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Abnormality Detection from Wireless Capsule Endoscopy Images

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Abstract: In Medical fields, the doctors use different types of imaging technologies among those Wireless Capsule Endoscopy is the one, it used to capture images from the patient body during examination time. Wireless Capsule Endoscopy is prevailing technology which is used by Gasterologist doctors to examine the human digestive system. During the investigation time, more than 57,000 images can be generated and then the doctor examines the images frame by frame to detect mucosal abnormalities (i.e Ulcer, Erosion, erthema, polyp, bleeding…etc). In fact, this is a boring and it takes a lot of time even for a skillful gastrologist doctor. In this paper, different existing abnormal image detection techniques are studied in detail. Recently, the Wireless Capsule Endoscopy (WCE) is an active research area in medical domain. Various research works have been done aiming to develop self-acting algorithms for abnormality detection using color, texture analyses, and other techniques. This paper more focuses on single abnormality detection techniques.
Keywords: Wireless Capsule Endoscopy (WCE), Gastrointestinal Tract, Gasterologist, Mucosal.

I. INTRODUCTION

WCE is a noninvasive diagnostic technology to examining human gasterinstinal tract such as the esophagus, stomach, large intestinal, small intestinal, colon and anus it has been started using in medical field by gasteoiglogist doctor since 2001. WCE is very advantages test for patient. The patient swallow the capsule of a size about 10 × 25 mm, which incorporate camera, LED light source, wireless transmitter, and battery. After swallowing by patient then the capsule starts traveling through the human digestive system by peristaltic contractions, takes the images, and transmits them through the sensory to the receiver which is worn by patient. After the image has been captured and stored in the receiver memory then gastologist doctor start uploading in to computer and start viewing the generated image frame by frame in order to find the disease but this consume a lot of time even for experienced gastroenterologist doctors. Nowadays the process has been supported by many researchers and several algorithms have been developed to automate the traditional disease detection techniques. The exstining methods have been classified in to three parts 1) vedio preprocessing 2) segematation and 3) decetcion. And we studied all methods, and also dectection method which classified in to two parts 1) single abnormalities and multiple abnormalities detection methods. In this work we more focused on available techniques that have been used to detect single abnormality like color based approach, texture and shape methods.

II. LITERATURE REVIEW

A. Using Range Ratio color to detect bleeding from WCE images

They used methods called Range Ratio Color for detecting abnormalities from WCE [2]. WCE is an imagining technology which used to detect abnormalities from a different part of human digestive system colon, esophagus, small intestinal and stomach, to separate bleeding from non-bleeding in WCE images is the most difficult job even for skillful gastroenterologist doctor. They used range ratio color for each of R, G, and B. Therefore, they divided each image into multiple pixels and they applied the range ratio color condition for each pixel. Then they count the number of the pixels that achieved the condition. If the number of pixels greater than zero, then the frame is classified as a bleeding type. Otherwise, it is a non-bleeding[2].

B. Video Analysis Platform for Automatic Bleeding Detection

Steven Yi, Heng Jiao, Mahmood Abedi, GANV [3]. Here they developed a Software platform for automatic bleeding detection from WCE videos. it examines a human digestive system which runs about 8 h and transmitted images and those images are manually reviewed by physicians to find the diseases such as ulcer, bleeding, and polyps...etc. As a result, the process is time-consuming and is prone to disease miss-finding. They solve the process of diseases finding from GI Sentinel and it automatically detects the disease and classifies it. As a whole software framework is designed and aimed at intelligent finding and classification of major GI tract diseases such as bleeding, ulcer, and polyp from the WCE videos. The software includes the following major functional modules, NCut segmentation algorithm, the feature selection and validation method, for example, illumination invariant, color and texture features, and the SVM classification for handling different types Gl tract scenes, for example, normal tissue, food particles, bubbles, fluid, and specular reflection. After evaluation, the result has shown zero bleeding instance miss-finding rate and 4.03% false alarm rate [3].

