Section: **Segmentierung, Registrierung**

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Abstract-Title:
ADVANCED 2D-3D REGISTRATION METHOD FOR TRANSARTERIAL CHEMOEMBOLIZATIONS

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Abstract-Text:
Purpose

Angiographic imaging is a widely used technique for intravascular interventions. In such treatments a preoperative 3D data set (e.g. coming from CTA) is usually acquired for diagnosis and planning. During the intervention a C-arm captures the current state of placed catheter and anatomy of the patient for navigation. In clinical practice, 2D fluoroscopic projections of the region of interest are acquired lacking spatial resolution compared to the preoperative data sets. Patients suffering from primary liver cancer are frequently treated with Transarterial Chemoembolizations (TACE). Here, in order to apply local chemotherapy and embolize the blood vessels supporting the tumor, a catheter is inserted into the arterial vasculature and guided to the tumor's location using DSAs. The navigation through the vessel system is rather difficult for physicians due to lack of depth perception. Registering pre- and intraoperative data sets would allow physicians to view the catheter in 3D together with detailed patient anatomy.

Method

We introduce one additional run of an angiographic CT phase that visualizes liver arteries (delay times with bolus tracking: 6 (angiographic), 10+/-2 (arterial dominant), 21+/-4 (portal-venous) seconds), see fig. 1. The aim is to let the interventionalist benefit from 3D high resolution CTA scans for planning before, and for navigation during the intervention. The spatial precision of the acquired scans could be reconstructed to 0.58x0.58x0.6 mm3 /voxel in a 512x512x(280-500) voxel volume. As confirmed by physicians, the additional radiation (approximately 6 mGy) exposure is acceptable for patients undergoing a TACE treatment.

Furthermore, we propose a registration algorithm using the new CT phase that aligns arterial structures with those of the DSA.
Preprocessing:
A set of curves is extracted from 2D and 3D data sets using anisotropic diffusion / Hessian-based filtering, region growing, thinning, and wave propagation to detect curve points and bifurcations (junctions between curves). A graph structure is used to represent

curves (edges) and bifurcations (vertices).
Initialization:
A first correspondence of the 3D root bifurcation is found by iterative x-y-translation and a DICOM-initialized approximate rotation and z-translation. Only those 2D bifurcations are inspected with a diameter of outgoing vessels similar to that in 3D (near projective invariance).
Optimization:
Given one fixed correspondence, 4 DOFs are optimized (3 rotations, 1 translation) using a distance measure based on the Euclidean distance of point pairs and topological information of the bifurcations (number of attached vessels and a breadth first search value coming from the inherent graph representation). A Downhill-Simplex Optimizer was used to converge to an optimum.Results

Studies of one phantom (rigid) and three patients (non-rigid) have been performed. From ground truth values for all parameters defined by physicians, displacements of 10°/10mm have been randomly generated and the registration method has been invoked (see fig. 2). The high displacement for the third patient is due to a very local distribution of curves. The Root Mean Square errors are acceptable for physicians to execute their plan despite of anatomy deformation. See fig. 3 for initialized and optimized pose of the patients.

Conclusion

We introduce a new CTA scanning protocol for liver interventions resulting in a benefit for interventionalists in terms of depth perception and 3D planning to the diagnostic value of 3D high resolution images. By developing a 2D-3D registration algorithm based on the newly acquired data we enable physicians to transfer planning information to the interventional room. The combination of geometrical properties of the vasculature like branching point coordinates and vessel diameter with topological properties of the vessel tree using an intuitive graph representation drives the registration process to an optimum quickly and robustly. According to physicians the accuracy of the registration complies with the goal of 3D navigation and visualization.

Bild 1/JPG

Bild 2/JPG

	$\sigma_\alpha[°]$	$\sigma_\beta[°]$	$\sigma_\gamma[°]$	$\sigma_t[mm]$	$RMS_\alpha[°]$	$RMS_\beta[°]$	$RMS_\gamma[°]$	$RMS_t[mm]$
Phantom	3.6	1.6	2.6	1.6	3.6	1.7	2.6	2.2
Patient 1	4.1	3.9	0.8	7.7	5.3	4.3	0.8	8.7
Patient 2	1.7	3.8	0.8	9.9	3.3	4.0	0.8	9.9
Patient 3	5.2	7.2	3.3	35.5	5.4	7.2	4.5	60.5

Bild 3/JPG