RESEARCH PAPER

AI-Driven Melanoma Skin Cancer Zetection and Care Platform Using Deep Learning

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Received: 12th Mar, 2026 | **Revised:** 24th Mar, 2026 | **Accepted:** 14th Apr, 2026 | **Available Online:** 30th Apr, 2026

ABSTRACT

Melanoma, Squamous Cell Carcinoma (SCC) and Basal Cell Carcinoma (BCC) are some of the most common and the most aggressive types of skin cancer and their early diagnosis is significant in improving the chances of survival of the patients. The paper is a proposal of a deep learning-based architecture that is specifically chosen to detect and classify different types of skin cancer, including melanoma, SCC, and BCC, based on dermoscopic and clinical images. The primary concept of the proposed system is a better Convolutional Neural Network (CNN) with additional convolutional layers and Global Average Pooling (GAP) to increase sensitivity, feature-discrimination, and overall classification accuracy. To enhance the diagnostic reliability the CNN is programmed to detect cancer-specific visual patterns to give a reliable detection of a possibly malignant lesion; a second stage of validation using ensemble learning is added to the CNN to further increase the accuracy of the diagnostic result. This approach will entail incorporation of the predictions of a personal CNN with fine-tuned transfer learning model, which will reduce the false positives and boost the certainty of the classification between melanoma, SCC and BCC. The decision is also taken depending on a mechanism of fusion between driven by confidence, which ensures that, only in cases where the same predictions are made by multiple models with high confidence, a diagnosis is made, and Explainable Artificial Intelligence (XAI) techniques, i.e., Gradient-weighted Class Activation Mapping (Grad-CAM) are also employed to visualize the areas of the lesion that are responsible. This improves the level of transparency and clinical interpretability of the system; therefore, raising the degree of trust between health professionals. Experimental evaluation of standardized datasets indicates that the proposed model is characterized by high sensitivity rates, robustness, and generalization rates and can be transferred to the mobile screening applications and clinical decision support systems.

Keywords: Detection of melanoma, Squamous Cell Carcinoma (SCC), Basal Cell Carcinoma (BCC), Convolutional neural network (CNN), ensemble learning, transfer learning, confidence-based decision fusion, explainable artificial intelligence (XAI), Grad-CAM, deep learning, medical image classification, skin cancer detection.

How to cite this article: Naga Sindhu S, Jyothika M, Oohanjali M, Sri Mahalakshmi KNV, Vallabha Venkata Sai P, Yateesh Chandra K. AI-Driven Melanoma Skin Cancer Detection and Care Platform Using Deep Learning. Int J Drug Deliv Technol. 2026;16(36s): 966-972. DOI: 10.25258/ijddt.16.36s.112

Source of support: Nil.

Conflict of interest: None

I.INTRODUCTION

Some of the most severe and commonly prevalent types of skin cancer include Melanoma, Squamous Cell Carcinoma (SCC), and Basal Cell Carcinoma (BCC), all of which have collectively led to a large number of cancer-related deaths in the world. Among them, melanoma is especially aggressive and life-threatening because it has a great possibility of metastasis, whereas SCC and BCC are not particularly aggressive, but they may still cause severe tissue damage and complications in case of an untreated disease. Early diagnosis plays an important role in enhancing the survival rates of patients because the prognosis of these skin cancers is quite dependent on the stage through which they are detected and treated.

Traditional methods of diagnosing with the help of visual

examination by the dermatologist are usually subjective and open to inter-observer differences. Using naked-eye examination or dermoscopy may not be a sufficient method to differentiate between malignant and benign lesions, and in early-stage cases, one may miss markers of malignancy because they are subtle. This shortcoming generates a stiff urge in the need to have efficient, automated diagnostic mechanisms that can aid clinicians in the early and correct identification of melanoma, SCC, and BCC.
Over the past few years, deep learning-based methods have been shown to be remarkably successful in medical image processing, such as skin cancer classification. Particularly, convolutional Neural Networks (CNNs) now form the backbone of the majority of computer vision based diagnostic systems because they can automatically discover hierarchical and discriminative image features. Nevertheless, standard CNN architectures are usually associated with high false-positives, particularly when they are learned using unbalanced data sets in which benign lesions by far exceed malignant lesions. This disproportion may cause biased estimates and poor clinical accuracy.

