Dual Modality Virtual Colonoscopy Workstation: Design, Implementation, and Evaluation

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Introduction: CT colonography (CTC) has become routine clinical procedure rapidly in recent years [1]. In contrast, the magnetic resonance colonography (MRC) is still stayed in a research setting at few research centers. One of the barriers to the MRC becoming a routine practice is the lack of efficient visualization tool for reviewing MRC images. The MRC exam acquires multi-sequence images. The current available CTC system could not load multi-sequence images simultaneously. Moreover, the spatial-intensity-inhomogenety makes it tough to applying uniform window-level for volume rendering the 3D endolumeinal view of the entire colon. Thus, an advanced visualization system for MRC procedure is highly desired.

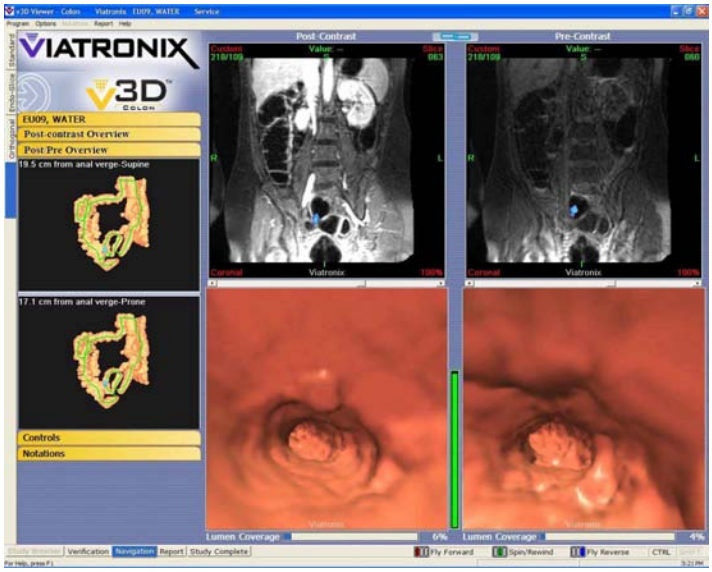
Purpose: The purpose of this study is to develop a virtual colonoscopy (VC) workstation that supports not only the popular CT procedure, but also the dark-lumen protocol MRC examination [2]. The new system is an enhancement of a successful commercial VC product for CT images – the V3D Colon (Viatronix Inc, Stony Brook, NY 11790). It is desired to fit the MRC procedure into the available GUI and workflow for CT procedure with minimum software engineering effort. As a result, it will require minimum amount of additional user training. That will facilitate switching image modality from one to another.

Methods and Materials: Although both CTC and MRC image the same abdominal body part, the acquired images are very different from intensity range, texture, imaging artifacts, and etc. For CTC, the patient's colon is distended with CO2 first. Then, a image series is acquired when patient lies on the back and stomach respectively. They are called supine and prone series. In the V3D Colon system, the 3D models of colon for both series are generated and displayed with 2D MPR views simultaneously. The system provides not only the automatic correlation between 2D and 3D views, but also the automatic registration between the 2 series. The radiologist detects polyp by performing a fly-through of the entire colon using the 3D endoluminal view. For dark-lumen MRC, the patient only lies in prone position. Warm tap water or air is filled in the colon. Subsequently, two 3D (T1-weighted) VIBE sequences (Magnetom Sonata; Siemens Medical Solutions, Germany) are acquired in coronal plane, one priori- and another post-IV contrast (Gd-BOPTA; Multihance, Bracco, Italy) injection. The IV contrast enhances the colon wall area to provide better contrast between wall, colon lumen, and fecal residues. By pretending the post- and pre-contrast series to be the supine and prone series, the entire data mechanism and GUI structure from CT procedure can be directly applied to the MR procedure. The only adjustment necessary is to replace the text on all the GUI fields to account for the modality specific terminology. For fecal tagging CTC, the system provides automatic electronic fecal cleansing. That allows displaying the cleansed and non-cleansed images by a single mouse click. Correspondingly, we are able to exploit the same mechanism to display subtracted and non-subtracted MRC images. The subtracted image is generated by subtracting pre-contrast image from the post-contrast image. Subtracted image may suppress imaging artifacts and enhance contrast to some degree.

The technological breakthrough is the real time volume rendering for the spatial-intensity-inhomogeneous MRC images. Unlike the CT images, the intensity range of the colon wall may vary greatly in MRC images even for the good imaging quality cases. A general window/level setting to the entire colon for volume rendering the 3D endoluminal view could not achieve accurate 3D depth for all segments of the colon. A new technique has been developed to deal with the problem.

Results: The new system was evaluated on 12 MRC cases. The cases were acquired from 2 different sites using the same sequences, but reconstructed using different voxel spacing (0.75 x 1.5 x 0.75 and 1.5 x 1.5 x 1.5 mm). The cases were categorized into 3 categories: Good (3), Moderate (5), and Poor (4) by radiologist based on the imaging quality. The newly system successfully accomplishes a fully automatic 3D endoluminal fly-through for all 3 good and 4 moderate cases. The system demonstrates good shape description for polyp in 3D endoluminal view. One moderate case and 4 poor cases could not successfully segment the colon lumen due to the severe imaging artifact.

Conclusion: A unified GUI layout can be provided and works very well for both CTC and MRC. The advantage is that radiologist who already is familiar with the CTC does not need any additional training to be able to evaluate MRC cases. The only pre-requisite is their understanding of the fundamentals of the MRC protocol rather than buttons and GUI. The preliminary evaluation results are promising on 7 out of 12 cases for polyp detection in 3D endoluminal view. The imaging artifact remained the basic barrier for delineating colon wall boundary in both 2D and 3D views.



Reference:

1. PJ Pickhardt et al., Computed tomographic virtual colonoscopy to screen for colorectal neoplasia in asymptomatic adults, NEJM, vol. 349, 2003, pp. 2191-2199
2. W Ajaj et al., Dark lumen magnetic resonance colonography: comparison with conventional colonoscopy for the detection of colorectal pathology, Gut, vol. 52, 2003, pp. 1738-1743

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