Surface registration

In image-guided surgery systems, image-to-patient spatial registration is to get the spatial transformation between the image space and the actual operating space. Although the image-to-patient spatial registration methods using paired-point or surface-matching are used in some image-guided neurosurgery systems, the key problem is that the global optimization registration result cannot be achieved. Therefore, this paper proposes a new rotation invariant feature for decoupling rotation and translation space, based on which a global optimization point set registration method is proposed.

The new rotation-invariant features, constructed based on the edges and the angles, are the rotation invariant, which has high feature resolution. And some of them are not only the rotation invariant but also the translation invariants. To obtain the global optimal solution, BnB search strategy is used to search the parameter space of the translation and the computational cost is reduced simultaneously. The registration accuracy of the spatial registration method is analyzed by comparing the difference between the estimated transform and the standard transform to calculate the registration error.

To validate the performance of the spatial registration method proposed, the registration performance was analyzed by comparing the experimental results with the results of the two mainstream registration methods (the ICP registration method and the CPD method). In the experiments, the comparison was based on the registration accuracy and the execution time. We show our registration method can obtain a higher accuracy in a shorter time in most cases. At the same time, when the ICP method is used for the refine in our method, the ICP method can converge in a very short time, which also shows that our method provides a good initial pose for the ICP method and can help the ICP converge to the global optimal solution faster. Our method can achieve an average rotation error of 0.124 degrees and an average translation error of 0.38 mm on 10 clinical data.

The results reveal that the surface registration method based on translation rotation decoupling can achieve superior performance regarding both the registration accuracy and the time efficiency in the image-to-patient spatial registration [1)].

1)
Fu K, Chen X, Wang M. Global optimization point-set registration based on translation/rotation decoupling for image-guided surgery applications. Med Phys. 2022 Jun 30. doi: 10.1002/mp.15839. Epub ahead of print. PMID: 35771730.