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# Detection and Classification Techniques for Skin Lesion Images: A Review

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***Abstract***

*Dermoscopy needs sophisticated and robust systems for successful treatment which would also help reduce the number of biopsies. Computer aided diagnosis of melanoma support clinical decision making which would provide relevant supporting evidence from the prior known cases to the dermatologists and practitioners and also ease the management of clinical data. These systems play an important role of an expert consultant by presenting cases that are not only similar in diagnosis but also similar in appearance and help in early detection and diagnosis of skin diseases. With the advances in technology, new algorithms have also been proposed to develop more efficient CAD systems. This article reviews various techniques that have been proposed for detection and classification of skin lesions.*

***Keywords:*** *BCC, SCC, Melanoma, Skin lesion, Malignant, Benign, ABCD.*

## INTRODUCTION

Skin is the largest part of human body. There are skin diseases like skin cancer caused due to the abnormal cell development which might spread to the whole body. Basal-cell skin cancer (BCC), squamous-cell skin cancer (SCC) and melanoma are the main types of skin cancers in which the first two are considered to be non-melanoma skin cancer. Melanoma is the deadliest form of skin cancer caused due to the melanocytes, a pigment containing cell. One way of overcoming skin disease is early diagnosis in patient prognosis. Fortunately, technology has a huge impact on the health care and digital technologies are coming up with new methods to help dermatologists to diagnose the skin diseases in early stages and in a more effective manner. In past few decades the level of interest in bio-medical image analysis and retrieval has shown significant growth. The aim is to use the technology and develop techniques which serve as diagnostic adjuncts for medical professionals and assist biologists.

This article reviews few techniques that have been proposed from past few years for the early detection of melanoma. Figure 1 shows different classes of skin disease like melanoma, seborrheic keratosis, bullae, shingles and squamous cell. Skin lesions are mainly classified as benign and malignant tumours which can aid dermatologists to identify early melanoma through the visual standards like asymmetry, border, colour and dimension (ABCD)[ 18] ,of which shape and edge of the pigmented lesion help differentiate the benign lesion from malignant lesion. The digital skin images captured for the analysis consists of the pigmented lesion and the normal skin which should further be segmented to obtain the region of interest i.e. the affected area. The proposed systems have used the color, texture and shape features for identifying the skin lesion and various image processing techniques to classify and retrieve the similar cases.


***Fig 1:*** *Different Classes of Skin Disease [17].*

## DETECTION TECHNIQUES

Ilias et al [7] proposed parametric active snake model for the pigmented skin lesion segmentation and boundary detection. The aim was to design a model for segmentation of digital skin images using active contour models also known as Snakes. An initial contour was created by entering minimum 3 non-linear points as an input to the snake model. In addition to the Gaussian filter for noise removal few parameters such as elasticity, rigidity, and viscosity were used to handle model's internal and external forces. 2-D GVF (Gradient Vector Flow) computations were implemented on Matrix Laboratory (MATLAB) platform. The curve was deformed, so that the curve can expand or contract. The default Contour iteration i.e. 40 iterations were chosen but often the contour converged before reaching the number of iterations set. The algorithm was tested by placing the control points in the vicinity of the lesion. The types of skin lesions considered were junctional nevus, melanoma, compound nevus, non-diagnostic naevus, dysplastic nevus and seborrheic keratosis. The selection of the initial points and the parameters used for the contour evolution play an important role and hence the 3 stage evaluation was done with 10 iterations each. In evaluations 1 and 3 the initial points were close to the irregular boundary of the image but the parameters used for the contour evolution were different and the final convergence closely matched the original lesion giving good convergence result. In evaluation 2 the initial points formed an ellipse with few points placed within the lesion and individual parameters were similar to the first evaluation. The final convergence of evaluation 2 did not closely match the original lesion giving poor convergence result. The proposed model failed to detect border crests, when initial points were not close to the actual boundary of the image and was delicate to the initial contour positioning.

Celebi et al [8] have presented a fast and unsupervised method for border detection of pigmented skin lesion based on the statistical region merging method (SRM), a region growing and merging method. Merging predicate and the testing order of the predicate are the major components of SRM. SRM does not use quantization or color space transformation. The lightness component of HSL color space removed the black frame introduced during the digitization process and a top-to-bottom scan was performed by setting a threshold value for the pixel. Artifacts were removed by median filter. The background skin color was determined and eliminated. In order to match the automatic border closer to manual border experiment was conducted with Majority filtering, Morphological dilation and Euclidian distance transform. Morphological dilation gave good results comparatively. The dermatologist determined border and automatic borders of five automated methods OSFCM (orientation-sensitive fuzzy c-means), DTEA (dermatologist-like tumour extraction algorithm), Mean shift clustering, JSEG and SRM were compared using grading system. The SRM gave best results followed by the DTEA and JSEG method. Error rates were high in case of melanoma due to the presence of higher border irregularity and color variation in the lesion. The SRM yields good results in spite of factors such as subtle edges, blood vessels and skin streaks.

