SEGMENTATION TECHNIQUES IN IMAGE PROCESSING TO DETECT MELANOMA

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Abstract— Melanoma is a type of cancer that is fatal in nature. More than ninety five percent of the affected people can be saved through early detection and treatment. Technological advancements have led to computerized systems aiding in various methods to diagnose cancer. Among the various steps involved in detection of cancer, segmentation plays a major role. Segmentation is a process where we partition the images into various parts. This paper discusses various segmentation techniques. ABCD rule, MEDS, MEDS boost techniques show a diversion of around 12 % from accuracy. Several other techniques which use colour, thresholding, border detection like PSO and MRF method ,Color pigmented boundary descriptors method, Color correlogram and texture analysis method ,Otsu's thresholding (Laplacian filter)technique , Otsu's thresholding (morphological filter , SVM classifier) technique ,Geometric analysis (k-NN classifier) method have a variable accuracy of 90 % to 95 %.The values are tabulated in a table that compares the accuracy , sensitivity and specificity output by these techniques .The values show Graph cut technique over different color spaces has a remarkable accuracy of 96.98 % and TDLS algorithm that considers texture of the lesion has an accuracy of 97.9 %.

Index Terms— Segmentation, Cancer, life threatening, Melanoma, Skin lesion.

I. INTRODUCTION

In the present situation the human health is a very important factor. With today's growing technology, health conditions are deteriorating day by day. Malnutrition, lifestyle play a very important role. These are leading to many diseases such as respiratory infections, heart disease, diabetes, Cancer, Alzheimer's, strokes and many more. Among these, few diseases are curable, due to the facilities available. Whereas few may be non-curable if care is not taken in the initial stages. Cancer poses the biggest threat among all life-threatening diseases. In 2018, millions of people around the world had cancer. This number increases every year. Among males, the most common types of Cancer have been that of Lung, Prostrate, Skin, Colorectal and stomach. While in women, it has been cancer of the Breast, Colorectal, Lung and Cervix. The statistics of the rates of cancer cases in the US is shown in figure 1 [1].

Skin is considered to be the largest organ of the human body. It is a collection of three layers among which epidermis is the outermost layer, within which is the dermis, interior to this is the hypodermis. The external surface of the skin called epidermis that is composed of three cells, the squamous, the basal and the melanocyte cell. Melanocyte cell produces a protective pigment which is melanin that is required to protect us from harmful rays and damage to the skin due to sunburns. If the melanocyte cells are affected it may lead to melanoma. Although melanoma occurs very rarely, death rate of melanoma is quite high. Melanoma spreads rapidly through the Blood stream or the Lymphatic system, to other organs. The Carcinoma of the Squamous Cell and the carcinoma of the Basal cell are the Non-Melanocytic cancer, which do not spread quickly and may be treated through minor surgical intervention and topical treatment. Figure 2 illustrates the Layers and components of the skin.

