2D Single Echo Acquisition with an increased matrix size MAMBA array

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INTRODUCTION

Recently there has been interest in encoding planar images within a single echo for ultra-rapid imaging. The single echo acquisition (SEA) technique (1) uses a 64 element RF strip array and receiver chain linked to conventional 1D pulsed frequency encoding to generate high frame rate images of a thin plane. The MAMBA 2D technique (2) alternatively uses only a single RF channel and volume RF coil with micro B_0 coils arranged in a 2D array to produce unique frequency encoding of a thin plane without any pulsed gradients. Images are formed after a single Fourier Transform and subsequent 2D image intensity allocation. The difficulty with the MAMBA 2D method is that the number of turns required for the individual B_0 coils rises as n^2 with the number of in-plane pixels n. Alternatively, the coils can be single turns fed with different currents but this becomes very complex to construct without e.g. a complex silicon chip design. Previously we designed a 5x5 matrix 2D coil using a genetic algorithm (2) but which resulted in a complicated coil layout. A new array concept is introduced which only requires 2n B_0 loops for single echo 2D planar encoding of n^2 pixels.

METHODS

Two sets of n loops with 1-n turns each are placed in proximity and orthogonal to each other. One set of loops has current I while the other set of loops has n x I. A MATLAB simulation was developed using the Bio-Savart law to model such a 2D array. A 20 x 20 matrix MAMBA 2D surface loop array was wound with 10mm spacing and 200mm length with turns varying from 1-20 along each axis.

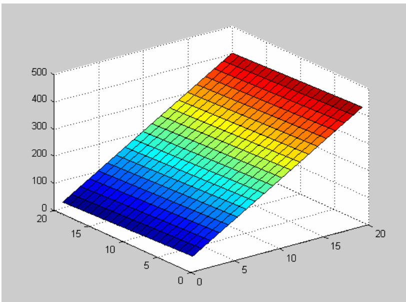
Fig 1


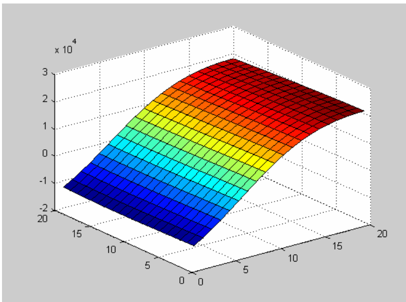
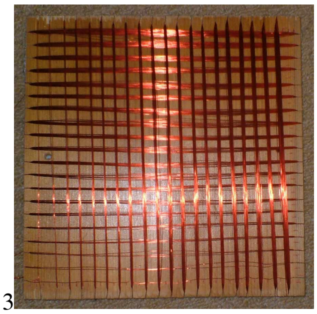
Fig 2


Fig 3


The Figure 1 shows an ideal 20x20 MAMBA 2D field with monotonically increasing B_0. Figure 2 shows the Biot-Savart law simulation of the magnitude of the B_0 field above each 'pixel' of the array in a plane 5mm above the loops and it can be seen that these vary in the required way although there is non-linearity near the edges of the array. Figure 3 shows the prototype 20x20 array constructed on a 220x220mm square former with 10mm spacing. The field above the array was checked using a small search coil and signal generator. Spectroscopic data was also acquired at 0.2T from a dedicated neonatal MR system (InnerVision MRI, London, UK) using a spin echo sequence with TR=500ms, TE=10ms, matrix =64x256, NEX=3 from a uniform 90mm diameter, 200mm length cylindrical phantom located parallel to one set of loops and offset from the centre by 6 loops. All gradients were switched off and currents of 25mA and 500mA were applied parallel and perpendicular to the 200mm dimension respectively.

RESULTS

Figure 4 shows the field measured from one set of loops of the array using a search coil showing the expected behaviour. The orthogonal set of loops behaved in a similar way and so could be used to generate a 2D varying field through superposition with the appropriate current applied. The spectroscopic acquisition shown in fig 5 confirmed that the stepped loops produced spatial localization of the signal through the spread in signal in the frequency direction. Figure 6 is a reallocation of the signal intensity into a 2D 'image' using a priori knowledge of the frequency versus position in the array.

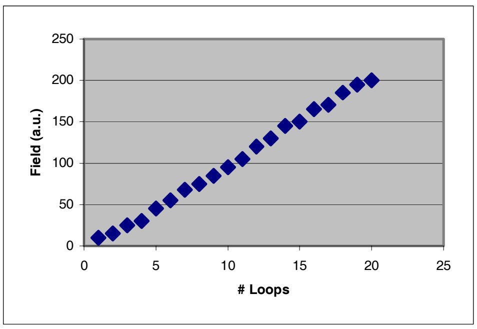
Fig 4


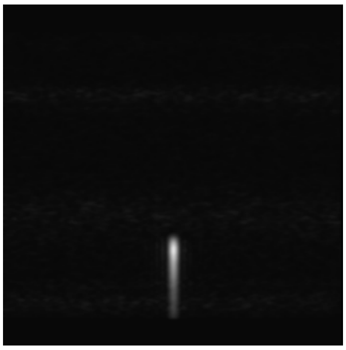
Fig 5


Fig 6


DISCUSSION

The dual axis stepped loop design generates a two dimensional varying B_0 field and provides a method to extend MAMBA 2D to higher matrix resolution, dependent on the frequency resolution of data acquisition, while minimizing the number of loops. Although the resolution is very poor, the acquired 'image' locates the phantom in the appropriate position on the array and suggests that signal localization can be achieved in 2D without use of pulsed field gradients. The field linearity could be improved further using additional correction loops at the edges of the array although having unique fields is more important than linearity. With further development, single echo acquisition in 2D could prove useful for imaging thin planar objects when acoustic noise or eddy current effects cannot be tolerated and where very high temporal resolution is required.

REFERENCES 1. Wright et al., MRM, 2005, 54; 386-392. 2. Lee et al., MRI, 2002, 20; 119-125.