Image-guided neurosurgery

see intraoperative MRI, 5-ALA or DTI-neuronavigation.

see Fluorescence-guided surgery

see Near-infrared image-guided surgery

Image-guided neurosurgery has become standard practice since the year 2000, with more than 2000 surgical navigation stations installed worldwide in 2006 [1)].

Nonetheless, the evidence supporting the use of these systems in surgery remains limited. New augmented reality platforms may improve performance in less-experienced surgeons. However, all image display modalities, including existing triplanar displays, carry a risk of inattentional blindness [2)].

Computed tomography angiography (CTA) fusion

In the same time several reports have also demonstrated the efficacy and accuracy of computed tomography angiography (CTA) in assessing cerebral vascular pathologies. Therefore, the CTA data have been implemented into the different navigation systems available on the market, making this new technique widely applied.

This fascinating technique can give some invaluable advantages on the management of cerebral vascular lesions and provides excellent information not always available on traditional digital subtraction angiography investigation. It has also proved to be very accurate, particularly regarding the correlation between the 3D volume-rendered CT angiography and the intraoperative findings. [3)]

Ultrasound fusion

Fusion of tracked ultrasound (US) with MR has many applications in diagnostics and interventions. Unfortunately, the fundamentally different natures of US and MR imaging modalities renders their automatic registration challenging.

RaPTOR computes local correlation ratio (CR) values on small patches and adds the CR values to form a global cost function. It is therefore invariant to large amounts of spatial intensity inhomogeneity. Rivaz et al., also propose a novel outlier suppression technique based on the orientations of the RaPTOR gradients.

The deformation is modeled with free-form cubic Bsplines. They analytically derive the derivatives of RaPTOR with respect to the transformation, i.e. the displacement of the B-spline nodes, and optimize RaPTOR using a stochastic gradient descent approach. RaPTOR is validated on MR and tracked US images of neurosurgery. Deformable registration of the US and MR images acquired respectively pre-operation and post-resection is of significant clinical significance, but challenging due to, among others, the large amount of missing correspondences between the two images. This work is also novel in that it performs automatic registration of this challenging dataset. To validate the results, they manually locate corresponding anatomical landmarks in the US and MR images of tumor resection in brain surgery. Compared to rigid registration based on the tracking system alone, RaPTOR reduces the mean initial mTRE over 13 patients from 5.9 mm to 2.9 mm, and the maximum initial TRE from 17.0 mm to 5.9 mm. Each volumetric registration using RaPTOR takes about 30 sec on a single CPU core. An important challenge in the field of medical image analysis is the shortage of publicly available dataset, which can both facilitate the advancement of new algorithms to clinical settings and provide a benchmark for comparison. To address this problem, we will make our manually located landmarks available online [4].

Indication

Tumor resection

Image guided neurosurgery uses a variety of technologies to help achieve extensive resection of tumors.

There is low to very low quality evidence (according to GRADE criteria) that image guided surgery using iMRI, 5-ALA or DTI-neuronavigation increases the proportion of patients with high-grade glioma that have a complete tumour resection on post-operative MRI. There is a theoretical concern that maximising the extent of resection may lead to more frequent adverse events but this was poorly reported in the included studies. Effects of image guided surgery on survival quality of life (QoL) are unclear. Further research, including studies of ultrasound guided surgery, is needed [5].

[1], [3]
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