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Automated Melanoma Detection -A Review

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***Abstract*— In this paper, a review on existing methods used for computerized analysis of melanoma is presented. A distinction between melanoma and other benign skin lesions is a challenging factor. We present different techniques used for melanoma identification but there are no bench marking technique available and it is to be evaluated. A detailed study on various techniques of image processing as applied to melanoma images for the past 20 years is presented. The techniques and methods which are helpful in each process are evaluated and summarized. The aim of this survey is to group and classify the sub categories available in the literature and to provide a summary of all the available methods in automatic identification of melanomic cancer.**

***Keywords*— melanoma, dermoscopy, literature survey, lesion identification, 3D skin texture**

I. INTRODUCTION

Melanoma is a cancer of pigmented skin lesions and has gained popularity in last three decades. It can be benign or malignant. If it is diagnosed in early stage, it can be treated effectively [1]. The pigment Melanin is created by melanocytes makes the skin appear in natural colour. Over exposure to sun produces more melanocytes that cause the skin to tan. Most skin cancer deaths occur due to melanomic lesions [2].It is difficult to differentiate melanoma and mole on naked eye examination. The survival rate of patient increases if melanoma is diagnosed and treated in early stage [3, 4].Hence automated melanoma identification is necessary. It has gained importance in recent years.

II. BACKGROUND

Melanoma types are divided into four classes (http://www.skincancer.org/). The common type is Superficial spreading melanoma where the melanoma develops on top most layer of skin and colour variation can be seen. Lentingo melanoma is found in people of older age and appears as a raised patch from the skin surface. Acral lentiginous melanoma is mostly found on people with dark skin and spreads more quickly than the other two types discussed .Nodular melanoma is diagnosed when it becomes a protruding lesion that is usually black or blue or brown in colour. More exposure to sun in childhood may increase the risk factor especially in fair skinned people.

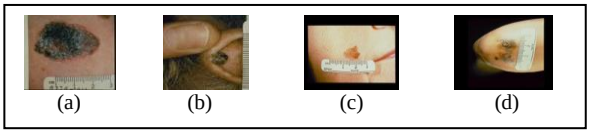


Figure 1. Types of Types of Melanoma- a) Superficial (b) Nodular (c) Letingo (d) Acral Lentiginous

III. STEPS IN SKIN CANCER DETECTION

In this paper a survey that address the above mentioned issues is done. The following section presents a review on common steps involved in early detection of melanoma.

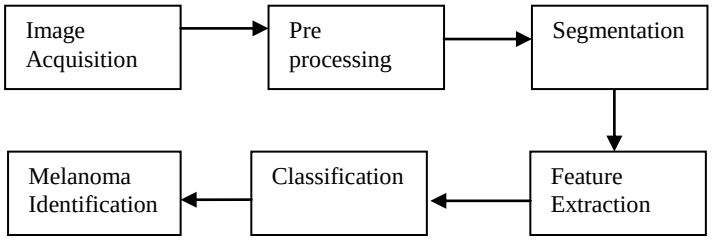


Figure 2. Steps in melanoma detection

A. *Image Acquisition*

This is the foremost step that involves acquiring digital images from different techniques available. The images are collected to form a dataset which is used for further processing to extract information and classification .The images can be captured using ELM (Epiluminence Microscopy) or TEM (Transmission Electron Microscopy) or still or video cameras. ELM (or dermoscopy) contains a magnifier, a non-polarized source of light, a see-through plate and a liquid medium between the device and the skin. It helps in clear inspection of skin lesions while TEM is a microscopy technique which uses fiber optics directed into the surrounding skin and images are captured using digitizing TV camera.

Binder.et al (1998) in his paper proves that Epiluminescence Microscopy (ELM) images are best for digital image analysis [5, 6]. Bauer. P et al (2000) states that the accuracy of the diagnosis using ELM is better compared to TEM or still images or naked eye examination [7]. Also images acquired using still cameras or video cameras did not have high resolution and hence did not provide good results especially for very small lesions (diameter< 0.5 cm)

Sample images are shown below

Figure 3 (a) Clinical Image 3(b) Dermoscopic Image

B. *Pre-processing*

Pre-processing is the first step in image processing. Melanomic images have irrelevant objects such as hairs, and air embolism around the lesion. Hence the correctness of the border detection is less and the calculation time becomes more. Artefact elimination is a vital step in pre-processing for diagnosis of pigmented skin lesions.

