3D Printing Openable Imaging Phantom Design

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1. Introduction

The purpose of this study is to design an openable phantom that can replace the internal measurement bar used for contrast comparison in order to increase the efficiency of manufacturing imaging phantom used in the medical industry and to improve convenience using 3D printer [1,2]. Phantom concept design, 3D printing, and Image reconstruction were defined as the scope of the thesis. Also, we study metal artifact reduction with openable phantom.

2. Methods and Results

This study introduces the production process of 3D printing phantom and conduct the analysis through the actual imaging of the phantom.

2.1 Conceptual Design

Conventional phantom use fixed material. Therefore, to measure a material with a different value, we must repurchase the new phantom. To solve the cost problem and to measure by various methods, the phantom is designed to be opened and closed to facilitate the replacement of the internal material.

We designed this phantom using SolidWorks software. In order to facilitate internal replacement, the phantom is fixed to the head and body through grooves, and the phantom's head and body assembled via the pins. The shape of the phantom is shown in figure 1.
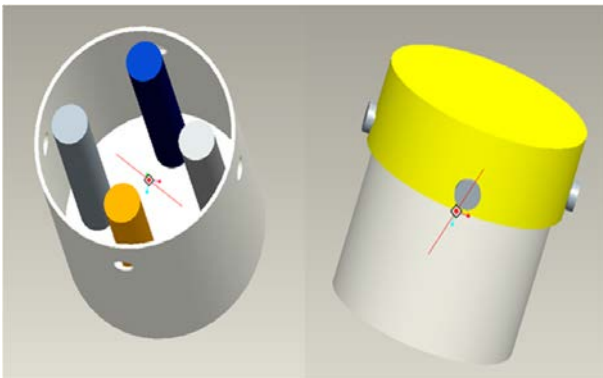

Fig. 1. Conceptual Desigon of Phantom

2.2 3D Printing

After converting the CAD file to .stl extension, We proceeded to 3D printing and adjusted the tolerances. Then, the phantom was checked through direct assembly and disassembly. In Figure 2, Openable phantom can be seen that the replacement of the inner material is very easy.

Fig. 2. 3D Printing Openable Phantom

2.3 Image Reconstruction

In order to study the distortion of the metal image, the image shooting was performed by inserting a metallic material inside the phantom. So, the image show metal artifact in Figure 3. The images were reconstructed a sinogram and filtered backprojection image using a Micro-CT in Pusan National University.
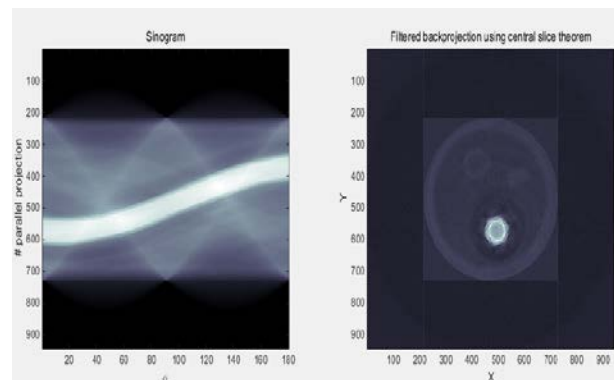

Fig. 3. Sinogram and Filtered Backprojection of metallic phantom

2.4 Metal Artifact Reduction

Metal artifact reduction performed by interpolation using Matlab [3]. The linear interpolation method shows that the principle is simple and the metal artifact reduction is excellent. As the number of interpolation points increases, the quality of the image is improved. However, there is a streak artifact, and it can be seen that different interpolation methods are needed to solve this problem.

The spline interpolation method is generally difficult to interpolate because it is sensitive to end conditions. As a result, the streak artifact becomes the worst. To solve this problem, we developed an interpolation method that finds two values in the graph and finds the other point by using the Max value.

The Max value interpolation method is different from the conventional spline in that the smooth part is extracted without damaging the sinogram part. But it is a bit brighter and the streak artifact can be seen as the smallest. In addition, the difference between the metal and the material boundary is reduced. Through the graph, we can see the effect through the data values of each method.
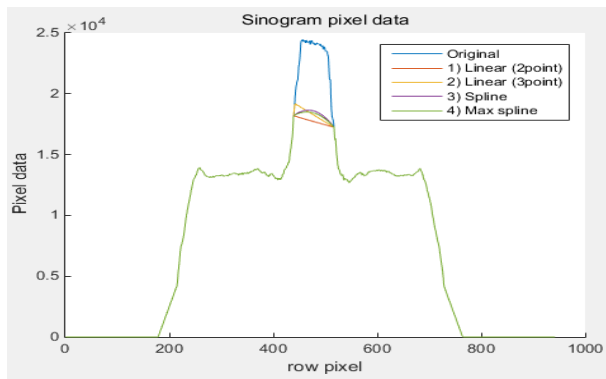

Fig. 4. Raw Pixel Data of Sinogram

3. Conclusions

We have designed a Openable phantom using 3D printing, and have investigated metal artifact reduction after inserting a metallic material inside the phantom. The openable phantom can be adjusted at any time to suit the user's experiment and can be easily replaced and useful.

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