Double Your Views – Exploiting Symmetry in Transmission Imaging

Alexander Preuhs[1], Andreas Maier[1], Michael Manhart[2], Javad Fotouhi[3], Nassir Navab[3], and Mathias Unberath[3]
[1]Pattern Recognition Lab, Department of Computer Science, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany
[2]Siemens Healthcare GmbH, Forchheim, Germany
[3]Computer Aided Medical Procedures, Johns Hopkins University, Baltimore, USA

Purpose

State of the Art:

- **Symmetry** is a **widely used concept** in computer vision
- In the **medical** context, **knowledge** of **symmetry plane** can be used for various tasks:
  - **Alignment** of volumes
  - **Detection** of "symmetry breakers" e.g. tumors
  - **Comparison** of blood flow in perfusion imaging
- **Symmetry** has **never** been inspected for **transmission imaging**

Contribution:

- **Projection-based** approach to **estimate** the **plane** of **symmetry**
- A novel **X-trajectory** for symmetric objects **that enables**:
  - **Tuy-complete imaging** with a short scan
  - **Estimation** of **in-plane motion** in the projection domain

Symmetry Plane Estimation

Having a plane symmetric object, **two distinct views** exhibit the very **same projection** of this object. This property is **exploited** to find the **plane of symmetry**. This is achieved by **enforcing geometric consistency** of a pair of projections, i.e. an acquired view and a virtual mirrored view.

Measure of Consistency: Epipolar Consistency (EC)

- The **epipolar lines** of two projections constitute a **weighted plane integral** of the underlying epipolar plane (cf. Fig. 1)
- **Grangeat's theorem** constitutes that both lines **must be equal** (after transformation, mainly integration and derivation)
- This is used to evaluate the geometric consistency of two views

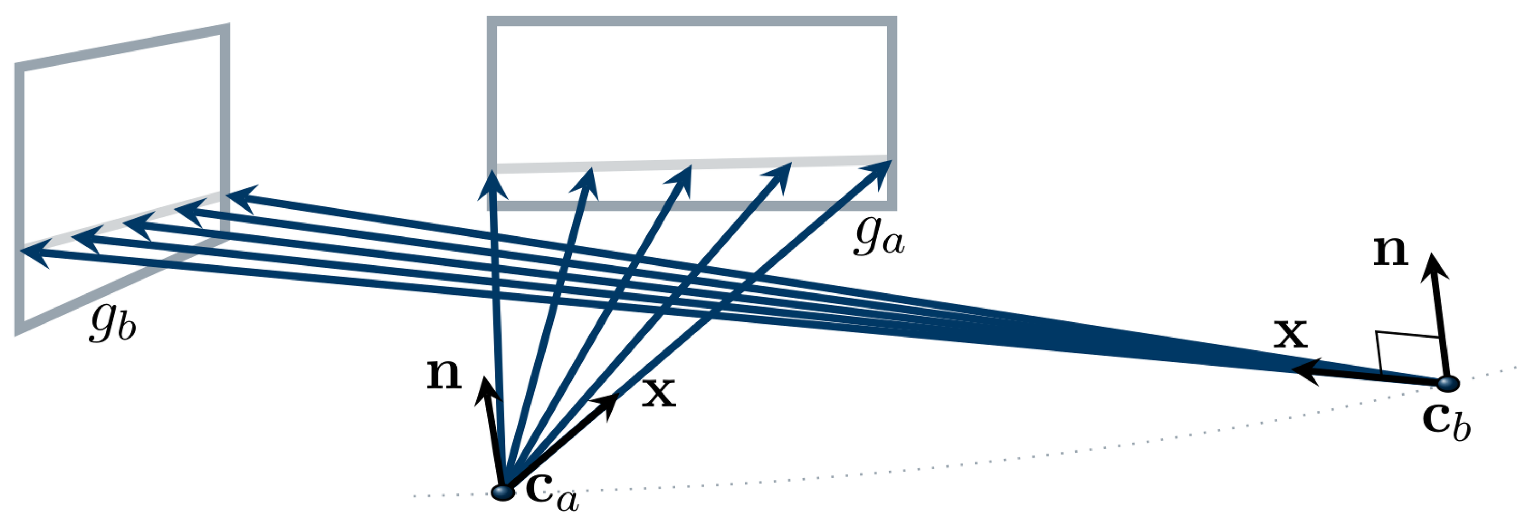

Figure 1: Schematic drawing of a two view geometry with drawn epipolar lines.

