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An Explainable AI Approach for Skin Disease Classification Using Ensemble Deep Learning and Grad-CAM Visualization

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ABSTRACT: Early and accurate diagnosis of skin diseases is critical for appropriate treatment and management. With advancements in artificial intelligence, deep learning models have proved to perform exceptionally well on medical image classification problems. Yet, their lack of explainability of the decision-making process is a serious concern, especially in sensitive fields like healthcare. In this paper, we propose an explainable AI model for skin disease classification using an ensemble of deep models with Grad-CAM visualizations. We blend the ResNet50 and DenseNet121 models to develop a robust ensemble and use a meta-classifier to enhance prediction accuracy. For dealing with explainability, we use Gradient-weighted Class Activation Mapping (Grad-CAM) to generate visual explanations with the detection of key regions influencing the model's decision. Experimental results show that the proposed system has excellent classification accuracy and offers clear and understandable explanations of its predictions. Together with performance and interpretability, this suggests the potential of our approach for real-world clinical deployment and promoting trust between healthcare providers and AI systems.

KEYWORDS: Skin Disease Classification, Deep Learning, Explainable AI, ResNet50, DenseNet121, Ensemble Learning, Grad-CAM Visualization

I. INTRODUCTION

Skin conditions, such as melanoma and non-melanoma, are a major global health burden. Proper diagnosis and early detection are key to treatment and management. Classical approaches, which are greatly dependent on the experience of dermatologists, tend to suffer in terms of precision and time constraints. As deep learning has made rapid advancements, AI has proved to be a vital prospect for automating and improving the diagnosis of skin conditions. While there are several existing AI models, they also have the black-box problem in that their decision process is not transparent or interpretable. This is especially problematic in healthcare, where clinicians need to know the rationale behind AI decisions.

In this paper, we introduce an explainable AI model for skin disease classification based on an ensemble of deep learning models. We merge ResNet50 and DenseNet121 architectures into a strong ensemble model and utilize a meta-classifier to enhance prediction accuracy. To overcome the major problem of explainability, we incorporate Grad-CAM visualization, which produces class activation maps to deliver clear insights into the model's decision process. This two-fold emphasis on good classification performance and interpretability allows healthcare experts to trust and comprehend AI-based predictions more.

II. LITERATURE SURVEY

Recent advancements in artificial intelligence (AI) and deep learning (DL) have significantly enhanced skin disease classification, with Convolutional Neural Networks (CNNs) consistently demonstrating high diagnostic accuracy across various studies. Research by Nigar et al. (2022) [1] incorporated Explainable AI (XAI) using ResNet-18 and LIME to

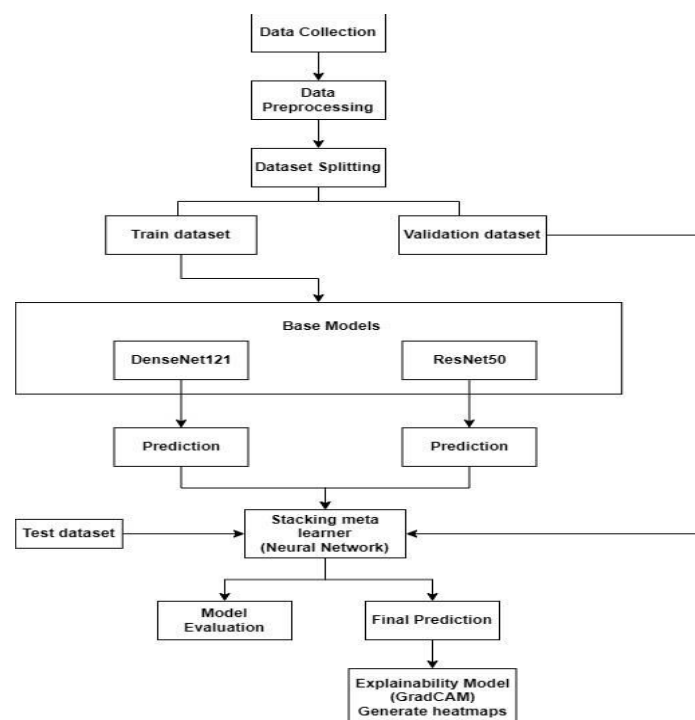
improve trust and interpretability in skin cancer diagnosis, while Oztel et al. (2023) [2] and Srinivasu et al. (2021) [3] focused on lightweight models like MobileNet V2 and LSTM for real-time mobile-based classification, enabling immediate diagnosis with accuracies reaching up to 85.34%. Ensemble learning has also shown promise, as highlighted by Liu et al. (2024) [4], who achieved an accuracy of 86.7% and an AUC of 0.96 using a stacking approach in their SkinNet model. Lightweight and interpretable architectures such as HI-MViT by Ding et al. (2023) [5] leveraged MobileViT modifications along with CAM for explainable mobile deployments. Comprehensive reviews by Aboulmira et al. (2024) [6], Vayadande (2024) [7], and Mohammed et al. (2021) [8] collectively emphasize the dominance of CNNs, the emergence of GANs, RNNs, transformers, and hybrid models, and the vital role of XAI techniques to bridge the gap between automated classification and clinical applicability. These studies collectively underline the transformative potential of AI-driven methods for accurate, rapid, and interpretable skin disease diagnosis.

