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Review on Techniques and Steps of Computer Aided Skin Cancer Diagnosis

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Abstract

Early stage detection of skin cancer needs computer aided detection. Automatic skin cancer diagnosis is one of the major challenging task in medical image processing. This paper discusses more efficient methods to reduce rate of error. Automatic diagnosis system works on two reliant steps – the first detect skin anomalies and second identifies the benign or malignant melanoma. This paper presents steps and methods for automatic skin cancer diagnosis. This paper provides useful information of techniques and basic steps of skin cancer diagnosis for researchers in their starting phase.

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Keywords: Skin cancer, Artificial neural network, Fuzzy rule based , Adaptive fuzzy inference neural network .

1. Introduction

Skin cancer is the deadliest form of cancer if it is not detected in early stage. Skin cancer may appear as benign melanoma and malignant melanoma. Benign melanoma is appearance of mole on skin [7]. Malignant melanoma is deadliest form of cancer thus it needs immediate detection. Malignant melanoma arises from cancerous growth in

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pigmented skin lesion. Melanocytes are the pigments giving color to skin which generally starts with a small region later spreads to the other skin areas through lymphatic system or blood. In normal case old cell replace by new cell while in case of cancer they grow in abnormal way it become cancerous due to genetic disorder by external or internal factor. Human skin is made of three layers - dermis, epidermis and hypodermis [3]. Cells in the outermost layer of skin produce melanin pigment which protects human skin from ultraviolet radiations. Dermatology is the bough of medical science that is concerned with diagnosis and treatment of skin based disorder.

Early stage detection of skin cancer needs computer aided detection. Generally, doctors use biopsy method for the diagnosis of skin cancer. Biopsy is the removal or scrapping off the skin and those skin samples are undergone many laboratory test hence it is time consuming and painful [7]. There are many features or sign of skin cancer such as blue-white veil, multiple brown dots, psuedopods, radial streaming, scar-like depigmentation, globules, multiple colors, multiple blue gray dots, pigmented network [11,8,4].

There are many steps for diagnosis of skin cancer such as pre-processing, image segmentation, feature extraction, classifier for diagnosis. In this paper we discuss each step and its methods for skin cancer diagnosis. As a classifier we can use artificial neural network, fuzzy rule based system or adaptive fuzzy inference neural network.

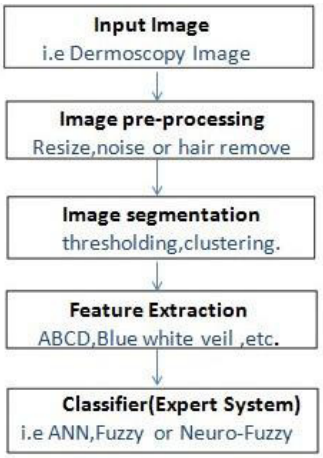


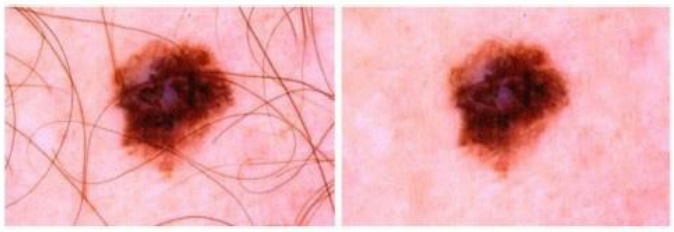
Fig. 1 Steps of skin cancer diagnosis.

2. Steps for Skin Cancer Diagnosis

Dermoscopy also known as Epiluminenescence. In diagnosis process, input image is dermatoscopic image. It is imaging technique used to examine skin lesions with a dermatoscope [7]. Skin cancer diagnosis includes different steps as shown in Fig. 1. In this paper we will discuss each step of diagnosis process.

2.1. Image pre-processing

Preprocessing is the first stage of detection to improve the quality of images, removing the irrelevant noises such as hair, bubbles etc. These noises cause inaccuracies in classification [7]. We need pre-processing of input image because of several reasons [4]: (i) low contrast between skin lesion and surrounding skin, (ii) irregular borders, (iii) artifacts such as skin lines, hairs, black frames, etc.



