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Computer Aided Diagnostic System for Detection and Classification of Skin Cancer

Akila Victor, Muhammad Rukunuddin Ghalib
VIT University, Vellore
Email: akilavictor@vit.ac.in

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Abstract

Computer Aided diagnostic systems reduce the time in decision making .The objective of our paper is to present the effectiveness in the diagnosis of skin cancer. The proposed methodology discusses on the Image enhancement, the combination of the basic statistical method with the grey level coocurrance matrix (GLCM) for feature extraction, the extracted features are then fed into the classifier that is the Support Vector Machine(SVM) for the final stage i.e. the classification. Thus it is used to classify the tumor is malignant or not. The result carried out 60 images consisting of 30 normal and 30 melanoma images. The classification accuracy of 96.9 % using the SVM classifier was relatively good. Thus the method proves to a better one for the detection and classification of skin cancer.

Keywords: *Adaptive median filter, median filter, CAD, GLCM, SVM*

1. INTRODUCTION

Cancer is the most dreadful disease. There are a lot of people who are actually a victim to cancer. There are various types of cancer internal and external cancer, the internal cancer occurs within the body the external cancers occur outside the body. Still in many cases the external cancers are also identified at the later stage. The early detection of cancer can cure whereas the cancer that is detected at the later stages is quite difficult to treat. Out of much external cancer we are going to discuss on the skin cancer that is quite common among people. Any mole can be a skin cancer if it changes in its shape, structure etc. Too much exposure to the sunlight may also cause the chance f skin cancer. It is always better to have a thorough eye on our body. The skin cancer can be of many types out of which the melanoma is the most life threatening one whereas the basal cell carcinoma and squamous can be much a curing one. How does a computer aided diagnostic system help in these aspects? When we have a doubt over the mole or any part in the skin it is better to approach a physician. Once then the image is taken and are subjected to the various processes involved are common but the methodology that we use differ based on the accuracy that is obtained. Many researchers have been carried out in the field of medicine since it helps to find out the way a person can be rescued. Especially the computer aided diagnostic system can be used by a physician to capture an image or a scanned image can be fed into the developed system that goes through these series of procedure and finally conclude the particular result. The most dangerous and risky one is to know that a person has a cancer at the very late stage where the treatment becomes really difficult for the physician, so it is always

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good to be careful with our own body, if some changes occur in the body it's always good on our part to go for a checkup. Now how does this process work the image is acquired as the first stage and then are subjected to the enhancement stage, there it takes the image that is it reduces the noise by means of various filtering concepts. These filters can help to get a noise free image. As of medical image processing, each and every value becomes a very important one where we have to be very careful with the assumptions. Assuming a value is really not a good practice as of medical imaging is concerned. Then the image may be used for segmentation methodology where segmenting an image splits it into various regions and helps in identifying the region of interest. There are various segmentation methodologies that are used. And then the segmented image is fed as an input to the feature extraction phase. Feature extraction is something which helps to extract the needed information; the attribute that we can use.

The feature extraction plays as a heart of the work as detecting the right feature can help in improving the classification accuracy. So the features can be carefully extracted for the identification of the images and the calculated features are then fed into the classifiers that they help for classifying the image as benign or melanoma. Benign are normal images that are not cancerous whereas a melanoma is a cancerous image. Our classification depends on if the identified features are normal or a cancerous feature. So these are the various steps the computer aided diagnostic systems go through and it is always better if such a design is built in a physicians desktop so as to take a picture of a patient and find if he has a cancer or not within minutes time. So our system helps in detecting the feature and classifying based on the image provided [Fig 1] discusses on the image enhancement with adaptive median filtering the output is fed into a statistical method come the gray level coocurrance matrix(GLCM). And the classification using support vector machine helps in classifying if the image is cancerous or not. Thus the skin cancer detection helps in finding out the necessary details so as to help in finding out the result properly.

