# Iterative Reconstruction Algorithm

## *- Group C -*

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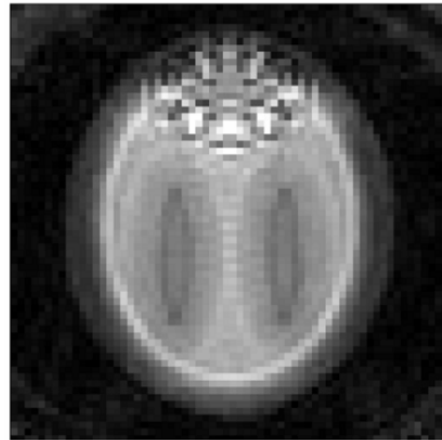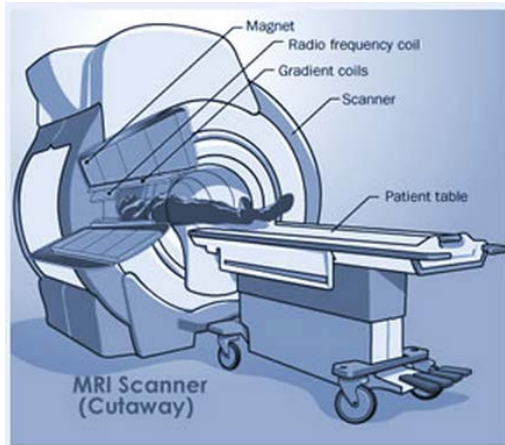*Department of Bio and Brain Engineering, KAIST*

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*Department of Mathematical Sciences, KAIST*

**KAIST**

# Fusion Study

1) Modality – MRI / CT
2) What is iterative reconstruction algorithm?
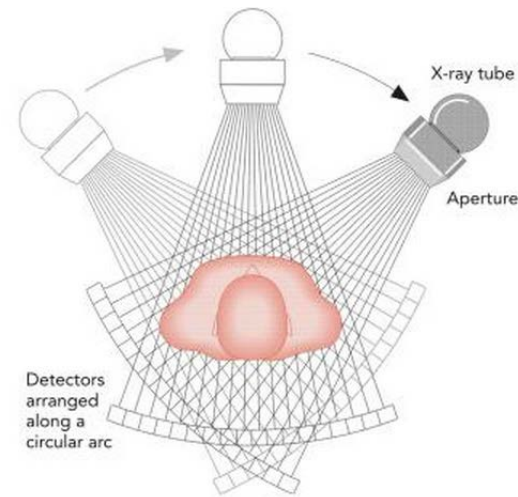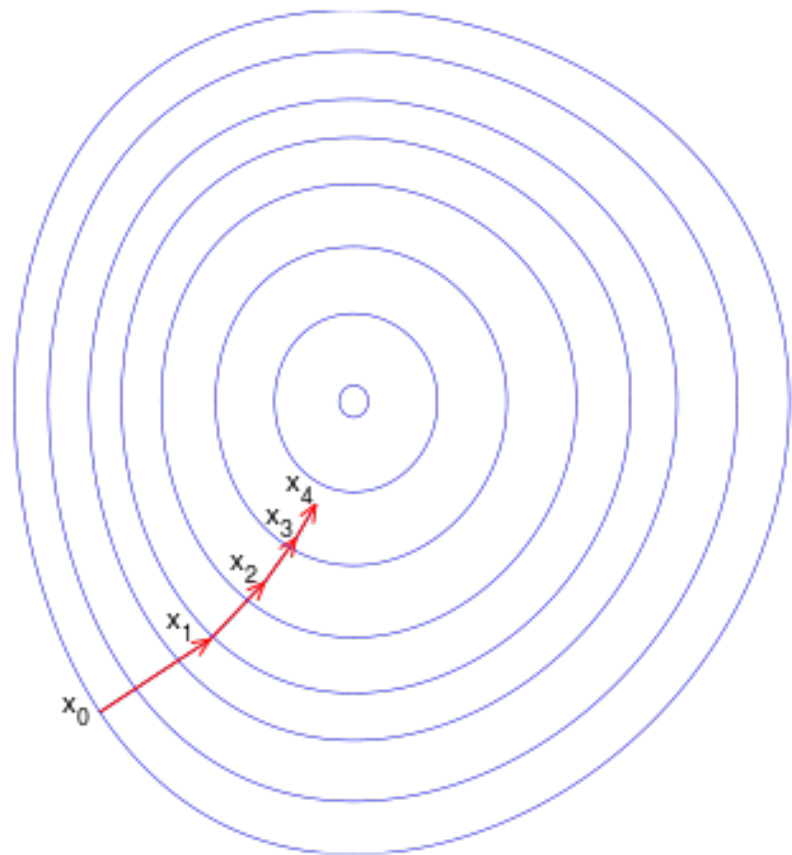3) Application