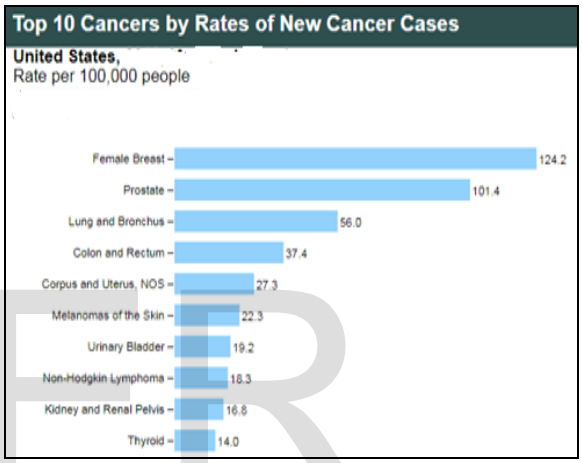

Figure 1. Statistics of rates of Cancer cases in the US

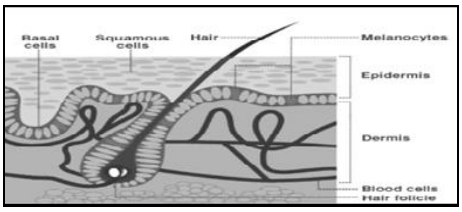

Figure 2: Layers of normal skin

An artificial patch or area of the skin that looks different and suspicious as compared to the neighboring skin [3] is called skin lesion. There are many reasons due to which skin lesions can start like, occurrence of some disease, initial birthmark, allergic responses, etc. Skin lesions are of two types, namely the primary skin lesion and the secondary lesion. Primary ones are those that are there from the time of birth like birthmarks and moles or those that can come at later stage of life due to some diseases or allergies from the surroundings or due to excessive heat from the sun. Secondary skin lesions occur in later point of life, when there is an injury or natural progression due to scratching, pricking etc. Few images of melanoma pictures are included in the Figure 3 given below. This includes photographs of moles and other skin lesions, that provide an hint of what melanoma skin cancer resembles.

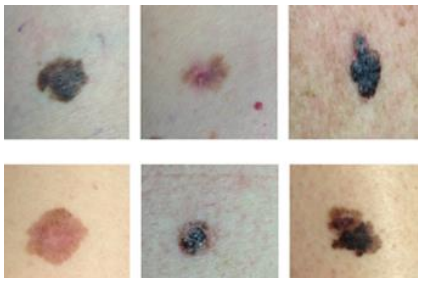

Figure 3 : Photographs of melanoma skin lesion

In order to find out the affected skin lesion, many features can be considered like color, boundary, texture, pattern and shape. In this paper various methods are discussed to detect the skin lesion. Early detection can lead to savior of many patient's life. This paper is organized as follows: segment 2 discusses about traditional method to spot affected region, drawback of traditional method and gives an introduction to computerized dermoscopy. Segment 3 speaks about various phases involved in image analysis for detection of skin lesion. Segment 4 discusses segmentation methods for finding the presence of infected skin lesion. Segment 5 discusses about the available datasets for melanoma images. Segment 6 justifies the comparison of various 2D methods using a list of values.

2. Related Background

Various methods have been proposed to help in detection of melanoma. Dermoscopy is one of the most important techniques to examine lesions on the skin. The traditional method to detect skin lesions is designated as surface skin microscopy or dermoscopy or Epiluminescence Microscopy (ELM) [4], which is non-invasive and is performed by skilled dermatologists. Images are obtained using dermoscopy examination by applying gel on the skin lesion. Analysis of melanoma from affected skin lesion is not straight forward, more so in the initial stage. Therefore, a spontaneous tool to judge this is vital for dermatologists. The main limitation in this method would be that an expert dermatologist is required. There is one more conventional [5] technique, which is doing a biopsy. This is a surgical procedure, where a part of the skin is scooped and sent to laboratory for further investigation. But this procedure is very painful, time consuming and is not cost effective. Biopsy can also be used as one of the methods, which are very painful, less cost effective, and more time-consuming technique.

The detection of melanoma is very important as early diagnosis leads to decrease in the mortality rate. With the use of computer aided techniques detection of melanoma would be accurate and fast. Computerized dermoscopy is a new technique that has replaced the traditional systems, which is primarily organized as five major components that are to acquire an image, preprocessing, segmentation, feature extraction, classification. A very essential step here would be to identify the region of interest [6]. Several segmentation algorithms have been proposed based on border detection, color and texture processing.

3. METHODOLOGY

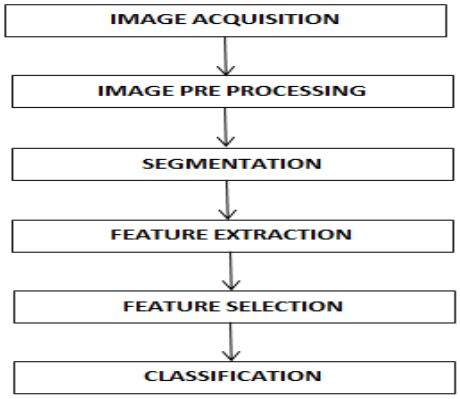

Figure 4 : Stages of computer aided diagnostic system

Technological developments have led to computerized systems assisting in various methods to diagnose cancer. Such computer aided diagnostic systems consists of five primary components:
Obtaining Dermoscopic image of skin lesions
Identifying the region of interest
Drawing out essential features
Feature selection
Use of machine learning techniques to implement decision making mechanisms.

