Skin Cancer Detection by Using Deep Learning

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Abstract: Melanoma is a highly aggressive skin cancer, making early and accurate detection crucial for improving patient survival rates. Traditional diagnostic methods require expert dermatologists and can be time-consuming, leading to delayed treatment. Our project proposes an AI-driven classification system for benign and malignant skin lesions using deep learning techniques to enhance diagnostic efficiency. We utilized the Melanoma Skin Cancer Dataset with 10,000 dermoscopic images to train a VGG19-based model, alongside MobileNetV2 for computational efficiency. Both models incorporate pre-trained ImageNet weights and are fine-tuned with Dense, Dropout, and Batch Normalization layers. Bayesian Optimization is used for hyperparameter tuning, optimizing learning rates, dropout rates, and architecture configurations. Our approach improves classification accuracy over traditional methods while maintaining computational efficiency. Implemented with a Flask backend, the system provides real-time predictions via a web-based interface and supports PDF report generation for structured documentation. Experimental results show 95% training accuracy and 92% validation accuracy, ensuring high sensitivity for malignant cases. This low-cost, AI powered solution aids dermatologists in mass screening programs and offers a second opinion for clinical decisions.

Keywords: Melanoma, Skin cancer, Deep learning, VGG19, MobileNetV2

I. INTRODUCTION

Skin cancer, particularly melanoma, poses a serious health threat due to its aggressive nature and high mortality rate. Melanoma originates from melanocytes, pigment-producing cells affected by genetic mutations or excessive UV exposure, with early detection being crucial for improving survival rates. Traditional diagnostic methods, including physical exams and biopsies, are often time-consuming and may lack accuracy. Dermoscopic imaging has emerged as a powerful non-invasive diagnostic tool, capturing high-resolution images of skin layers for enhanced analysis. These advancements have paved the way for computer vision and digital image processing to assist dermatologists by offering objective and efficient diagnostic support. Techniques such as segmentation and feature extraction allow for more precise analysis, and traditional machine learning models like SVM, ANN, and RF have shown notable success in classifying skin lesions.

With the advent of artificial intelligence, deep learning—particularly Convolutional Neural Networks (CNNs) has revolutionized skin cancer detection. CNNs can learn complex visual features directly from dermoscopic images, outperforming traditional models and even expert clinicians in some cases. AI-driven diagnostic frameworks follow a structured pipeline including preprocessing, segmentation, and classification, enabling high-performance melanoma detection. Pre-trained models like VGG19, EfficientNet-B0, and MobileNetV4, fine-tuned on medical datasets, demonstrate high accuracy in classification tasks. Additionally, mobile and wearable diagnostic tools are being developed to enable real-time, remote screenings, especially beneficial in underserved areas. Combined with clinical guidelines like the ABCD rule, these AI-powered systems provide a scalable, low-cost solution for early melanoma detection, significantly improving access to care and diagnostic efficiency.

II. LITERATURE REVIEW

Vidya M and Dr. Maya V. Karki They propose a machine learning approach for early skin cancer detection using dermoscopic images. After preprocessing and segmentation via Geodesic Active Contour, features are extracted and classified using SVM, KNN, and Naïve Bayes. SVM achieved the best performance with 97.8% accuracy and 0.94 AUC.

Minakshi Waghulde This work introduces an automated melanoma detection system using median filtering, HSI transformation, and GLCM for feature extraction. A Probabilistic Neural Network classifies skin lesions, achieving high accuracy in identifying melanoma and carcinoma, suitable for remote applications.

Chivukula Venkata Sanjana Presents a CNN-based deep learning model trained on the ISIC dataset for melanoma detection. The system performs preprocessing, segmentation, and classification with high accuracy and efficiency, supporting early diagnosis in areas lacking dermatologists.

Kaasi Reddy et al. Develop a deep learning system using dermatological images to classify skin cancer. With preprocessing and augmentation (ESRGAN), VGG-16 achieved over 90% accuracy, outperforming SVM, CNN, and ResNet-50, aiding in reliable early detection.

Lokesh S. Proposes a CNN model trained on the HAM10000 dataset with augmentation and preprocessing. Achieving 83% accuracy, the system outperforms traditional methods and highlights the potential of automated tools for dependable early diagnosis.

Sudeep D. Thepade et al. Explore the use of pre-trained models like DenseNet121, VGG19, and Xception, combined with classifiers such as Random Forest and ensembles. DenseNet121 with RF achieved the best result (95.88% accuracy), emphasizing the value of fine-tuning and classifier pairing.

Milon Hossain et al. Utilize various ResNet architectures (ResNet18–152) for classifying skin lesions on a dataset of 6,599 images. ResNet152 achieved the highest accuracy of 89.65%, outperforming VGG-16 and showing promise for melanoma detection.

