A Novel Catheter Tracking Method Using Reversed Polarization

H. Çelik[1], A. Ulutürk[2], Y. Eryaman[1], T. Tali[2], E. Atalar[1,3]

[1]Electrical and Electronics Engineering, Bilkent University, Ankara, Turkey, [2]Medicine, Gazi University, Ankara, Turkey, [3]BME, The Johns Hopkins University, Baltimore, MD, United States

INTRODUCTION:

Accurate visualization of guidewires and catheters during a vascular intervention(1,2) procedure is critically important. With this aim, many tracking techniques have been developed. Automatic identification of the position of the catheter in passive tracking techniques(3) is difficult, but in active catheter tracking techniques(1,2,4), it is possible to obtain a catheter and background image simultaneously. However, the catheters need to be electrically connected to the scanner and this causes both RF safety problems and creates difficulties in device handling. Recently, Quick et.al.proposed wireless active catheter visualization(4) by using an inductively coupled RF (ICRF) coil; this can be classified as an intermediate method between active and passive techniques. The design is a good compromise that reduces the heating problems and decreases the handling issues. However, as in the passive tracking techniques, it is impossible to see both catheter and background images simultaneously.

In our study, we propose a novel technique for catheter tracking using an inductively coupled RF coil that enables simultaneous acquisition of background and catheter images thus allowing real-time, color-coded display of the RF coil on the background image. Reverse circular polarization is used to obtain an image of ICRF. We also demonstrated the feasibility of the proposed method with an in-vivo animal experiment.

THEORY:

Polarization is a description of how the direction of the magnetic field vector changes with time at a fixed point in space. Assuming phasor representation of –*z* directed magnetic field vector is given by: $\overline{H} = \hat{a}_x H_o + \hat{a}_y H_o e^{i\phi}$. According to this equation, the *x* and *y* components of the magnetic field vector have the same magnitude and there is ϕ radians phase difference between them. If this phase difference is $2n\pi$, where $n = 0,1,2,...$, the wave is called a linear polarized field. On the other hand, if the phase is $\phi = -(0.5 + 2n)\pi$, then the field is circularly polarized in a forward direction. Furthermore, a magnetic field is said to be reverse polarized if $\phi = (0.5 + 2n)\pi$.

Standard quadrature birdcage (5) coils are designed to receive only the forward polarized field, because during an MRI scan, hydrogen atoms in the body are forward polarized. A coil, which creates a reverse polarized field can receive only noise. If a standard birdcage coil is connected in reverse, no signal from the body can be obtained. On the other hand, the inductively coupled RF loop coil picks up the MRI signal from the body and radiates it as a linearly polarized field, which is a combination of both forward and reverse polarized fields. Therefore, a reverse connected birdcage coil will generate a signal so that the corresponding image will have a background-free image of the ICRF coil.

METHOD:

In our work we used a 1.5 T GE Signa Excite imaging system and a home-made receive-only birdcage coil with two feeds. The feeds are placed on the coil at 90º to each other. Each of these feeds is connected to the scanner directly using a dual phased array adaptor without a quadrature power splitter. This enabled us to reconstruct both forward and reverse polarization images with single acquisition. While the forward polarization images become the desired background image, the reverse polarization creates a background-free image of the inductively coupled coil. Raw data files were obtained from two channels. A MATLAB (version 7.0;Mathworks Inc.) code was written to reconstruct color coded images. For the experiment, a small inductively coupled RF loop was constructed on a naso-gastric tube inserted into esophagus of a rabbit.

RESULTS:

In order to show the effectiveness of the new method, we acquired inductively coupled images using a SSFP sequence with 40 degrees flip angle. As Figure 1a shows, it is difficult to see where the catheter is if a standard image reconstruction technique is used. By using a reverse polarization image, we were able to eliminate background from the catheter image (See Figure 1b) and overlay the color-coded catheter image on the background (See Figure 1c.)

CONCLUSION:

We have demonstrated a novel method of simultaneous acquisition of both an inductively coupled coil and background body images on a color-coded image. This method can be used very effectively for accurate catheter tracking.

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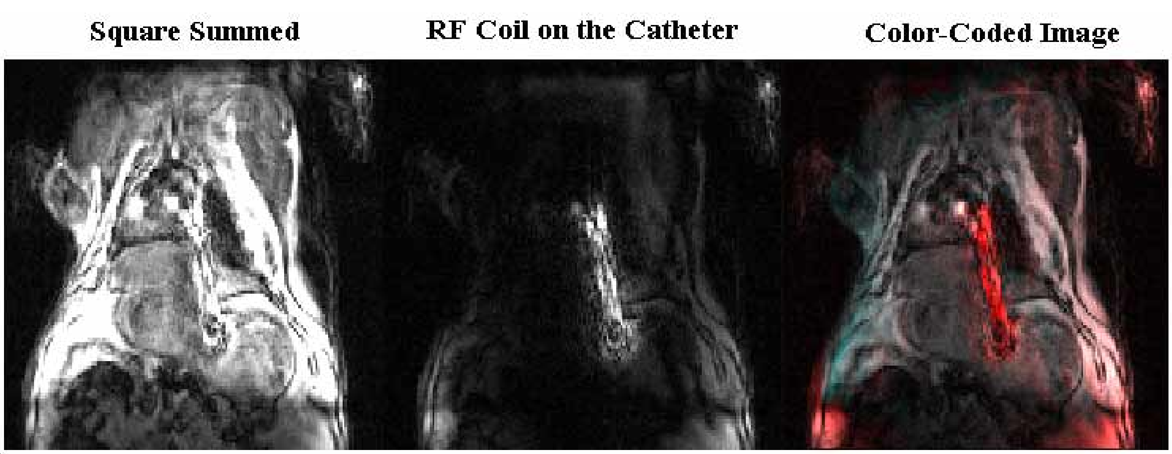

Figure 1a Figure 1b Figure 1c

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