2. EXISTING SYSTEM

The computer aided diagnostic system for early detection of skin cancer can play a very vital role in a human's life. An early detecting system always helps in curability. But still there is always a chance even found at the later stages but the treatment for early stage is quite easier when compared to that of the later stages. There are various processes that discuss on the preprocessing methodology that helps to remove the noise and reduce the error rate. There are various methodology for preprocessing as directional filters, image filters, image cropping, image resizing, color quantization, contrast stretching [1][2].Similarly there are various segmentation methodology that are discussed such as fuzzy C means , Random Markov Random field [1] , K means , Absolute thresholding , segmentation color based image retrieval, [3][4]. Feature Extraction is the next phase and the information are retrieved and the algorithms related to that are discussed for GLCM, ABCD etc [4][5]. And the final stage is the classification stage . The classification methodology can be as artificial neural network [6][7],convolution neural network(CNN) etc. Our proposed methodology can speak about the image enhancement phase and then the feature extraction phase and most importantly the classification phase. These are the various steps

involved in detecting a skin cancer in an image. The image enhancement with the adaptive median filtering and the feature extraction with the statistical parameters and the GLCM parameters and classification using the SVM.

3. PROPOSED METHODOLOGY

Our proposed methodology can speak about the image enhancement phase and then the feature extraction phase and most importantly the classification phase. These are the various steps involved in detecting a skin cancer in an image. The image enhancement with the adaptive median filtering and the feature extraction with the statistical parameters and the GLCM parameters and classification using the SVM.

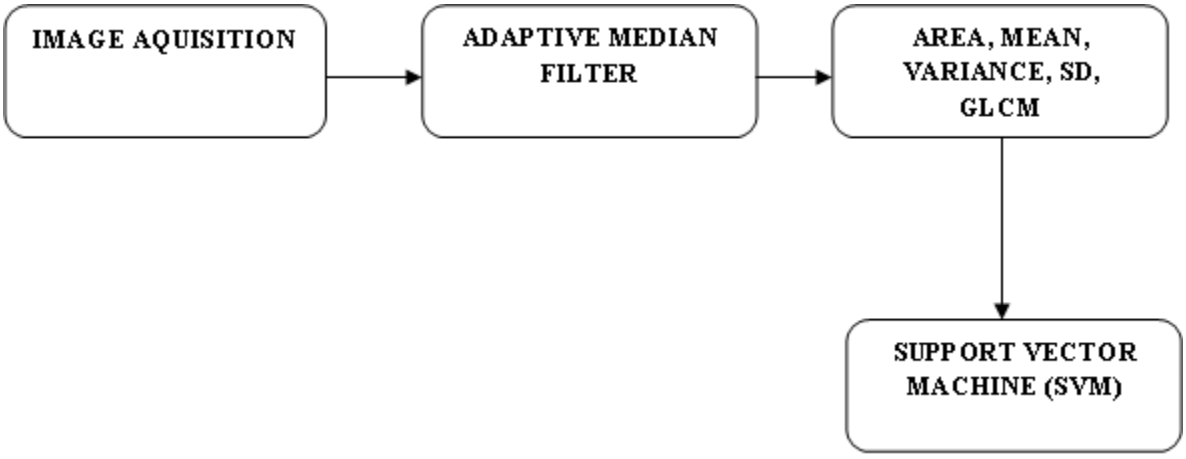

Figure 1: The various methodology involved in computer Aided Diagnostic based detection and classification

3.1 Image Enhancement

The first and the foremost phase in the early detection of computer aided diagnostic system for skin cancer images are image acquisition and image enhancement. The image acquisition can be any image scanned or the magnetic resonance image (MRI),positron emission tomography(PET) images, X ray images and so on. These images are then sent to the enhancement phase where it helps to filter the noise that is a noise free image helps in the further processing. As a medical image requires much more importance than any other image since it is directly associate with any human beings. The image enhancement uses an adaptive median filter which is an updated version of a median filter. The adaptive median filter helps in filtering the noise and to give a noise free image.

The working of the adaptive median filter can be as follows. An image is represented in the form of a matrix. So the adaptive median filter can be adaptive towards the neighborhood values. An initial basic masking is used in the image. The filter size is different based on the application that we choose. The algorithm for adaptive median filter has two steps and are as follows

Stage 1

H1 = $F_{median} - F_{min}$

H2= $F_{median} - F_{max}$

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If F1 > 0 and F2 < 0 GOTO stage 2

