Selin Kandemir, Grayson Rohmiller, Pranav Narayanan

Dr. Charlotte Sappo

Introduction to Engineering: BME

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Resolution Phantom (Kevin)

Introduction & Motivations

Phantoms offer a way for developers to test various metrics of MRI systems, including resolution, image uniformity, and sound-to-noise ratio (SNR). They come in many different forms and can be made of a wide variety of materials. Phantoms ensure that images taken on MRI machines are reproducible and reliable, and they can be helpful in comparing MRI machines from different manufacturers, with different softwares, and with different magnetic field strengths. There are also different types of phantoms, such as resolution phantoms, which test the resolution of MRI systems, and anatomical phantoms, which are designed to mimic human anatomy.

The goal of designing the resolution phantom was to create a way to measure the resolution of the MRI machine. The other groups' dimensions and requirements were also taken into account to ensure that the phantom would fit in the machine to be able to be measured. The materials used were decided upon after researching and looking at what options were available.

Methods

A preliminary sketch of the resolution phantom was created based on the article (Figure 2), where cylindrical vials were filled with liquid (Keenan 2017). Based on Keenan's article, cylindrical wells were incorporated into the design of the resolution phantom (Figure 1). To adequately test the resolution, holes of different sizes and different spacing were designed. With materials on hand and for ease of design, the cylindrical wells were incorporated into a cubical shape. The sketched design was then created in Autodesk Fusion 360 (Figure 2), with one edit to add an extra well, and 3D printed using resin. After printing, the phantom was soaked in an alcohol bath and excess material was removed from inside the wells and outside of the cube. The wells were filled with mineral oil for optimal detection in the MRI, rather than the initially intended water. A plastic lid was successfully attached using hot glue so that the phantom would be water-tight and prevent leakage into the machine.

Results

The phantom was successfully printed and assembled (Figure 4). The final dimensions of the resolution phantom were 2.5x2.5x2.5 inches, with the three wells' diameters being 0.5, 0.3, and 0.2 inches, respectively. The holes were extruded 2 inches into the cube. This report was written before the phantom was able to be scanned in the MRI, therefore, results of the success of the phantom are not yet available. Information and data on performance in the MRI are to come.

Discussion

If the resolution phantom were to be redesigned or reconstructed, more variation in hole size and shape would be implemented to obtain a more detailed summary of the resolution capabilities of the MRI machine. The physical model would have been sanded and and would have spent more time in the alcohol bath, to ensure a cleaner visual and for the cylindrical wells to be more sharply defined. Additionally, there would have been more variation in the hole sizes and the distance between them, in order to further test the clarity/resolution of the MRI. It may have been interesting to test other aspects of resolution, with different liquids and shapes.

