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Artificial Neural Network for SkinCancer Detection

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Abstract

In this study, we investigated a computer aided diagnosis system for skin cancer detection problem. Early detection of skin cancer has the ability to reduce mortality and morbidity. There are many diagnostic technologies and tests to diagnose skin cancer. Conventional diagnosis method for skin cancer detection is Biopsy method. It is done by removing or scraping off skin and that sample under goes a series of laboratory testing. To prevent these problems, we are using a neural network system (NN) as promising modalities for detection of skin cancer. The different stages of detection involves- collection of Dermoscopic images, filtering the images for removing hairs and noises, segmenting the images using Maximum Entropy Threshold, feature extraction using GLCM and c1assification using Artificial Neural Network (ANN).It c1assifies the given data set into cancerous or non-cancerous image. Cancerous images are classified as melanoma and non-melanoma skin cancer.

Keywords:- Artificial Neural Network, BCC, GLCM, SCC, Skin Cancer.

1.INTRODUCTION

Skin Cancer is a deadly condition affecting the skin [1]. Skin Cancer is the disease affecting the skin. There are two main types of skin cancer Melanoma and Non-Melanoma. Skin cancer may appear as malignant or benign form. Malignant melanoma is the appearance of sores that cause bleeding [7]. Malignant Melanoma is the deadliest form of all skin cancers. It arises from cancerous growth in pigmented skin injury. If diagnosed at the right time, this disease is curable. Melanoma diagnosis is difficult and needs sampling and laboratory tests. It can spread out to all parts of the body through lymphatic system or blood. Laboratory sampling often causes the inflammation or even spread of lesion. So, there has always been lack of less dangerous and time-consuming methods. There are some unique symptoms of skin cancer, such as: Asymmetry, Border irregularity, Color variation, Diameter and Evolving. Those are popularly known as ABCD parameters [3]. Asymmetry is one half of the tumor does not match the other half. Border Irregularity is the unevenness of images. Color intensity change in the lesion region is irregular. Malignant melanoma is having a diameter greater than 6 mm. Squamous cell cancer (SCC) and basal cell cancer (BCC) are the most common types of skin cancer. Both are known as non-melanoma skin cancer .BCCs are abnormal, uncontrolled growths or lesions that arise in the skin's basal cells, which line the deepest layer of the skin. BCCs often look like open sores, pink growths, shiny bumps, or scars. It usually occurs in places that have been in the sun. In people with fair skin, basal cell skin cancer is the most common type of skin cancer. Squamous cell carcinoma (SCC) is an uncontrolled growth of abnormal cells arising in the squamous cells, which compose most of the skin's upper layers (the epidermis). SCCs often look like scaly red patches, open sores, elevated growths with a central depression, or warts; they may crust or bleed. SCC is mainly caused by cumulative UV exposure over the course of a lifetime. In people with dark skin, squamous cell skin cancer is the most common type of skin cancer, and it's usually found in places that are not in the sun, such as the legs or feet. Neural networks (NN) are a large class of models developed in the cognitive sciences, the structure of which was inspired by that of the nervous system of living beings. Certain applications of NN in medicine have led to significant improvement in medical decision making, including pigmented skin lesions and skin cancer. Each NN has an input layer, hidden layers, and output layer. Log-sigmoid transfer functions have often been used by multilayer a network, which gives an output of 0 or 1. Zero represents non-cancerous or benign condition and one represents cancerous condition.

Stages of skin cancer

The term 'stage of cancer' means the stage the cancer was at when it was first diagnosed. Being sure about the stage is very important because it is a critical factor in deciding the best way to treat the cancer. Stages of skin Cancer are given below [8][9]:

1. Stage 0

Stage 0 is also called Bowen's disease or carcinoma. It means the cells are still in the place where they started to develop. So the cells have started to turn into cancer, but they have not yet spread or grown into surrounding areas of the skin. If it is not treated, Bowen's disease can develop into a squamous cell skin cancer. So doctor may describe this stage as pre- cancerous or pre malignant.

