Review of an Automated Clinical Decision Support System for Skin Abrasion Recognition and Classification

Khushmeen kaur brar[1] & Ashima Kalra[2] & Piyush Samant[3]
[1]Student, Department of Electronics and Communication, Chandigarh Engineering College, Mohali, India.
[2]Associate professor, Department of Electronics and Communication, Chandigarh Engineering College, Mohali, India.
[3] Assistant Professor,Chandigarh University, Gharuan

Received: January 25, 2019 Accepted: March 11, 2019

ABSTRACT: *Skin cancer prevalence rates have been strengthening constantly. This is absolutely the fatal classification of ailment for the reason that it is greatly supposable to expand to further body parts with the exception of analyzing and medicating prematurely. Premature observation of skin cancer demands computer assisted determination. There is an essential requirement of Computer Aided Diagnosis for the practitioners that are not well trained. The incentive of this paper is to recapitulate all manners of experimentation that have been brought about in skin cancer recognition. The optimum focus of the very paper is to proffer a run-through of automatic recognition of skin cancer, miscellaneous steps associated with this diagnosis and differing tactics for timely identification of skin cancer. In this research, we have investigated various techniques and algorithms in use for prematurely diagnosing the skin cancer. This paper aims to highlight the various enhancements that have already been performed and the importance of the CAD system in early diagnosis of the skin cancer.*

Key Words: : *Computer-Aided Diagnosis, Dullrazor, Texture analysis, PH2 database, Pigment Network, MEDS.*

Introduction: Skin cancer is menacing of all sorts of cancers, exempting diagnosed prematurely. The skin cancer can conceivably be segregated into salient categories: benign and the malignant. The malignant condition is more utmost threatening amidst the two. It commences from a cancerous magnification of skin abrasion. Malignant condition of skin cancer is one of the noted cancers from the time being. Conveniently, if skin cancer is diagnosed prematurely, it is operable. The analysts associated with dermatology imaging presume the determination of skin cancer to be computerized in regard to explicit features and color data that are attributes of different classes of skin cancer. It has been exhibited that matlab is an influential tool for diagnosing skin cancer prematurely maneuvering miscellaneous image processing methodologies [1], [2], [3]. The, not many lines code as a program is sufficient for algorithms. Moreover with the help of programming, the evaluation amid diverse algorithms turns out to be really uncomplicated and proficient. Because it is hard and subjective for human to diagnose the skin cancer manually, the automatic diagnosis turns out to be the necessary tool. The less qualified general practitioners maneuver automatic diagnosis to obtain accurate results. The use of both computer vision and machine learning provides yet another innovation in accurately diagnosing the skin cancer automatically [4][5]. Even though other technologies offer promising outcomes, dermoscopy is still far and wide exercised tool for skin abrasion diagnosis. The practitioners pursue the proposals of computer-aided diagnosis if they are in doubt in their own diagnosis. This has been proven specifically comparing the performances of ND(Nevus Doctor) and ME(Mole Expert) with that of CAD technology [6]. The most important steps engaged in automatic detection are pre-processing, segmentation, feature extraction and classification. That one may efficiently diagnose skin cancer; miscellaneous segmentation techniques have been introduced. The image segmentation technique put into practice maneuvering matlab followed by STOLZ and TDS algorithm is given by [7] . The frequently used being the otsu's thresholding[8]. There are a variety of ways by which otsu's thresholding may possibly be put into practice[9]. The border detection method seems to be another popular segmentation methodology. According to [10] border detection is an imperative step in automatic diagnosis of skin cancer. The author proffered a fast and precise way for identifying skin abrasion boundaries and the methodology

