FAST FOURIER TRANSFORM ALGORITHM FOR EXTRACTION OF ATTENUATION, PHASE, AND SCATTERING IMAGES IN PHASE-CONTRAST IMAGING

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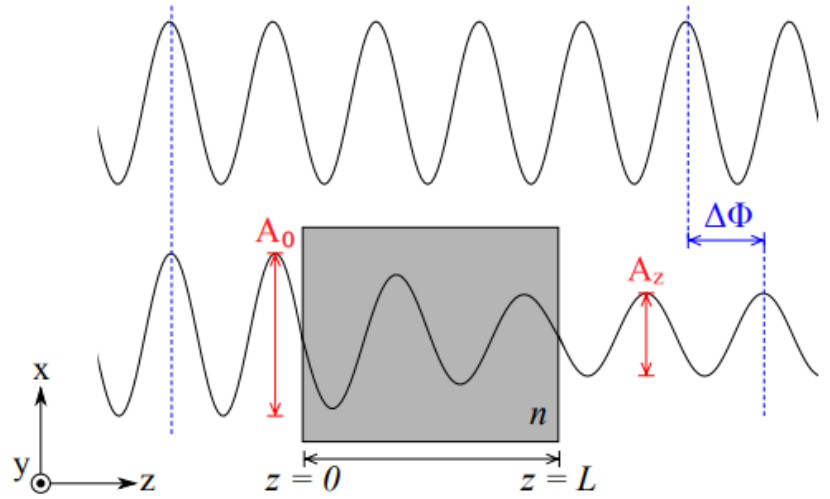
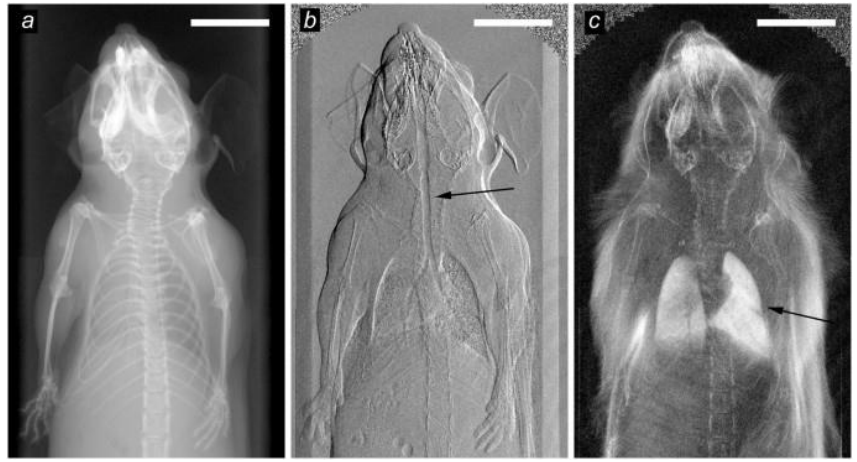
Phase contrast imaging

- Based on the refraction of the X-ray beam.
- Improved visibility of soft tissues.
- Potential to reduce dose in tissue.
- Enhanced contrast in images.
- Three different images in one phase-stepping exposure.



