Journal of Theoretical and Applied Information Technology
30th September 2018. Vol.96. No 18

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

COMPARISON OF SKIN LESION IMAGE BETWEEN SEGMENTATION ALGORITHMS

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ABSTRACT

Melanoma is the most common dangerous type of skin cancer. Furthermore, if found in an early stage, there is a high likelihood of cure. For that reason, various types of imaging techniques have been investigated. Dermoscopy is one non-invasive imaging technique for diagnosis. The accuracy of diagnosis using dermoscopy is very important and depends on the experience of dermatologists. Visual examination is a waste of time, so there is currently wide attention paid to the development of computer-aided diagnostic systems to aid the clinical evaluation of dermatologists. Image Segmentation is very important in digital-image processing and self-discovery, with an important role to play in solving many difficult problems, particularly those related to chronic diseases, such as skin cancer. Analysis of automatic dermoscopy images usually has three stages: a) feature selection and extraction, b) image segmentation, and c) feature classification. In this work, we suggest and test two methods that are applied to 22 dermoscopy images: a) active contour modeling, and b) a proposed method of fuzzy clustering based on region growing. We evaluated our methods using three metrics: accuracy, sensitivity, and specificity as a result, our proposed method of fuzzy clustering based on region growing achieved the best ratio. Our research limitation can be addressed through applying a large amount of dermoscopy images and use different processing algorithms to reach a better classification will enrich our result that are left for future work.

Keywords: *Image Segmentation, Dermoscopy, Skin Cancer, Melanoma, Skin Lesion.*

1. INTRODUCTION

Skin cancer is among the most common types of human cancers [1]. There are two types of skin cancer; Melanoma and non-Melanoma. Because of the increasing rate of skin cancer, this problem is recognized at national and international levels. The government of UK aims to stop the rise of cancer [2]. In the United States, the appropriate terms for non-melanoma are basal-cell carcinoma (BCC) and squamous-cell carcinoma (SCC). The reason for such a wide range of estimates is that many early skin-cancer lesions are easily treated. Malignant Melanomas may be removed easily with an excellent prognosis [3].

The largest organ in the human body is the skin, comprising 15% of total body weight in humans. Skin has several fundamental functions it protects against external physical, chemical, and biological attackers, avoids additional water loss from the body, and has the responsibility of thermoregulation [4].

Skin is composed of three layers. Epidermis the the outermost layer of skin. It is made of flat cells named squamous cells. Under the squamous cells in the inner part of the epidermis are the basal cells. Melanocytes cells are distributed amongst the basal cells. They are located in the most inner part of the epidermis. Melanocytes create the skin color. In case of ultraviolet radiation explosion melanocytes generate more pigment and cause darkness of the skin.The second layer is dermis. This is the middle layer that located between the epidermis and subcutaneous layer. It contains connective tissue in the form of collagen in bulk and elastin in minimal quantities, with a rich intertwining blood supply. The cells that are found in the dermis are fibroblasts, mast cells and

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

histocytes. Dermis also contains hair follicles, nerves, lymphatic vessels and sweat glands. The third and last layer is hypoderm which are also called as subcutaneous tissue is the deepest layer mostly composed of fat which protects the skin from injury, produces heat. It is like a cushion for the body [5].

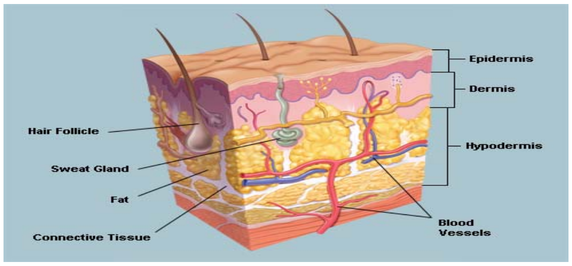

Figure 1: The Types Of Skin Tissue In Three Layers: The Epidermis, Dermis, And Hypodermis [6].

