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Preliminary Study toward Automated Polyp Detection for Screening Colonoscopy Images

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1. Introduction

Colorectal cancer has been a major cause of death in Japan. In 2010, it is the second leading cause of cancer-related deaths among woman and forth among men in Japan [1]. Colorectal cancer can be treated with the colonoscopy in early diagnosis. Naturally, increasing rates in colorectal cancer causes an increase in number of colonoscopy examinations taken recent years. Hence, such increase in colonoscopy examinations causes huge workload on physicians which may lead to serious problems such as inaccurate diagnosis and diagnosis failures. In fact, recent studies suggest that there is a significant miss-rate for the detection of even large polyps and cancers [2]. Thus, it is crucial issue to develop intelligent systems toward colonoscopy examination which may offer good support and guide to physicians by enabling accurate and precise polyp detection. As a principal step toward such intelligent systems, we propose an automated polyp detection method.

2. Proposed Polyp Detection Method

2.1 Overview of Proposed Method

The whole process consists of the learning phase and the test phases as shown in Fig 1. Both in the learning and the test phases, image preprocessing is performed to enhance the characteristics of polyps from normal intestine wall with a proposed edge detection method, and to reduce the effects of specular highlights which usually exist in frame of a colonoscopy video. Next, gray-scale HLAC (Higher-order Local Auto-Correlation) features [3] are extracted as geometric characters to make a feature vector for each image. Then, the base vectors which are forming the normal subspace are estimated by applying PCA (Principal Component Analysis) subspace method [4]. After all, the distance between the feature vector of the test image and the normal subspace is calculated. According to this distance, the abnormality degree is measured to classify the images for normal and non-normal (polyp is existed).

2.2 Image Preprocessing

In a frame of a colonoscopy video, the edges around the polyps are not quite distinguishable at every time. Moreover, specular highlights are existed if the camera of colonoscope was focused a reflecting surface at the front which makes white saturation on the image. Therefore, image preprocessing is performed to enhance the characteristics of polyps from normal intestinal wall and to reduce the effects of specular highlights. The image preprocessing includes proposed edge detection method and a process of disabling specular highlights as shown in Fig.2.

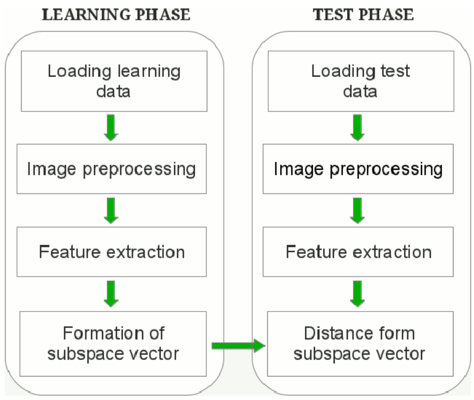

Fig. 1 Flow of polyp detection method

2.2.1 Proposed Edge Detection Method

The process of the edge detection method is shown in Fig.2 as a part of image preprocessing and demonstrated with samples in Fig.3, which shows the processing of original polyp image (a). The Laplacian operator provides relatively strong edges when the grey level changes slowly from dark to bright levels [5]. Thus, the proposed edge detection method is based on Laplacian operator (b). Because the colonoscopy images are predominantly colored red, the detected edges of the polyps with Laplacian are commonly in red colors. Hence, the red pixels of Laplacian operated image provides the most useful information and they are extracted for the subsequent steps (c). In the next step, the image is converted to HSV colorspace to extract its S-plane

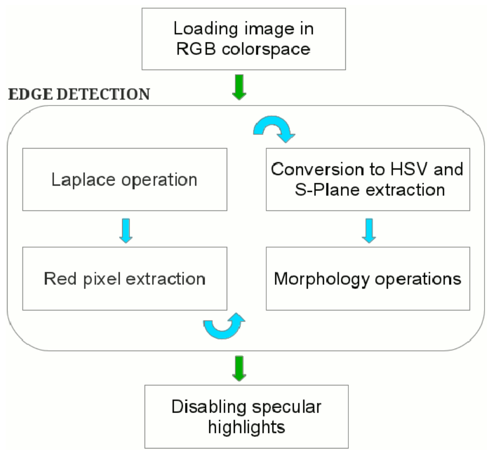

Fig. 2 Flow of image preprocessing

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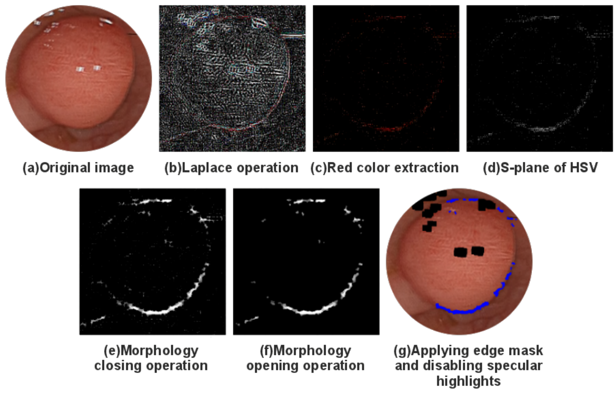