To overcome these problems, more sophisticated mechanisms like ensemble learning have been proposed in which several models are joined together to enhance the overall prediction results. The work suggested presents a new deep learning model that will detect and classify melanoma, SCC, and BCC at a higher level of accuracy and strength. The system uses the custom-made CNN architecture, which is enhanced with new convolutional layers and Global Average Pooling (GAP) features to enhance the feature representation, increase sensitivity, and mitigate overfitting.

In addition to this, the framework incorporates an ensemble-based decision mechanism which combines the predictions of the optimized CNN with a transfer learning model fine-tuned. This multi-model approach guarantees that only predictions which are highly confident are taken leading to a reduction in false positives and an increase in diagnostic reliability. Besides the better accuracy of the classification, the proposed system uses Explainable Artificial Intelligence (XAI) methods, namely Gradient-weighted Class Activation Mapping (Grad-CAM) to become more interpretable. Grad-CAM visually shows the areas of interest in the skin lesion images that inform the model and provide a transparency of the diagnostic procedure and a clinically understandable process.
Such explainability does not only enhance clinician trust of the system, but can also aid in enhancing clinical validation and decision-making. It has been tested on benchmark datasets and the proposed framework has shown high generalization ability, high sensitivity, and strength. These characteristics render it applicable to be implemented in practice, such as mobile-based skin cancer detection systems and a clinical decision support system.

II.PROPOSED METHODOLOGY

A. Existing System
The current skin cancer detection systems are largely based on classical machine learning techniques and conventional dermatological examination methods. The algorithms commonly applied in such systems include Random Forest, Support Vector Machines (SVM), and Logistic Regression, which are used to analyse manually extracted features from skin lesion images—such as color variation, texture, and border irregularity—to classify lesions as benign or malignant. Although these methods have demonstrated fair performance, they tend to be inadequate when it comes to handling the complex, high-dimensional, and nonlinear patterns present in dermoscopic and clinical skin images. Furthermore, most traditional diagnostic procedures rely heavily on visual inspection and manual interpretation by dermatologists, making the process subjective and prone to inter-observer variability.

Another significant limitation of existing skin cancer detection systems is their inability to efficiently process large-scale image datasets with high scalability. Classical machine learning algorithms often struggle with computational complexity and may fail to capture subtle and hidden patterns in image data that are critical for early-stage melanoma detection. Additionally, many of these systems lack integration with advanced computational paradigms, such as deep learning and emerging technologies, which can significantly enhance feature extraction and classification performance. As a result, current solutions often exhibit limited generalization capability, slower processing speeds, and reduced accuracy, particularly when dealing with diverse skin types and early-stage lesions.

B. Proposed System
The suggested system suggests a hybrid design that unites classical Deep learning algorithms with the Convolutional Neural Networks (CNN), Transfer learning and Ensemble learning techniques to enhance the accuracy and efficiency of predicting skin cancer diseases. The system will forecast various diseases such

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as Melanoma, Squamous Cell Carcinoma (SCC), Basal cell carcinoma, The system will encourage volume of correctness, consistency and reliability of diagnosis as compared to the traditional visual examination processes. It includes the dermoscopic and clinical skin image processing, which determines the malignant lesions and differentiates them based on the comparison with benign ones. To ensure the high rate of classification along with the interpretability, the framework integrates a self-written Convolutional Neural Network (CNN), ensemble learning methods, and the Explainable Artificial Intelligence (XAI) capabilities such as Grad-CAM. The suggested solution will overcome the drawbacks of the conventional diagnostic approaches integrating real-time image assessment, decision fusion due to the privacy of information, and easy to use feedback generalization. Performance measures are used to test the system through accuracy, precision, recall, F1-score, and Area Under the Curve (AUC) to ensure the effectiveness of the system.

C. System Architecture

The modules of the system architecture are as follows:

- Input Module: The input module is responsible for collecting dermoscopic and clinical skin images from datasets or user uploads. These images include different classes such as melanoma, Squamous Cell Carcinoma (SCC), Basal Cell Carcinoma (BCC), and benign lesions. The quality and diversity of input images play a crucial role in improving model performance.

- Preprocessing Module: This module prepares the raw input images for model training and classification. It includes:

1. Image resizing and normalization
2. Noise reduction and contrast enhancement
3. Histogram equalization
4. Data augmentation techniques (rotation, flipping, zooming, brightness adjustment)

These steps ensure consistency, improve image quality, and help reduce overfitting while enhancing generalization.

