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Comparison of Filtering Techniques for Cell Image Segmentation

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Abstract

In segmentation of cell image for the objective diagnosis by medical laboratory experts, there are some preprocessing activities that is carried out before segmentation. The preprocessing includes noise removal. This paper proposes the comparison of filtering techniques for cell image segmentation in order to state the best filter suitable for noise removal. The filter being compared are mean, median and Gaussian filters. MATLAB IDE software was used to implement each of the filter's algorithm. The results obtained were evaluated and compared to identify which of the filter is best used for the preprocessing of the cell images. The result shows that the median filter outperformed the mean and Gaussian filters with 92.70% of accuracy for the median filter.

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1.0. Introduction

Well A cell is the basic structural, functional and biological unit in all living organisms [1]. It is an important part of the human body which are continuously created or destroyed to maintain human health [2]. When there is instability in the formation of the new cell and destruction in the old cell, it leads to accumulation of excessive cells that leads to formation of masses known as tumours [3]. In the diagnosis of cell, samples of the cells are collected from body fluids (such as urine or blood) or from organs. These samples are taken to the laboratory for microscopic study in order to look for defective cells that are caused by diseases or cells that grows abnormally such as cancerous cell. This process is quite tedious and time consuming. There is every likelihood of great amount of human error to be present under this kind of diagnostic procedure. This is due to the fact that these procedures are done manually and highly subjected to human's judgement over the years, various image processing and computer vision techniques have been applied to cell segmentation such as in [4, 5, 6] and tumour detection such as in [2, 7] with promising results [4]. Aiming to achieve a better diagnostic result using digital image processing technique, there are various steps involved in the processing of the image before getting the final output. These steps include; image acquisition, image preprocessing, image segmentation and image analysis [8]. Segmentation plays an important role in image processing techniques [9]. Prior to image segmentation, there are various image enhancement techniques that are employed in order to achieve a better result during the segmentation of the image. These enhancement techniques are employed because the captured images might be corrupted due to the presence of noise. Some commonly available image enhancement techniques or filters to de-noise an image, especially cell images are; Gaussian filter, mean (average) filter, median filter and many more. Removing the noise entails passing the image through digital image filter. Therefore, there is a need for the comparison of the filtering techniques for cell segmentation in order to determine which filter best fit the filtering process of cells in order to obtained better results during segmentation process.

2. Materials and Methods

2.1 Materials

The specification of the personal computer used is given as; system type: 64-bit operating system, x64-based processor, with an operating system of windows 10 professional, a Read Access Memory (RAM) of 8GB and a processor specification as Intel ® Core ™ i5-3320M CPU @ 2.60GHz.

2.2 Methods

2.2.1 Dataset

The dataset for this research was sourced from the following link "http://murphylab.web.cmu.edu/data/2009_ISBI_Nuclei.html" [10]. The dataset contains forty-eight (48) images.

2.2.2 Cell Image Enhancement

Cell image enhancement is the process of improving the quality of the original cell images in the dataset before segmentation. In general, it is to convolve the original cell image I(x,y) of size mxn with a mask to obtain an output cell image O(x,y). The three (3) different filtering techniques used in this paper namely; Gaussian, Median and Mean (Average) filter.

The Gaussian filter is obtained by computing the sum of products among the input image and the Gaussian mask. It is mathematically defined as [11]:

$$O_g(x,y) = \sum_{i=0}^{m-1}\sum_{j=0}^{n-1} G(x,y) I(x-i, y-i) \tag{1}$$

$$G(x,y) = \frac{1}{2\lambda\sigma^2} e^{\frac{-x^2+y^2}{2\sigma^2}} \tag{2}$$

where, G is the Gaussian mask at the location (x,y), x is the distance from the origin in the horizontal axis, y is the distance from the origin in the vertical axis and σ is standard deviation of the Gaussian distribution.

