Vidhyayana - ISSN 2454-8596
An International Multidisciplinary Peer-Reviewed E-Journal
www.vidhyayanaejournal.org
Indexed in: Crossref, ROAD & Google Scholar

36

Melanoma Skin Cancer Detection Using Different Machine Learning Technique

Viranchkumar Mayurbhai Kadia

Assistant Professor,

Sardar Patel College of Engineering, Bakrol

Viranchkadia.ce@spec.edu.in

Nikulkuamar Vipinchandra Patel

Assistant Professor,

Sardar Patel College of Engineering, Bakrol

Email id: nikulpatel.it@spec.edu.in

Abstract:

Expanded rate of skin cancer is vast**.** Melanoma is one of the most increased cancers since past decades. It should be detected early because of its aggressiveness. To diagnose melanoma earlier, skin lesion should be segmented correctly and characterize the benign and malignant cases. In this study, we combine handcrafted and automatic feature of CNN to generate the high classification accuracy with all CNN layers and combining integrated approach of CNN, sparse coding and Neural Network and K-Nearest Neighbor to identify melanoma and classify and plot it using principal component analysis algorithm and classified the melanoma skin lesion and train and test the skin lesion image and evaluate the skin lesion sensitivity, specificity, accuracy and generate the ROC Curve. The outcome of tentative evaluation proves

that using ISIC, ISBI, VGG database to achieve 97% accuracy, 96% specificity and 95% sensitivity.

Keywords: Melanoma, Dermatoscope, CNN, SVM, Preprocessing, Diagnosis, Feature Extraction, skin lesion identification, segmentation, ABCDE, handcrafted, color, texture feature, classifier

Introduction:

Remarkable tumor of unit which is spread vastly on human body is called skin cancer. skin symptoms are recognized using four different parameters which are Actinic Kerasotes, Bascal cell carcinoma, Squamous cell carcinoma and Melanoma. Melanoma is very unsafe skin cancer and it is a malignant cancer of melanocytes, it is collected of melanin cells which produce color to the skin. Melanoma skin lesions are having uncommon symptoms like asymmetric design For example one half is not equal to other half, irregular border, different colors like pink, red and brown where normal skin lesions have black color lesions. UV ray and tanning beds are causes of melanoma skin cancer and it is overcome and identify by visual analysis of skin lesion for detached features and a set of accepted features that all melanoma to extent that contain. these features are expressed using ABCD and enhanced the mnemonic to add letter E [1]. they are used for recognizing melanoma. seven-point check list method is also used for identifying melanoma. To expanded and speed up the analytical execution of melanoma using dermoscopy technique. It grants the descriptions of lots of acceptable feature such as a coloring grid, point/drops, traits, blue white regions and marks the skin in provision of color and texture and noninvasive skin imaging procedure to take a enhanced and clarity picture of skin portion for improve transparency of the posts which eject the skin injury facade observation [2]. High volume of visual similarity of melanoma and non-melanoma lesion resulting in trouble to differentiate between each other. For classification method skin lesion segmentation is essential step. For skin lesion segmentation automated algorithms can be built in [3, 4]. Accurate distribution can assist the exactness of sequential lesion categorization.

For partitioning of skin lesion an independent histogram pursuit algorithm (IHP) is used [5]. Examine on different dermatological database and gain 97% accuracy and used transfer learning to achieve more accuracy on dermatological dermoscopy images. For both segmentation and classification of skin lesion fully connected residual network is introduced and come up with 97.5% and 86% accuracy. handcrafted features are used for extract melanoma recognition and these color and texture features are segmented and classified for skin lesion region [6]. Application for melanoma skin cancer detection is the biomedical and color histogram distribution application which are used for biomedical image processing with HOG (Haar wavelet and histogram oriented gradient) to extract and organize salient skin lesion information that can solve the automatically extracted features of skin lesion and color histogram distribution application generate HSV color extent with border chart with edge guidance and dimension with multistage color LBP that include 4 color channel RGBH(Red, green , blue and Hue) which are extracted across multiple scales and whole into single histogram, burdened by the converse of structural range. features were extracted with whole image and lesion cropped region contexts.