We can classify the skin cancer into three groups in which only Melanoma is dangerous. Basal-cell skin cancers (basal-cell carcinomas). This type of skin cancer is very common cancer and therefore it considered very important. Eight of 10 skin cancers are basal-cell carcinomas (known as basal-cell skin cancers). Squamous-cell skin cancers (squamous-cell carcinomas). Two of 10 skin cancers are squamous-cell carcinomas. Melanoma begins in melanocytes (pigment cells).Melanoma starts in melanocytes; since most of these are in the skin, melanoma can be on any skin surface. In affected men, it is often seen in the head, neck, between the shoulders, and hips. However, in affected women, it is often seen in the lower area of the leg, between the shoulders, or the hips. People with darker skin colors rarely face melanoma, but if the disease develops in them, it mostly starts under the fingernails, toenails, and palms of the hand or feet [6].

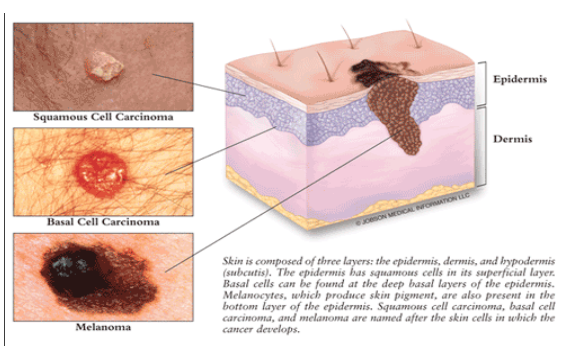

Figure 2: Types Of Skin Cancer [6].

To effectively detect skin cancers at an early stage without taking any skin biopsies, which was necessary, today digital image segmentation has been suggested using dermoscopy, photography, infrared thermal imaging, spectral imaging, and magnetic resonance imaging (MRI) [7]. Among these current imaging techniques, dermoscopy is the most suitable for diagnosing melanoma.

Dermoscopy is an imaging technique for diagnosis that is not invasive, used for bodily examination of pigmented skin lesions in dermatology. So, there is now wide attention to the development of diagnostic systems that are computer-aided in order to help analyze skin lesions [8]. Automatic analysis of dermoscopy images includes three main steps; a) Feature selection and extraction, b) Image segmentation, and, c) Feature classification. Among these three main steps, image segmentation plays a major role in digital-image processing, self-discovering the details of objects in important areas [9].

The reminder of this work is organized as follows. Section 2 summarizes relative works of different methods, in section 3, the characteristics of digital segmentation methods has been discussed, section 4 provides our evaluation criteria, while in section 5, a set of our results are calculated, and finally section 6 presents our discussion and conclusion.

2. LITRATURE REVIEW

Many methods of segmentation have been investigated for these purposes, comprising four main types: thresholding, edge-based, region-based, and clustering-based. Many researchers have been working on computer-vision approaches to skin-cancer detection. In order to segment skin lesions in the input image, existing systems use manual, semi-automatic, or fully automatic modes.

A wide ranging study of different methods has been applied to segmentation of skin lesions in dermoscopy images. Wherein each method have common three steps which are Preprocessing, Segmentation and Post-processing [10]. And the result depends on the metrics that is used to evaluate methods.

Lately [11] suggested a Multilevel Thresholding algorithm (MT) that iteratively divide the image histogram into several classes that identify the threshold value by the Otsu's method.

Among the segmentation algorithms thresholding is said to be better because of its simple, fast and can get decent results in images that have a good contrast between the lesion and the skin. This technique in dermoscopy images sometimes fails because it does inconsistent result in some images there is smooth between the skin and lesion, and sometimes there is low contrast.

Researchers claim that region based methods is not easy in the situation of excessive types of colors with various skin types and textures in pigmented skin lesions, this demonstrates to over segmentation [8, 12].

According to their functionality segmentation of dermoscopy images it is divided into two techniques: supervised and unsupervised techniques. In supervised segmentation technique, it requires user interaction while unsupervised technique does not need user interference and initialization. Furthermore unsupervised technique is ideal to make sure that the results are reproducible. Though in order to correct an improper segmentation results user intervention is still required [13].

