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Efficient Method for Polyp Detection and Density Estimation Using MRF Segmentation in Colon Endoscopy

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***Abstract*—Colon cancer is a major cause of cancer in women and colorectal polyps are the important cause to colon cancer. Colonoscopy is one of the best methods for detecting the colon cancer Colon endoscopy is a technique in which the image of the intestine can be obtained through the camera attached to endoscope, video sequence of the patient is further analysed for the presence of polyps. Algorithms for the automatic detection of polyps are being developed, but not at all efficient. In this paper, a novel algorithm is proposed for the detection of polyps. In this paper two types of segmentation methods are adapted. In the first method, linearthresholding is used to detect the saturated region from the HSV image. In the second method, Markovian Random Field is used to segment the image depth-wise. The proposed algorithm is based on extracting certain texture as well as color information from the frames captured by the camera. Here Markovian Random Field (MRF) is proposed which aims at combining color and texture features to segment the images depth-wise.The proposed algorithm, is very simple, fast and efficient method which is highly helpful for the radiologists in detecting polyps. Classifier is used to predict the disease condition using the texture vector and color correlogram vector. This system is successfully tested with colon endoscopy video images and achieved 96.7% accuracy.**

***IndexTerms*— Colonoscopy, Colon polyp, HSVConvertion, MarkovianRandom Field, SVM Classifier**

I.INTRODUCTION

Abnormal multiplying of cells can cause cancer. It causes abnormal cell growth with the potential to invade or spread to other parts of the body. Colorectal cancer is a type of cancer occurs in colon. In women colorectal cancer is considered as second cause and in men it is the third most cancer [1].Colon polyps may lead to colon cancer. Polyps are the abnormal cell growth on the walls of the gastrointestinal tract and large intestine. Endoscopy is a less invasive diagnostic medical procedure.

Colonoscopy is a process of looking inside and typically refers to looking inside the body for medical reasons using an endoscope an instrument used to examine inside the esophagus, stomach, and small intestine The video sequence obtained as a result consists of thousands of frame for a single patient. Each image frame has to be further analyzed by the doctor for the detection. Many existing methods are there to find out the polyps based on the shape of the polyp such as Shape index and Curvedness [2] or the Gaussian Mean curvatures [3].The main disadvantage of that approaches is that, these computations are mainly based on the differentiation of shapes; sometimes protrusions are also classified as polyp. The image sometimes consists of protrusions, mucosal tissue folds other than polyps. So here the major drawback is that the algorithm sometimes measures these protrusions as a polyp.

Due to the lack of human efficiency when size of dataset increases, the development of computer-assisted and automated detection techniques is very crucial. In the proposed method, both geometric as well as texture information about the polyp is taken into consideration, assuming that the polyps are highly textured [4].Texturing helps in the segmentation and classification of the polyps. In this paper polyp detection as

well as the density of the polyp can be estimated by depth segmentation method.

II.METHODOLOGY

In diagnosing and clinical treatment, endoscopy and capsule endoscopy are used. In diagnosis, computers play a major role which has inbuilt software for detection. The software uses algorithm to find anatomical structures and region of interest. The algorithm takes each of the frames as input and the output can be classified as whether the frame contains polyp or the normal frame. For the analysis of the algorithm each of the single frames from the video sequence has to be analysed further for the detection of polyp.

The method deals with basic image processing steps along with image segmentation by Markov Random Field to find density of the polyp. Markov random field is used to model various low to mid-level tasks in image processing and computer vision. The input images are used here for the detection of polyps are the endoscopic images. The database used for in this work is the data set courtesy of the Medical college Hospital, Trivandrum. The database consists of endoscopic videos of 10 patients consists of 2100 frames.

