FEATURE BASED ROBUST NON-RIGID IMAGE REGISTRATION IN SPATIAL AND FREQUENCY DOMAINS

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ABSTRACT

Non-rigid image registration plays an important role in medical image analysis, disease diagnosis and statistical parametric mapping. In this proposal, we particularly focus on developing novel features for robust registration and designing an efficient evaluation protocol to measure the robustness and discriminant power of the features.

First, in the spatial domain, a new image feature called the uniform spherical region descriptor (USRD) is proposed. USRD is consisted of two complementary features, namely the uniform spherical structure patterns (USSP) and the uniform gradient spherical patterns (UGSP). The USRD feature is rotation and monotonic gray-level transformation invariant, and is also computationally efficient. Each voxel is represented by its own USRD feature signature. The USRD feature is integrated with the Markov random field labeling framework for image registration.

Second, we propose the symmetric alpha stable ($S\alpha S$) filters to extract image features in the frequency domain. The $S\alpha S$ filters are proposed because the energy spectrums of brain MR images often exhibit non-Gaussian heavy-tail behaviors which

cannot be satisfactorily modeled by the conventional Gabor filters. It is proved that the conventional Gabor filter is a special case of the $S\alpha S$ filters. The maximum response orientation criterion is designed to make the $S\alpha S$ feature rotation invariant. The $S\alpha S$ feature is integrated with the subvolume deformation model in the registration process. Moreover, in this proposal, we propose the Fisher's separation criterion (FSC) protocol which can directly evaluate the discriminant power of various types of features.

Finally, the feature based non-registration approaches based on the proposed USRD and $S\alpha S$ features are evaluated by performing non-rigid registration experiments. The proposed methods are also compared with several state-of-the-art registration approaches. It is demonstrated that the proposed methods consistently achieve the highest registration accuracies among all the compared methods, which is matched with the results obtained from the proposed FSC evaluation protocol.