paper addresses the preprocessing, segmentation, feature extraction, classification and identification of melanoma skin cancer detection using convolution neural network and processing the image with feature extraction of skin lesion to train and test the image and generate the ROC curve with skin sensitivity, specificity and accuracy. The aim of this paper is combining the handcrafted and automatic feature of CNN to generate the high classification accuracy with all CNN layers and mixture technique that combine convolution neural network, sparse coding and support vector machine to detect melanoma. System made using current development in deep learning and machine learning method for skin injury categorization and classification and occupied a fully convolution network to pull out multi-scale attribute for melanoma identification. Using Principal Component Analysis Based Algorithm that plot the normal and cancerous part with the help of neural network and k-nearest neighbor. PCA takes and set the image path using input dataset and after that plot the values in 2 categories which are normal and cancer as well as in melanoma it gives malignant and benign.

Literature Review:

The propose system is work to detect melanoma skin cancer using visual analysis of skin lesion to distinct feature ABCDE to recognize melanoma and handcrafted features to extract melanoma identification with classification of skin lesion in texture and color with skin region. using dermoscopy technique to enhanced symptomatic operation of melanoma with viewable comparison between melanoma and benign with skin lesion surface reflection to eject transparency spot. segmentation is vital step for classification purpose and can aid the accuracy of consequent lesion classification and developed an independent histogram pursuit for skin injury division and fully connected residual network are used for both segmentation and classification of skin lesion. with using both handcrafted and automatic feature of CNN to gain high classification accuracy with all CNN layers and use different approach like deep learning, SVM and sparse coding to extract multi-scale feature of melanoma identification. In literature review various methods are perform for automated melanoma detection, classification and identification of skin cancer from the dermoscopic images. Abuzaghleh et al. [7] suggests automatic system that detect and prevent melanoma detection using real time non aggressive skin injury technique and include two components: (1) generate an equation which alert and help the user to prevent skin injury and (2) analysis of computerized image component is capable to classify and capture the injury images and this component contain image acquirement, hair ejection, lesion partition, attribute descent, and categorization. The method that measures a fitness of classified number of instances and generate classification accuracy for imbalance dataset which is not appropriate. For image acquisition and hair removal of melanoma pictures, various process recommended in the related work concentrate on hair eliminate and contrast improvement. former structure, named Dullrazor, was establish by Lee et al [8] to displace hair and picture commodities. It is one of almost broadly acknowledged software in dermoscopic pictures [9]. With a correspondent purpose, Abbas et al. [10] recommended a technique using Gaussian method for hair recognition with its similar refinement. Mirzaalian *et al.* [11] suggested a different technique to identify hair in dermoscopic pictures that evaluate the agitation quaternion [12] that extends the complex numbers using double correspond filter. After completing the image acquisition and hair removal of melanoma skin cancer, the next challengeable work is disjuncture of melanoma

bruise from refined picture. Zhou et al. [13] recommended a new pattern of effective intensity for division of illuminate skin scrape in dermoscopy pictures. Abbas et al [14] expected a unique conceptually adapt address for melanoma boundary recognition by combine two segmentation techniques based on area and sharpness. To remove hair and some anomaly elements from skin closing operation is use. For this reason, to implement two segmentation processes, given that two distinct pictures. First picture is constructed by identifying the skin area and the second one is built by using border recognized with Delaunay navigation. At last, the architect unifies two pictures to elicit the final contusion region. Delgado D et al [15] has used mean filter for histogram smoothing so as to eliminate insignificant local extrema. Median Filter reduces the artifacts and at the same time they preserve the edge which helps in separation of lesion from the surrounding skin. Celebi,M [16] had declared that Analytical area combine a technique that is firm for boundary recognition and is based on developing area and coming together. After border detection with skin region merging the feature extraction step is come. we use seven-point check list method Also using texture feature, where grey-surface co-appearance was absorbed. Multi-scale harshness descriptors were consumed by Clawson et al. [17], Capdehourat et al. [18] and Arroyo and Zapirain [19], where the founder evaluated relevant algebric character as divergence, hessian grid and decline. Using guassian character to elicit different values of special pattern features and σ. last step is classification in workflow of melanoma skin cancer recognition. Maryam Sadeghi et al [20] has proposed an approach which can detect and analyse irregular streaks in dermoscopic images Esteva et al. [21] established the grouping of skin contusion using convolutional neural network that train and test the images, using singly pixels and classify stricker. Ebtihal et al. [22] imported a mongrel technique for epidermis abrasion categorization using color and surface character. Friedman et al (1998) have coined the mnemonic “ABCD” to distinguish between benign lesion and melanoma [23, 24]. Later, Abbasi et al(2004) expanded the ABCD formula to including the letter E for an “evolving” injury over time. Catarina et al. [25] defined the approach of combining local and global character. The local features which is also known as bag of feature and global feature is known as shape and geometric character and they are extort from original picture and merge these features based on early and late combination. Codella et al. [26] arduously pre-separate pictures, earlier cut nearby the part of importance, have been used in