C. Automatic blood detection in capsule endoscopy video

Adam Novozámský, Jan Flusser, Ilja Tachecí, Lukáš Sulík, Jan Bureš, and Ondrej Krejcar[9]. They proposed two automatic methods for detecting bleeding in WCE videos of the small bowel. They used two techniques the first one color information and the second one incorporates blood spot shape and size. The original idea is namely the definition of a new color space that provides good separability of blood pixels and intestinal wall [9].

D. Bleeding detection through wireless capsule endoscopy

Kumari Priya, K.S. Archana, Dr. S. Neduncheliyan[8]. The WCE is noninvasive which is recently established and doesn't require any wired device. The device is used for detection of abnormalities in WCE images during its visiting time of GI tract (i.e.colon, esophagus, small intestine, and stomach). At one time visiting it can generate 57,000 images. To determine bleeding images out of 57,000 WCE images is very hard and it takes time. They used super pixel segmentation and support vector machine (SVM) classifier for detecting the bleeding from WCE images [8].

E.Bleeding Detection in Wireless Capsule Endoscopy Images Based on Binary Feature Vector

Shangbo Zhou, Xinying Song, Muhammad Abubakar Siddique, Jie Xu and Ping Zhou [4]. WCE is a noninvasive way which is getting its popularity in many hospitals for GI examination. However, it generates a large number of images at one way of human GI tract; this creates a huge burden for physicians. To reduce this huge burden of the physicians they proposed an automatic method based on Support Vector Machine. And they used binary feature vector to overcome the drawbacks of the traditional color histogram; basically, this color histogram compares the similarity between histograms rather than checks out the existence of a specified pattern. They are experimental proved that the binary feature vector is the more effective than histograms for detecting a bleeding pattern from WCE images [4].

F. Bleeding Detection based on Color Invariants and Spatial Pyramids Using Support Vector Machines.

Guolan Lv, Guozheng Yan, and Zhiwu Wang [5]. A wireless capsule endoscopy is a newly emerging imaging technology it can inspect the whole GI tract in a non-invasive way. However, viewing WCE images is time-consuming for physicians. They proposed bleeding detection method for WCE images. Which combines both color and spatial information are designed. And they deployed histogram intersection to verify a performance of proposed descriptors [5].

G. Image analysis and ulcer detection using texture information from various colour Models

Vasileios S. Charisis, Leontios J. Hadjileontiadis a,∗ , Christos N. Liatsos, Christos C. Mavrogiannis, George. Sergiadis WCE is a newly emerging imaging technology it is slowly gaining ground, which helps to examine gastrointestinal tract special small bowel. However, the reviewing a large number of images produced by a WCE is a burden for the physicians. The paper focuses on discriminating images of the ulcer from other images. The techniques they used colour–texture features in order to know how the structure information of normal and abnormal tissue is distributed on (RGB, HSV and CIE Lab) colour spaces. The Wireless Capsule endoscopy images are pre-processed using bidimensional ensemble empirical mode decomposition so as to facilitate differential lacunarity analysis to extract the texture patterns of healthy and abnormal/ulcerous regions. Classification performance (mean accuracy > 95%).

H. Using filter Bank and Local binary pattern to detect abnormal from WCE images

Ruwan Nawarathna, JungHwan Oh, Jayantha Muthukudage, Wallapak Tavanapong, Johnny Wong, Piet C. de Groen, Shou Jiang Tang [1]. Detecting mucosal abnormalities from human gastrointestinal tract such as erythema, blood, ulcer, erosion, and polyp are the intestinal diseases that identified by Wireless Capsule endoscopy. Typically these abnormal frames appear in a small number of frames near to 5% of the total frame number, the automated detection abnormality can save doctor's time significantly. In this paper, the author proposed a new multi-texture analysis approach that effectively detects images that showing mucosal abnormalities from

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normal images, abnormalities in Wireless capsule endoscopy images have textures that are clearly discernable from normal textures using an advanced image texture analysis method. They used texton histogram of an image block as texture feature. The histogram acquires to distribute different texton that represents various endoscope images. As feature extractor, they used Leung and Malik filter bankand Local Binary Pattern, by combining both as one LM-LBP filter bank. They achieve 92% recall and 91.8% specificity on wireless capsule endoscopy images [1].

