DETECTION OF ULCER IN THE GASTROINTESTINAL TRACT USING THE WIRELESS CAPSULE ENDOSCOPY IMAGES

P.G student Adin Shirly P,
Embedded System Technology
SriSairam Engineering College,
Chennai, Tamilnadu.

Asst Professor, C.N.Savithri.,
Electronics and Communication
SriSairam Engineering College,
Chennai, Tamilnadu.

Abstract-- In this project, we propose a fully automated computer aided detection system to detect ulcer from the Wireless Capsule Endoscopy (WCE) images. Ulcer is one of the most common lesions of the gastrointestinal tract that affects most of the people in the world. WCE is used to provide painless, noninvasive inspection of the small bowel. The WCE capsule takes direct images from the patient’s gastrointestinal tract. Preprocessing of image is done using denoising by multidimensional filter. The proposed method segment the image into multi-level super pixel segmentations. The value of each pixel in the edge detected image is evaluated based on the comparison of corresponding pixel in the input image with its neighboring pixels by the morphological operation. Erosion and dilation erodes and adds pixels respectively to the edge detected image, so that the value of the output pixel has the maximum pixel value. Super pixel segmentation algorithm gives the neighbor pixel information, boundary information, and reduces the computational complexity than the other traditional segmentation methods. The abnormal region is detected by applying the threshold to segment light grains from the dark background, labeling the individual grains with different color, edges of the detected grains and extracting the area values from the detected object. The segmented image is fed into the support vector machine (SVM). SVM classifies the normal images and the abnormal images.

Keywords— WCE; multi-level super pixel segmentation; preprocessing; morphological operation; support vector.
I. INTRODUCTION

In the field of Biomedical and Health Informatics, Detection of ulcer is always problematic due to similar intensity between affected areas and normal tissues. Ulcer can occur anywhere in the body that consists of soft tissue found in the mouth, skin, intestinal tract and the brain. Lesions can also be caused by metabolic processes, like an ulcer, cancer, or autoimmune activity. Many researchers used different techniques to detect the lesion area in the targeted tissue. Manual detection of lesion area is slow and difficult; therefore automatic multiple sclerosis lesion detection is used to find the multiple lesion in the targeted region. A fast and accurate method for evaluating the size of lesions in the damaged region is used to diagnose the disease and helps the doctors in treatment decision.

Due to the food practice and emotional stress, ulcer in stomach is the emerging problem nowadays. These ulcers are developed from the lesions which occur in the soft tissues of the stomach. An endoscopy is considered the best procedure for diagnosing digestive ulcers, Wireless Capsule Endoscopy images shows the clear view of the gastrointestinal tract as in Figure 1. The lesions and ulcers developed in the intestinal region should be detected using the scanned image before it leads to cancer. Early detection of lesion helps in further
treatment. Although the WCE has shown significant advantages over the traditional endoscopies to inspect the ulcer nidus in the small intestine, there are new challenges associated with this technology. WCE creates 55000 images for each patient, and the captured abnormal images occupy only 5% of the whole WCE images collected, it is tedious for clinicians to go through all these images manually frame by frame to locate the abnormal images. Therefore, it is crucial to design an automatic computer-aided system to assist the clinicians to analyze the ulcer images.

Fig 1 (a) normal image (b) ulcer image

In medical field computational time is the most important parameter for analysis of any diseases and their treatment. Detection of lesion area reduces computational time for clinical diagnosis.

II. ULCER REGION DETECTION

A. Preprocessing:

Preprocessing of images commonly involves removal of low frequency noise, removing reflections of images, normalizing the intensity of the individual voxels of the image, and masking portions of images. Therefore input image must be preprocessed. All medical images contain some form of noise due to environment, where the scan is taken. This noise should be removed using filters based on the nature of the noise present in the input scan image. The goal of image is to remove the noise while retaining the important image features like edges, details as much as possible. Denoising of image includes smoothing of images; reduce noise, and preserving edges. A Guided multidimensional filter must be used to perform smoothing, reducing and preserving edges of the image without the loss of original information. Fig 2 shows the image preprocessing steps.

Medical image contains the signal subspace and the noise subspace is very close such that all the useful information is difficult to extract. This leads to artifacts and loss of spatial resolution. Multidimensional Filtering is used to denoise the intestinal image where signal subspace and noise subspace are difficult to filter. Hence the signal subspace dimension is reduced as well as signal to noise ratio is enhanced.