Figures

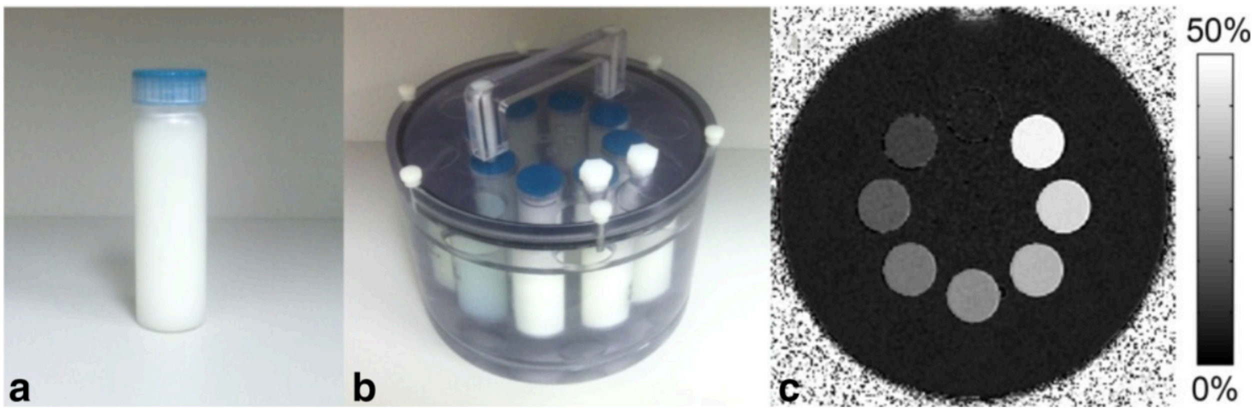

Figure 1: Image demonstrating cylindrical well idea, from reference paper

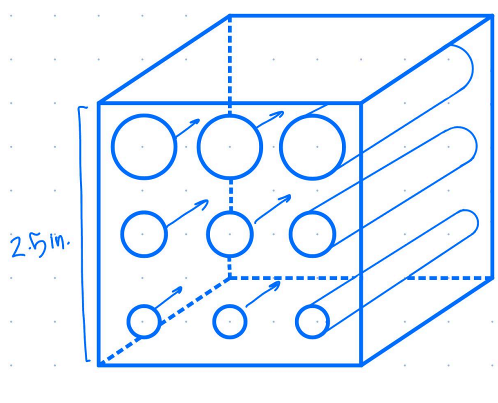

Figure 2: Phantom design sketch

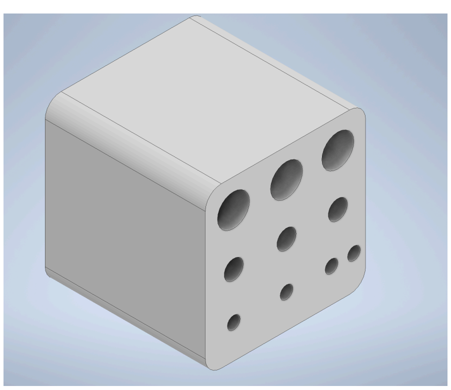

Figure 3: Phantom 3D Design

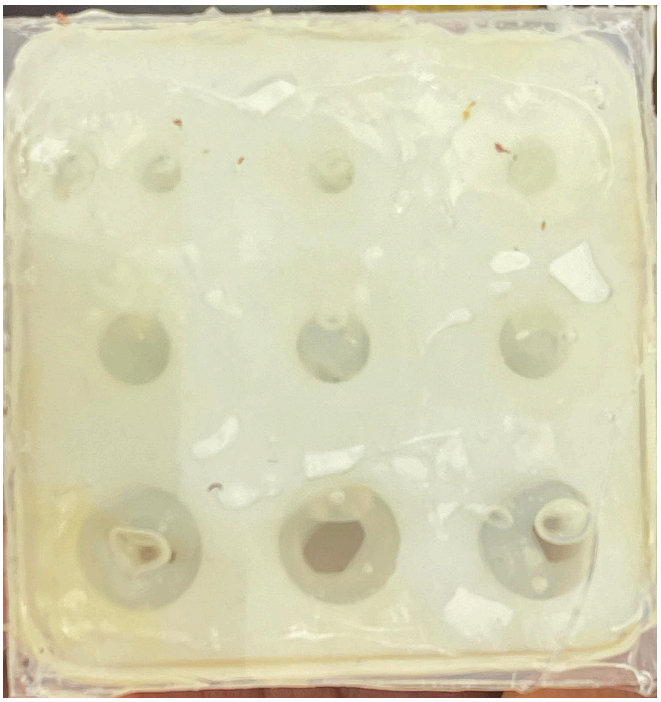

Figure 3: Completed resolution phantom (top-down)

References

Keenan, K. E., Ainslie, M., Barker, A. J., Boss, M. A., Cecil, K. M., Charles, C., Chenevert, T. L., Clarke, L., Evelhoch, J. L., Finn, P., Gembris, D., Gunter, J. L., Hill, D. L. G., Jack, C. R., Jackson, E. F., Liu, G., Russek, S. E., Sharma, S. D., Steckner, M., … Zheng, J. (2017). Quantitative magnetic resonance imaging phantoms: A review and the need for a system Phantom. *Magnetic Resonance in Medicine*, *79*(1), 48–61. https://doi.org/10.1002/mrm.26982