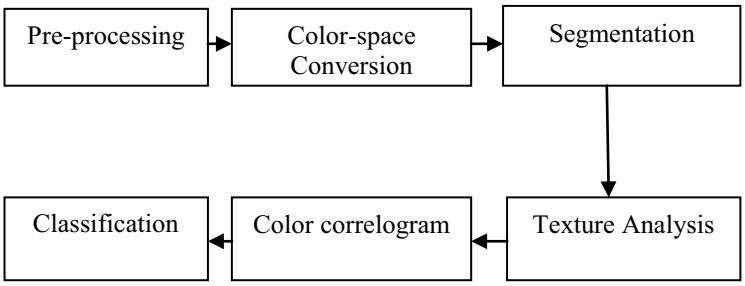


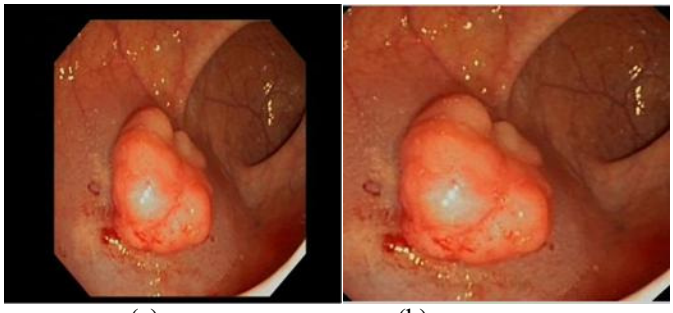
Figure 1:-Block diagram of proposed method

A. Pre-processing

The images obtained by the endoscopic video sequence are in circular shape. Using linear extrapolation technique, from the circular portion of the image, values can be extended to the outer portion of the circular frame with solid color. Linear extrapolation is done by solving the linear system which corresponds to an upwind discretization of the following PDE [4]

$$\nabla f \cdot r = 1 \qquad (1)$$

Where f denotes a pre-processed frame on an $N_x x N_y$ cartesian grid, r is a unit vector field.



(a) (b)

Figure 2:- (a) input image (b) pre-processed image

B. Color space conversion

By using the color space conversion the image intensity value can be obtained for the analysis of the image for the segmentation purpose. The frame is converted in to HSV colorspace.HSV is cylindrical coordinate system in which the points in RGB model is representated as cylindrical coordinates. Hue (H) is the attribute of a visual sensation and is a measure of spectral composition of a color represented when the angle varies. Saturation(S) refers to the purity of color of a stimulus relative to its own brightness. Value (V) is the intensity of the pixel. HSVseperates image intensity values from the color information and is helpful for the histogram image equalization.

C. Segmentation

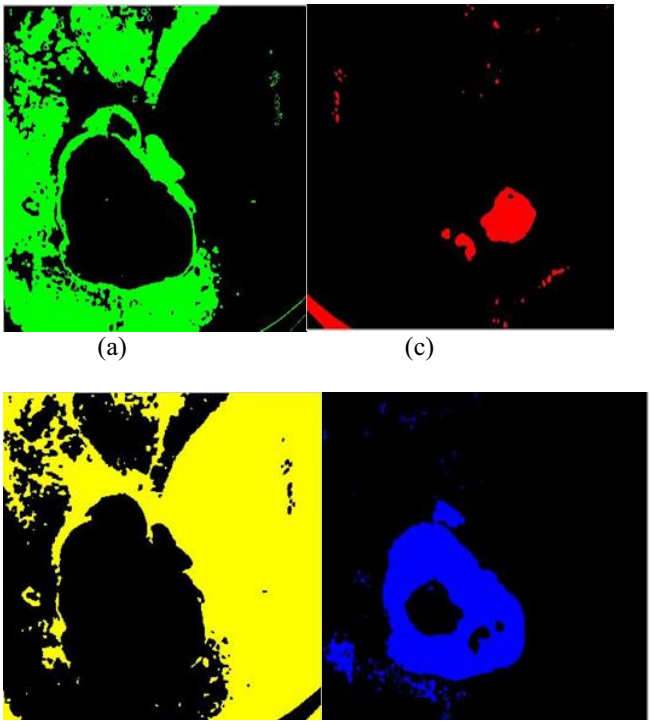
In this step, the main portion or the region of interest is been detected for further process and are done based on the thresholding .Thresholding is done to find out the actual area or the region of polyp. For this the thresholding parameter or the value is varied manually as a trial and error method. The mostly used normal and simple method is canny edge detection. By this method can be able to find the edge features so that the outline of the polyp portion is obtained.

For finding the actual depth of the polyp together with thresholding, MarkovianRandom Field is used for segmentation.

Markovian random fields (MRFs) have been widely used in the field of image processing is for computer vision problems, like image segmentation [6], depth inference [7].The MRF algorithm [8] steps are as follows.

-Convert the image to 2D gray-level, to find out the intensities based on the Gaussian distributions and segments are extracted.