association with hand coded and un- supervised character to gain the results in melanoma detection responsibility, with database of 2000 pictures. Abbes et al.[27]; research in [16, 12] have been put-upon in literature, stretch a conjunction of hand coded feature, sparse coding technique, HOG and support vector machine are used in baksheet.

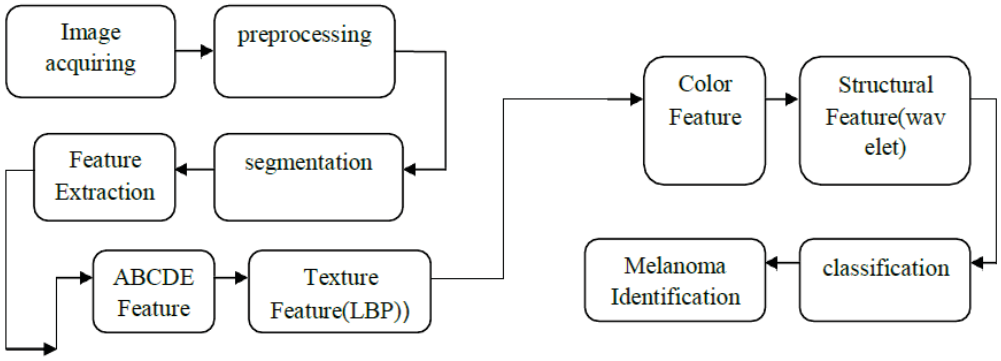
In the literature, Codella et al. [28] integrating deep learning, sparse coding and support vector machine learning algorithms. The recommended method operation is evaluated by three different expressions which are sensitivity, specificity and accuracy. sensitivity is use to evaluate the rate of positives that are accurately recognized; outcome indicates assuredly (sickness).It is evaluate as Sensitivity : TP/(TP + FN) * 100%. For Melanoma revelation computed as sensitivity = accurately find melanoma shell / entire melanoma shell. specificity is employed to estimate the scale of denial that are decently recognized; the outcome imply adversely (non-sickness). It is calculated as specificity : TN / (TN+FP)*100% For Melanoma Detection It can be specificity = accurate find benign shell / entire benign shell. Accuracy is measure by the probability that the demonstrative examination is accomplished perfectly and a combination of both sensitivity and specificity and it can be computed as : (TP+TN) / TP+TN+FP+FN *100%. For melanoma detection case it can be compute as accuracy = true detected cases / all cases.

Where TP is stand for True Positives that decorously determined positive shell; TN is pronounced by True Negative that rightly detect negative cases, FP is known as False Positives that is not accurately interpret negative cases, and Full form of FN is False Negative that is not truly determine positive cases. The achievement evaluate to analysis malignant melanoma category is ended by the manifestation of sensitivity, specificity, accuracy

Methodology:

In this description that address the above-mentioned issue is done. The following system level diagram display step by step procedure to recognize the melanoma skin cancer.

Vidhyayana - ISSN 2454-8596
An International Multidisciplinary Peer-Reviewed E-Journal
www.vidhyayanaejournal.org
Indexed in: Crossref, ROAD & Google Scholar



A. Image Acquiring:

This is the first step that involves acquiring digital images from different techniques available. The images are gathered to form a dataset which is used for further processing to extract information and classification. The images can be captured using ELM dermoscopy contains a enhancers a non-contrasted origin of brightness, see-through cover and a liquor intermediate among the artifice and the epidermis. It helps in clear inspection of skin lesions. Binder.et al proves that ELM images are best for digital image analysis.

