Ground Truth Evaluation of One Touch Cardiac Imaging

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Introduction

Automation of medical diagnostics will increasingly play a role in medicine, and MRI scanners will follow this trend. Traditionally, a skilled technologist or physician is required to perform a complex procedure such as a cardiac MR examination. A critical component of a cardiac examination is the acquisition of images along standard cardiac axes. These acquisitions, along double oblique planes, typically culminate in short-axis, 4-chamber and 2-chamber images. A concern with these technologist-driven acquisitions is inter-operator and intra-operator variability, which can reduce the quality of an examination, and increase the total examination time. Advances in cardiac feature recognition and automation has led us to replace the standard MRI scan subsystem with an intelligent scan subsystem, capable of fully automatic, algorithm-driven operation. The scan-analysis subsystem, driven by a state machine, is capable of full control of image acquisition, using feedback derived from analysis of acquired data. This technology has been applied to the automation of short-axis, 4-chamber and 2-chamber acquisitions. Other modes allow scan-analysis to assist the operator when operated in a semi-automated or manual fashion as well. The scan-analysis subsystem was used to collect cardiac images from 12 volunteers. These images were scored by a cardiac radiologist for accuracy of prescription along the standard cardiac axes.

Methods

All data were acquired on a 1.5 T GE CV/i scanner with an 8-element cardiac phased array coil, using a custom, integrated scan-analysis subsystem. After obtaining written informed consent, 12 healthy volunteers were scanned, with the entire workflow automated and initiated by a single button push from the user interface. The state machine of the scan-analysis subsystem was programmed to follow this sequence: 1) Acquire 2-plane localizer images, using an ungated free-breathing FIESTA sequence 2) Initiate algorithm to compute the prescription for cardiac views. The algorithm fits the elevation and azimuth of the left ventricle orientation using feature recognition techniques, and determines the short-axis (SA) and long-axis (LA) planes using anatomic priors and heuristics. 3) Acquire gated, breath-held 2D FIESTA short-axis CINE images, in multiple slice locations covering the entire left ventricle. 4) Acquire gated, breath-held 2D FIESTA CINE 4-chamber and 2-chamber images of the heart. All SA and LA images were scored offline by a cardiac radiologist to provide ground truth for accuracy of prescription (on a 4 pt. scale; 1=unacceptable, 2=marginal but diagnostic, 3=good, 4=excellent).

Results

Figure 1 shows sample SA, HLA and VLA images automatically acquired from a healthy volunteer. Overall, the acquisition of free-breathing axial and sagittal FIESTA localizers took approximately 2.3 minutes. Computation of the prescription for the SA and LA slices was completed in 11 seconds on the MR scanner. Acquisition of gated, breath-held FIESTA CINE images, including SA, 4-chamber and 2-chamber, respectively 10, 5, and 5 slices, took approximately 9 minutes. The entire exam was completed in less than 12 minutes from the initial button push. Table 1 shows the results of scoring of accuracy by a cardiac radiologist. For the 12 volunteers, on average, the short-axis images were rated as 3.8 ± 0.4, 4-chamber images as 3.5 ± 1.0, and 2-chamber images as 3.3 ± .9.

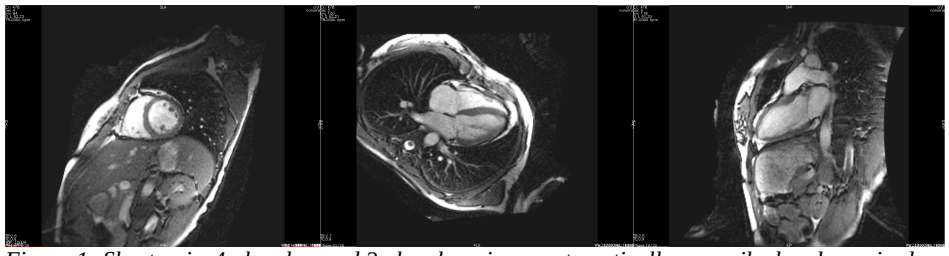

Figure 1: Short-axis, 4-chamber and 2-chamber views, automatically prescribed and acquired.

Discussion and conclusions

We have implemented an accurate and efficient system for cardiac image acquisition, with a custom integrated scan-analysis subsystem that automatically computes and acquires standard cardiac scan planes. With the current implementation, the system begins to acquire short-axis images in less than 2.5 minutes from the start of the exam. A 10-slice breath-held short axis CINE series can be acquired in less than 7 minutes without operator intervention. The scored accuracy of the system shows it is capable of producing images of diagnostic quality. Further improvements to the registration algorithm are expected to yield higher accuracy in the scoring. Moreover, this work in progress can easily be extended to incorporate additional elements of an integrated cardiac exam, such as a 3-chamber view. A future study will compare One Touch Cardiac acquisition results with those from skilled operators, for both speed and accuracy.

	Mean	Standard Deviation
Short-axis	3.8	0.4
4-chamber	3.5	1.0
2-chamber	3.3	0.9

Table 1:Scored accuracy of 12 studies, on a 4 pt. scale: 1-4.

References

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