There are many methods have been used in a segmentation dermoscopy image like region based method. [12], proposed the JSEG algorithm for segmentation of skin lesion. This algorithm consists of two parts: color quantization and spatial segmentation. Furthermore, [14] proposed statistical region merging (SRM) algorithm that is a new color image segmentation method based on region growing and region merging. This method is compared with (modified JSEG method, fuzzy c-means, mean shift clustering, and tumor extraction by dermatologist), the SRM got the best result.

For edge-based method, it is found in [15] that used geodesic active contour model or the geodesic edge tracing approach to the segment skin lesion. The snake (active contour) is the common segmentation method that uses in this area, especially in the medical image area. This method is based on distortion a curve towards the minimization of a given energy function.

A weak edge in some dermoscopy images makes a problem with edge-based approaches produce a smooth between the skin and lesions. For these problems are used contour that can solve the weak boundary to passing over it. Another problem there is a nice point (hair, skin line, air bubbles, blood vessels, etc.) that make the image appear less accuracy. That makes segmentation of skin lesion incorrectly. Furthermore, there are a wide number of parameters in this technique that impact the contour's attitude and implementation and it must be validated. [8, 16].

In order to discover the boundary of dermoscopy skin image (GVF) snakes is used [16]. For this study to segment the lesion image automatically, automatic snake initialization technique is used. The GVF is advantageous of being non sensitive to initialization and it has the ability to pass through concavities of the borders.

Six different techniques are recommended in the area of dermoscopy image segmentation [8], including both supervised and unsupervised segmentation tools: a) adaptive threshold, b) gradient vector flow (GVF), c) the level-set method, d) adaptive snake (AS), e) expectation-maximization level set method (EM-LS), and f) fuzzy-based split and merge algorithm (FBSM). Silveira and her friends [8] found that the most appropriate segmentation results were found when using two supervised segmentation techniques, namely adaptive snake and the expectation-maximization level set tools. Also, they concluded that completely automatic techniques have somewhat poorer results.

In our research, we compared two segmentation methods, including active contour modeling and fuzzy-clustering based on region growing (FCR), achieving high accuracy and high sensitivity of segmenting skin lesions using the fuzzy-clustering based on region growing method. By these methods, accuracy, sensitivity, and specificity metrics have been compared.

3. DIGITAL SEGMENTATION METHODS

In our work, we used 22 images of melanoma skin lesions obtained generously from the Pedro Hospital Hispano (HPH) database. The implementation of algorithms are performed with MATLAB® 2015. The MATLAB® built-in functions for image processing were the choice of the program.

3.1 Pre-Processing

Pre-processing stage has three main steps;

a. converting the image from color (RGB) into grayscale.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

b. image filtering.
c. detection of dark regions in the corners of the dermoscopy image.

In the following subsections the preprocessing steps are presented in details.

3.1.1 image conversion from rgb to grayscale:

The first step is converting the RGB color image into a grayscale image. After that, the blue color channel from the image is chosen. It has been experimentally confirmed that the blue color channel in dermoscopy images presents the best contrast between lesions and the skin, thereby obtaining the best result for segmentation [5, 13].

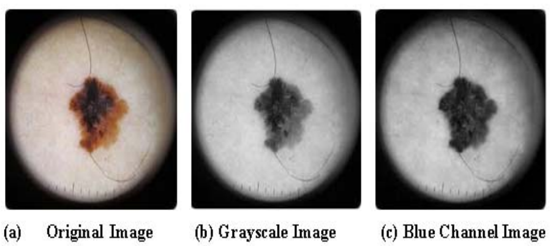

Figure 3: (a) Shows The Original Image Of The Skin Lesion, (b) Shows The Conversion Of The Original (RGB) Image Into Grayscale, And (c) Shows The Result Of Selecting The Blue Channel From The Image.

