ABNORMALITY DETECTION IN ENDOSCOPIC IMAGES OF THROAT CANCER BY MORPHOLOGICAL OPERATIONS

Deepti Shikha and B.V. Dhandra*
Department of P.G. Studies and Research in Computer Science
Gulbarga University, Gulbarga

Abstract

Mathematical morphology provides a number of important images processing operations and become the foundation of biomedical computing. The data extracted from images continues to be a fundamental technique for achieving scientific progress in experimental, clinical, biomedical, and behavioural research. Image segmentation is an important component of image analysis, which partitions the whole image under study into various disjoint regions based on potential features such as gray value, color, texture, etc. An algorithm was developed to perform the segmentation, classification and analysis of medical images, especially the endoscopic images for the identification of commonly occurring throat cancer abnormalities. It was observed that the proposed segmentation generates larger number of regions in the abnormal images as compared to normal. Further, it was seen that a large number of segmented regions generated in normal images due to the presence of noise such as lumen regions, bright spots generated by the reflection of light sources, etc.

Introduction

Medical imaging has been undergoing a revolution in the past decade with the advent of faster, more accurate, and less invasive devices. This has driven the need for corresponding software development which in turn has provided a major impetus for new algorithms in signal and image processing. Digital image processing is important for many biomedical applications. The medical images analyzed, used as diagnostic tools and quite often provide insight into the inner working of the process under study. It allows one to enhance the image features of interest while attenuating detail irrelevant to a given application, and then extracts useful information about the scene from the enhanced image [1, 2]. Often the raw image is not directly suitable for this purpose and must be pre-processed in a form suitable for processing. Image segmentation is the fundamental and important component of image analysis, which partitions the whole image under study into various disjoint regions based on potential features such as gray value, color, texture, etc. The segmentation process presents both the uniformity of features within the region and an edge evolution, in both the cases, the result should be balanced between adherence to the possible noisy and incomplete data. The smooth segmentation results help for further analysis [3].

Throat cancer is one of the cancers which occur in the throat. This is disease is found with different names like vocal cord cancer, throat cancer, laryngeal cancer, cancer of the glottis. This is the cancer which is found in both men and women. Throat cancer is one of the major causes of death around the world. Throat cancer affects more men than women. It affects more people aged over 50 years and the risk factor includes smoking of cigarettes, chewing tobacco and heavy alcohol consumption. Throat cancer can start in the oesophagus (food pipe), larynx (voice box), thyroid gland or cells lining of the throat (squamous cells). The early detection and characterization of throat cancer helps reduce the need for therapeutic treatment and minimizes pain and suffering [4, 5, 6]

Endoscopy provides images better than that of the other tests, and in many cases endoscopy is superior to the other imaging techniques such as traditional x-rays. In some cases, a physician may discover an apparent abnormality during examination that requires further analysis. This analysis can help to determine the cause of the abnormality such as inflammation, infection and cancer. The process of computerized visualization, interpretation and analysis of endoscopic images assist the physician for fast identification of the abnormality in the images. In this direction, research works are being carried out for classifying the abnormal endoscopic images based on their properties like color, texture, structural relationships between the image pixels, etc [3, 7, 8].

One of the most rewarding areas of image processing is Mathematical Morphology. Set theory forms the substratum of Mathematical Morphology. The objects in an image are analogous to the sets in Mathematical Morphology. The geometric relations amidst the points of such sets serve as the crux for the morphological operations [9].

Some of the premier operations that are instrumental for diverse image processing problems include erosion, dilation, opening and closing. However, the drawback of the mathematical morphology technique is that a part of the noise still remains [10]. A detailed introductory explanation of mathematical morphology is provided in [11, 12, 13]. It is particularly useful in providing basic building blocks to more sophisticated imaging applications [14]. Using mathematical morphology, image data can be filtered to either preserve or remove features of interest, sizing transformations can be constructed, and information relating to shape, form and size can be easily applied.

