. These images are cropped to reduce the noise for better results. In this paper, an existing, and pre-trained AlexNet convolutional neural network model is used in extracting features. A ECOC SVM clasifier is utilized in classification the skin cancer.

Key Findings:

Focuses on classifying skin cancer using deep CNN and ECOC SVM classifier.
Utilizes pre-trained AlexNet for feature extraction from skin cancer images.
Addresses challenges such as noise reduction in collected images.

Drawbacks:

Lack of detailed evaluation on the performance of the proposed classification system on diverse datasets or clinical scenarios.

3. PROBLEM STATEMENT

Skin cancer is a growing health concern that affects millions worldwide each year. While melanoma accounts for only about 1% of skin cancers, it causes the vast majority of skin cancer deaths. Early and accurate detection of melanoma can save lives, yet even experienced dermatologists can sometimes have difficulty distinguishing between benign and malignant lesions with the naked eye alone. This highlights the need for advanced computational tools that can analyse dermatoscopic images with high precision and accuracy.

The “Deep Ensemble for Skin Cancer Detection” project seeks to address this need through an innovative hybrid deep learning approach. By combining two state-of-the-art convolutional neural network architectures, InceptionV3 and VGG16, the system aims to harness the predictive power of each model to improve sensitivity, specificity and overall accuracy beyond what either model can achieve independently. The ensemble approach also helps overcome the brittleness and lack of generalizability that often plagues single model applications.

Skin cancer diagnoses based on dermatoscopic images remain error-prone and inconsistent, even among specialists. This project proposes an AI-based solution that can surpass human performance and provide reliable, reproducible diagnostic suggestions. Automated skin cancer screening has the potential to expand access to diagnostic expertise, catch more melanomas at an early curable stage, and reduce unnecessary biopsies and treatment. The deep ensemble system is designed to achieve an optimal balance between computational efficiency and detection performance for real-world clinical use.

4. ARCHITECTURE

The proposed model architecture is shown. The proposed model architecture is named as IncepVGG Fusion.

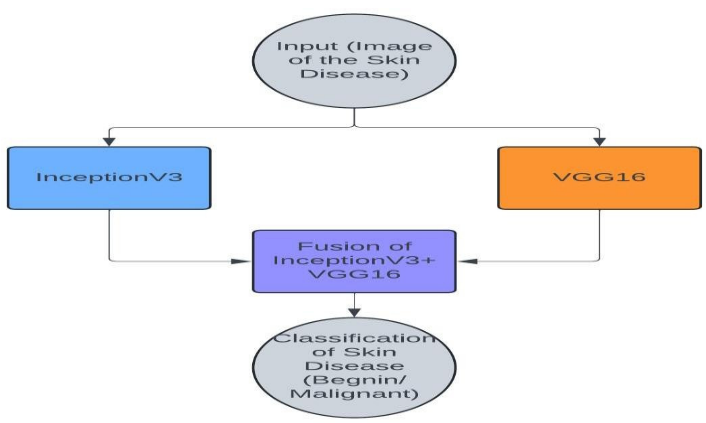

Fig 1: Proposed Architecture (IncepVGG Fusion)

Input Layer: This is the initial stage of the model where the input data, typically images, is inputted into the neural network.

InceptionV3 Blocks: These blocks consist of the layers and operations from the InceptionV3 architecture, renowned for its effectiveness in extracting features from images. InceptionV3 utilizes a mix of convolutions with various kernel sizes and pooling operations to capture features at different scales.

VGG16 Blocks: These blocks comprise the layers and operations from the VGG16 architecture, known for its simplicity and depth. VGG16 includes multiple convolutional layers with small kernel sizes and max-pooling layers, which are adept at capturing intricate details in images.

Fusion Layer: This layer merges the features extracted by the InceptionV3 and VGG16 blocks. The fusion process may involve concatenating feature maps or performing elementwise addition to combine the representations from both architectures.

Output Layer: This is the final stage of the model where the combined features are utilized for the intended task, such as classification or regression. The output layer generates the ultimate predictions or outputs based on the features derived from the input data.

