Title: Volumetric data processing for CT enterography

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Abstract: The overall goal of our work is to develop algorithms for efficient processing, segmentation and tracking of the small intestine in CT enterography scans. The small intestine is a complex organ, the shape of which can vary considerably between patients: and in addition to this, its location and shape can change significantly between subsequent scans of the same person. The CT enterography process uses contrast agents to improve the visibility of the intestine, so that various potentially problematic features, such as inflammations, obstructions and so on, can be properly seen. However, due to the convoluted shape of the organ, manual diagnosis of raw CT enterography data is still a difficult and time-consuming task, and is prone to diagnostic errors. We have prepared a set of methods for automatic preprocessing, segmentation and tracking of such data that aims at providing a much clearer data visualization: such tools can greatly improve the diagnostic process.

Our first contribution is to make a high quality denoising method for volumetric data practically usable: so far, it had been impractical due to its too high computational cost. This is solved by devising a GPU-friendly implementation scheme of the algorithm in question. Lowering its computation time from tens of minutes, or even hours, to a few minutes at most (depending on HW), finally makes it possible to use this algorithm for everyday practical work: and such a high quality denoising step is crucial for a later successful segmentation of the data. The next contribution is a system for computing the probability of intestinal lumen and intestinal walls on watershed-segmented regions. We propose a system for computing this probability based on several statistical features that are computed over the watershed regions. We also provide a discussion of the performance and suitability of the most promising subset of these features.

Using these computed lumen and wall probabilities, we then propose a robust algorithm for tracking the small intestine path through the bowel area: within this technique, we also address problems caused by the data imperfections that are typical of real CT scans. Furthermore, we propose an algorithm for precise segmentation of the lumen that is usable for wall analysis on tracked data. Finally a set of visualization possibilities is presented, as suggestions for practical usage of the results that are provided by the proposed pipeline.

Overall, we manage to create an automatic pipeline for processing noisy thin-slice CT enterography scans into segmented and tracked data: the result is much more suitable for diagnostic purposes than the original raw CT data. The only manual processing step in our pipeline is a simple removal of certain unwanted features, such as a distended colon, that are very similar in appearance to the small intestine. Our techniques allow for visualization of the entire bulk volume of the intestine to show topological locations and possible regions of interest, as well as a detailed visualization along individual intestinal segments for closer inspection.

Keywords: segmentation, GPU, denoising, CT enterography