Else increase the filter size

If filter size < = S_{max} repeat Stage 1

Else output F_{median}

Stage 2

G1 = F_{xy} - F_{min}

G2 = F_{xy} - F_{max}

If G1 > 0 and G2 < 0, display F_{xy}

Else display F_{median}

So the above algorithm states that the an image is considered and the mask is identified first and then the value of median in that particular mask is subtracted with the minimum value and then the median is subtracted with the maximum value and the results are compared if the former is greater than 0 and the later is less than 0. The algorithm moves to stage 2. Else the filter is increased. S_{xy} is the support of the filter centered at x,y. and the F_{median} is nothing but the median of gray levels at S_{xy}. And F_{min} and F_{max} are the minimum and the maximum gray levels at S_{xy}.. F_{xy} is simply the gray level at coordinates x,y. and S_{max} is the maximum size allowed size of S_{xy}.. Now the filter size is compared with the maximal size allows and then stage 1 is repeated again else the output is the median. In stage 2 the value that is the center pixel is subtracted from the minimum value and then it is subtracted from the maximum value and then the minimum value output must be greater than o and the later must be less than 0 and then the value at F_{xy} is displayed else the median value is finalized. So this is how an adaptive median filter works on any image given and the process repeats until the nth element is calculated.

The adaptive median filter results are attached in the table below to express how the values are actually displayed and the calculated value of peak signal to noise ratio, mean squared error and signal to noise ratio are tabulated below.

The adaptive median filter in table [1] compares various metrics that are related to the preprocessing technique to finalize that the adaptive median filtering can be used to reduce the noise and give us a noise free image. Then the noise free image is fed into the feature extraction phase as an input.

3.2 Feature extraction

The feature extraction is another important and the heart of the entire process that is determined. Features are nothing but the meaningful information necessary for the early detection. The extracted features play a very vital role. The feature extraction is done by means of a basic statistical feature extraction method which includes area, mean, variance, and standard deviation (SD). And these are clubbed along with the gray level coocurrance(GLCM) features like energy, entropy, homogeneity, correlation, contrast, homogeneity, sum average, sum entropy, difference average, difference entropy etc. What is a gray level concurrence matrix the

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input image is now taken and checked for its position if horizontal, vertical, and positive and negative diagonal. Then the GLCM matrix is constructed accordingly. The equations for the feature extraction of mean, variance, area and standard deviation are as follows.

$$\text{Area} = \sum_{i=0}^{height-1} \sum_{j=0}^{width-1} F(i,j)$$

$$\text{Mean} = \sum_{i=0}^{height-1} \sum_{j=0}^{width-1} \frac{F(i,j)}{N}$$

$$\text{Variance} = \sum \frac{(J-\mu)}{M}$$

$$\text{Standard Deviation} = \sqrt{\sum_{sd=0}^{L-1} (sd - sd)^2 \; P(sd)}$$

The above equations explains the basic statistical methods like area where it defines the value of the height and width of the image considered and then the mean exactly calculates them and divide it by the total number of elements. The variance used the difference of the particular pixel and its corresponding mean and finally divided by the total. And the standard deviation is also calculated.

GLCM

GLCM is a second order feature it is calculated at a distance d with an angle θ.The input is arranged as its corresponding co- occurrence matrix which has nearly 20 features to be considered the features are entropy, energy, contrast, correlation, homogeneity, cluster prominence, cluster shadowing, dissimilarity, maximum probability, sum of squares, sum average, sum variance, sum entropy, difference variance, difference entropy, etc. The formula that is used to calculate the above features are as listed below.

Table 2 explains the various GLCM Features that are used in the proposed work so as to do a meaningful classification. The formula that are used to calculate the above table can be discussed as follows

Homogeneity

They contain the homogenous that is the same gray level values

$$Homogeneity = \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} \{F(x,y)\}^2 \; \ldots (5)$$

Contrast

The measure of local intensity variation

$$Contrast = \sum_{k=0}^{N-1} k^2 \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} \big(f(x,y)\big) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Local Homogeneity

Relatively higher value will be obtained out of this feature

$$Local\ Homogenity = \sum_{x=1}^{N-1} \sum_{y=1}^{N-1} \frac{1}{1+(x-y)^2} f(x,y) \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Entropy

It is actually representing the disorders

$$Entropy = -\sum_{x=1}^{N-1} \sum_{y=1}^{N-1} f(x,y) \times \log(f(x,y)) \ldots\ldots (8)$$

Correlation

The measure of intensity dependence

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$Correlation \quad \sum_{x=1}^{N-1}\sum_{y=1}^{N-1}\frac{\{x \times y\}\times f(x,y)-\mu_i \times \mu_j}{\sigma_i \times \sigma_j}$ ……………………………………..…… (9)

Sum of square: Variance

It is the average of the mean

$Variance = \sum_{x=1}^{N-1}\sum_{y=1}^{N-1}(x - \mu)2\, f(x,y)$……………………………..…….. (10)