entails the amalgamation of numerous thresholding techniques. The segmentation of various images can be carried out effectively only if there are no clamors. Most of the skin abrasion images are delimited by hair, distinctively thick hair. The presence of thick hair offers inadequate results. So the algorithm namely Dullrazor has been presented that eliminates unnecessary hair from the imagery[11]. The amalgamation of diverse segmentation techniques is another enhancement in automatic diagnosis of skin cancer[12]. The amalgam technique counting two algorithms for categorizing benign and malignant skin abrasion was given by[13][14]. The fusion of region growing and ABCD rule that enhances the segmentation and analytical technique in given in[15]. This was to develop an interface that can support dermatologists in the indicative stage. The paper presented by [16] offer comparison of six segmentation methodologies. The output of automatic segmentation and manual segmentation were also compared. In yet another paper, the amalgamation of co-occurrence matrix and artificial neural network is presented. This is a favorable technique for distinguishing malignant melanoma from melanocytic nevi images[17]. The inclusion of three algorithms pertaining the segmentation of dermoscopic images is another effective proposal[18]. The use of active contour model for segmenting the dermoscopic portrayals is another innovation for classifying the images into benign and malignant form[19]. The segmentation based on pigment network for the skin cancer diagnosis is another powerful tool subjecting to skin abrasions[20][21][22]. The utilization of color space for automatic diagnosis is another proficient methodology[23]. The yet another paper introduced a novel technique for the automatic diagnosis of skin cancer. The technique called MEDS or Mimicking Expert Dermatologists' Segmentation is a robust, precise and exceptionally fast approach for segmenting the melanocytic skin abrasions. The technique can endure minute pictorial imperfections like air bubbles or jagged lighting[24].

The feature extraction is another chief step involved in automated diagnosis of skin cancer[25]. The paper describing the visual features for categorizing benign and malignant skin cancers is defined in[26]. The paper described the procedure to extract features involved all the way through digital image processing and presented the most prominent classification technique. The yet another paper made use of geometrical features for premature diagnosis is a better procedure[27]. The outcomes revealed that the features employed were capable of discriminating ordinary and cancerous abrasions. The features are extracted mostly based on colors, texture[21][28]or both. The approach including color-texture categorization was given in [29] with the inclusion of clamor resistant version of LBP. The fusion algorithm was exercised to pull out color and texture features jointly. The introduction of smart phone application for the diagnosis of skin cancer is another innovation that helps in premature detection. The development of convenient library for diagnosing skin cancer automatically be used as a smart phone application provides additional benefits[30]. The proposed library by means of advanced image processing algorithms, generate outstanding results. The use of deep neural network and deep convolution neural network methodologies for accurate extraction of an abrasion area enhances the diagnostic performance[31][32].

The leading standardized and comparative study sustained the investigation and improvement of various algorithms. For this, the challenge was partitioned into 3 assignments: segmentation of abrasion, feature detection and categorization of disease. The very challenge entailed 593 registrations, 81 pre-submissions and 46 final submissions[33].

The ruling steps comprehended in skin cancer diagnosis are: image acquisition, pre-refining, segmentation, feature extrication, classification.

1.1 Image acquisition: most of the papers made use of popular PH^2 dermoscopic dataset. This is the public database holding total of 200 skin cancer images. The dataset holds 160 benign and 40 malignant images[34].

1.2 Pre-refining: This is the foremost part of skin cancer recognition. The pre-refining part enhances the condition of the procured image by withdrawing the extraneous clamors, for instance hair on the ground that these clamors might induce miscalculations in categorization. Pre-refining might be accomplished by image magnification, restoration and hair evacuation.

1.3 Segmentation: The subsequent step necessitates image segregation. This process segregates the ROI in distinction to background. In other words the cancerous and the healthy components of portrayal are segregated.

1.4 Feature extraction: The subsequent step necessitates the extrication of features. There are numerous particular features that qualify benign skin cancer from the malignant one. After ascertaining skin abrasion region, the

color correspondent, appearance correspondent and border correspondent features are extricated. These features are categorized as internal and external features.

1.5 Classification: This is the final stage of skin cancer recognition operation. It is maneuvered in furtherance of segregating malignant and benign skin cancer.

Literature review: Numerous analysts have been on the track of computer vision perspective for skin cancer recognition. Considerable methodologies for skin cancer recognition have been propounded. That one may enhance the diagnostic pursuance of skin cancer the dermatology modus operandi was flourished. Comprehensive effort has been succeeded in segregating skin abrasions amidst dermoscopy portrayals. As of now analysts have emerged diverse computer algorithms for instance clustering, thresholding, region merging and splitting, active contour models etc.

Palak mehta[a*]*et.al*[35] presented an evaluation on approaches and steps of computer aided skin cancer recognition. The author carried out that AFINN i.e., adaptive fuzzy inference neural network administered precise outcomes than NN and fuzzy rule based methodology.