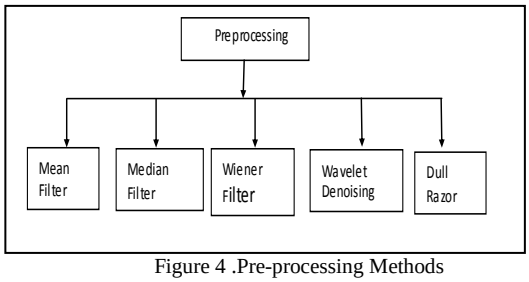


Figure 4 .Pre-processing Methods

Removal of artefact from dermoscopy images contains the works of Schmid et al. and Fleming et al. A method for removal of hair and other irrelevant objects using global morphological operations and thresholding was proposed by Schmid and his co-authors [8, 9].They found that hairs are often thin structures which appear darker than their background.

One of the popular methods for hair removal in dermoscopic images is Dull Razor which was proposed in 1997[10].The Wiener filter was developed by Norbert Wiener in 1940s.. It is most commonly used to de noise audio signals, especially speech, as a pre-processor before speech recognition.

Fleming et al (2000) developed an algorithm for identifying hair as long, curved structure but its performance was not high [11]. To improve the shape and edges of image, post processing was done.

Delgado D et al (2008) in his paper has used mean filter for histogram smoothing so as to eliminate insignificant local extrema [12]. Median Filter reduces the artefacts and at the same time they preserve the edge which helps in separation of lesion from the surrounding skin.

Sachin D(2010) has concluded that wavelet based de noising was proved to be better than other methods as it is faster in computation and preserves original information and other *parameters of the image[13]*.

C. ***Segmentation***

Segmentation process accurately isolates skin lesions from normal skin surrounding it. It is an important step as the accuracy of forthcoming steps relies on this step. A large number of image segmentation techniques were presented by researchers according to their application and it has been found from the survey that one single technique suitable for all applications is not yet proposed.

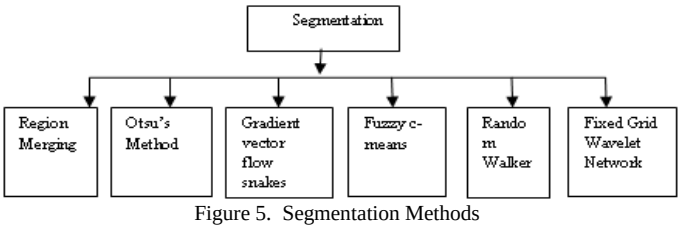


Figure 5. Segmentation Methods

Alexander Wong et al(2011) has presented a method based on Iterative Stochastic Region Merging for segmentation of skin lesions[14] and is proven to be better than the deterministic region merging algorithm which was proposed by Nock and Nielson(2004)[15]

A new algorithm called Fixed Grid Wavelet Network for segmentation was presented and compared with four other methods and results are proven to be better. Celebi,M (2007) had stated that Statistical region merging is an approach that is fast for border detection and is based on region growing and merging[16,17].

Hance et al. in his paper made a comparison of six segmentation methods such as split and merge, fuzzy c means, multi resolution, centre split, adaptive thresholding and PCT/median cut .The last two methods were proven to be effective[18].

A comparative study of six segmentation methods in melanoma images was done by Silveira M et al. (2009) . It includes gradient vector flow (GVF) , Chan's level set method(C-LS),adaptive thresholding (AT), adaptive snake (AS), EM Level set (EM-LS), and fuzzy-based split and-merge algorithm (FBSM).The best results were obtained by the semi supervised methods like AS and EM-LS methods. The best fully automatic method was FBSM that has results only slightly worse than AS and EM-LS [19].

Paul Wighton et al (2009) in their paper have adopted a fully automatic Random Walker segmentation for Skin Lesions and concluded that this method outperforms the Otsu's method [20].The random walker method takes colour and texture features for segmentation.

