Towards Understanding Preservation of Periodic Object Motion in Computed Tomography

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Introduction

- Motion during acquisition results in artifacts.
- Ventricles appear blurred in the reconstruction, while arteries cause streaking artifacts.
- **Stationarity of the ventricles and motion of the arteries** in the forward projection (Fig. 1).
- Identify the influence of **object shape and motion type** on the artifacts.

Materials and Methods

- **Phantom** to mimic the anatomy:
  - **Temporally varying circle**, either shifted or pulsating.
  - Variation of the edge sharpness by a Gaussian filter kernel.
- Simulation procedure:
  - Compute the Radon transform to obtain a sinogram.
  - Reconstruct each sinogram (Fig. 2) with a filtered back-projection algorithm.
  - Forward projection (Fig. 3) of the reconstructed image.
- Observation:
  - **Reprojected sinogram may retain a fraction of the original motion**
- Experiments:
  - Comparison of the original and the reprojected sinogram.
  - **Quantitative measure** for the remaining motion:

$$q = \frac{\xi_f(\mathcal{F}\{s_{reproj}\})}{\xi_f(\mathcal{F}\{s_{orig}\})}$$

  - s_{reproj} and s_{orig}: sequence of line integral through a fixed point.
  - $\mathcal{F}$:Fourier transform
  - ξ_f: summation of an element-wise multiplication with $N(f,1)$

Results and Discussion

- Fig. 4 summarizes the results of the simulation.
- The amount of **retained motion decreases with increasing frequency**.
  - **Low frequencies**: The **motion type has a stronger impact** on the preserved amount of motion.
  - **High frequencies**: The **effect** is **more dependent on** the **edge sharpness**
- Preserved motion is linked to streaking artifacts (Fig. 2)
- Further work: Incorporate the knowledge in the design of reconstruction filters.

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Figures

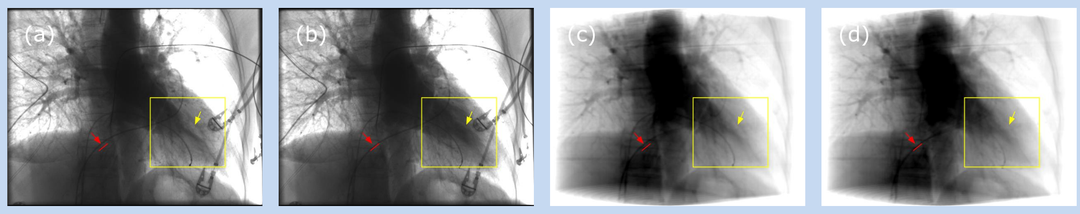

Figure 1. Frames of a rational angiogram at time t_1 (a) and t_2 (b) and corresponding digitally reconstructed radiographs at time t_1 (c) and t_2 (d).

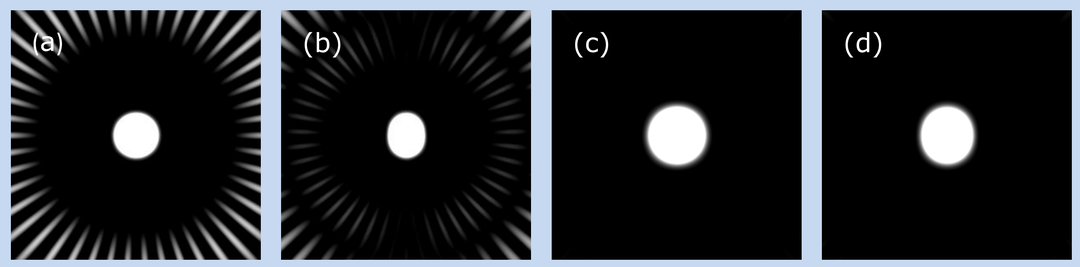

Figure 2. Reconstructed images of the pulsating (a, c) and the shifted (b, d) object, where $\sigma = 5$ (a, b), $\sigma = 10$ (c, d) and $f = 25\ cycles$

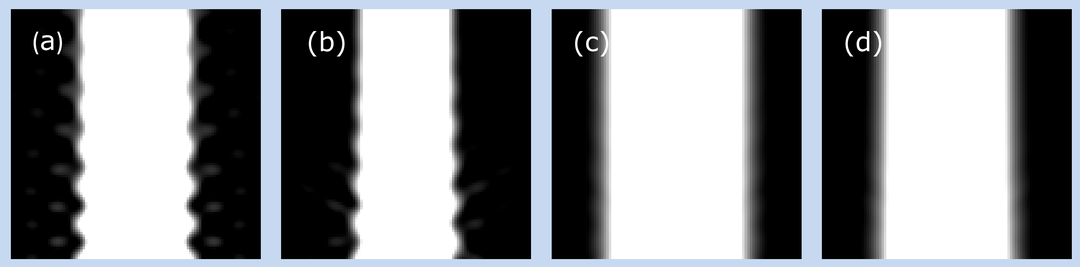

Figure 3. Reprojected images of the pulsating (a, c) and the shifted (b, d) reconstructed object, where $\sigma = 5$ (a, b), $\sigma = 10$ (c, d) and $f = 25\ cycles$

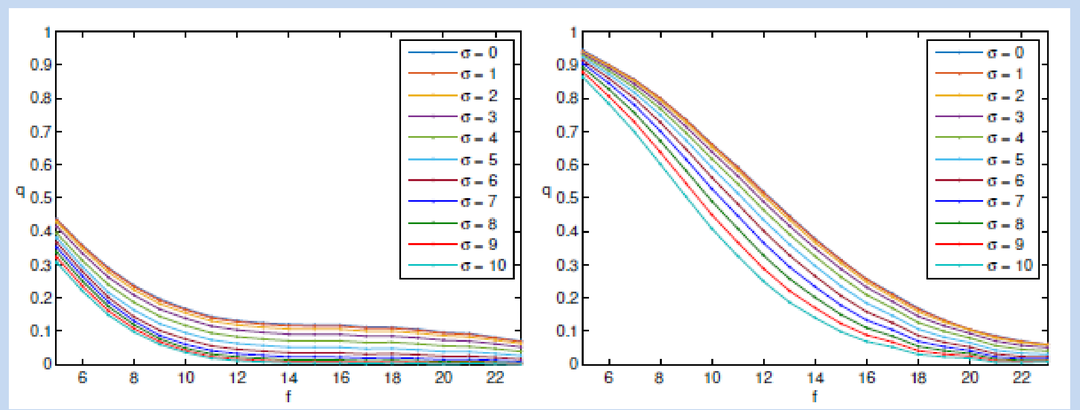

Figure 4. Plots over the fraction of preserved motion q of the pulsating (left) and the shifted (right) object over the frequency f for different values of σ.

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