Table 2.1 Method comparison

No .	Title	Detecting Abnormalities	Features	Dataset	Classifier	Average performance
1	Bleeding detection by using Range Ratio color from WCE images	Bleeding	Range Ratio color	100	Their own classifier	98%
2	Video Analysis Platform for Automatic Bleeding Detection	Bleeding ,Ulcer , Poly	NCut segmentation algorithm, illumination invariant features, color independent features, and symmetrical texture features	1317	Support vector machine, cascade classifier	86.4%
3	Automatic blood detection in capsule endoscopy video	Bleeding	Color information , The blood spot and size	390	There own classifier	90%
4	Bleeding detection through wireless capsule endoscopy	Bleeding	Super pixel segmentation	-	Support Vector Machine	-
5	Bleeding Detection in Wireless Capsule Endoscopy Images Based on Binary Feature Vector	Bleeding	binary feature vector	-	Support Vector Machine	93.85%
6	Bleeding Detection based on Color Invariants and Spatial Pyramids Using Support Vector Machines.	Bleeding	Color Invariants and Spatial Pyramids	560	Support Vector Machines	-
7	Image analysis and ulcer detection using texture information from various colour Models	Ulcer	Color models (RGB, HSV, CIE Lab)	174	Support vector machine, Neural Network	96.5%
8	Abnormal image detection by	Erythema,	Leung and Malik and Local	57,000	KNN and their own	Recall 92%

	using filter Bank and Local binary pattern	blood, ulcer, erosion, and polyp	binary Pattern		classifier	And specificity 91.8%

III. METHODS

Methods that recognize the detection of bleeding in the frame regardless of its particular color and size. It more focused on detection of small bleeding spots (with a diameter around 5 pixels or less), which cannot be detected by most of the earlier methods. They proposed two different methods for blood detection, which can be used either individually or their results can be combined by various fusion rules. Let us call it Method A and Method B.

A. Method A

Method A has working pixel-wise and is based solely on the color. However, it doesn't work in standard RGB space because of it has been proven both in the literature and also, it is proven in their own experiments, that the RGB space does not provide enough discriminability of blood pixels (see Fig. 1). We define our new color space such that the separability of blood pixels and the intestinal wall should be maximized. The study we performed on fifteen patients shows that an appropriate color space can be defined, as shown below in the first step. Complete algorithm for Method A

1. $K = \min(1 - R, 1 - G, 1 - B),$

   $M = (1 - G - K),$

   where $R, G,$ and $B \in \langle 0, 255 \rangle$. This color space is similar to the popular CMYK space. The pixels with a low value in green and high values in red and blue are well separated.

2. $R_1 = \sqrt{G^2 + B^2},$

   $$R_n = \begin{cases} 0 & \text{if } R_1 = 0 \wedge R < 128 \\ 255 & \text{if } R_1 = 0 \wedge R \geq 128 \\ R/R_1 & \text{if } R_1 \neq 0 \end{cases}.$$

   This transform emphasizes the red channel.

3. The classification criterion C is defined as

   $C = R_n \cdot M.$

   The number of pixels of the frame, where the C-value exceeds 200, is denoted as N_C.

4. Finally, N_C is compared to a user-defined threshold of "the required number of blood pixels" t. If $N_C \geq t$, the frame is classified as positive (i.e., as one that may contain blood).

The main advantage of method A is its speed because it does not contain any high-level operations. As we will see in the experimental section, the method provides a good TP rate.

