Segmentation of Small Bowel Tumors in Wireless Capsule Endoscopy Using Level Set Method

1Alizadeh. M
Department of Bioengineering, Temple University, Philadelphia, USA
tuf07723@temple.edu
2Soltanian Zadeh. H
Radiology Image Analysis Lab, Henry Ford Health System, Detroit, USA

Abstract — In this paper, we proposed an algorithm to segment small bowel tumors. In order to increase effectiveness of Level Set Method (LSM) we applied adaptive gamma correction method (AGCM) that is based on prior information of illumination of images. We applied this method on 10 small bowel tumor images captured by Wireless Capsule Endoscopy (WCE). The performance measurements (i.e. sensitivity, specificity, and accuracy) by using hand ground method are computed for different parameters of a (0.05, 0.07, 0.09, 0.11, and 0.13) in AGCM, and then compared with traditional LSM and Snake method. The proposed method shows increased sensitivity up to 0.87 in a=0.13 while other performance measurements decrease by increasing value of a. the sensitivity of the other methods are 0.2 and 0.22, respectively. The optimal value of these measurements is 0.73 that takes place in a=0.1.

Keywords: wireless capsule endoscopy, level set method, adaptive gamma correction method, image segmentation.

I. INTRODUCTION

Recently, Wireless Capsule Endoscopy (WCE) is used to evaluate the entire small bowel tract, noninvasively which is not accessible by conventional techniques. The detection of small bowel tumors is challenging due to limited evaluation of the small bowel with conventional systems. The ability of WCE is detecting small bowel tumors at the early stage of growing. However, the early diagnosis of small bowel tumor is difficult, because signs are vague and laboratory tests are unhelpful. Recently, different methods [1,2,3] has been suggested as small bowel tumor segmentation but they all are specified for both detecting and segmenting. So, we need a separate method for just segmenting to use for further analysis such as surgery or radiation therapy. In this paper, we used the gradient feature of images in order to segment tumor area. First, we applied a method as gradient enhancement then applied LSM as segmentation method.

II. METHODS

A. Gradient improvement

We applied an Adaptive Gamma Correction Method (AGCM) in order to improve the gradient of an image. This method is performed without prior knowledge on intensity of image and ordinal relationship of pixels is used to improve image contrast. For color images, it is performed separately for each of the three color components (R, G, B). The performance of this method has been evaluated in our previous paper [6]. AGCM is specified based on the illumination information of WCE images. As we discussed in previous paper the best parameter of “a” in AGCM is closed to 0.06. SNR and CNR for different values of a, are listed in table 1.


<table>
<thead>
<tr>
<th>a</th>
<th>SNR</th>
<th>CNR</th>
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<tbody>
<tr>
<td>0.05</td>
<td>18.5</td>
<td>6.6</td>
</tr>
<tr>
<td>0.06</td>
<td>18</td>
<td>7.5</td>
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<tr>
<td>0.08</td>
<td>17</td>
<td>8.8</td>
</tr>
<tr>
<td>0.1</td>
<td>15.5</td>
<td>9.53</td>
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</tbody>
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Fig. 1: Component of WCE: 1- Optical dome; 2- Lens holder; 3- Lens; 4- White LEDs; 5- CMOS image sensor; 6- Battery; 7- Transmitter and 8- Antenna [4], and Examples of small bowel tumors (from atlas of Given Imaging).

B. Level set method

The LSM is used as numerical techniques for tracking interfaces and shapes that is introduced by Osher and Sethian. In LSM a function φ(p,t) is applied to the space the interface inhabits, where φ is the level set function, p is a point in that space and t is time. The LSM tries to represent a closed curve Γ by using an auxiliary function φ, called level set function. Γ is represented as the zero level
set of \( \varphi \) as \( \Gamma_0 = \{(x, y) | \varphi(x, y) = 0\} \). Defining a distance function \( \varphi(x, y, t) = d \), where \( d \) is the distance from point \( p \) to the curve at the time \( t = \theta \), shows that \( \varphi \) takes positive value inside the region delineated by the curve \( \Gamma_\theta \) and negative value outside. These models perform image segmentation by starting with an initial curve and evolving its shape using the corresponding equation. During the evolution process, curvature and/or constant deformation are used as the speed of curve evolution and locally depend on the image data. The ultimate goal of curve evolution is to yield desirable image segmentation for \( t \to \infty \): on the other hands, curve evolution should stop at object boundaries [8].

III. RESULTS

We considered an area with high intensity of illumination as initial contour. Actually, initial contour can be located anywhere but the right place can increase accuracy and reduce computational cost. For this reason we used intensity heat map to define initial contour, correctly. The performance of our proposed method was evaluated quantitatively by comparing resulting extractions with gastroenterologist hand-drawn ground-truth images pixel by pixel. In this way, we marked the regions of interest of 10 small bowel tumor images by using MATLAB software. Three sample resulting methods consist of improved level set with five parameters of \( a \) (0.05, 0.07, 0.09, 0.11, 0.13), level set and snake has been applied to 10 tumor images captured by PillCam capsule endoscopy system (Table 2).

IV. CONCLUSION

In this paper we proposed and approach for identification of tumors in WCE images. This approach is based on illumination differences between pixels, which behave successfully as a segmentation method. The overall performance of proposed method is more efficient than LSM, and snake method.

REFERENCES


<table>
<thead>
<tr>
<th>improved Gradient (( a = 0.05 ))</th>
<th>sensitivity</th>
<th>specificity</th>
<th>accuracy</th>
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<td>0.97</td>
<td>0.81</td>
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<tr>
<td>Improved Gradient (( a = 0.09 ))</td>
<td>0.6</td>
<td>0.9</td>
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<td>Improved Gradient (( a = 0.11 ))</td>
<td>0.86</td>
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