3-D Visualization and Virtual Endoscope of Human Digestive System from Chinese Digital Human

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Abstract

Alimentary canal is one of the most complex systems of human body. 3D rendering and virtual endoscope techniques are important means for understanding the 3D scenes of medical image data. This paper presents a method to reconstruct the anatomical structures of alimentary canal from slice data set of human body. The contours of some regions of interest in each single slice are extracted and added to the processed volumes into 3D Slicer. The output of the segmentation process is a set of label maps of the interested area. Based on the label maps, we can reconstruct the 3D surface model of the interested tissues. Both 3D and endoscope views are obtained based on the processed volume data. The main purpose of this study is to build a 3D virtual endoscope model for the Virtual Chinese Human Project and provide a more accurate, complete and facilitated means to 3D view and virtual endoscope of human organs for the medical research and anatomical education.

Keywords: 3D reconstruction, digestive system, Virtual Endoscope , 3D Slicer

1. Introduction

In recent years, virtual endoscope has become a new imaging and visualization technique to explore the human anatomy. Virtual Endoscope is the simulation of endoscope interventions using methods of Virtual Reality and Computer Graphics, it combines the features of endoscope viewing and cross-sectional volumetric imaging.

Usually, 3D volume data from CT, MRI, 3D ultrasound, rotational angiography, or other sources are used to generate a 3D view of the inside of the respective structures. Those volumetric data can provide information not accessible by the endoscope. Therefore, virtual endoscope presentation of image data enables the operator not only to explore the inner wall surfaces but also to navigate inside the virtual organs extracted from CT or MR images. Also, Virtual Endoscope can avoid uncomfortable caused by the optical endoscope. Because of these promising features, virtual endoscope has been applied to many different organs, including bronchoscope, colonoscopy, pancreatoscope, laryngoscope, sinus endoscope or otoscope.

2. Materials and Methods

The original data were selected from Virtual Chinese Human – Female (VCH-F) data sets. After image pre-processing, we used the 3D Slicer to build the 3D models and some virtual endoscope views of human digestive system.

2.1. About The 3D Slicer

We use the 3D Slicer as our software tool to reconstruct the 3-D models and to create a virtual Endoscope model of human digestive system.

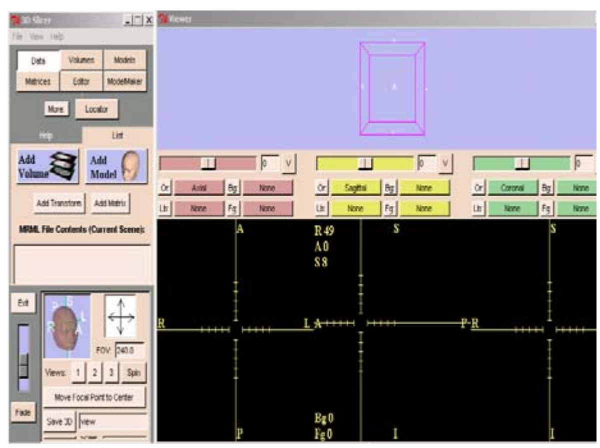

Fig. 1: 3D Slicer User Interface

The 3D Slicer is developed under cooperation between the MIT Artificial Intelligence Lab and the Surgical Planning Lab at Brigham & Women's Hospital, which is affiliated with the Harvard Medical School. The 3D Slicer is based on MRML (Medical Reality Modeling Language), that is an approach to describe 3D scenes of medical data sets from various modalities of. medical imaging. 3D Slicer provides capabilities for automatic registration, semi-automatic segmentation, generation of 3D surface models, 3D visualization, and quantitative analysis (measuring distances, angles, surface areas, and volumes) of various medical scans. Its main interface is shown in Fig 1.

2.2. The Data Source

The data source of this work is from VCH-F. The raw data set was acquired by The First Military Medical University, VCH research group. The VCH female was frozen at -70°C, then cryomacrotomed into 8556 slices. The thickness of each slice is 0.2mm. The image size is 3024*2016 pixels (anatomic image), and the pixel size of every slice is 0.19μm*0.19μm.

2.3. Image Pre-processing

The image pre-processing before 3D reconstruction includes background removal, image registration, image segmentation and ROI extraction.

When making specimen, in order to fix the dead body, surroundings of the cadaver were perfused with glutin. In order to improve image viewing or image preprocessing functions, and also to decrease the size of an archived or transmitted image, two methods are commonly used for removing background. One is based on a histogram analysis and another uses a dynamic thresholding technique, where the threshold is found by a statistical analysis of the background. We used the histogram approach to remove the background outside specimen boundary. This method is based on an assumption that the intensity values of foreground and background are distinguishable. Fig.2 shows a slice of 2D image after background removal.