The early applications of medical imaging sought to diagnose simple pathology such as bone fracture or foreign bodies. Today, medical imaging has become a discrete medical discipline and an essential part of prevention, diagnosis, and high treatment standards throughout the world, revolutionizing virtually every aspect of clinical medicine. A number of imaging modalities are routinely employed not only to rule out overt disease or injury but also to reveal anatomical abnormality and dysfunction of organs, often well ahead of clinical manifestations. Thus, medical image analysis has gained importance [15]. Medical imaging refers to the techniques and processes used to create images of the human body (or parts thereof) for clinical purposes (medical procedures seeking to reveal,

diagnose or examine disease) or medical science (including the study of normal anatomy and physiology) and depends on the analysis medical experts detect the cancerous region based on the color information obtained from the endoscopic images as discernible to their eyes [16].

In the present investigation, we have developed the algorithms and methods to perform the segmentation, classification and analysis of medical images, especially the endoscopic images for the identification of commonly occurring throat cancer abnormalities to assist the physician for further diagnosis and treatment. The proposed worked is described in section 2, experimental results of our algorithm in section 3 and conclusions are given in section 4.

Proposed method

Image preprocessing and segmentation

The endoscopic images of the throat cancer considered as input images. The RGB color image contains data three times more than a gray-scale image. So, after the image pixels resized to a fixed value 128 * 128, the resized RGB image was converted into a grayscale image. In the process of the conversion, the hue and saturation information are eliminated, retaining the intensity component of each pixel in the image. The grayscale image was

smoothed using the average filter with the mask size 3X3, thereby reducing the noise present in the image. Further, the bright spots formed due to the reflection of light source present in the endoscope were eliminated by replacing such pixels with the average intensity value.

The pre-processed images fill the bright spots with average intensity value; this increases the contrast of the resultant image. The complement of the pre-processed image was computed by subtracting every pixel of the image with 255 as the intensity value in a gray scale images are ranging from 0 to 255. In the output image, dark areas become lighter and light areas become darker. The extended minima transform applied on the complemented image, extended minima transform was a kind of threshold operation which bring most of the valleys present in the image terrain to zero. The imimposemin function also changed a valley's pixel values to zero, deepest possible valley for unit 8 images. The combined process of extended minima transform and the image imposition controlled the excessive over segmentation of the image.

Feature Extraction

When the input data to an algorithm was too large to be processed and it is suspected to be notoriously redundant (much data, but not much information) then the input data were transformed into a reduced representation set of features (also named features vector). Transforming the input data into the set of features called as *feature extraction*. If the features extracted are carefully chosen it was expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input. Some of the following features were extracted from the resultant segmented images:

Area: the actual number of pixels in the region.

Eccentricity: the eccentricity of the ellipse that has the same second-moments as the region. The eccentricity is the ratio of the distance between the foci of the ellipse and its major axis length. The value is between 0 and 1 (0 and 1 are degenerate cases; an ellipse whose eccentricity is 0 is actually a circle, while an ellipse whose eccentricity is 1 is a line segment). This property is supported only for 2-D input label matrices.

On Pixel Density: The on pixels density of an image is the number of pixels in the extracted region by the size of the image.

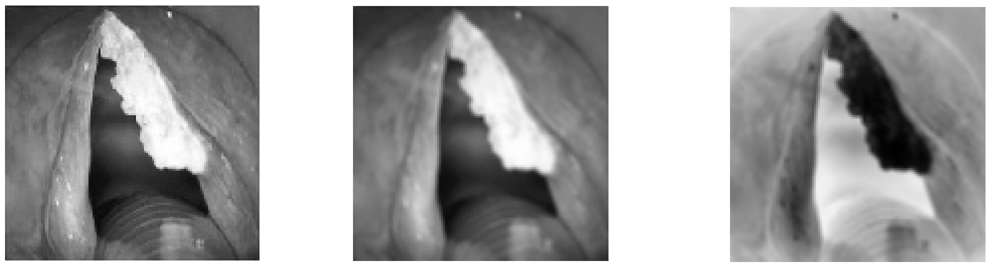
$$\text{On pixel density} = \frac{\text{no of pixels}}{\text{size of the image}}$$

Experimental results

The morphological image segmentation method for detection of throat cancer in endoscopic images was proposed and implemented on 20 abnormal and 7 normal endoscopic images. The 20 images of sized 128x128 pixels containing the cancerous region of the throat are considerd, which were assumed to be free from lumen region and

are preprocessed. The preprocessing involves smoothing of color images using average filter. The results depicted in Fig.1 shows the experimental results of segmentation of abnormal regions detected in the below test image using the proposed method.