MRI machine and image



CT machine and image

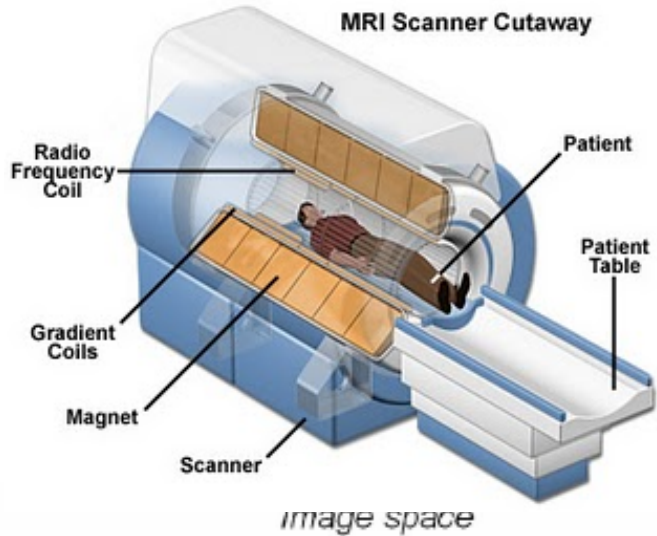# Iterative Algorithm

$$y = Ax$$

A : Modality mapping matrix
x : Image
y : Measurement

1) Set initial guess $x_0$
2) Find new approximation $x_{new}$ from $x_{old}$
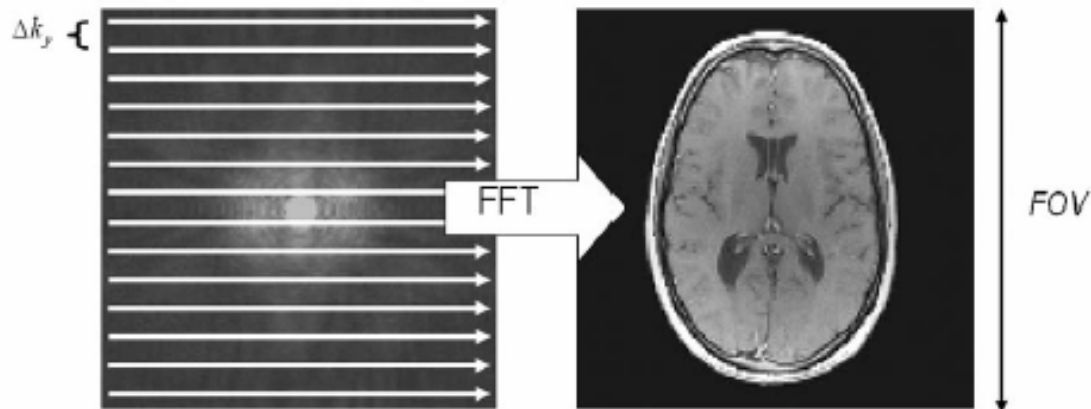3) Repeat 2)

