Remote Analysis for Brain Shift Compensation

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Abstract. The compensation for brain shift is assisted by intraoperative imaging. For the purpose of fast registration and interactive visualization, a framework is presented based on local desktop computers and remote high-end computers with a maximum of compute power and graphics capacity. In this context, functional markers resulting from preoperative measurements (MEG, fMRI) are mapped to the intraoperative situation. Overall, results from 5 cases demonstrate the value of the suggested environment.

Keywords: Brain Shift, Registration, Visualization

Introduction Preoperative planning and navigation in neurosurgery are assisted by information from different imaging modalities. As a drawback, preoperative data invalidates during surgery due to the brain shift phenomenon. Therefore, intraoperative imaging is applied for compensation providing anatomical data. However, functional information resulting form magnetoencephalography *(MEG)* or functional MRI *(fMRI)* is exclusively based on preoperative imaging [1]. Therefore, alternative approaches try to predict the occurring deformation or calculate the transformation based on pre- and intraoperative anatomical images. These approaches are based on mathematical models using registration or simulations strategies.

Methods The framework of the presented work aiming at the compensation for brain shift is based on an environment introduced in [2] allowing for access maximal compute power and graphics capacity. For the rigid registration of pre- and intraoperative MR data a hardware accelerated approach suggested in [3] was integrated operating on the remote graphics server. It is based on mutual information and applies 3D texture mapping hardware for all interpolation operations. The subsequent analysis of the image data has been performed with 3D texture mapping on the remote computer applying direct volume rendering which is interactively controlled on the local computer. For the comparative analysis of pre- and intraoperative data synchronized 3D representations are used applying communicating Java viewers. For the transformation of markers indicating functional areas, the brain volume is segmented in the registered datasets using a volume growing strategy. Then, a newly developed approach automatically detects and evaluates corresponding sulci within the registered data. This reference information is consecutively applied to determine the position of preoperatively obtained functional markers within the intraoperative image data. As a result the obtained image data can then be used for an intraoperative functional update of the neuronavigation system.

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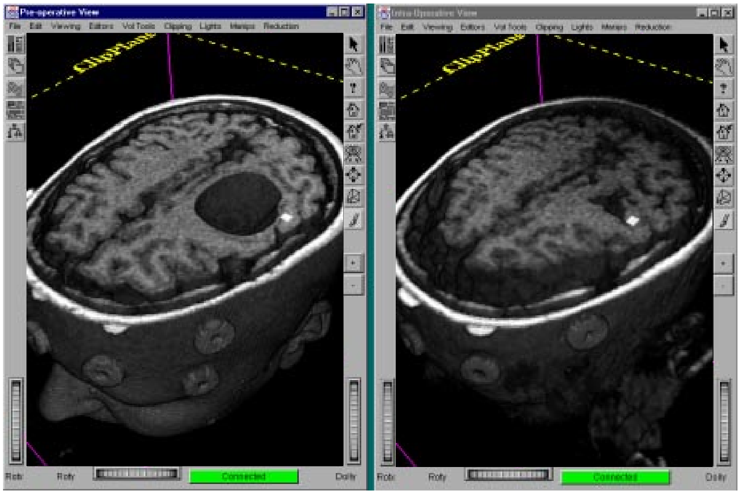

Fig. 1. Communication windows on local client computer: The synchronized 3D representations show preoperative MR *(left)* with a marker from MEG (white square) and intraoperative MR *(right)* including the correct intraoperative location of the MEG marker after transfer.

Results The presented prototype framework was applied in 5 cases with functional markers identifying eloquent brain areas. For an example see Fig. 1. All computation was remotely performed with a SGI Octane ($2\times$R12000, 300MHz) with 128 Mbytes of graphics memory. The client was located at the operating room providing only low-end graphics capabilities. The connection to the remote server was established via Internet with a communication rate of 10 Mbits/sec. For the visualization a view-port of 600x600 pixels led to a frame rate of 3 fps which is increased to 9 fps reducing the size of the transferred images by a factor of 4. Considering the voxel based registration (about 45 sec) and the mapping of the functional markers an overall processing time of about 10 min was achieved including the transfer of the data to the remote computer. The reduction by a factor of 3.5 compared to a purely local setup enables intraoperative application of the presented approach.

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References

1. C. Nimsky, O. Ganslandt, H. Kober, M. Möller, S. Ulmer, B. Tomandl, and R. Fahlbusch. Integration of Functional Magnetic Resonance Imaging Supported by Magnetoencephalography in Functional Neuronavigation. *Neurosurgery*, 44:1249–1256, 1999.
2. K. Engel, O. Sommer, and T. Ertl. A Framework for Interactive Hardware Accelerated Remote 3D-Visualization. In *Proc. VisSym*, pages 167–177. Joint Eurographics - IEEE TCVG Symposium on Visualization, 2000.
3. P. Hastreiter and T. Ertl. Integrated Registration and Visualization of Medical Image Data. In *Proc. CGI*, pages 78–85, Hannover, Germany, 1998.