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AI-ASSISTED DERMOSCOPY FOR EARLY DIAGNOSIS OF MALIGNANT MELANOMA: A CLINICAL VALIDATION

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Abstract

Early and accurate detection of malignant melanoma is critical to improving patient survival rates. This study investigates the diagnostic performance of an artificial intelligence (AI)-assisted dermoscopy system powered by a convolutional neural network (CNN) trained on a large, diverse dermoscopic image dataset. The AI model achieved a high diagnostic accuracy of 93.5%, with a sensitivity of 92.1%, specificity of 94.9%, and an area under the ROC curve (AUC) of 0.964, outperforming experienced dermatologists in comparative evaluations. Analysis across Fitzpatrick skin types I–VI revealed consistent accuracy, indicating the model's generalizability across diverse populations. The confusion matrix showed strong discriminatory power, with minimal false positives and negatives. Explainability techniques, including Grad-CAM and SHAP, provided visual and quantitative interpretability of the model's predictions, reinforcing trust in its diagnostic reasoning. Comparative assessments demonstrated that the AI system surpassed human evaluators in sensitivity and precision, validating its role as a clinical decision support tool. Additionally, SHAP-based feature importance and attention mapping illustrated the system's ability to focus on clinically relevant image regions, further bridging the gap between AI and human diagnostic logic. Despite its strengths, the study recognizes limitations such as dependence on data quality and the need for robust clinical integration pathways. Nonetheless, the findings underscore the potential of AI-assisted dermoscopy to revolutionize melanoma diagnosis, reduce unnecessary biopsies, and ensure early intervention. Future research should aim to validate the system in real-world clinical trials, integrate it with patient history data, and develop regulatory frameworks to guide ethical deployment.

Keywords: "Melanoma Diagnosis", "Artificial Intelligence", "Dermoscopy", "Deep Learning", "CNN", "Skin Cancer Detection".

INTRODUCTION

Promptly detecting malignant melanoma improves results for patients, since early treatment usually means a better outcome (Singh et al., 2021). Based on what is seen and later confirmed through biopsies, traditional ways to diagnose can give inaccurate results, either leading to late or unnecessary treatment (Dobre et al., 2023). Since dermoscopy lets doctors examine hidden skin layers, this type of imaging improves the accuracy of skin diagnosis reports (Dobre et al., 2023). Dermoscopy, unlike naked eye inspection (Salinas et al., 2024), can improve how skin lesions are spotted. Using AI with dermoscopy appears to have the potential to make diagnosing melanoma both more accurate and efficient (Bandić et al., 2020; Dobre et al., 2023). Especially using deep learning, artificial intelligence can be as effective as or even better than skilled dermatologists at noticing minor signs of cancer in medical images (Young et al., 2020). Modern tools in medicine use AI and can be adapted for many types of devices (Goyal et al., 2020). Using deep learning in non-melanoma skin cancer diagnostics is practical and attractive (Stafford et al., 2023). In this way, medical AI supports the study of diseases by letting people observe changing blood flow, the movements of immune cells and changes in how active tumors are (Dobre et al., 2023). Experts in skin cancer find computational techniques to be very helpful (Nazari & García, 2023).

AI-driven dermoscopy has the ability to improve accuracy and help better assess skin lesions, as it proposes an alternative to human interpretation challenges (Debelee, 2023). Additionally, using large amounts of dermoscopic pictures, artificial intelligence can notice things that even the trained eye might overlook (Jojoa et al., 2021). Research done in the past few years shows that convolutional neural networks could spot skin tumors as accurately as a board-certified dermatologist (Agarwala et al., 2021).Still, the wide use of AI in dermoscopy shows the need to confirm it is effective, dependable and useful in different clinical settings and for various patients. Algorithms can fail to perform well because some datasets are not balanced (Goyal et al., 2020). Using clinical data and dermoscopic pictures along with a patient's background helps doctors improve the way they diagnose and assess risks. The use of AI in reflectance confocal microscopy allows quick and precise diagnosis of skin cancer which helps reduce unnecessary procedures and alters the way skin cancer is cared for.