# Medical Image Reconstruction

**iFFT (inverse Fourier Transform)**
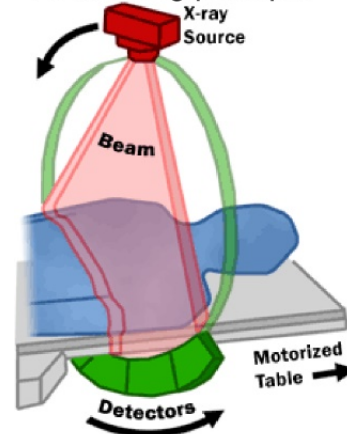


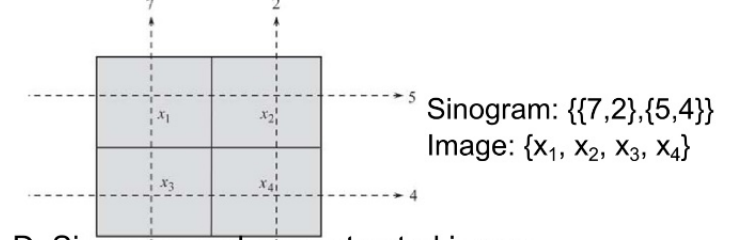**FBP (Filtered back projection)**

A. Clinical CT Scanner

B. Working principle

C. Simplistic explanation of reconstruction

Sinogram: {{7,2},{5,4}}
Image: {$x_1$, $x_2$, $x_3$, $x_4$}

D. Sinogram and reconstructed image
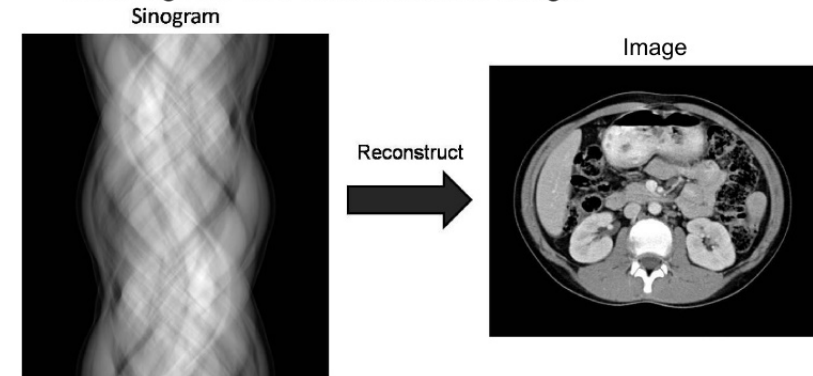
# Reconstruction Algorithm

- Sometimes, analytical method is inadequate.

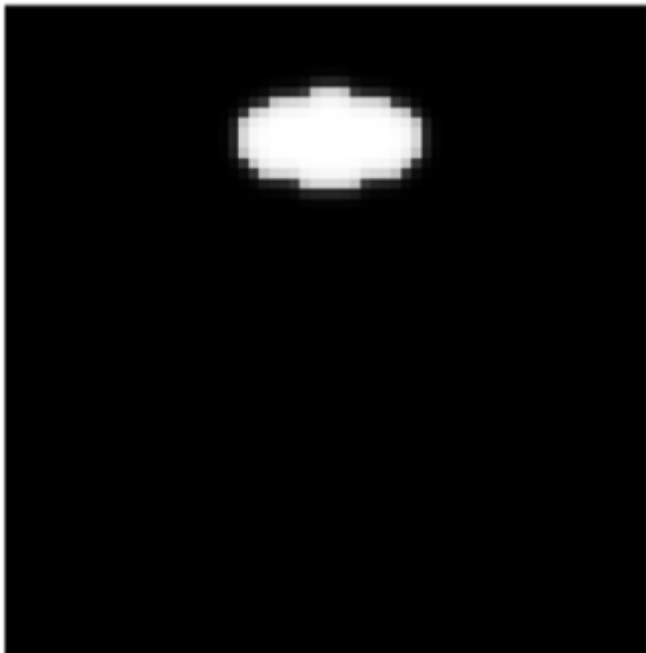| MRI | CT |
|---|---|
| ➢Non-cartesian sampling patterns<br>➢Non-Fourier physical effects<br>➢Nonlinear magnetic fields<br>➢Deliberate undersampling to reduce scan times | ➢Metal artifacts<br>➢Noise reduction<br>➢Sparse view<br>➢Low dose |

➡ Iterative reconstruction methods!