2. Stage 1

Stage 1 means the cancer is 1 to 2 mm across or less and has 1 or no high risk features. High risk features mean the cancer

- Is more than 2mm thick
- Has grown into the lower dermis
- Has grown into the space around a nerve (peri neural invasion)
- Started on the ear or lip
- Looks very abnormal under the microscope (the cells are poorly differentiated or undifferentiated)

3. Stage 2

Stage 2 means the cancer is more than 2 mm across, or has 2 or more high risk features

4. Stage 3

Stage 3 means the cancer

- Has grown into the bones in the face, such as the jaw bone or the bone around the eye, OR
- Has spread to a nearby lymph node (or lymph gland) on the same side of the body (and is more than 3cm)

2.PROBLEM STATEMENT

Conventional diagnosis method for skin cancer detection is Biopsy method. It is done by removing or scraping off skin and that sample undergoes a series of laboratory testing. It is painful and time consuming one. Computer based skin cancer detection is more advantageous to patients, by which patients can identify the skin cancer without going to hospital or without the help of a doctor. Skin cancers found and removed early are almost always curable. To obviate these problems, image processing techniques, a neural network system (NN) are used in this paper as promising modalities for detection skin cancer. Neural Network is able to solve highly complex problems due to the nonlinear processing capabilities of its neurons. In this study a feed forward multilayer network is used.

3.METHODOLOGY

The methodology uses image processing techniques and Artificial Intelligence. The dermoscopy image of skin cancer is taken and it is subjected to various pre-processing for noise removal and image enhancement. Then the image is segmented using Maximum Entropy Thresholding. There are certain features unique for skin cancer regions. Such features are extracted using feature extraction technique – Gray level co-occurrence matrix. These features are given as the input nodes to the neural network. Artificial Neural Network act as classifier and Back-Propagation Neural (BPN) Network is used for classification purpose. It classifies the given data set into cancerous or non-cancerous.

1) Dermoscopy

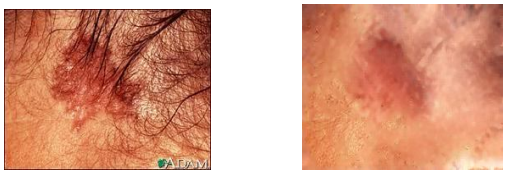
Dermoscopy is also known as Dermatoscopy or Epiluminescence Light Microscopy (ELM) [1]. The image obtained from such a dermatoscope is called Dermoscopic Image.

2) Dull Razor Filtering

The Dermoscopic Images are in Digital format. Pre-processing is done to removes the noise, fine hair and bubbles in the image. The Hair removal is done here by using Dull Razor Filter [2].

Dull Razor performs the following steps:

1. It identifies the dark hair locations by a generalized grayscale morphological closing operation.
2. It verifies the shape of the hair pixels as thin and long structure, and replaces the verified pixels by a bilinear interpolation.
3. It smooths the replaced hair pixels with an adaptive median filter.



a) With **hair** **b)** Without hair

Fig. 1 Dull Razor Filter

3) Converting to gray scale

The standard image size is taken as 360x360 pixels. Before preprocessing, the color cancer image converted into grayscale image by eliminating hue and saturation. The algorithm is to convert RGB values to grayscale values by forming a weighted sum of R,G and B Component [11]:

$$0.2989\times R+0.5870\times G+0.1140\times B \quad (1)$$

4) Contrast Enhancement

In this step, we are trying to increase image clarity and obtain better performance [4]. It is done to enhance the shape and edges of image. In addition, contrast enhancement can sharpen the image border and improve the accuracy for segmentation.

