Association of several motion sensors for free breathing reconstruction method

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INTRODUCTION:

The quality of Magnetic Resonance Imaging (MRI) can be altered by physiological motion, especially respiratory and cardiac motion. The motion artifacts often make the subsequent diagnosis less accurate by hiding crucial information. The precise knowledge of these motions leads to the suppression of motion artifacts through motion compensated image [1]. For this purpose, a model that estimates patient motion from information extracted from external motion sensors would be helpful.

GRICS (Generalized Reconstruction by Inversion of Coupled Systems) [2] is a reconstruction strategy for free breathing acquisitions which uses a motion model based on prior knowledge provided by external sensors, such as respiratory belts. To operate properly and give the best results, as many motion sensors as possible are required, which provide information well-correlated with the observed motion. Consequently, new external MR compatible sensors have been developed measuring the acceleration of a localized region of the body [3]. They give additional information about patient respiratory motion during MR examination and have been used as physiological inputs to the GRICS reconstruction to reduce motion artifacts and improve image quality [4]. Here, the benefit of using a combination of several accelerometer-based sensors and respiratory belt is being investigated.

MATERIALS AND METHODS:

To reduce the size of the device, an external sensor based on acceleration measurements was developed using an SMD technology. A microcontroller was added to easily adjust and adapt the gain and the offset of the signals to the respiration of the volunteers. It also allows converting analog acceleration measurements of into digital signals which are compatible with optical transmission.

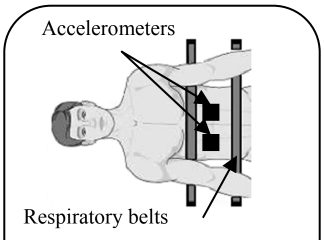

Figure 1: Sensor positioning

The proposed sensor was evaluated through a test protocol accepted by the local ethics committee. Three healthy volunteers underwent a cardiac examination on a 1.5T or on a 3T MR scanner (Signa HDxt, GE Healthcare, Milwaukee, WI). For each subject, the same short axis view was acquired five times with Black Blood Fast Spin Echo (BBFSE) sequences, once in breath-hold, as reference, and four times in free breathing. The parameters were the same for all acquisitions (TE= 35ms, TI=500-600ms, BW=125 kHz, matrix size: 512x512) except the echo train length which was set to 16 for breath-held acquisitions and 8 for free breathing. Two pneumatic belts were used as motion respiratory sensors and connected to a custom Maglife (Schiller Medical, France), a device dedicated to physiological monitoring in MRI. In addition, two accelerometers were placed on the abdomen between the two respiratory belts (Figure 1). Physiological signals from all sensors (including the proposed sensors) were acquired and recorded using SAEC (Signal Analyzer and Event Controller), a real time signal processing unit comprising a dedicated computer and electronics system [5].

RESULTS:

Four reconstructions have been performed on the acquired date: (i) standard reconstruction on the breath-held acquisitions (*Apnea*), and GRICS reconstruction on the free-breathing acquisitions (ii) with the thoracic respiratory belt (*Belt*), (iii) with only one accelerometer (*Acc*), and (iv) with all available motion information (Acc+Belt) as prior knowledge. Then, image quality has been assessed using image entropy, which increases with artifacts and noise.

	Image entropy (less is better)			
		GRICS		
	Apnea	Belt	Acc	Belt +Acc
Subject 1	3.67	3.65	3.74	3.62
Subject 2	3.77	3.81	3.84	3.82
Subject 3	3.42	3.43	3.45	3.42

Table 1: ***Quantitative assessment of image quality***

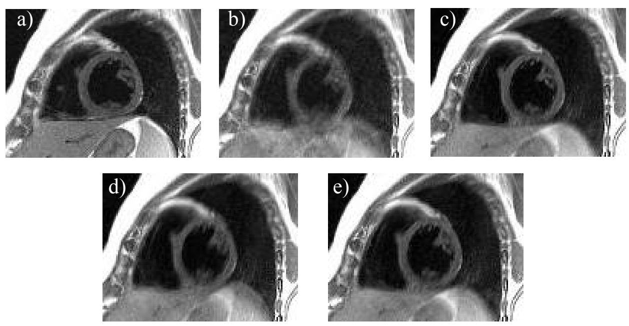

Figure 2: ***Short axis view acquired a) in breath hold, b-e) in free breathing, b) without post-processing, with GRICS reconstruction using c) one respiratory belt, d) one accelerometer and e) all the sensors.***

Image quality was generally better when all available motion information is taken into account for the GRICS reconstruction, instead of information extracted from a single sensor (Table 1). The images resulting from the GRICS reconstruction were less blurred than the images in free breathing and respiratory artifacts were efficiently reduced (Figure 1).

CONCLUSION:

The feasibility of integrating accelerometer-based sensor as physiological inputs for GRICS reconstruction had already been demonstrated [4] but this work stresses that the association of several motion sensors used as physiological inputs increases the image quality. The use of a microcontroller enables to better adjust the amplification parameters to each volunteer. Future work will focus on determining the minimum number of motion signals to be integrated as physiological prior to the GRICS reconstruction.

REFERENCES:

[1] Batchelor *et al.*, MRM. 54: 1273-1280 (2005); [2] Odille *et al.*, MRM. 60: 146-157 (2008); [3] Rousselet *et al.,* ISMRM 1550 (2010); [4] Rousselet *et al.*, ISMRM 5024, (2010); [5] Odille *et al.*, IEEE TBME, 54: 630-640(2007).