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Evaluating the Effectiveness of Smartphone Apps for Melanoma Detection: A Comprehensive Review

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Abstract

Background: This paper presents a comprehensive analysis of smartphone applications for skin cancer detection. It explores their features, functionalities, performance metrics, and limitations. These apps offer melanoma detection, self-examination techniques, and risk factor assessment, with some providing advanced services like image analysis and dermatologist reviews.

Methods: The performance evaluation assessed the accuracy of these apps in identifying skin lesions, with a focus on the chance of misidentifying benign lesions. Performance variations across iOS and Android devices were examined. Concerns regarding overdiagnosis or false alarms for certain lesion types and clinical scenarios were investigated. Algorithm comparison highlighted diverse approaches, with SkinVision demonstrating balanced performance.

Results: The evaluation revealed a relatively high accuracy in identifying skin lesions but a moderate chance of misidentifying benign lesions. Variations in performance between iOS and Android devices were observed. Concerns were raised about overdiagnosis or false alarms in specific cases. SkinVision demonstrated a well-balanced performance in the algorithm comparison. Advanced algorithms optimized for mobile devices achieved high accuracy and specificity.

Conclusions: While these apps should not replace professional healthcare advice, they can be useful for self-examination and lesion monitoring. Caution is required due to the limitations of algorithm-based apps in accurately identifying melanomas. Ongoing research is crucial to strike a balance between technological innovation and clinical reliability in healthcare.

Keywords: Artificial intelligence; Melanoma detection; Smartphone apps; Skin cancer; Dermatology

Introduction

This paper explores the impact of artificial intelligence (AI) integrated into mobile applications for melanoma detection [1]. It discusses the benefits, challenges, and future implications of using AI in this context [2]. The use of AI algorithms, such as Convolutional Neural Networks (CNNs), in analyzing skin lesion images has shown commendable accuracy in identifying melanoma [3]. These AI-powered mobile apps offer immediate screenings, enhanced accuracy, accessibility, continuous monitoring, educational information, integration with health systems, and reduced workload on healthcare systems [4]. While these apps provide valuable preliminary diagnostics and democratize access to screenings, they should complement rather than replace professional medical examinations [5]. Early detection of skin cancer remains crucial, and self-examinations, along with professional photographic surveys, play a significant role [6]. Recent studies have demonstrated the effectiveness of CNNs in distinguishing suspicious pigmented lesions from benign lesions, approaching the diagnostic precision of experienced dermatologists [7].

The integration of AI into mobile applications has revolutionized melanoma detection, improving patient care and providing timely assessments, particularly for underserved areas [8]. It also facilitates communication between patients and healthcare providers and reduces unnecessary clinical visits [9]. However, the limitations and challenges of relying solely on AI-based apps for melanoma diagnosis should be considered [2]. Ongoing research and collaboration between AI technology and dermatologists are necessary to ensure a balance between innovation and clinical reliability in healthcare [2].

Medgit

The Medgit mobile application is a user-friendly tool in digital dermatology that utilizes AI technology for skin analysis. It simplifies the process of skin examination into three steps and provides educational information about skin conditions. It offers advanced features like mole tracking and AI-generated probability assessments for skin cancer [10].

AI Dermatologist

The "AI Dermatologist" application combines AI and dermatological expertise to revolutionize skin condition monitoring and assessment. It identifies over 29 different diseases, provides quick risk assessments within 60 seconds, and offers user convenience and affordability [11].

Model Dermatology

The mobile application "Model Dermatology" utilizes Convolutional Neural Networks (CNNs) to accurately identify a wide range of 184 skin conditions. It undergoes extensive evaluation to ensure accuracy and generalization across different settings [12].

Miiskin

The mobile application "Miiskin" utilizes advanced technology to improve early diagnosis and monitoring of skin health and melanoma. It incorporates machine learning and augmented reality to measure and compare mole sizes and offers mole mapping through magnified photos. It enables home-based diagnostics and provides visual comparisons and alerts for significant changes [13].

SkinVision

The mobile application "SkinVision" assists users in the early detection of skin cancer. It captures close-up photos of skin lesions, employs deep learning algorithms for risk assessment, and provides a risk score and recommendations based on the analysis results. It continuously improves through user feedback [14].

UMSkinCheck

The "UMSkinCheck" app developed by the University of Michigan empowers individuals with self-examination capabilities, offering features like photographic storage, lesion tracking, and educational resources. It incorporates machine learning and computer vision techniques for risk assessments [15].

These apps showcase the integration of AI in dermatology, offering enhanced accessibility, accuracy, and efficiency in skin cancer detection and monitoring.