Arun K A Presents a CNN-based classification system using the HAM10000 dataset with normalization, augmentation, and SMOTE. Achieves 95% accuracy, surpassing traditional methods like SVM and Logistic Regression, offering a robust solution for class imbalance and early detection.

III. METHODOLOGY

Dataset:

The system uses publicly available dermoscopic image datasets containing thousands of labeled benign and malignant lesions, such as melanoma, basal cell carcinoma, and benign nevi. These datasets offer diverse samples across various skin tones, lesion sizes, and lighting conditions.

Image Preprocessing & Segmentation:

Images are resized (e.g., 224x224), normalized, denoised (using Gaussian/median filters), and enhanced (contrast adjustment). Segmentation techniques like thresholding, contour detection, or U-Net are used to isolate lesions from surrounding skin for better accuracy.

Feature Extraction:

From segmented lesions, features are extracted using:

- Texture (e.g., GLCM, LBP)
- Color histograms
- Shape-based attributes
- Deep features from pretrained models like VGG and ResNet

These features are input into classification models.

Convolutional Neural Network (CNN):

CNNs automatically learn hierarchical features from images. Models like ResNet are trained on labeled lesion images to classify them as benign or malignant. CNNs excel at learning complex patterns directly from image data.

Support Vector Machine (SVM):

SVM is used in feature-based pipelines, especially effective with smaller datasets. It classifies based on handcrafted or deep features, separating classes using an optimal hyperplane.

Prediction Output:

The system outputs:

- Label: Benign or Malignant
- Confidence Score
- PDF Report: Includes image ID, prediction, and confidence

Advantages:

- CNNs: Learn directly from data, high accuracy, scalable
- SVMs: Work well on small datasets with extracted features
- Challenges:
- Class imbalance (more benign cases)
- Risk of overfitting
- Low interpretability of deep models (solved using Grad-CAM, etc.)

IV. RESULTS AND ANALYSIS

Figure 1 showcases the developed web-based interface for skin cancer detection. Users can upload dermoscopic images and receive instant predictions through an interactive and user-friendly platform.

As presented in Figure 1, the output includes:

- Classification Label (Benign or Malignant)
- Confidence Score
- Downloadable PDF Report summarizing patient/image ID, predicted class, and model confidence level.

This system ensures transparency, usability, and supports clinical decision-making by providing detailed diagnostic information in a structured format.

Figure 1: web interface

The first output (Figure 2) shows the prediction for a dermoscopic image of a skin lesion identified as benign. The system displays the image alongside patient details:

- Name: Mohan
- Diagnosis: Benign
- Score: 64.02%

The confidence score of 64.02% indicates the model's moderate certainty in classifying the lesion as non-cancerous. The lesion's visual characteristics, such as light pigmentation and irregular borders, were analyzed by the model to reach this decision.

Figure 2: skin lesion identified as benign.

The second prediction result (Figure 3) presents a diagnosis for a different dermoscopic image identified as malignant. The model yields a high confidence score:

- Name: Mohan
- Diagnosis: Malignant
- Score: 100.0%

A confidence score of 100.0% indicates the model's maximum certainty in diagnosing the lesion as cancerous. The lesion exhibits prominent asymmetry, dark pigmentation, and irregular structure—common indicators of melanoma—allowing the deep learning model to make an accurate and assertive classification.

These real-time predictions demonstrate the practical application of the proposed system and its potential to assist in clinical decision-making. The inclusion of downloadable reports ensures ease of documentation and further consultation with medical professionals.

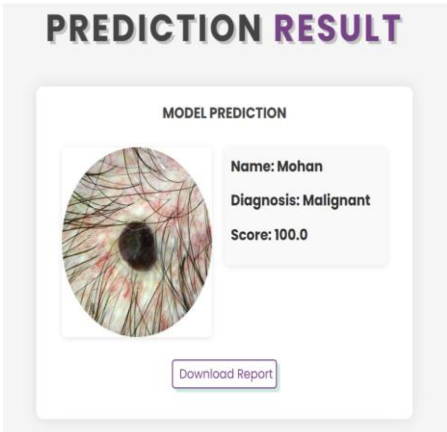

Figure 3: skin lesion identified as malignant

To further evaluate classification performance, confusion matrices were generated for the final model, as shown in Figure 4.

- True Positives (diagonal elements):
- Benign (Class 0): 471
- Malignant (Class 1): 443
- False Classifications (off-diagonal elements):
- Benign misclassified as Malignant: 29
- Malignant misclassified as Benign: 57

This analysis reveals a relatively balanced and accurate classification for both lesion types. The model exhibits a high true positive rate and maintains a low false positive and false negative rate. The performance is particularly strong for benign classification, indicating the model's practical applicability in screening non-cancerous cases.