(b)



(c) *(d)* *(e)*

(f) *(g)* *(h)*

Fig 1: Segmentation process for endoscopic image of throat cancer

Input color endoscopic image, (b) resized image to pixel 128 * 128, (c) converted grayscale image, (d) Image after smoothing, (e) Inverse transform image,(f) Complemented Image, (g) Extended minima transform, (h) Image after imposition process.

The Table 4.1 and 4.2 exhibits the above described features obtained after the proposed segmentation process applied on the abnormal and normal images. The results are shown for 20 abnormal images and 7 normal images.

	Area	**Eccentricity**	**On Pixel Density**
Cancer01	1772	0.96005	0.10815
Cancer02	313	0.9135	0.019104
Cancer03	4326	0.88148	0.26404
Cancer04	962	0.92178	0.058716
Cancer05	665	0.84245	0.040588
Cancer06	4447	0.79415	0.27142
Cancer07	604	0.98703	0.036865
Cancer08	2020	0.78793	0.12329
Cancer09	2772	0.93687	0.16919
Cancer10	903	0.92426	0.055115
Cancer11	721	0.97731	0.044006
Cancer12	419	0.86558	0.025574
Cancer13	6130	0.28642	0.37415
Cancer14	213	0.95002	0.013
Cancer15	1592	0.74536	0.097168
Cancer16	1711	0.59126	0.10443
Cancer17	468	0.93967	0.028564
Cancer18	2273	0.53358	0.13873
Cancer19	2485	0.53038	0.15167
Cancer20	535	0.95113	0.032654

Table 4.1: Extracted features from the segmented abnormal images

	Area	**Eccentricity**	**On Pixel Density**

Normal01	2405	0.5392	0.14679
Normal02	0	0	0
Normal03	0	0	0
Normal04	0	0	0
Normal05	1982	0.53458	0.12097
Normal06	0	0	0
Normal07	0	0	0

Table 4.2: Extracted features from the segmented normal images

Further it was seen that a large number of segmented regions generated in normal images due to the presence of noise such as lumen regions, bright spots generated by the reflection of light sources, etc.

The following given hypothesis was considered from the normal images.

$$H_o: \underline{\mu} = (620, 0.10, 0.05) \quad (1)$$

$$H_1: \underline{\mu} \neq (620, 0.10, 0.05) \quad (2)$$

Given as X_1 = Area, X_2=Eccentricity and X_3= On Pixel Density, were measured and obtained the following results.

$$\bar{X}_1 = 1766.55$$

$\bar{X}_2 = 0.8160105$

$\bar{X}_3 = 0.1078212$

The covariance and inverse of covariance matrix is given as

$$\text{Covariance matrix} = \begin{bmatrix} 0.56329 & 0.0026 & 0.0003 \\ 0.0026 & 0.0000 & 0.0000 \\ 0.0003 & 0.0000 & 0.0000 \end{bmatrix} \quad (3)$$

$$\text{Inverse of Covariance} = \begin{bmatrix} 0.0000 & 0.0026 & -0.0000 \\ 0.0000 & 0.1407 & -0.5629 \\ -0.0000 & -0.5629 & 4.5036 \end{bmatrix} \quad (4)$$

The Hotelling's T^2 statistics was computed for testing the above hypothesis and was given by

$$T^2 = 20 [1766.55 - 620, 0.8160105 - 0.10, 0.1078212 - 0.05] \begin{bmatrix} 0.0000 & 0.0026 & -0.0000 \\ 0.0000 & 0.1407 & -0.5629 \\ -0.0000 & -0.5629 & 4.5036 \end{bmatrix} \begin{bmatrix} 1766.55 - 620 \\ 0.8160105 - 0.10 \\ 0.1078212 - 0.05 \end{bmatrix}$$

$$= 15.30 \quad (5)$$

Critical value was calculated by the following given formula.

$$\text{Critical Value } \frac{(n-1)p}{n-p} \quad F_{p.n-p}(0.10) = 8.18 \quad (6)$$

The observed $T^2 = 15.30 > 8.18$

Here 8.18 the null hypothesis of normal images being rejected at 10% level of significance.