The suspected skin area has to undergo several steps of examination, before it is detected to be malignant. The image needs to be acquired, preprocessed to remove unwanted noise in the image. The next step would be to find the area of interest, followed by measuring the required features. Next step would be to select the features, among the selected features. The last process makes use of machine learning methods to make decisions on malignancy. The stages involved in detection of affected area are depicted in figure 4.

3.1 IMAGE ACQUISITION:

Image processing has seen a rapid growth in technology and has been an interdisciplinary field of research from basic sciences, medicine, and field of computers, engineering, and statistics. With the current technology growth, Computer-aided diagnostic processing methods have also evolved significantly. Accompanied by progress in current technology, use of various imaging modalities present more challenges. This also increases the volume of images to be analyzed significantly. The image needs accurate processing to get high quality end results, helping in detection of disease diagnoses and treatment. The readings, also known as 'image intensities' in the relevant bio medical images can be measured using X-ray imaging, ultra sound, or MRI. The field of medical imaging has been seeing a marked improvement with the beginning of quicker, more precise and better invasive devices. This has motivated researchers to work on corresponding software development which will provide a major push towards newer algorithms in signal and image processing. Figure 5 shows the various acquisition tools like dermoscope, x-ray machine, smartphone.

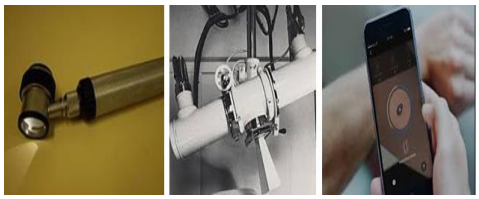

Figure 5: Acquisition tools for capturing skin lesion

3.2 IMAGE PRE- PROCESSING:

The image that will be considered has noise. Hence there is a need to remove noise [7] for better quality improvement in the further steps. The image should be free of any hair obstacles, blur, and any other noise. Image enhancement, image restoration, Restoration from noise, restoration from blur needs to be performed. Filter needs to be applied to remove the noise. Removal of hair is also an important part for preprocessing an image. An enhanced image will have better clarity. This provides enhanced inputs for automated techniques.

Figure 6: Removal of artifacts from the acquired image

Two main methods here would be spatial domain method and frequency domain method. Image restoration may be used when there is a need to recover the image which is blurred and noisy. Image preprocessing removes few artifacts [8] such as hair, oil bubbles, reflections .One such example is depicted in figure 6 given below. The input image is fed into the filter and filtered image is available for segmentation.

3.3 SEGMENTATION:

Among all the stages of processing an image, a very important role is played by segmentation or region of Interest Identification of skin lesions. The preprocessed image needs to undergo segmentation. This identifies the region of interest. Various properties like brightness, texture, color, shape may be applied to support segmentation of skin lesion. One such example of a segmented image is shown below in figure 7.

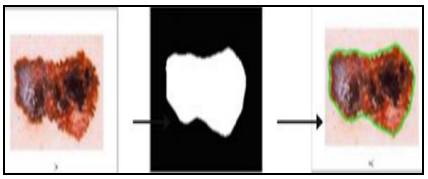

Figure 7 : Process of segmentation

3.4 FEATURE EXTRACTION:

Extracting the required features is very important stage while classifying the images as malignant or benign. The features need to be extracted to feed the classification stage. In the proposed research texture, shape and color features would be considered to move to the classification stage. The texture feature can be extracted when the skin lesion has a different texture compared to the surrounding area. The shape feature characterizes the properties with respect to shape, which gives how circular or irregular or elliptic the mole is. Color of the mole can be checked for irregularity. Best features are extracted and recorded in a table. Few features that consider asymmetry and color variation are shown in figure 8 below.

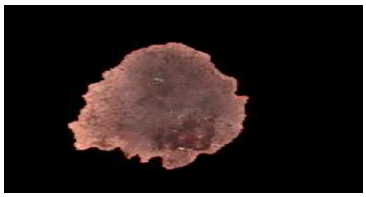

Figure 8: Feature extraction considering asymmetry and color variation.

3.5 FEATURE SELECTION:

Feature selection identifies a subset of the features that are extracted. As there are complex interactions among various features, feature selection is a very difficult task. In the proposed method the features imparting highest discriminating power would be adopted. Color, texture, 2DShape, 3D Shape features would be selected with highest discriminating power and would be accepted for an accurate image identification for classification. Feature subset selection can be done with the help of various algorithms [9].Size of the feature subset should also be decided in this phase.