B. Edge detection:

Matrix area value is higher than a given threshold value, then the center pixel is regarded to be as an edge. The edge detection process serves to simplify the analysis of images by drastically reducing the amount of data to be processed, while at the same time preserving useful structural information about object boundaries. Edge detection is used to view, particularly in the areas of feature detection and extraction. The aim of the edge detection is to identify points in a digital image in which image brightness that changes sharply or, more formally, the points where discontinuities are present. The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges. The edge detection operation is performed by forming a matrix centered on a pixel chosen as the center of the matrix area. If this Gradient based edge detectors are Sobel, Canny and Prewitt operators. The gradient based algorithms have kernel operators that calculate the strength of the slope in directions which are orthogonal to each other, generally vertical and horizontal. Afterward the diverse components of the slopes are combined to give the total value of the edge strength. In Intestinal area the lesion may found in all the edges, in these case canny edge detector cannot be used. Lesion detection consists of high intensity images, Sobel
operator is used to detect the edges in this case.

The Sobel operator performs a multidimensional spatial gradient measurement on an image. It is used to find the approximate absolute gradient magnitude at each point in an input.
grayscale image. The operator consists of a pair of 3x3 convolution masks is shown in Figure 3. The detector uses the masks to compute the first order derivatives Gx and Gy, is given in Equation 1(a) and 1(b),

\[
G_x = Z7 + 2Z8 + Z9 \quad (a)
\]
\[
G_y = Z1 + 2Z2 + Z3 \quad (b)
\]

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<tr>
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Fig 3. Image neighborhood of Sobel operator

The advantage of Sobel operator is intuitiveness and easiness. The Sobel edge detection is used for edge detection and finding directions of gradient magnitude as the approximation of gradient magnitude is easy. Hence Sobel edge detection detects the edges of the gray converted image and the direction of gradient magnitude is found in the intestinal image.

C. Morphological processing:

Morphological processing is an operation that process images based on shapes. Morphological operation is one in which the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighboring pixel. The most important morphological operations are dilation and erosion. Dilation adds pixels to the boundaries of objects in an image, whereas erosion removes pixels on object boundaries. Enhancement of images with poor contrast and detection of background is done using morphological transformations. Image enhancement has been carried out by the two methods. Information from image background analysis by blocks is used by the first method employs, whereas the second transformation method utilizes the opening and closing operation, which is engaged to define the multi background grayscale images. The basic effect of the erosion operator on a binary image is to erode away the boundaries of regions of foreground pixels (i.e. white pixels, typically). Thus areas of foreground pixels get smaller in size, and holes within those areas become bigger. The basic effect of the dilation operator on a binary image is to gradually enlarge the boundaries of regions of
foreground pixels (i.e. white pixels, typically). Thus areas of foreground pixels grow in size while holes within those regions become smaller.

In a binary image, if any of the pixels is set to the value 1, the output pixel is set to 1 based on the correlation of eroded and dilated image. The purpose of the morphological operators is to separate the abnormal part of the image. The separated part of the image has the highest intensity than other regions of the image. Perform a morphological opening on each segment subtract the opening from the original segment to obtain regions to be reassigned to neighboring segments of the intestinal image.

D. Super pixel segmentation:

Segmentation is the process of partitioning an image into dissimilar segments. These segments correspond to various tissues, pathologies, or other biologically significant structures in the field of medical imaging. Medical image segmentation is made intricate by noise, and other imaging ambiguities. Even though preprocessing technique by image segmentation were exists, some are being used distinctively for medical image computing. Detection of the corresponding area in image by Thresholding is the simplest method. Thresholding is the simplest non contextual segmentation technique. With a single threshold, it transforms a grayscale or color image into a binary image considered as a binary region map. This map contains two probably disjoint regions, one region containing pixels with input data values smaller than a threshold and another relating to the input values that are at or above the threshold.

Pixel and encompassing features which are the basic data unit of image representation form the key for the qualitative and quantitative output of any image processing step. The result exhibiting similar features within local or global neighborhood is termed as Super pixel. The job of grouping pixels into super pixels by comparing the values of each and every neighborhood pixel within specific connectivity, defining the boundary strength of super pixel, and the midpoint of super pixel called the seed point. The complexity of images from
hundreds of thousands of pixels to only a few hundred super pixels reduces the computational cost and increases the image processing speed. Super pixel based image segmentation techniques applies many sophisticated algorithms for fast 2D image segmentation are universally defined as constricting and grouping uniform pixels in the image, which are widely used in image segmentation and object recognition. In addition to the above performance, clustering technique comparison gives extraordinary results. The super pixel map is natural and perceptually meaningful representation of the input image. For that reason, the super pixel representation greatly reduces the number of image primitives and improves the representative efficiency when compared to the traditional pixel representation of the image. The effectiveness of super pixels to compute the region based visual features provides important benefits for the vision tasks such as object recognition.

