Registration and segmentation of multislice 3DCT images: Application to laparoscopic surgery of the upper urinary system

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1. Purpose

A clear identification of arteries, veins and urinary tracts, together with their simultaneous visualization in 3D is required when planning laparoscopic surgery on kidneys. To this aim, multiple contrast-enhanced CT scans are acquired at different times during blood circulation, but the kidney motion, among other causes, seriously hampers their direct fusion. This study aims at developing algorithms to represent in 3D, from such images, the kidney surroundings as close as possible to the surgical reality.

2. Methods

For each patient, 3 acquisitions are made on a multidetector row CT scan (MDCT) with 16 channels (Sensation 16, Siemens, Erlangen) after the intra-venous injection of a contrast agent: arterial phase (t=0), venous phase (+1 min) and excretory phase (+5 min).

First, volumes are non-rigidly registered by pairs, by maximization of a local cross-correlation score. Second, simple image processing operations are applied either on the original volumes or on pairwise combinations of volumes. Bones, arteries, veins, ureters and kidneys are thereby extracted. A local affine correlation-based registration, around the kidney of interest, comes in the end to fine-tune the registration.

3. Results

To date, 4 patients have been analyzed by comparing the segmentation result to intra-operative laparoscopic images, as well as volume rendering (VR) images generated independently for each single original volume. A good surgical realism of the virtual images our method produces, was put forward. However, general critics concern the lack of visibility of very small vascular structures in some cases (1 to 2 mm in diameter).

4. Conclusion

This study showed that simple algorithms, leveraging the surgeon's knowledge through manual input, could be applied systematically to obtain a segmentation of the structures surrounding the kidneys. Preliminary comparisons are very promising that such a visualization can simulate in a realistic way the laparoscopic surgical views, and thereby ease and secure the planning of the intervention.

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