- EM Algorithm is used to find out the parameter set
- MAP Estimation is used for finding the sum of energy function and to reduce the energy value of the function.
- The difference between MRF and HMRF will affect the parameter set. In a HMRF image segmentation bugs are formed, for solving the HMRF problem EM algorithm is used. MRF uses the intensity parameter for segmentation.



(a) (c)

(b) (d)

Figure 3:-Different layers obtained as a result of MRF segmentation

D. Texture Analysis

The texture content computation in the frame is a vital step of the algorithm for the texture analysis .Since the polyps are highly texture, higher the texture content the more will be the presence of polyp region. The pre-processed frame f contains both texture as well as cartoon components, to separate the pre-processed frame into the texture and cartoon components, Buades et al. [5] algorithm is used. Using thresholding technique, texture content is estimated [4].

$$T_{max}=\max T_{ij},\ 1 \leqslant i \leqslant N_x,\ 1 \leqslant j \leqslant N_y \qquad (2)$$

E. Color correlogram

Color correlogram expresses spatial correlation of color features when the changes in the distance occurs. In correlogram ,an image is a table indexed by color pairs, where d-the entry for row (i,j) specifies the probability of finding a pixel of color j at a distance d from a pixel of color i in the image.

F. Classification

Here SVM classifier is used for classification. Cancerous polyps can be estimated by using SVM technique. For finding out the texture and to find out the polyp conditions classifier is used.SVM is a supervised learning process in machine learning approach. The main purpose of SVM is to build optimal separating hyper planes [22] and it accepts data and identifies patterns used for classification. SVM method consists of the steps includes [21], Firstly, mapping input data to high-dimensional feature space. Then select a kernel and computes the hyper planes, to find the maximum distance between the closest points and then detect the outer boundaries.

III.RESULTS AND DISCUSSIONS

The automatic detection of polyp using depth segmentation method helps to find out density of polyp. There are many segmentation techniques are used in earlier methods. But the depth of the image is not calculated in any of the methods to find density. For polyp detection, this method uses the texture information and the color information in the frame. An algorithm has been developed and implemented.

At first the video sequence is converted into different frames. From the frames, take one frame as the input frame for the processing of the algorithm. As the first step pre-processing is done to the selected frame is fig 4.

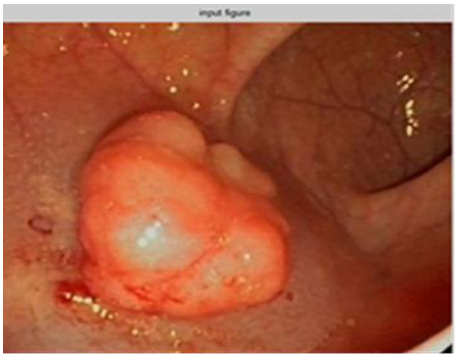


Figure 4:- Pre-processed input frame

Using the color space conversion input pre-processed frame is converted into HSV converted frame for the analysis of the image for the segmentation purpose is shown in the fig 5.

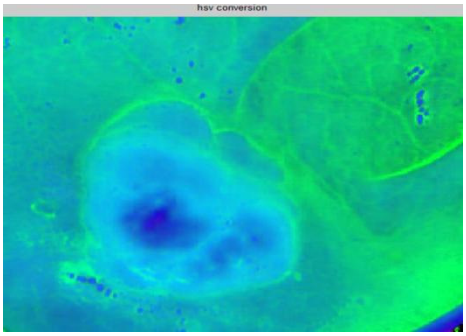


Figure 5:- HSV converted frame

From the above texture analysis, find out the region which is highly textured. Using thresholding method, the image is converted in to binary image with segmented portions is shown in the fig6.

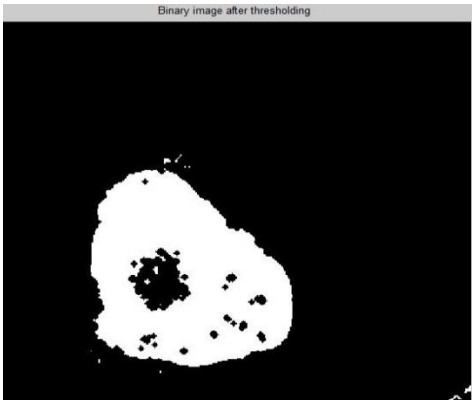


Figure 6:- Binary image after segmentation

For finding the actual depth of the polyp together with thresholding, Markovian Random Field is used for segmentation. Using MRF method, different layers of region can be separated using Gaussian intensity distribution and the layers can be viewed by different colors.