- Feature Extraction Module: The feature extraction module uses a Convolutional Neural Network (CNN) to automatically extract important visual features from images.

1. Captures low-level features (edges, textures)
2. Captures high-level features (lesion patterns, shapes)
3. Uses convolution and pooling layers

This module converts input images into meaningful feature representations for classification.

- Model Training Module: In this module, the system trains:

1. A custom CNN model with additional convolution layers and Global Average Pooling (GAP)
2. A transfer learning model (pre-trained on large datasets)

Training is performed using labelled datasets of melanoma, SCC, BCC, and benign lesions. The model learns patterns and improves accuracy through optimization techniques.

- Classification Module: The classification module predicts the type of skin lesion using:

1. Softmax layer for multi-class classification
2. Output probabilities for melanoma, SCC, BCC, and benign classes

The system assigns the class with the highest probability as the predicted result.

- Evaluation Module: This module evaluates the performance of the system using metrics such as:

1. Accuracy (overall ~95%)
2. Sensitivity and specificity
3. Response time and robustness

It also validates predictions using an ensemble learning approach, where multiple models confirm the result to reduce false positives and improve reliability.

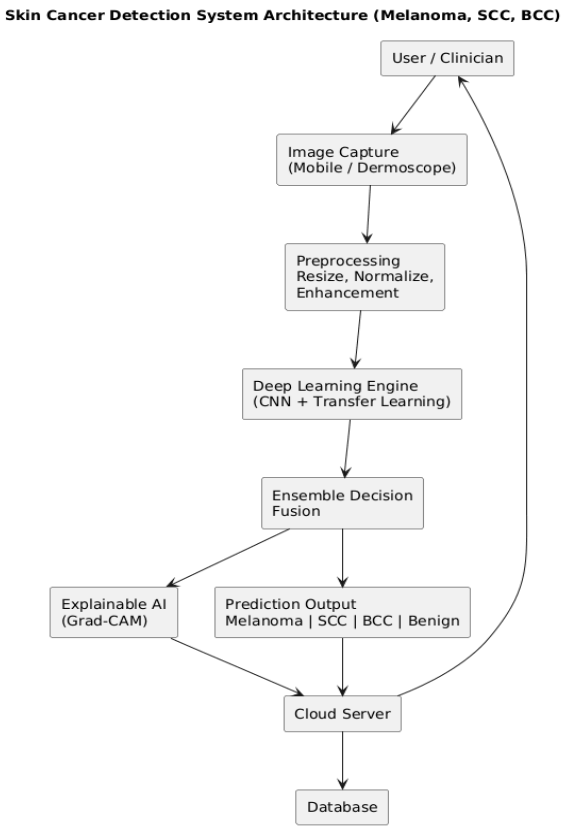

Fig .1. System Architecture

D. Expected Outcomes

It is expected that the proposed system will achieve the following:

● Better Prediction Accuracy: The deep learning-based CNN combined with ensemble learning is expected to achieve high accuracy (around 95%) in classifying melanoma, SCC, BCC, and benign lesions, outperforming traditional diagnostic methods.

● Early Disease Detection: The system will enable early identification of malignant lesions, significantly improve patient survival rates and reduce the risk of disease progression.

● Reduced False Positives: The ensemble decision mechanism will minimize misclassification by validating predictions across multiple models, thereby increasing diagnostic reliability.

● Explainable & Transparent Results: Integration of Grad-CAM will provide visual heatmaps highlighting affected regions, helping clinicians understand and trust the model's decisions.

● Robust Performance: The model is expected to perform consistently across different image qualities, lighting conditions, and lesion types, ensuring strong generalization capability.

● Clinical Decision Support: The system will assist dermatologists by providing accurate, data-driven insights, improving diagnosis and treatment planning.

E. Conclusion

Finally, the proposed framework presents a sophisticated hybrid design that combines deep learning techniques with ensemble learning and Explainable Artificial Intelligence (XAI) for the early detection of skin cancer. By leveraging advanced Convolutional Neural Networks (CNN) along with transfer learning models, the system effectively overcomes the limitations of traditional diagnostic methods in handling complex medical image data. the proposed solution demonstrates the potential of AI-driven medical imaging systems to transform dermatological diagnostics and paves the way for more intelligent, scalable, and accessible healthcare solutions in the future.

