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Algorithm for Bleeding Determination Based On Object Recognition and Local Color Features in Capsule Endoscopy

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***Abstract*—**Automatic determination of blood in less bright or noisy capsule endoscopic images is difficult due to low S/N ratio. Especially it may not be accurate to analyze these images due to the influence of external disturbance. Therefore, we proposed detection methods that are not dependent only on color bands. In locating bleeding regions, the identification of object outlines in the frame and features of their local colors were taken into consideration. The results showed that the capability of detecting bleeding was much improved.

***Keywords*—**Endoscopy, object recognition, bleeding, image processing, RGB.

I. Introduction

CAPSULE endoscopy is easy to operate since no insertion of a long endoscopic bundle. Unfortunately due to the nature of capsule endoscopy, image quality is not as good as the conventional endoscopy and the frame rate is as low as three per second [1]. For this reason, there are problems of low temporal coherence among the subsequent frames and naturally capsule images are more difficult to analyze than other medical images. Therefore, it is advisable to develop automatic detection algorithm suitable especially for capsule endoscopy [2].

Our previous researchers studied algorithms to detect blood in the intestinal tracts [3]-[5]. We came up with the parameters called the features that were computed from optical characteristics of blood. Bleeding was determined through statistical analysis and in consideration of morphological characteristics. Our algorithm provided with a sensitivity of 87% and a specificity of 90% in detecting blood of human small intestine. However, 81% sensitivity and 88% specificity were achieved when the same algorithm was applied for the other images whose brightness ranged from low to high. Individual prediction accuracy with respect to brightness varied as shown in Fig. 1. In this figure, brightness was derived from root mean squares of the average of R, G and B values. Sensitivity and specificity drop as image brightness decreases. Both sensitivity and specificity were less than 40% when brightness was 0.5 since the algorithm used only the amplitude of RGB that may be susceptible to external disturbances under low brightness. It is not appropriate to use only R, G and B color bands to analyze the images.

In general, regions of low brightness in capsule image were associated mainly with particular objects such as wrinkles, air bubbles and digestive fluids and regions away the image sensor. We examined these regions very carefully whether there was room for increase of prediction accuracy. In this study, we were particularly interested in developing algorithms to improve the capability of image analysis in the images under low brightness. We introduced, for this purpose, a detection algorithm of object outline in an image frame and their color separations within a particular outline. Object recognition and their local color analysis were implemented as a part of program and used in predicting bleeding regions.

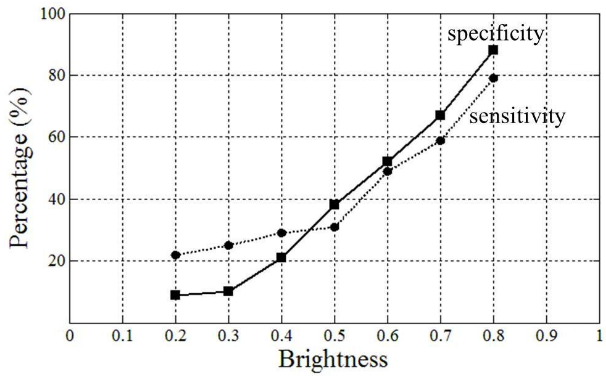

Fig. 1 Capability of detecting bleeding regions as image brightness varies

II. Methods

Capsule images were obtained using MiroCam® (IntroMedic Co. Ltd, Seoul, KOREA).

A. Image Segmentation Using Canny Edge Detection

Canny Edge Detection is a 2-D first derivative edge detection method of Gaussian function reported by John F. Canny in 1953 [6]. First, RGB image is converted into gray scale image and Gaussian filtering is performed. This reduces noises that might be generated during first derivation. Based on this blurred image, extrema of first derivatives were found from Norm and angle of the gradient computed by applying Sobel function to the image pixels horizontally and vertically. Threshold known

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as Non-maximum suppression and edge tracking by hysteresis are obtained through this process and they are used to get edge information.

In digestive tract, polyp or normal intestinal fold appears like the small spot with its low intensity [7]. In general, what we have interest in are the outlines in order to find out shapes of structures, particular objects or foreign substances whose size are relatively large. Therefore, there will be numerous small outlines along with contours of biological tissue structures when we use well-known edge detection algorithm such as Sobel, Frewitt and Roberts [8]. Small outlines will make it difficult to find biological contours of our interest. Canny edge detection, however, makes images blurred by applying Gaussian filtering in the first place and the contours of some polyps or normal folds can be smeared out.

