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Segmentation of WCE Images Using Fuzzy Active Contour Method

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Abstract: ***Nowadays bowel tumor becomes an eminent issue in grasping the attention of both the medical and scientific fields because of the hindrance in treating the disease. Wireless capsule endoscopy assists in diagnosing GI conditions in the small bowel. In this method an average of nearly 50,000 images are taken. Scrutinizing and evaluating all those recorded images is tedious and time consuming. Hence we go for computerized approaches in order to deteriorate the physician's burden. In this paper a fuzzy active contour based image segmentation method is proposed and its result is analogized with other methods like Adaptive Thresholding(AT),Edge detecting and Region Growing by Adaptive threshold(RGA) in terms of parameters like Energy, Relative Entropy(RE) and Elapsed time(ET). The experimental results validate that our model works efficiently.***

Keywords: Wireless Capsule Endoscopy, Gastro Intestinal tract, Image segmentation, Fuzzy Active Contour, Adaptive Thresholding

1. Introduction

Bowel cancer is a malignant growth found most customarily in the lining of the large bowel and progress from tiny growths called polyps. It is the third common cancer in the world with nearly 1.8 million new cases in 2013. Approximately 95% of colorectal cancers are adenocarcinomas. Statistics shows that this will rise upto 2.44 million by 2035.

As most bowel cancers emerges as polyps, all polyps should be detached to diminish the risk of developing the disease as explained in [1]. Even if a polyp develops into cancer, when spotted in its early stage, it can be rehabilitated by surgery. In certain approaches like colonoscopy, esophagogastroduodenoscopy, sigmoidoscopy some portions of the small intestine are left unexamined. Hence we go for wireless capsule endoscopy, in order to examine the small intestine in a more reliable and detailed manner.

Capsule endoscopy is a procedure that uses a tiny wireless camera to capture pictures of the digestive tract. This technique involves swallowing a small (size of a large vitamin pill) capsule, which is of 11 mm diameter and a length of 26 mm. The capsule consists of a complementary metal oxide silicone imager(color camera chip), lens, light source(white LEDs), transmitter, two batteries as shown in fig 1. Once swallowed the camera moves naturally through the digestive tract and takes nearly two pictures per second for 8 hours, transmitting those images to a data recorder about the size of a portable CD player that patients wear around waists. Finally the images from the recorder are downloaded into a computer workstation and viewed by the physicians to analyze the potential sources of different diseases in GI tract. Capsule is disposable and will be passed naturally in the bowel movement. Capsule endoscopy helps physicians to view small intestine's internal structure- an area that isn't easily reached with convectional endoscopy in a more distinct way[2].

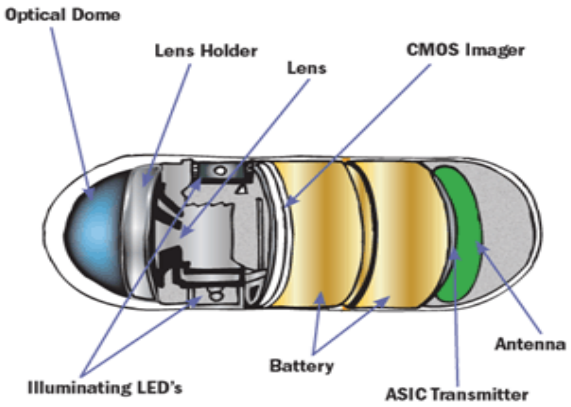


Figure 1: Endoscopy Capsule

On an average nearly 50,000 images are taken during 8 hours of the overall scenario. The process of examining all those images is normally tiring and time consuming. Hence we go for computerized approaches in order to support physicians, which lead to reduction in processing time. This new technology explores great value in evaluating the disease in the digestive tract such as Crohn's disease, ulcer, gastrointestinal bleeding and so on. Further improvements are needed for WCE, although the new technology has tremendous advantages over traditional examination techniques.

