curac2004
3. Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie e.V.

Analyse des Fiducial Localisation Error in automatisierter und manueller VorregistrierungPreregistration

Analysis of Fiducial Localisation Error in Automated and Manual Preregistration

Georg Eggers[1], Josef Kozak[2], Sascha Däuber[3], Olaf Deppe[4], Werner Korb[1], Thomas Welzel[5], Stefan Hassfeld[1]

[1]Universitätsklinik für MKG-Chirurgie, Heidelberg
[2]Aesculap AG, Tuttlingen
[3]Institut für Prozeßrechentechnik, Automation und Robotik, Universität Karlsruhe
[4]Evotec Technologies, Hamburg
[5]Universitätsklinik für Radiologie, Heidelberg

Purpose

Fiducial marker registration is the gold standard for accuracy in patient to image registration.
For analysis of the accuracy of point based registration, three measures of error have been suggested: Fiducial Localization Error (FLE) is the error in locating the fiducial points. Fiducial Registration Error (FRE) is the distance between corresponding fiducial points after registration. Target Registration Error (TRE) is the distance between corresponding points other than fiducials after registration.
In this study the accuracy of semiautomated fiducial marker localisation [1] was compared to manual preregistration.

Methods

Special markers for automated preregistration and titanium screws for manual preregistration were placed on human cadaver heads prior to CT-scanning.
In the image data the hollow cone markers positions were located automatically using a software tool [1]. For manual preregistration, the centers of the heads of the titanium screws were located manually in the image data.

The actual position of the markers on the head was determined using a mechanical localizer arm (MicroScribe G2, Immersion Corp., San Jose, California, USA).
Fiducial marker registration was performed for every selection of four fiducials out of each set of markers. Using the subset of four fiducial markers, a rigid-body transformation matrix was calculated. The transformation matrix for the selected fiducials then was applied to the remaining markers that had been defined as targets. The TRE (Target Registration Error) as the difference between the real target position and the calculated target position was calculated for each target. Finally, according to [2], an estimate of the FLE was calculated.

Results

In manual preregistration, all titanium screw markers could be detected in the 2mm CT-scan as well as in the 4mm-CT scan.
For automated preregistration only 12 of the 13 markers could be evaluated, because one marker loosened. During automated preregistration, 10 of the remaining 12 markers were detected in the 2mm CT-scan and 11 of the remaining 12 markers were detected in the 4mm CT-scan.
Measured values for FRE and TRE were always better in automated preregistration, as was the calculated estimate of the FLE. The accuracy was more robust to lower CT resolution.

Discussion

Three reasons can be assumed for this gain in accuracy: Firstly, in automated preregistration, all voxels that belong to the marker, are weighted with their gray-scale value. Thus a better approximation of the depicted object is made. Secondly, the coordinates of the calculated center of gravity can be anywhere between the discrete image coordinates, while in manual preregistration a voxel of the imagedata is selected as the fiducial point. This also explains the increased error with lower resolution CT-imaging. Thirdly, during registration the hollow cone is a better target than the center of a titanium screw.

References

1 Kozak-J, Nesper-M, Fischer-M, Lutze-T, Göggelmann-A, Hassfeld-S, Wetter-T: Semiautomated Registration using New Markers for Assessing the Accuracy of a Navigation System. Comput Aided Surg. 2002;7(1):11-24

2 Fitzpatrick-JM, West-JB, Maurer-CR Jr: Predicting Error in Rigid-Body Point-Based Registration. IEE Trans Med Imaging 1998; 17(5):694-702