(a) (b)

Fig. 2 (a) original image (b) hair removal [4].

We can apply various filter such as median filter, adaptive median filter, mean filter, gaussian filter and adaptive wiener filter for de-noising from gaussian noise, salt and pepper noise, poisson noise and speckle noise [2]. For instance, image that contain hairs it may lead to misclassification hence we have to remove hair as shown in Fig. 2. We can also use dull razor software or morphological operations for removing hair. Fig.3 describes techniques of preprocessing of dermatoscopic image.

The aim of the pre-processing stage can be achieved through three process stages of image enhancement, image restoration and hair removal. As shown in Fig. 3, image enhancement can be categorized in image scaling, color space transformation and contrast enhancement. Image restoration can be categorized in restoration from noise and restoration from blur. We can remove hair using morphological methods, curvilinear structure detection, etc. Input images are gathered from many sources hence we have to convert in standard size, standard colour and remove the irrelevant information such as noise, bubbles, hair, etc.

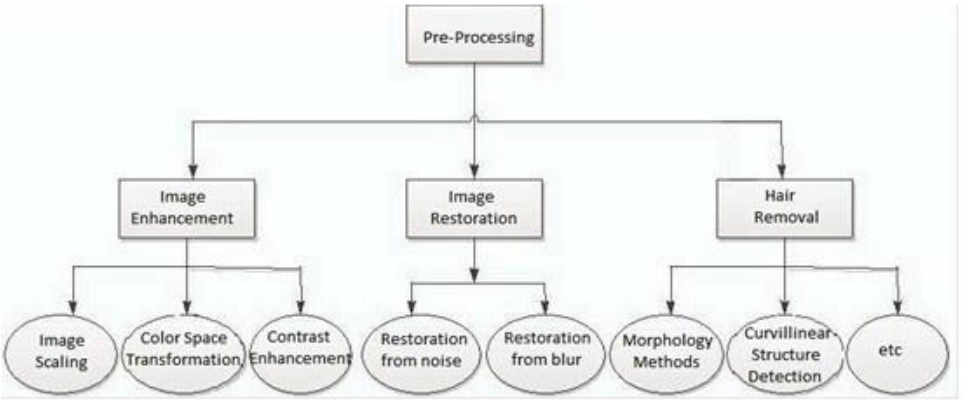
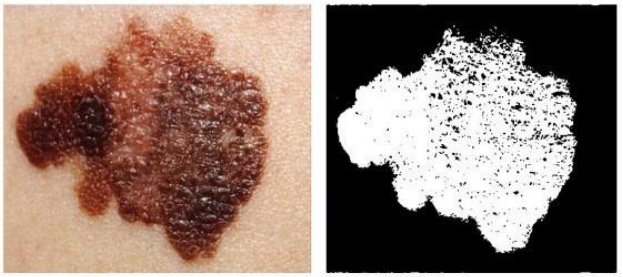


Fig. 3 Techniques of pre-processing [1].

2.2. Image Segmentation

Segmentation separates ROI image from background. ROI is a region that we want to examine. Output of this step is separated cancerous part of image and healthy part of image. There are mainly four types of segmentation method [7, 4, 12, 10]:

(i) Threshold base - This type includes method such as otsu's method, local and global thresholding, maximum entropy, histogram based, etc.
(ii) Region based - This type includes methods such as seeded region growing, watershed segmentation, etc.
(iii) Pixel based - This type includes methods such as fuzzy c - means clustering, markov random field, artificial neural network that is reinforcement algorithm, etc.
(iv) Model based - This type includes methods such as parametric deformable model, level sets, etc.



(a) (b)

Fig. 4 (a) original image (b) segmented image [7].

Skin lesion and surrounding skin is separated as shown in Fig. 4. We can use IMAGEJ software for color segmentation [7]. We can also use EDISON (edge detection and image segmentation system) for detect edge between skin lesion and background image. Accurate detection of edge between skin lesion and background skin is very essential because area or diameter of skin lesion is important parameter for this reason sometimes it leads to misclassification of benign melanoma and malignant melanoma.

