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Abstract of Doctoral Thesis

Title：Robust Non-Rigid Registration of Medical Images

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Non-rigid medical image registration plays an important role in the analysis of medical images in recent years. Non-rigid image registration has been widely applied to surgical navigation, serial-image analysis, medical image fusion, and so on. Non-rigid registration is a process for maximizing a spatial image correspondence of two images within constrains of a transformation model. The process of registration can be divided into four phases, which are: transformation, interpolation, criterion, and optimization. In this thesis, I proposed three novel approaches for robust and accurate medical image registration. Two of them are focused on the phase of criterion, another is concentrated on the phase of optimization. In addition, an improved non-rigid image application for assessing quality of locoregional therapy of hepatocellular carcinoma is also developed in this thesis. The main contributions of this thesis are summarized below:

1. We proposed a novel optimization method called hybrid particle swarm optimization (HPSO) as a new optimization approach of medical image registration to improve accuracy and efficiency of the registration. We also compared conventional methods such as Genetic Algorithms (GA) and particle swarm optimization (PSO) for each experiment. Experimental results show that the proposed HPSO performs better for registration results than conventional GA and PSO.

2. We proposed a PCA based regional mutual information method (PRMI) as a robust similarity criterion to overcome disadvantage of traditional mutual information method (MI) and efficiency problem of regional mutual information (RMI). Our method successfully contains spatial information into traditional MI, and also prevents the computing cost issue of RMI by combining the concepts of principle component analysis (PCA), MI, and RMI.

3. We proposed a new non-rigid registration method to evaluate treated margin of locoregional therapy of hepatocellular carcinoma from medical images of livers. This method overcomes the weakness of classical intensity based non-rigid registration by containing the anatomical structures as a constrained term. Classical methods usually destroy internal structures to align the shape structure of liver. Experimental results show our method not only aligns the shape structure of livers well, but also reasonably maintains the correspondence of internal structures.

4. We developed a system for assessing quality of locoregional therapy of hepatocellular carcinoma using our proposed anatomical structures constrain based non-rigid registration method, which also includes semi-auto liver and tumor segmentation functions together with 3D image fusion and visualization functions. The system was evaluated by doctors and showed the utility and possibility for real clinical use.