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A Novel Gating Technique for Cardiac NMR Imaging using Heartbeat Time Intervals Forecast

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Most of the Nuclear Magnetic Resonance (NMR) Imaging techniques require to send and receive long electromagnetic pulse sequences [1]. To scan regions of the body which remain static is relatively simple, but in the case of Cardiac Imaging, due to the continuous movement of the heart, the pulse sequences have to be divided and its parts sent during different heartbeats in order to capture the heart always at the desired phase of its cycle. Therefore, a single image normally contains the averaged information of 256 heartbeats.

In order to synchronise the data acquisition with a specific phase of the cycle, electrocardiographic (ECG) signals can be employed (these known as Electrically Gated Imaging Techniques [2-4]). After the detection of the onset of the systolic electrical activity of every heartbeat (the QRS wave of the ECG), a constant time offset dictates the moment for collecting the data pulse. In this way, the phase of the cycle to be imaged is selected by assigning a prefixed value to the offset. The longer the offset, the later the phase of the cardiac cycle [1].

These methods assume that the position of the heart within the cycle is uniquely determined by the time elapsed since the occurrence of the QRS wave in the electrocardiogram (independently of other factors such as the length of the whole cardiac cycle which evidently affect the nature of the contraction-relaxation process). However, this is only an approximation [5-7]. Data collected to form an image proceed from somewhat different phases of the cardiac cycle, and the obvious consequence is the degradation of the images, particularly those of the late (diastolic) phases.

In this work we propose a new imaging method where the time offset used for gating is not constant but changes from beat to beat. We use the expected length of every cycle (basically the R-R intervals) to calculate an offset that can point more accurately towards the desired phase of the cardiac cycle. For this purpose we need (1) to evaluate the existent formulas that relate R-R interval to the diastolic fraction [5-8], and then, during the time of imaging, (2) to predict the length of the next R-R interval using a priori knowledge of the dynamics of the heart and information of the data patterns obtained during the first minutes of the study.

We must realize that although there exist several time series forecasting techniques [9-11], this problem requires the development of a combined method in order to achieve a very fast response using relatively short data series.

Preliminary results suggest that using a simple computer this forecast can be made with the brevity necessary in order to allow the computed offset time to be sent to the scanner as a real time feedback.

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