3.1.2 image filtering

For an accurate result of segmentation preprocessing, firstly, I smoothed the images using image filtering to remove some innate features of the image, such as dark hair, blood vessels, and air bubbles.

3.1.2.1 hair removal

Dermoscopy images, mostly, have some hair textures and innate objects due to human nature. These affect segmentation, therefore we firstly removed these objects from the images. The morphological close filtering is most accurate filtering among the list, this is the reason that I chose it. Morphological Close Filtering is used on grayscale images to remove the dark detail [17].

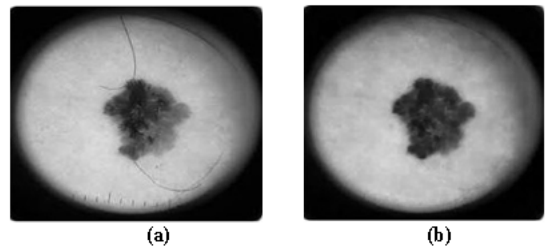

Figure 4: (a)Shows An Image With A Dark Hair Or Line, Which Is Removed In (b) Using Morphological Close Filtering.

3.1.2.2 image smoothing

With the removal of hair from the dermoscopy image, some small, dark dots can be remain, one of the reasons is the hair may not be removed completely. To address this problem, I used a median filter to smooth the images. The median filter is a non-linear smoothing method that replaces the original gray-level pixels with the median pixels in a specified area:

$$y(i,j)=\text{median}\ \{x(m,n),(m,n)\ 2\ z\ (i,j)\} \quad (1)$$

In Equation 1, x is the input image, y is the output image, and z is an area centered at image coordinates (i, j) [18, 19].
This filter is useful to reduce noise. In our work, noise is indicated by dark points [18, 20, 21].

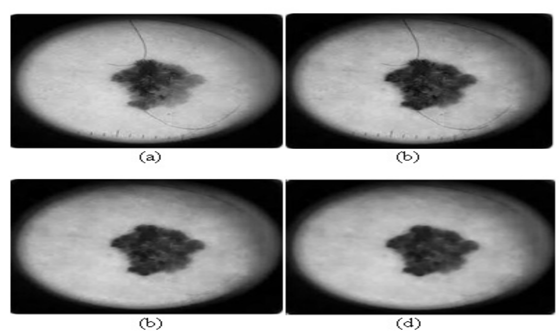

Figure 5: (a) Grayscale Image; (b) Blue-Channel Image; (c) Image After Morphological Close Filtering; (d) Image After Using Median Filter.

Figure 5. shows the steps of the pre-processing process; (a) clarifies after converting the image from RGB to Grayscale. (b) explains selecting the blue channel, which shows the image more clearly. After that (c) removes hair from the image using morphological close filtering. Finally (d) refers to the median filter to reduce the noise.

Journal of Theoretical and Applied Information Technology
30th September 2018. Vol.96. No 18

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

3.1.3 detection of dark regions in the corners of dermoscopy image

Most dermoscopy images have four dark regions, in grayscale these regions have the same intensity and will reduce the performance of segmentation.

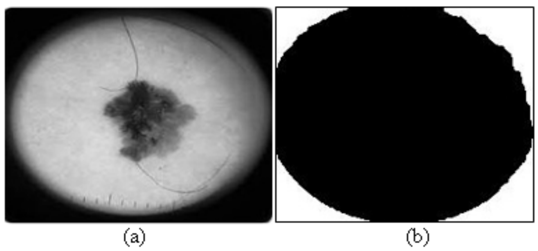

Figure 6: (a) Shows The Creation Of A Corner Mask, Both The Grayscale Original Image, And (b) The Binary Mask Of The Dark Regions At The Four Corners Of The Image.

3.2 Segmentation Methods

Image segmentation is a procedure that separates an image into disjoint regions that are similar in some features, such as intensity, color, or texture. All of the regions that union must match to all images [20].