2.3. Feature Extraction

Malignant melanoma and benign melanoma visible same in initial stage therefore difficult to differentiate melanoma. There are some unique features such as blue white veil, irregular streaks, multiple color, and multiple brown dots that distinguish malignant melanoma from benign melanoma. Some researcher uses natural computing method such as reaction diffusion cellular neural network and cellular automata [5]. After skin lesion area determine, color related, texture related and border related features are extracted [14].

The features are classified as internal features and external features. Internal features we can extract from dermoscopic image such as globules, pigmented network, irregular streaks, blue white veil, area of cancerous part, etc. External features include information obtain from patient such as itching on skin, age, family history, etc. There are some attributes that are obtained from dermatoscopic image. For instance, contrast or local intensity of pixel, correlation, energy, homogeneity, mean, skewness, kurtosis, entropy, distribution, standard deviation, etc [20]. There are many methods that are used in diagnosis process such as ABCD rule, menzies method, seven-point checklist method and pattern analysis [8].

2.3.1 ABCD rule –

This method differentiates benign melanoma or malignant melanoma [10]. This rule is based on semi-quantitative analysis of the criteria: asymmetry (A), border (B), color (C), different dermoscopic (D) structures [17]. Some of the researcher follows D as diameter, if diameter is larger than 6 millimeter and / or growing in followed one month than it is malignant melanoma [5]. In ABCD method, each assign score and multiply it with factor. This value is referring as TDV (Total Dermoscopic Value).

- Asymmetry (A): The dermoscopic image is divided into two perpendicular axis that are placed in such a way so that they generate a lowest possible asymmetry score [15]. As shown in table, if the dermoscopic image shows asymmetry properties with respect to axis, the score is 2. If dermoscopic image shows asymmetry on one axis then the score is 1 and the score will be 0, if asymmetry is absent in dermoscopic image.
- Border (B): The image of the lesion is divided into eighth and a sharp, abrupt cut-off of the pigment pattern at the periphery within one eighth has a score 1 [15]. Dermoscopic image with score 0 has a gradual, hazy cut-off.
- Color (C): Cancerous skin is characterized by three or more colors such as black, blue-white, dark red, light - brown. These colors are counted in the color score.

Table 1. ABCD rule method [19].

Criteria	Score	Factor	TDV
Asymmetry	0 - 2	1.3	0 – 2.6
Border	0 - 8	0.1	0 – 0.8
Color	1 - 6	0.5	0.5 – 3.0
Dermoscopic structures	1 - 5	0.5	0.5 – 2.5
Total Score		Benign	< 4.76
		Suspicious	4.76 – 5.54
		Malignant	>5.54

- Dermoscopic Structure or Diameter (D): Dermoscopic structures are globules, irregular steaks, dots, pigmented network, etc. If diameter is greater than 6 mm in this case lesion classified as malignant melanoma.

After all the features of ABCD are evaluated, calculation of TDV is done [15]. Formula of TDV is define by [15]:

TDV = 1.3 * A + 0.1 * B + 0.5 * C + 0.5 * D

This equation used to distinguish benign melanoma, suspicious and malignant melanoma. If TDV > 5.54 than lesion classified as malignant melanoma.

2.3.2 Menzies method –

To diagnose a lesion to be malignant or benign it must have neither of both negative features and one or more of nine positive features [15].

Table 2. Menzies method [15].

Negative Features	Positive Features
• Symmetry of lesion • Presence of single color	• Blue-white veil • Multiple brown dots • Psuedopods • Radial Streaming • Scar-like depigmentation • Globules • Multiple 5-6 colors • Multiple blue –gray dots • Broadened network

Positive and negative features that are mentioned in Table 2 define by [11,15,16,18] :

- Symmetry of lesion: Symmetry of pattern requires all the axis passes through center of lesion and does not require symmetry of shape.
- Presence of single color: Colors such as black, gray, blue, dark brown, red and tan are scored. White is not scored as color.
- Blue-white veil: Irregular, structure less areas of confluent blue pigmentation with an overlying white “ground-glass” film.
- Multiple Brown dots: Multiple dark brown dots in skin lesion area.
- Radial Streaming: It is linear extension of pigment at the periphery of a lesion as radially arranged linear structures in the growth direction.
- Psuedopods: It is finger-like projections of dark pigment (brown to black) at the periphery of the lesion.
- Scar-like depigmentation: Areas with white, distinct, irregular extension.