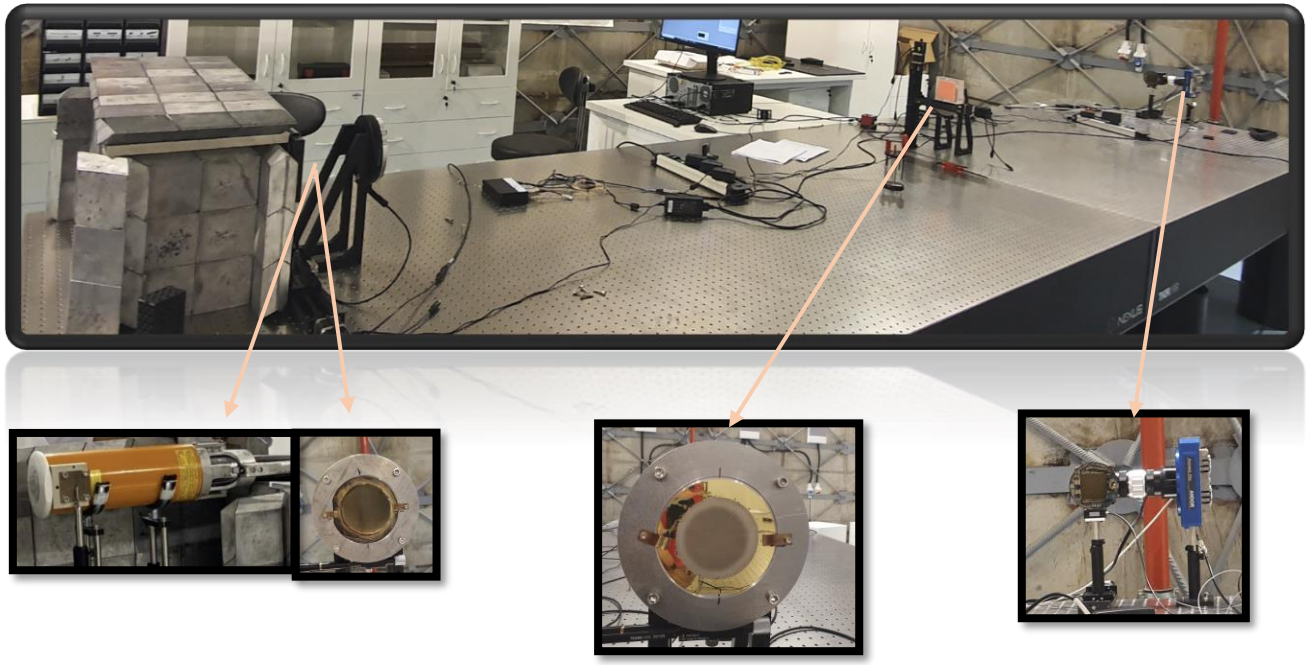
Attenuation image | Phase image | Scattering image

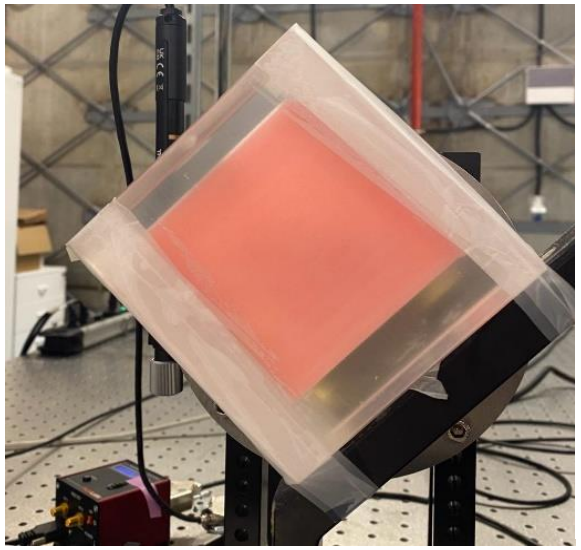


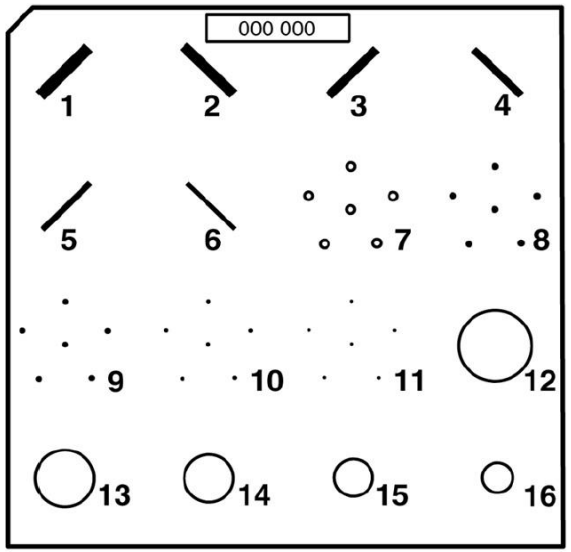
M. Bech et. al., Sci. Rep., 2013.