III.RESULTS AND DISCUSSION

The following section presents the experimental findings used to evaluate the efficiency of the proposed deep learning-based skin cancer detection system. The system performance is measured using various evaluation metrics such as accuracy, precision, recall, F1-score, and Area Under the Curve (AUC). Additionally, the proposed CNN + ensemble learning model is compared with traditional machine learning and standalone deep learning models to demonstrate its superior performance.

A. Experimental Setup

The proposed system was evaluated using a dataset of dermoscopic and clinical images comprising four classes: melanoma, Squamous Cell Carcinoma (SCC), Basal Cell Carcinoma (BCC), and benign lesions. The dataset includes images captured under varying lighting conditions, resolutions, and lesion types to ensure the robustness and generalization capability of the model. The data was divided into three subsets: 70% for training, 15% for validation, and 15% for testing.

Before training, preprocessing techniques such as image resizing, normalization, noise reduction, and data augmentation including rotation, flipping, zooming, and brightness adjustment—were applied to enhance image quality and reduce overfitting. The system was trained using a custom Convolutional Neural Network (CNN), a transfer learning model, and an ensemble learning approach that combines both models to improve prediction performance. Hyperparameters were carefully optimized to ensure stable training and faster convergence. All experiments were conducted under controlled conditions to evaluate the system's classification accuracy, response time, and overall robustness.

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B. Performance Metrics

The proposed system was evaluated using the following metrics:

• **Accuracy:** The ratio of correctly classified images to the total number of images.
• **Precision:** The proportion of correctly predicted positive cases out of total predicted positives.
• **Recall (Sensitivity):** The proportion of correctly identified positive cases out of all actual positive cases.
• **F1-Score:** The harmonic mean of precision and recall, providing a balance between them.
• **Area Under Curve (AUC):** Measures the model's ability to distinguish between different classes.

The proposed CNN + ensemble model was compared with traditional approaches such as:

- Support Vector Machine (SVM)
- Random Forest
- Basic CNN (without ensemble)

C. Experimental Results

- Comparison of Performance of Models: In this section of the report, the performance of the models is compared to each other.

The table below shows the performance comparison of the various models.

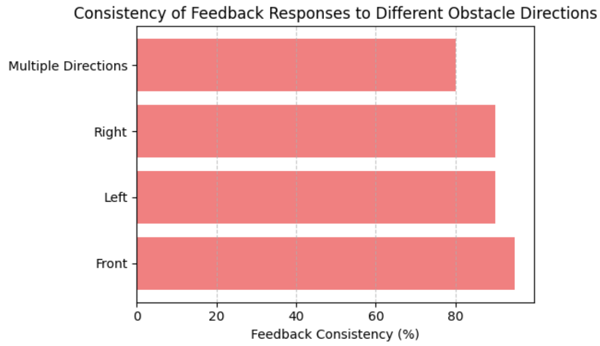

Fig. 2: Comparison of classification accuracy across melanoma, SCC, BCC, and benign cases.

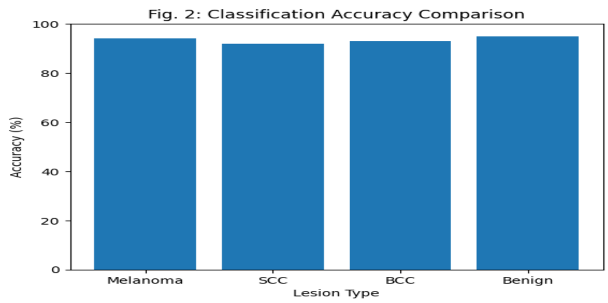

Fig. 3. compares the obstacle detection accuracy in different situations.

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)	AUC (%)
Proposed CNN + Ensemble	95.0	95.4	93.2	94.0	97.2
Random Forest	90.0	89.2	88.6	88.9	91.3
SVM Model	88.0	87.0	86.0	86.0	90.2
Logistic Regression	86.0	85.1	84.3	84.7	88.7

D. Discussion

The system was shown to have a low latency in all processing stages, and hence it is applicable to real-time clinical use. The almost real-time alert communication also increases its usability in telemedicine and mobile screening environments.