The principle of operation of the median filter is to take each pixel value of the original digital image and replaced with the median value obtained after the pixels of the mask (W) are arranged in the order of gray levels [12]. The median filtering output is given as [12]:

$$O_m(x,y) = median\{I(x-i, y-j), i, j \in W\} \tag{3}$$

The principle of operation of the mean filter is the implementation of a local averaging operation where the value of each pixel is replaced by the average of all the values in the local neighbourhood [13]. It is mathematically represented as:

$$O_a(x, y) = \frac{1}{M} \sum_{(i,j)\in W} I(x-i, y-j) \tag{4}$$

where, M is the total number of pixels in the neighbourhood W.

2.2.3 Cell Image Segmentation

The thresholding-based segmentation technique is the simplest and useful segmentation technique that segments an image based on the intensity of the pixels value. The thresholding-based segmentation technique is the simplest and useful segmentation technique that segments an image based on the intensity of the pixels value. Cell image segmentation is to segment the cell from the entire image in order to locate the boundaries of the cells known as foreground or region of interest and the background. In order to achieve the cell image segmentation, thresholding segmentation technique is applied to the image. The thresholding segmentation technique segments an image based on the intensity of the pixels' value and produce a binary image from the gray level image [14]. The cell which is the foreground is being represented by value "1" which is the white colour and value "0" which is the black colour of the segmented image. The thresholding segmentation technique is mathematically represented as [14]:

$$S_{th}(x, y) = \begin{cases} 1 & if \quad O(x; y) \quad > \quad T \\ 0 & otherwise \end{cases} \tag{5}$$

where, T is the threshold and $O(x; y)$ is the filtered image.

2.2.4 Performance Measure

The thresholding-based segmentation technique is the simplest and useful segmentation technique that segments an image based on the intensity of the pixels value. The thresholding-based segmentation technique is the simplest and useful segmentation technique that segments an image based on the intensity of the pixels value. The performance measure is based on accuracy obtained after comparing the proposed filtered images with the ground truth images. Accuracy is simply the ratio of correctly predicted observation to the total observations. The accuracy is given as [15]:

$$Acc = \frac{TP+TN}{TP+TN+FP+FN} \tag{6}$$

where, TP (True Positive) is when the positive pixels in the ground truth image is correctly identified as positive pixels in the proposed segmented image, TN (True Negative) is when the negative pixels in the ground truth image is correctly identified as negative pixels in the proposed segmented image, FP (False Positive) is when negative pixels in the ground truth are observed as positive pixels in the proposed segmented image and finally FN (False Negative) is when the positive pixels in the ground truth and observed as negative pixels in the proposed segmented image.

3. Results and Discussion

Table 1: Quantitative result of the filters on some images

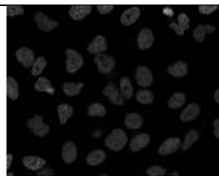
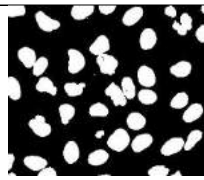
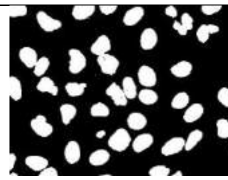
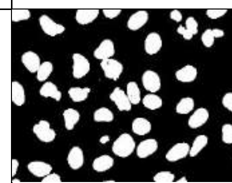
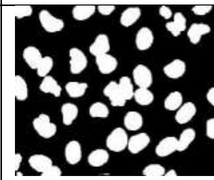
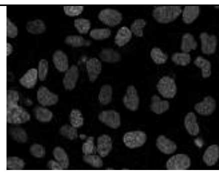
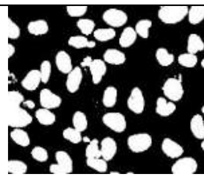
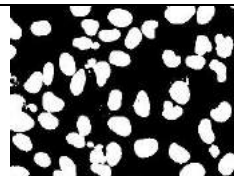
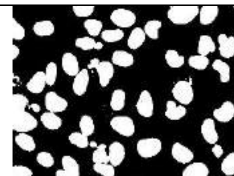
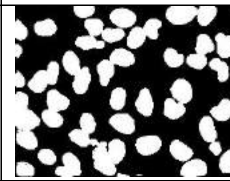
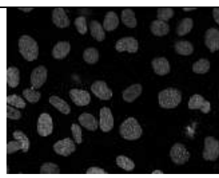
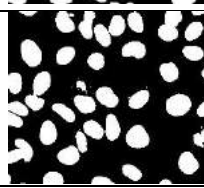
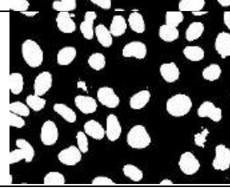
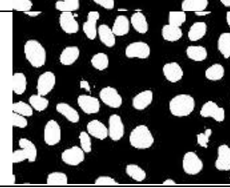
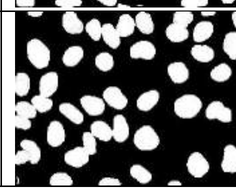
S/N	ORIGINAL IMAGES	MEDIAN	GUASSIAN	MEAN	GROUND-TRUTH
1					
2					
3					