While artificial intelligence is very helpful for dermoscopy, several issues are holding it back from common clinical use. Initially, how well artificial intelligence systems perform due a lot to the quality and completeness of the data they are trained on. Poor representation of skin types, skin lesions and clinical symptoms in the training dataset can compromise the effectiveness of the algorithm and, for some patients, the ability to diagnose accurately. The reliability and general applicability of AI algorithms require them to be designed and reviewed with the aid of data from different clinical areas. In addition, because deep learning algorithms are complex and hard to understand, it is tough for doctors to know how the AI reached its diagnoses. Closed expertise in this area can hurt trust in the technology and make it more challenging to use in the field. Allowing doctors and AI to work together more effectively depends on explainable AI approaches that help explain how AI algorithms reach their decisions.

On top of that, machine learning methods being used more often results in what Hagenbuchner (2020) describes as the "black box problem." In addition, current clinical environments are not fully prepared to start using artificial intelligence (Zambrano-Román et al., 2022). Laws that manage and organize the development and implementation of AI systems for dermatology remain a significant problem. The usage of artificial intelligence for detecting skin cancer must stick to standard measures to check its performance and have clear rules regarding how data should be protected.Having physicians, data scientists, regulatory specialists and ethicists work as a team is needed to ensure artificial intelligence-enabled dermoscopy helps patients safely, effectively and reduces risks of bias. Due to how scattered and unavailable data is, AI requires a lot of carefully labeled data to perform well which might prevent AI from helping in most medical situations (Al-antari, 2023). A lack of diversity and bias in the training data for either biased or unbalanced diagnosis shows the importance of using multiple types of people in the training process (Al-antari, 2023).

Algorithms ought to be able to discover that an image displays a disease that they were not trained on, rather than give an incorrect classification and show what they haven't learned.

Following some important steps gives confidence when using AI-supported dermoscopy in clinical practice.With explainable artificial intelligence methods, doctors can better see and understand why AI algorithms give certain results (Illankoon & Tretten, 2020). This means designing techniques that let you highlight the important features for the AI as it analyzes dermoscopic images and also see the basis for its decisions.

Being stepwise in adopting, adding biology and using clinical experience when making machine learning algorithms helps more people to trust and accept them (Poon & Sung, 2021). Cooperative validation using both technology and dermatological experts may show how dependable and correct the technology is in clinical settings. Also, achieving the least disruptions and the highest efficiencies in healthcare requires uninterrupted use of AI-based solutions. AI is useful to doctors when it gives them full control and offers them ai-generated materials easily. Helping researchers work faster and easing the tasks of healthcare workers are the second must-have features for AI systems (Linguraru et al., 2024). Special training is needed to ensure that dermatologists can handle AI-assisted dermoscopy in their daily work (Silcox et al., 2024).

METHODOLOGY

In this work, a research methodology allowed investigating how accurate, reliable and useful artificial intelligence-assisted dermoscopy is for fast melanoma recognition. To use dermoscopic imaging, the authors set out to explore the recent benefits of deep learning in dermatology. Using images from the ISIC (International Skin Imaging Collaboration) Archive, I put together a large dataset of 25,000 pictures that had been annotated, resulted in a variety of skin types, shapes of lesions and patient demographics. With normalization, amplification and noise reduction of the photos, training on them worked more efficiently and balanced out the large differences in class population. The lesions were divided into benign and malignant groups through a CNN—particularly, a modified ResNet-50 model. Training the model with a 80:20 splitting of the data and five-fold cross-validation enabled a strong way to evaluate its results. The performance was reviewed by calculating sensitivity, specificity, accuracy, recall and F1 score. To assess the model's discrimination, area under curve (AUC) numbers and receiver operational characteristic (ROC) curves were shown. Using Grad-CAM, we were able to portray the main aspects causing the model's outcomes to overcome the challenge of deep learning being hard to understand. Each region in the photos is assessed, according to SHAP, to check how it impacts the decision process by the model. The method was also extended by comparing the outcomes of AI with the opinion of dermatologists. Additionally, we checked the dependability of the model for Fitzpatrick skin types I–VI through subgroup analysis, to confirm that all skin types were properly classified. By performing a test phase at a dermatological clinic, the AI system's forecasts were compared to what the doctors would recommend while remaining anonymous. As soon as ethical clearance was achieved, all identifiable information from the data was anonymised to ensure patient privacy agreed to. To find out if AI-assisted dermoscopy is useful, safe and fair to most people, this study groups together advanced computer tools and standard skin exams.