Set up and sample used

Normal Incidence Interferometer







- High sensitivity ~to 0.82 μradians *(defined as ratio between the period of the G_2 grating and the distance between the G_1 and G_2 gratings)*
- Fringe visibility ~15% (defined as V= $(I_{max}+I_{min})/(I_{max}-I_{min})$)

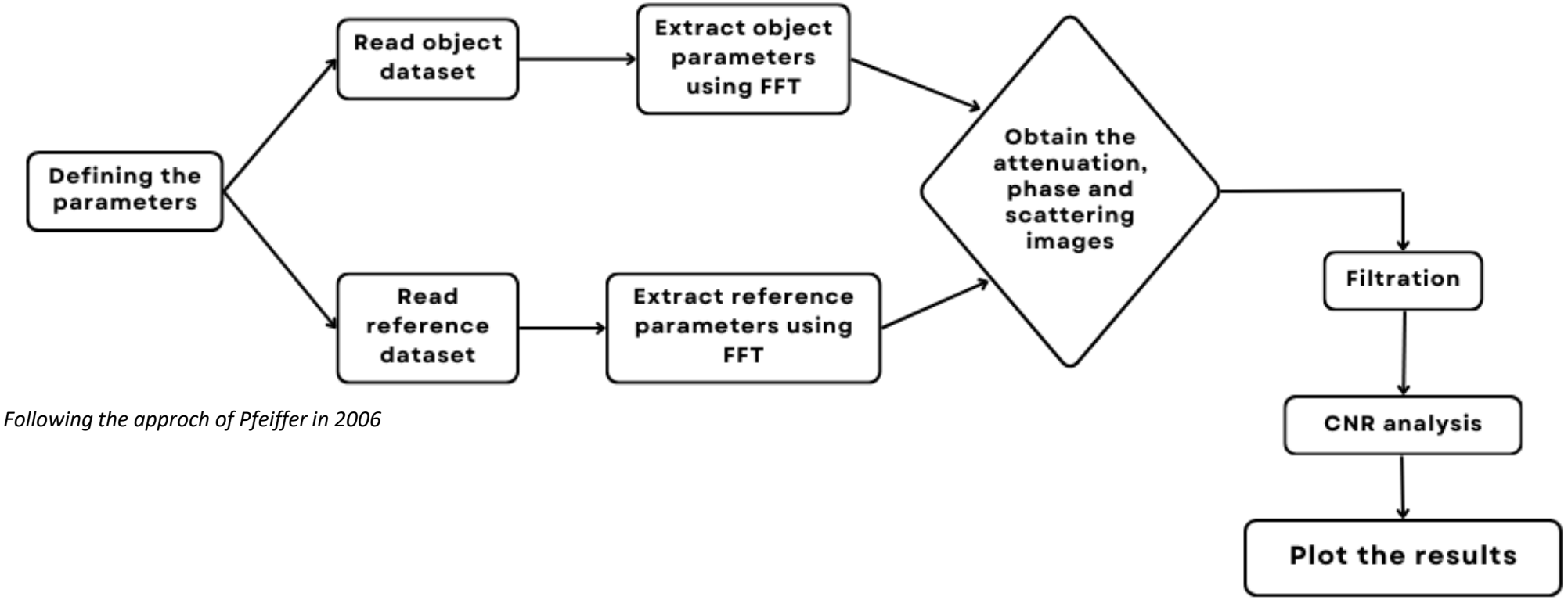
- This phantom imitates a compact breast composed of 50% fibrous tissue and 50% adipose tissue and contains 16 objects.