Symmetric View Augmentation

- The scene in Fig. 2 is plane symmetric under transformation $\mathbf{F}$
- In the trivial case, $\mathbf{F}$ just flips the sign of the $\mathbf{x}$ component
- We can **find the plane of symmetry** by finding a **geometry** $\mathbf{PF}$, that most **consistently describes** a projection acquired under $\mathbf{P}$

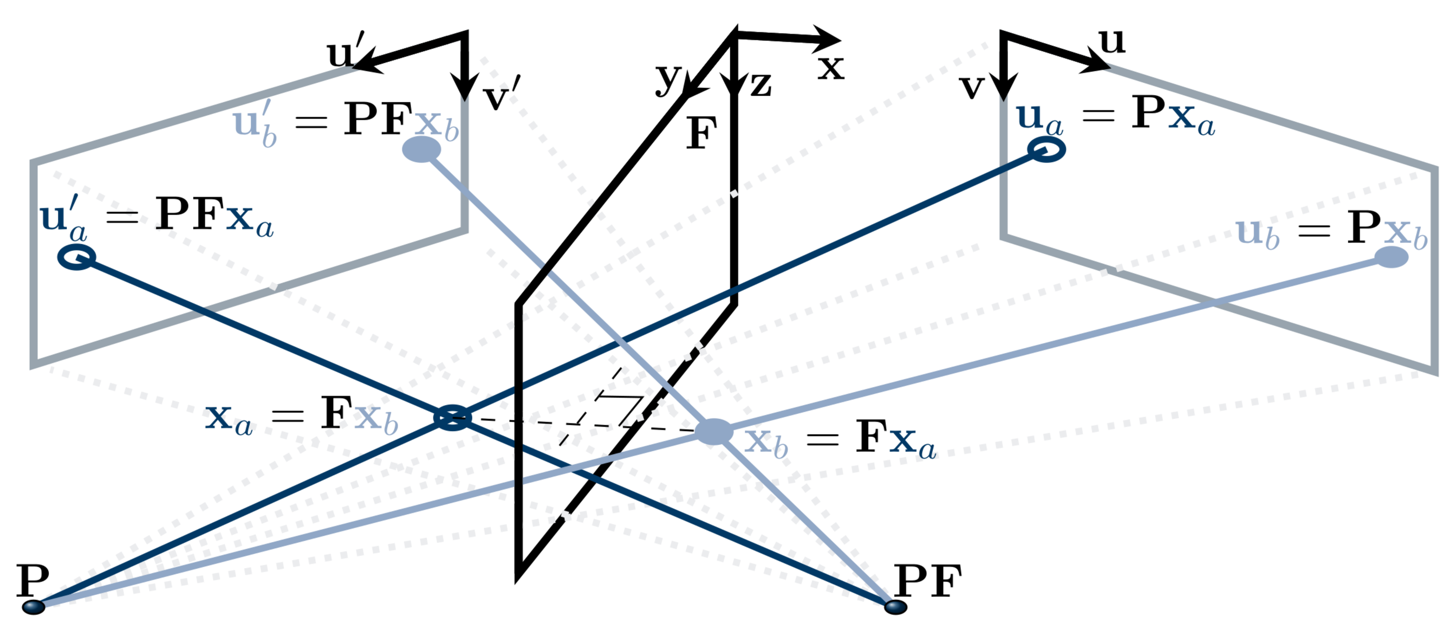

Figure 2: Visualization of a plane symmetric scene.

Flowchart: Processing sequence. Light gray denote steps using epipolar consistency.

The X-Trajectory

- With the symmetry transformation $\mathbf{F}$ we can **generate** a **virtual trajectory**, with known projection images
- The **acquired** and **augmented trajectory** will form the **X-trajectory** depicted in Fig. 3.