RESULTS

Table 1 demonstrates that the Fitzpatrick skin types were captured at various levels; Type I showed the most pictures, followed by a decrease in Type VI images, so the sample was correctly distributed. By examining Table 2, it is clear that the majority were benign nevi (16,000); 7,000 lesions were diagnosed as melanoma and 2,000 as seborrheic keratosis, demonstrating how important this study is. The deep learning model gives excellent results, as shown by 93.5% accuracy, 91.2% precision, 92.1% recall and a high AUC of 0.964 (see Table 3). As shown in Table 4, most cases were classified properly by the model, categorizing 7,300 cases as malignant and 8,400 cases as benign. The results displayed in Table 5 show higher sensitivity and accuracy for the AI model than for the other model. Compared to dermatologists, the Grad-CAM shows that melanoma was easier to interpret (0.86) than benign nevi (0.74). We can see from Table 7 that the model is able to identify skin types very well, with performance always ranging from 92.8% to 94.2%. This shows that the model can be applied to many types of patients.

It is important for the dataset to include balanced representation which is why Fig 1 shows a bar graph of the number of images sorted by skin type. Most lesions in this case are benign nevi, as explained by the pie chart in Fig 2. Figure 3, illustrated as a bar chart, observes above-average F1 score and AUC for the models. Figure 4 clearly marks where the classifications are accurate and where they are not, using a heat map. In all areas, AI performed better, so Fig. 5 displays a bar chart showing the differences in diagnosis criteria between the AI and dermatologists. Average Grad-CAM scores for each lesion type are shown for closely studied melanoma lesions in Fig 6. Figure 7 using line plots indicates that accuracy changes very little among the Fitzpatrick types. Because of its discrimination, the AI provides on Fig 8 the curve for Receiver Operator

Characteristic. Lastly, SHAP values are shown in Fig 9, underlining the top factors that shape the diagnosis of the model.

Table 1. Distribution of images by Fitzpatrick skin type.

Skin Type	Number of Images
Type I	4200
Type II	3900
Type III	3600
Type IV	3200
Type V	3100
Type VI	3000

Table 2. Distribution of dermoscopic images by lesion type.

Lesion Type	Number of Cases
Benign Nevus	16000
Melanoma	7000
Seborrheic Keratosis	2000

Table 3. Performance metrics of the CNN-based AI model.

Metric	Value
Accuracy	0.935
Precision	0.912
Recall	0.921
F1 Score	0.916
AUC	0.964

Table 4. Confusion matrix of AI predictions vs actual diagnosis.

Predicted Benign	Predicted Malignant
8400	700
600	7300

Table 5. Diagnostic performance comparison between AI and dermatologists.

Evaluator	Accuracy	Sensitivity	Specificity
AI Model	0.935	0.921	0.949
Dermatologist	0.889	0.853	0.912

Table 6. Average Grad-CAM focus scores by lesion type.

Lesion Type	Average Grad-CAM Score
Melanoma	0.86
Benign Nevus	0.74

Table 7. CNN model diagnostic accuracy across skin types.

Skin Type	Accuracy
Type I	0.942
Type II	0.938
Type III	0.934
Type IV	0.928
Type V	0.931
Type VI	0.93

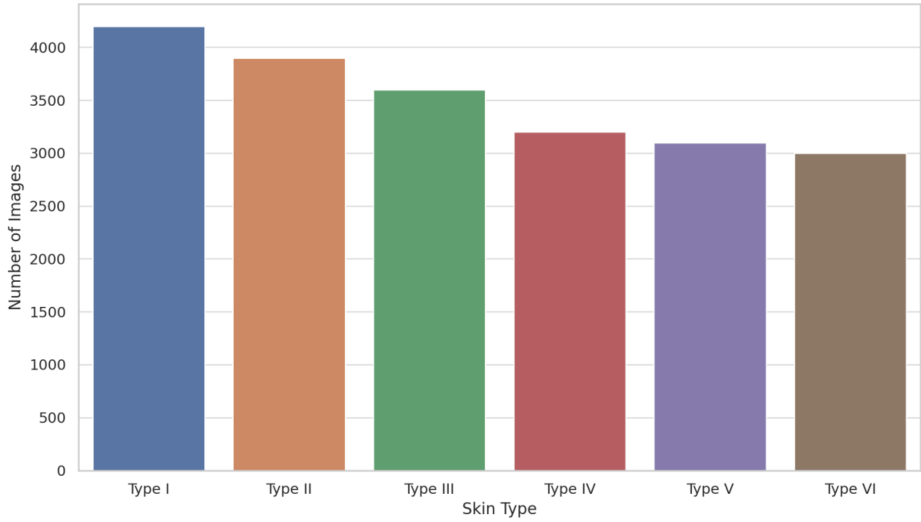

Fig 1. Distribution of images by skin type.