Collecting data

➢ „Phase-stepping” procedure

$$I = a_o + a_1 cos(x + \phi)$$

Algorithm



Following the approch of Pfeiffer in 2006

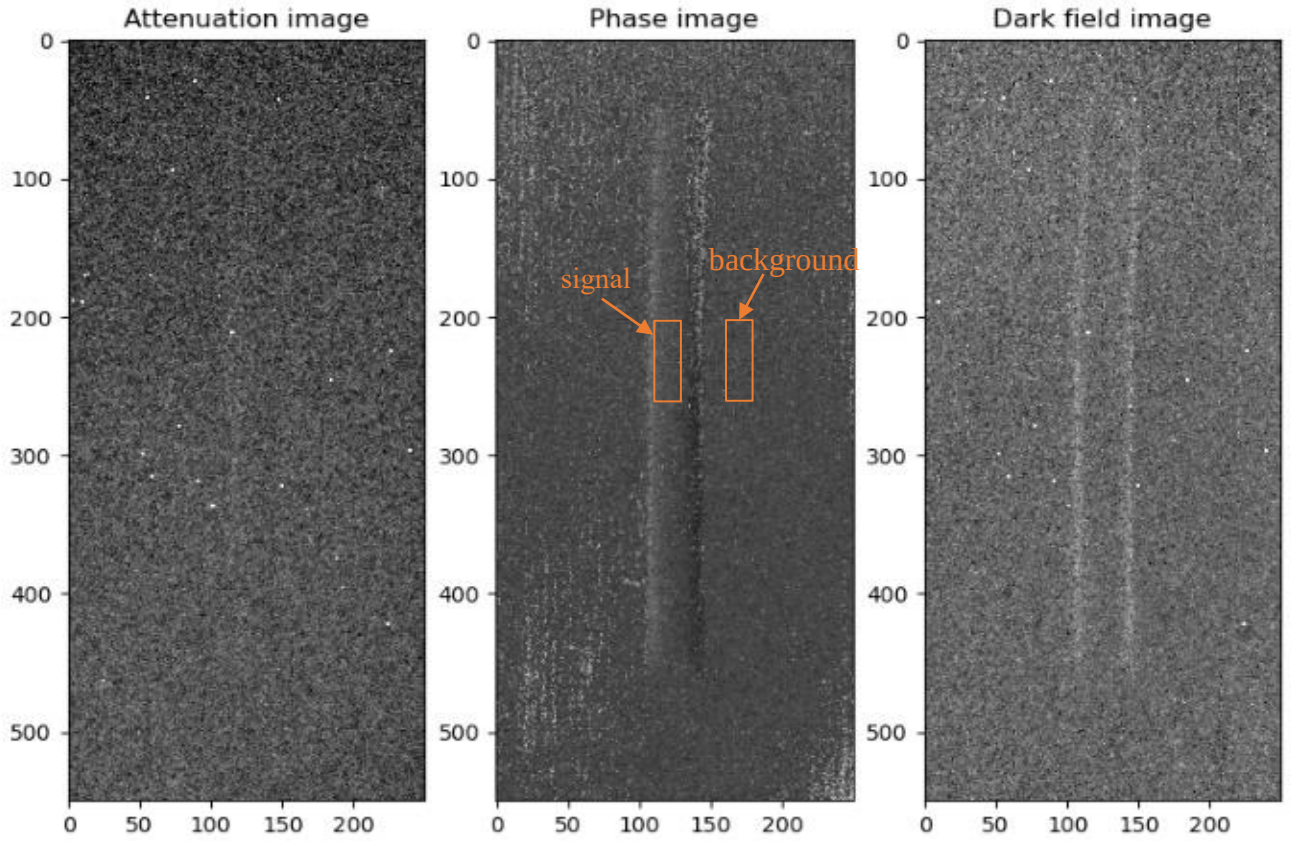
- median filter was applied
- CNR analysis *(CNR=*$\frac{mean(pixel\ signal\ values)-mean(background\ pixel\ values)}{std(background)}$*)*

Results

- Attenuation, phase and scattering images have noise caused by photon statistics.

CNR for attenuation, phase, and scattering images

	Attenuation image	Phase image	Scattering image
CNR before filtration	0.13	1.1	0.81



