Point set registration

In computer vision and pattern recognition, point set registration, also known as point matching, is the process of finding a spatial transformation that aligns two point sets. The purpose of finding such a transformation includes merging multiple data sets into a globally consistent model, and mapping a new measurement to a known data set to identify features or to estimate its pose. A point set may be raw data from 3D scanning or an array of rangefinders. For use in image processing and feature-based image registration, a point set may be a set of features obtained by feature extraction from an image, for example corner detection. Point set registration is used in optical character recognition, augmented reality and aligning data from magnetic resonance imaging with computer aided tomography scans.

Surface matching (and more generally the matching of structures) is an important subject of computer vision, which has given rise to an important amount of research papers.

In the past, the accuracy of surface matching has been shown to be disappointing.

Mongen and Willems aimed to determine whether this had improved over the years by assessing application accuracy of current navigation systems, using either surface matching or point-pair matching.

Eleven patients, scheduled for intracranial surgery, were included in this study after a power analysis had shown this small number to be sufficient. Prior to surgery, one additional fiducial marker was placed on the scalp, the "target marker," where the entry point of surgery was to be expected. Using one of three different navigation systems, two patient-to-image registration procedures were performed: one based on surface matching and one based on point-pair matching. Each registration procedure was followed by the digitization of the target marker's location, allowing calculation of the target registration error. If the system offered surface matching improvement, this was always used; and for the two systems that routinely offer an estimate of neuronavigation accuracy, this was also recorded.

The error in localizing the target marker using point-pair matching or surface matching was respectively 2.49 mm and 5.35 mm, on average ($p < 0.001$). In those four cases where an attempt was made to improve the surface matching, the error increased to 6.35 mm, on average. For the seven cases where the system estimated accuracy, this estimate did not correlate with target registration error ($R2 = 0.04$, $p = 0.67$).

The accuracy of navigation systems has not improved over the last decade, with surface matching consistently yielding errors that are twice as large as when point-pair matching with adhesive markers is used. These errors are not reliably reflected by the systems own prediction, when offered. These results are important to make an informed choice between image-to-patient registration strategies, depending on the type of surgery at hand [1].

[1]
Mongen MA, Willems PWA. Current accuracy of surface matching compared to adhesive markers in patient-to-image registration. Acta Neurochir (Wien). 2019 Mar 16. doi: 10.1007/s00701-019-03867-8. [Epub ahead of print] PubMed PMID: 30879130.

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