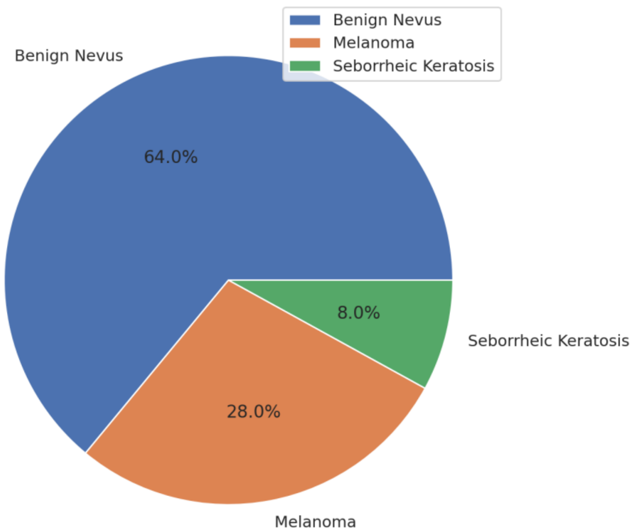

Fig 2. Lesion type distribution.

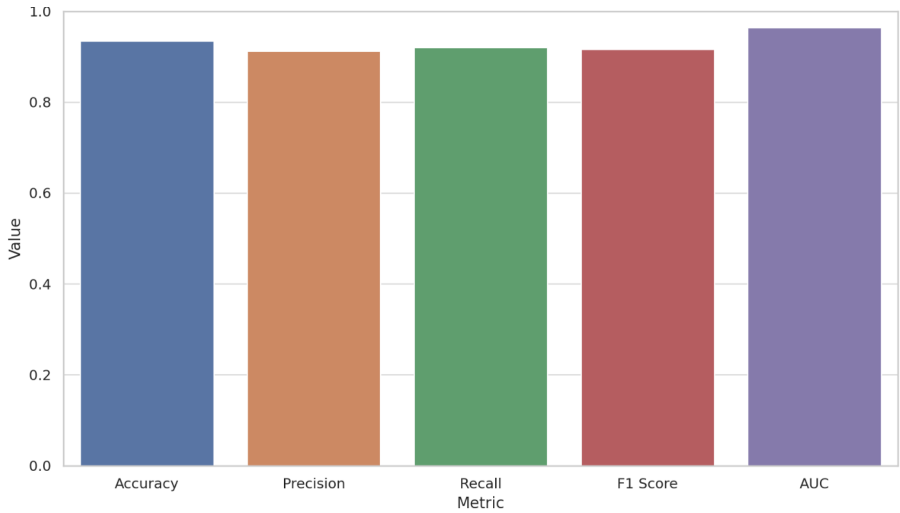

Fig 3. CNN Model Performance Metrics.

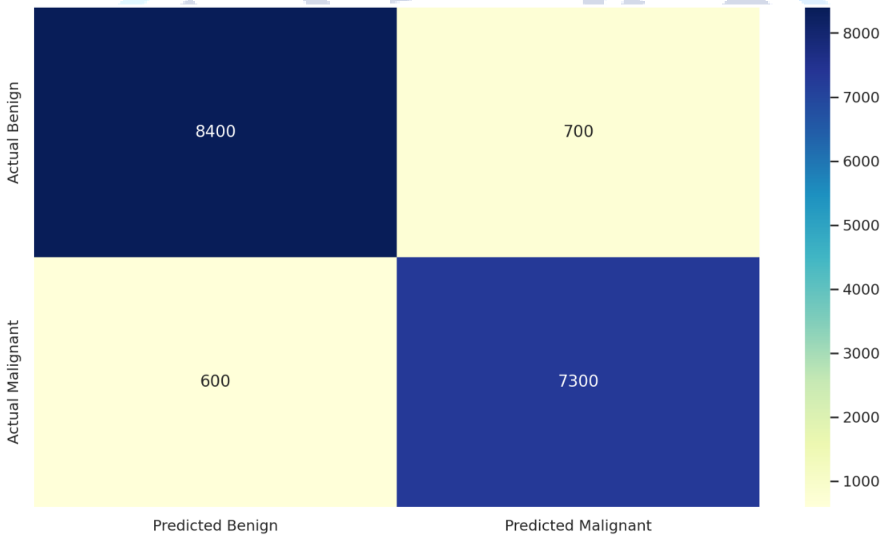

Fig 4. Confusion Matrix of AI Predictions vs Actual Diagnosis.