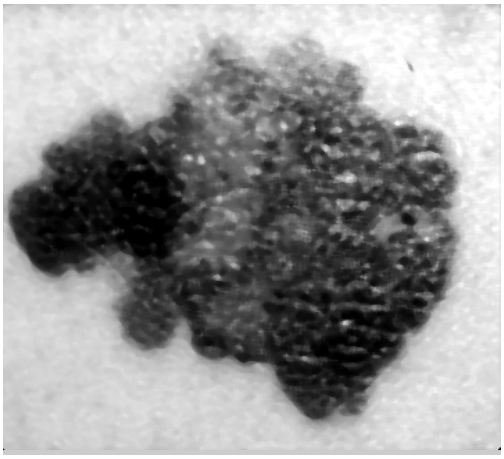


Fig. 2 Contrast Enhancement

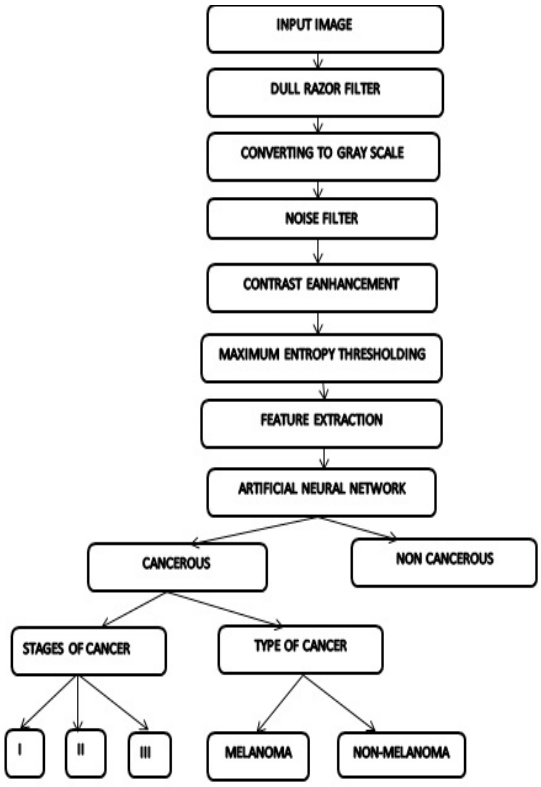


Fig. 3 Block Diagram representation

5) Noise Filtering

We used Median Filtering to remove noise. Median filtering is used for minimizing the influence of small structures like thin hairs and isolated islands of pixels like small air bubbles [2]. It is used to remove pepper and slat noise.

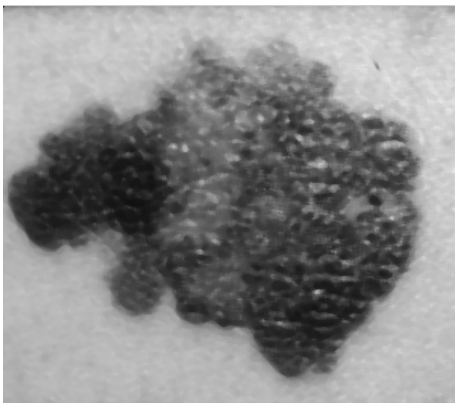


Fig.4 Noise Filtering

6) Maximum Entropy Thresholding

Segmentation removes the healthy skin from the image and finds the region of interest. Segmentation used is Maximum Entropy Threshold Segmentation. The input to a Thresholding operation is typically a grayscale. After segmentation, the output is a binary image. Segmentation is accomplished by scanning the whole image pixel by pixel and labeling each pixel as object or background according to its binarized gray level.

Fig. 5 Threshold Segmentation

Maximum entropy Thresholding is based on the maximization of the information measure between object and background [6]. The motivation of using the maximum entropy method to solve threshold selection problem is from Shannon's classic notion of entropy. The 2-D maximum entropy method is based on the 2-D histogram of the image [6]:

$$P_{ij} = \frac{n_{ij}}{N \times N} \quad (2)$$

Where N × N denotes the image size, and n_{ij} denotes the number of a pixel whose grey value equals i and local average value equals j.