- Globules: Black dots found at or near the region of interest area.
- Multiple colors: Colors such as black, gray, blue, dark brown, tan and red found in region of interest area.
- Multiple blue-gray dots: Foci of multiple blue or gray dots frequently described as "pepper-like" in pattern.
- Broadened network: A network made up of irregular, thicker cords.

Manzies method provide highest sensitivity due to this reason many researchers refer this method for diagnose malignant melanoma or benign melanoma.

2.3.3 Seven Point Checklist Scoring Method –

This method defines only seven standard dermoscopic criteria. A scale is given from 1 to 7. Scaling method is based on major and minor criteria present in lesion. Presence of major criteria adds 2 points and presence of minor criteria adds 1 point. If the score is greater or equal to 3 than it classified as malignant melanoma. If we compare the performance of ABCD rule method and seven-point checklist methods, seven-point check list method allows less experienced observers to achieve higher diagnostic accuracy value [17]. This method refers chromatic characteristics, the shape, and texture of lesion. As shown in Table 3, major criteria for diagnosis skin cancer are blue - white veil, atypical pigmented network, atypical vascular pattern and minor criteria are irregular streaks, irregular pigmentation, irregular dots/globules, and regression structures.

Table 3. Seven-point check list method [15,17].

Criteria	Score
Major criteria	
1. Atypical pigmented network	2
2. Blue-White veil	2
3. Atypical vascular pattern	2
Minor criteria	
4. Irregular streaks	1
5. Irregular pigmentation	1
6. Irregular dots/globules	1
7. Regression structure	1
Score	<=3 non melanoma >= malignant melanoma

2.3.4 Pattern Analysis –

These methods try to find specific patterns which may be global or local. Global patterns can be reticular, globular, cobblestone, homogenous, starburst, parallel multi component, unspecific [15]. Local patterns are pigment network, irregular streaks, globules or black dots, inadequate pigmentation, blue-white veil, regression structures, vascular structures. This method is based on the qualitative assessment of numerous individual dermatoscopic criteria [17].

2.4 Classifier

Classifier is used to classifying malignant melanoma or benign melanoma. We can use artificial intelligence approaches such as artificial neural network, fuzzy based inference system and adaptive fuzzy inference neuro system. Some researcher does not use this type of classifier. For instance, irregular streak and blue white veil are the sign of malignancy. They find the irregular streaks by orientation of streaks and direction of streaks and validate them using algorithms [11]. This type of diagnosis methods are not accurate compare to machine learning methods because it depend only on one feature or criteria. We will discuss machine learning methods as follows:

2.4.1 Artificial Neural Network

Neural network is capable to solve highly complex tasks due to the nonlinear processing capabilities of neurons.

Artificial neural network can be successfully used with medical images due to the prediction power. Patient information plays important role in diagnosis of skin cancer but this information is difficult to be synthesized by human brain and this is the point where ANN proves its power [6].

Skin cancer diagnosis is difficult because in initial stage malignant melanoma visible similar as benign melanoma. This problem overcomes by artificial neural network because neuron leans from example. First some tested dermoscopic image is given to neuron for training. Back propagation algorithm is used to train neurons. In back propagation algorithm, flow will be in forward direction. The output from network is compared with desired output, if it is not match then error signal generated and error propagate backward direction. Weights are adjusted to reduce the error [6]. This process continues until error is zero. Error is defined as difference between output of network and desired output.