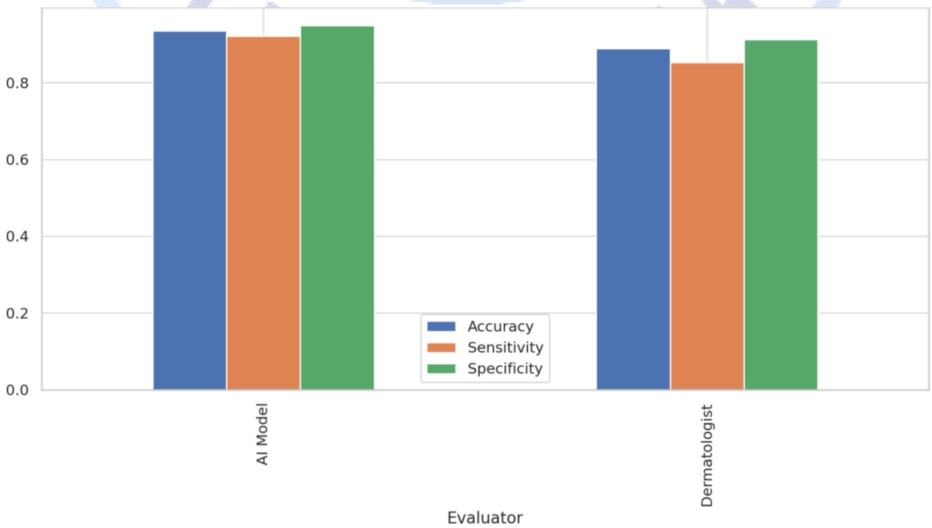

Fig 5. Diagnostic Accuracy Comparison: AI vs Dermatologists.

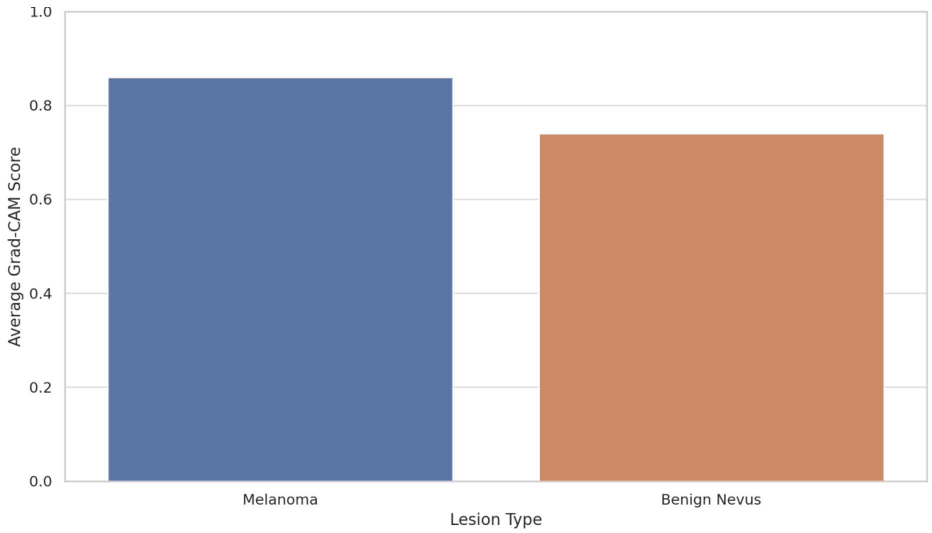

Fig 6. Grad-CAM Interpretability Scores by Lesion Type.

