Ulcer Detection and Diagnosis Using Linear Coding for Wireless Capsule Endoscopy

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Abstract-

Ulcer is most familiar and common indication of many severe diseases in the human digestive tract. Existing techniques are not able to detect ulcer in small bowel of digestive tract. Therefore wireless capsule endoscopy (WCE) technique is widely accepted and used for diagnosis and clinical management of ulcer detected especially in small bowel. Proposed system is based on two-staged fully automated computer-aided detection system which can recognize ulcer from WCE images. Firstly, saliency reorganization method is utilized to detect ulcer candidates by segmenting image into multi-level superpixel segmentations. Then we estimate the corresponding saliency in accordance with the color and texture features in superpixel region of each level. Finally generated texture and color based saliency maps are fused together.

Index Terms— Simple Linear Iterative Clustering (SLIC),multi-level superpixel representation, saliency, saliency map, LLC

I. INTRODUCTION

ULCER is most familiar and common contusions of the gastro intestinal (GI) tract which influence about 10% of the people in the world. Ulcer is a chronic inflammatory sore or erosion on the inner mucous membranes. Mainly, there are two vital origins of ulcer in the digestive tract as Helicobacter pylori bacteria and non-steroidal anti-inflammatory drugs (NSAIDs) [1]. Though ulcer is not destructive, it is indication of several severe diseases. Crohn's disease and ulcerative colitis are two diseases caused by ulcer whose complication may lead to death.

Push and sonde enteroscopy is commonly used imaging practice for ulcer. In the examination practice of ulcer, push and sonde enteroscopy will be put in to patient's mouth or anus by skilled physicians to analysis the GI tract [2]. Even if conventional techniques play a significant task to analyze the upper and lower poins of the GI tract, they are extremely persistent to the patients. But to examine and to acquire complete access to the small intestines, these conventional practices are technically complicated.

Wireless capsule endoscopy (WCE) is a substitute for existing practices which delivers direct, painless and noninvasive examination of the small bowel. It delivers the means to optically and non-invasively investigate the interior of the small intestine.WCE has yield a firm place in the catalogue of assessment tools which exists in modern gastroenterology [1], [3]. It is extensively used by patients as they believe that WCE is less traumatic than existing traditional gastroscopy or colonoscopy. WCE also delivers the way to optically and non-invasively envision the interior of the small intestine.

The existing available WCE typically contains an optical dome, an illumination part, an imaging sensor, batteries, and a radio frequency transmitter. Once WCE is inhaled by a patient, then it is forced by peristalsis to gradually travel through the small intestine. WCE captures 2–4 images per second as it kept for 8 hours in patient's GI track [4], [5], [6]. Data recording device is connected to patient's waist where these images are transmitted wirelessly in compressed format. All these images become available off-line so that any time doctors can download and examine images for further treatment and diagnostic decisions [7]. Figure 1 shows an example of ulcer image taken by a WCE during inspection.

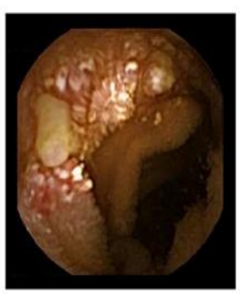

Figure1: (a) WCE device (b) Ulcer in WCE

Although the WCE has shown important compensations over the existing conventional endoscopies procedures to scrutinize the ulcer nidus in the small intestine, there are some challenges linked with this new technology. A WCE used to captures 55,000 images for each patient. But among these only 5% images captured are abnormal. So, it is tedious job for doctors to go through all these images to find out the abnormal images. Therefore, it is critical to construct an automatic computer-aided system to support the clinicians to scrutinize the ulcer images.

II. RELATED WORK

A. Related Work

There are many efforts has been taken to construct an automated computer-aided detection (CAD) for ulcer by using WCE. Li and Meng [8] invented a novel approach of texture feature which combines qualities of discrete curvelet transform (DCT) and local binary pattern (LBP).Combination of these two techniques yields enhanced descriptions of textures with multi-directional characteristic.