We implemented two of the most common image segmentation algorithms:

a) Active contour modeling.
b) Fuzzy Clustering based on Region growing (FCR).

3.2.1 active contour

Active contours, also known as *snakes*, which have been applied using Snake algorithms. By a minimization algorithm, the shape of the contour is calculated, in which the sum of all energies reaches a minimum. Instead of the minimization can actually be carried out very often changed and then considered that form as a result of the shape of the snake, in which the sum of the energies is minimal [22].

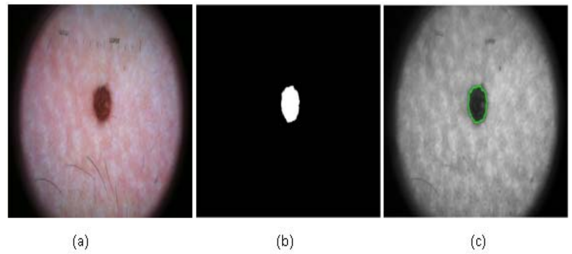

Figure 7: Shows The Segmentation Of A Skin Lesion Imaged By Dermoscopy Using The Active Contour Model Over 120 Iterations For The Convergence Of The Algorithm.

3.2.2 Segmentation of Melanoma in Dermoscopy Images Based on Fuzzy Clustering Method and Image Region Growing:

There was a paper used an algorithm that integrated fuzzy-c-mean (FCM) and region growing techniques to automatically segment tumor images from patients with meningioma. The study used non-contrasted T1- and T2-weighted MR images from 29 patients with meningioma. After FCM clustering, 32 groups of images from each patient group were put through the region-growing procedure for pixels aggregation. Later, using knowledge-based information, the system selected tumor-containing images from these groups and merged them into one tumor image. An alternative semi-supervised method was added at this stage for comparison with the automatic method. Finally, the tumor image was optimized by a morphology operator. Results from automatic segmentation were compared to the “ground truth” (GT) on a pixel level. Overall data were then evaluated using a quantified system [23].

In our method, we used fuzzy-c-mean clustering to segment skin cancer (melanoma). From three fuzzy clusters, we then calculated the standard deviation of each cluster, selecting the largest of them. After that, we used the image-region growing method for the selected cluster. In Subsections 3.2.2.1 and 3.2.2.2, we discuss fuzzy clustering and region growing.

3.2.2.1 fuzzy clustering

In fuzzy clustering, each object belongs to a clustering class with different membership degrees. This algorithm is more useful in many situations than other clustering algorithms, in which an object is forced to completely belong to a single cluster class. After Zadeh’s introduction of fuzzy

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

logic in 1965, a solution was suggested in which the similarity of each object to each class is illustrated by characterizing the similarity between an element and a group of functions by using membership values from 1 or 0. If the value is nearer to one, that means a greater similarity, while values near zero represent smaller similarities. Consequently, the fuzzy clustering problem is ideal for defining a characterization of this type [24]. The fuzzy clustering method has been broadly used in various fields, such as image processing, systems engineering, and parameter estimation.

3.2.2.2 region growing

Region growing is a method that misuses spatial framework by collecting neighboring pixels together into big regions. The main principle in merging the region is similar. To recognize different objects there are some parameters as grayscale level, color and texture [18].

The procedure of region growing begins with a pixel or collection of pixels that is called as the seeds of a desired object. This process can be done manually in which user states an algorithm or it can be done automatically using seeds finding techniques. The following is scanning the neighbor pixels each time and put them in the growing region. In order to collect all homogenous pixels in the growing region, the process of finding non similar seeds is repeated until there is no pixels satisfy the homogeneity criteria [20].

Region growing techniques usually get good results in segmentation that matches the edges of objects in an image that are visually seen. From this procedure, it is understood that areas inside an object grow and merge till their boundaries touch the edge of the object. However region growing algorithm is computationally more costly than the simpler methods, the techniques can be used to in applying numerous image parameters concurrently and directly in defining the last boundary location [18, 25].