Sum Average

The Sum of Average is something where the total value is found

$sumAverage = \sum_{x=1}^{2N-2} x\, P_{i+j}\ (x)$ ……… (11)

Sum Entropy

The Sum Entropy is as foll

$sumEntropy\ \sum_{x=1}^{2N-2} p_{(i+j)}\,(x) \log P_{i+j}\ (x)$(12)

Difference Entropy

The Difference Entropy is as follows

$Difference\ Entropy = -\sum_{x=1}^{N-1} P_{(i+j)}\,(x) \log P_{(i+j)}$(x)………….. (13)

Cluster Shade

The cluster shade is as follow

$$Shade = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1}\{x + y - \mu_{x-}\ \mu_{y\}}^{3} \times f(x,y) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

Cluster Prominence

The cluster prominence is as follow

$Prom = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1}\{x + y - \mu_x - \mu y\}4 \times f(x,y)$…………………….. (15)

Thus the equation(1) , (2),(3),(4),(5),(6),(7),(8),(9),(10),(11),(12),(13), (14) and (15) explains how various features are extracted from the above equations mentioned. GLCM thus explains various features with the help of that formula that are discussed above.

3.3 Classification

Support Vector Machine (SVM) is the supervised algorithm. The supervised algorithm is something which knows already a set of desired output that is trained for the required input. The feature extraction parameters are fed as an input to the SVM classifier and it helps in classifying the input as benign or melanoma.SVM is one of the classifier which helps in improved results. It defines a kernel and is said to be a kernel method. It uses a hyperplane to classify the features and display the result accordingly. SVM is one of the best classification methods that are in practice. The GLCM features are fed into the classifier and the classification rate are obtained.The classification accuracy that is obtained is 96.9 %.

4. PERFORMANCE EVALUATION

The input with the adaptive median filter is fed as an input to the GLCM and statistical feature vectors and the support vector machine is the classifier that is used. Performance measures are evaluated using the accuracy, specificity, and sensitivity.

The accuracy can be calculated from below equation

$$ACCURACY = \frac{TP + TN}{TP + TN + FP + FN} \quad \ldots\ldots\ldots\ldots.\quad (16)$$

The sensitivity can be calculated from below equation

$$SENSITIVITY = \frac{TP}{TP + FN} \quad \ldots\ldots\ldots\ldots\ldots \quad (17)$$

The specificity can be calculated from below equation

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$$SPECIFICITY = \frac{TN}{TN + FP} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (18)$$

5. RESULTS

The Receiver Operating characteristic curve (ROC) explains the SVM classification based on the features taken. The curve gives an accuracy of 96.9% and the area under the curve is supposed to be 0.991837. Thus the proposed method shows a clear understanding of how the features are selected and the features are fed into the classifier to give an accurate result. The adaptive median filter also gives the noise free image and the feature extraction methodology plays a very vital role in this particular methodology. The sensitivity and the selectivity value is also obtained. Sensitivity can be calculated by dividing true positive with the sum of true positive with false negative. The specificity can be calculated by true negative with the sum of true negative with false positive. And the accuracy is calculated by the sum of true positive with true negative divided by the sum of the True Positive (TP), True Negative (TN), False positive (FP) and False Negative(FN).

The ROC curve shows that the classification rate has shown a promising rate for the above feature extraction methods. SVM uses a hyperplane to classify the input image. The class 1 is benign and class 2 as melanoma. So using the confusion matrix the following table 3 shows the performance measures of the obtained features with the value that are plotted. And the classifier gives an accuracy that is 96.7% which is comparatively a satisfied result. The performance measures are calculated and the results are analyzed accordingly. The computer aided diagnostic system thus helps us to find the value easily without stealing much of the time. But still the accuracy can be improved by considering various other factors so that the medical imaging can give a hundred percent accurate result than the clinical one.

The table 3 compares the value with the SVM and the metrics are used to measure and better classification accuracy is obtained by using the above algorithm.