Charisis et al. [9] defined a new technique which first developed the complete WCE image with a color rotation operation (CR), then fetched the uniform rotation invariant LBP (ULBP) feature. Eid et al. [10] presented a curvelet-based lacunarity texture extraction method (DCT-LAC). The complete textural information is obtained by computing the lacunarity index of DCT sub-bands of the WCE images. Yu et al. [11] proposed a superior bag of word model to discover the ulcer region by means of spatial pyramid kernel and feature fusion practices. Karagyris et al. [12] outlined method to apply log-Gabor filter bank to segment the Hue component in the HSV color space of the WCE images to acquire the ulcer candidates. Then the RGB values and texture information are fetched to categorize the ulcer images and the normal ones.

Existing traditional ulcer classification techniques possesses some confines. Sometimes, image features fetched from WCE images cannot be too much effective to illustrate the precise ulcer information. Features extracted from non-ulcer area can carry noisy and redundant data which can retain problem while using complete WCE image. To deal with such problems Karagyris et al. [13] invented the ulcer candidates and fetched all features directly from the ulcer.

The saliency technique abstracts the most significant region from the image. This technique gains more attention due to its superior segmentation results. Therefore, proposed system used saliency based detection method to outline ulcer region from WCE images and then further apply generated saliency map to encode image features which are useful in ulcer image classification task.

In the field of automatic medical image diagnosis, abnormal image classification is challenging task which mainly depends on image representation. Therefore the bag of feature (BoF) model has been widely used which assures superior performance in many natural images applications.

The BoF method consider a single image as an order-less collection of local key point features, and characterize images as the histograms of the visual words. In the BoF model, each key point feature from an image is assigned to the nearest codeword by hard assignment, which will cause severe information loss when the feature locates around the boundary of several codewords.

B. The Proposed Methods and Original Contributions

Proposed system used a two-staged fully automated computer-aided recognition system to recognize ulcers from WCE images. This method mainly provides attention on automatic assessment of salient regions across the WCE images. In existing traditional saliency extraction methods computes a pixel-based saliency [14], overlooking the neighbor information and boundary information of the object. Proposed system deliver alternate way for existing techniques in which method adopts superpixel representation for ulcer saliency reorganization in the WCE images.

A superpixel is a set of pixels which is collected in several constraints of local image attributes such as color, texture, or intensity. It conserves the image composition and significantly decreases the complexity of the image processing tasks. Sometimes, single level superpixel does not yield the accurate contour of objects [15]. Thus, proposed saliency computation procedure is depends on the multi-level superpixel representation for the images.

As ulcer illustrate significant color and texture information on the WCE mucosa surface as shown in Fig. 1(b), we scrutinize these image features to estimate the equivalent saliency value for each superpixel and acquire the saliency map for each level. The ultimate saliency map is computed by a fusion approach which incorporates the generated saliency maps from all levels.

Further, system utilizes the generated saliency maps for the ulcer classification procedures. Due to superior results yielded by bag-of-words (BoW) [16] model and its variants, we intend to categorize the ulcer images by performing coding on WCE images with a modified Locality-constrained Linear Coding (LLC) method. The proposed customized LLC technique combines the original LLC method with a saliency based max-pooling to lay emphasis on the salient region for ulcer classification.

III. SALIENT REGION DETECTION

Salient regions are those which describe regions that could clearly represent the major significant or semantic contents. For the implicit images containing numerous objects or cluttered scenes, no uniform saliency metrics is invented that could represent the saliency. Therefore, WCE images containing ulcer lesions can be clearly categorized by color and texture contrasts. By utilizing these features of WCE image salient region recognition technique can segment the salient foreground region from WCE images. Thus, salient region recognition approach is particularly suitable to be used as a first step towards the ulcer recognition problem.

Proposed system provides a framework to recognize ulcer abnormalities all the way through visual saliency evaluation depending on texture and color contrasts.
The proposed saliency recognition approach is executed in three main steps as follows:

1) The first step includes multi-level segmentation, which decomposes the input image into multiple superpixels from a coarse level to a fine one.

2) Then, we perform the regional saliency assessment step by the color and texture contrasts on each superpixel level.

3) Further at last, the final saliency map is generated by fusing multi-level saliency maps together. The flowchart of the structure of the integrated saliency map is shown in Fig. 2.