# Applications (1) MRI
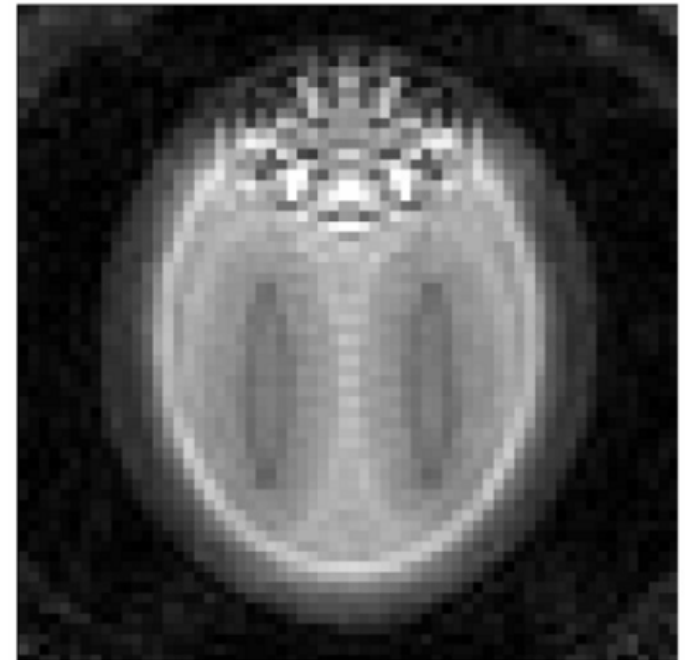
MRI Field inhomogeneity artifact



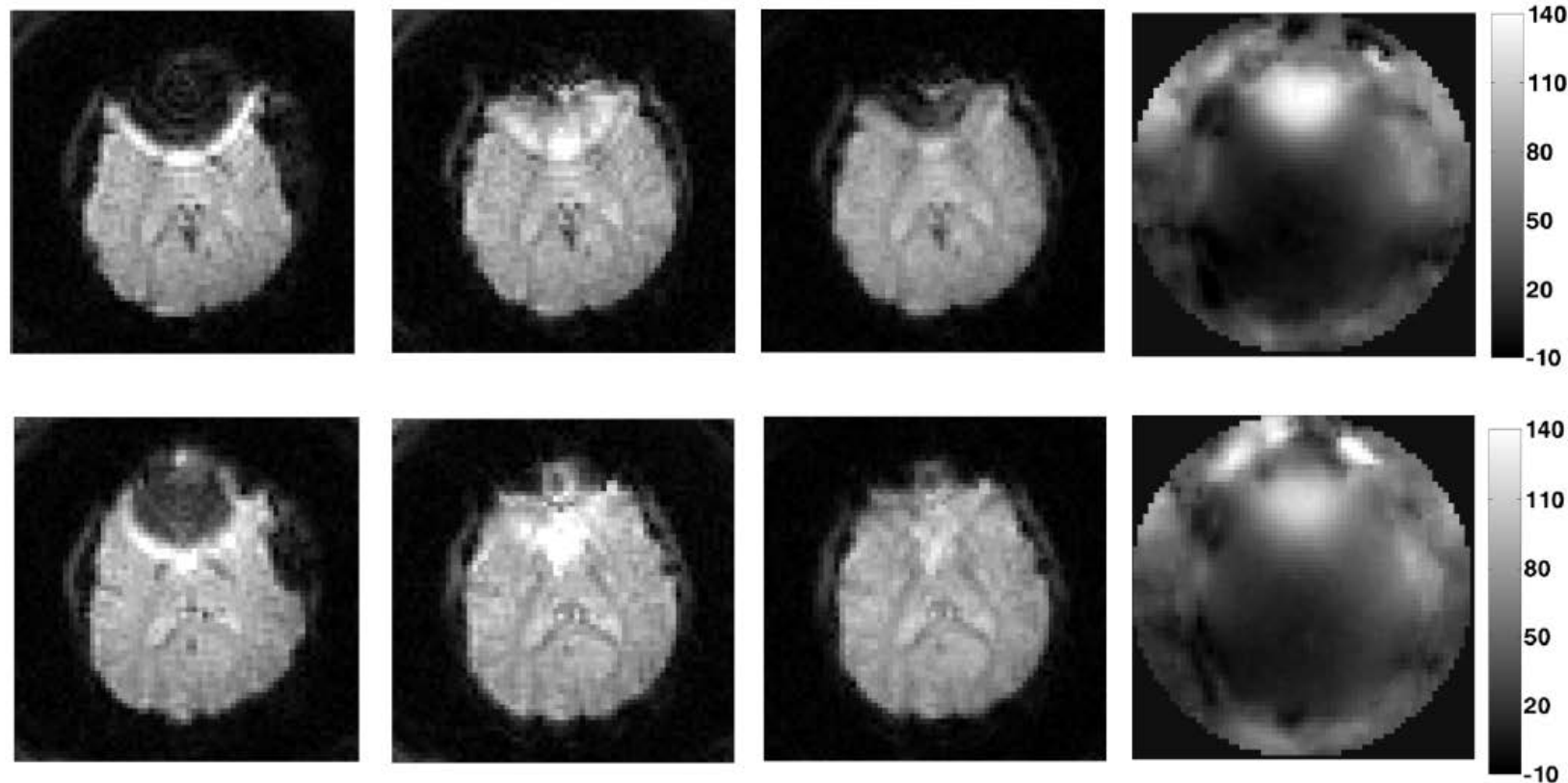Object        Field map        Uncorrected image