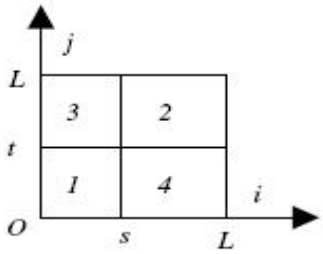


Fig. 6 The 2D histogram Plane

Suppose the area 1 and area 2 has different probability distributions. According to the threshold vector (t, s), we denote P1 and P2 as:

$$P_1 = \sum_{i=0}^{s-1}\sum_{i=0}^{t-1} P_{ij}\,, P_2 = \sum_{i=s}^{L-1}\sum_{i=t}^{-1} P_{ij} \quad (3)$$

Then the 2-D discrete entropy can be defined as:

$$H = -\sum\sum P_{ij} \log P_{ij} \quad (4)$$

The 2-D entropy of area 1 can be derived as follows:

$$H(1) = logP_1 + \frac{H_1}{P_1} \quad (5)$$

The 2-D entropy of area 2 can be derived as follows:

$$H(2) = logP_2 + \frac{H_2}{P_2} \quad (6)$$

Where, H_1 and H_2 are described as,

$$H_1 = -\sum_{i=0}^{s-1}\sum_{j=0}^{t-1} P_{ij} \log P_{ij} \quad (7)$$

$$H_2 = -\sum_{i=s}^{L-1}\sum_{j=t}^{-1} P_{ij} \log P_{ij} \quad (8)$$

The Function entropy is:

$$\phi(s,t) = H(1) + H(2) \quad (9)$$

4) Feature Extraction

.Feature Extraction technique used is gray Level Co-occurrence Matrix (GLCM)[1] .It is a powerful tool for image feature extraction by mapping the gray level co-occurrence probabilities based on spatial relations of pixels in different angular directions [1]. They are mean, standard deviation, Skewness, Kurtosis,Contrast,Energy, Homogeneity [5]. Mean or expected value provides a measure of distribution. It is calculates as follow:

$$\text{mean} = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n} P_{ij} \quad (10)$$

Variance is a measure of dispersion in the distribution, the square root of the variance is called standard deviation.

$$\text{Standard Deviation} = \sqrt{\frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}(P_{ij} - \text{mean})^2} \quad (11)$$

Skewness is a measure of asymmetry. A data set, is symmetric if it looks the same to the left and right of the center point.

$$\text{Skewness} = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}\frac{(P_{ij} - mean)^3}{(standard\ deviation)^3} \quad (12)$$

Kurtosis is a measure of whether the data are peaked or flat relative to a normal distribution. That is, data sets with high kurtosis tend to have a distinct peak near the mean.

$$\text{Kurtosis} = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}\frac{(P_{ij} - mean)^4}{(standard\ deviation)^4} - 3 \quad (13)$$

The contrast measures the coarse texture or variance of the grey level. The contrast is expected to be high in coarse texture, if the grey level of contrast corresponds to large local variation of the grey level.

$$\text{Contrast} = \sum_{i=1}^{m}\sum_{j=1}^{n}(i-j)^2 P_{ij} \quad (14)$$

The Angular Second Moment (ASM) measures textural uniformity. The ASM (or energy) is computed as:

$$\text{Energy} = \sum_{i=1}^{m}\sum_{j=1}^{n} P_{ij}^{\ 2} \quad (15)$$

The homogeneity is computed as:

$$\text{Homogeneity} = \sum_{i=1}^{m}\sum_{j=1}^{n}\frac{P_{ij}}{1+|i-j|} \quad (16)$$

The correlation texture measures the linear dependency of gray levels on those of neighboring pixels. This feature is computed as:

$$\text{correlation} = \sum_{i=1}^{m}\sum_{j=1}^{n}\frac{(ij)(P_{ij} - \mu_i'\mu_j')}{\sigma_i'\sigma_j' j'} \quad (17)$$