One of the advantages of the region growing method is segmenting regions properly with similar properties and they are partitioned spatially. Furthermore, it produces connected regions. On the other hand the main problem of the region growing is the selecting of homogeneity criterion. In case of failure in choosing homogeneity criterion the region may spread out to neighboring regions or merge with areas that are not belonging to the desired object [26].

In this study, I used three clusters for fuzzy clustering and also to grow the region. The intensity threshold was set at 0.49. These values were derived experimentally, as shown in Table 1:

Table 1: Intensity Threshold.

parameters	T	Number of clusters
Values	0.49	3

We determined that three clusters was enough, because with more than three clusters, we obtained a poor result. In the following figures, we show the results of using two, three, four, five, and six clusters.

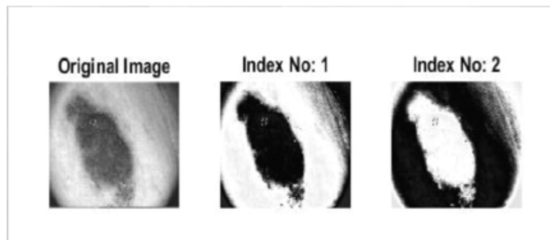

Figure 8: Number Of Cluster =2.

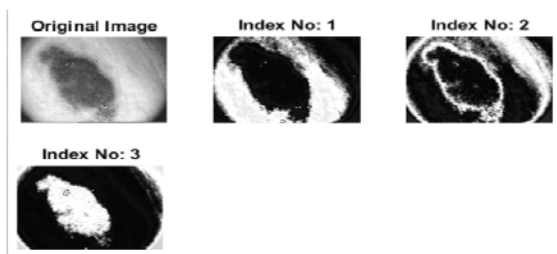

Figure 9: Number Of Cluster =3.

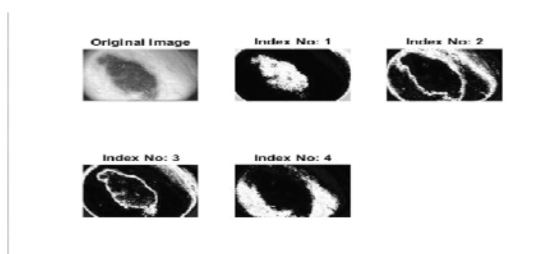

Figure 10: Number Of Cluster =4.

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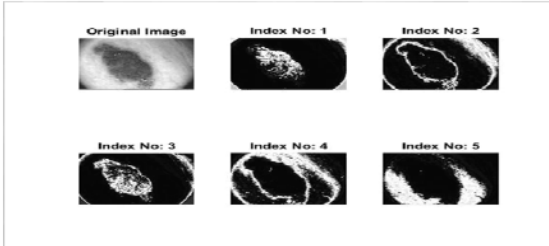

Figure 11: Number Of Cluster =5.

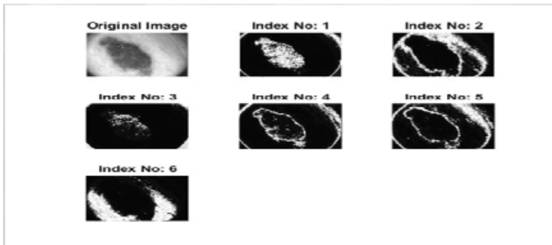

Figure 12: Number Of Cluster =6.

As possibly seen in these results, there is no need for more than three clusters.

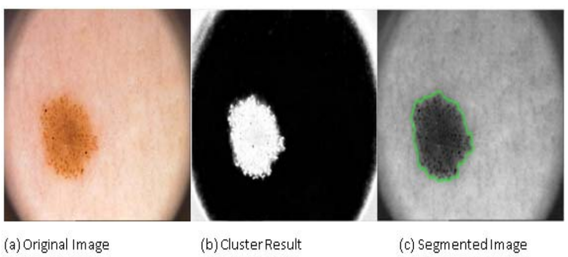

Figure 13: (a) Original Image; (b) Result Of Simulation; (c) Segmented Lesion.

