Metal Artifact Removal in C-arm Cone-Beam CT

Group 4

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Project mentors/advisors

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- Tina Ehtiat, PhD (Siemens Healthcare)
Mission

Construction of brain phantoms and acquisition of CT images for a quantitative data analysis and assessment of (a) image quality and (b) metal artifact removal algorithm accuracy.
Technical Background

• X-ray computed tomography (CT) is an imaging modality that uses reconstruction methods to create cross-sectional images from x-ray attenuation data.

• *Artifacts* is a term that refers to any discrepancy between attenuation data of the reconstructed image and the true attenuation of the object.
Technical Background (cont.)

- Metal artifacts are artifacts caused by the presence of dense metal materials in the object. These cause a degradation on the image quality.

- Metal Artifact Removal (MAR) algorithms have been developed to reduce and/or remove these artifacts, and are ready for clinical testing.
Clinical Background

• Neurovascular interventions are minimally invasive procedures for treatment of: aneurysms, intercranial stenosis, and AVMs

• Treatment of these diseases, which include the use of clips, coils, stents and other metal-based materials, depend on CT imaging acquisition in the surgical environment.
Significance

• Optimizing image quality through MAR algorithms will ensure a safer, more accurate use of CT imaging in the surgical environment.
Available resources

• Hollow brain phantom (‘scarecrow’), brain-equivalent inserts, and other materials

• Experimental Imaging bench: CT imaging system available at the I-STAR lab, JHU Medical Campus

• Zeego/Axiom Artis Zee: Siemens C-arm, cone-beam 3D imaging system available at the JHU Medical Campus
Deliverables

• **Phantom Construction**
  – Minimum: solid metal sphere and contrast vasculature
  – Expected: coils and/or clips and contrast vasculature
  – Maximum: liquid embolic system (“ONYX”) and contrast vasculature

• **Image Acquisition**
  – Minimum: Experimental Imaging Bench
  – Expected: Zeego / Axiom Artis Zee Imaging system
  – Maximum: Writing algorithm capable of transferring data between the Experimental Imaging bench and the Zeego console.

• **MAR Algorithm**
  – Minimum: run and implement algorithm
  – Expected: adapt and extend for performance improvement
  – Maximum: suggest and implement algorithm improvements
Deliverables (cont.)

• **Data Analysis: Image Quality**
  – Minimum: quantitatively measure contrast resolution (CNR)
  – Expected: measure spatial resolution, artifact distortion magnitude
  – Maximum: individual artifact-specific measurable parameters

• **Data Analysis: Segmentation Accuracy of the MAR algorithm**
  – Minimum: application of segmentation algorithm on acquired data
  – Expected: quantitatively measure segmentation accuracy
  – Maximum: segmentation algorithm improvement and suggestions
Technical Approach: Dependent Parameters

Phantom Construction:

- **Metal fillings:**
  - Diameter
  - Volume
  - Density
  - number and shape of coils and clips

- **Simulated vasculature:**
  - number of vessels
  - contrast
  - volume and shape
  - material

Image Acquisition:

- Energy of beam (kVp)
- Number of projections
- Dose
- Tube current
- Pitch
- Acquisition time
Technical Approach: Measurable Variables

Data Analysis:
- Contrast resolution
- Spatial resolution
- Signal-to-noise ratio
- Artifact magnitude

MAR Methods:
- Comparison between known volume/shape of metal objects and the segmentation

MAR segmentation on spheres
Image provided by De Man, et.al.
Schedule/Responsibilities

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Week number</th>
<th>Responsibilities</th>
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<tbody>
<tr>
<td>1. First stage</td>
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<td>1.1 construction of phantom: metal sphere</td>
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<td>1.2 image acquisition: bench</td>
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<td>1.3 image acquisition: zeego</td>
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<td>1.4 data analysis</td>
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<td>2. Second stage</td>
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<td>2.1 construction of phantom: coils and/or clips</td>
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<td>2.2 image acquisition: bench</td>
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<td>2.3 image acquisition: zeego</td>
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<td>2.4 data analysis</td>
<td>12</td>
<td>Marta</td>
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<td>3. Third stage</td>
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<td>3.1 construction of phantom: ONYX</td>
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<td>3.2 image acquisition: bench</td>
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<td>3.3 image acquisition: zeego</td>
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<td>3.4 data analysis</td>
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<td>Marta</td>
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<td>4. CIS course key dates</td>
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<td>Cay</td>
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<td>4.3 project checkpoint</td>
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<td>4.4 poster session</td>
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<td>Cay</td>
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<td>4.5 final report</td>
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Dependencies:
Experimental Imaging bench

Dependency: Availability

- **Resolution:** Image acquisition will be done in a two-week period once in every project stage. Scheduling depends on Dr. Siewersden and lab members.
- **Backup-plan:** Zeego system will be used instead.
- **Resolved by:** End of each brain phantom construction period.
- **Affects:** Image acquisition for image quality assessment.

Dependency: Training/Supervision

- **Resolution:** Training of equipment will occur during 2/17-2/23. Lab member supervision (if required) will be scheduled previously.
- **Backup-plan:** Zeego system will be used instead.
- **Resolved by:** 2/17-2/23.
- **Affects:** Image acquisition for image quality assessment
Dependencies: Zeego/Axiom Artis Zee

Dependency: Availability
- **Resolution:** Image acquisition will be done in a three-week period once in every project stage. This imaging system is in clinical use and therefore has an undependable schedule. Scheduling depends on Dr. Ehtiai.
- **Backup-plan:** Bench imaging system will be used instead.
- **Resolved by:** The end of each brain phantom construction period.
- **Affects:** Image acquisition for MAR assessment.

Dependency: Training/Supervision
- **Resolution:** Supervision (by Dr. Ehtiai or technician) will be needed during each image acquisition.
- **Backup-plan:** Bench imaging system will be used instead.
- **Resolved by:** The end of each brain phantom construction period.
- **Affects:** Image acquisition for MAR assessment.
Dependencies: Brain phantom and materials

Dependency: Availability

• **Resolution:** The I-STAR lab already is in possession of the phantom (just available to us this semester) and insert materials (brain-equivalent jello, soft-tissue inserts, coils, clips, etc)

• **Backup-plan:** If the material is not available in the lab, then a request will be made to Dr. Siewersden for ordering at least two weeks prior of its intended use.

• **Resolved by:** The end of each image acquisition period.

• **Affects:** Further image acquisition.
Dependencies (cont.)

- Software available in bench and Zeego
- Travel to/from Homewood/Medical Campus
- Availability of Dr. Radvany and lab technicians
- Permissions constraints (these will be investigated and requested if needed):
  - Permission to operate Zeego and/or bench
  - Access to the hospital interventional radiology suite
  - Access to the I-STAR lab
Management Plan

• Weekly meetings (members and mentors) every Thursday at 8:00 am

• Weekly meetings (members) every Saturday and Monday

• All documents related to the project will be available in a Dropbox account accessible to both members

• The web page will be edited weekly (every Saturday)

• A sign-up sheet document will keep track of the members’ hours and tasks
References


• For further references, refer to the project web page.
Thank you.

Questions?