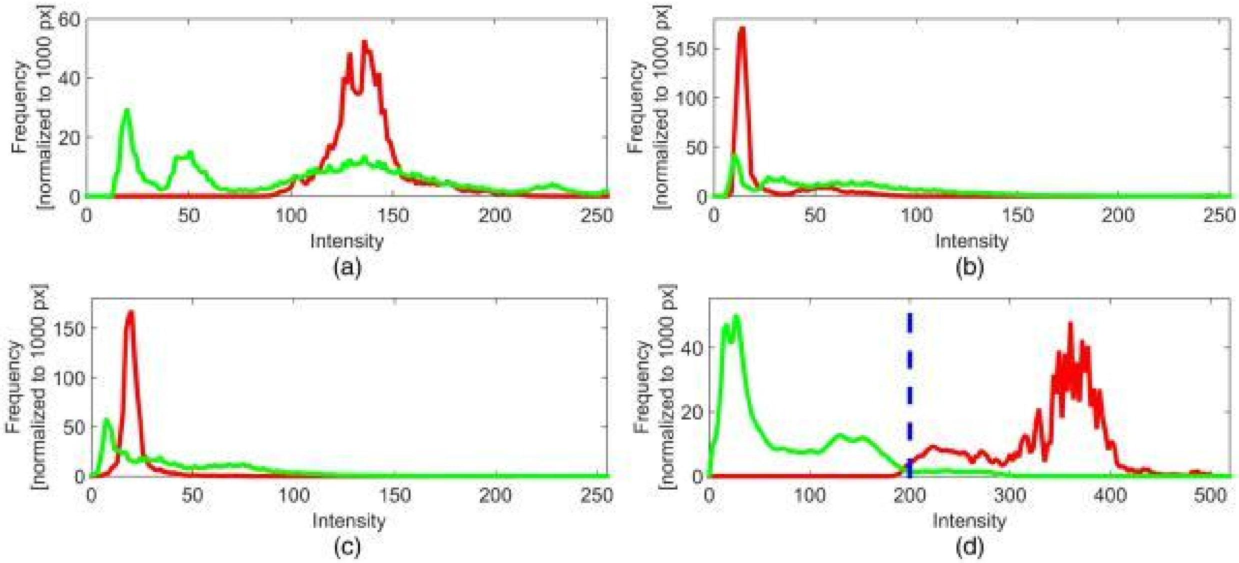


Fig. 3.1. (a)–(c) The separability of blood (red histogram) against the background (green histogram) in various color bands. The histograms were calculated over several hundred manually selected blood and blood-free patches. None of the RGB channels provides a sufficient discriminability. (d) The new color space separates the blood very well even in one dimension, given by the value of C. The empirically selected decision threshold on this training data is about 200. This value was used in all experiments in this paper.

B. Method B

Method B uses a more sophisticated approach that not only is based on pixel colors but also incorporates the assumption that the blood in the frame forms a continuous region (or a few such regions). In other words, it eliminates isolated pixels or small spots with a color similar to blood but that probably do not exhibit actual bleeding. Thanks to this, method B achieves a low FP rate; however, it is at the expense of the computational time. On the other hand, it yields generally higher false-negative rate than A.

Algorithm for method B

1) The Canny edge detector16 is applied to find closed boundary regions.
2) Morphological erosion is applied to remove small regions. The term “small” is given by a user-defined maximum diameter.
3) The color of the input image is converted to HSV. If the color is within the interval of blood color, defied in advance by training, we mask the respective pixel.
4) The intersection of the outputs of step 2 and step 3 is classified as a blood spot

