Intra-procedural Prostate MRI Registration: A Data-efficient Siamese Neural Network (SNN) Design

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The process of registering intra-procedural prostate magnetic resonance images (MRI) with corresponding pre-procedural images improves the accuracy of certain surgeries, such as a prostate biopsy. Registration models use machine learning, often in the form of convolutional neural networks, to efficiently automate the alignment process. However, gathering the necessary data for training a registration model is a problematic step. Many smaller hospitals may not have the resources needed to obtain an annotated training dataset, making the training of standard deep convolutional neural networks (CNN) difficult. To address this issue, I created a siamese neural network that registers prostate MRI images taken during a prostate biopsy to pre-procedural prostate MRI images. It works by randomly augmenting the moving image (intra-procedural), producing different copies, and then choosing the best aligned copy with respect to the reference image (pre-procedural). The result is a training model that can accurately register MRI images using a small training dataset. This model is superior to a baseline obtained with standard image processing techniques as well as a deep CNN model. The best parameters found for building the couple set for the model reveal that a rule based on the Mutual Information allows the model to be unsupervised, since the segmentation is no longer necessary for training. Finally, research on the size of the augmented set showed that producing 18 different candidates is sufficient for good performance. With this model design, model training can be accomplished with far less data and with a meaningfully smaller resource burden.

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