B. Preprocessing:

This step is important for recognizing and shrinking number of commodities from pictures. The familiar procedure in pre- processing step is given below; to remove the processing time, pictures are resized to inferior determination picture element. Binary mask is generated to delete bright area around the lesion and bring about a new pictures. To eliminate additional region picture is crop. Next step is by removing the hair by performing filtering. At last, to contain broad variant within the contusion and backdrop, and also different skin color variations reduces the effect, and transformed the authentic color RGB pictures into grayscale images.

C. Segmentation:

Image segmentation is the procedure of division of fractional picture into many section. Aim of the image division is to simplified or change the representation of an image into something that is more under stable and easier to count. It is characteristically used to found objects and image boundaries (lines, curves, etc.) in images and processed of assigned a label to every pixel in an image such that pixels with the same label share certain characteristics. It is stated to the splitting of an image into personal regions that are identical with respect to chosen assets such as luminance, color, texture etc., and techniques can be divided in to Histogram thresholding, clustering.

D. Feature Extraction:

Unique features must be identified for the melanoma region using relevant feature extraction techniques and such features are given as input for classification purpose. Friedman et al (1998) have coined the mnemonic "ABCD" to distinguish between benign lesion and melanoma and expanded to ABCDE Feature.

Structural Feature: Wavelets were employed initially for feature extraction [29]. It gathers prohibited directional notification suitable to its insufficient adaption perspicacity and due to recognize design with extent uniqueness.

Color Feature: It must include mean, skewers, and standard derivation and extract the color instant descriptor recommended in [30].

Texture Feature: It consists contrariety, interconnection, force and conformity and calculated from GLCM suggested in [31] for gray level picture of melanoma type.

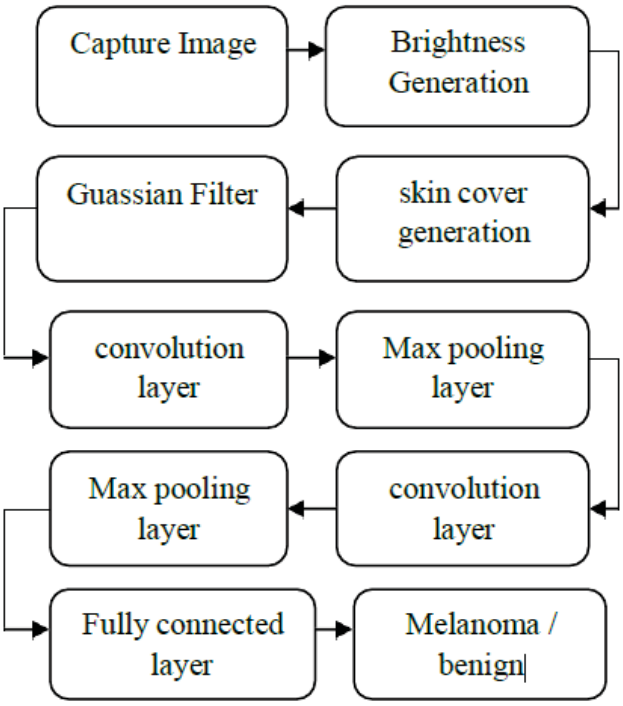
E. Classification:

The last step of proposed method is the classification part afterward a adequate classifier is create and use to categorize each new occurrence upcoming in [32]. Distinct kind categorization pattern which can be bunch into common classes. The corresponding measured functions are absorbed to estimate the execution of dermoscopic element ancestry and

Vidhyayana - ISSN 2454-8596
An International Multidisciplinary Peer-Reviewed E-Journal
www.vidhyayanaejournal.org
Indexed in: Crossref, ROAD & Google Scholar

laceration arrangement. Average precision precise in [33] is also concerned. The basic cadent grade the outcome of these two tasks are the area under the roc curve, for example by calculating the accurate positive rate is generated by AUC.

PROPOSED METHOD USING CNN:



In this system level diagram, the pictures are captured using digital camera and generate the brightness and illuminate, remove the noise and hair of the skin lesion images. Skin cover generation that can cover the lesion border and identify the skin lesion border with different color.

After the skin cover generation, next step is to use the Gaussian filter to verify and check the brightness and mask generation and combine them at a time and check the both images can be removing noise and lesion border correctly or not.