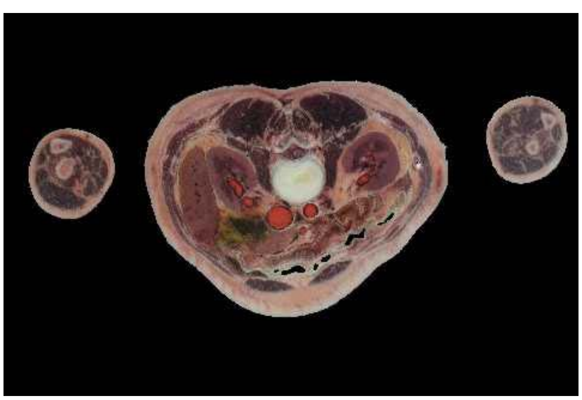

Fig. 2: An example of 2D image after background removal

2.4. Image Segmentation

After a long term of data acquisition, many factors may cause misalignment of the images such as slight shifting of the milling tool or digital camera， minute change of illumination. Using marks on slices, a coarse registration is completed with affine transformation. Then a more elaborate multi-slice registration based on mutual information was implemented.

Filtering noise and removing background, some regions of interest are extracted with homemade image segmentation software. Some manual editing is needed when ambiguous boundary exists between ROI and neighboring areas.

3. Results

The anatomic structures of the digestive system were reconstructed using 3D Slicer, including the esophagus, the stomach, the small intestine, the large intestine., the jejunum, the ileum, the colon, and the rectum. Almost all the major organs were segmented and 3D rendered. All the organs can be viewed separately or in any combination from different angles.

Fig. 3 to Fig. 5 shows some examples of our results. They are: Anterior view of the esophagus, stomach and Posterior view of the digestive system respectively.

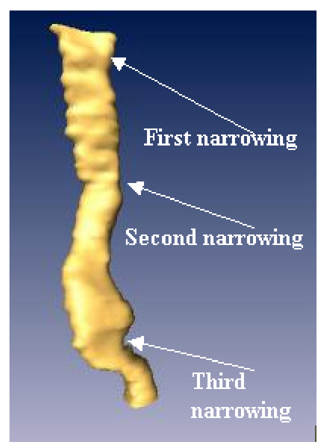

Fig. 3: Anterior view of the esophagus (left)

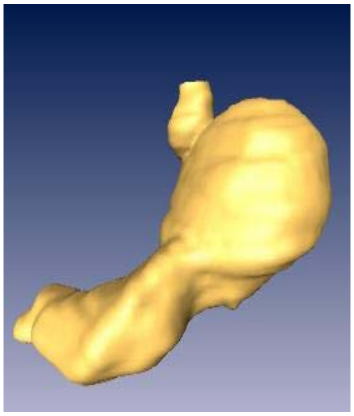

Fig. 4: The stomach (right)

Fig. 5: Posterior view of the digestive system (right)

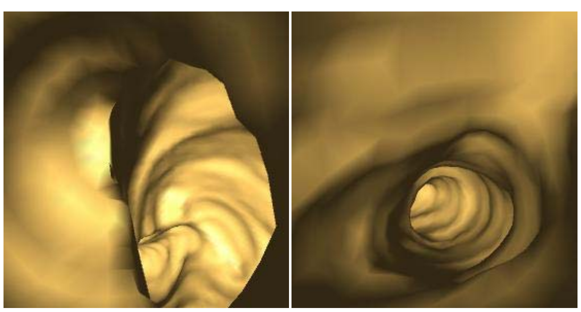

Figure 6. virtual endoscope views

Compared with optic endoscope, virtual endoscope has many special features, such as non-invasive, flying-through the whole body and any parts without the limits of tubular structure. For the detection of lesions and tumor of digestive system, virtual endoscope is no doubt an effective means. Some endoscopic views of the intestines and rectum are shown in figure 6.

4. Conclusion

Alimentary canal is one of the most complex systems of human body. 3D rendering and virtual endoscope techniques are important means for understanding the 3D scenes of medical image data. Our method can be used to reconstruct the anatomical structures of alimentary canal from slice data set of human body. Both 3D and endoscope views are obtained based on the processed volume data of Virtual Chinese Human – Female data set. Also, 3D Sliser provides a powerful and sophisticated means to 3D view and virtual endoscope of human organs for the medical research and anatomical education.

5. Acknowledgement

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6. References

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