Comparison of Different Apps

Table 1 shows that "Model Dermatology" and "Miiskin" have received positive user ratings on both the Apple Store and Google Play Store, indicating a favorable reception. The involvement of professionals in these apps, such as "Model Dermatology," "Miiskin," and "SkinVision," enhances their credibility and accuracy. The accessibility and cost of these health apps are important factors for user adoption. Some apps offer free downloads while others have paid subscriptions or one-time fees, reflecting different monetization strategies. The global origin of these apps reflects a diverse landscape in digital dermatology, influenced by healthcare frameworks and technological advancements. These factors, including professional endorsement, user trust, accessibility, and cost, shape the user experience and the potential integration of these apps into routine healthcare practices.

Table 1: Comparison of Ratings for Different Mobile Apps

Model Dermatol[2]	**4.8**	**5**	**4.4**	**1.84K**	**100k+**	**19-4-2023**			**IDerma**	**Free**	**United States**
Miiskin Skin[23-24]	4.4	955	4	1.8K	100k+	27-7-2023			Medical Advisor: Gregor Jemec (MD), Associate Professor of Dermatology University of Copenhagen.	Free to download,Subscription $_{i}ny4.99permonthor$34.99 Annually	Denmark
AI Dermatologist[2]	5	6	4.5	2.17K	100k+	30-7-2023			Acina	Free to download,Subscription $_{i}ny8.07permonthor$35.56 Annually	
Medgic[2]	-	-	4.8	5.53K	500K+	5-4-2021			MEDNET PTE LTD	Free	Singapore
SkinVision[23, 24]	4.6	665	2.3	5K	500K+	31-7-2023			Associated with Prof. Thomas Ruzicka, Prof. Dedee Murrell, Prof. Chris Baum, and Daniel Mark Siegel, MD, MS (all dermatologists).	$29.41 for 12-month Membership	Netherlands
MoleScope[23, 24]	4.1	16	2.2	66	10K+	16-01-2023			Participating dermatologists	Free to download; MoleScope Attachment $_{i}ny99; MolescopeAttachment$ 299	Canada
Skin Check[2]	4.4	7	3.6	197	10k+	21-10-2022			Labirent Artificial Intelligence UG	Free to download;	Germany
UMSkinCheck[23,24]	2.3	12	1.2	208	10K+	27-09-2017			The University of Michigan	Free	USA
	Apple store		Google play store				Professional, scientific, or clinician input into applications				
App name	**Rating(of 5)**	**Numberof raters**	**Rating(of 5)**	**Numberof raters**	**Downloads**	**Last update**	**Professional body, scientific, or clinician input**	**Peer reviewresearch**	**Organization(s) or individuals involved**	**Cost**	**Country of Origin**

Table 2 categorizes surveys, including traditional methods and mobile applications, with cited references spanning from 2017 to 2022. Deep learning methods and benchmark datasets are prominently featured, while mobile applications receive less attention. However, the prevalence of discussions and findings across surveys indicates a strong interest in analyzin and interpreting research results, contributing to the advancement of the field.

Table 2: Comparison of the Presented Survey with Others

Survey #	Contents	2022 [16]	2021 [17]	2020 [18]	2020 [19]	2020 [20]	2019 [25]	2017 [21]
1	Traditional methods							
2	Deep learning methods			X				X
3	Benchmark datasets				X		X	X
4	Challenges		X		X			X
5	Mobile Apps		X	X	X	X	X	X
6	Discussion/Findings			X	X			X

Figure 1 is a bar chart that visually compares user ratings from the Apple Store and Google Play Store for different mobile apps, providing important information for app selection. The ratings are on a scale of 1 to 5, indicating varying levels of user satisfaction across different apps. The differences in ratings may reflect variations in app usability, accuracy, features, or user experience. Notably, the Apple Store generally has higher app ratings compared to the Google Play Store, suggesting potential differences in user expectations or experiences on these platforms. These rating disparities are relevant for developers and researchers as they can identify areas for improvement in app design or functionality.

