Walk-Through MRI: Affordable Technology for Well-Patient Cancer Screening

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Background

Mammography is the ‘gold standard’ for early detection of breast cancer, but it misses half!

- 40,000 US women die of breast cancer each year.
- 1.2% of all women will be diagnosed with breast cancer during their lifetime.
- 98.6% of patients survive >5 years if cancer is detected while it is localized.

\[ \text{Key to long-term survival is early detection.} \]

Mammography has several limitations:

- It has a high rate of false positives – it flags lesions that are not invasive.
- It has a high interval cancer rate: women have a negative mammogram, then palpate a tumor within a year!
- It has a high rate of false negatives – it misses tumors that are invasive.

Dynamic MRI is dramatically more effective in early detection, but it is not affordable!

Dynamic MRI today is done only in whole-body MR imagers. It takes one hour to image one patient. Time is money - Breast MR costs ~$1,000.

It is not affordable for well-patient screening.

We undertook to develop a way to project a domain of 1.5 T field with homogeneous \(<0.1\) ppm outside the magnet/cryostat - Open MR.

Open MR has been in manufacture and use for many years, but never with 1.5 T and never with 0.1 ppm homogeneity.

Cable-in-Conduit: enabling coil technology for IR magnets

Motorized bend tools form windings in precise contours. Form racetrack or flared-end windings. Demonstrated that finished windings have same \(l\), as wires.

Splice/lead joint is easily mounted/demounted, manifold SCs flow

Magnetic fields you can walk into for imaging

A whole-body MRI scanner produces a "homogeneous field in its center by extending the body long enough to make it homogeneous, then the patient is inhomogeneous."

The field distribution in the final region strongly diverges, so you cannot do MRI there.

Now make a structural coil, in which the current in each element is an independent variable. You can adjust the currents however, but you can’t get homogeneous field in the end region.

We have developed an optimization algorithm in which the region of currents is meshed, and an orthonormal basis of multipoles is generated on the desired homogeneous region.

We have developed a method of killing vectors in which each succeeding multipole is removed by re-optimization, including the nonlinear response of the steel flux return elements.

We have a toroidal region with \(<0.1\) ppm homogeneity that is suitable for dynamic breast imaging in a walkthrough geometry.

The projected cost per image is comparable to that of mammography. This work was supported in part by the Cancer Prevention Research Institute of Texas.