Some researchers have begun studies towards the direction of maximizing the automatic inspection of WCE images so as to shrink physician's burden. Using a synergistic methodology that proposes several methods such as k means segmentation algorithm, HSI color domain segmentation, dominant color histogram descriptor into a unique, new, non conventional methodology capable for automatically and accurately detecting, extracting and recognizing abnormalities in WCE images was formulated [3] [4] [5]. Our method is inspired by the following research: a study analysis on the different image segmentation techniques[6].In this paper, a new method based on fuzzy active contour segmentation is proposed. The rest of the paper is organized as follows: Section II provides information about image preprocessing and segmentation , as well as some related works. Section III describes the

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proposed segmentation method. Experimental results are discussed in Section IV which is followed by the conclusion and future work in section V.

2. Image Preprocessing and Segmentation

Image pre-processing is an indispensable and challenging factor in the computer-aided diagnostic systems. In medical image processing, especially in tumor segmentation task it is very essential to pre-process the image in order to make the segmentation and feature extraction algorithms work precisely.

The exigency for pre-processing includes, the removal of marks or labels present (Film artifacts) which can impede in the post-processing of the images, to formulate the images more suitable for further processing in CAD systems, to enhance the quality of the image and to remove noise[9]. Proper detection and segmentation of the tumor leads to exact extraction of features and classification of those tumors as shown in fig 2. The accurate tumor segmentation is possible if image is pre-processed as per image size and quality. Image segmentation is the process of cleaving an image into eloquent, non-overlapping regions or objects. The intrinsic goal is to divide an image into several parts that have strong correlation with objects of the real world.

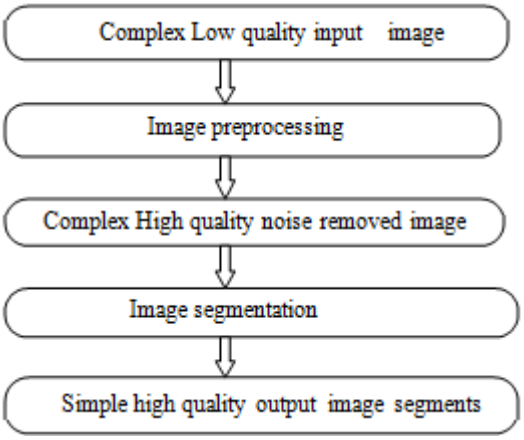


Figure 2: Methodology

Segmented regions are homogenous according to some property, such as pixel intensity or texture. Image segmentation is one of the first steps leading to image analysis and interpretation. It is used in many different fields, such as machine vision, biometric measurements and medical imaging [8].

Automated image segmentation is a demanding problem for many different reasons. Noise, partial occluded regions, missing edges and lack of texture contrast between regions and background are some of these reasons. Noise is an artifact often found in images which makes the segmentation process intricated. In the process of generating medical images, noise is often introduced by the capturing devices. As a pre-processing step before segmentation, the image can be smoothed to reduce noise. In the context of medical images segmentation usually means a delineation of anatomical structures. This is important for e.g. measurements of volume or shape. Low level segmentation methods are usually not sufficient to segment medical images. Hence, higher level segmentation methods that are more complex and gives better results are used. The substantial dissimilarity between low-level segmentation methods and higher level segmentation methods is the use of apriori information. Low-level methods usually have no information about the image to be segmented, while high-level segmentation methods can incorporate different types and amount of apriori information. Here a high level segmentation method of fuzzy active contour model is used whose result is shown later in fig 4.

3. Fuzzy Active Contour Segmentation

An active contour is an energy minimizing spline that detects specified features within an image. It is a flexible curve (or surface) which can be dynamically adapted to required edges or objects in the image (it can be used to automatic objects segmentation). It consists of a set of control points connected by straight lines as shown in fig 3 The active contour is defined by the number of control points as well as sequence of each other. Fitting active contours to shapes in images is an interactive process.

