Displacement Field Estimation from CSPAMM Images without Segmentation of the Myocardium

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Abstract. We present a method for the estimation of the displacement field in 2D CSPAMM tagged image time series for both ventricles which does not rely on a previous detailed segmentation of the myocardial contours. The automatic tag extraction is restricted to the myocardium by evaluating the motion characteristics of local maxima and minima. The motion field in the whole myocardium is then obtained by interpolating the displacement field of these points.

Introduction. In cardiac MR imaging, tagging techniques, where a spatial modulation of the magnetization is applied to the myocardium at end-diastole, permit a detailed imaging of the heart wall motion. CSPAMM (Complementary Spatial Modulation of Magnetization) tagging even allows slice following and produces relatively stable tags for a whole heart cycle [1]. However, since evaluation of such images is still quite cumbersome and usually involves a fair amount of user interaction, the method is not widely used yet. Besides, most studies so far have been restricted to the evaluation of the motion of the left ventricle. Here, we present a method which is related to that presented in [2]. However, our approach is applied to both ventricles, needs only the rough definition of a polygonal ROI, and does not make use of a functional fit to the motion field.

Material and Method. We use CSPAMM tagged images, where for the short axis slices a series with vertical and horizontal tags were acquired successively, but within one breath hold. In CSPAMM images, also the grey value maxima between the tag lines are quite pronounced. The tag extraction algorithm therefore first searches for local maxima and minima in the direction perpendicular to the tag direction. In the first frame, connected components are extracted and tags in all frames labeled according to their proximity to tags in the previous frame. To eliminate erroneously detected points (e.g. tags in the blood pool which disappear over time or tags in other tissue which do not move at all), the motion of tag points perpendicular to the tag line direction is evaluated. Tag points which do not exhibit a plausible motion characteristic, as well as tag points whose Laplacian changes too much over time, or is in general too small, are deleted. Only then, lines are fitted to the extracted tags in the first frame, and a previously defined polygonal ROI (see Fig. 1) is used to restrict this fitting

to the myocardial region. This ROI is needed to eliminate points in other tissue outside of the heart which moves similarly to the heart and therefore could not be removed by evaluating the motion. On the basis of the calculated reference tag positions, a new evaluation of the motion of tag points is performed, and points moving inconsistently are again eliminated. Here, it is also taken into account that between two maxima there should be a minimum and vice versa. The resulting backward displacement [2] for the extracted tags (maxima and minima) is then used as a basis for interpolating the displacement for myocardial points not on a tag line. For each tagging direction, the displacement perpendicular to the tag direction is interpolated, and the results for both directions combined to give the 2D displacement field.

Results. Figure 1 shows a typical result from the procedure described above.

Fig. 1. Displacement from end-diastole to end-systole, superimposed on the corresponding end-diastolic (left) and end-systolic (right) image. The shaded polygonal ROI shown is only used in the evaluation of the displacement map. The arrows are derived from the displacement map obtained by interpolating the results for the tag lines for horizontal and vertical directions. The resulting image was created by multiplying the horizontally and vertically tagged images.

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References

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