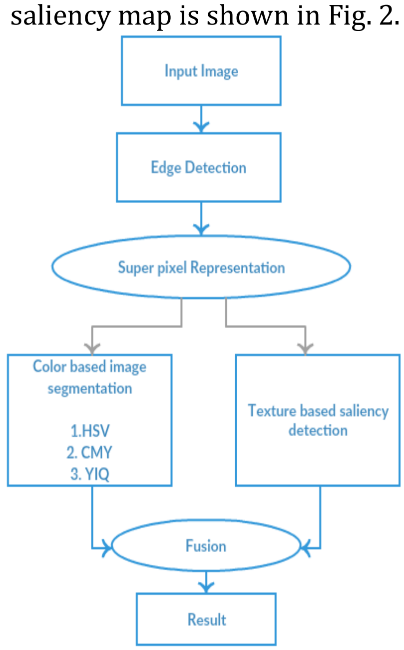

Figure 2: Flowchart of saliency detection system

The main working includes firstly is representing the multi-level superpixel in the image. Simple Linear Iterative Clustering (SLIC) is the algorithm that is applied as pre-processing method for WCE image saliency detection. Because it not only provides good segmentation results, but also generates suitable size of superpixels for WCE image analysis. In the next process, a saliency map feature of the image is extracted based on the texture by using Leung-Malik (LM) filter bank. The LM filter bank is a multi-scale, multi-orientation filter combination with 48 filters. Along with it the saliency map features of the image is also extracted based on the color by different color components of various color spaces such as RGB, CMYK, HSV and many more. Finally the texture and color based saliency maps are fused together by applying the matrix Hadamard product in an arithmetic manner. It gives the regions with higher values in the final saliency and provide the effective ulcer detection.

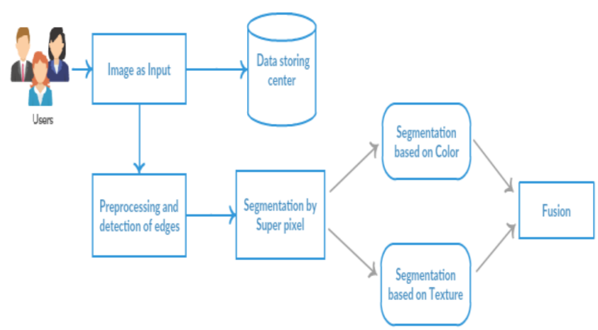

Figure 3: Architecture of system

A. Super pixel representation

A superpixel can be described as the significant entity by assembling spatially neighboring pixels which possesses analogous property. Simple Linear Iterative Clustering (SLIC) superpixel algorithm is widely utilized because it offers results with preferred number of regular, compact superpixels with a little computational overhead. Propose system applies SLIC superpixels algorithm as a pre-processing procedure for WCE image saliency recognition. It provides good segmentation results as well as creates appropriate size of superpixels for WCE image examination.

In the proposed SLIC scheme, depending on the color space and spatial distances, the local -means clustering is carried out on the pixels. Further, to acquire the precise number of the superpixels, isolated small clusters are combined with the largest neighbor clusters.

Each and every segmented superpixel is utilized as a processing unit in the proposed model. Selection of an appropriate number of superpixels for the WCE image is empiric and case-specific. Large number of superpixel results into over-segmentation, whereas too few superpixels lead into loss of the boundary information of the objects. Usage of single superpixel size for the purpose of segmentation is not capable to define accurate boundaries in some specific cases. Hence we need a multi-level superpixel method that first segments the image by utilizing numerous diverse numbers of superpixels, then fuses all superpixel segmentation in all levels later.

B. Saliency Region Detection Based on Texture

Proposed method utilized Leung-Malik (LM) filter bank to fetch texture feature of superpixels. It is invented by Leung-Malik in 1999.The LM filter bank is a multi-scale, multi-orientation filter blended with 48 filters. L M filter holds first and second derivatives of Gaussians filters at 6 orientations and 3 scales, 8 Laplacian of Gaussian (LOG) filters, and 4 Gaussians.
LM filter used to collect filter responses from sample of images which are possibly taken over multiple viewing conditions. It performs vector quantization of textures which results into textons. It then describes new images in terms of distribution of textons.
Given an image MxN, the response RMxN to the mth filter wm out of 48 filters in the LM filter bank can be calculated by

$$R_m\,(x, y)= \sum_s \sum_t\, w_m\,(s,t)\; I\,(x+s, y+t)$$

Where (s, t) stands for the matrix entry of the corresponding matrix.