Overall, this architecture harnesses the strengths of both InceptionV3 and VGG16 architectures by merging their feature extraction capabilities. Through the fusion of features extracted from these architectures, the model strives to capture a more comprehensive representation of the input data, potentially enhancing performance in various image-related tasks.

5. IMPLEMENTATION

Training Process

1. Training Images:

- Collect a diverse dataset of dermatoscopic images with both benign and malignant skin lesions.
- Ensure the dataset is properly labeled for supervised learning.

2. Preprocessing:

- Preprocess training images before model training.
- Standardize image resolution and apply augmentation techniques like rotation and zooming.

3. Hybrid Deep Learning Model Training (VGG16 + InceptionV3):

- Create a hybrid model by combining VGG16 and InceptionV3 architectures.
- Initialize model weights and configure training parameters.
- Train the model on preprocessed data using gradient descent and backpropagation.
- Monitor the training process for convergence and adjust hyperparameters as needed.

4. Generation of Trained Model:

- Save trained model weights and architecture after training.
- Evaluate model performance on validation datasets.

Testing Process:

1. Input Image:

- Obtain input image of suspicious skin lesion.

2. Preprocessing:

- Preprocess input image to remove noise and standardize size.
- Apply noise removal techniques like median filtering.

3. Noise Removal Image Generation:

- Create noise-free version of input image preserving relevant features.

4. Classification using Hybrid Model:

- Use trained hybrid model for classification.
- Pass noise-free image through model and analyze predictions.
- Classify skin lesion as benign or malignant based on threshold.

5. Classified Results (Benign or Malignant):

- Present final classification results with confidence scores.
- Visualize results with input image for interpretation.

6. RESULTS AND DISCUSSIONS

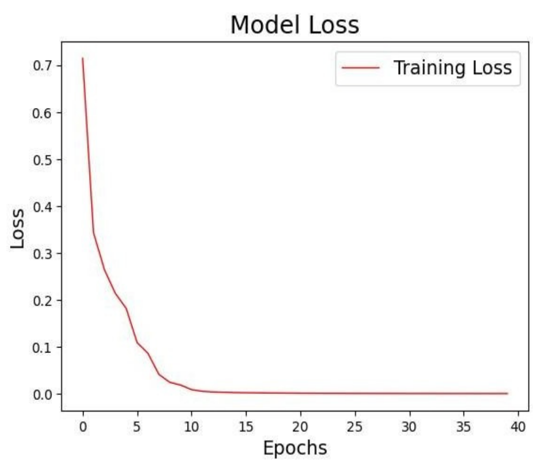

Fig 2: Model Loss

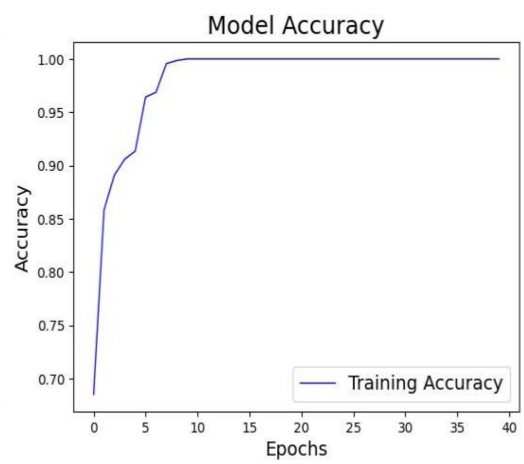

Fig 3: Model Accuracy

	precision	recall	f1-score	support
0.0	0.94	0.97	0.96	300
1.0	0.97	0.94	0.96	283
accuracy			0.96	583
macro avg	0.96	0.96	0.96	583
weighted avg	0.96	0.96	0.96	583