Celebi et al [9] have proposed a machine learning approach which involves contextual pixel classification using a decision tree classifier for the detection of blue-white `veil and related structures in dermoscopy images. Two dataset were used in this study the CD-ROM Interactive Atlas of Dermoscopy and a pre-publication version of the American Academy of Dermatology DVD on Dermoscopy. The decision tree classifier was used as it generates easy to understand rules which are clinically accepted by CAD systems; also they are fast to train and apply. Another classifier was developed to differentiate melanoma and benign lesions based on the presence/absence of the blue-white veil features. A numerical feature is used to detect the blue-white areas. To avoid the misclassification of blue nevus as melanoma they used additional features that characterize the circularity and /or ellipticity of lesion. *C4.5* algorithm with 10-fold cross-validation was used in the pixel classification procedure, to generate a classification model based on the features $S1$, $S2$(circularity), and $S3$(ellipticity). The decision tree classifier method gave better results for detection of blue veil in melanoma recognition when compared to the lesion combined with a simple shape descriptor.

Xiaojing et al [11] have proposed a novel multi-modal skin lesion segmentation method based on region merging and narrow band graph partitioning. Two stage frameworks were used to integrate region fusion and narrowband graph portioning (NBGP). The proposed region-fusion-based segmentation framework used Chan–Vese model [3] for image segmentation and were merged based on centroid intensity and gradient information. The active contours used the intensity feature of each pixel within the image. Active contours were iteratively applied within each segmented region. The overlapping and/or non-overlapping regions were merged based on centroid and gradient criterion. In Narrow band graph partitioning image segmentation algorithm, the curve evolution was fast for the level set function update and the region-based energy similarity measure as it developed over a relatively small ring (narrow band). For the region-based similarity measure the size of inward and outward narrow band was assumed to be same. The narrow band approach was adopted while updating the level set function which considered only the pixels close to the current contour. When the contour is very close to the borders of the current band the contour position and the set of narrow band pixels were updated to reduce the cost of updating the narrowband. A multiscale technique was combined with NBGP curve evolution to reduce computational cost and improve the convergence speed. Initial curve for NBGP and GPAC (graph partitioning active contour) were taken from the results of Chan–Vese model. The proposed hierarchical region-fusion-based segmentation framework based on narrow band energy yields a computationally efficient curve evolution method. The new NBGP curve evolution scheme used the local features and produced the best segmentation results and achieved precision very close to manual segmentation by specialists. It was vigorous for lesions with edge crests, highly asymmetric lesions, dense hair, noise and other artifacts.

Content-based image retrieval (CBIR) by Evolutionary Feature Synthesis was proposed by Lucia et al [12] for skin lesion images. They have focused on Actinic Keratosis (AK), Basal Cell Carcinoma (BCC), Melanocytic Nevus / Mole (ML), Squamous Cell Carcinoma (SCC), Seborrhoeic Keratosis (SK). The color and composite texture features were considered. Normalised RGB was chosen after experimenting with RGB, HSV (Hue, Saturation, Value), CIE Lab, CIE Lch (Munsell colour coordinate system [6]) and Otha [2] colour spaces as it gave better result comparatively. A generalised co-occurrence matrix (CGM) which is the extension of the co-occurrence matrix [1] to multispectral images was used to extract texture feature. Evolutionary algorithms were applied to feature synthesis problems. Simple features were combined using a series of operators to derive each synthesised feature. The evolutionary phase uses genetic algorithm (GA). Synthesised feature entails the index of the simple features to be selected and the operators used to combine them. Each chromosome is composed of part which encodes the index set of the simple features and a part which encodes the operators. In the proposed work results were obtained by applying each operator to a pair of features and 6 operators {1,2,+,−, _, /} were used. Where, first 2 operators indicate that either the first or the second features of the pair is selected and given mathematical operations are performed on the two features of the pair by the last 4 operators. The GA (genetic algorithms) has integer numbers in the chromosomes which was the result of encoded feature indexes and the operators. There were 10 features and 5 operators (one for each pair of the 10 features) in each chromosome. Bhattacharyya distance metric similarity measure was used. The evolved composite features gave better results when compared to the standard features. The experimentation was conducted on small set of feature combination operators which gave motivating results to conduct further experimentation on random features using large set of operators.