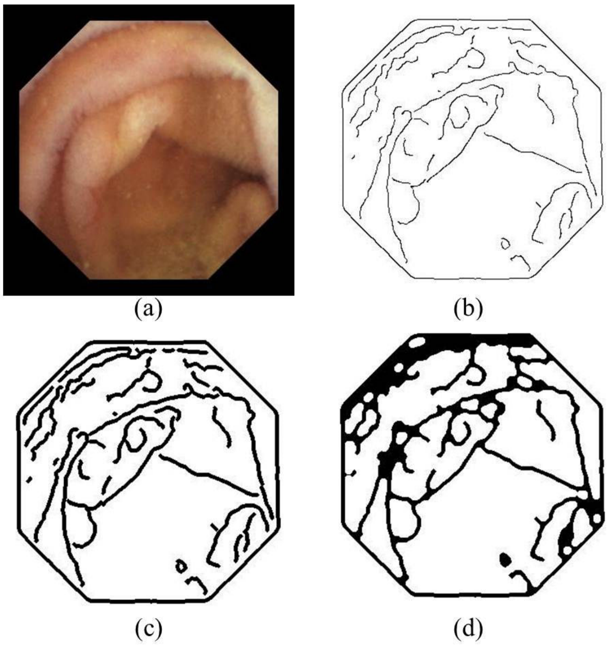

Fig. 2 Steps of tissue segmentation (a) an endoscopic image with bleeding in human small bowel (b) output image after canny edge detection (c) output image after application of morphological erosion function (d) output image that shows the outlines after application of morphological opening function.

However, the outlines of subject of no concern or relatively large objects cannot be removed. In order to minimize single edges generated during this process, Gaussian filtering is applied once again before Canny edge detection [9]. Outlines obtained by this process have gaps and holes. It is advantageous to remove gaps and holes and to have closed outlines for the purpose of image segmentation. We applied morphological erode and opening function to remove single edge induced by gaps and holes.

Fig. 2 depicts the steps of tissue segmentation. Fig. 2 (a) is a capsule image of small intestine. Fig. 2 (b) is the image that was Gaussian-filtered and then went through Canny edge detection. Fig. 2 (c) is the result after morphological erode function and Fig. 2 (d) is the final segmentation obtained from morphological opening function and the contours are clearly revealed.

B. Color Features for Local Area

Colors of the digestive tract become important factor for image analysis. Abnormal tissue structure or disease that is of our concern shows different color. For example, in general, normal tissue appears to be bright red while bleeding is dark red. Ulcer often looks white and digestive fluid red. Therefore, color information plays a vital role in analyzing a particular tissue [10].

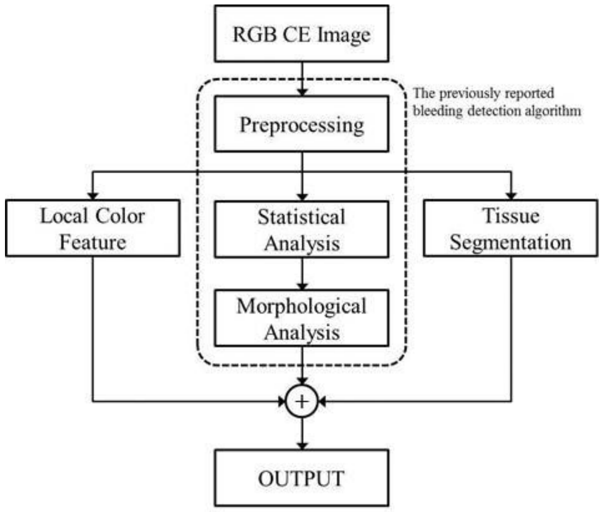

Fig. 3 A functional block diagram for detecting bleeding. The dot line indicates our previous algorithm and the rest are additional methods proposed in this investigation. They are supplemented with tissue segmentation and feature analysis of local colors in a segmented zone.

There are diverse color models such as RGB, HSV, CMYK, YUV, Luv and Lab. A particular color model is chosen depending on a specific objective. Monitor screen adapts RGB color space, but is not appropriate for human visual system. Thus, we are going to use HSV color space for image analysis.

HSV color space is represented by Hue, Saturation and Value. Hue displays color where red in the longest visible spectrum is set to be 0 degree and colors up to 360 degrees are arranged. Saturation represents the purity or intensity of a color where high saturation looks rich and low saturation looks dull. Saturation ranges from 0 to 100%. Value shows brightness of color with a range between 0 and 100% that is the maximum of R, G and B. We set 6, 3 and 3 categories for hue, saturation and value respectively and have a total of 54 categories.

