Chapter 5

Backprojected space in image reconstruction

Contents

5.1 Theory of backprojected space ........................................ 100
5.2 A weighting scheme based on dissimilarity .......................... 106
5.3 Non-linear backprojection $\omega$BP for tomosynthesis ............ 111
5.4 Weighted $\omega$SART for tomosynthesis ............................... 120
5.5 Weighted $\omega$SART for metal artifact reduction in CT .......... 125
5.6 Interpolation in BP-space for metal artifact reduction in CT 133

Backprojected space (BP-space) is a sinusoid-like decomposition of the projection data. The BP-space is a four-dimensional space which connects the projection space and the image space. It gives a new possibility to represent the backprojection operator and to control it with more flexibility. It allows for introducing non-linear weighting coefficients in the backprojection operator to control the contribution of each projection value into each voxel individually. It can be used when the projection data are incomplete or inconsistent to reduce the influence of incompleteness/inconsistency of the data. Additionally, the BP-space offers a new methodology to follow the sinogram flow without any segmentation or registration. This can be used for data interpolation.

This chapter includes a literature review of the stackgram representation which is the BP-space in the two-dimensional case. The BP-space will be introduced as generalization of the stackgram approach for the third dimension and the properties of the BP-space will be discussed. Then, a motivation for a non-linear weighted

backprojection for tomosynthesis will be given (Levakhina 2012a). The weighting scheme will be discussed and reconstruction results will be shown. Afterwards, the weighting scheme will be extended for the usage in the SART algorithm with some results (Levakhina 2012c, Levakhina 2013b). As the last part of this chapter, unpublished work regarding metal artifact reduction in CT using ωSART and interpolation in BP-space will be presented.

5.1 Theory of backprojected space

In this section, the literature review and the properties of the stackgram representation and the BP-space will be presented. To the best of our knowledge, the detailed properties of the planes of different orientation in the stackgram and BP-space have never been discussed in literature before.

5.1.1 Stackgram representation in literature

A concept of the stackgram representation has been introduced by A. Happonen in 2002 and summarized in 2005 in his PhD dissertation (Happonen 2005a). The stackgram is an intermediate three-dimensional domain between the two-dimensional image domain and the two-dimensional sinogram domain. First, it has been proposed for sinogram denoising of PET data. Data processing along sinusoidal curves has a potential (Happonen 2002, Krestyannikov 2004a) and a superiority (Happonen 2005b) to other sinogram filtering methods for this imaging modality. An application of stackgram denoising to the attenuation-corrected PET data can be found in (Krestyannikov 2004b). A study on exact formulation of filters can be found in (Peltonen 2010). A similar technique has also been proposed for noise reduction of low-dose CT data (Happonen 2007b). The stackgram filtering was also used for denoising of SPECT data (Happonen 2007a). A method based on a similarity comparison within the neighborhood of locus-signals in stackgram has been proposed for alignment of tomographic data in dynamic PET (Happonen 2003, Happonen 2004, Kostopoulos 2006). Another application of the stackgram, which can be found in literature, is an extrapolation of limited-angle data (Happonen 2005c). A similar sinogram decomposition approach has been proposed by A. Zamyatin for restoration of the truncated data (Zamyatin 2007). J. Caramelo (Caramelo 2005) proposed a reconstruction method based on the sinogram decomposition into single sinogram curves, which has similarities to the stackgram approach. Another paper was published in 2012 which proposes an inpainting based on sinusiod-like curve decomposition and uses an eigenvector-guided interpolation (Li 2012).