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Towards a More Objective Visualization of the Midbrain and its Surroundings Using 3D Transcranial Ultrasound

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Introduction. Ultrasound investigations of the midbrain have been proven to be sensitive for the detection of changes associated with movement disorders [Berg et al., 2008]. A critical issue about this method remains a dependency upon the observer and his experience. To reduce inter-rater variability, a 3D analysis of e.g. echo-hyperintense Substantia nigra (SN) structures would be beneficial. Therefore we are on the way to develop a system which enables us to reconstruct a more objective 3D structure on the basis of the far used 2D ultrasound data.

Methods. Freehand 3D Ultrasound acquisition combines a series of 2D image slices with 3D position information of the transducer for each slice, utilizing a commercial medical ultrasound device (Siemens Accuson Antares) together with a medically certified optical tracking device (NDI Polaris Spectra). A probe calibration step is performed prior to the image acquisition with the Single Wall method, which is reported to have an average error of 0.5mm [Mercier et al., 2005]. For the 3D reconstruction step, the Backward-Warping Ultrasound Reconstruction as proposed by Wein et al. [2006] is used. Additionally, a 3D reconstruction of blood vessels alone can be performed by filtering of colored pixels in color Doppler scans. Ultrasound slices with arbitrary orientation can be reconstructed from the resulting volume rapidly and compared to optically co-registered slices from the patient's MRI volume.

Results. Freehand 3D ultrasound volumes were acquired transcranially for a series of 7 subjects (two healthy, one Parkinson patient, one Parkinson and one Dystonia patient with deep brain stimulation electrodes, one NPH, one patient with cerebral aneurysm; four male, three female, age 28-78). The entire volume of the midbrain area and surrounding pathologies could be reconstructed in 3D in all subjects. Angiographic 3D reconstruction of blood vessels was successfully performed for the aneurysm patient.

Discussion. This study indicates that transcranial sonography of the entire midbrain area can be improved by 3D Freehand Ultrasound volume scanning, reducing the intra- and inter-observer variability which is inherent to the scanning procedure in 2D. Initial evaluation of results in 7 subjects yielded high-quality volumetric data, indicating diagnostic relevance of the obtained images. Our next step aims at a quantitative statistical comparison concerning diagnostic relevance of 2D vs. 3D scans. Future work is directed towards the incorporation of procedures for automatic 3D segmentation of certain anatomic structures such as the SN or also towards vessel-based registration of ultrasound volumes with MRI volumes.

Mercier, L. & Lang, T. & Linkseth, F. & Collins D.L. (2005). A Review Of Calibration Techniques For Freehand 3-D Ultrasound Systems. *Ultrasound in Med. & Biol.*, 31 (4): 449-471.

Berg, D. & Godau, J. & Walter, U., (2008). Transcranial sonography in movement disorders. *Lancet Neurology*, 7: 1044-55.

Wein, W. & Pache, F. & Roeper, B. & Navab, N. (2006). Backward-Warping Ultrasound Reconstruction for Improving Diagnostic Value and Registration, *Proc. of Medical Image Computing and Computer-Assisted Intervention (MICCAI), LNCS*, 4191: 750-757.