Grouping of pixels through super pixel segmentation is to reduce the computational complexity while maintaining high diagnostic accuracy. Red ratio in RGB space extracts the feature of each super pixel which is then fed into support vector machine for classification. To reduce the computational cost and make abnormal tissue detection faster, group the pixels based on color and location first, and the detect abnormalities at super pixel level. Gray image is converted to color image in super pixel segmentation to maintain the intensity. The relative difference between any two colors which is approximated as points in 3-D space is obtained using the Euclidean distance between them. Similarity of any two pixels depends not only on color similarity but also on spatial distance the similarity measure can be obtained by

\[ S = S_{\text{color}} + \times S_{\text{spatial}} \]  \hspace{1cm} (2)

Intestinal image is segmented using super pixel; hence the exact geometry of the lesion is segmented using grouping of pixels. The lesion is found based on the inconsistency of spatial location from the segmented part. The segmented region of the intestinal image shows the pixels where the correlation test has to be performed.
E. Support vector machine:

The SVM uses linear mapping to transform the original training data into a higher dimension. The SVM locates the hyper plane by using support vectors and margins. A hyper plane can be constructed as a quadratic optimization problem so that the margin between the hyper plane and the nearest point is maximized. SVM classifies the normal images and the abnormal images by applying the threshold to segment light grains from the dark background, labeling the individual grains with different color, edges of the detected rains and extracting the area values from the detected object.

III. PROPOSED METHODOLOGY

The major functional blocks of our proposed method shown in Figure 3, explains the proposed system of lesion area detection. This Methodology helps in detection of lesion using super pixel segmentation; intestinal image is segmented by super pixel segmentation, this method includes the following steps of work:

1. Wireless Capsule endoscope image is converted into M file.
2. Read the input image into the GUI.
3. Apply multidimensional filter to the input image.
4. Denoised image is restored.
5. Denoised image is converted into green intensity image to separate the layers of the image and the damaged region is examined closely using this green intensity image.
6. After the step 6, green intensity image is converted to grey scale image using grey intensity image to separate the layers of the image and the damaged region is examined closely using this green intensity image.

Fig 3 proposed system
conversion. Luminosity method is used for conversion of green intensity image to Gray image, for human perception as shown in Equation 3,

\[
0.21R + 0.72G + 0.0 B
\]  

(3)

**Step 7:** Edge detection is used for feature detection and feature extraction. Sobel operator is used for edge detection using Sobel convolution matrix.

**Step 8:** Morphological operation using both erosion and dilation is used to enhance the processed image. The value of each pixel in the output image is compared with the corresponding pixel of input image with its neighbors.

**Step 9:** The enhanced image after the step (8) is segmented using super pixel segmentation which groups the identical pixels using Euclidean distance and helps to detect the exact infected region in the image shown in Equation 2. Pixels are grouped based on the similarity of pixel color and spatial distance.

**Step 10:** The segmented image is encoded and classified using support vector machine.

**IV RESULTS**

The images used for the development and evaluation of the proposed approach were extracted from 20 patients’ WCE videos with ulcerous diseases, such as unexplained ulceration, ulceration from NSAID, ulcerative colitis and Crohn’s diseases. Actually it is difficult to gather large numbers of cases of ulcers in WCE videos since the patients who took the WCE examination may not suffer from the ulcers or they may carry multiple cases. Even if we have a clear ulcer case, bubbles in the GI tract may block the nidi and make it difficult to collect the ulcer images from patients. Thus, in this paper, we composed a dataset that consists of 25 ulcer and 25 normal images from the examination data of 10 patients. The 25 ulcer images were obtained from different ulcer regions to achieve the lowest possible similarity. Furthermore, the normal images including both simple and confusing healthy tissue are used to simulate the actual discrimination process. Super pixel segmentation is implemented in GUI. The intestinal input image is processed using Denoising, Layer separation, Gray conversion, Edge detection, Morphological operation, and Super pixel segmentation and support vector machine.
V CONCLUSIONS

In this paper, we proposed a fully automated computer-aided detection system to detect ulcer from WCE images. A saliency map extraction approach which is based on multi-level super pixel was proposed to segment the ulcer candidates. The obtained result shows that the detection of ulcer in intestinal tract. The supportive systems mainly aim at reducing the time spent at detecting endoscopic images. The fact of good pixel packing and uniformity in size of pixels is determined to have better performance than the other pixel based algorithm. Experiment results achieve promising accuracy and sensitivity, validating the effectiveness of the proposed method. Furthermore, the comparison experiments showed that our method outperforms the state-of-the-art methods on the WCE ulcer classification task.

REFERENCES


