Abstract: Double Your Views: Exploiting Symmetry in Transmission Imaging

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For a plane symmetric object we can find two views – mirrored at the plane of symmetry – that will yield the exact same image of that object. In consequence, having one image of a plane symmetric object and a calibrated camera, we can automatically have a second, virtual image of that object if the 3D location of the symmetry plane is known. In this work, we show for the first time that the above concept naturally extends to transmission imaging and present an algorithm to estimate the 3D symmetry plane from a set of projection domain images based on Grangeat's theorem. We then exploit symmetry to generate a virtual trajectory by mirroring views at the plane of symmetry. If the plane is not perpendicular to the acquired trajectory plane, the virtual and real trajectory will be oblique. The resulting X-shaped trajectory will be data-complete, allowing for the compensation of in-plane motion using epipolar consistency [1].

Utilizing Grangeat's theorem, we can measures the pairwise consistency of two projections by comparing corresponding epipolar lines. The theorem explains a transformation of the projection images, such that two values must match if they correspond to two epipolar lines. This value equals a transformation of the object mass within the epipolar plane – i.e. the derivative of the Radon transform. It directly follows, that inconsistency induced by a rigid object motion within the epipolar plane cannot be detected, as the object mass within the epipolar plane is not affected. In a circular trajectory, most of the measurable epipolar planes are parallel to the acquisition plane, limiting the detectable inconsistencies to motion that steps out of the acquisition plane. As a result, out-plane motion is well compensable while in-plane motion remains an open challenge.

This limitation can be mitigated by the X-shaped trajectory. This enables epipolar planes in more directions and it is shown that with an adequate tilde between the acquisition plane and the plane of symmetry, in-plane motion becomes well detectable.

References

1. Preuhs A, Maier A, Manhart M, et al. Double your views: exploiting symmetry in transmission imaging. Proc MICCAI. 2018; p. 356–364.