# Applications (1) MRI



(a) Uncorrected
(b) Conjugate phase
(c) Fast iterative
(d) Field map (Hz)

Sutton B, et al. "Fast, iterative image reconstruction for MRI in the presence of field inhomogeneities." *Medical Imaging, IEEE Transactions*

# Applications (2) CT



Metal Artifact Reduction (MAR) is one of the hot issues in X-ray CT

# Applications (2) CT



**Given Data**

**Want to be**

Image processing
**Iterative approach**
Reconstruction

Small error
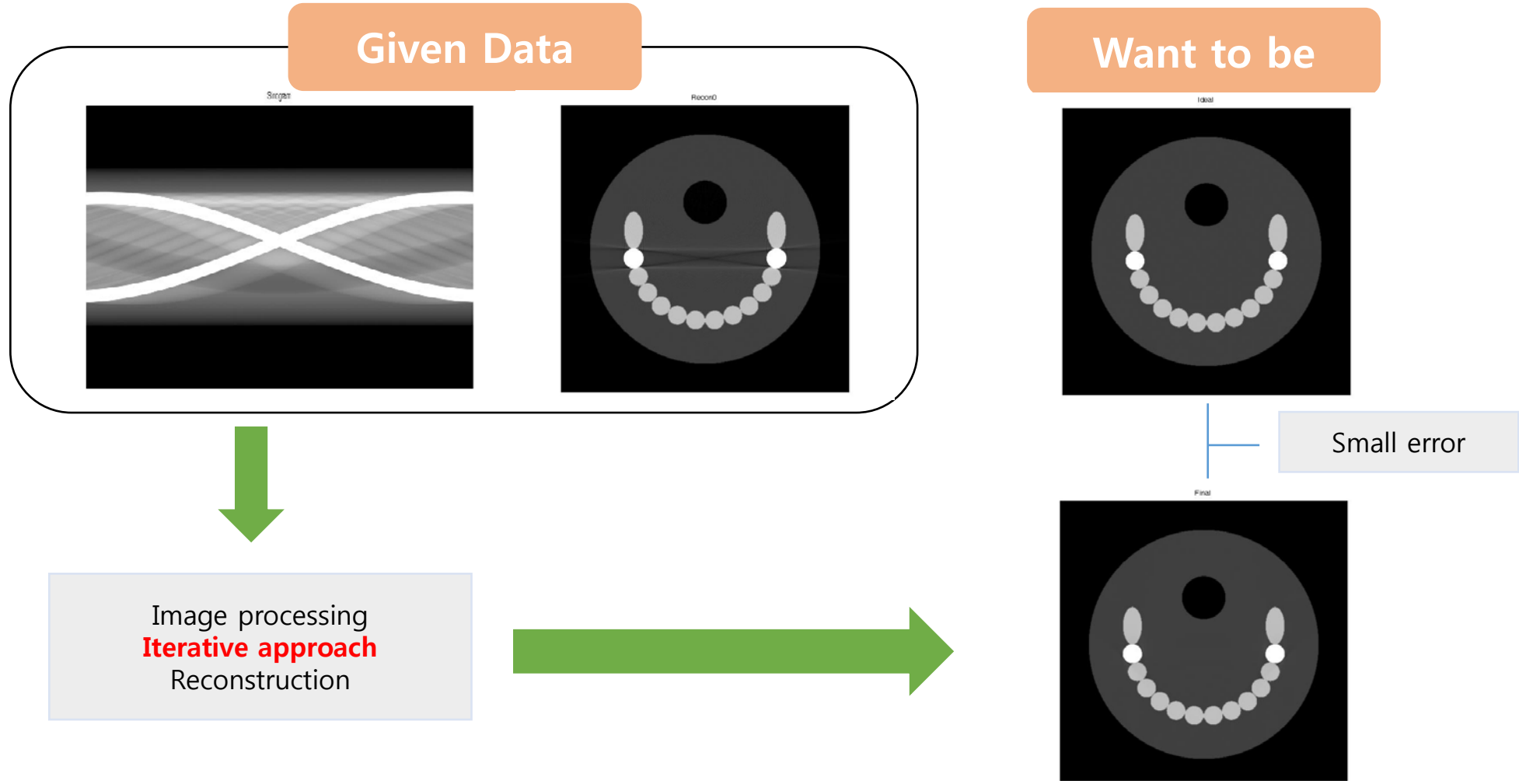
# Applications (2) CT: simulation result