C. Saliency Region Detection Based on Color

The ulcer in a WCE image illustrates different color information as evaluated against normal mucosa. However, it is very critical to select a color component that yields the most helpful information to articulate the abnormality of ulcer. We acquire a trial-and-error procedure and scrutinize the ulcer images under distinct color components of a variety of color spaces such as RGB, CIELAB, CIEXYZ, YUV, YIQ, CMYK, HSV and HSI. WCE images in the HSV and CMYK color spaces highlight the ulcer regions and separate ulcer mucosa tissues from the uninformative parts which is clear than any other color spaces. Therefore, we extract the saliency regions for all the WCE images in these two color planes.

The color feature matrix color F_l Ɛ R^{4xK} for the lth level that contains K superpixel regions may be described by using the mean and variance values in the S and M color planes. The ith column of the matrix described feature vector of the ith superpixel region at lth level.

$${}^{color}F_l(i)= [{}^{i}\mu_s, {}^{i}\sigma^2{}_s, {}^{i}\mu_M, {}^{i}\,\sigma^2{}_M]^T$$

where ${}^{i}\mu_s$ and ${}^{i}\sigma^2{}_s$ are the mean and variance of the ith superpixel in the S and M color planes.

D. Final Saliency Region Fusion

Based on the texture and color saliency we derive the proposed multi-level superpixels saliency method for the WCE images in a data fusion manner. Given image R_{MxN}, we have calculates two saliency maps ${}^{texture}S$ and ${}^{color}S$ depending on the texture and color contrast information, respectively. Then the ultimate saliency map can be defined as,

$$^{final}S = {}^{color}S \,.\, {}^{texture}S \,.\, K$$

where . stands for matrix Hadamard product. $K \in R^{M \times N}$ is used as a Gaussian kernel which is centralized at the image center and gradually declines to the edge to mimic human attention property.
The matrix Hadamard product is applied on the color and the texture saliency maps to fused them in one another in an arithmetic manner in such a way that the regions with superior values in both texture and color features could achieve superior values in the final ultimate saliency. On the opposing, if a region has high value in only one of the saliency maps, the Hadamard product will reduce it by multiplying a small saliency value to it. In this way, the final saliency map put emphasis on the regions due to both color and texture contrasts.

E. Locality-constrained Linear Coding (LLC)

In order to fetch the variety of the image uniqueness, we abstract distinct descriptors of the WCE images and then merge them together to characterize images. The first feature fetched is the dense SIFT (dSIFT) features. The SIFT characteristic is familiar as one of the most robust characteristics with respect to different geometrical changes. In SIFT feature, a local descriptor is generated by structuring a histogram of gradient orientations and magnitudes of image pixels in a small window. Instead of at key points, dSIFT descriptors are fetched at regular image grid points. The technique provide advantage of that the dSIFT descriptor could be independent to the key point discovery process which often fails due to missing texture or ill-illuminated images. Further after generation of codebooks, system maps each image descriptor matrix to the codebooks to acquire the image representation. The original LLC is first applied to encode the individual descriptors of each training and testing image. Without loss of generality, we take dSIFT descriptors as an example for the rest of the introduction and the left superscripts of different descriptors are dismissed for simplicity. After coding each descriptor vector, the codes are pooled together to generate a WCE image representation.

Pseudocode for Ulcer Detection:

1) Get the input image: I=imread('Path');
2) Extract Sobel edge of image I
3) Represent superpixel by extracting RGB component
4) Colour based Ulcer segmentation
   (i)HSV:rgb2hsv(I);
   (ii)CMY:cat(3,C,M,Y);
   (iii)YIQ:cat(3,Y,I,Q);
5) Texture based Ulser Segmntation
   (i)Compute Lab average value
   (ii)Compute Ssliency map
6) Get Resultant Fused Saliency map of ulcer

IV. CONCLUSION

Proposed system is based on a two-staged fully automated computer-aided recognition system to discover ulcer from WCE images. A saliency map extraction approach which is based on multi-level superpixel was proposed to segment the ulcer candidates in the first stage. In the second stage, the obtained saliency map is incorporated with the image features such as color and texture for performing the ulcer image recognition tasks. Finally, both the texture and color based saliency maps are fused together by applying the matrix Hadamard product in an arithmetic manner. It gives the regions with higher values in the final saliency and provides the effective ulcer detection. Proposed system contains saliency max-pooling method integrated with the Locality-constrained Linear Coding (LLC) method to characterize the images.