Vidhyayana - ISSN 2454-8596
An International Multidisciplinary Peer-Reviewed E-Journal
www.vidhyayanaejournal.org
Indexed in: Crossref, ROAD & Google Scholar

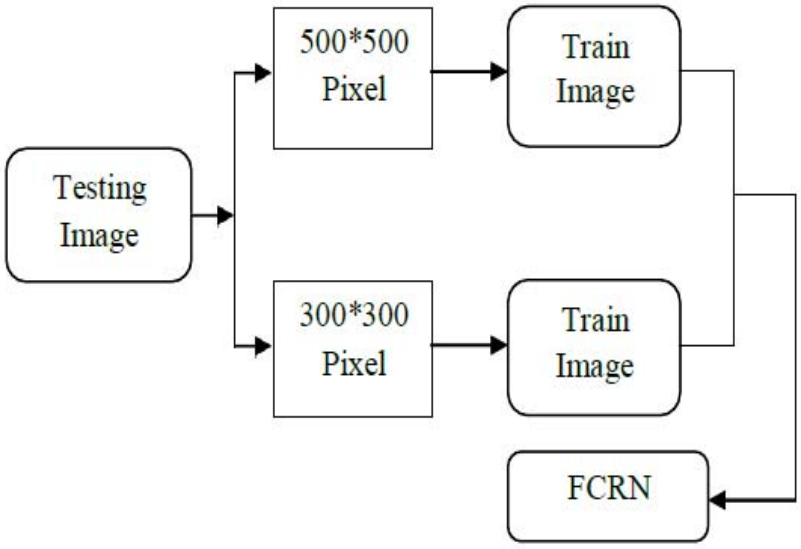
Here we coming up to the convolution layer that can consist of rectangular grid of image block means input layer with filter and filter is weighted by the volume of the picture. Output function in convolution neural network is to give the cropped image exact output.

Then next layer is introducing max pooling layer which is used to shrinking of the dermoscopy image that can add the extra padding to the image and remove if need to delete.

The process of the convolution and max pooling layer is continued when the image must be crop and generate the correct output.

After convolution and max pooling layer the fully connected layer is come to fed the neurons and weights determined by backpropogation. When we obtained sufficiently neuron from the digital dermoscopy images we have to classify the melanoma skin cancer into melanoma or benign.

PROPOSED METHOD USING FCRN:



[System level diagram using FCRN]

The system level diagram represents the recommended method to use in fully connected residual netwrok [32] that discourse the assignment of injury partition and categorization. Data augmentation technique that includes two fully connected residual network that train the picture with dataset.

The next stage in the fully connected residual network is testing stage that prospect with different injury capacity. The skin injury picture comparably rearranges the picture in 300*300 and 500*500 size and broadcast them to fully connected residual network reciprocally. The outcome of the different scope to the authentic declaration to examine the picture and summarize the common ability of skin injuries.

DATABASE DISCRIPTION:

Different Database are used for melanoma skin cancer detection.

1) ISIC Database:

International skin imaging collaboration is primarily employed on account of melanoma automated skin envision to assist to decrease melanoma impermanence. Melanoma is easily recoverable when identified and care for in its earliest stage. It directly cooperates the melanoma examination through tele dermatology, clinical determination support and automated diagnosis and exponent pictures of skin burning can be used to instruct experienced and the public. Presently insufficiency of model for dermatologic imaging sabotage the excellence grade and helpfulness of skin injury imaging. It is enlarging recommended ensign to discourse the automation, method, and phraseology employ in skin imaging with especial observation to the result of secrecy and interoperability. In accession, international skin imaging collaboration has developed and is enlarging an open-source public approach gain of skin images to test and verify the expected scale. These chronicles give as a public reserve of pictures for teaching and enlargement and examination for automated diagnostic method. With all benefit from three development categories that help to ensure quality, privacy and interoperability with optimal use of skin lesion imaging standards for optimal use of pictures for education, diagnosis and tele diagnosis, mole observation, documentation and coordination.