C. Bleeding Detection Algorithm

Fig. 3 shows the overall steps of bleeding detection algorithm in addition to tissue segmentation and color analysis for local area. First data preprocessing is performed. Capsule images are filtered and certain regions are masked in order to speed up analysis time. Then statistical analysis of blood pixels and morphological characteristics of bleeding regions are examined based on only RGB. Statistical analysis includes the extraction of features from optical characteristics of blood as well as normal tissue. This time we examine local areas which are obtained from image segmentation. We apply the same statistical analysis for the local areas and find whether pixels belong to blood or normal tissue. We confirm pixels as blood when local area prediction on them gives higher probability than the whole frame prediction does.

III. Results

We prepared a total of 20 endoscopic images which are from human small intestine. In order to verify our algorithm, clear bleeding sites were tested in the first place. Boundary regions between blood and normal tissue and some pixels which were difficult to be identified were not used for our evaluation. Fig. 4 shows the results where Fig. 4 (a) is the original endoscopic image. Fig. 4 (b) clearly shows that bleeding sites located in low-illumination region could not be predicted. Only bleeding sites in the upper-middle part with bright illumination are correctly predicted as blood. Fig. 4 (c) is the image processed by our proposed algorithm and all the bleeding pixels are correctly diagnosed.

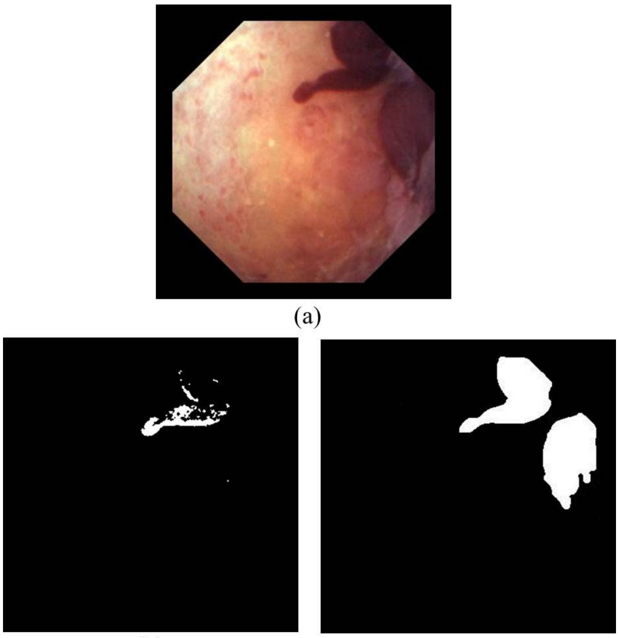

Fig. 4 Comparison between the previous algorithm and proposed algorithm; (a) original image, (b) predicted bleeding sites (shown in white) by the whole frame processing, (c) predicted bleeding sites (shown in white) by image segmentation and local area processing.

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References

[1] A. Glukhovsky, “Wireless capsule endoscopy”, *Sensor Review*, vol. 23, no. 2, 2003, pp. 128–133.

[2] D. G. Adler and C. J. Gostout, “Wireless Capsule Endoscopy”, *Hospital Physician*, 2003, pp.14-22.

[3] Y.-G. Lee, and G. Yoon, “Bleeding Detection Algorithm for Capsule Endoscopy,” *World academy of science engineering and technology*, vol. 81, pp. 672-677, Sem., 2011.

[4] Y.-G. Lee, and G. Yoon, “Real-Time Image Analysis of Capsule Endoscopy for Bleeding Discrimination in Embedded System Platform,” *World academy of science engineering and technology*, vol. 59, pp. 2526-2530, Dec., 2011.

[5] Y.-G. Lee, and G. Yoon, “Improvement of Blood Detection Accuracy using Image Processing Techniques suitable for Capsule Endoscopy,” *World academy of science engineering and technology*, vol. 65, pp. 1096-1099, May, 2012.

[6] J. F. Canny, “A Computational Approach to Edge Detection,” *IEEE Trans. Pattern Analysis and Machine intelligence*, vol. PAMI-8, no. 6, pp. 679–698, Nov. 1986.

[7] W. M. Bayliss and E. H. Starling, “The movements and innervation of the small intestine,” *J. Physiology*, vol. 24, no. 2, pp. 99–143, May 1899.

[8] F. Y. Shin, *Image processing and pattern recognition fundamentals and techniques*. New Jersey: John Wiley & Sons, 2010, ch. 3.

[9] M. Ali and D. Clausi, “Using The Canny Edge Detector for Feature Extraction and Enhancement of Remote Sensing Images,” in *Proc. Inter. Geoscience and Remote Sensing Symp., IGARSS*, Sydney, Australia, 2001, pp. 9–13.

[10] B. Li and M. Q.-H. Meng, “Analysis of the gastrointestinal status from wireless capsule endoscopy images using local color feature,” in *Proc. 2007 Inter. Conf. Information Acquisition*, Jeju City, Korea, 2007, pp. 553–557.

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