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Interactive 3D Virtual Colonoscopic Navigation For Polyp Detection From CT Images

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Abstract

Optical colonoscopy is an invasive procedure used to examine surface lining of the colon, by inserting a flexible tube with a light and camera into the body. Virtual colonoscopy is emerging as a non-invasive alternative to optical colonoscopy. This paper describes 3D reconstruction of colon structure from patient specific CT images, interactive visualization and navigation through the reconstructed colon, automated computation of the navigation path and automated polyp detection with 90.91% sensitivity. This enables a doctor to perform a fast diagnosis through virtual exploration of the colon and resort to invasive colonoscopy procedures only if suspicious polyps are detected.

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Keywords: Endoscopy; Polyp; Volume Rendering; 3D thinning; Surface Rendering; Dijkstra's algorithm;Principal Curvature; Gaussian Curvature

1. Introduction

According to the International Agency for Research in Cancer Globocan 2012 data, colon cancer is one of the leading cancers with 1.3 million new cases reported every year [1]. Early stages of colon cancer occur as *polyps* along the inner lining of the colon surface. Typical diagnosis is through a colonoscopy for visually examining the colon by a gastroenterologist. This procedure requires elaborate patient preparation to cleanse and air distending the colon for clear access. The actual procedure itself takes a few hours and usually requires some kind of sedation to reduce the discomfort, especially to elderly patients. Large polyps and improper preparation also may prevent the

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procedure from completion, requiring repeat procedures. Growths on the outer surface of the colon also go completely undetected.

This paper aims to develop a Virtual Colonoscopy system that augments clinical colonoscopy. Virtual Colonoscopy is an imaging test to visualize the 3D model of a patient's anatomy and navigation of a virtual camera through the same tubular structures, without having to insert any physical device into the body. It has applications in the early detection and diagnosis of cancer and other abnormalities inside the human body, while being faster and less discomforting than conventional endoscopic procedures. If any suspicious polyps are seen, a biopsy is done to confirm malignancy and further surgical procedures and treatment. This system provides automatic navigation through 3D reconstructed segmented colon with automatic polyp detection.

2. Materials and Methods

2.1.Medical Image Data

In this study, 21 distinct DICOM (Digital Imaging and Communications in Medicine) image data sets of human abdomen were collected for volume reconstruction [2]. Each data set consists of around 500 images with dimension 512 x 512 pixels and slice thickness ranging between 0.6888 $x10^{-3}$ and $1x10^{-3}$ m. The DICOM data consists of images of distended colon and meta information of the polyps present.

2.2.Software Environment

The software is implemented using Microsoft Visual C++ 2013, using MFC (Microsoft Foundation Classes) application framework. 2D visualization is done using GDI Plus and 3D visualization and Navigation using VTK 6.3 (Visualization Tool Kit). Segmentation Module is implemented using Open CV 3.1 (Open Source Computer Vision Library). Medial axis thinning is done using ITK 4.10.1 and polyp detection using MATLAB 2011b.The operating system is Microsoft Windows 64 bit.

2.3.Software Flow

The software flow of the system is as shown in Fig. 1. The input data is acquired as CT images in DICOM format. Segmentation is performed on the 2D slices to separate the Region of Interest (ROI) from the other organ parts. The 3D reconstruction, volume rendering technique retains all voxel data and require optimization of upper/lower threshold and opacity level.

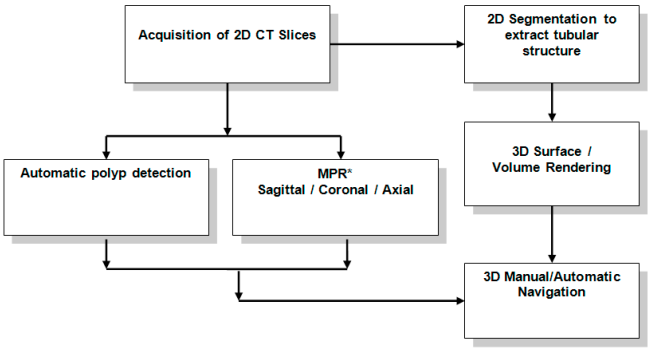

Fig. 1: The Software Flow of the System

This 3D model provides the ability to navigate through the created structure. Both user interactive manual navigation [10] and software specific automatic navigation are implemented. It also aims at computer-aided detection of polyps from the data and provides the locations of suspicious polyps for radiologists. The source images are the axial 2D images. Multi planar reconstructions (MPR) can be viewed in standard Coronal and Sagittal planes.