2) ISBI Database:

Across all scale of observation international symposium on biomedical imaging brings out a scientific convention which is devoted to mathematical, algorithmic, computational view of biomedical imaging. It brings up integrating approach in biomedical imaging with knowledge transfer among different imaging communities and countries. The contest dataset accommodates 900 annotated dermoscopic pictures for training 173 melanoma images and 379 pictures in a held-out test set for calculation of 75 melanoma pictures. The investigate contain three parts. first one is lesion segmentation, second one is lesion feature extraction and third one is including lesion classification. Segmentation and feature extraction is categorized into sub parts and represented the dermoscopic feature extraction problem as a classification task, whereas other one is present as a segmentation task. The purpose of this breakdown was to quantify how the border of the problem shaped end method execution. lesion classification conferred the disease classification operation. with belongings ground truth segmentations from the held out examine dataset, whereas another one is equipped the ground truth injury segmentation with the held out database. The aim of this decomposition was to understand the ground truth partition affects disease classification achievement.

3) VGG19 Database:

It was declared by to put classical neural network to place support vector machine classifier at top of the net that improve the classification outcomes [34]. Accordingly, after the vgg database training we take output vectors from the final fully affiliated layer of VGG19 network and used to train support vector machine classifier with RBF kernel. To perform grid search method that find the value of kernel width with soft margin parameter. This method were to put up within the grades of 2,17,2,4 and 2,7,28 for kernel and soft margin reciprocally. The pair of parameters kernel is 2,7 and soft margin is 8 establish during the grid search approved to receive the better outputs. Using convolution neural network to extend the network by adding two convolution layer, two fully connected layer and one neuron with sigmoid function. The input picture is passed directly through convolution layer and some of them were skipped and added the result to the stacked layer.

4) PH2 Database:

PH2 database use dermoscopic picture acquire by dermatology service under situation of mole analyst method using magnification. RGB picture with 768*560 pixels that contain overall two hundred dermoscopic pictures with melanocytic injury. It also includes medical pattern of overall clinical analysis appraisal of various criteria and performed the parameter by dermatologist which use in scientific analysis, injury, color partition and dots. Come up with PH2 browser that use as a public in Microsoft windows with 32 and 64 bits.

Discussion:

Here are Experimented Results of Different Machine Learning Techniques Like Neural Network, Convolution Neural Network and K- Nearest Neighbor. The Below Given Table Display the 3 Method Name Which Dataset I Used and How Much Accuracy I achieved.

Methods	Dataset	Accuracy
Convolution Neural Network	DermIS, DermQuest	99.47%
K- Nearest Neighbor	ISIC, PH2	87.42%
Neural Network	DermIS, ISBI	91.1%

Conclusion:

To be in nutshell of this paper use different machine learning technique like convolution neural network, sparse coding, support vector machine to identify melanoma skin cancer. Different steps like image acquisition, preprocessing, categorization, feature extraction and classification to recognize the melanoma and preprocessing is use to remove noise and hair removal in skin lesion pictures. segmentation is vividly use to find object and picture borders in lines and curves. Using independent histogram pursuit to partition the skin injury. Then come up with fully connected residual network to train and test the dermoscopy pictures with skin lesion partition and classification. Using different feature extraction step like ABCDE, color, texture

and structure feature to gain the high classification accuracy and also combine the handcrafted and automated feature of all CNN layer to achieve the high classification accuracy, sensitivity and specificity and generate the ROC curve and pull out multi scale attribute for melanoma identification.

References:

1. Abbasi, R. N. (n.d.). Early diagnosis of cutaneous melanoma - revisiting the ABCD criteria. *The Journal of American Medical*.

2. M. Binder, M. Schwarz, A. Winkler, A. Steiner, A. Kaider, K. Wolff, and H. Pehamberger, "Epiluminescence microscopy. A useful tool for the diagnosis of pigmented skin lesions for formally trained dermatologists," vol. 131, no. 3, pp. 286-291, 1995.

3. M. E. Celebi, Q. Wen, H. Iyatomi, K. Shimizu, H. Zhou, and G. Schaefer, *A state- of-the-art survey on lesion border detection in dermoscopy images*, pp. 97-129: CRC Press, 2015.

4. F. Bogo, F. Peruch, A. Fortina, and E. Peserico, *Where's the lesion?: variability in human and automated segmentation of dermoscopy images of melanocytic skin lesions*, pp. 67-96: CRC Press, 2015.

5. Erkol, B.; Moss, R.H.; Stanley, R.J.; Stoecker, W.V.; Hvatum, E. Automatic lesion boundary detection in dermoscopy images using gradient vector flow snakes. Skin Res. Technol. 2005, 11, 17–26.