Pratic Dubal *et.al*., [36] presented a methodology that discovered and distinguished skin abrasion as benign and malignant through the medium of neural networking. The author computed the thorough accuracy of 76.9% on accounts of asymmetry, border, color and diameter.

Supriya joseph *et.al.,*[37] presented an impressive hair segregation methodology for segregating skin abrasion region into benign and malignant form. The author computed thorough accuracy of 91.5% and 93.5% for the second classifier.

Shivangi jain *et.al.,*[38] presented a CAD system for skin cancer recognition maneuvering image processing appliances. The paper carried out the outcomes to be more appropriate for rural regions wherein professionals in pharmaceuticals department might not be accessible.

Azadeh noori hoshyar *et.al*,[39] presented the pre-refining approach considering automated skin cancer recognition approach. The entire undertaking has been segregated into image amplification and restoration.

Navneet singh *et.al*, [40] presented a review of miscellaneous image processing methodologies that are maneuvered for diagnosis of skin ailments. The crucial objective of the paper was to proffer contrast amidst diverse methodologies maneuvered to diagnose skin complications.

Sumithra R[a]*et.al*, [41] presented a representation for segregation and categorization of skin abrasion. The segregation was accomplished amidst SVM, KNN, and amalgamation of SVM and KNN.

Skin cancer detection using texture analysis: Md. Nazrul Islam[1]*et.al*[42] outlined skin cancer recognition maneuvering neural network characterized by texture investigation. The author maneuvered GLCM features for the extrication of features and neural network for categorization. The thorough accomplishment of procedure was calculated concerning 80% of accuracy, 71% of SE and 87.5% of SP.

Catarina barata *et.al*.,[43] contrasted two different approaches for the observation of skin cancer in dermoscopy portrayals depending upon local and global features. Additional objective incorporated with paper is consideration of the enact by color and texture features. The paper concluded that color features accomplished better than texture features exclusively with sensitivity of 93%and specificity of 85% and the outstanding global system outcomes were attained when abrasion area was cleaved into two sub ranges, instigating the sensitivity of 96% and specificity of 80%. Nonetheless local system accomplished preferable results concerning categorization with sensitivity of 100% and specificity of 75%

Skin cancer detection using color features: Nikos petrellis [44] presented categorization of skin chaos maneuvering color signatures. The paper suggested an image processing methodology that can be enacted as a smart phone application and makes allowance for the size and color features of abrasion.Catarina barata *et.al* [45] presented a paper to boost dermoscopy portrayal categorization maneuvering color constancy. The author scrutinized four color constancy algorithms. The color constancy enhanced the categorization of multi source portrayals, intensifying the sensitivity of bag-of-features system from 71% to 79.7% and specificity from 55.2% to 76%.Omar abuzaghleh *et.al*, [46] presented a computerized skin abrasion examination based on color and shape geometry feature sets. The approach contrasted two varieties of classifiers. The normal, atypical and melanoma portrayals were systematized with accuracies of 90.3%,

92.1% and 90.6% with 1-level classifier. With 2-level classifier the accuracies of 90.6%, 91.3% and 97.7% were computed.

Skin cancer detection using ABCD segmentation: Nurulhuda Firdaus Mohd [47] presented the examination of automated segregation called ABCD rule in image segmentation. The interpretation exhibit that ABCD segmentation rule outstandingly allocated the portrayals with high value of total dermoscopy score, TDS. M.Monisha[1][48] classified the malignant and benign form of skin cancer by maneuvering back propagation neural network and ABCD rule. The approach computed the thorough accuracy of 95% and sensitivity of 90%.

Skin cancer detection using fusion of features: Faouzi Adjed *et.al*[49] presented an amalgamation of statistical and textural features. The statistical features were extricated from wavelet and curvelet transform wherein textural ones were extricated from differing variants of local binary pattern operators. For statistical features, the wavelet coefficients revealed better pursuance in contrast to curvelet coefficients with thorough accuracy of 85.5% and 79.85%. the amalgamation of wavelet and LBP^{U2}propounded best outcomes with sensitivity value of 78.93%, specificity value of 93.25% and accuracy of 86.07%. Also the outcomes were validated maneuvering SVM classifier.

