Technology Development Opportunity

UNIVERSITY OF SASKATCHEWAN

PORTABLE AND AFFORDABLE MRI

A wrist-sized Magnetic Resonance Imager (MRI) has been designed to enable access to medical images without the use of ionizing radiation. This portable MRI uses new approaches to MRI magnet design and radio transmitter design to encode spatial information into the nuclear magnetic resonance (NMR) signal, reducing the mass of the MRI by an order of magnitude over existing approaches. The MRI design mass is less than 5kg, and it is intended for imaging the wrist for clinical assessment of bone and muscle health for indications such as osteoporosis. This new device, when scaled up, will help provide MRI access to remote regions, in primary health care settings, in the emergency room and in the operating room for use with minimally invasive and robotic surgery. The device is also optimally suited for use in space, where there is a need to monitor bone and muscle conditions while considering constraints on the mass and size of imaging tools.

Available for Collaboration and Development

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Publications:

- Sarty GE et al., 65th International Astronautical Congress, 2014: IAC-12-A1.3.13
- G.E. Sarty, Magnetic Resonance Imaging, 33, 304-311, 2015
- G.E. Sarty, et al., 63rd International Astronautical Congress, Naples: 2012: IAC-12-A1.3.13
- G.E. Sarty, et al. AIAA Space 2012:
- Sarty GE, and Obenaus A., Canadian Aeronautics Space Journal, 2012: 58, 60-68.

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Need for a portable MRI: A portable MRI would be especially useful in remote locations, for deployment in war and disaster zones and especially space. The availability of an MRI in a northern mining or military base community's health clinic could reduce cost and improve the quality of health care. The device could also be economically installed in primary health care locations, like x-ray clinics and nursing homes reducing demand for high-field MRIs in hospitals. Portable MRI would also be useful in the emergency room (ER) and, eventually, in air and ground ambulances. In the ER. a portable MRI would complement portable X-ray tomographs currently deployed; MRIs are safer for children than X-ray tomographs which deliver high doses of ionizing radiation that is potentially carcinogenic. Finally portable MRIs will find application in the operating room where they will be useful for minimally invasive and robotic surgery. In this way operating procedures already developed using open MRI systems, including robotic neurosurgery performed with the use of a massive moving MRI will be extended. The benefits of developing the technology are summarized in Fig. 1.

Fig. 1: Benefits of portable MRI technology

Portable MRI design: Clinical MRIs use cryogenic superconducting magnets that weigh many tonnes and use imaging gradients that use tens to hundreds of amps of electric current. This is a serious constraint for a portable MRI and may be overcome through use of lower field magnets (B_0 = 0.15T as opposed to $B_0 \geq$ 1.5T) which have a wide range of diagnostic utility (Merl et al., 1999). We use lower field permanent magnets with Halbach geometry to reduce the external stray field (Halbach, 1980). A recent Canadian breakthrough in MRI technology also allows for the elimination of the power consuming magnetic gradient field hardware. Instead of using magnetic field gradients to encode spatial information into the nuclear magnetic resonance (NMR) signal, transmit radio frequency (RF) coils may be used if the phase of the transmitted RF magnetic field, B_1, varies spatially. This RF encoding method (Sharp et al. 2013), accompanied by published wrist images (Deng et al., 2013) puts our technology at readiness level (TRL) 4 according to NASA and US DoD guidelines. Combining lightweight Halbach magnet geometries with RF image encoding technology enables the design of an MRI that is portable, and potentially less expensive to build and operate.

A. B. C.

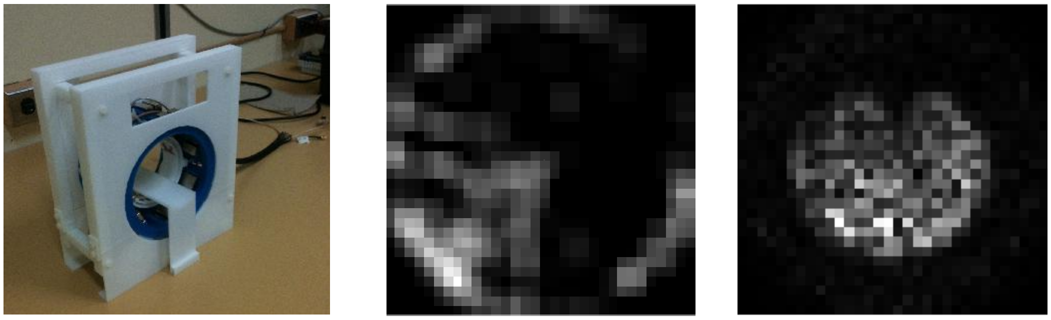

Fig. 2: A. Prototype" gpmri01" (for Generalized Projection MRI) uses built-in magnetic gradients and RF spatial magnitude variation for image encoding. The magnet and receiver RF coils turn with a stepper motor. Images B. and C. are before-and-after and show the improvement in the image reconstruction of a water bottle cross-section following optimization of magnetic field models in the image reconstruction algorithms.

A. B.

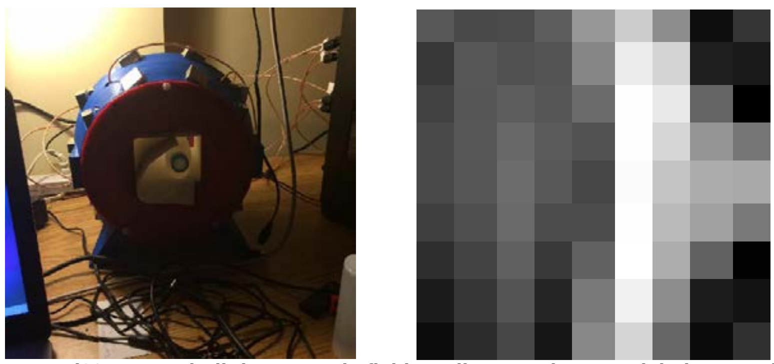

Fig. 3: A. Prototype "gpmri02" - uses built-in magnetic field gradients and RF spatial phase variation for image encoding. It has no moving parts. The prototype evolved from a version of the design proposed to the Canadian Space Agency for the ISS and was built in the summer and fall of 2015. B. One of the very first images is a 9x9 pixel image, made for hardware verification, longitudinally through the bottle seen in A. The quality of the image formation is improving with active iterative development with improvements similar to that shown in Fig. 2 expected.

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