Group 4

Metal Artifact Removal in C-arm Cone-Beam CT

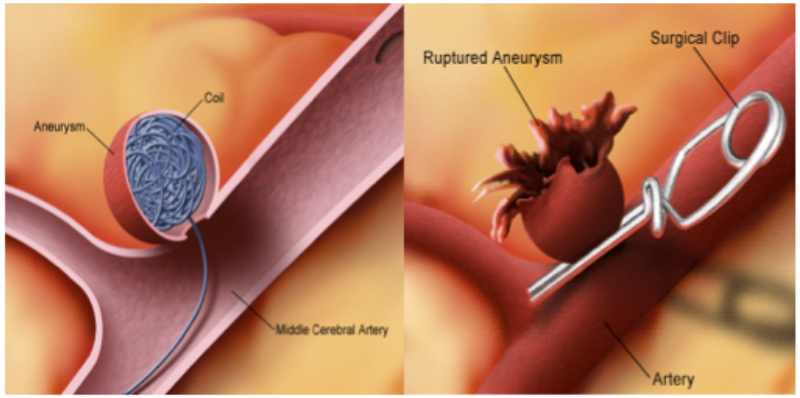
Seminar Presentation by:
Carolina Cay-Martinez

Fellow member: Marta Wells
Project Mentors: Dr. Siewerdsen, Dr. Radvany and Dr. Ehtiati

CIS Project Mission

Construction of brain phantoms that simulate neurovascular interventions for a quantitative data analysis and **assessment** of image quality and **metal artifact removal** algorithm **accuracy**.

'scarecrow' brain phantom
Image provided by the I-star lab



Coil procedure (left) and clipping treatment (right) for cerebral aneurysm.
Image provided by hopkinsmedicine.org

Paper Seminar Selection:
"Normalized metal artifact reduction (NMAR) in computed tomography"

Authors:

Esther Meyer, Institute of Medical Physics, University of Erlangen–Nürnberg, Germany; Rainer Raupach, Michael Lell; Bernhard Schmidt; Marc Kachelrieß

Published:

October 2010 in *The International Journal of Medical Physics*, Vol. 37 (10)

Purpose:

To introduce a generalize normalization technique that will function as an extension of previously developed interpolation MAR techniques.

Importance to our project:

Provides step-by-step metal artifact removal computational algorithms and results of their applications.

Problems

- Presence of metal objects result in streaking patterns called metal artifacts that degrade the image quality of a CT image.
- The loss of information in the metal trace from previously developed MAR techniques introduces new artifacts.

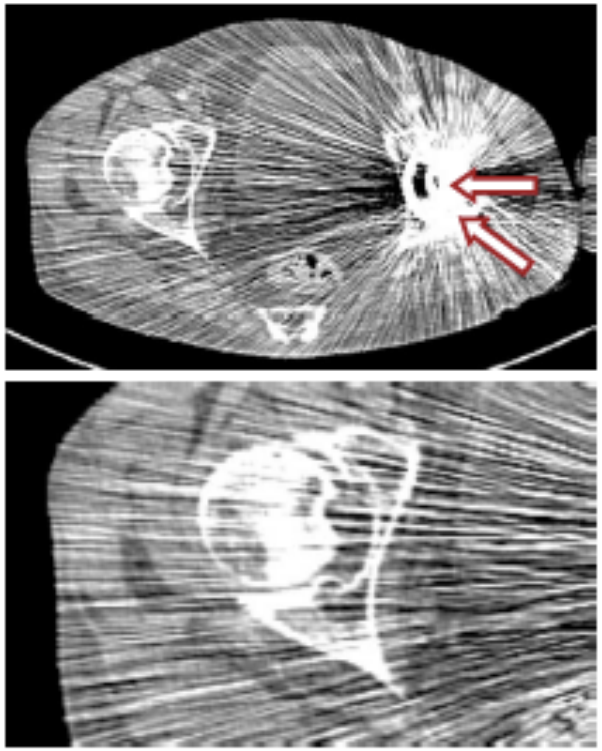


Image provided by Meyer et. al.

Key Result and its Significance

- The **NMAR algorithm restores** traces of **high-contrast objects** in the metal shadow that were otherwise **obscured in previous MAR** algorithm applications.

- NMAR therefore provides an optimization of the image quality that facilitates a **safer**, **more accurate** use of CT imaging in the surgical environment.

Background

- Computed Tomography measures linear attenuation of x-rays by different objects in the body.