Classification using SVM: Hiam Alquran *et.al*, [50] presented an image processing based approach to diagnose, extricate and categorize the abrasion from dermoscopic portrayals. The author maneuvered segregation maneuvering thresholding and the features were extricated maneuvering GLCM. The features were selected maneuvering principle component analysis. The author maneuvered SVM classifier for categorization and attained the accuracy of 92.1%.

Teck Yan Tan *et.al*,[51] presented an intelligent decision support system for the recognition of malignant and non-malignant skin abrasions from portrayals. The portrayals were segregated maneuvering pixel limitation methodologies and features were extricated maneuvering ABCD rule and the epiluminescence microscopy criteria. The author maneuvered SVM classifier and attained the accuracy of 92%. Genetic algorithm has also been employed in order to improve the accuracy.

Table.1 analysis of various techniques, algorithms and datasets used for skin cancer diagnosis

Database	**Pre-processing criteria**	**Features extracted**	**Classifiers used**	**Segmentation techniques used**
Dermweb dataset[5]	Median Filtering	Color and textural features	SVM classifier	k-means clustering
Internet source[9]	RGB to Grey conversion	GLCM Features	MLP(multilayer perception) Classifier	No segmentation involved
Dermquest and Dermis datasets[12]	RGB to Grey conversion	Geometric Features	KNN classifier	Thresholding and ABCD
Internet source[13]	Morphological closing and Median Filtering	Color features	Color space	2-D Otsu's Thresholding
UCI dataset[14]	Sharpening filter, median filter, smooth filter, binary mask, RGB extraction, sobel operator.	Color histogram; presence or absence of bumps, patches, nail beds in the afflicted skin images.	Decision Tree, NN, KNN	Otsu's thresholding, GVF
DSSA[15]	Dullrazor	Textural features	MLP classifier	Region Growing
Department of Dermatology[17]	Median filtering	Color, textural features	BPNN and SVM	Thresholding
PH^2 dataset[19]	Artifacts removal	Statistical means and standard deviation features	ANN classifier	___
Camera images[22]	RGB to Grey	Textural features	SVM	ISODATA, Fuzzy c-means and Active contour

Department of Dermatology[23]	Median filtering, Spatial filter and Morphological Closing	Textural and color features	TDV	Region Growing
SSC dataset[24]	RGB to Grey conversion	GLCM features	Multiclass-SVM	___
Dermquest dataset[27]	Guided Filter	Local and Global texture features	___	Convolutional CNN
Internet source[31]	Image Cropping	Artinic keratoses, BCC, SCC, melanoma	ECOS-SVM	Deep Convolutional NN
PH^2 dataset[37]	Morphological closing and Thresholding	2-D FFT, 2-D DCT, Complexity Feature Set, color feature set, lesion orientation feature, lesion margin feature, lesion intensity pattern feature.	SVM classifier	Otsu's Thresholding

Table.1 specifies the various datasets involved for acquiring the images for skin cancer diagnosis. Also the table presents the pre-processing methodologies involved in various researches for accurate detection. The features extracted, classifiers used and the segmentation techniques maneuvered for the accurate diagnosis and to improve the performance of skin cancer detection has been proffered in the above table.

Conclusion: This paper scrutinized various tactics for the categorization and diagnosis of skin cancer.For premature diagnosis the paper reflected five ruling steps for computerized diagnosis of skin cancer. Miscellaneous methodologies that are beneficial in recognition of skin cancer have been implicated. The paper revealed that true diagnosis reduces the risk. In this research we have investigated various techniques and algorithms in use for prematurely diagnosing the skin cancer. This paper aims to highlight the various enhancements that have already been performed and the importance of CAD system in early diagnosis of the skin cancer.

By reviewing various papers we can formulate some objectives:

- The feasibility of advocating novel refined algorithms and to bring into play the existing segregation algorithms.
- Analysis of aforementioned features and to commence innovative features through which the pursuance might conceivably be ameliorated.
- Administering prominent feature selection and/or feature reduction algorithms.