3.6 CLASSIFICATION:

For classification classifiers will be used. A class of feed forward artificial neural network is multilayer perceptron, also known as MLP. MLP utilizes a supervised learning technique called " Back propagation" for training. Auto encoders are similar to MLP except that its output layer is same as its input layer, while number of classes represent the output layer. MLP requires labeled data for training while auto encoders belong to the category of unsupervised learning. It is used for dimensionality reduction, reconstruction of the original image from noise corrupted version and also as a feature extractor for classification. In medical applications, auto encoder layers are often trained individually (training a 2nd hidden layer by the outputs of the 1st layer and so on) after which the network is fine-tuned in a supervised manner.

4. SEGMENTATION TECHNIQUES

There are various segmentation methods. In the proposed research the existing algorithms will be modified or extended or both can be applied together to get better results. This gives us a better 2 D image. In the conservative procedure [11], the methods of analyzing affected area data are known as

a) "ABCD" method
b) Pattern investigation
c) Menzies technique
d) Seven-point specification
e) Texture examination

Several segmentation algorithms have been proposed based on border detection and color & texture processing. ABCD rule of dermoscopy makes use of the feature set [12] asymmetry in shape, irregularity of the border, variation in color and differential structure. A calculation called the TDS score is done, on the basis of which the skin lesion can be segregated as melanoma or non-melanoma. Irregularity in the shape of the lesion is one of the most vital parameter for recognizing an infected region. Asymmetry index is calculated based on the values of horizontal, vertical and diagonal axis. The border of the skin lesion can also be checked back for melanoma. The color of the infected region also depicts the presence of melanoma. The longest distance of the skin lesion called the diameter plays the most important step in detection of the infected region.

Use of Pattern analysis can help in detecting the infected skin lesion with automatic diagnosis [6]. The method described here finds the presence of a typical pattern to determine whether the infected lesion is melanoma or not. There can be global patterns which can be depicted by textured structures or local patterns that are present in most of the cases. These patterns may be present, which may signify the type of lesion or they may be absent, in which case the lesion is said to be benign. The pattern analysis constitutes of steps that check the size of the pattern, and mainly how they are distributed. The benign lesion structures are uniform.in most of the cases. Therefore, the presence of at least three global patterns tells us that there is a higher rate of occurrence of melanoma. The number of criteria in pattern analysis is very low. A method for automatic detection of melanomas by using a diagnostic method was projected [13], which discusses a set of seven features, called "ELM 7-point checklist", which considers color and texture features and describes the malignancy of the infected skin area. The seven point checklist includes both shape and texture feature of the lesion. Few features are Significant grid with asymmetrical shape, Uneven, gray-blue to whitish blue, Linear, globular red structures which may be dotted, distribution may be uneven. Dermoscopy is a technique for early diagnosis of malignant melanoma and the differential identification of pigmented lesions of the skin. It has been recognized, therefore, as a technique to increase accuracy over the traditional clinical visual inspection by Physicians.

Mimicking Expert Dermatologists Segmentations (MEDS) [14] is a segmentation method that proceeds in five stages. The first step is to preprocess the image. The color space dimensionality is simplified to a one dimension by using the principal component analysis (PCA) of the relevant color statistics. Then to this image a filter is applied to remove the noise. The next stage uses an innovative thresholding algorithm that distributes the pixels to form two clusters. This is quite similar to what a dermatologist does, hence the name "MEDS". This image is finally divided into regions corresponding to lesional and to those corresponding to non lesional skin. For variations like illumination in digital photos of skin lesions, which is a tough problem for segmenting the photograph [15] one method was proposed. One of the algorithms that can account for digital photographs is the DLS algorithm. There are two main steps. To begin with, a collection of texture grouping that signify skin and affected region textures are learnt. Subsequently, a TD metric is computed to check amount of difference in the dispersal of texture from all other distributions. As a final step this TD metric is applied to classify areas of the image as fragment of the Regions not affected or Regions which are affected. The TDLS algorithm can be compared to four advanced lesion segmentation algorithms. The first algorithm that is known as L-SRM, although intended for dermatological images, it can also be used for lesion photographs. The SRM algorithm is used for normal skin to detect the malignant lesion. Out of the other three algorithms, one algorithm (Otsu-R) uses the red color channel to calculate the Otsu threshold. By making use of the second algorithm (Otsu-RGB) Otsu onsets for each channel are calculated. The concluding algorithm, known as Otsu-PCA, finds few more effective channels to calculate the threshold value.

