Adaptive phase-unwrapping improves myocardial motion tracking with displacement-encoded MRI

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Introduction

Displacement-encoded MRI is a phase-shift technique which realizes tissue motion-tracking by directly measuring the displacement vectors of the pixels(1). The phase shifts are proportional to material displacement, and frequently exceed 2π. This necessitates phase-unwrapping. This abstract describes an adaptive phase-unwrapping technique and its performance in myocardial motion tracking in volunteers (n = 12).

Material and Methods

This study was performed on a 1.5 T clinical scanner. A cine-DENSE pulse sequence using sEPI readout(2) was implemented to acquire four cine sets in a breath-hold of 18 seconds. These four sets are displacement-encoded in difference directions in 3D space, and when combined give the 3D Cartesian displacement vectors. Other imaging parameters were matrix size of 128×48, field-of-view of 450×169 mm^2, temporal resolution of 30 ms, and 19 to 25 cine frames were acquired depending on the heart rate. Two long-axis and 3 to 4 short axis slices were acquired, giving a total of 1419 cine frames for all volunteers.

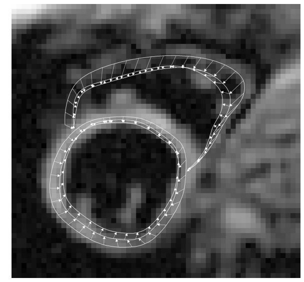
Figure 1

The displacement-encoded phase maps were unwrapped with a conventional quality-guided region-growth technique(3) and an adaptive technique. In conventional quality-guided techniques the unwrapped area progressively expands from a seed point, based on phase continuity in space and/or time. When including new pixels into the unwrapped area, they are prioritized according to a generic quality measure such as local phase gradient or signal level. In the new adaptive technique, pixels are prioritized according to their closeness to the mid-line contours of the left and right ventricles. A phase-gradient threshold is also imposed. The contours are drawn manually for the last cine frame, and propagated to the other frames using the available displacement information (Fig.1).

Results and Conclusion

Figure 2 shows an example in which the conventional technique failed in the RV and the adaptive technique gave the correct results. Figure 3 shows the rate-of-failure statistics for several phase-gradient thresholds. Thresholds lower than 0.8 resulted in unacceptable loss of pixels. The adaptive technique reduced the number of failed cine frames from 94 to 3, or from 6.62% to 0.21%.

The adaptive technique significantly improves the robustness of phase-unwrapping in the processing of displacement-encoded images.

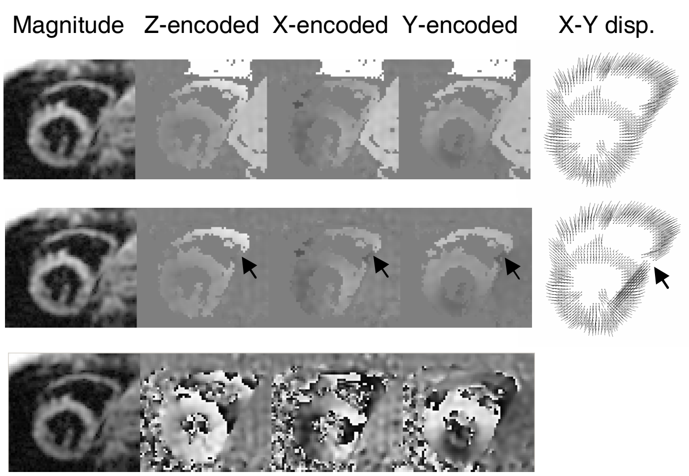

Figure 2 Bottom: raw data; Middle: arrows point to errors from conventional phase-unwrapping; Top: adaptive technique.

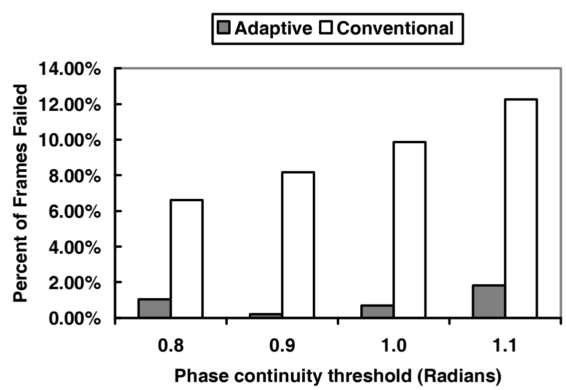

Figure 3 Failure rates of the adaptive technique are lower than conventional quality-guided techniques.

References

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