Prior-based Artifact Correction (PBAC) in Computed Tomography

Thorsten Heußer¹, Marcus Brehm¹,², Ludwig Ritschl³, Stefan Sawall¹,², and Marc Kachelrieß¹,²

¹German Cancer Research Center (DKFZ), Heidelberg, Germany
²Friedrich-Alexander-University (FAU) Erlangen-Nürnberg, Germany
³Ziehm Imaging GmbH, Nürnberg, Germany
Computed Tomography (CT) Data Acquisition and Image Reconstruction

- Data acquisition
- Projection data
- Image reconstruction

Detector

X-ray source

Missing / corrupt projection data cause image artifacts!
Artifacts in CT
Simulation of Artifacts

- Metal artifacts
  - Two titanium pedicle screws
  - Beam hardening
  - Scatter and partial volume effects not considered

- Truncation artifacts
  - Reduced field of measurement (FOM)
  - FOM indicated by yellow circle

- Limited angle artifacts
  - Reduced total scan angle
  - Source trajectory indicated by yellow arc
Artifacts in CT
Standard Correction Methods

- **NMAR**\(^1\) + **FSMAR**\(^2\)

- **Adaptive detruncation**\(^3\)

- **Angular outfading**

---

Ground Truth (GT) | Uncorrected Image | Standard Correction
---|---|---

**Metal**

**Truncation**

**Limited Angle**

Center = 0 HU / Width = 1000 HU
Idea

- Use prior data to replace missing or corrupt patient projection data

Prior data

- Different scan of the same patient or scan of a different patient
- Needs to be registered to the patient before data is inpainted into the missing data regions

Prior Knowledge

Registration
Compensate for Differences between Patient and Prior

- Deformable registration
  - Based on the Demons algorithm
  - Local, voxel-specific deformation
  - Sensitive to image artifacts

- Two approaches
  - Standard registration: Registration onto std. correction
  - Idealized registration: Registration onto GT

Uncorrected Image | Prior | Standard Registration | Idealized Registration
--- | --- | --- | ---

Center = 0 HU / Width = 1000 HU (reconstructions and difference images)
Results
Simulations

Ground Truth | Uncorrected Image | Standard Correction | Standard Registration | Idealized Registration

Metal

Truncation

different patient as prior

different patient as prior

Limited Angle

same phantom as prior

Center = 0 HU / Width = 1000 HU
Results
Patient Data

Center = 0 HU / Width = 1000 HU
Conclusions and Outlook

• Conclusions
  – PBAC effectively corrects for common CT artifacts.
  – PBAC appears to be superior or at least comparable to standard CT artifact correction methods.

• Outlook and future plans
  – Develop and implement artifact-insensitive deformable registration (e.g. rawdata-based)
  – Generalize PBAC to be applicable to other modalities (e.g. MRI and PET/MRI)
Thank You!

This presentation will soon be available at www.dkfz.de/ct.

This work was supported in parts by the Helmholtz International Graduate School for Cancer Research, Heidelberg, Germany.

Parts of the reconstruction software were provided by RayConStruct® GmbH, Nürnberg, Germany.