III. METHODOLOGY

We use a deep learning method of skin disease classification with an ensemble of two strong CNN models: ResNet50 and DenseNet121. ResNet50 uses skip connections for handling the vanishing gradient problem and is well-suited for complicated medical image analysis tasks. DenseNet121 uses dense connections, promoting feature reuse and smooth gradient flow, which improves its capacity to learn complex patterns in skin lesion images. In order to leverage their strengths, we employ an ensemble learning approach in which a meta-classifier combines the predictions of both models, improving overall accuracy and resilience by balancing out individual weaknesses and taking advantage of complementary features.

For interpretability, we use Gradient-weighted Class Activation Mapping (Grad-CAM) to produce heatmaps identifying significant image areas that affect predictions. Grad-CAM is applied on the ensemble output, giving clinicians easy-to-understand visual explanations of the system's choices.

Our data includes skin lesion images from the Kaggle Melanoma dataset, resized to 224×224 pixels. We use data augmentation methods like random rotations, flipping, and zooming to enhance data diversity and reduce overfitting. Training is carried out with the Adam optimizer and categorical cross-entropy loss and 80-20 train-validation splitting. Performance is measured in terms of accuracy, precision, recall, and F1-score. Grad-CAM visualizations post-training further verify the interpretability and clinical decision support suitability of the model.



(a)

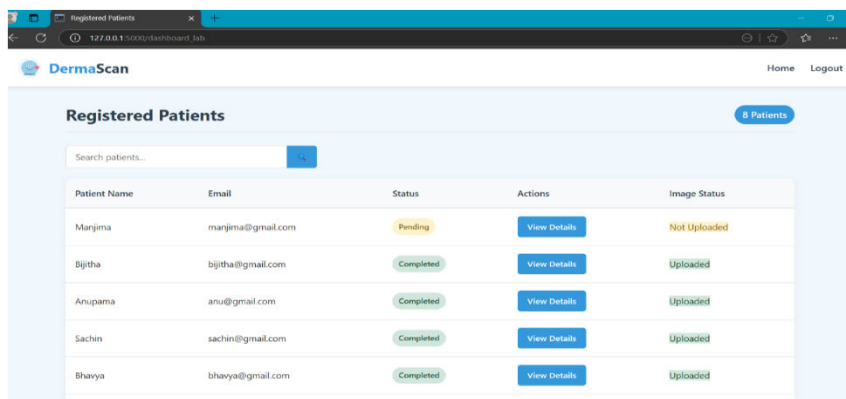
Fig. 1. Shows the system architecture of explainable skin disease classification using ensemble learning

IV. EXPERIMENTAL RESULTS

The main objective of this research was to distinguish between benign and malignant skin lesions through the application of deep learning models such as ResNet50, DenseNet121, and their ensemble. Testing on an unseen set of 1,000 images (500 benign, 500 malignant) indicated that ResNet50 and DenseNet121 both produced an accuracy of 92%, with the ensemble model beating them at 93% accuracy. This enhancement illustrates the strength of model combination in taking advantage of complementary features to generalize more effectively. As specifically observed, the ensemble produced F1-scores of 0.94 and 0.93 for benign and malignant cases, respectively, compared to the respective lower F1-scores of individual models. Grad-CAM visualizations also ensured that the ensemble model pinpointed lesion regions more accurately, offering interpretable evidence of decision-making robustness. In general, these findings show that the ensemble method improves prediction accuracy and clinical reliability in classifying skin lesions.

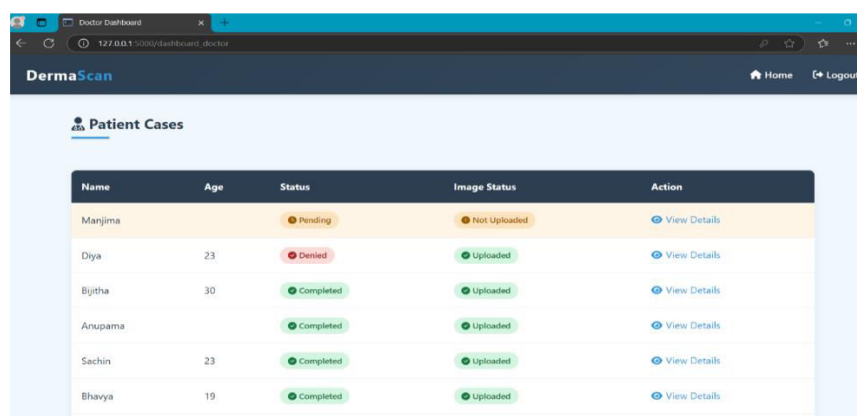
Model	Precision (Benign)	Recall (Benign)	F1-Score (Benign)	Precision (Malignant)	Recall (Malignant)	F1-Score (Malignant)	Accuracy
ResNet50	0.87	0.99	0.92	0.99	0.85	0.91	0.92
DenseNet121	0.87	0.99	0.93	0.99	0.85	0.92	0.92
Ensemble Model	0.90	0.97	0.94	0.97	0.89	0.93	0.93