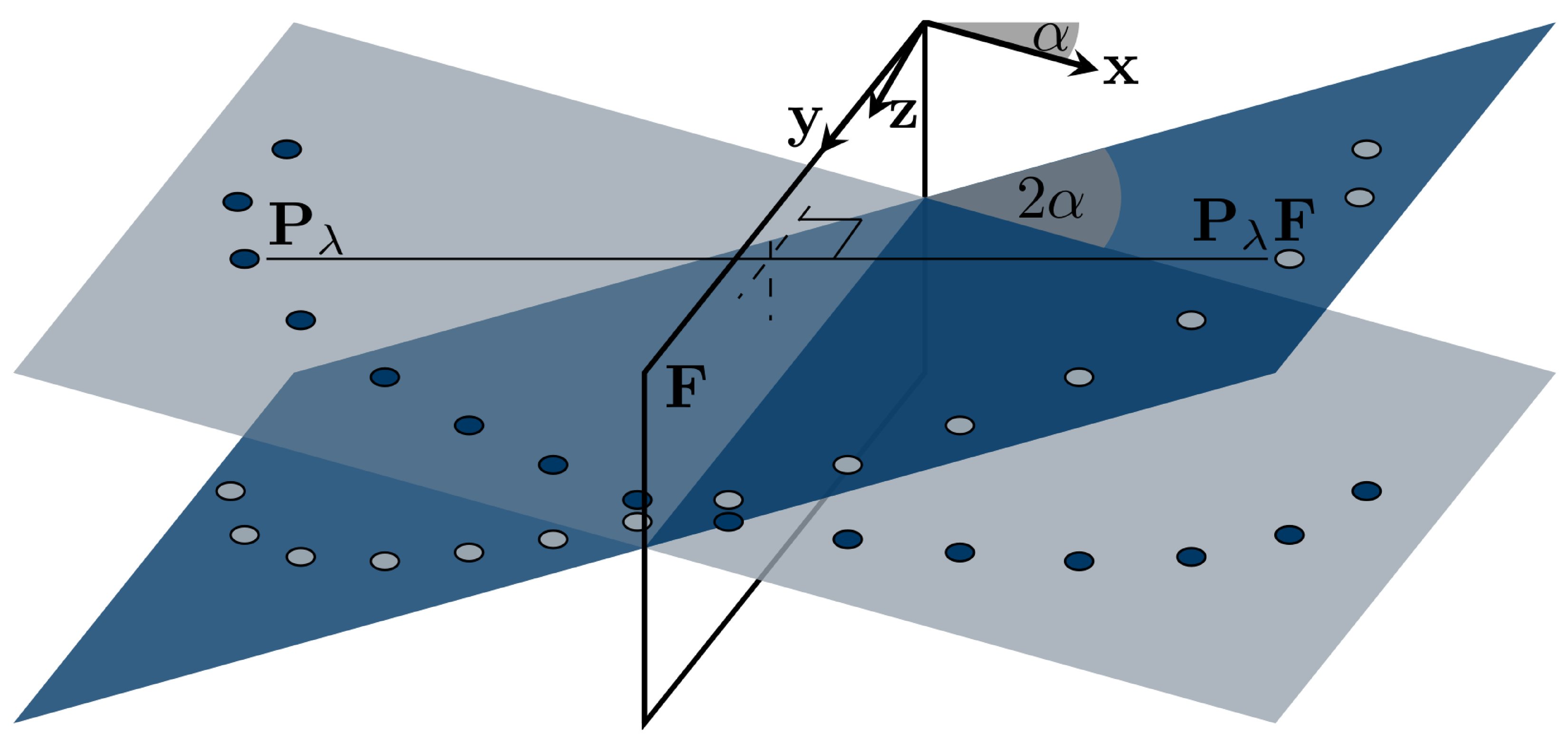

Figure 3: X-trajectory formed by acquired (blue dots) and virtual (gray dots) trajectory.

- With adequate tilt between the trajectory planes:
  - X-trajectory is **Tuy-complete**
  - **In-plane motion** is **detectable** by EC

Results

Symmetry Plane Estimation

1. **Accuracy** on synthetic data **in range ~10^{-4}** mm/degree
2. Well defined on anthropomorphic head phantom (cf. Fig. 4)

