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Assessment of optical localizer accuracy for computer aided surgery systems.

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Abstract

The technology for localization of surgical tools with respect to the patient's reference coordinate system in three to six degrees of freedom is one of the key components in computer aided surgery. Several tracking methods are available, of which optical tracking is the most widespread in clinical use. Optical tracking technology has proven to be a reliable method for intra-operative position and orientation acquisition in many clinical applications; however, the accuracy of such localizers is still a topic of discussion. In this paper, the accuracy of three optical localizer systems, the NDI Polaris P4, the NDI Polaris Spectra (in active and passive mode) and the Stryker Navigation System II camera, is assessed and compared critically. Static tests revealed that only the Polaris P4 shows significant warm-up behavior, with a significant shift of accuracy being observed within 42 minutes of being switched on. Furthermore, the intrinsic localizer accuracy was determined for single markers as well as for tools using a volumetric measurement protocol on a coordinate measurement machine. To determine the relative distance error within the measurement volume, the Length Measurement Error (LME) was determined at 35 test lengths. As accuracy depends strongly on the marker configuration employed, the error to be expected in typical clinical setups was estimated in a simulation for different tool configurations. The two active localizer systems, the Stryker Navigation System II camera and the Polaris Spectra (active mode), showed the best results, with trueness values (mean +/- standard deviation) of 0.058 +/- 0.033 mm and 0.089 +/- 0.061 mm, respectively. The Polaris Spectra (passive mode) showed a trueness of 0.170 +/- 0.090 mm, and the Polaris P4 showed the lowest trueness at 0.272 +/- 0.394 mm with a higher number of outliers than for the other cameras. The simulation of the different tool configurations in a typical clinical setup revealed that the tracking error can be estimated to be 1.02 mm for the Polaris P4, 0.64 mm for the Polaris Spectra in passive mode, 0.33 mm for the Polaris Spectra in active mode, and 0.22 mm for the Stryker Navigation System II camera.

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