References:

1. G. Grammatikopoulos, "Automated malignant melanoma detection using MATLAB," Proc. 5th Int. Conf. Data …, no. October, pp. 91–94, 2006.
2. S. Laddha and K. Paliwal, "A Review of Melanoma Skin Cancer Detection Techniques using Medical Image Processing," Int. J. Adv. Res. Comput. Commun. Eng. ISO, vol. 3297, no. 9, pp. 400–405, 2007.
3. M. A. and A.-J. A.A., "Computer aided diagnostic support system for skin cancer: A review of techniques and algorithms," Int. J. Biomed. Imaging, vol. 2013, 2013.
4. V. S. Vinayshekhar Bannihatti Kumar, Sujay S Kumar, "Dermatological Disease Detection using Image Processing and Machine Learning," Int. Conf. Artif. Intell. Pattern Recognit., pp. 88–93, 2016.
5. F. International, C. On, R. Trendsinformation, C. Science, and E. G. Chennai, "An Automated Computer Aided Diagnosis of Skin Lesions Detection and Classification for Dermoscopy Images," 2016.
6. K. Møllersen, H. Kirchesch, M. Zortea, T. R. Schopf, K. Hindberg, and F. Godtliebsen, "Computer-Aided Decision Support for Melanoma Detection Applied on Melanocytic and Nonmelanocytic Skin Lesions: A Comparison of Two Systems Based on Automatic Analysis of Dermoscopic Images," Biomed Res. Int., vol. 2015, 2015.
7. A. Bhardwaj and D. J. S. Bhatia, "An Image Segmentation Method for Early Detection and Analysis of Melanoma," IOSR J. Dent. Med. Sci. e-ISSN, vol. 13, no. 10, pp. 853–2279, 2014.
8. C. Hima Bindu and K. Satya Prasad, "An Efficient Medical Image Segmentation Using Conventional OTSU Method," Int. J. Adv. Sci. Technol., vol. 38, pp. 67–74, 2012.
9. H. J. Vala and P. A. Baxi, "2013-a-Review-on-Otsu-Image-Segmentation-Algorihm,"