Fig. 3 Steps of image preprocessing with samples

(saturation channel) which provides the intensity of extracted red pixels previously (d). Afterwards, Morphology operations are applied to the processed image in an order of closing operation with large parameters (e) and opening operation with small parameters (f). At the end, the processed image is applied to the original image as an edge mask, and specular highlights are set to black (g).

2.2.2 Disabling Specular Highlights

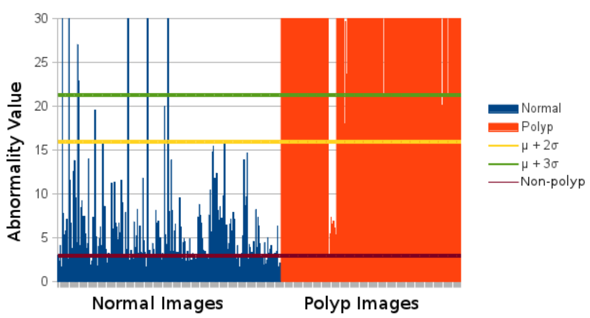
To be able to normalize the images, the specular highlights are disabled from feature extraction with setting the color of the region to black (all three color channels are set to 0).

This process is performed after the edge detection, otherwise disabled area would also be detected as edges. In addition, possibly mis-detected edges because of the specular highlights in the previous step, can be also disabled simultaneously.

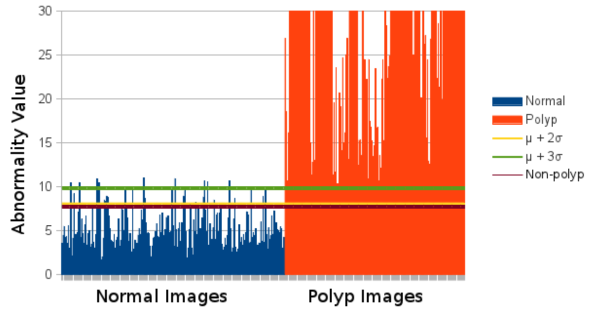
3. Experimental Results

Performance of the proposed method demonstrated with and without image preprocessing procedure. In the learning phase 380 images which are clear images of the normal intestine wall were used. In the test phase 371 images including normal images and polyp images were used. 205 of the test images were normal images which include both clear and blurry images. 166 of them are the polyp images which were included polyps with a diameter greater than about 1cm.

Because in the learning phase only the normal images are used, in the test phase if the distance is near it is classified as normal and if the distance is far it is classified as polyp. The classification was made for the thresholds $\mu + 2\sigma$, $\mu + 3\sigma$ and *Non-polyp line* which means to lowest deviation distance for polyp images in the test phase.



Graph 1 Results without image preprocessing



Graph 2 Results with image preprocessing

Table 1 Experiment results

	Threshold		Polyp %	Polyp Rate	Normal %	Normal Rate
Without image pre-processing	$\mu + 2\sigma$	15.97	95.8	159/166	94.6	194/205
	$\mu + 3\sigma$	21.28	94	156/166	95.6	196/205
	Non-polyp	2.98	100	166/166	20.5	42/205
With image pre-processing	$\mu + 2\sigma$	8.01	**99.4**	165/166	86.3	177/205
	$\mu + 3\sigma$	9.86	**99.4**	165/166	95.1	195/205
	Non-polyp	7.69	100	166/166	**85.9**	176/205

With image preprocessing the accuracy rate of polyp detection was increased in each case, as shown in Table 1 and the distinction between polyp and normal images became more noticeable as shown in Graph 2.

4. Conclusion and Future Works

As a step of developing intelligent systems for optical colonoscopy examinations, a preliminary study toward automated polyp detection was proposed. To better distinguish polyp images from the normal, colonoscopy images were preprocessed with a new edge detection method and a process of disabling specular highlights. Accordingly, polyp detection rate reached to 99.4% and almost all polyps were detected within the test images.

In future work, to classify smaller sizes of polyps extension of the proposed image preprocessing method, and to include lumen images a study based on region segmentation [6] are expected to be conducted.

References

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