6. Gómez, D.D.; Butakoff, C.; Ersbøll, B.K.; Stoecker,W. Independent histogram pursuit for segmentation of skin lesions. IEEE Trans. Biomed. Eng. 2008, 55, 157–161.

7. Dhawan, A. P., & Sim, A. (1992). Segmentation of images of skin lesions using color and texture information of surface pigmentation. *Computerized Medical Imaging and Graphics: The Official Journal of the Computerized Medical Imaging Society*, *16*(3), 163–177. doi:10.1016/0895-6111(92)90071-g

8. Abuzaghleh, O., Barkana, B.D., Faezipour, M.: Noninvasive real-time automated skin lesion analysis system for melanoma early detection and prevention. IEEE J. Transl. Eng. Health Med. 3, 1–12 (2015).

9. Zhou, H., Schaefer, G., Celebi, M. E., Iyatomi, H., Norton, K., Liu, T., & Lin, F. (2010, August). Skin lesion segmentation using an improved snake model. *2010 Annual International Conference of the IEEE Engineering in Medicine and Biology*. Presented at

the 2010 32nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC 2010), Buenos Aires. doi:10.1109/iembs.2010.5627556

10. Qaisar, A., Celebi, M. E., Carmen, S., Fondón, G. I., & Ma, G. (2013). Pattern classification of dermoscopy images: a perceptually uniform model. *Pattern Recogn*, *46*, 86–97.

11. Delgado, D., Butakoff, C., Ersboll, B. K., & Stoecker, W. (2008). Independent histogram pursuit for segmentation of skin lesions. *IEEE Transactions on Biomedical Engineering*, *55*, 157–161.

12. Celebi, M. E., Kingravi, H. A., Iyatomi, H., Lee, J., Aslandogan, Y. A., Van Stoecker, W., … Marghoob, A. A. (2007, March 8). Fast and accurate border detection in dermoscopy images using statistical region merging. In J. P. W. Pluim & J. M. Reinhardt (Eds.), *Medical Imaging 2007: Image Processing*. doi:10.1117/12.709073

13. Celebi, M., Kingravi, H., Iyatomi, H., Aslandogan, Y., Stoecker, W., & Moss, R. (2008).' Border detection in dermoscopy images using statistical region merging. *Journal of Skin Research and Technology*.

14. Sadeghi, M., Lee, T. K., Mclean, D., Lui, H., & Atkins, S. (2013). ' Detection and Analysis of Irregular Streaks in Dermoscopic Images of Skin Lesions. *IEEE Transactions on Medical Imaging*, *32*(5).

15. Esteva, A., et al.: Dermatologist-level classification of skin cancer with deep neural networks. Nature 542(7639), 115–118 (2017).

16. Almansour, E., & Jaffar, M. A. (2016). Classification of Dermoscopic Skin Cancer Images Using Color and Hybrid Texture Features. *IJCSNS Int J Comput Sci Netw Secur*, *16*(4), 135–139.

17. Argenziano, G., Fabbrocini, G., Carli, P., Giorgi, V. D., Sammarco, E., & Delfino, M. (1998). Epiluminescence microscopy for the diagnosis of doubtful melanocytic skin

lesions: Comparison of the ABCD rule of dermatoscopy and a new 7-point checklist based on pattern analysis. *Archives of Dermatological Research*, *134*(12), 1563–1570.

18. Nachbar, F., Stolz, W., Merckle, T., Cognett A, A. B., Vogt, T., Landthaler, M., … Plewig, G. (1994). The ABCD rule of dermatoscopy: High prospective value in the diagnosis of doubtful melanocytic skin lesions. *Journal of American Academy of Dermotology*, *30*, 551–559.

19. Barata, C., Emre Celebi, M., & Marques, J. S. (2015, August). Melanoma detection algorithm based on feature fusion. *2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. Presented at the 2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Milan. doi:10.1109/embc.2015.7318937

20. Codella, N., Cai, J., Abedini, M., Garnavi, R., Halpern, A., & Smith, J. R. (2015). Deep learning, sparse coding, and SVM for melanoma recognition in dermoscopy images. In *Lecture Notes in Computer Science*. *Machine Learning in Medical Imaging* (pp. 118–126). doi:10.1007/978-3-319-24888-2_15

21. Abbes, W., & Sellami, D. (2016). High-level features for automatic skin lesions neural net-work based classification. In *2016 International Image Processing, Applications and Systems (IPAS). pp. 17.*

