The Recent Development of a Low-field Permanent-magnet-based MRI Head Imager

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Introduction: A portable magnetic resonance imaging (MRI) imager may help this medical imaging modality to reach out areas that are remote or/and hard to access, and situations that the environment is dynamic, for example, in an ambulance. This talk reports the recent progress of the development of a low-field permanent-magnet-based MRI head imager in Singapore University of Technology and Design (SUTD). It includes the latest design of an inward-outward (IO) ring-pair magnet array, which supplies a strong longitudinal magnetic field with a monotonical pattern, and an investigation of the encoding field in general that is supplied by a permanent magnet array, in terms of its effects on image quality.

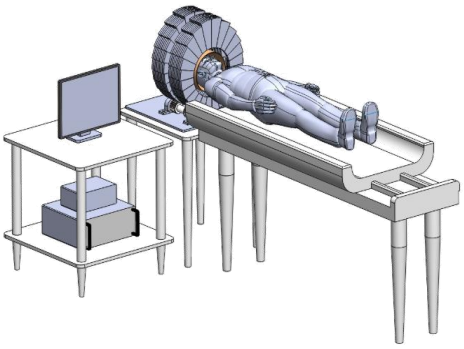

Fig. 1: An illustration of a low-field permanent-magnet-based MRI head imager.

Method, Results & Discussions: IO ring-pair arrays (Fig. 2 (b) and (c)) were proposed that supply a relatively strong magnet field along a longitudinal direction for signal encoding for MRI. They are based on an IO ring pair which has one ring that has the magnetization pointing radially inward and the other pointing radially outward [1]. The IO ring-pair aggregate and the irregular array supply a concentric (average field (B_{0avg}) of 170mT, homogeneity (ΔB_0) of 24,786ppm) and a nearly monotonic field patter (B_{0avg} = 133mT, ΔB_0 = 151,840ppm), respectively. They both do not have linear gradients. Compared to a short Halbach sparse array (Fig. 2 (a), B_{0avg} = 68mT, ΔB_0 = 42,000ppm) [2-3], they both have much stronger magnetic field. The uniqueness of the field patterns they generate are identified. They are further compared in terms of the image quality numerically when they are rotated and used to encode signals in an MRI system. Local k-space and point spread function are used to analyze the relation between the field patterns and the image quality.

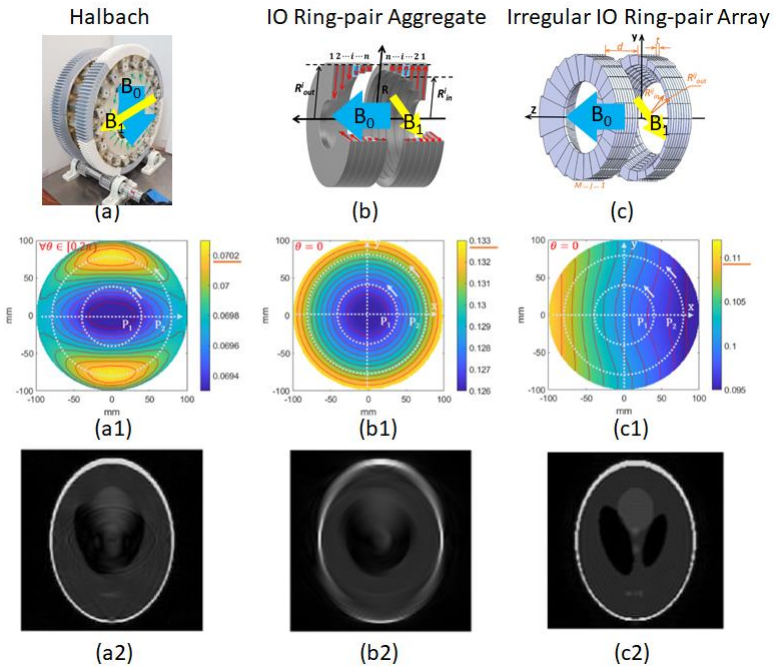

Fig. 2 Different magnet arrays (row one), their magnetic fields (row two, and the numerical reconstructed images (row three) when they rotate.

Conclusion: The IO ring-pair magnet arrays can be good candidates for low-field permanent-magnet-based MRI systems. The method for analyzing the relation between a permanent-magnet-generated magnetic field with a non-linear gradient, and the quality of the corresponding reconstructed image can be used to guide the design of permanent magnet arrays to improve quality of MRI of this type.

References: [1] G. Miyajima, Japanese Patent JPS60210804A (1985) [2] C. Z. Cooley et al., Magn. Reson. Med., (2015) [3] Z. H. Ren, et al, IEEE MTT-S Int. Microw. Symp. Dig., (2015)