Surface MRI Using a Rastered Backprojection

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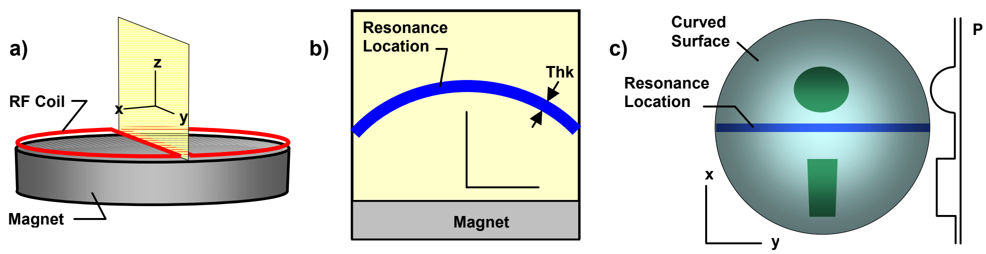
Surface MRI of skin using a stand-alone system has great potential in dermatology. We are exploring various techniques for performing tomographic imaging to depths of 1 cm using a stand-alone SMRI system. This abstract describes one such technique, which we call a rastered backprojection, and preliminary results on the implementation of the technique.

The general approach we are taking is imaging in an inhomogeneous magnetic field.[1] Although several localization techniques could be used to map the magnetic resonance signal,[2,3] we focus on one here. Consider a rare-earth permanent magnet source (Fig. 1a) for B_o along the Z axis and a butterfly coil adjacent to the magnet surface producing a B_1 field perpendicular to B_o. The resulting imaging-sensitive region for this configuration is defined by a plane parallel to the Z axis and bisects the center of the RF coil. For an RF coil resonant at ν_o, B_o equals ν_o / γ in a curved surface above the magnet. Due to the requirement that $B_1 \perp B_o$, spins are only excited in an arc above the magnet and RF coil, and in the above mentioned curved surface. The thickness (Thk) of the arc is determined by the bandwidth of the excitation RF pulses and the gradient in B_o. The X location of the RF coil can be varied to change the location of the arc on the curved surface within this plane. The area under NMR signal as a function of the X location of the RF coil represents the projection of the NMR signal from within the resonance location onto the projection axis, P, or X-axis in this case. (See Fig. 1c) Varying the orientation of the RF coil in the XY-plane will produce projections at angles ϕ about Z. This imaging is similar to projection imaging except the imaged surface is curved. Reconstruction of the image involves warping of the result of the inverse Radon transform onto the curved surface. Imaging of the volume above the magnet can be achieved by acquiring signal from a series of concentric curved planes, achieved by changing ν_o or by varying the distance between the RF coil and magnet.

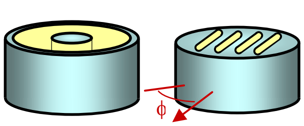
Fig. 1. Schematic representations of the a) proposed apparatus, b) resonance location in the ZY plane, and c) projection of the signal in the resonance location as the RF coil is moved along X

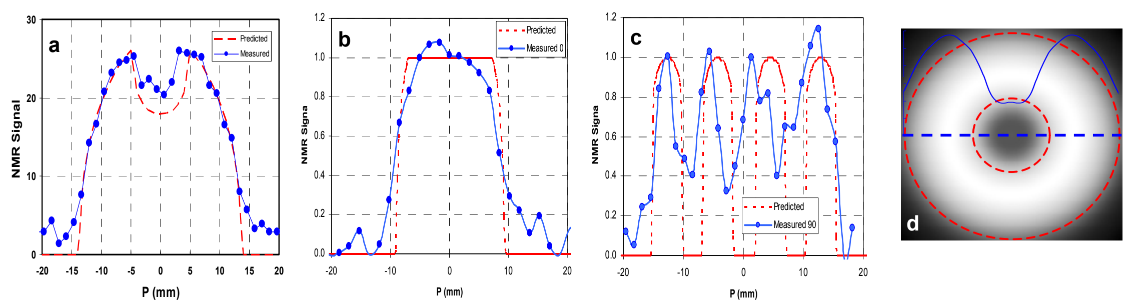


Our prototype apparatus of the Fig. 1 design consisted a stack of four 7.62 cm diameter by 1.27 cm thick disc NdFeB magnets, and a 7 cm diameter inductively coupled butterfly coil resonant at ν_o = 15 MHz. Both magnet and coil are described in detail elsewhere.[4] A Bruker DRX-300 NMR spectrometer was used for the RF source, detection, and processing. A Hann spin-echo sequence is used to record the NMR signal along the resonance arc. Translation of the RF coil in X and rotation of the sample about Z to achieve the projections was performed mechanically.

Four petroleum jelly filled Teflon phantoms were imaged: 1) a cylinder, 2) two cylinders, 3) a cylinder with a cylindrical zero signal plug, and 4) four adjacent torus shaped cylinders. Projections through the phantoms were taken at various angels ϕ and displayed in Fig. 2. A tomographic image of phantom #3 was constructed from its projection and compared to its predicted image (Fig. 2c).

Fig. 2. Phantom geometries #3 and #4; corresponding projections (a) and (b); and c) tomographic backprojection image through phantom #3.





The projections and images present the feasibility of surface MRI using this rastered projection technique. Resolution is currently limited by the number of acquisitions in the P direction and the signal-to-noise ratio. Further work is needed to optimize the signal-to-noise ratio, resolution and acquisition speed.

References
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