22. Ahlberg, C., Williamson, C., & Shneiderman, B. (1992). Dynamic queries for information exploration. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems - CHI '92*. Presented at the the SIGCHI conference, Monterey, California, United States. doi:10.1145/142750.143054

23. Bakheet, S. (2017). An SVM framework for malignant melanoma detection based on optimized HOG features. *Computation (Basel, Switzerland)*, *5*(1), 4. doi:10.3390/computation5010004

24. Tian, P. (2013). 'A Review on Image Feature Extraction and Representation Techniques". *International Journal of Multimedia and Ubiquitous*, *8*, 385–396.

25. E. Alaa, and H. Demirel, "Co- occurrence matrix and its statistical features as a new approach for face recognition."

26. Codella, N. C. F., Gutman, D., Celebi, M. E., Helba, B., Marchetti, M. A., Dusza, S. W., … Halpern, A. (2018, April). 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). *2018 IEEE 15th International Symposium on Biomedical Imaging (ISBI 2018)*. Presented at the 2018 IEEE 15th International Symposium on Biomedical Imaging (ISBI 2018), Washington, DC. doi:10.1109/isbi.2018.8363547

27. Arroyo, J.L.G., Zapirain, B.G.: 'Detection of pigment network in dermoscopy images using supervised machine learning and structural analysis', *Comput. Biol. Med.*, 2014, 44, pp. 144–157

28. Capdehourat, G., Corez, A., Bazzano, A., Alonso, R., & Musé, P. (2011). Toward a combined tool to assist dermatologists in melanoma detection from dermoscopic images of pigmented skin lesions. *Pattern Recognition Letters*, *32*(16), 2187–2196. doi:10.1016/j.patrec.2011.06.015

29. Clawson, K. M., Morrow, P., & Scotney, B. (2009). *Analysis of pigmented skin lesion border irregularity using the harmonic wavelet transform'. 13th Int. Machine Vision and Image Processing Conf.* 18–23.

30. He, K., Zhang, X., Ren, S., & Sun, J. (2016, June). Deep residual learning for image recognition. *2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*. Presented at the 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Las Vegas, NV, USA. doi:10.1109/cvpr.2016.90

31. Arevalo, J., González, F. A., Ramos-Pollán, R., Oliveira, J. L., & Guevara Lopez, M. A. (2016). Representation learning for mammography mass lesion classification with convolutional neural networks. *Computer Methods and Programs in Biomedicine*, *127*, 248–257. doi:10.1016/j.cmpb.2015.12.014

32. Barata, C., Celebi, M. E., & Marques, J. S. (2015). Improving dermoscopy image classification using color constancy. *IEEE Journal of Biomedical and Health Informatics*, *19*(3), 1146–1152. doi:10.1109/JBHI.2014.2336473

33. Abuzaghleh, O., Barkana, B. D., & Faezipour, M. (2014, May). Automated skin lesion analysis based on color and shape geometry feature set for melanoma early detection and prevention. *IEEE Long Island Systems, Applications and Technology (LISAT) Conference 2014*. Presented at the 2014 IEEE Long Island Systems, Applications and Technology Conference (LISAT), Farmingdale, NY, USA. doi:10.1109/lisat.2014.6845199

34. Korotkov, K., Garcia, R.: 'Computerized analysis of pigmented skin lesions: a review', *Artif. Intell. Med.*, 2012, 56, (2), pp. 69–90

35. Capdehourat, G., Corez, A., Bazzano, A., *et al.*: 'Toward a combined tool to assist dermatologists in melanoma detection from dermoscopic images of pigmented skin lesions', *Pattern Recognit. Lett.*, 2011, 32, (16), pp. 2187– 2196

36. Yuan, X., Yang, Z., Zouridakis, G., & Mullani, N. (n.d.). *SVM-based Texture Classification and Application to Early Melanoma Detection", Proceedings of the 28th IEEE EMBS Annual International Conference*. New York City, USA.

37. M. J. Ogorzaek, G. Surówka, L. Nowak, C. Merkwirth," New Approaches for Computer-Assisted Skin Cancer Diagnosis", The Third International Symposium on Optimization and Systems Biology (OSB'09) Zhangjiajie, China, September 20–22, 2009