Huiyu Zhou et al (2009) have introduced a Fuzzy C-means algorithm based on mean shift which gives better results for segmentation. In this method, similar pixels are clustered in an repetitive way and on each iteration the cluster centres are found quickly and results are excellent especially for medical images [21].

But these results were not unified in all the articles and there were different views and results from different papers. It may be because of different datasets taken by them and different evaluation rules applied by them. Most of the articles had sensitivity and specificity as the main metrics for evaluation.

D. ***Feature Extraction***

Feature Extraction is the process that takes out the properties that are hidden on the image that is further used in the classifier. 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 [22, 23]. Later, Abbasi et al(2004) expanded the ABCD formula to ABCDE by including the E for an "evolving" lesion over time. In 2005, G. N. Fox included FG to ABCDE criteria for diagnosis of melanoma.Pellacani et al. (2006) in his paper concludes that asymmetry is the most reliable factor for melanoma identification.

TABLE1
ABCD FORMULA

Asymmetry	One half of the tumour does not match the other half.
Border Irregularity	The edges are ragged, notched, Blurred

Colour	Pigmentation is not uniform
Diameter	Greater than 6 mm and growing
Evolving	Evolving lesion over time
Firm	Lesion is firm to touch
Growing	Growing rapidly in short time(a few months or weeks)

The seven point check list was developed by Professor Rona Mackie (1991). They include

- Major features
  - Change in size
  - Irregular shape
  - Irregular colour
- Minor features
  - Diameter >7mm
  - Inflammation
  - Oozing
  - Change in Sensation

Grob and Bonerandi (1998) pioneered in finding the "ugly duckling" (UD) concept – they observed that different nevi in same person may resemble each another and that melanoma that is malignant is different from these nevi [24].

Maryam Sadeghi et al (2013) has proposed an approach which can detect and analyse irregular streaks in dermoscopic images [25].

The feature that are to be extracted may be lines,edges,textures or even points but the novelty lies in the optimal selection of features which may be texture based, border based or may be based on geometric properties.

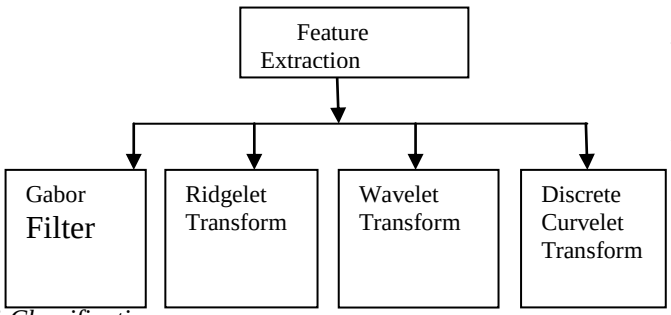


Figure 6. Feature Extraction Methods

The fast wavelet transform was first proposed by Mallet (1989).Wavelets were employed initially for feature extraction [26]. It captures restricted directional information due to its poor orientation selectivity and suitable to detect objects with point singularities [27].

Emmanuel Candes (1999) proposed that Ridgelet is most efficient in detecting linear radial structures and is able to represent objects with line singularities [28]. Gabor filters are described by frequency, width and direction and is applied to detect derived optimal design parameters for detection of step edges and to detect grain boundaries in electron microscopy images.

Emmanuel Candes et al (2006) employed a new technique Fast Discrete Curvelet Transform [FDCT] for effectively identifying the curves in an image [29,30]. Tobias Geback and Petros Koumoutsakos (2009) used the discrete curvelet transform, to extract directional information from the image in addition to time and frequency. This method is compared with Gabor filters and canny edge detection method and results show that curvelets perform better in detecting larger, elongated structures [31].