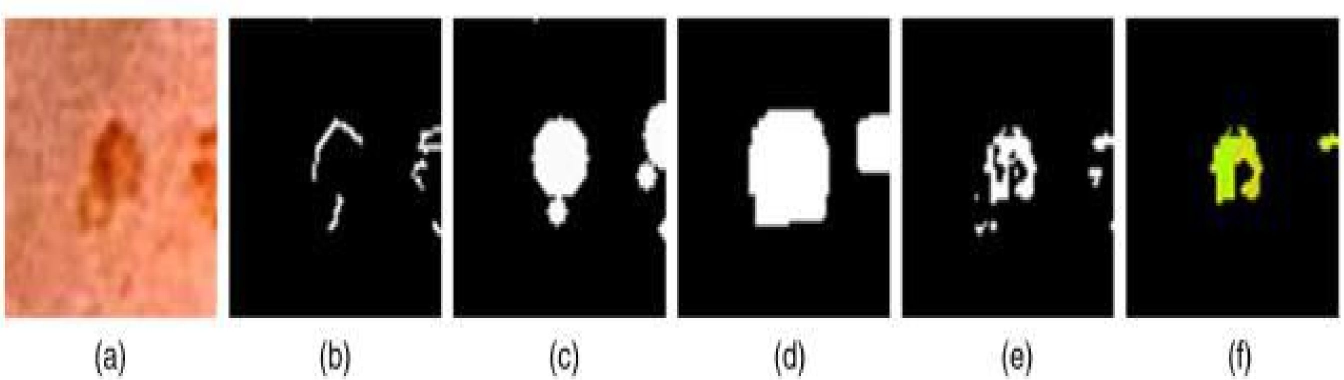


Fig.3.2. Blood detection by Method B. (a) Input image. (b) Output of Canny detector. (c) Approximative closed-boundary regions. (d) Morphological operation. (e) At the same time, the input image (a) is converted to HSV and potential blood pixels are masked. (f) The output created by intersection of (d) and (e).

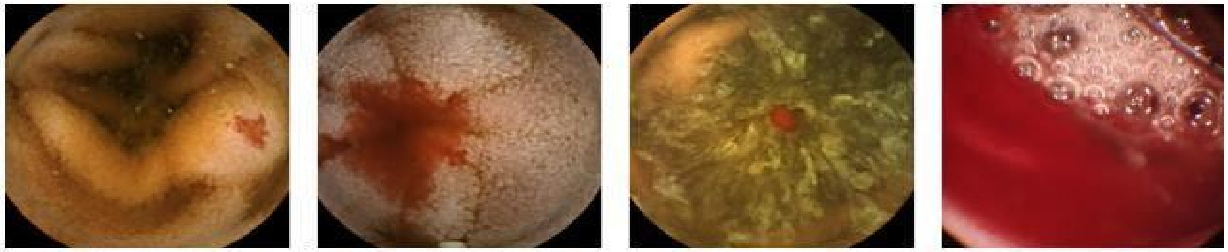
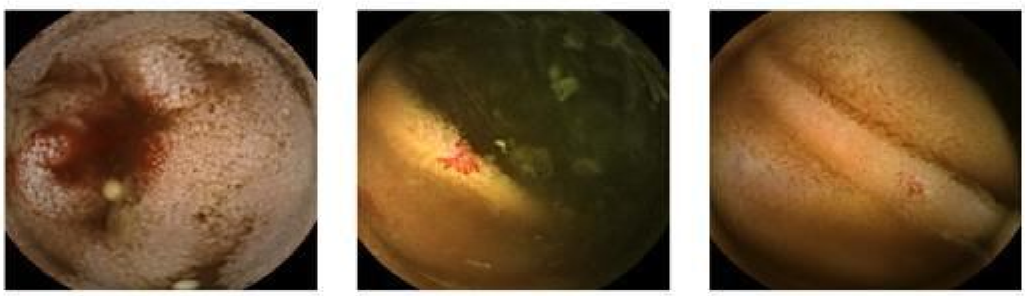


Fig.3.3. Examples of frames containing blood annotated by a doctor.

Fig. 3.4. Examples of blood-free frames annotated by a doctor.



(a) (b) (c)

Fig.3.5. Examples of hard-to-detect blood frames. (a) Found by A, missed by B. (b) Found by B, missed by A. (c) Not found.

IV. CONCLUSIONS

Discerning WCE abnormal images like bleeding from normal images in WCE images and videos is a major concern when a gastroenterologist doctor's reviews the images or videos. In this paper, we tried to survey the major techniques which have been used by different researchers to detect different abnormalities from WCE images. Basically, We tried to classified the methods which have been used by different researchers into three distinct parts such as video preprocessing, segmentation, and detection. And the detection methods also classified into two parts such as single abnormalities detection methods and multiple abnormalities detection methods. However, we focused specifically on single abnormalities detection methods based on color approach.

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