CBCT scatter correction by curve fitting technique

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Outline

- Introduction
  - Other methods
- Method
- Results
- Discussion & Conclusions
- References

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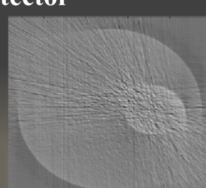
Introduction

- High scatter with large detector
  - Distortion
  - Contrast loss



- Remove the spatial information from initial signal

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Other SC methods

- Hardware
  - Anti-scatter grid
  - Air gap
  - Beam stop array
- Software
  - Primary modulation
  - Monte Carlo

R. Ning, X. Tang, and D. Conover, "X-ray scatter correction algorithm for cone beam CT imaging," Med phys. 31,1195–1202(2004).

Zhu, L.,Bennett, N.R. and Fahrig, R., "Scatter correction method for x-ray CT using primary modulation: Theory and preliminary results," IEEE Trans. Med. Imaging 25, 1573–1587(2006).

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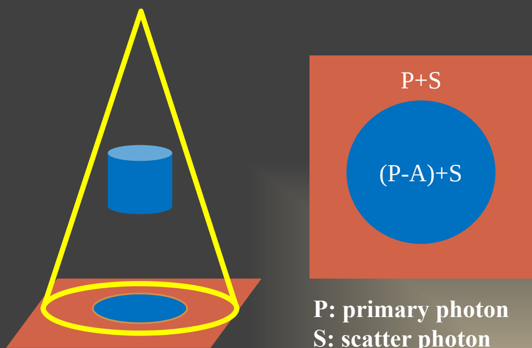

P: primary photon
S: scatter photon
A: attenuated photon

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Purpose

- **Estimate the scatter distribution by the information from ROI aside object.**

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Our methods

- **A simple method to estimate the scatter**
- **Validate the our method using Monte Carlo**

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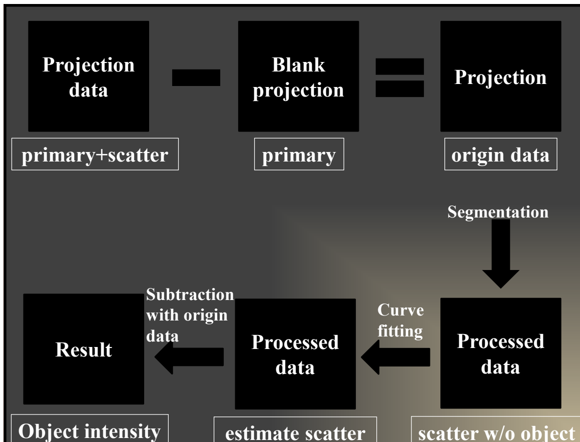

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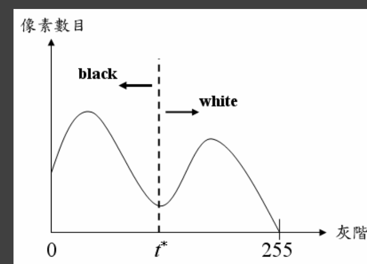
Segmentation

- Fuzzy c-means clustering
- Otsu's method

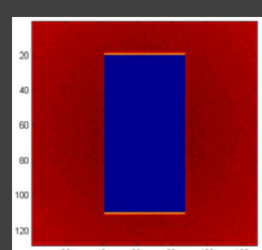
Otsu's method

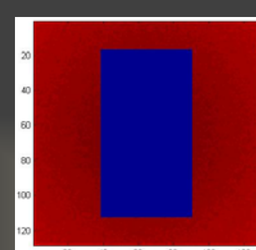


Fuzzy c-means clustering

- Finding a centroids of dataset
- Fuzz the data and calculate a function close centroids