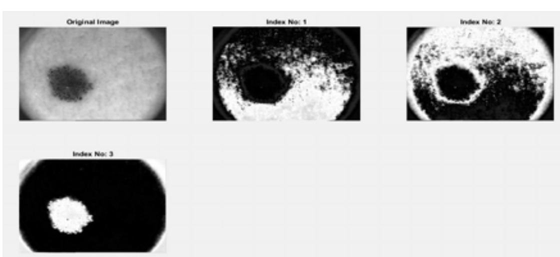

Figure 14: Result Of Fuzzy-Clustering Mean Algorithm

The first step of digital segmentation is preprocessing. In my work, I used 100 images of melanoma skin lesions obtained generously from the Pedro Hospital Hispano (HPH) database. The implementation of algorithms are performed with MATLAB® 2015. The MATLAB® built-in functions for image processing were the choice of the program.

4. EVALUATION CRITERIA

There are different parameters that are used with the description of sensitivity, specificity and accuracy. The terms are: True Positive (TP) which refers to the presence of the disease, the absence of the disease True Negative (TN), TP and TN indicate a reliable result between the diagnostic analysis and the proved disease.

False Negative (FN), and False Positive (FP),though every diagnostic investigation are not correct, so when the test result shows a disease that is not existed in the patient the test result is considered as FP. And if the test fails to indicate the disease that exists in the patient for sure, the result is FN. Both of FP and FN show that the diagnostic result conflict with the real situation.

4.1 Sensitivity

Sensitivity is a measure which indicates the proportion of the true positive samples from diagnostic set, correctly identified as positive samples and can be expressed as follow:

Sensitivity = $\frac{TP}{TP+FN}$ this means (Number of true positive assessment)/ (Number of all positive assessment)

4.2 Specificity

Specificity is a measure of the ability of the classifier to accurately identify the proportion of negative samples correctly identified from the negative samples and can be expressed as follows:

Specificity = $\frac{TN}{TN+FP}$ it means (Number of true negative assessment)/ (Number of all negative assessment)

4.3 Accuracy

Accuracy is defined as the proportion of the samples correctly classified out of the total number of samples and can be defined as follows:

Accuracy =$\frac{(TN+TP)}{(TN+TP+FN+FP)}$ it means (Number of correct assessments)/Number of all assessments).

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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

5. RESULTS

We calculated the area, perimeter, and centroid of the segmented object; these results are shown in Table 2 and Table 3:

Table 2: Simulation Results Of Active Contour Method.

Image	Area	Perimeter	Centroid (X)	Centroid (Y)
1	7724	476.051	107.0647	76.20469
2	5813	402.041	87.37296	77.16945
3	3111	366.578	129.3041	84.69142
4	2603	283.686	99.61468	68.94737
5	3616	334.375	86.53595	76.5141
6	3460	271.24	105.0312	76.19711
7	6967	459.965	48.92665	53.06689
8	6451	363.502	91.83243	72.4652
9	4993	302.799	72.26517	65.18486
10	2443	196.964	94.02374	69.66598
11	2581	215.498	61.86478	68.06548
12	3249	217.003	103.7101	88.67775
13	4028	255.832	104.7438	86.73312
14	6883	521.631	73.44167	68.91385
15	2331	224.379	99.77864	92.17932
16	4619	332.035	100.9502	75.60749
17	6892	451.581	104.613	66.98476
18	7646	459.809	98.79689	74.57036
19	11489	568.398	78.88694	68.95187
20	3240	235.809	87.04691	85.04599
21	2264	218.187	92.4894	56.93993
22	3132	277.855	108.8758	84.23276

Table 3: Simulation Results Of Fuzzy-Clustering Based On Region Growing.