One of the important signs for Melanoma diagnosis using dermoscopy images is existence of Irregular streaks [16]. Further analysis on the appearance of detected streak lines leads to identification of the presence or absence of streaks in the skin lesions. Indication of streaks in a pigmented skin lesion can result in one of the three cases i.e., they can be absent, regular or irregular. STOLZ algorithm demonstrates a method to detect melanoma using ABCD rule [17] using a mobile phone. Asymmetry index (A) is calculated by means of partitioning the image into horizontal and vertical synchronized images. The border irregularity (B) is identified and then compactness index is calculated using the perimeter of the image. The suspected lesion has more than one color. The suspicious lesion RGB value (C) is calculated. Diameter is calculated (D). The Stolz's algorithm assesses various criteria and assigns a numeric score to each feature. Each score demonstrates empirically determined position which is scaled by weight factor. A total of these scores return the total dermoscopy score or TDS .Finally, Dermoscopy score is premeditated using the method TDS = [A x 1.3] + [B x 0.1] + [C x 0.5] + [D x 0.5].A mechanized method for [18] melanoma boundary detection by merging the (PSO) Particle Swarm Optimization and (MRF) Markov random field methods is possible. The method of image segmentation makes use of the Markov method where it is calculated to be the best among all the existing energy functions. The particle swarm optimization method is used to implement the initial labeling. For each pixel in the image , the best class label is brought out by using a group of artificial particles. The numbers of particles present are found and then the value of the position of these particles is set to random values within the boundary of the search space. The particles are distributed randomly between initial value zero and final value 255.The fitness value is calculated. Each of the particles compares their fitness data with the best data available, which gives Pbest solution. The fitness data of the complete swarm gives Gbest result. The features obtained by Gbest and Pbest are matched using PSO and MRF to get the results, that are better compared to earlier methods.

A method to detect melanoma based on novel [19] boundary and variation in the colour of the skin images is proposed. These structures are then coupled with other Texture and morphology factors to progress further into the results. Varying color distributions are found in the boundary pixels of Malignant melanoma lesions. In every color channel the Value deviation from the mean position of every pixel in the edge in a melanoma region varies from that of a non-melanoma region. A mean square error (MSE) standard is used to calculate the modifications for a particular lesion in each color channel. An advanced algorithm for faster melanoma recognition using colour correlogram [20] and texture analysis is presented. Colour correlogram method is used to

calculate the colour correlation. Two images may be having the same histogram, but the correlogram which throws light on the spatial correlation of colour distribution with distance may not be the same. A texture analysis method is required with the colour correlogram. To analyze iterating patterns in the segmented lesion texture features are made use of. By modifying the algorithm proposed here, skin lesions can be detected with different illumination conditions.

A segmentation method called Grab cut algorithm is present. It is a derivative from the graph cuts [21] with predefined information about the background and the foreground represented by a rectangular selection around the area of interest. The first step is acquisition of the image followed by enhancement of the image, where brightness and contrast modifications are made. Then, certain features like color, shape and geometry are extracted using image processing techniques. The grab cut algorithm distinguishes the affected skin lesion from the normal skin area. Further the segmented image needs post processing through mean shift filtering and median blurring to smooth out the edges and eliminate the noise. Features such as boundary, shape and color are extracted. Decision is then made on malignancy by using SVM. One more method is proposed called as "Skin melanoma CAD system" [22] that uses texture analysis method.

Morphological bottom-hat filter is used for hair removal. For filtering the image a median filter is used. Evaluating the five broadly used texture investigation methods that are co-occurrence matrix of grey level, Gabor filters, oriented gradient's histogram, regional binary pattern and regional directional number is done in the feature extraction stage. A multilayer perceptron is used for classification of the images into melanoma.