Table 1 shows the quantitative results of the different filters on some of the dataset images. It can be observed that the cells (foreground) boundaries and location are properly identified as regards to the original images. Even with low brightness in some of the original images, the filters helped in enhancing the images before the application of segmentation. This shows the importance of filtering process in cell segmentation.

Table 2: Performance Measure Based on the Accuracy of the filters.

S/N	GAUSSIAN FILTER	MEAN FILTER	MEDIAN FILTER
1	0.94467	0.944635	0.945754
2	0.907607	0.907432	0.908926
3	0.941642	0.941823	0.940909
4	0.948292	0.948005	0.951133
5	0.967705	0.96792	0.966665
6	0.900886	0.900592	0.90569
7	0.94835	0.948239	0.949302
8	0.936827	0.937085	0.935482
9	0.95891	0.959005	0.958596
10	0.941645	0.941595	0.942301
11	0.915181	0.914946	0.918979

12	0.811114	0.811013	0.812918
13	0.909725	0.90962	0.912596
14	0.953661	0.953518	0.955077
15	0.92766	0.927826	0.927347
16	0.953717	0.953862	0.953337
17	0.847977	0.847994	0.854601
18	0.97873	0.978752	0.978555
19	0.889821	0.889738	0.891514
20	0.942802	0.942955	0.942912
21	0.963003	0.963082	0.962926
22	0.868576	0.868361	0.875001
23	0.963478	0.9636	0.96305
24	0.932027	0.931886	0.933509
25	0.948772	0.948914	0.948237
26	0.927651	0.927508	0.92901
27	0.871908	0.871714	0.877341
28	0.924732	0.924505	0.927182
29	0.923157	0.923407	0.922097
30	0.936349	0.936752	0.934304
31	0.948894	0.948715	0.949883
32	0.94049	0.940344	0.941192
33	0.930738	0.930778	0.931058
34	0.932006	0.931954	0.93263
35	0.924085	0.923893	0.927455
36	0.90154	0.901152	0.905704
37	0.904179	0.904013	0.908954
38	0.948435	0.948745	0.947678
39	0.919809	0.919868	0.919852
40	0.798157	0.797774	0.80685
41	0.944139	0.944347	0.943645
42	0.908388	0.9081	0.912057
43	0.938191	0.938225	0.938381
44	0.952621	0.952431	0.954194
45	0.90734	0.907031	0.9106
46	0.935404	0.935376	0.935898
47	0.956561	0.956766	0.955558
48	0.951444	0.951666	0.950531
AVERAGE (%)	92.5604	92.5572	92.7029

Table 2 shows the performance measure based on the accuracy of the filters. The accuracy of each image from the dataset was computed and the average of the 48 images obtained is 92.56% for the Gaussian filter, 92.56% for the mean filter and 92.70% for the median filter. It therefore shows that for cell image segmentation, the median filter outperformed the mean (average) and Gaussian filter. This is so because the median filter is very good in preserving edges of an object in an image unlike the other filters that blurs the object in an image.

4. Conclusion

This paper shows that the median filter outperformed the mean and Gaussian filters according to percentage average of the accuracy values for different variances. The accuracy value which is higher shows good quality filter better than the others.

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