I. Ciobanu et. al., UPB Sci. Bull, 2023.

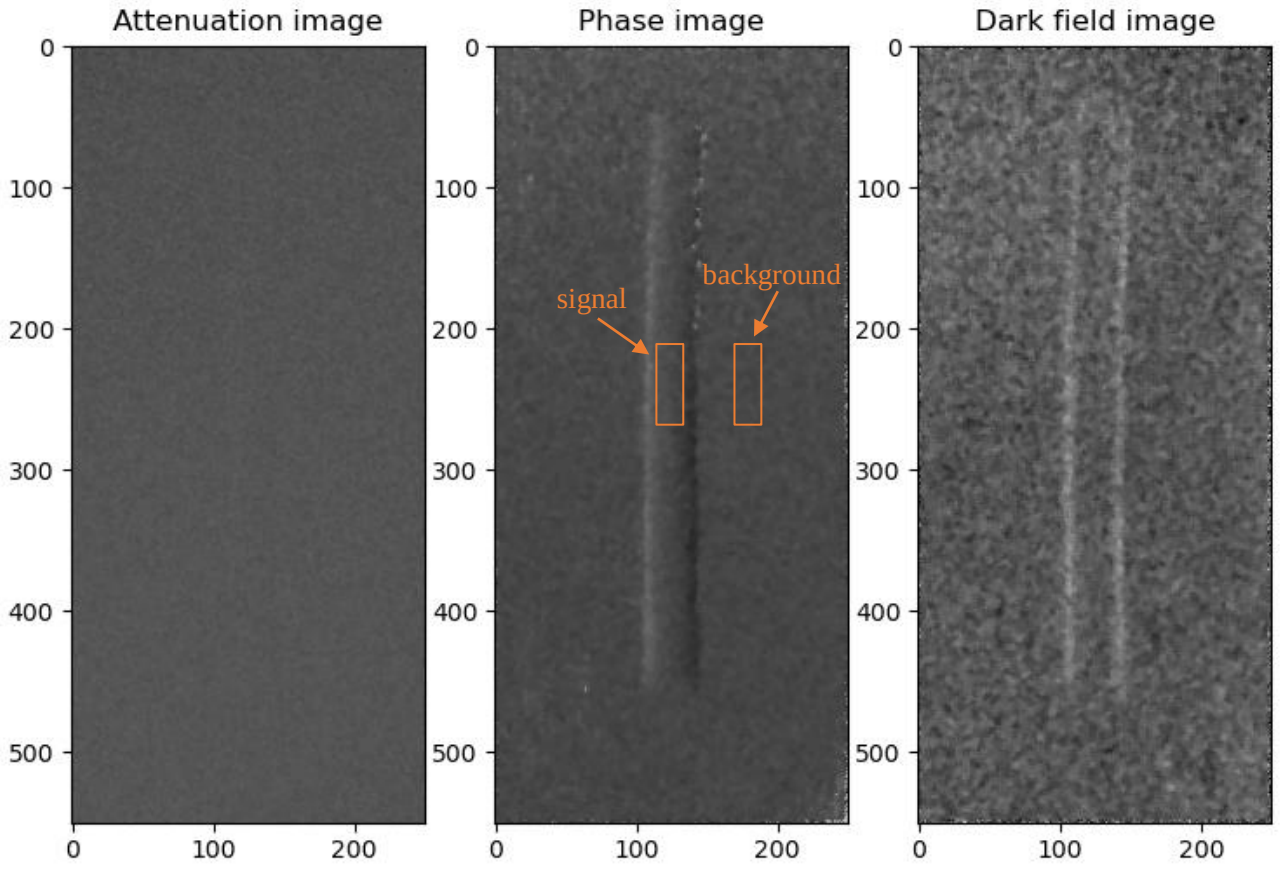
$$T = -ln\left(\frac{a_{0s}}{a_{0r}}\right) \qquad \Phi = \varphi_s - \varphi_r \qquad D = \frac{a_{1s}}{a_{0s}} * \frac{a_{0r}}{a_{1r}}$$

Improving the CNR

- window of dimensions (2*k+1)x(2*k+1):
  - Attenuation image: k=1
  - Phase image: k=2
  - Dark field image: k=2
- The noise is reduced, the images start to blur, but the edges are more defined

CNR for attenuation, phase, and scattering images

	Attenuation image	Phase image	Scattering image
CNR after filtration	0.26	5.66	1.09



I. Ciobanu et. al., UPB Sci. Bull., 2023

Conclusions

- The three images extracted provide different details of the object.
- Biggest improvement in CNR is in the phase image;
- We analyzed 15 more images (5 attenuation images, 5 phase images, and 5 scattering images). All the phase images from this data set have a CNR after filtration 4-5 times higher.
- Increase the quality of the images, and improve the identification of the fiber by application of a basic non-linear filtration.
- After filtration, the noise caused by photon statistics is removed and the fiber is much more visible.


Thank you!