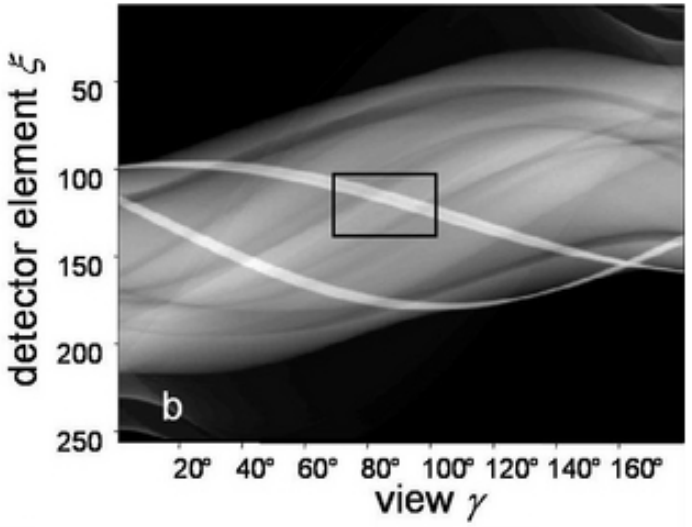
- Concepts: *Projection*, *Sinogram*, *'Filtered Backprojection Summation'*

Video provided by the Medical Training Solutions channel

Background

Previously developed MAR technique:
'Sinogram inpainting method'

- treats metal affected values as missing data
- removes these values
- uses interpolation or forward projections to complete the sinogram



Theory

If the interpolation is performed on a normalized sinogram, the transition between original data and interpolated values is very smooth, reducing newly introduced artifacts.

Proposed Algorithm

1. Reconstruct uncorrected image.
2. Obtain metal image segmentation by a thresholding.
3. Compute prior image of soft tissue and bone.
4. Obtain corresponding sinograms.
5. Normalize original sinogram by dividing it by the forward projected prior image.
6. Apply the interpolation-based MAR to the normalized projections.
7. Obtain corrected sinogram.
8. After reconstruction, insert metal segmentation back into the corrected image.

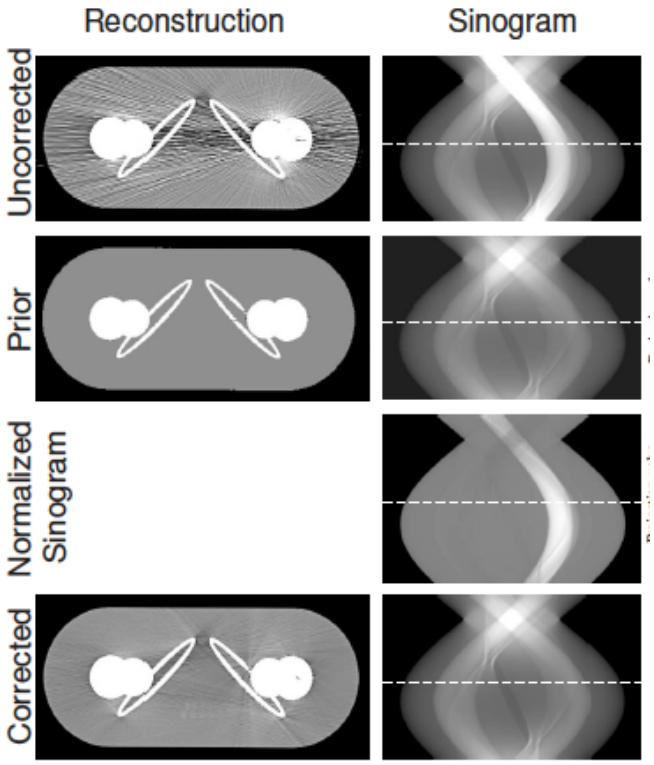


Image by Meyer et.al.