Hanzheng et al [13] have developed a watershed algorithm for automatic skin lesion segmentation in dermoscopy images. Since the intensity value of hair sometimes matches the pigmented lesion area, a technique for hair removal with the morphological closing operator was introduced. The blue plane image was used on red lesion rim image to avoid the errors and boundary enlargement. Watershed algorithm uses topographic representation in which the high intensity pixels represent hills and the low intensity pixels denote valleys. Using the philosophy of the watershed algorithm, the flooding modification of the watershed algorithm is compared to the immersion of the relief in a lake flooded from holes at minima. To avoid the merging of different labels of lakes a dam is built and this is done when the flooding process reaches the global maximum. The dam boundaries here are referred to as watershed lines. In the implementation an optimized threshold area of the watershed objects was introduced. The lesion ratio estimate (LRE) based on the outer bounding ratio was determined. The centre of the image was processed by the outer bounding box. The LRE merges the watershed objects based on the watershed object histogram. The merged border segmentation is then treated with second-order B-Spline closed curve fitting, which gave the satisfactory final segmentation results. The lesion size was controlled by the LRE and bounding box methods. The flooding variant of the watershed algorithm yields good results for automatic segmentation of pigmented skin lesions.

An automatic skin cancer classification system has been proposed by Khaled et al [15]. Wavelet and curvelet transforms are used for the feature extraction. The image database used contains both digital photos and Dermoscopy images collected from Hospital and websites. The wavelet transform extracts the cancerous features from the image. Since wavelets ignore the geometric properties of objects with edges in higher dimensions, the curvelet transform was proposed to improve the method for edges with curve. The work also highlights the use of 3-Layer Back Propagation Neural Networks as a classification method. The result of this work showed that the curvelet with BNN (Back-Propagation Neural Network) has a higher accuracy than the wavelet method.

Catarina et al [16] have used bag of features model to identify and classify the point of interest i.e. the area of lesion with specific texture patterns such as lines and blobs. Harris-Laplace detector [10] was used to compare the performance of intensity salient points against the color salient points. The experiments were conducted on $PH^2$ datasets of 176 dermoscopy images (25 melanomas) and manual segmentations of the skin lesions were used to avoid segmentation error. SIFT [5] has been used to detect the point of interest and describe the extracted patches. The extracted patches have been clustered using K-means algorithm where each centroid acts as a visual word forming a visual dictionary [4]. The patch features of image are compared to the visual dictionary to retrieve the similar images. Since SIFT ignores the color description which carries the discriminative information, Color-SIFT [14] was included which is the combination of SIFT vector and color histogram. They performed a comparative study where performance of Color-SIFT surmounts SIFT in the case of Harris Laplace and Color Harris points, which showed that adding color information constructs better dictionary.

A novel approach for automatic segmentation and classification of skin lesion was proposed by R Sumithra et al [17]. In addition to melanoma, squamous cell, seborrheic keratosis diseases they have also considered bullae and shingles diseases. Dataset was created using the images available online. Gaussian filters were used for image enhancement. The initial seed points were decided using the region growing method i.e. pixel based image segmentation technique. The color, texture and color histogram features were used. The results of segmented image was compared with the ground truth using few segmentation performance measures such as Measure of Overlap (MOL) , Measure of Under Segmentation (MUS) , Measure of Over Segmentation (MOS), Dice Similarity Measure (DSM). In addition to these methods to calculate the error in segmentation a method called Error Rate was used. For the classification of extracted features linear Support Vector Machine (SVM), k- Nearest Neighbour (k-NN) classifiers and the fused results of SVM and k-NN using OR rule were used. On analysing the F-measure value, SVM classifier gave better performance than the k-NN classifier, but maximum results were obtained by the fusion of SVM and k-NN. The classifiers have shown very good results for seborrheic keratosis when compared to other classes of skin disease. The overall analysis proved that SVM-KNN fusion based classifier surmounts the performance of individual classifiers.

Piotr et al [19] have proposed a new dermatological asymmetry measure of skin lesions by concentrating on 3-point checklist and 7-point checklist methods of diagnosis to calculate the asymmetry of shape, structure and hue. The databases considered are $PH^2$, DB, DermDB. Specific values were assigned to perform

DASM (Dermatological Asymmetry Measure) to achieve high precision. The values assigned were continuous, they are as follows:

• Shape < 0, 2 >
• Color/hue < 0, 2 >
• Structure < 0, 2 >

The asymmetry of hue and structure was included which in turn increased the asymmetry count. This method predicts the asymmetry division into asymmetry of shape, hue/color and structure. GSSPT thresholds (geometrical shape symmetry precision threshold) are used to calculate the symmetry axes which then construct a vector of shape symmetry (VoSS). The proposed dermatological asymmetry measure DASM shape (Dermatological Asymmetry Measure of Shape symmetry/asymmetry) considers only asymmetry in shape and hence does not give any evidence if symmetry in shape gives symmetry in hue or structure.

## CONCLUSION

In this study, few techniques that have been proposed and developed overtime for segmentation, feature extraction, classification and retrieval of skin images have been reviewed. Segmentation method based on region merging and NGBP, active snake model, statistical region merging method, watershed algorithm are reviewed. Curvelet transform for edges with high dimensions, shape symmetry/asymmetry measure for segmented lesions, Bag of features model with the color-SIFT for classification and identification of region of interest, CBIR method for the retrieval of similar images are the various techniques studied.

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