Table 1. Shows the performance metrics table



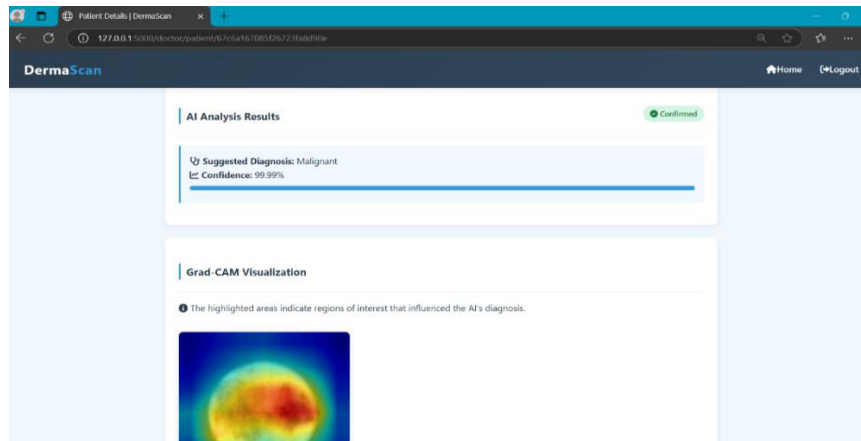
Patient Name	Email	Status	Actions	Image Status
Manjima	manjima@gmail.com	Pending	View Details	Not Uploaded
Bijitha	bijitha@gmail.com	Completed	View Details	Uploaded
Anupama	anu@gmail.com	Completed	View Details	Uploaded
Sachin	sachin@gmail.com	Completed	View Details	Uploaded
Bhavya	bhavya@gmail.com	Completed	View Details	Uploaded

(a)

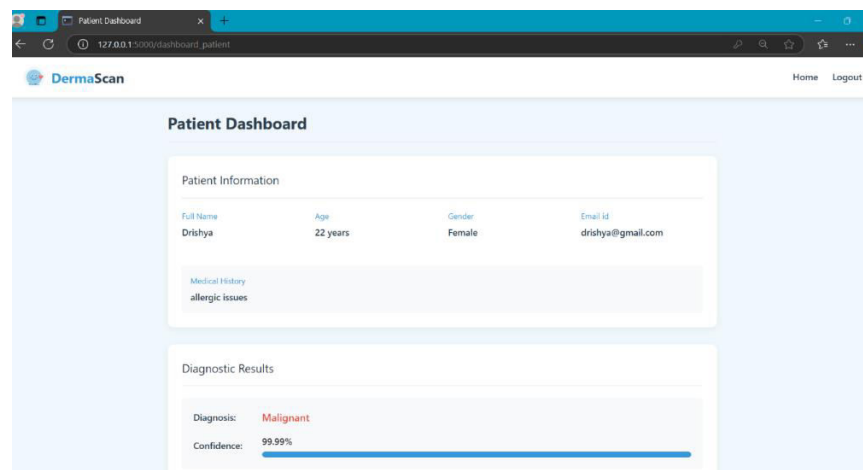


Name	Age	Status	Image Status	Action
Manjima		Pending	Not Uploaded	View Details
Diya	23	Denied	Uploaded	View Details
Bijitha	30	Completed	Uploaded	View Details
Anupama		Completed	Uploaded	View Details
Sachin	23	Completed	Uploaded	View Details
Bhavya	19	Completed	Uploaded	View Details

(b)



(c)



(d)

Fig. 2. Shows the result of explainable skin disease classification using ensemble learning (a) Lab Dashboard, (b) Doctor Dashboard, (c) Doctor Result Analysis, (d) Patient Dashboard

V. CONCLUSION

The Explainable Skin Disease Classification System proposed here uses deep learning methods to classify skin lesions as benign or malignant with high accuracy, overtaking previous achievements. In contrast to other existing models that tested various ensemble methods but did not have interpretability, which used XAI for interpretability without taking advantage of ensemble learning, our work underpins both performance and transparency. Through the application of a stacking ensemble of ResNet50 and DenseNet121, our model had 93% accuracy, performing better than individual models and prior works. Further, Grad-CAM visualizations add interpretability, ensuring AI-based decisions become more reliable for healthcare professionals. The model's performance in precision, recall, and F1-score shows that it is reliable for clinical use in the real world.

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