Neural networks are structured in layers. Layers consist a number of interconnected nodes which contain an activation function. Activation functions such as sigmoid function, piecewise linear function, tangent hyperbolic function, threshold function, etc. The network consists of an input layer of source neurons from where patterns are presented to the network, which communicates to at least one middle or hidden layer of computational neurons and an output layer of computational neurons.

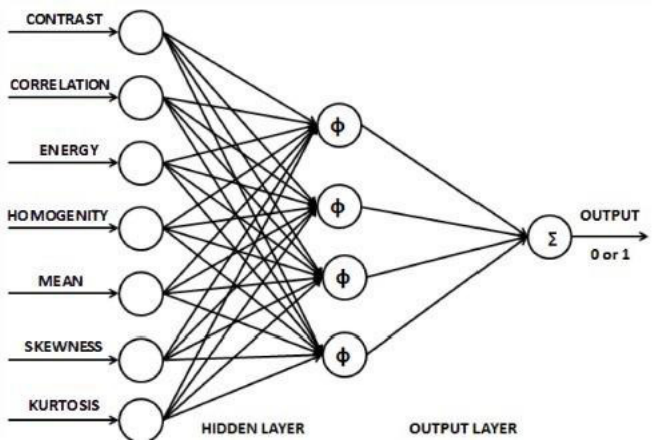


Fig. 5 structure of artificial neural network [7].

As shown in Fig. 5, internal features of dermatoscopic image such as kurtosis, mean, skewness, energy, contrast given as input and applying log sigmoid activation function which gives output zero or one [6]. Zero represent benign condition and one represent malignant condition.

2.4.2 Fuzzy rule based system –

Fuzzy rule based system has a number of properties that make it suitable for formalizing the uncertain information on which medical diagnosis is based. The Fuzzy inference is the process of mapping a given input to an output using fuzzy logic. For instance, features such as color of skin lesion extracted from dermatoscopic image that is given as input. This input fuzzified using membership function. Membership function are bell membership function, Gaussian membership function, sigmoid membership function, Z-shape membership function, S-shape membership function, etc. Fuzzy set allows intershade variation and color shade variation among skin lesion [9]. Fuzzy inference system provides accurate identification of skin cancer [10]. Fuzzy logic provides reasoning methods that is capable to infer from rules. For simple illustration, suppose the fuzzy system contains two fuzzy rules [13]:

Rule 1: IF x is A_1 AND y is B_1, THEN $f_1 = p_1x + q_1y + r_1$

Rule 2: IF x is A_2 AND y is B_2, THEN $f_2 = p_2x + q_2y + r_2$

Fuzzy inference system infers f from rule f_1 and f_2 and f define by [13]:

$$f = w_1f_1 + w_2f_2 / w_1 + w_2$$

In skin cancer diagnosis, if one image has blue - white veil feature and another image have globules than it may

infer the colors blue, white, dark red and compare with multi color feature and also infer that malignant melanoma have both blue - white veil and dark red patches then it classified as malignant melanoma.

2.4.3 Adaptive fuzzy inference neural network (AFINN) –

AFINN compromises the advantage of fuzzy inference rules and neural network by combining the human expert knowledge, inference ability of fuzzy and ability to adapt or learn of neural network. Hence this approach is more powerful than neural network and fuzzy logic. Some researcher use information gain method to reduce number of input in AFINN system [13]. AFINN consist of two layers, one is input-output layer and another is rule layer. I/O layer consist of input part and output part. Each node in rule layer consists of one fuzzy rule [14]. Weights from the input part to rule layer and rule layer to output part is fully connected. They store if – then rules in which input part to rule layer store if parts and rule layer to output part store then parts. The shape of membership function is adjusted automatically in learning. AFINN adjust parameters such as w_{ij} in learning phase and weights are adjusted using back propagation algorithm.

3. Conclusion

The objective of this paper is to discuss all the phase of computer aided diagnosis of skin cancer and its efficient methods. We conclude that AFINN gives more accurate result than neural network and fuzzy rule based system and computer aided diagnosis is more appropriate than traditional biopsy method. Patient information plays important role in diagnosis process. Henceforth, we can combine patient history such as itching on skin, age, hair loss, etc in classification phase.

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