The basic idea is to start with initial boundary shapes represented in a form of closed curves, i.e. contours, and iteratively modify them by applying shrink/expansion operations according to the constraints of the image. Those shrink/expansion operations, called contour evolution, are performed by the minimization of an energy function like traditional region-based segmentation methods or by the simulation of a geometric partial differential equation.

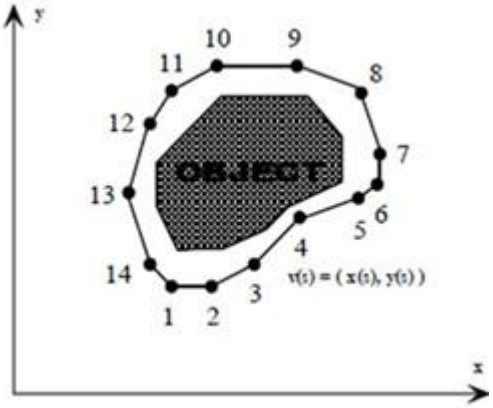


Figure 3: Basic Form of Active Contour

An advantage of active contours as image segmentation methods is that they partition an image into sub-regions with continuous boundaries, while the edge detectors based on threshold or local filtering, Sobel operator, often result in discontinuous boundaries. The use of level set theory has provided more flexibility and convenience in the implementation of active contours. Depending on the implementation scheme, active contours can use various properties used for other segmentation methods such as edges, statistics, and texture[12][13].

In this paper, the proposed active contour models using the statistical information of image intensity within a sub-region. As image segmentation methods, there are two kinds of active contour models according to the force evolving the contours: edge- and region-based. Edge-based active

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contours use an edge detector, usually based on the image gradient, to find the boundaries of sub-regions and to attract the contours to the detected boundaries. Region-based active contours use the statistical information of image intensity within each subset instead of searching geometrical boundaries.

A) EDGE-BASED ACTIVE CONTOURS

Edge-based active contours are closely related to the edge-based segmentation. Most edge based active contour models consist of two parts: the regularity part, which determines the shape of contours, and the edge detection part, which attracts the contour towards the edges. Since WCE images do not contain sharp edges we opt for region based active contours.

B) Global Region-Based Active Contours

Most region-based active contour models consist of two parts: the regularity part, which determines the smooth shape of contours, and the energy minimization part, which searches for uniformity of a desired feature within a subset. A nice characteristic of region-based active contours is that the initial contours can be located anywhere in the image as region-based segmentation relies on the global energy minimization rather than local energy minimization. Therefore, less prior knowledge is required than edge-based active contours. Due to the global energy minimization, region-based active contours generally do not have any restriction on the placement of initial contours. That is, region-based active contour can detect interior boundaries regardless of the position of initial contours. The use of pre-defined initial contours provides a method of autonomous segmentation. Also, they are less sensitive to local minima or noise than edge-based active contours.

However, due to the assumption of uniform image intensity, most methods are applicable only to images where each subset is represented by a simple expression, e.g. single Gaussian distribution or a constant. If a subset, i.e. class, consists of multiple distinctive sub-classes, these methods would produce over-segmented or under-segmented results. We propose novel region-based active contour models which produce improved results using multivariate mixture density functions. Region-based active contour models have shown attractive characteristics, such as the unrestricted position of initial contours, the automatic detection of interior boundaries, and reasonable segmentation due to global energy minimization though the segmentation results are still case dependent. It evolve deformable shapes based on two forces: energy minimization based on the statistical properties, which pursues the uniformity within each subset, and curvature motion motivated by level set function, which keeps the regularity of active contours[9].