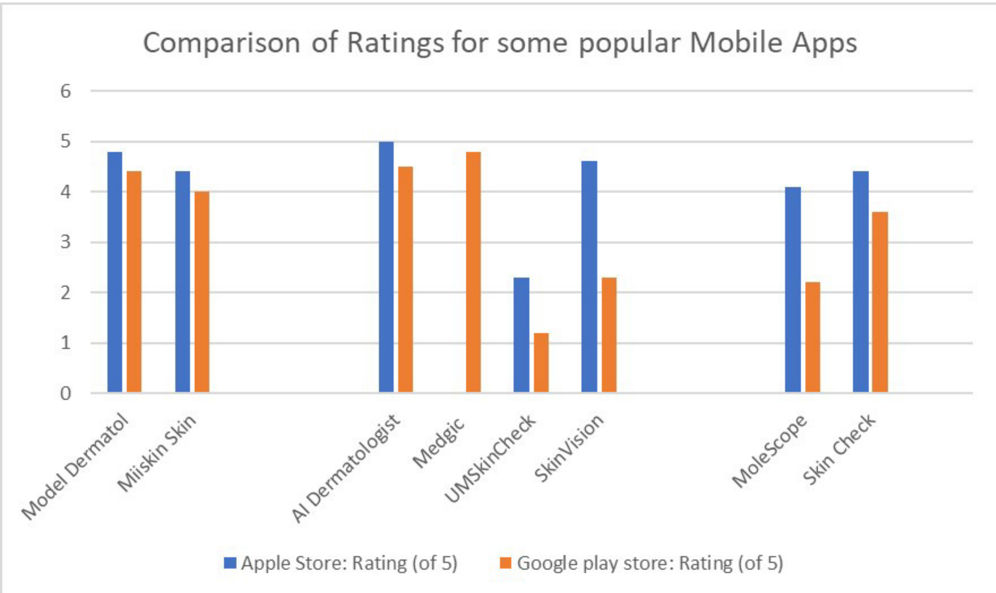

Figure 1: Comparison of ratings for some popular mobile Apps

Table 3 provides a comprehensive comparison of mobile applications for skin cancer and melanoma detection, summarizing academic contributions and user opinions. It evaluates features such as UVR/sun exposure advice, skin self-examination techniques, dermoscopic attachment association, image analysis, dermatologist review, and monitoring capabilities. The listed apps support melanoma detection, with additional features for preventive care. 'Model Dermatol' and 'SkinVision' offer advanced diagnostic algorithms, while 'MoleScope' provides dermoscopic attachment. The table also discusses user engagement and medical utility, highlighting monitoring and tracking functions for early detection. The availability and descriptions of the apps in 2023 provide insights into the user experience. Table 3 serves as a guide for selecting an app that meets individual needs, showcasing the evolution of mobile health technologies in empowering patients while ensuring medical accuracy.

Table 3: Functional properties of apps for skin cancer prevention by nonspecialist users

Model Dermatol[28]											
Miiskin Skin[26]											App stores mole photos, monitors, reminds, and educates about melanoma and skin cancer[27]
AI Dermatologis[28]											
Medgic[26]											
SkinVision[26]											App archives user pictures, tracks changes, shares with doctors, provides recommendations[33]
MoleScope[26]											App captures mole pictures, sends to DermEngine for specialist analysis[27].
UMSkinCheck[26]											App for skin cancer self-exam, photo library, video access, and melanoma risk calculator[27].
Name of App	**Melanoma /Skin Cancer**	**UVR/Sunexposureadvice**	**Skin SelfExaminationTechniques**	**Risk factor assessment**	**DermoscopicAttachmentAssociated**	**ImageAnalysis**	**DermatologistReview**	**Monitoring/Tracking**	**Availablein 2023**		**Description**

Table 4 presents a statistical analysis of a study evaluating a mobile application for skin assessment. The app shows an overall accuracy of 86.9% sensitivity and 70.4% specificity, indicating a high likelihood of correctly identifying skin lesions but a moderate chance of misidentifying benign lesions as suspicious. Sensitivity is higher on iOS devices (91.0%) compared to Android devices (83.0%), with statistically significant differences. Specificity does not significantly differ between device types. The app exhibits higher sensitivity for skin fold lesions (92.9%) but significantly lower specificity, indicating a higher rate of false positives. Sensitivity remains consistent for suspicious and nonmelanocytic lesions, but specificity is notably lower for suspicious lesions, suggesting potential overdiagnosis. The app performs better in general practitioner and non-dermatology referrals than in follow-up consultations. These findings emphasize the app's overall performance and outcomes based on device, lesion type, and clinical relevance. Integration into clinical practice should be approached cautiously, particularly in areas with low specificity, to minimize false alarms and overdiagnosis.

Table 4: Overall sensitivity and specificity of the app in detecting skin premalignancy and malignancy

Assessment type	N (%)	Sensitivity (95% CI), %	p value	Specificity (95% CI), %	p value
Overall app accuracy[22]	785 (100)	86.9 (82.3–90.7)		70.4 (66.2–74.3)	
Android deviceiOS device	425 (54.1)360 (45.9)	83.0 (75.7–88.8)*91.0 (84.9–95.3)*	0.02	71.5 (65.9–76.7)69.0 (62.6–75.0)	0.27
Melanocytic skin lesions Nonmelanocytic skin lesions	179 (22.8)606 (77.2)	81.8 (59.7–94.8)87.4 (82.6–91.2)	0.26	73.3 (65.6–80.0)69.1 (64.0–73.9)	0.17
Skin fold lesion areasSmooth skin lesion areas	138 (17.6)647 (82.4)	92.9 (85.3–97.4)*84.2 (78.2–89.1)*	0.01	56.6 (42.3–70.2)*72.0 (67.6–76.1)*	0.02
Suspicious skin lesionsBenign control lesions	418 (53.3)367 (46.7)	86.9 (82.3–90.7)–		45.5 (37.1–54.0)***80.1 (75.7–84.1)***	<0.001