Expert dermatologists make use of use surgical methods for precise recognition of melanoma [23] that are usually accompanied with discomfort, lot of time spent and finally spending lot of money. Technology development in the area of mobile phones has helped in initiation of many applications to detect the presence of melanoma. In this method the authors project an application by means of image handling approaches and pattern recognition algorithms by using Android Studio software, Java and the Open CV library. All steps for finding the presence of melanoma are carried out using an Android O/s based smartphone. For segmenting the image Otsu's thresholding method is used. This is followed by the use of a Laplacian filter. Dermoscopy is the basis for all computer aided techniques [24] that capture the image of the skin. This method completes pre-processing of the lesion image followed by removal of surrounding noise, unwanted hair and bubbles. Preprocessing is done by using a Gaussian filter. After pre-processing the lesion area the segmentation is completed by using Otsu's image segmentation technique which is later sent to morphological filtering. Feature extraction is done in the next step through which distinctive structures are extracted from the lesion region. After the features are extracted the final step classification is prepared by using support vector machine. The system proposed in this technique shows that the support vector machine that uses linear kernel performs well with better accuracy.

Geometric features of the skin [25] lesions can also be used for classification and detection of skin cancer skin cancer. Geometric features include the parameters of ABCD Law of Dermoscopy, which are asymmetry in the image, image border, color discretion and finally diameter. The first step is to resize or rescale the image, after which the image blurring takes place in the direction of smoothening the image and removal of any noise. Conversion information from the RGB color image to gray scale image takes placed .In segmenting the image; initially thresholding procedure is done followed by edge detection. During the segmentation procedure the smallest and largest diameter, circularity index are measured. All the data measured during segmentation are stored in the data set. For classification of skin lesion k-Nearest Neighbors (k-NN) algorithm is applied. The lesion area can be later classified as malignant, benign or unknown. A lot of developments have taken place [26] on different methods of segmentation .The procedure of graph cuts is one more system for segmenting clinical images. Various color spaces like RGB, HSV, HSI and HSL need to be segmented. The technique consists of three major phases, preprocessing, image segmentation and post processing phase. During the preprocessing phase, the non-homogenous illumination leads to transformation of the medical image in RGB to HSV, HIS and HSL. For the segmentation phase Graph-cuts technique is used that makes use of energy minimization algorithm. The graph cut algorithm is considered as a graph G that consists of a number of vertices and image pixels . This divides the image into melanoma foreground and background images. A Post processing phase is applied to remove the pixels that contain noise.

A mobile application is developed to detect [27] melanoma. The ABCDE parameters, image Asymmetry, boundary irregularity, variation of Color, image longest diameter and evolving (ABCDE) are considered. Diverse techniques are used like Grey scale conversion, Segmentation of the image, outline tracing and histogram analysis. The intensity of each pixel in the image is calculated and placed in a matrix. The numbers lie between 0 and 255.Thus they are converted from RGB to grey scale. For segmentation gradient vector flow algorithm is used. This is an extension of active contour or snakes algorithm. Feature extraction is the next step where the four features image Asymmetry, boundary irregularity, variation of Color, image longest diameter are extracted. This application has a reduced cost as compared to other methods, as the calculations for individual pixels are avoided here. A method for discovery of melanoma by image processing tools [28] is required for early detection of melanoma. The computerized dermoscopy helps in finding the skin lesion. Feature extraction is a very important phase, which depends on the segmentation phase. Initial phase includes using a dull razor filter to remove hair and presence of air bubble in the picture. In the next phase the picture is transformed to grey scale after which noise needs to be filtered out. Segmentation stage uses the techniques of hybrid threshold, iterative threshold, multilevel thresholding and Automatic Threshold. Many datasets are available, among which MED-NODE [29] dataset is one. First the image available is preprocessed. Then to achieve segmentation of the image, A Method known as "Active contour segmentation" is used. The color topographies are also recorded as part of segmentation. Classification is done using Naïve Bayes, Decision Tree, and KNN. The scheme accomplishes a better precision value on Decision Tree which is better than other classifiers.

5. DATA SET

There are many databases available out of which one is the PH2 [30], a dermoscopic image database that has been developed at the Dermatology Facility of the Portuguese division of Hospital Pedro Hispano. The PH2 database consists of experimental verdict, recognition of many skin lesion configurations in the set of around 200 dermoscopic

images. This databank is scientifically progressive and is used for research. The PH2 dataset has dermoscopic lesion images around 200 of them. Among these melanocytic 80 images are common Nevus type, next 80 of them are atypical Nevus type and remaining 40 are Melanoma images. The database [31] has a dermoscopic dataset that is free of cost and is publicly available. ATLAS is one more dataset available in public. MED-Node and DermWeb are few atlases where dermoscopic images are available online.