4. Experimental Results

The performance of our proposed model is evaluated by comparing the fuzzy active contour based segmented bowel images with other methods such as AT(Adaptive Threshold),Edge Detecting, RGA(Region Growing using Adaptive threshold) .The parameters used to evident that the proposed method is efficient are Energy, Relative Entropy(RE) and Elapsed time(ET). Experiments are conducted using Matlab 11. Benchmark images taken for analysis are provided by VGM hospital, Coimbatore. To test the accuracy of the segmentation algorithms: i) A bowel image is taken as input. ii) The proposed fuzzy active contour model is applied to the medical image. iii) Then the performance evaluation is obtained by the statistical parameters like Energy, Relative Entropy (RE) and Elapsed time(ET). Most of the images used are bowel images with defect and without defect images. The Energy value, Relative Entropy (RE), Mutual Information (MI) and Elapsed Time (ET) must be a less value for a better segmentation algorithm[9].

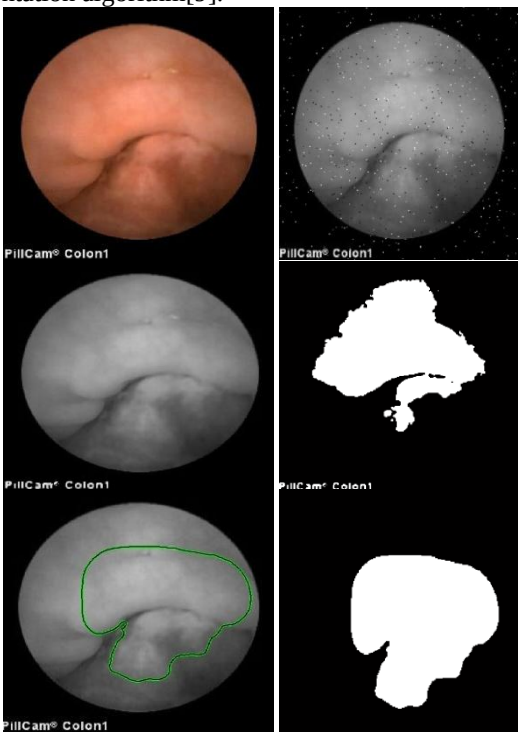


Figure 4: Tumor affected bowel image and its corresponding preprocessed and segmented images.

A) Energy

The gray level energy indicates how the gray levels are distributed. It is formulated as,

$$E(x)= \sum_{i=1}^{x} p(x) \quad (1)$$

Where E(x) represents the gray level energy with 256 pixels and p(i) refers to the probability distribution functions, which contains the histogram counts. The energy reaches its maximum value of 1 when an image has a constant gray level. The larger energy value corresponds to the lower number of gray levels, which means the defect is simple and cured by medicine or with simple medical applications . The smaller energy value corresponds to the higher number of gray levels, which means the defect is complex cured only by surgery.

B) Relative Entropy (RE)

Two discrete probability distributions of the images have the probability functions of p and q, the relative entropy of p with respect to q is defined as the summation of all possible outcomes that occur. This entropy gives the features which are similar or any nearer value to the common features of the images which are related.

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$$d = \sum_{i=1}^{k} p(i) \log_2 \frac{p(i)}{q(i)} \quad (2)$$

C) Elapsed Time

Elapsed Time (ET) of a filter is defined as the time taken by a digital computing platform to execute the filtering algorithms when no other software, except the operating system (OS), runs on it. Though ET is not only dependant on the clock time. Rather, in addition to the clock-period, it depends on the memory-size, the input data size, and the memory access time. However, the measure ET is very important in case of real-time application. The execution time taken by a filter should be low for online and real-time image processing applications. Hence, a filter with lower ET is better than a filter having higher ET value when all other performance-measures are identical.