vol. 2, no. 2, pp. 387–389, 2013.
10. M. Emre Celebi, Q. Wen, S. Hwang, H. Iyatomi, and G. Schaefer, "Lesion Border Detection in Dermoscopy Images Using Ensembles of Thresholding Methods," Ski. Res. Technol., vol. 19, no. 1, pp. 1–7, 2013.
11. T. Lee, V. Ng, R. Gallagher, A. Coldman, and D. McLean, "Dullrazor®: A software approach to hair removal from images," Comput. Biol. Med., vol. 27, no. 6, pp. 533–543, 1997.
12. N. Paliwal, "Skin Cancer Segmentation, Detection And Classification Using Hybrid Image Processing Technique 72 www.ijeas.org," no. 4, pp. 71–73, 2016.
13. A. Chiem, A. Al-Jumaily, and R. N. Khushaba, "A novel hybrid system for skin lesion detection," Proc. 2007 Int. Conf. Intell. Sensors, Sens. Networks Inf. Process. ISSNIP, pp. 567–572, 2007.
14. A. F. De Araujo, A. S. Pereira, N. Marranghello, B. Rossetti, and J. M. R. S. Tavares, "Hybrid methodology to segment skin lesions based on active contour and region growing techniques."
15. N. Smaoui and S. Bessassi, "A developed system for melanoma diagnosis," Int. J. Comput. Vis. Signal Process., vol. 3, no. 1, pp. 10–17, 2013.
16. T. Mendonça et al., "Comparison of segmentation methods for melanoma diagnosis in dermoscopy images," IEEE J. Sel. Top. Signal Process., vol. 3, no. 1, pp. 6572–6575, 2007.
17. M. A. Sheha, M. S. Mabrouk, and A. Sharawy, "Automatic Detection of Melanoma Skin Cancer using Texture Analysis," Int. J. Comput. Appl., vol. 4220, no. 20, pp. 975–8887, 2012.
18. H. Castillejos, V. Ponomaryov, L. Nino-De-Rivera, and V. Golikov, "Wavelet transform fuzzy algorithms for dermoscopic image segmentation," Comput. Math. Methods Med., vol. 2012, 2012.
19. M. K. A. Mahmoud and A. Al-Jumaily, "Segmentation of skin cancer images based on gradient vector flow (GVF) snake," 2011 IEEE Int. Conf. Mechatronics Autom. ICMA 2011, pp. 216–220, 2011.
20. N. Alfed, F. Khelifi, A. Bouridane, and H. Seker, "Pigment network-based skin cancer detection," Proc. Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. EMBS, vol. 2015–Novem, pp. 7214–7217, 2015.
21. and S. A. O. A. Damilola A. Okuboyejo, Oludayo O. Olugbara, "Automating Skin Disease Diagnosis Using Image Classification," vol. II, pp. 23–25, 2013.
22. N. J. Dhinagar and M. Celenk, "Analysis of regularity in skin pigmentation and vascularity by an optimized feature space for early cancer classification," Proc. - 2014 7th Int. Conf. Biomed. Eng. Informatics, BMEI 2014, no. Bmei, pp. 709–713, 2014.
23. C. Sagar and L. M. Saini, "Color channel based segmentation of skin lesion from clinical images for the detection of melanoma," 1st IEEE Int. Conf. Power Electron. Intell. Control Energy Syst. ICPEICES 2016, pp. 1–5, 2017.
24. F. Peruch, F. Bogo, M. Bonazza, V. M. Cappelleri, and E. Peserico, "Simpler, faster, more accurate melanocytic lesion segmentation through MEDS," IEEE Trans. Biomed. Eng., vol. 61, no. 2, pp. 557–565, 2014.
25. R. Maurya, S. K. Singh, A. K. Maurya, and A. Kumar, "GLCM and Multi Class Support vector machine based automated skin cancer classification," 2014 Int. Conf. Comput. Sustain. Glob. Dev., pp. 444–447, 2014.
26. I. Maglogiannis, C. N. Doukas, and S. Member, "Overview of Advanced Computer Vision Systems for Skin Lesions Characterization," vol. 13, no. 5, pp. 721–733, 2009.
27. R. Moussa, F. Gerges, C. Salem, R. Akiki, O. Falou, and D. Azar, "Computer-aided detection of Melanoma using geometric features," Middle East Conf. Biomed. Eng. MECBME, vol. 2016–Novem, pp. 125–128, 2016.
28. P. Mohanaiah, P. Sathyanarayana, and L. Gurukumar, "Image Texture Feature ExtractApproach," vol. 3, no. 5, pp. 1–5, 2013.
29. F. Permissions, "Impulse-Noise Resistant Color-Texture Classi fi cation Approach Using Hybrid Color Local Binary Patterns and Kullback – Leibler Divergence," no. iii, 2017.
30. T. Wadhawan et al., "SkinScan c : A PORTABLE LIBRARY FOR MELANOMA DETECTION ON HANDHELD DEVICES Departments of 1 Computer Science , 2 Electrical and Computer Engineering , and 3 Engineering Technology , University of Houston , Houston , TX 77204 , USA," pp. 133–136, 2011.
31. M. H. Jafari, E. N. Nader, S. M. R. Soroushmehr, S. Samavi, and K. Najarian, "Extraction of skin lesions from non-dermoscopic images for surgical excision of melanoma," 2017.
32. U. Dorj, K. Lee, J. Choi, and M. Lee, "The skin cancer classification using deep convolutional neural network," pp. 9909–9924, 2018.
33. N. C. F. Codella et al., "SKIN LESION ANALYSIS TOWARD MELANOMA DETECTION : A CHALLENGE AT THE 2017 INTERNATIONAL SYMPOSIUM ON BIOMEDICAL IMAGING (ISBI), HOSTED

BY THE INTERNATIONAL SKIN IMAGING COLLABORATION (ISIC) IBM T . J . Watson Research Center , Yorktown Heights , NY , USA University of Central Arkansas , Conway , AR , USA Memorial Sloan-Kettering Cancer Center , New York , NY , USA Missouri University of Science and Technology , Rolla , MO USA Medical University of Vienna , Vienna , Austria," no. Isbi, pp. 168–172, 2018.

