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Graphische Qualitätssicherung bei 3D-Navigation

Graphical quality assurance for 3D-navigation

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Problem

A large variety of intraoperative navigation systems, providers and applications is on the market currently. It is essential to have a unified strategy available for easy and reliable quality assurance, especially in ENT surgery. Mostly, root-mean-square values (RMS-values) are being given in order to characterize the quality of the achieved intraoperative patient-to-image referencing. This is not acceptable, since this value does not reflect what the surgeon needs: an information about how exact the probe is localized in the patient. It may happen, however, that even despite of a small RMS-value no good clinical application accuracy is achieved. Reversely, a bad RMS-value is only a hint for a bad clinical application accuracy. Ground truth is provided by the intraoperative verification only.

Materials and Methods

Currently, the proposed model has been developed and is available under laboratory conditions, but even for the lab no standardized approach exists. A specified number of anatomic landmarks and / or extrinsic structures (markers, implanted screws, etc.) are CT-scanned with the anatomic object and prepared for navigation. A set of well-defined points on the object is used as a measuring matrix and is pointed at with the navigation system. Based on the position shown, the difference between actual and theoretical positions are evaluated in a patient-specific coordinate system. This coordinate system is defined by the standard views: anterior-posterior (x-axis), cranial-caudal (z-axis) and medial-lateral (y-axis). A Matlab routine evaluates the measured triples of deviations as follows: a graphics for a spatial density-plot of measured data (i. e. the weighted distribution of points: the more points, the thicker the associated blob) and the standard deviations in the three spatial directions. The xy-, xz- and yz-planes contain projections of

the weighted data and the ellipses defined by the according standard deviations as the principal axes..

Results

The investigations performed to-date did show a great acceptance from the ENT surgeons. The data were stored in an Excel-file, readable by Matlab. The script is interactive and only allows the choice of the graphics to be displayed; thus, the script is reduced to the minimum user interface. The plots can be rotated in space and allow the intuitive perception of the quality of the registration.
A point-cloud of weighted points around the origin with no outliers and symmetric standard deviations in all three dimensions represents the ideal, error-free measurement without systematic error.

Conclusion

Evidently, it is a laboratory model. However, there is a significant potential to extend this to a clinical valuable tool, willingly accepted by the surgeons. It has, obviously, to obey specific criteria: ease of use, no significant workload, reliability and speed. And, most importantly, an easy to understand presentation of results. It will suffice to show trends of the errors, in the minimal case the deviations as determined in the eight octants. These could be added up to yield a „vector of deviation" in a symbolic model which is intuitively to handle for the surgeon intraoperatively.

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