Dual Echo Tip Tracking with Orthogonal Dephaser Gradients

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Introduction

In interventional MRI instruments are localized and tracked e.g. using active tracking techniques with small rf coils that are attached to the instruments. These marker coils can be rapidly localized using a fast projection technique, since their limited rf sensitivity profile creates a highly localized projection signal. Unfortunately, both marker coil and connecting cable act as receive antennas, and the projection data thus show a superposition of both signals. If the cable orientation is perpendicular to the projection direction, even small individual signal contributions of the cable can add up to an additional, highly localized signal in the projection which mimics a second marker coil. In this work we propose a projection technique for marker coil localization which utilizes two projections measured in a double-echo technique. The two echoes differ in the preparation of the projection signal which is optimized to suppress background from lengthy cable structures.

Materials and Methods

Suppression of background signal in projection imaging can be achieved with the help of dephasing gradients (z-dephaser [1]), which introduce a phase dispersion for signals from larger structures that add up distructively during projection. Amplitude G and duration t of the dephaser gradient determine a characteristic object length $\Delta z = \gamma G t / (2\pi)$ in projection direction - homogeneous objects of this and larger sizes are optimally suppressed. Unfortunately, dephasing can be accomplished in a single direction only.

In the dual-echo technique two projection data sets are acquired with orthogonal directions of the dephasing gradients. To save time, the projection data are acquired as a double gradient echo sequence with rewinding of all image encoding and dephasing gradients (cf. Fig. 1). After Fourier transformation, a point-wise multiplication of the projection data is performed to enhance the localized marker coil signal, while suppressing the cable signal (Fig. 2).

The dual-echo localization method was implemented on a commercial 1.5 T whole body MR system (Siemens Magnetom Symphony, Erlangen, Germany). For tracking, a small catheter coil was mounted on the tip of a 1.2m-long intravascular 5F catheter. The catheter coil was connected to the MR receiver via a home-built preamplifier. The tracking was tested in phantom experiments and an animal experiment in the arterial system of a pig.

The following parameters were used for the dual-echo tracking part of the real-time pulse sequence: $\alpha = 10°$, FOV: 500 mm, 256 data points. The tracking part was introduced in an interactive trueFISP real-time pulse sequence with automatic slice positioning. Before and after the tracking block the trueFISP steady state magnetization was stored and re-called using $\alpha/2$ rf pulses. The total acquisition time of the tracking block amounted to 27 ms. The dephasing length Δz could be controlled interactively via a dedicated user interface.

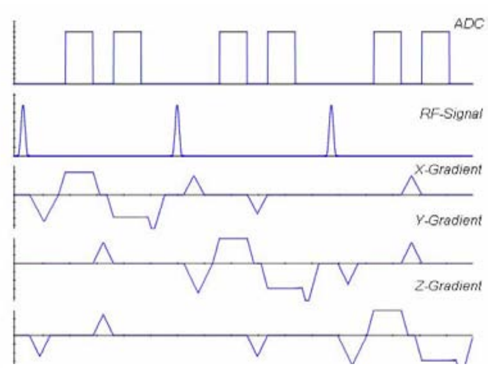

Fig 1: Dual-echo tracking part of the real-time pulse sequence. Projection data are acquired in the three spatial directions x, y, and z with two gradient echoes each. The traingular dephaser gradients are refocused after the first echo and played out in the other projection direction.

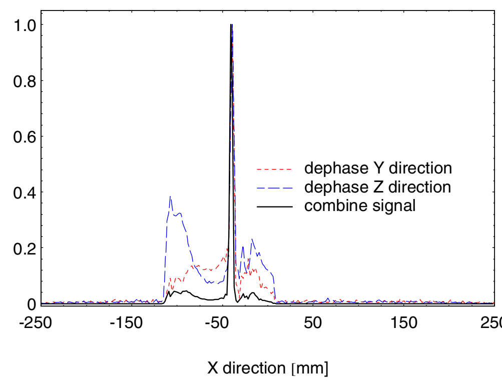

Fig 2: Normalised projection signal in a phantom with the cable parallel to the y-direction. Individual projection signals are shown in blue and red, and the product signal is plotted in black.

Fig. 3: Sagittal image of an interactive tracking sequence with trueFISP contrast. The white cross marks the tip of the catheter in the heart of the animal.

Results and Discussion

Compared to a single-echo projection technique the dual-echo approach lengthens the tracking block by 66%. The projection data in Fig. 2 show that the cable signal can be effectively suppressed even in situations, when a longer part of the cable is oriented parallel to the projection direction. In this example the signal-to-background-ratio (SBR) was improved by a factor of 10.

An optimal cable suppression (SBR = 200) was achieved when the dephasing length was comparable to the size of the marker coil (4-5 mm). The very sensitive steady state of the real-time trueFISP sequence was not disturbed significantly by the dual-echo tracking block. The technique provided stable catheter tracking in the animal experiment even in the vicinity of moving tissue such as the heart (cf. Fig. 3).

The proposed dual-echo tracking technique can easily be combined with other tracking techniques such as Hadamard encoding [2] and provides reliable position detection in the presence of unwanted background signals with only minimal additional scan time.

References

[1] Oppelt A, *et al. Mag. Res. Med.* **40**: 356-362(1989)

[2] Dumoulin CL, *et al. Mag. Res. Med.* **29**: 411-415(1993)