34. [34] T. M. P. M. Ferreira1 and J. S. M. A. R. S. M. J. R. Abstract—The, "PH2 - A dermoscopic image database for research and benchmarking*," J. ACM, vol. 14, no. 4, pp. 677–682, 1967.
35. [35] P. Mehta and B. Shah, "Review on Techniques and Steps of Computer Aided Skin Cancer Diagnosis," Procedia Comput. Sci., vol. 85, no. Cms, pp. 309–316, 2016.
36. P. Dubai, S. Bhatt, C. Joglekar, and S. Patii, "Skin cancer detection and classification," Proc. 2017 6th Int. Conf. Electr. Eng. Informatics Sustain. Soc. Through Digit. Innov. ICEEI 2017, vol. 2017–Novem, pp. 1–6, 2018.
37. S. Joseph and J. R. Panicker, "Skin lesion analysis system for melanoma detection with an effective hair segmentation method," in International Conference on Information Science, ICIS, 2016, pp. 91–96.
38. S. Jain, V. Jagtap, and N. Pise, "Computer aided melanoma skin cancer detection using image processing," Procedia Comput. Sci., vol. 48, no. C, pp. 736–741, 2015.
39. A. N. Hoshyar, A. Al-Jumaily, and A. N. Hoshyar, "The beneficial techniques in preprocessing step of skin cancer detection system comparing," Procedia Comput. Sci., vol. 42, no. C, pp. 25–31, 2014.
40. N. Singh and P. Kaur, "Comprehensive review of techniques used to detect skin lesion," 2017 2nd Int. Conf. Converg. Technol. I2CT 2017, vol. 2017–Janua, pp. 100–105, 2017.
41. R. Sumithra, M. Suhil, and D. S. Guru, "Segmentation and classification of skin lesions for disease diagnosis," Procedia Comput. Sci., vol. 45, no. C, pp. 76–85, 2015.
42. M. N. Islam, J. Gallardo-Alvarado, M. Abu, N. A. Salman, S. P. Rengan, and S. Said, "Skin disease recognition using texture analysis," 2017 IEEE 8th Control Syst. Grad. Res. Colloquium, ICSGRC 2017 - Proc., vol. 1, no. August, pp. 144–148, 2017.
43. C. Barata, M. Ruela, M. Francisco, T. Mendonca, and J. S. Marques, "Two systems for the detection of melanomas in dermoscopy images using texture and color features," IEEE Syst. J., vol. 8, no. 3, pp. 965–979, 2014.
44. N. Petrellis, "Using Color Signatures for the Classification of Skin Disorders," 2018 7th Int. Conf. Mod. Circuits Syst. Technol., pp. 1–4, 2018.
45. A. Fidalgo Barata, E. Celebi, and J. Marques, "Improving Dermoscopy Image Classification Using Color Constancy," IEEE J. Biomed. Heal. Informatics, vol. 2194, no. c, pp. 1–1, 2014.
46. O. Abuzaghleh, B. D. Barkana, and M. Faezipour, "Automated skin lesion analysis based on color and shape geometry feature set for melanoma early detection and prevention," 2014 IEEE Long Isl. Syst. Appl. Technol. Conf. LISAT 2014, 2014.
47. N. F. M. Azmi, H. M. Sarkan, Y. Yahya, and S. Chuprat, "ABCD rules segmentation on malignant tumor and Benign skin lesion images," 2016 3rd Int. Conf. Comput. Inf. Sci. ICCOINS 2016 - Proc., pp. 66–70, 2016.
48. A. Rajesh, "Classification of malignant melanoma and Benign Skin Lesion by using back propagation neural network and ABCD rule," Cluster Comput., pp. 1–8, 2018.
49. F. Adjed, S. J. Safdar Gardezi, F. Ababsa, I. Faye, and S. Chandra Dass, "Fusion of structural and textural features for melanoma recognition," IET Comput. Vis., vol. 12, no. 2, pp. 185–195, 2018.
50. H. Alquran et al., "The melanoma skin cancer detection and classification using support vector machine," 2017 IEEE Jordan Conf. Appl. Electr. Eng. Comput. Technol. AEECT 2017, vol. 2018–Janua, pp. 1–5, 2018.
51. T. Y. Tan, L. Zhang, and M. Jiang, "An intelligent decision support system for skin cancer detection from dermoscopic images," 2016 12th Int. Conf. Nat. Comput. Fuzzy Syst. Knowl. Discov. ICNC-FSKD 2016, pp. 2194–2199, 2016.