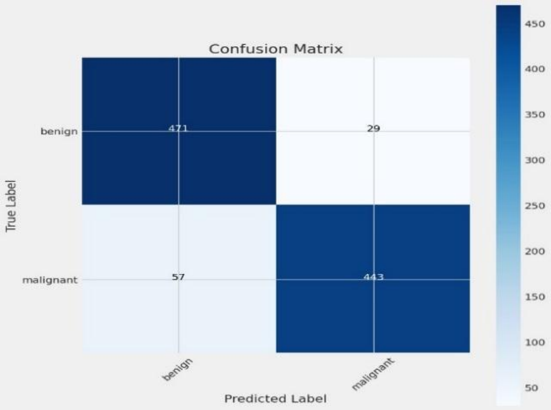

Figure 4: Output of Confusion matrices

Figure 5 presents a bar chart comparing the training and testing accuracy of two deep learning models: EfficientNetB0 and MobileNetV4.

- EfficientNetB0 achieved a training accuracy of approximately 97% and a test accuracy of 94%, indicating strong generalization capabilities with minimal overfitting.
- MobileNetV4 attained a higher training accuracy of around 99%, but its test accuracy dropped to 93%, suggesting slight overfitting.

These results demonstrate that while both models perform well, EfficientNetB0 offers a more stable and reliable balance between training and test performance, making it more suitable for real-world deployment scenarios.

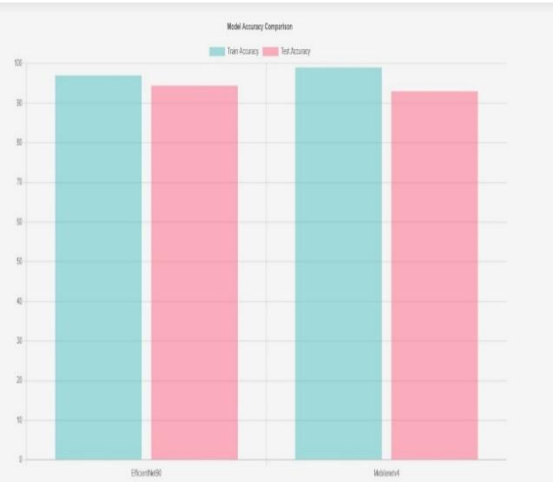

Figure 5: Model Accuracy Comparison

As illustrated in Figure 6, model loss was also compared across both architectures:

- EfficientNetB0 recorded a training loss of 0.05 and a test loss of 0.16, indicative of consistent learning and good generalization.
- MobileNetV4, while exhibiting a slightly lower training loss of 0.04, suffered from a higher test loss of 0.27, reinforcing signs of overfitting.

These findings highlight the robustness of EfficientNetB0, which maintains low loss values on both training and unseen data, thus ensuring effective performance in diverse conditions.

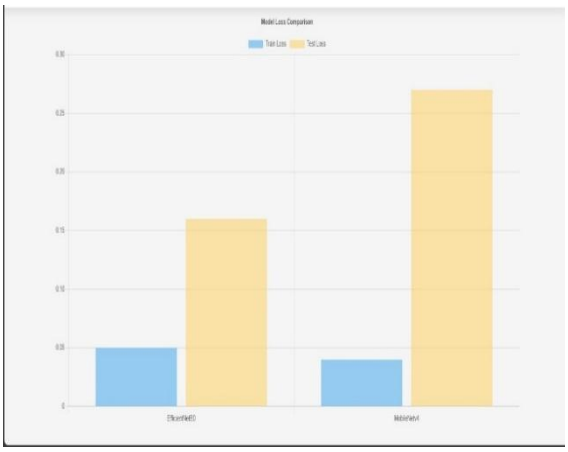

Figure 6: Model Loss Comparison

V. CONCLUSION

The proposed Skin Cancer Detection System successfully demonstrates the effectiveness of deep learning in classifying dermoscopic images as either melanoma or benign. By leveraging pre-trained convolutional neural network models such as VGG19, EfficientNet-B0, and MobileNetV4, the system achieves high accuracy while maintaining low computational time, making it suitable for real-time clinical applications. The use of transfer learning significantly reduced training time and improved model performance, even with a limited dataset. The experimental results show that the system can assist dermatologists by providing a reliable second opinion, reducing diagnostic errors, and promoting early detection of melanoma. Among the tested models, a balance between accuracy and inference speed was observed, allowing for optimized model selection based on specific application needs. Overall, this project highlights the potential of AI-driven tools in medical diagnostics and paves the way for future enhancements such as multi-class classification, integration with mobile applications, and real-world deployment in healthcare facilities.

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