Table 1: Comparison of PSNR, SNR, MSE values of Adaptive Median Filter used for preprocessing

Input Image	PSNR	SNR	MSE
1	32.8177	28.2152	52.1294
2	34.169	29.8256	24.2677
3	31.9478	27.7946	26.7344
4	30.2266	26.05	30.4705
5	32.6065	25.9556	55.2646
6	29.6225	25.9313	41.8588
7	30.0273	26.6006	34.3551
8	29.9059	25.4595	38.0873
9	30.329	26.522	38.6791
10	31.4466	25.8673	24.4702
11	29.1108	25.1612	30.7278
12	28.075	25.9492	28.0483
13	29.085	25.049	53.3695
14	33.8174	28.9424	23.4498
15	34.2554	28.9412	22.7558
16	32.1612	27.9163	31.2433

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Table 2 The various GLCM features that are calculated for three different input image

Features	Image 1	Image 2	Image 3
Auto correlation	63.80197	63.79652	63.79737
Contrast	0.14805	0.15702	0.15627
Correlation1	0.231044	0.190702	0.191454
Correlation 2	0.231044	0.190702	0.191454
Cluster Prominence	24.58858	22.11154	22.07639
Cluster Shadowing	-2.27284	-2.12664	-2.12154
Dissimilarity	0.021149	0.022431	0.022324
Energy	0.993059	0.992846	0.992877
Entropy	0.026617	0.027207	0.027109
Homogeneity	0.997356	0.997196	0.997209
Homogeneity 2	0.997039	0.99686	0.996875
Maximum Probability	0.996521	0.996414	0.996429
Sum of Squares	63.62666	63.6257	63.6257
Sum Average	15.97244	15.97223	15.97233
Sum Variance	254.5731	254.5455	254.551
Sum Entropy	0.024523	0.024986	0.024898
Difference Variance1	0.148045	0.157018	0.15627
Difference Variance 2	0.020547	0.021603	0.021515
Difference Entropy	-0.12963	-0.10083	-0.10106
Informational measure of correlation	0.060685	0.053711	0.053772
Informational Measure of correlation 2	0.99859	0.998505	0.998512
Maximum Correlation Coefficient	0.99869	0.99861	0.998617
Mean	0.7609	0.4475	0.777
Variance	0.1819	0.2472	0.1733
Standard Deviation	0.4265	0.4972	0.4162
Area	49966.75	29358.875	50948.875

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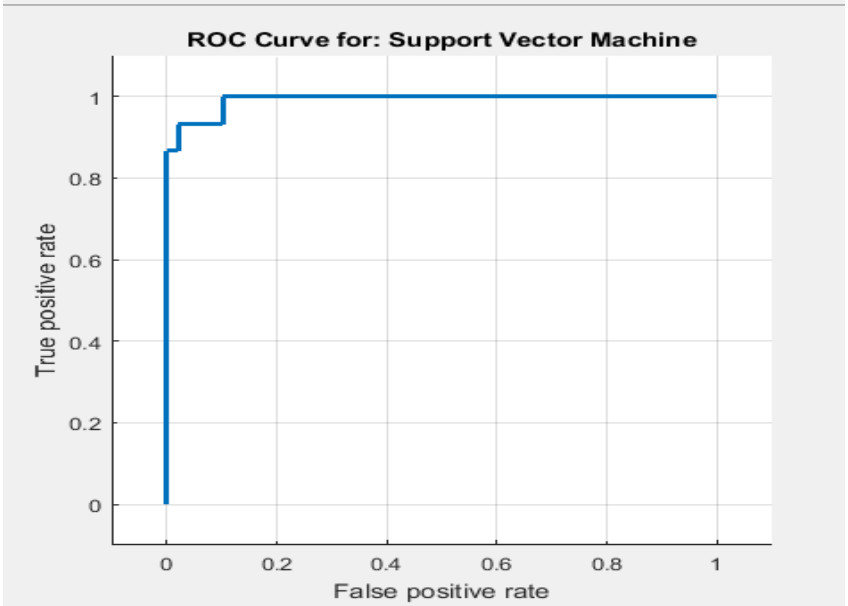

Figure 2: ROC curve for the features that were fed in by using support vector machine

Table 3: Performance evaluation using SVM classification

Performance Measures	Percentage (%)
Accuracy	96.9
Sensitivity	93.333
Specificity	97.95

6. CONCLUSION AND FUTURE WORK

The proposed work was to detect and classify the skin cancer images by various methodologies. The noise removal algorithm that we used was adaptive median filter and the feature extraction was with gray level cooccurance matrix and the statistical measures were used to extract the features. Then the features are fed into the classifier and have obtained an accuracy result of 96.9 %. But as of medical imaging is concerned the accuracy can be improved. So the future work may concentrate on adding more features to the feature extraction techniques and improving the accuracy rate.

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