Where,

$$\mu_i' = \sum_{i=1}^{m}\sum_{j=1}^{n} i * P_{ij}$$

$$\mu_j' = \sum_{i=1}^{m}\sum_{j=1}^{n} j * P_{ij}$$

$$\sigma_i' = \sum_{i=1}^{m}\sum_{j=1}^{n} P_{ij}(i - \mu_i')$$

$$\sigma_j' = \sum_{i=1}^{m}\sum_{j=1}^{n} P_{ij}(j - \mu_j')$$

Where, m is the row of the gray level co-occurrence matrix, n is the column of the gray level co-occurrence matrix, and P_{ij} is the value of GLCM on rows i and column j.

5) Artificial Neural Network Classifier

Classifier is used for classifying Malignant Melanoma from other skin diseases [1]. Based on the computational simplicity Artificial Neural Network (ANN) based classifier is used. In this proposed system, a feed forward multilayer network is used. The neural network classifier structure consists of Input layer, Hidden layer and Output layer. The hidden and output layer adjusts weights value based on the error output in classification. The output of the network is compared with desired output. If both do not match, then an error signal is generated. This error is propagated backwards and weights are adjusted so as to reduce the error. The modification of the weights is according to the gradient of the error curve, which points in the direction to the local minimum. In BPN, weights are initialized randomly at the beginning of training. There will be a desired output, for which the training is done. Supervisory learning is used here. The aim of this network is to train the net to achieve a balance between the ability to respond correctly to the input patterns that are used for training [12]. During forward pass of the signal, according to the initial weights and activation function used, the network gives an output. That output is compared with desired output. If both are not same, an error occurs.

Error = Desired Output - Actual Output

This pattern recognition network consists of 7input, 10 hidden layer and one output.

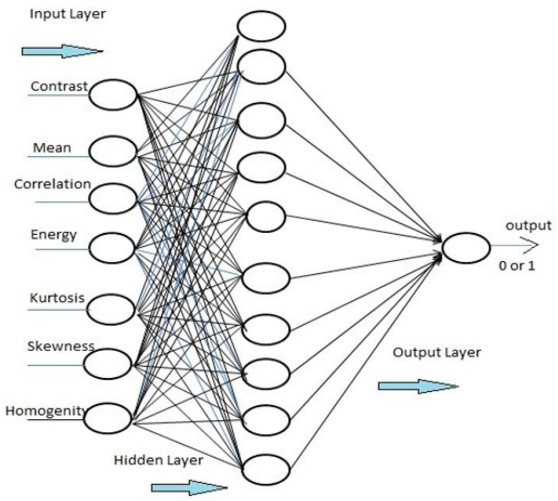
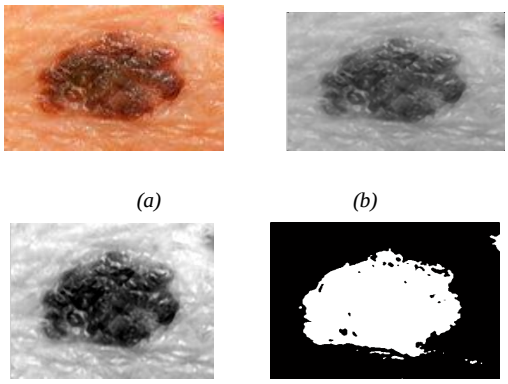


Fig. 7 Structure of Artificial Neural Network

4.RESULT AND DISCUSSION

In this system, Dermoscopic images were collected from Internet[7-9]. They were undergone hair removal by Dull Razor software and filtered using Median Filtering. After that, Filtered images were segmented by Maximum Entropy Threshold Segmentation. Feature Extraction technique used is GLCM. The obtained Features were given as inputs to a Feed Forward Neural Network, which gives an output of 0 or 1. Zero represents non-cancerous or benign condition and one represents cancerous or malignant condition.