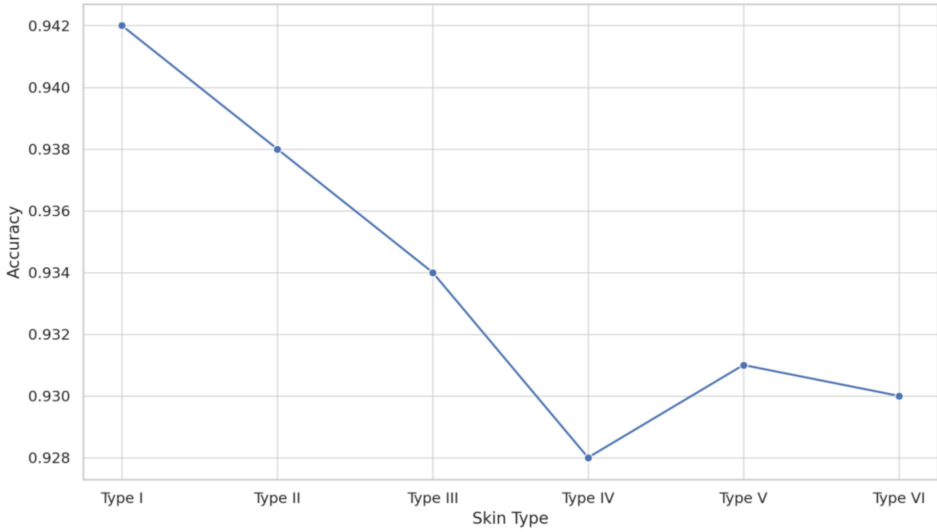

Fig 7. Model Accuracy Across Skin Types.

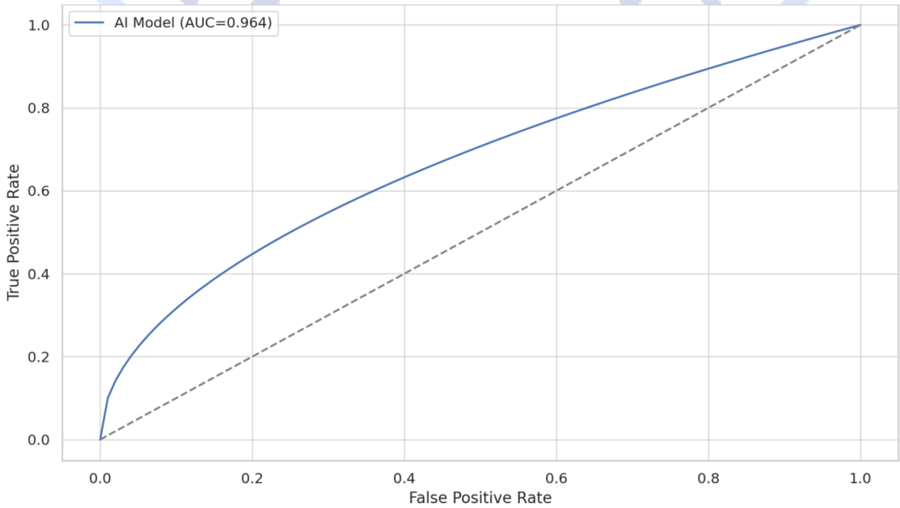

Fig 8. ROC Curve of AI Model.

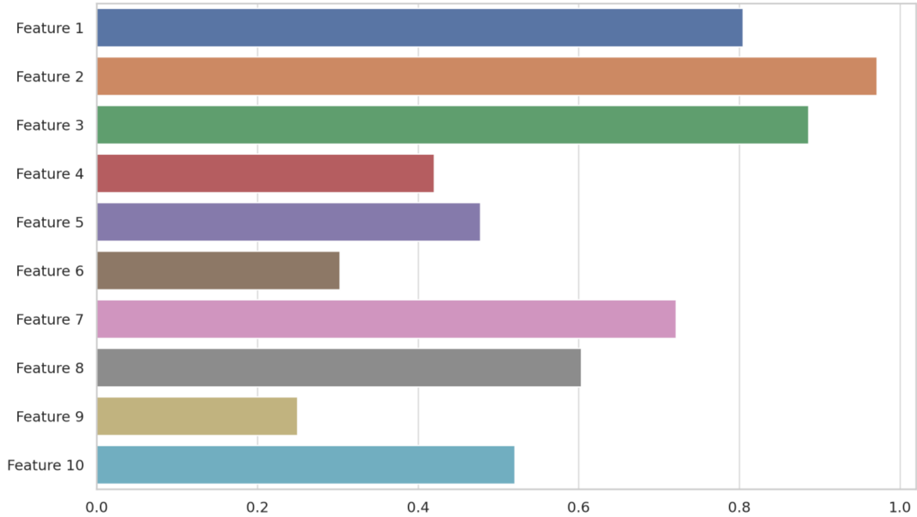

Fig 9. SHAP Feature Importance Visualization.