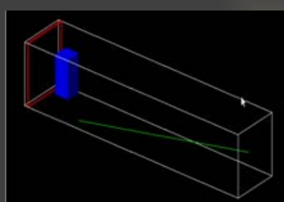
Dilate

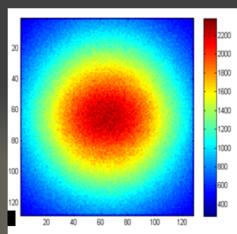

Before


After

Standard scatter

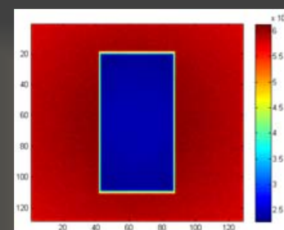
- Geant4 application for tomographic emission, GATE

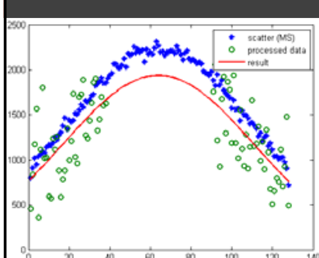




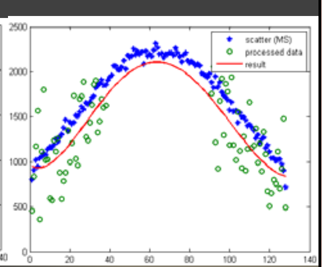
Digital phantom(1)

- Material: aluminum(rectangular)
- 50kev mono-energy
- Only one projection





Gaussian model



polynomial model

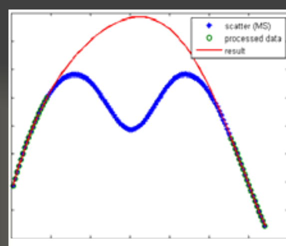
Digital phantom(2)

- Material: water phantom inserted two cylinders of iron
- 80kev mono-energy

Contrast(C)= $|\bar{u}_{iron} - \bar{u}_{water}|$

$t_{cup}=100(\bar{u}_{center} - \bar{u}_{edge})/\bar{u}_{edge}$

- Complex object will affect the real scatter!



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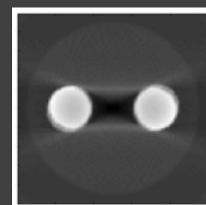
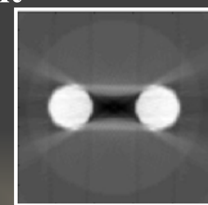
Result



Before correction



After correction

- ROIs: 20*20
- Contrast:11%→17%
- Cupping artifact reduction: 88%→67%

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Discussion

- Noise wouldn’t affect fitting processing
- Fit well in simple object

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Conclusions

- Independent on
  - Source
  - OID
- Improve contrast:11%→17%
- Reduce cupping artifact : 88%→67%

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References

- J. M. Boone and J. A. Seibert, "An analytical model of the scattered radiation distribution in diagnostic radiology," Med. Phys,15, 721–725(1988).
- Siewerdsen JH, Daly MJ, Bakhtiar B "A simple, direct method for x-ray scatter estimation and correction in digital radiography and cone-beam CT." Med Phys,33, 187–197(2006).
- R. Ning, X. Tang, and D. Conover, "X-ray scatter correction algorithm for cone beam CT imaging," Med phys. 31,1195–1202(2004).
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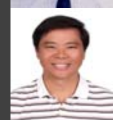

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- Thank you for attention!

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- Using poly-energy to simulate the system matching real situation
- Finding a fitting model
- Downsample to suppress noise

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Fuzzy c-means clustering

$$J_m = \sum_{i=1}^{c}\sum_{k=1}^{N} u_{ik}^{m} ||x_k - v_i||^2$$

$$U \in \left\{ u_{ik} \in [0,1] \middle| \sum_{i=1}^{c} u_{ik} = 1, \ \forall k \quad \text{and} \quad 0 < \sum_{k=1}^{N} u_{ik} < N, \ \forall i \right\}$$

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