Image	Area	Perimeter	Centroid (X)	Centroid (Y)
1	33604	884.218	213.4855	153.2312
2	24355	664.19	175.0958	153.4601
3	13692	584.35	257.8634	168.4694
4	11999	533.546	199.1358	137.4722
5	14627	523.24	167.6111	150.6204
6	15408	477.556	210.1937	151.3294
7	28430	900.889	97.97622	106.96
8	27529	670.014	183.362	145.0463
9	21988	575.798	144.3662	130.2754
10	11186	412.652	187.4136	139.3082
11	11854	414.314	123.9106	136.0914
12	14563	456.906	206.9107	176.7432
13	18023	514.508	209.1787	173.4053
14	30339	787.312	146.4895	136.8762
15	10867	433.98	199.579	184.6637
16	20167	619.16	202.0086	150.432
17	29877	717.946	208.6524	133.3929
18	29319	761.91	200.3186	153.8177
19	49023	899.32	157.263	137.6751
20	14824	484.042	172.796	169.362
21	10082	403.57	185.1071	113.8908
22	15010	639.318	216.6837	164.9803

Table 4: The Average Calculated Criteria For Each Segmentation Method Applied To 22 Images.

Method	Accuracy (%)	Specificity (%)	Sensitivity (%)
Active Contour	96.2	98.30	95.54
FCR	**97.6**	96.82	**96.94**

Based on the knowledge gained by table 4, the values in bold correspond to the best performance on each metric which cannot be found in any research investigated in this area.

6. DISSCUSSION

Several segmentation algorithms have been suggested to apply to this problem, comprising four major types of method: thresholding, edge/contour-based, region-based, and clustering based methods. Many researchers have been working on computer-vision approaches to skin-cancer detection. To segment skin lesions in an input image, existing systems use manual, semi-automatic, or fully automatic methods.

Our work to detect skin cancer is proposed. Two different methods; active contour, and a new proposal within this work named fuzzy-clustering method based on region growing are compared. These methods have never before been compared together in one study. We implemented our method on 22 images that we obtained from

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Pedro Hospital Hispano (HPH). We selected images randomly and ground-truth images were available in the database. We used three different metrics to compare these three methods: accuracy, sensitivity, and specificity. The best method was our proposed method of fuzzy clustering based on a region growing method, which has high accuracy (97.6%) and high sensitivity (96.4%). Its specificity was (96.82%). The active contour model had accuracy of 96.92%, sensitivity of 95.54%, and specificity of 98.30%.

According to these results, our proposed method obtained the best result in terms of accuracy and sensitivity. Regarding specificity, the best result was obtained from the level-set method. The fastest execution time was with the active contour method.

We used an active contour model to segment skin lesions, active contour is one of the segmentation methods used commonly to segment and analyze medical images in the literature. The biggest advantages of active contour are that it partitions an image into sub-regions with continuous boundaries [22]. As a result, our FCR method is better than the other methods; it is also more robust than the other methods, because our method alone uses fuzzy clustering to find the object. A future work might increase the number of sample images and use different processing algorithms to reach a better classification.

7. CONCLUSION

Melanoma skin cancer is the most widely diagnosed type of cancer. As the number of cases grows each year, effective, quick, and early detection of melanoma is very important. If skin cancer is detected in early stages, it may be treated easily. The removal of skin-cancer lesions at last stages is expensive, while in early stages lesions are easy and economical to treat.

To achieve an active way to detect malignant melanoma early without doing unnecessary skin biopsies, digital image segmentation for skin lesions has been investigated. Among imaging techniques, dermoscopy is the most suitable for melanoma diagnosis. Image segmentation is very important in digital image processing and allows automatic discovery of the details of objects in important areas. This capability has an important role to play in solving many difficult problems, particularly problems related to many chronic diseases, such as skin cancer.

We used two segmentation methods to detect melanoma skin cancer: a) active contour, b) fuzzy-clustering based on region growing. After simulation, and after evaluating each method in terms of accuracy, sensitivity, and specificity, we obtained the best result from our proposed method, fuzzy-clustering based on region growing, as it demonstrated both high accuracy and high sensitivity.

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