Conclusions

Medical image analysis are crucial for obtaining solutions for the problems like image guided surgery, description of anatomical regions, deformation analysis and visualization of anatomical and physiological processes. Hence there is necessity to carry out the potential research work in this direction. Therefore, in this present work, an attempt was made for segmentation and analysis of endoscopic images for the detection of possible presence of abnormality, which may assist the physician for the fast diagnosis of diseases and quick treatment.

The segmentation results were compared with the manual segmentation performed by the medical experts. The experimental results showed good agreement with the manual segmentation. Thus, the proposed segmentation method can be used for automatic detection of cancerous region in endoscopic images, which assists the physician for faster and proper diagnosis of the disease for immediate treatment.

As stated above, the proposed method depends on the endoscopic equipment. The change in the endoscope may lead to changes in the color property of the image, which may not yield the expected results and large number of segments would be generated because due to the presence of noise such as lumen regions, bright spots generated by the reflection of light sources, etc. The limitations of the algorithm examined so far are certainly prone to segmentation errors if the objects portrayed in the color images are affected by highlights, shadowing, and shadows. These phenomena will cause the uniform colored surfaces to change drastically. This may lead to the over segmentation of the regions. The only way to overcome this drawback is to analyze how light interact with colored materials and to introduce models for this physical interaction in the segmentation algorithms.

References

Jain, A.K., Fundamentals of Digital Image Processing, Prentice Hall, 1989.

Gonzalez R. and R. Woods, Digital Image Processing, Addison-Wesley Publishing Company, 2008.

Dhandra, B. V., Hegadi R., Active Contours without Edges and Curvature Analysis for Endoscopic Image Classification, International Journal of Computer Science and Security, Vol.1 (1), pp. 19-32, 2005.

http://www.healthline.com/channel/throat-cancer.html

http://www.cancercenter.com/throat-cancer-symptoms.html

http://www.cancer.org/document/PED/content/PED-2-3X-Endoscopy.asp

Hiremath, P. S., Dhandra B.V., Humnabad I., Hegadi R., Rajput G. G., Detection of Esophageal Cancer (Necrosis) in the Endoscopic images using color image segmentation, Proceedings of second National Conference on Document Analysis and recognition (NCDAR 2003), *Mandya, India*, Vol. 1(1), pp 417-422, 2003.

Wang, P., Krishna S. M., Kugean C., Tjoa M. P., Classification of Endoscopic Images based on Texture and neural Network, Proceedings of 23rd Annual EMBS International Conference, pp 3691-3695, 2001.

Basha, S.S. and K. S. Prasad, Automatic Detection of Breast Cancer Mass in Mammograms Using Morphological Operators and Fuzzy C-Means Clustering, Journal of Theoretical and Applied Information Technology, 2009.

Soille, P., Morphological Image Analysis: Principles and Application, Springer-verleg, 1999.

Ella, H. A. and T. A. E. Hadi, Digital mammography image analysis system based the on mathematical morphology, IEEE computer society, 7th International Conference on Intelligent Engineering Systems INES 2003, March 4-6 Assiut-Luxor, Egypt, pp 141-147, 2003.

Dengler, J., S. Behrens and J. F. Desaga, Segmentation of micro calcifications in mammograms, IEEE Trans. Medical Imaging, vol. 12(4), 1993.

Ali, J. M. and H. A. Ella, Mathematical Morphology Approach for Enhancement Digital Mammography Images , International Conference on Biomedical Engineering (BioMED2004) February 16-18, 2004.

Srismobut, P., Morphological Image Processing, IP Seminar, 4 November 2004.

Dhawan A., Medical Image Analysis, IEEE Computer Society Press, 2003.

Hiremath, P.S. and H.Y. Iranna.Automatic Detection of Abnormal Regions in Endoscopic Images of Esophagus Using a Skin Color Model, AIML Journal, Vol. 6 (4), pp 56, 2006.