Rigid Registration of Delayed-Enhancement and Cine Cardiac MR Images using 3D Normalized Mutual Information

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Delayed-Enhancement Cardiac MRI (DE-CMRI) is nowadays the imaging technique of choice for visualizing and quantifying the myocardial infarction extent. In clinical routine, segmental evaluation of myocardial gadolinium uptake in infarcted zones is visually performed by blinded observers. However, the hyperenhancement causes a loss of contrast between myocardium and ventricular cavity, making difficult myocardial contours delineation and accurate image interpretation. In this paper, we propose a method to take advantage of the good contrast of Cardiac MR Images (Cine-CMRI) to resolve this difficulty. First, epicardium and endocardium contours of the left ventricular cavity were automatically segmented from breath-hold Cine-CMRI, which present high intensity contrast between muscle and cavity. The obtained contours were then superimposed on DE images, acquired in a second breath-hold, to localize the hyperenhancement information obtained from the DE-CMRI on the Cine-CMRI corresponding images. A global spatiotemporal alignment was performed to correct spatial misalignment resulting from potential patient movement between the two acquisitions and to temporally synchronize DE and Cine images. An automated rigid registration method which uses the maximization of 3D Normalized Mutual Information (NMI) was developed to locally register the cardiac images. This method was applied to 3D data, acquired through short-axis views, from the apex to the base of the heart. Ten patients with proven myocardial infarction were studied and for each patient, three different DE-CMRI exams, obtained at 5, 6 and 7 minutes after contrast agent injection were processed. The registration accuracy evaluation was qualitatively performed by superimposing segmented endocardic and epicardic contours on DE images and quantitatively using the Sum-of-Squared intensity Differences (SSD). The proposed rigid registration method showed high-quality alignment results for more than 92 % of the processed data, with a mean displacement value of 2.66 ± 2.45 mm in the short-axis plane and inter-slice maximal displacement value of 9 mm.