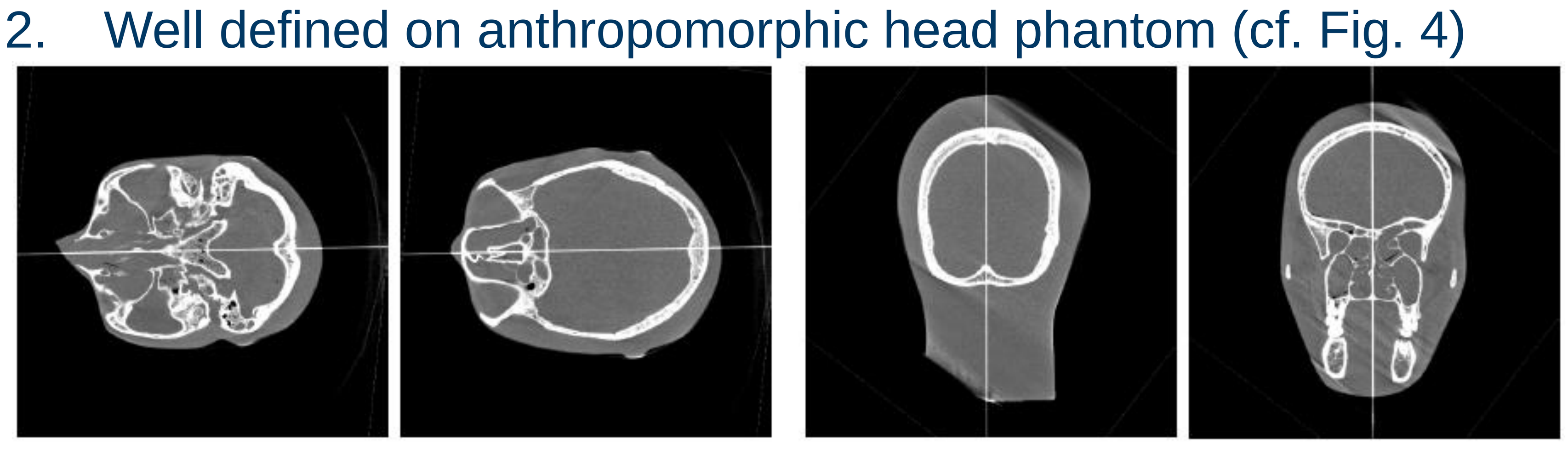

Figure 4: Aligned reconstruction of anthropomorphic head phantom with estimated symmetry plane (Artis zeego, Siemens Healthcare GmbH, Forchheim, Germany).

Application to Rigid Motion

- Motion impulse applied separately in all 6 DoF
- In-plane motion is not detected using conventional EC (cf. Fig. 5)
- **In-plane motion** becomes **detectable** on **X-trajectory**

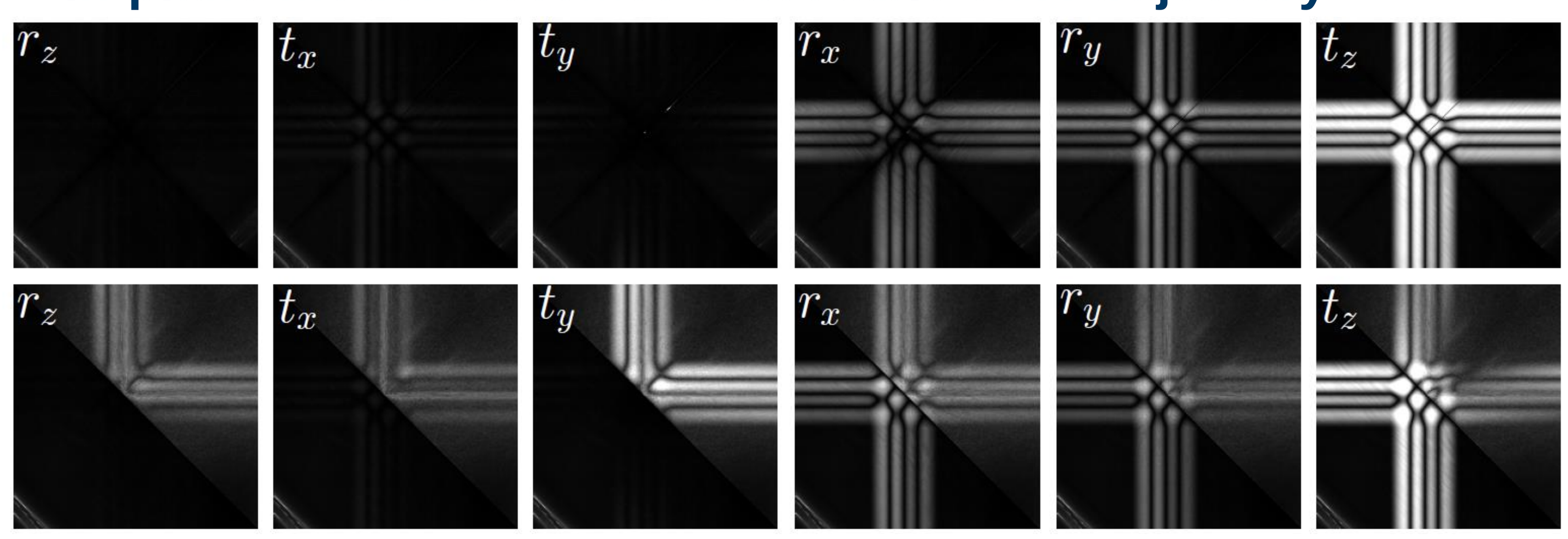

Figure 5: Consistency plots with white color encoding detected consistency. **Upper row**: no tilt between mirrored and acquired trajectory. **Lower row**: X-trajectory with $60°$ tilt ($2\alpha = 60°$). Each plot shows the **conventional EC in the lower left** triangle of the grid, and the **consistency of the X-trajectory in the upper right triangle**.

Contact

Alexander Preuhs
Pattern Recognition Lab, Department of Computer Science, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany
✉ Alexander.Preuhs@fau.de
☎ +49 9131 85 56 58 68

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