GP and nondermatology referrals Follow-up consultations	213 (27.1)205 (26.1)	89.6 (83.4–94.1)84.0 (76.6–89.8)	0.09	39.1 (27.6–51.6)51.4 (39.4–63.2)	0.07
* p < 0.05, *** p < 0.001					

Table 5 offers a comprehensive comparison of algorithms used in mobile applications for skin cancer detection, focusing on accuracy, specificity, and sensitivity. SkinVision is highlighted as the most popular app with 900K users, showing a specificity of 78% and an impressive sensitivity of 95%, indicating reliable identification of skin cancer cases. However, m-Skin Doctor and SpotMole have lower sensitivity rates of 80% and 43% respectively, potentially impacting their ability to accurately detect melanoma. The specificity of these apps ranges from 75% to 80%, suggesting reasonable performance in identifying non-cancerous lesions. The discussion explores advanced algorithms like Alex-net, Mobilenet-V2, Resnet, and DenseNet169, known for high accuracy and specificity. However, the evaluation of these algorithms on different datasets may contribute to variations in reported performances. Optimization for mobile efficiency, as seen in Srinivasu et al.'s application combining MobileNet with LSTM, is crucial for practical use, achieving an accuracy of 85.34% and a specificity of 92%. These metrics consider both performance and usability in mobile technologies.

Table 5: Comparison of different approaches on skin different disease

SkinVision[16]	**Conditional generative adversarial neural network (segmentation) and SVM (classification)[4]**				**78%[16]**	**95%[16]**	**Smartphone app with 900K global users. Utilizes conditional generative adversarial neural network and SVM[16].**
m-Skin Doctor (removed)[16]	Gaussian (noise removal), Grab cut algorithm (segmentation), SVM (classification)[29]				75%[16]	80%[16]	Researchers create mobile system detecting melanoma using image processing, computer vision[16].
SpotMole[16]	Image processing techniques, ABCDE rule[29]				80%[16]	43%[16]	This android app allows direct and indirect image submission for analysis[16].
Alex-net[30]	Alex-net (Pretrained networks with TL)	PAD-UFES-20	-	96.103%	98.75%	87.274%	

Mobilenet-V2[30]	Mobilenet-V2 (Pretrained networks with TL)	PAD-UFES-20	-	92.207%	97.5%	78.184%	Suitable for mobile applications
Resnet[30]	Resnet (Pretrained networks with TL)	PAD-UFES-20	-	93.392%	99.375%	75.457%	
Mobilenet[31]		HAM10000 dataset	-	80.17%	68%	80%	MobileNet architecture optimized for mobile and embedded devices' efficiency.
Kousis etal. (2022)[32]	DenseNet169	HAM10000-2 classes		91.10%	95.67%	82.49%	
Srinivasu et al. (2021)[32]	MobileNet+LSTM	HAM10000-7 classes		85.34%	92%	88.24%	
SkinScan[29]	Image processing technique, ABCDE rule[29]				Not found	Not found	
UMSkinCheck[16]					Not found	Not found	Michigan app requires 23 photos for lesion comparison, calculates melanoma risk using ten factors.[16]
App name	**Algorithm**	**Dataset**	**Mobile App**	**Accuracy**	**specificity**	**sensitivity**	**Descriptions**

Overall, the comparison highlights the diverse range of approaches in the development of mobile applications for skin cancer detection, each exhibiting varying levels of success in terms of diagnostic accuracy. The advancements in algorithm design and the utilization of machine learning techniques play a significant role in enhancing the performance of these applications, which is crucial for their adoption in clinical settings and by the general public for early detection of skin cancer.

Conclusion

The discussion section of the paper provides a comprehensive overview of mobile applications for skin cancer detection, analyzing their performance metrics, strengths, and limitations. It highlights the various algorithms used and their contributions to advancing skin cancer detection. These apps are seen as empowering tools that promote self-examination, risk assessment, and sun exposure advice for proactive skin health monitoring. However, the paper acknowledges the limitations of algorithm-based apps, including concerns about overdiagnosis and false alarms. It emphasizes that these apps should be viewed as aids rather than substitutes for professional medical guidance. While the paper cautions against relying solely on these apps for clinical use due to inconsistent and subpar performance, it recognizes their potential for self-examination and monitoring suspicious lesions. Healthcare professionals should educate users about the limitations of these apps and discourage sole reliance on them. The paper highlights the ongoing need for research and improvement to achieve a balance between technological innovation and clinical reliability in healthcare.

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