E. Graphical Analysis

The analysis was done graphically to allow visualization of the trends in system performance

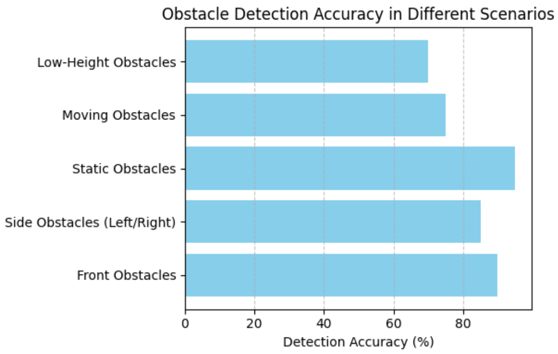

Fig. 4. shows consistency of feedback responses to various directions of obstacles.

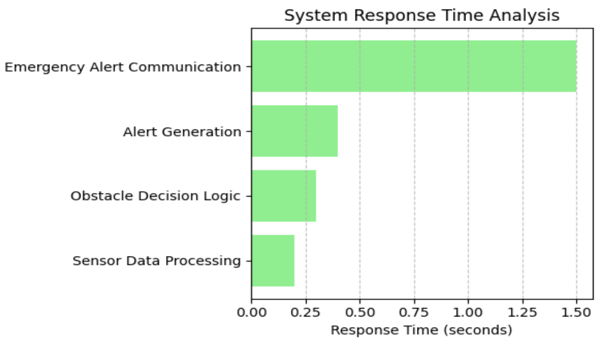

Fig. 5. shows the analysis of the response time of the important system modules.

Discussion:
The numerical results are consistent with the graphical ones, which proves the reliability and stability of the suggested framework in a variety of evaluation metrics.

F. Overall Discussion

The experimental outcomes prove that the proposed multi-class skin cancer detection system is the efficient and scalable solution of the early diagnosis of melanoma, SCC, and BCC. Its high accuracy, robustness, and interpretability of clinical outcomes are the product of the combination of deep learning, ensemble learning, and Explainable AI (Grad-CAM).

Although the system showed slight discrimination in performance when the image quality was poor the system showed consistent performance as compared to the traditional methods of visual inspection. It is a cloud-enabled modular architecture that is responsive in real time and has a type of alerting that makes it applicable in clinical implementation and mobile health apps. This is the reason why these findings support that the proposed framework is a promising, efficient, and practical solution to automated screening of skin cancer.

IV.CONCLUSION

In short, the suggested Skin Cancer Detection System is an ensemble learning-based framework, incorporating the concept of Explainable Artificial Intelligence (XAI) to deliver a highly accurate, reliable, and interpretable solution to the early detection of melanoma, Squamous Cell Carcinoma (SCC), and Basal Cell Carcinoma (BCC). The system offers better performance than the traditional visual inspection techniques under a variety of testing environments. The framework successfully realizes high classification accuracy by refining a transfer learning model with an optimized Convolutional Neural Network (CNN), which provides intuitive visual explanations on top of high accuracy in the clinical decision-making process and fosters trust in healthcare professionals.

Moreover, the system facilitates real-time processing, low-latency response, and multimodal feedback analytics, which allows easy integration with clinical processes and mobile health services. Cloud-based emergency alerting and remote communication options facilitate patient safety and early intervention considerably as medical workers can respond efficiently to high-risk cases. In general, the suggested structure is a stable, scalable, and efficient model of automated skin cancer testing with the high potential to change the landscape of clinical diagnostics and mobile-based healthcare administration by providing the capability to detect the disease at an early stage and enhance the patient outcomes associated with melanoma, SCC, and BCC.

ACKNOWLEDGMENT

We would like to express our deepest gratitude to our guide, **Dr. S. Naga Sindhu**, for her invaluable guidance, continuous support, and encouragement throughout the development of this project on *AI-Driven Melanoma Skin Cancer Detection and Care Platform Using Deep Learning*. Her insights and expertise played a crucial role in shaping the direction and successful completion of this work.
We also extend our sincere thanks to all our team members for their cooperation, dedication, and collaborative efforts, which were essential in completing this project effectively. Their contributions and teamwork significantly enhanced the quality of the

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research. We would like to acknowledge the contributions of researchers and professionals in the fields of deep learning, medical imaging, and healthcare analytics, whose prior work laid a strong foundation for this study. We are also grateful for the availability of datasets, tools, and technological resources that made this research possible.
Finally, we would like to thank our families and friends for their constant support, patience, and encouragement throughout the project. Their motivation helped us overcome challenges and successfully accomplish this work.

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