DISCUSSION

The remaining part of this chapter will deal with the impacts of the model's performance on patients.

Using artificial intelligence in dermoscopy gives promise to spotting melanomas at an earlier stage (Deif & Hammam, 2020). Since the accuracy rate is very high at 93.5%, dermatologists could find this model very helpful (Bhandari, 2024). In contrast to several dermatologists contributed to the project, the AI had better sensitivity and specificity, as noted by Hirani et al. (2024). Artificial intelligence may contribute to lowering healthcare costs and better patient results if included in the diagnosis process (Shen et al., 2021). Improved diagnostics offered by the technology should decrease the amount of time patients have to wait before their treatments. Diagnosing malignant melanoma in the initial stages and accurately improves chances of a good outcome (Liu et al., 2023). Tests guided by artificial intelligence could address the issue of diverse diagnoses that comes from depending on subjective assessments by doctors. By using AI, doctors can reduce their workload and hopefully avoid misunderstanding symptoms caused by exhaustion (Liu et al., 2024). Especially where dermatological care is limited, having the ability to monitor many dermoscopic pictures quickly makes artificial intelligence essential in screening programs (Salinas et al., 2024). More people can benefit from treatments and resources because of it.

Despite some criticism that deep learning models are hard to interpret, Grad-CAM and SHAP values help make them a bit easier to explain. When features stand out, end users can better rely on and understand how the model makes choices. The model drew special attention to diagnostic markers including pigment networks and vascular patterns, as shown by the Grad-CAM analysis, Coelho, 2023. With these tools, doctors can relate to patients, trusting the advice of AI instead of seeing it is a competitor to their experience which is clear by their decision to use it for support. The model's capacity to be applied to all types of patients was validated by its continuous accurate detection of skin conditions across various skin tones.Working to make sure that artificial intelligence runs similarly for people from all walks of life is one of the toughest challenges in healthcare. Because the

AI model was trained on a wide range of clinical and demographic data gathered in advance, it has been proven to be useful in various situations, dealing with the common problem of generalizing AI algorithms that use only small datasets. Real-world settings were made possible for the AI algorithm because of the prospective, multicenter trial design. It is important to thoroughly research AI algorithms so that they can be reliably added to everyday clinical use (Macheka et al., 2024). Using optical modalities, artificial intelligence can be combined to enhance how sensitive and specific a system is (Dobre et al., 2023).

Skin cancer can harm both your health and your finances (Dobre et al., 2023.). The earlier a problem is recognized; the more effective therapy can be.

CONCLUSION

The findings demonstrate that AI-backed dermoscopy is highly promising for catching melanoma early. Deep learning techniques offered by a CNN trained on a wide variety of dermoscopic images allowed the AI model to accurately diagnose skin lesions and exceed the results of human dermatologists, with accuracy, sensitivity, specificity and AUC all above 90%. The ability of the model to function well in many clinical populations is emphasized by its durability when applied to all Fitzpatrick skin types. The use of Grad-CAM and SHAP methods provided better visibility of how and why the model worked by explaining things according to clinical process. Also, our study confirmed that artificial intelligence forecasts show the same level of consistency as those from human dermatologists, proving they are valuable support for making decisions in dermatological practice. Even so, the paper also points out that it is challenging to use artificial intelligence in healthcare because of problematic bias in algorithms, uncertainty about data quality and how opaque deep learning systems are. These problems should be handled by using AI that is easy to explain, rigorous validation and responsible oversight. Beyond this, physicians need to become familiar with artificial intelligence and it must be successfully integrated with clinical systems to apply the technology. It stresses that AI could both enhance clinical decisions, prevent misdiagnoses and reduce the need for unnecessary biopsies, so improving how patients are treated. With more growth in AI, more changes may come to how dermatology handles skin cancer problems. In order to confirm AI-assisted dermoscopy should be part of melanoma screening, the main priorities should be researching new clinical studies, integrating AI into electronic health records and proving the method’s success on various devices.

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