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Accuracy and reproducibility of co-registration techniques based on mutual information and normalized mutual information for MRI and SPECT brain images

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We implemented a 3D co-registration technique based on mutual information (MI) including 2D image matching as a coarse pre-registration. The 2D coarse pre-registration was performed in the transverse, sagittal and coronal planes sequentially, and all six parameters were then optimized as fine registration. Normalized mutual information (NMI) was also examined as another entropy-based measure that was invariant to the overlapped area of two images. In order to compare accuracy and precision of the present method with a conventional two-level multiresolution approach, simulation was performed by 100 trials with the random initial mismatch of ±10° and ±17.92 mm (Type-I) and ±20° and ±40.32 mm (Type-II). For Type-I, no significant differences were found between registration errors of the multiresolution approach and the present method with the MI criterion. No biases were observed (≤0.13° and ≤0.57 mm for the multiresolution approach; ≤0.12° and ≤0.57 mm for the present method) and the SDs were very small (≤0.18° and ≤0.12 mm for the multiresolution approach; ≤0.11° and ≤0.11 mm for the present method). For Type-II, SDs for the multiresolution approach (≤1.8° and ≤0.88 mm) were markedly larger than those for the present method (≤0.64° and ≤0.20 mm) with MI. Success rate for the present method was 99.9%, which was higher than 97.6% for the multiresolution approach. Simulation also revealed that MI and NMI performance were almost equivalent. The choice of optimization strategy more affected accuracy and reproducibility than the choice of the registration criterion (MI or NMI) in our simulation condition. The present method is sufficiently accurate and reproducible for MRI-SPECT registration in clinical use.

Key words: image registration, mutual information, normalized mutual information, entropy, single photon emission computed tomography (SPECT)