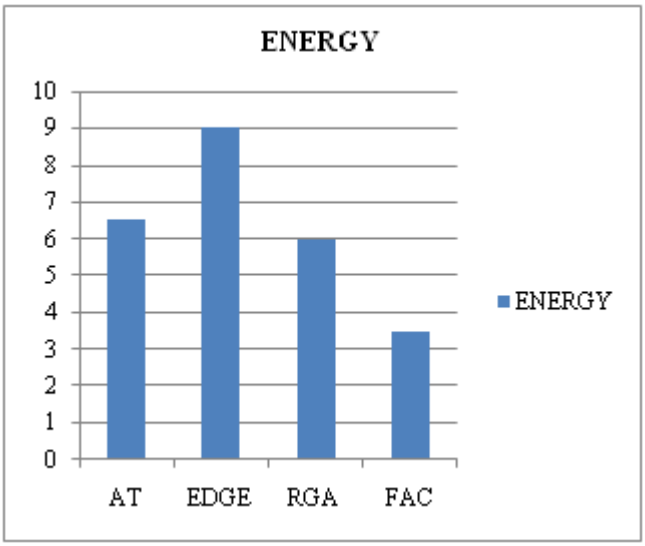


Figure 5: Energy value for the above mentioned segmentation methods

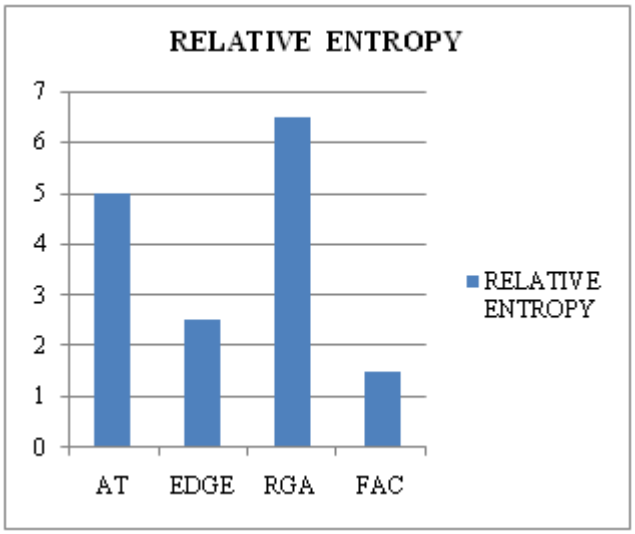


Figure 6: Relative Entropy value for the above mentioned segmentation methods

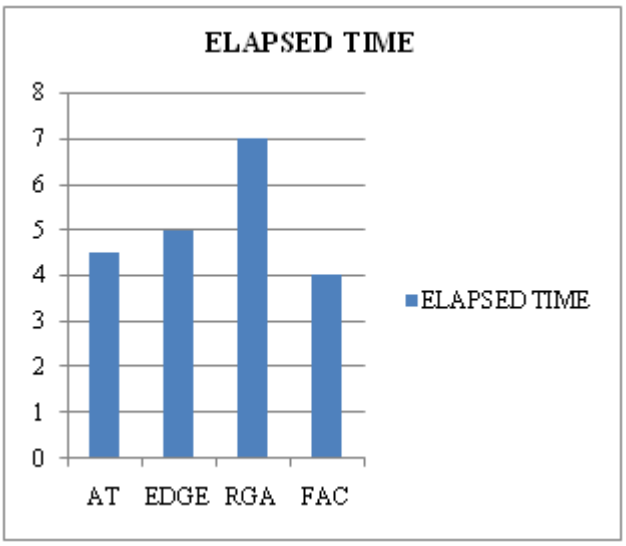


Figure 7: Elapsed Time value for the above mentioned segmentation methods

This experimental results for different segmentation methods shows that the proposed fuzzy active contour model gives better and accurate segmented output images as shown in fig 5,6,7.

5. Conclusion and Future Work

Our proposed work aims at scrutinizing the burden of physicians while examining the wireless capsular endoscopy images. This paper consists of two stages namely preprocessing and segmentation. In the first stage bowel images are preprocessed in order to enhance their quality by removing noise using a median filter. Then in stage two, these images are get segmented using fuzzy active contour model and compared with some of the existing methods[14] and proved as the best. As a future work these images are subjected to classification in order to obtain a more precise output.

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