(a) *(b)*

c) *(d*

Fig 8 a) input image b) without Noise c) Enhanced Image d) Segmentation using Maximum Entropy Thresholding

Table 1 shows the result of the feature extraction using GLCM. Fig.9 shows the Best Validation performance.

TABLE 1. FEATURE EXTRACTION USING GLCM

Contrast	Correlation	Homogeneity	Energy	Mean	Skewness	Kurtosis

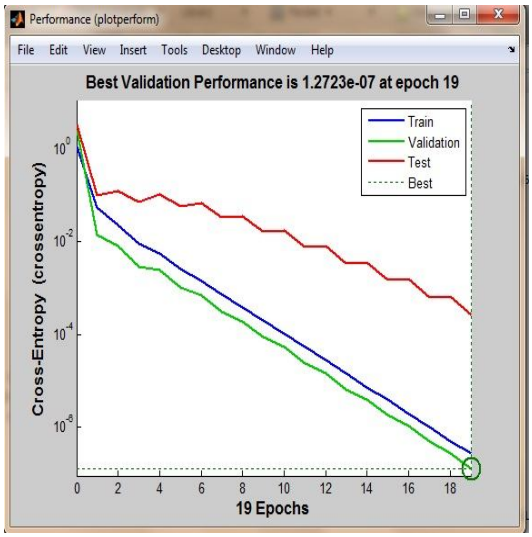


Fig. 9 Best validation Performance of Using GLCM Method

The experiments were designed to test the effectiveness of input features in discriminating cancerous images from other. We used 90 images for training and for testing; we randomly selected 30 images from training database. The ANN classifier classified the given data into cancerous and noncancerous. From collected database 20 images are classified as cancerous and 6 images are classified as Non-cancerous. There are total 4 miss-classification. Also, we are able to find the stages of the cancer depending upon the area of the lesion and type of cancer (Melanoma and Non-Melanoma) depending upon the color variation. Fig . 10 the confusion matrix of the test image witch give the 96.6% accuracy.

