Three-dimensional localization of narrow point distributions using a hybrid optimization technique

The spatial correlation of three-dimensional (3D) objects with two-dimensional (2D) images of those objects is important for medical applications such as catheter navigation and patient positioning. Previously, we presented a technique that determines accurately the 3D orientation and position of a distribution of points using a single projection image, given the 3D distances between points. However, as the point distribution narrows to approximately one millimeter, the SPT becomes increasingly sensitive to local solutions, thereby, impairing its accuracy.

To improve the reliability and accuracy of the SPT for application to narrow point distributions, a genetic algorithm (GA) was used to search for a global estimate of the 3D orientation and position of the points based on 2D reprojection error. Subsequently, the SPT iteratively aligns the reprojected points with their corresponding image points to refine the initial estimate provided by the GA.

In simulation studies, this hybrid optimization technique (GA-SPT) was applied to points distributed along 5 fr catheters placed at 100 random orientations. Preliminary results indicate that, on the average, the GA-SPT computed orientations that were 38 times more accurate, and positions that were 5 times more accurate, than those computed by the SPT alone. Similarly, the reliability of the GA-SPT exceeded that of the SPT alone. These results indicate that accurate and reliable orientations and positions can be obtained for objects as small as a catheter.