Parameters and Measurements

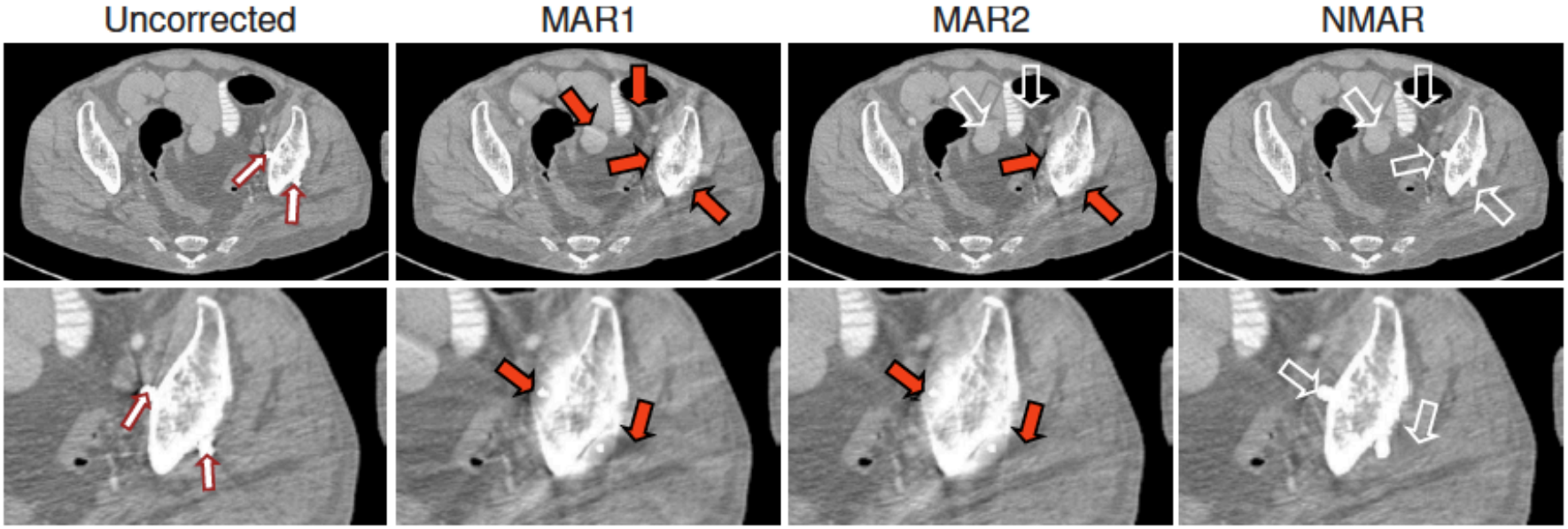
Parameters:

- 2 Phantoms
  - Hip replacement
  - Spinal fusion
- 4 Clinical Patients
  - 2 Hip endoprostheses
  - Dental fillings
  - Spinal fusion

Measurements:

- “visual inspection” of image quality

Results



Patient 2 with unilateral total hip endoprosthesis. Image provided by Meyer, et. al.

Positive/Negative Aspects

Positive:

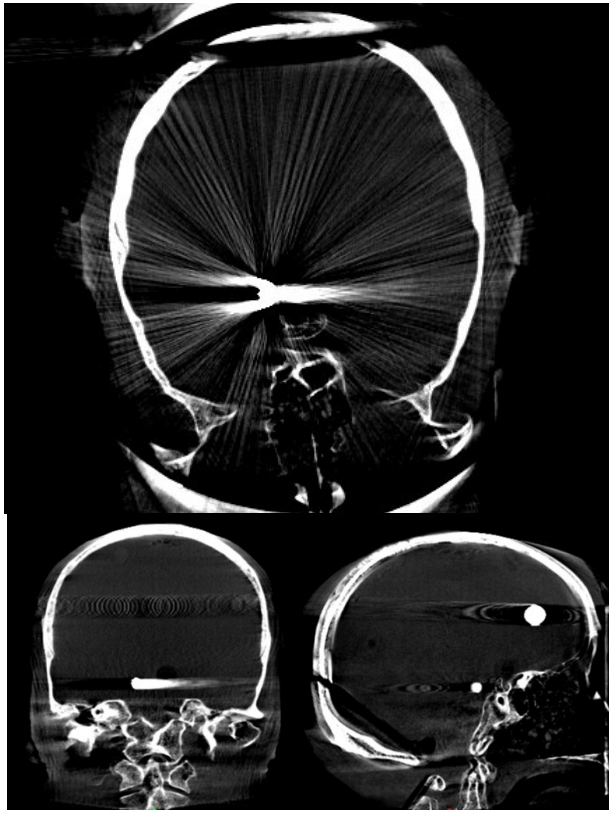
- NMAR is an additional step that could be applied to conventional MAR techniques.
- Specifically attacks the problem of blurring due to loss of information of metal trace, found in previous MARs.
- Computationally effective and inexpensive when compared to iterative methods.

Negative:

- Highly depends on an accurate segmentation operation of the metal object.
- Lack of quantitative measurements of image quality.

What's next?

- Accurate segmentation methods
- Quantitative analysis with measurable variables
- Application of NMAR to other MAR techniques (e.g. statistical methods, frequency-splitting)
- Clinical testing, especially in interventional radiology image guidance



6.35 mm stainless steal sphere near clivus.
Image provided by Cay, Wells.

Conclusion

- Metal artifacts introduce image quality degradation and might render CT images diagnostically useless.
- NMAR can reduce newly introduced artifacts by previously developed MAR algorithms.
- There is a need for thorough quantitative testing of MAR algorithms and improvement of segmentation techniques.
- In the future it could provide real-time, accurate, and safe CT image guidance in interventional radiology.

Thank you.

Questions?