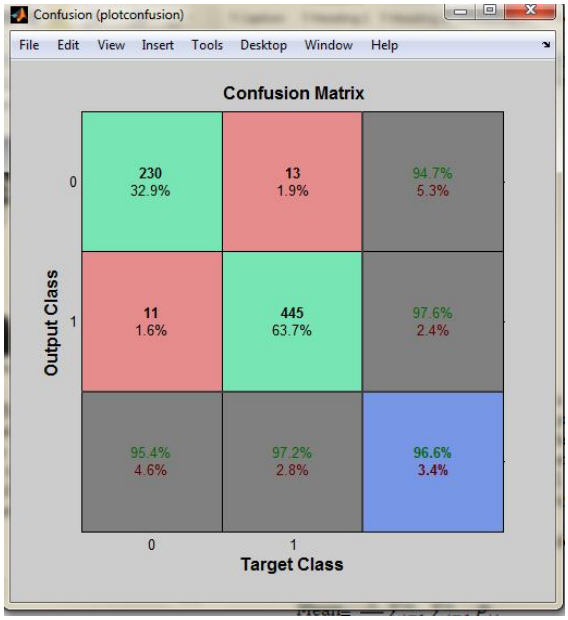


Fig 10: Confusion Matrix

TABLE 2. CLASSIFICATION RESULT

Contrast	correlation	Homogeneity	Energy	Mean	skewness	Kurtosis	O/P	Type	Stages
0.0776	0.9526	0.98864	0.16583	95.29	-5.5231	5.0096	1	Melanoma	III
0.06014	0.9489	0.99716	0.13957	95.280	-7.0549	7.3247	1	Melanoma	III
0.07915	0.9593	0.98851	0.1843	99.54	-4.9618	4.0624	1	Melanoma	III
0.0565	0.9526	0.99909	0.1456	98.76	-6.1943	6.5494	1	Non-Melanoma	III
0.0644	0.9996	0.9952	0.2548	95.29	-3.2095	2.156	1*	--	--
0.0694	0.9575	0.99246	0.1688	95.28	-4.94917	4.1434	1	Non-Melanoma	II
0.0859	0.9502	0.98472	0.159	99.54	-3.8128	2.8521	1	Melanoma	III
0.0494	0.9537	1.00249	0.1441	98.76	-9.2152	11.5421	1	Melanoma	III
0.0567	0.95439	0.99882	0.14994	95.59	-5.2958	4.7334	1	Melanoma	I
0.0541	0.9988	1.0001	0.2503	101.72	-3.13344	1.941	1*	--	--
0.0567	0.9543	0.9988	0.1499	98.74	-5.2958	4.7334	1	Melanoma	I
0.0973	0.9374	0.9796	0.1378	96.93	-9.0447	11.068	1	Non-Melanoma	III
0.0812	0.9507	0.986974	0.1572	97.79	-4.10102	3.246	1	Melanoma	III
0.0776	1.0267	0.98864	0.16583	95.29	-5.5231	5.0096	1	--	--
0.11062	0.94209	0.97240	0.1621	94.42	-6.3718	6.3922	1	Melanoma	III
0.0988	0.9976	0.97847	0.3224	103.5	-4.95666	4.079	1	Melanoma	I
0.0768	0.9533	0.988795	0.1664	99.96	-5.29143	4.3923	1	Non-Melanoma	III
0.0944	0.94831	0.98021	0.1657	97.58	-5.3120	4.6582	1	Melanoma	II
0.05846	0.9531	0.99805	0.1489	95.75	-6.3794	6.2303	0	--	--
0.0807	0.9776	0.9879	0.2457	100.29	-4.776	3.7977	1	Melanoma	III
0.115	0.96181	0.9705	0.2113	94.80	-4.5130	3.476	0*	--	--
0.052	0.9673	1.0011	0.1818	96.48	-4.55	3.7448	1	Non-Melanoma	III
0.04202	0.9609	1.0070	0.1525	96.20	-5.3798	5.0833	0	--	--
0.06345	0.98135	0.9955	0.2209	94.84	-3.76375	2.8147	0	--	--
0.0759	0.9620	0.9892	0.1906	95.02	-5.90990	5.6941	1	Melanoma	III
0.0423	1.0274	1.0063	0.3524	94.70	-3.73337	2.5608	0	--	--
0.03522	1.01184	1.009	0.2652	100.56	-3.14119	2.1410	0	--	--
0.1559	0.9462	0.9546	0.199	98.43	-5.62267	4.826	0	--	--
0.0980	0.9527	0.9789	0.1804	94.857	-5.40441	5.1568	1	Non-Melanoma	III
0.0987	0.9861	1.009	0.1547	92.00	-3.001	4.123	1*	--	--

(* -Misclassification)

TABLE 3.NEURAL NETWORK DIAGNOSTIC RESULTS

Number of Images Tested	False Acceptance Ratio (%)	False Rejection Ratio (%)	Accuracy (%)
30	13.33	12.33	86.66

5.CONCLUSION

A Computer aided skin cancer detection system can achieve a new discovery of detecting benign or malignant skin lesions and separating them from healthy skins. The diagnosing methodology uses Digital Image Processing Techniques and Artificial Neural Networks for the classification of Malignant Melanoma from benign melanoma. Dermoscopic images were collected from different sites and they are processed by pre-processing. Dull Razor and Median Filter are used to remove hair, air bubbles etc. from Dermoscopy images. After pre-processing images is segmented using maximum entropy method. Maximum Entropy Thresholding is used to find out Region of Interest. The unique features of the segmented images are extracted using feature extraction techniques. This Methodology has got 86.66% accuracy. By varying the Image processing techniques and training algorithms of ANN, the accuracy are improved for this system and the images are classified as cancerous or non-cancerous.also we able to find the type of cancer and stages of cancer.

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