6. CONCLUSION

Melanoma is a deadly disease, among all the other types of cancer. It is a curable form of cancer, if diagnosed early. With the current trends in image processing various methods are available for detection of melanoma. Usage of non-invasive high-tech dermoscopy systems to diagnose skin lesions is implemented quite commonly. As seen from Table 1, various techniques are available with varying accuracy values.

The conventional methods like ABCD rule, MEDS, MEDS boost techniques show a diversion of around 12 % from accuracy. Several other techniques which use colour, thresholding, border detection like PSO and MRF method ,Color pigmented boundary descriptors method, Color correlogram and texture analysis method ,Otsu's thresholding (Laplacian filter)technique , Otsu's thresholding (morphological filter , SVM classifier) technique ,Geometric analysis (k-NN classifier) method have a variable accuracy of 90 % to 95 %. The values are tabulated in the table that shows the accuracy , sensitivity and specificity output by these techniques .The values show Graph cut technique has better accuracy of 96.98 % and TDLS algorithm that considers texture of the lesion has an accuracy of 97.9 %.Further the machine learning methods for finally classifying an image may add up to better performance.

TABLE 1: Segmentation techniques with performance results [AC: Accuracy, SE: Sensitivity, SP: Specificity]

Sl no	2D Technique	Features	Observations			Author	[Reference] Year
			AC	SE	SP		
1	ABCD rule	asymmetry, borders, colour and dermoscopic structures	ABCD rule has improved diagnostic accuracy as compared to the traditional method used by less experienced observers			Nurulhuda Azmi, Haslina Sarkan, Yazriwati Yahya and Suriayati Chuprat.	[3], 2016
2	MEDS	Color	MEDS obtained an average accuracy of 12.35% disparity with expert dermatologists			Francesco, Federica, Michele, Vincenzo, and Enoch.	[14] , 2014
3	MEDS BOOST	Color	MEDS obtained on average an accuracy of 11.27% disagreement with expert dermatologists			Francesco, Federica, Michele, Vincenzo, and Enoch.	[14] , 2014
4	TDLS algorithm	Texture	97.9 %	90.8 %	98.8%	Jeffrey Glaister, Alexander Wong , David A. Clausi,	[15] , 2014
5	PSO and MRF method	Border	95%	94%	98%	Khalid Eltayef, Yongmin Li and Xiaohui Liu	[18] , 2017
6	Color pigmented boundary descriptors	Color	92%	95%	88%	Saeid Amouzad Mahdiraji , Yasser Baleghi, Sayed Mahmoud Sakhaei	[19] , 2017
7	Color correlogram and texture analysis	Color and texture	91.5%	---	---	Soumya, Neethu, Niju, Renjini, Aneesh.	[20], 2016
8	Otsu's thresholding (Laplacian filter)	Thresholdin g	95%	98%	92%	Seyed Mohammad Alizadeh, Ali Mahloojifar	[23] , 2018
9	Otsu's thresholding (morphological filter , SVM classifier)	Color, shape and texture	93.3%	90.9%	92.3%	Soniya Mane , Dr. Swati Shinde	[24] , 2018
10	Geometric analysis (k-NN classifier)	Thresholdin g and Edge detection	90%	---	---	Noel B. Linsangan, Jetron J. Adtoon, Jumelyn L. Torres	[25], 2018
11	Graph cut technique over different color spaces	Boundary	96.98%	89.68%	98.96%	Olusoji Akinrinade , Pius Adewale, Chunling & Temitope	[26], 2018
12	Active contour segmentation (Decision tree)	Boundary and color variation	82.35%	---	---	Shalu , Aman Kamboj	[29],2018
13	Menzies method	Symmetry , color	---	92%	71%	Scott Menzies · Ralph P. Braun	[32] , 2018
14	ELM seven point checklist	color and texture parameters	---	91%	85 %	Joanna Jaworek-Korjakow ska, Paweł Kłeczek	[33] ,2017

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