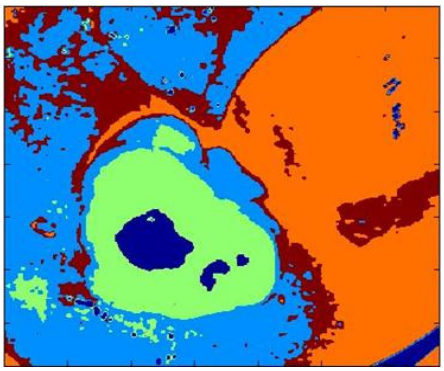


Figure 7:- Markovian based segmentation result

To find the texture content of the frame, the input image is processed. The polyp is highly textured by analyzing the texture content; the frame containing higher density of polyp is estimated and is shown in fig 8.

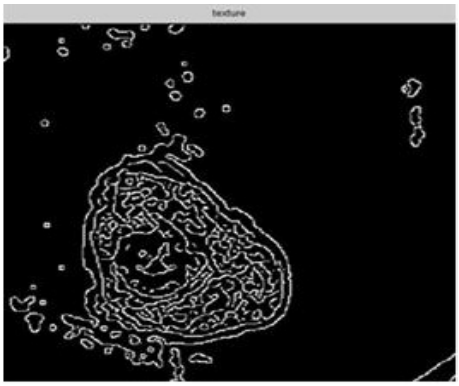


Figure 8:- Texture Analysis of the frame

After the texture is analysed ,using the color correlogram method,the polyp portion is detected is shown in the figure 9.

Figure 9:- Polyp Detection

Density Estimation is done for the condition to detect and classify the affected or the polyp regions of the colon. and which deals with the simple path of the volume detection. The density of the polyp detected can be estimated using the volume of the colon frame and is shown in fig 10.

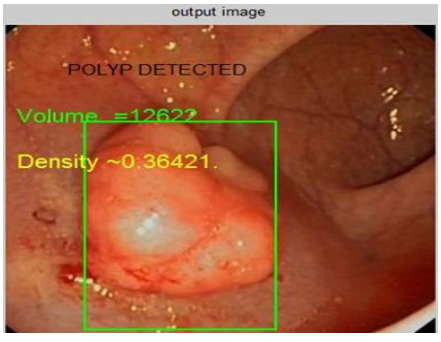


Figure 10:- Density estimation of polyp

In real conditions, good performance of the algorithm is tested with the database. The algorithm shows high sensitivity, high specificity and accuracy for polyp detection. The sensitivity measure which is the true positive rate [TPR]

and the specificity measure which is the false positive rate [FPR] have been measured [4].

$$\text{Accuracy} = \frac{(TP+TN)}{(TP+TN+FP+FN)} \quad (3)$$

$$\text{Sensitivity} = \frac{TP}{(TP+TN)} \quad (4)$$

$$\text{Specificity} = \frac{FP}{(FP+TN)} \quad (5)$$

Number of frames	True Positive (TP)	True Negative (TN)	False Positive (FP)	False Negative (FN)
2000	970	964	36	30

Figure 11:-Performance analysis

Accuracy of the proposed method is 96.7%

Algorithm	Accuracy
LDA	90%
QDA	92.6%
Proposed Method	96.7%

Figure 12:-Comparison with the proposed method

IV.CONCLUSION

An efficient algorithm with Markovian Random Field segmentation technique has to be developed for achieving better resolution and depth of the image. Using this algorithm automatically the polyp can be detected, which reduces the number of frames to be evaluated by the doctor and hence reduces the processing time. Images obtained by endoscope that are suffered from illumination intensity problem, poor contrast are pre-processed for segmentation. The developed algorithm is used for depth-wise segmentation and hence density can be estimated..The approach for image segmentation in the detection of polyp is highly advantageous because of applicability, suitability, performance, computation and efficiency of the algorithm.Segmentation techniques based on gray level techniques such as thresholding, and region based techniques are the simplest techniques and have limited applications. Multi class SVM,MRF have high applications and results on medical image segmentation and cancerous polyps are predicted using the classifier. Here by efficient method of segmentation based on MRF is proposed and a successive result is obtained with an high accuracy. This method is efficient accurate, reliabile, robust and less dependency on the operator.

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