**Phantom**
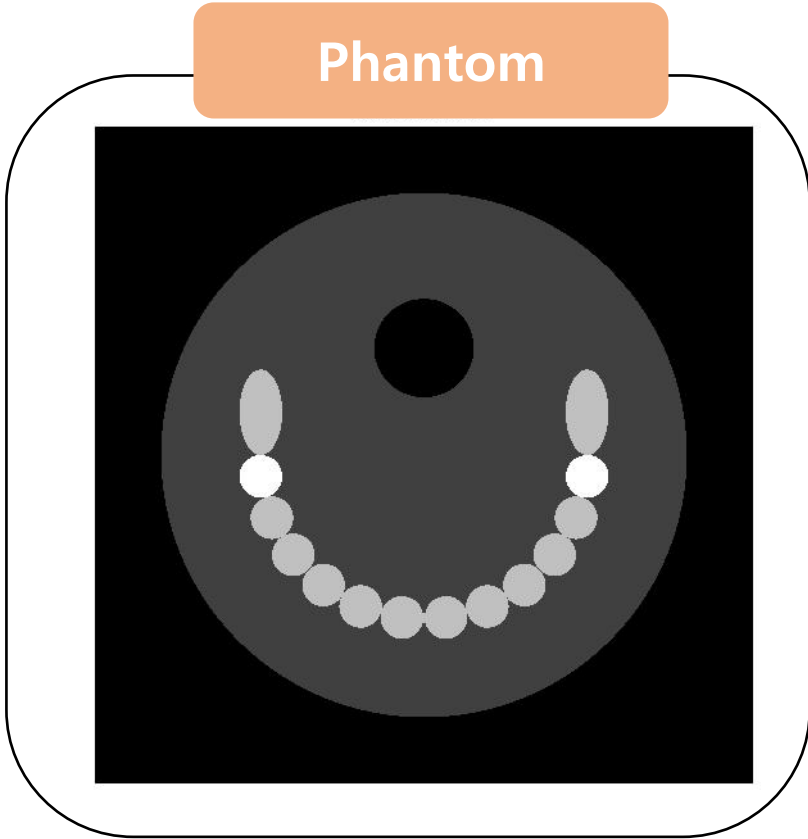
Recon0

Final

Max error: 0.23636
L2 error: 0.05308

**Iter: 8**

Max error: 0.07180
L2 error: 0.01205

# Applications (2) CT: simulation result



**Phantom**

Recon0

Final
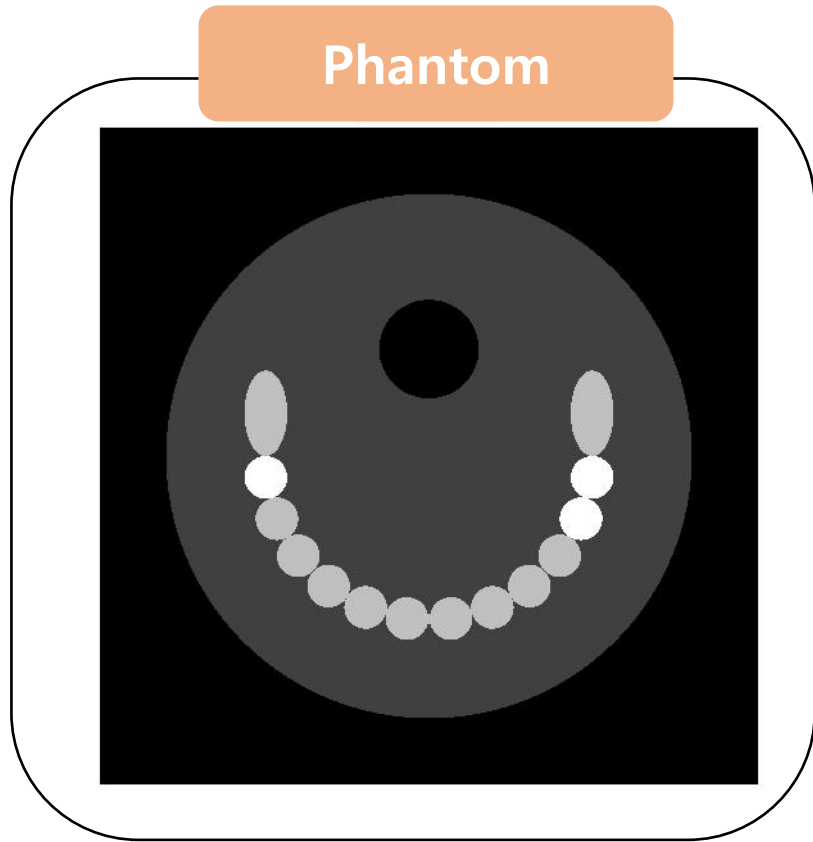
Max error: 0.74819
L2 error: 0.08764

**Iter: 7**
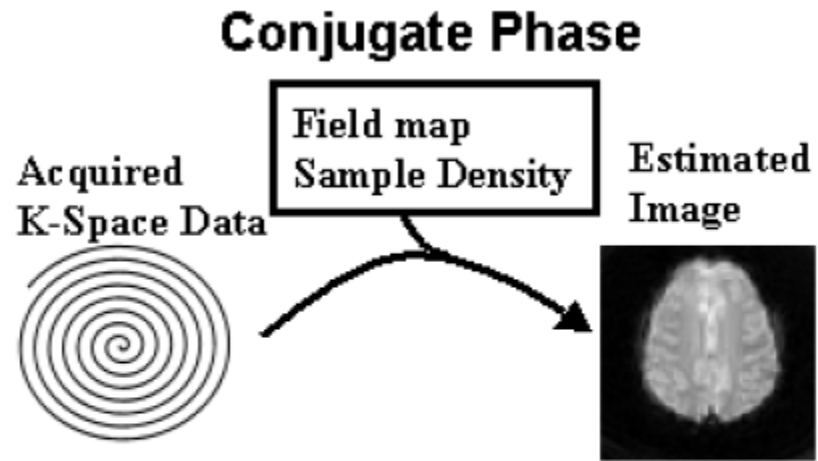
Max error: 0.08981
L2 error: 0.01308

# Conclusions

- Iterative method can resolve the limit of direct method.
- Iterative method can be applied to many medical image modality.
- Iterative method can be designed for its own purpose.

| | MRI | CT | Others |
|---|---|---|---|
| Updated variable | k-space data | Sinogram data | Measurements Parameter ... |
| Purpose | Field inhomogeneity Non-cartesian pattern | Missing data due to metal Low-dose | Various problems |

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Thank you!

# Algorithm: MRI



**Conjugate Phase**

Acquired K-Space Data

Field map Sample Density

Estimated Image

- Need: field map information
       k-space trajectory
       **sample density**