Visual Accuracy Inspection for Laser Surface Scanning Registration

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Purpose

We apply a laser surface scanning device to register preoperative image data to patient coordinates for use in a navigation system. The device has been designed for a flexible use, where the surface to be scanned may be outside of the field of view of the tracking cameras. In addition to the insufficient RMS error statement we provide supplementary information about registration quality by means of a new visual inspection tool.

Material and Methods

For surface scanning we use a hand-held device consisting of a tracked laser distance sensor. It uses a visible laser beam to measure the distance to a surface point, while the position of the device is located by an optical tracking system. After a one-time calibration procedure, we can determine the reflection point position in the tracking coordinate system.

Image data is registered to the patient's head by scanning the shape of the patient's face with the laser point. The measured surface coordinates are automatically matched to a surface model, which has been generated from image data.

After the registration the surgeon is able to check and validate the registration result interactively by means of a visual inspection tool. The application includes a special display method of two attached views. A 3D-view shows the patient's surface model together with all matched registration points. The second window shows a two-dimensional cross section through the surface model, so the displacement between matched points and a profile line of the surface can be evaluated. The position of the cross section plane is visualized in the 3D-view to help the surgeon to select the section plane. This interaction offers a visual presentation of all information used for registration.

Results

The laser scanning device is easy-to-use and very flexible. The patient's face can be scanned, even if it is not in the field of view of the tracking cameras, by appropriately holding the device in the camera's field of view during the scan. This is especially useful in neurosurgical interventions, when the patient is placed in prone position.

The used registration algorithm works fast and delivers results with calculated root mean square error (RMS) < 1 mm, if the scan is properly accomplished. However this information reveals how close the measured coordinates are to the model surface, it doesn't give sufficient

information about the registration quality. In spite of a small RMS error the registration result might be poor.

Therefore in addition to the RMS error the inspection tool helps the surgeon to evaluate the actual registration quality, by presenting the actual distances of measured points and pertinent surface slices. Furthermore the additional information indicates appropriate areas for laser scan acquisition.

Conclusion

The laser scanning device allows registering the patient via surface scanning even in an unfavorable OR setting. Using the visual inspection mechanism allows a more detailed and significant assessment of the registration accuracy than standalone statistical methods. The different factors of misalignment such as facial soft tissue movement can effectively be identified and excluded from the registration procedure.

Deutscher Titel:

Visuelle Genauigkeitsinspektion für Registrierung durch Laser-Oberflächen-Abtastung