Fig 4: Performance measures

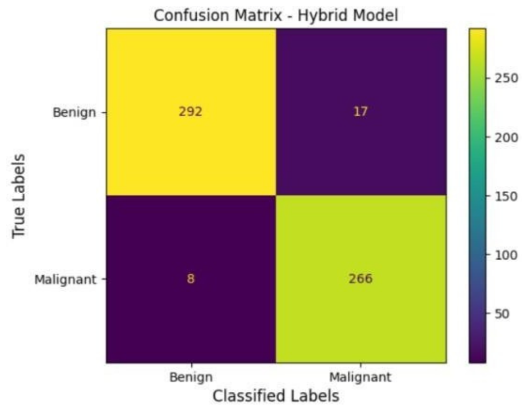

Fig 5: Confusion Matrix

Web Application

A web application has been developed using both Front end and back end. The web application is developed using Streamlit. Home page appears as soon as the user opens the web application. The user has to upload image of the skin disease to get the classification. As the user uploads the image, the page displays the image that they have uploaded. After clicking the submit button, the noise removal image and the name of the skin disease will be detected and displayed as shown in Fig 6.

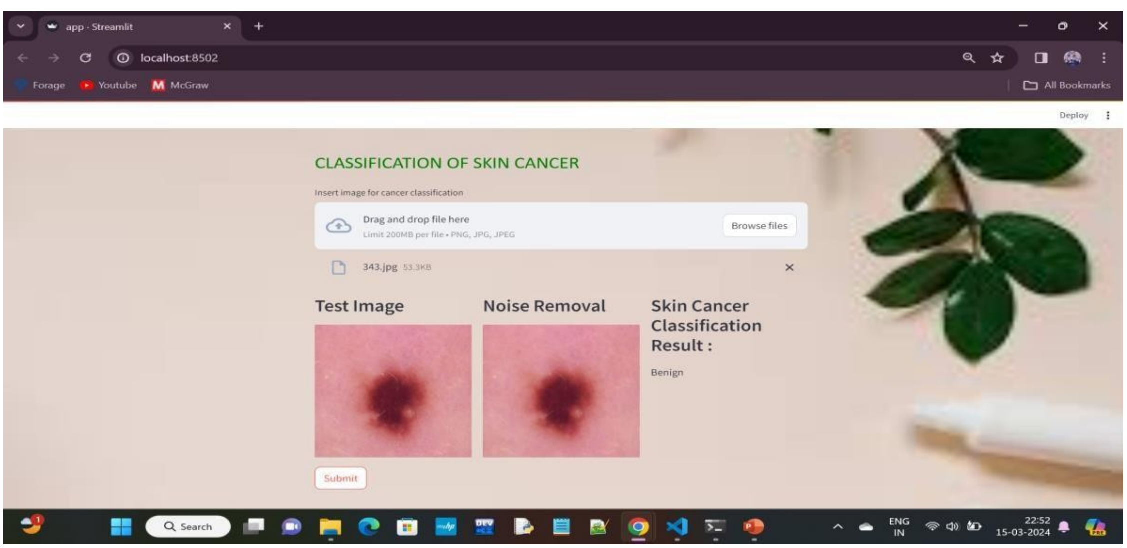

Fig 6: Noise Removal Image and Classification (Benign)

7. CONCLUSION

In conclusion, the deep ensemble learning algorithm that combines VGG16 and InceptionV3 architectures marks a significant advancement in automated skin cancer detection. By merging the strengths of both models, it achieves exceptional accuracy of 95.71% and outperforms individual models in identifying various skin lesions from dermatoscopic images. This breakthrough offers valuable assistance to dermatologists and healthcare providers by enabling early detection and diagnosis of skin cancer, ultimately enhancing patient outcomes and reducing burdens on healthcare systems.

Beyond the numerical results, this progress highlights the transformative potential of technology in healthcare. By streamlining and improving the diagnostic process, the algorithm empowers healthcare professionals to make well-informed decisions and provide timely interventions. Furthermore, its success underscores the significance of collaborative efforts and interdisciplinary approaches in tackling complex healthcare challenges. Moving forward, it is essential to continue leveraging innovation and collaboration to advance medical technology and enhance patient care.

Essentially, the deep ensemble learning algorithm serves as a beacon of hope in the battle against skin cancer. Its exceptional accuracy and potential to revolutionize skin cancer detection emphasize the importance of sustained investment in research and development in the field of medical imaging and artificial intelligence. Through ongoing innovation and collaboration, we can further build on this success to create even more effective tools and strategies for combating diseases and improving healthcare outcomes for everyone.

8. REFERENCES

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