REFERENCES

[1] Yixuan Yuan, Jiaole Wang, Baopu Li, and Max Q.-H. Meng, "Saliency Based Ulcer Detection for Wireless Capsule Endoscopy Diagnosis", IEEE TRANSACTIONS ON MEDICAL IMAGING, VOL. 34, NO. 10, OCTOBER 2015.

[2] M. Appleyard *et al.*, "A randomized trial comparing wireless capsule endoscopy with push enteroscopy for the detection of small-bowel lesions", *Gastroenterology*, vol. 119, no. 6, pp. 1431–1438, 2000.

[3] V. S. Charisis, L. J. Hadjileontiadis, J. Barroso, and G. D. Sergiadis, "Intrinsic higher-order correlation and lacunarity analysis for WCE based ulcer classification," in *Proc. 25th Int. Symp. IEEE Comput Based Med. Syst.*, 2012, pp. 1–6.

[4] B. Upchurch and J. Vargo, "Small bowel enteroscopy," *Rev. Gastroenterol Disorders*, vol. 8, no. 3, pp. 169–177, 2008.

[5] M. Manno, R. Manta, and R. Conigliaro, "Single-balloon enteroscopy," in *Ileoscopy*, A. Trecca, Ed. New York: Springer, 2012, pp. 79–85.

[6] G. Iddan, G. Meron, A. Glukhovsky, and P. Swain, "Wireless capsule endoscopy," *Nature*, vol. 405, p. 417, 2000.

[7] N. M. Lee and G. M. Eisen, "10 years of capsule endoscopy: An update", *Expert Rev. Gastroenterol. Hepatol.*, vol. 4, no. 4, pp. 503–512, Aug. 2010.

[8] B. Li and M. Q.-H. Meng, "Texture analysis for ulcer detection in capsule endoscopy images," *Image Vis. Comput.*, vol. 27, no. 9, pp. 1336–1342, 2009.

[9] V. S. Charisis, C. Katsimerou, L. J. Hadjileontiadis, C. N. Liatsos, and G. D. Sergiadis, "Computer-aided capsule endoscopy images evaluation based on color rotation and texture features: An educational tool to physicians," in *Proc. IEEE 26th Int. Symp. Comput.-Based Med. Syst.*, 2013, pp. 203–208.

[10] A. Eid, V. S. Charisis, L. J. Hadjileontiadis, and G. D. Sergiadis, "A curvelet-based lacunarity approach for ulcer detection from wireless capsule endoscopy images," in *Proc. IEEE 26th Int. Symp. IEEE Comput.-Based Med. Syst.*, 2013, pp. 273–278.

[11] A. Karargyris and N. Bourbakis, "Detection of small bowel polyps and ulcers in wireless capsule endoscopy videos," *IEEE Trans. Biomed Eng.*, vol. 58, no. 10, pp. 2777–2786, Oct. 2011.

[12] L. Zhang, Z. Gu, and H. Li, "SDSP: A novel saliency detection method by combining simple priors," in *Proc. 20th IEEE Int. Conf. Image Process.*, 2013, pp. 171–175.

[13] A. Karargyris and N. Bourbakis, "Detection of small bowel polyps and ulcers in wireless capsule endoscopy videos," *IEEE Trans. Biomed Eng.*, vol. 58, no. 10, pp. 2777–2786, Oct. 2011.

[14] L. Zhang, Z. Gu, and H. Li, "SDSP: A novel saliency detection method by combining simple priors," in *Proc. 20th IEEE Int. Conf. Image Process.*, 2013, pp. 171–175.

[15] R. Achanta and S. Susstrunk, "Saliency detection using maximum symmetric surround," in *Proc. 17th IEEE Int. Conf. Image Process.*, 2010, pp. 2653–2656.

[16] M.-M. Cheng, G.-X. Zhang, N. J. Mitra, X. Huang, and S.-M. Hu, "Global contrast based salient region detection," in *Proc. IEEE Conf. Comput. Vis. Pattern Recognit.*, 2011, pp. 409–416.