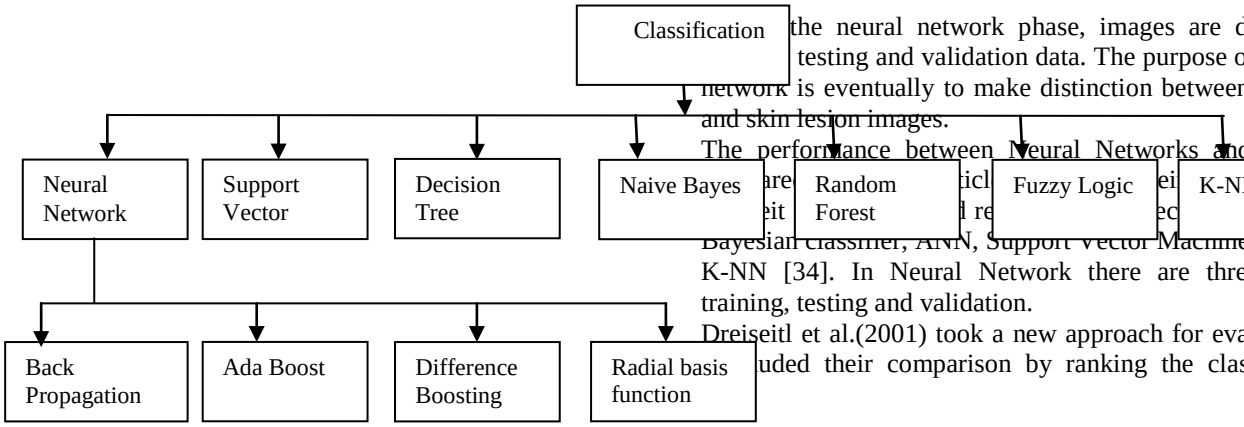
The multi-directional features in curvelets are very efficient and useful for edge detection and to extract the significant features from medical images.

G.Geetha et al (2010) in their paper has concluded that curvelet is better in identifying curved and elongated structures in melanoma images [32]. Curvelet Transform is an extension of wavelet and ridgelet transforms. Since we need to classify melanoma images which are curved images curvelet transform will better suit our processing as it aims to deal with curved edges more effectively. In addition, the curvelets provides us with directional information at each point that can be used for better edge detection.

From the literature survey, it is clear that the feature selection is an important factor for the performance of the classifiers. In the steps for melanoma identification, there are large number of articles published on border detection methods and classification methods.

3.5 *Classification*

The inputs given to neural network are the features extracted using curvelets that classifies the given data set into cancerous or non-cancerous. This is the last step in melanoma identification.



the neural network phase, images are divided into testing and validation data. The purpose of the neural network is eventually to make distinction between melanoma and skin lesion images.

The performance between Neural Networks and SVM are [illegible] an Bayesian classifier, ANN, Support Vector Machines and K-NN [34]. In Neural Network there are three stages – training, testing and validation.

Dreiseitl et al.(2001) took a new approach for evaluation and [illegible]uded their comparison by ranking the classifiers into

three types as performing well (K-NN), very well (ANN, SVM and logistic regression) or not well suited (decision trees paradigm—due to continuous input variables)[35].

Lucia Ballerini et al (2012) had presented a hierarchical K-Nearest Neighbour algorithm for classification of skin lesions but the results were based on normal colour images and not on dermoscopy images from special sensors [36].

V.Lalitha,G.Geetha(2014) have applied canny edge detection algorithm for segmentation and wavelet based decomposition for feature extraction The features that are extracted are then fed as input into neural network for classification and the results retrieved are proven to be better in diagnosis of melanoma[37].

The classifier chosen is responsible for the performance of the above methods and it is difficult to come to a conclusion that only so and so classifier is best as it depends on various factors like dataset, different classifier applied on different studies. A classifier that performs better in one comparison shows lower performance in another application. Hence according to the application and dataset available the classifier must be chosen to show better performance.

IV. CONCLUSION

From the above survey, it is evident that there is no one method that is proven to be best for each stage and it depends on the dataset used and evaluation rules applied .But it has been proved from the results that wavelet based de noising is better for pre-processing especially for skin with artefacts like hair growth and other types of noise. For feature extraction, curvelets are better than wavelets especially for skin cancer images or images with curves. Finally for classification, several methods are discussed and according to the application the apt methods can be selected. It is evident that artificial neural network gives better results for classification than decision trees and other methods.

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