Purpose:

To develop a neural network based registration quality evaluator (RQE) that can improve the 2D/3D image registration robustness for pediatric patient setup in external beam radiotherapy.

Methods:

X-ray setup images of six pediatric patients with brain tumors received proton therapies were retrospectively registered with their treatment planning computed tomography (CT) images. A neural network based pattern classifier was used as an RQE to classify 2D/3D rigid registration solutions as successful or unsuccessful based on features of the similarity value surfaces near the point-of-solution. The supervised training and test datasets were generated by rigidly registering a pair of orthogonal daily setup x-ray images to the treatment planning CTs. The best solution for each registration task was selected from 50 optimizing attempts that differed only by the initial transformation parameters. The distance from each individual solution to the best solution in the normalized parametrical space was compared to a user-defined error threshold to determine whether that solution was successful. The supervised training was then used to train the RQE. The performance of the RQE was evaluated using the test dataset that consisted of registration results that were not used in training.

Results:

With the optimized sampling step size, i.e., 5 mm, in the feature space, the RQE has the sensitivity and the specificity in the ranges of 0.865-0.964 and 0.797-0.990, respectively, when it was used to detect the registration error with the mean voxel displacement (MVD) greater than 1 mm.

Conclusions:

The proposed RQE can potentially be used in a 2D/3D rigid image registration system to improve its robustness by rejecting unsuccessful registration solutions. The RQE is non-patient specific and needs only to be trained once for each treatment site. The implementation the RQE in a 2D/3D registration system results only 10% to 20% increase of the overall computation time.

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The authors have no conflict of interest to disclose.