Viewpoint Planning for Quantitative Coronary Angiography

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Purpose

Coronary Angiography:

- Assessment of coronary blood supply by **2-D X-ray projections** of contrasted arteries
- Immanent **dimensionality reduction** by projection
- **Viewpoint** is **critical** to guarantee appropriate view on affected artery

Aim:

- Compute **optimal viewpoints** for **assessment** of coronary **arteries** (Fig. 1)

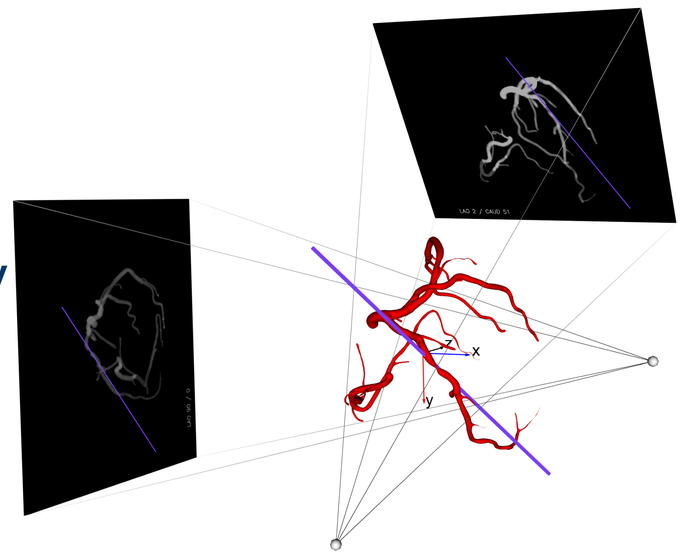


Figure 1: Visualization of coronary arteries and two optimal views. The views are rotated around an axis and orthogonal to the vessel of interest.

Material and Methods

We introduce the **concept of optimal viewpoint planning** solely **based** on a **single angiographic** X-ray **image** (cf. Fig. 2).

1. **Principal ray alignment:**
   - If vessel is **not** on the **central ray**, it is already **observed** from a certain **cone angle**
   - This is **corrected** by the principal ray alignment
2. **Isocenter rotation:**
   - A rotation axis is defined that is **incident to the isocenter** and has the **same orientation as the vessel**
   - The aligned **view is angulated** around the rotation axis, by a **physician determined angle**
3. **Isocenter offset correction:**
   - If the **rotation axis** is not the **actual vessel**, then we rotate around the wrong rotation center
   - The isocenter **offset minimizes this error** by an additional **translation**

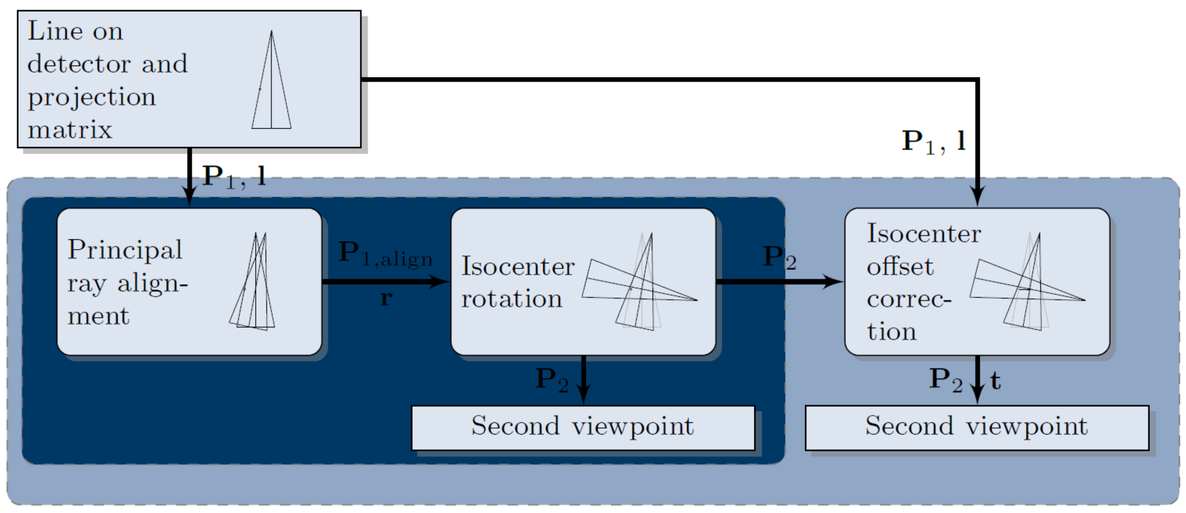


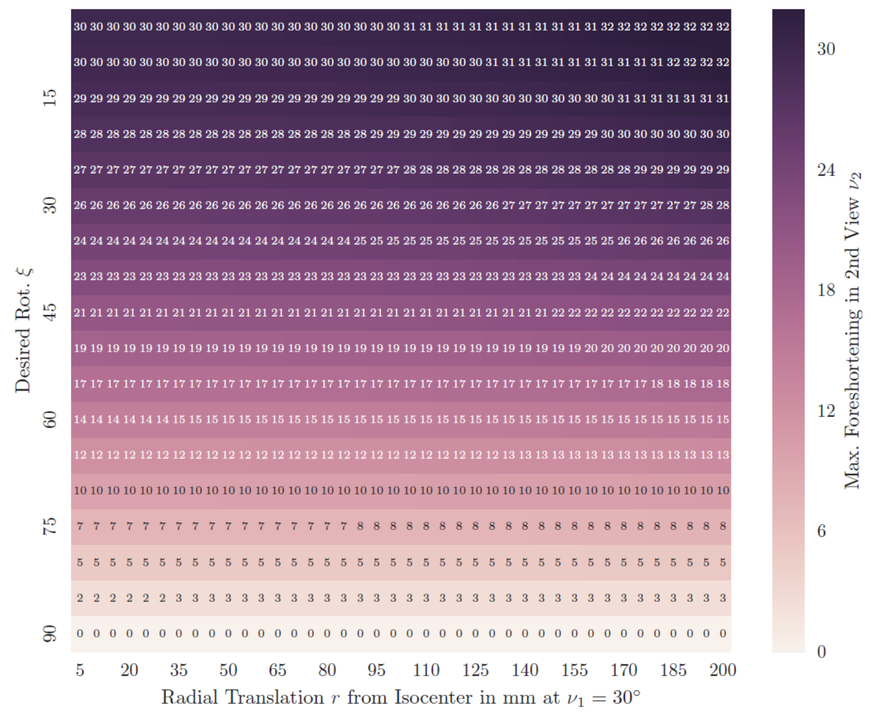
Figure 2: Flowchart showing the proposed viewpoint planning. The input is a line defined on the detector, the output is the proposed optimal viewpoint for the C-arm.

Evaluation and Results

- The **precision** of the algorithm (foreshortening in second view ν_2 and deviation from desired rotation ϵ) **depends on** the **input view** (initial foreshortening ν_1) and the desired rotation ξ
- We **evaluate** the algorithm **regarding its reliability** within a clinical workflow (Fig. 3-5)

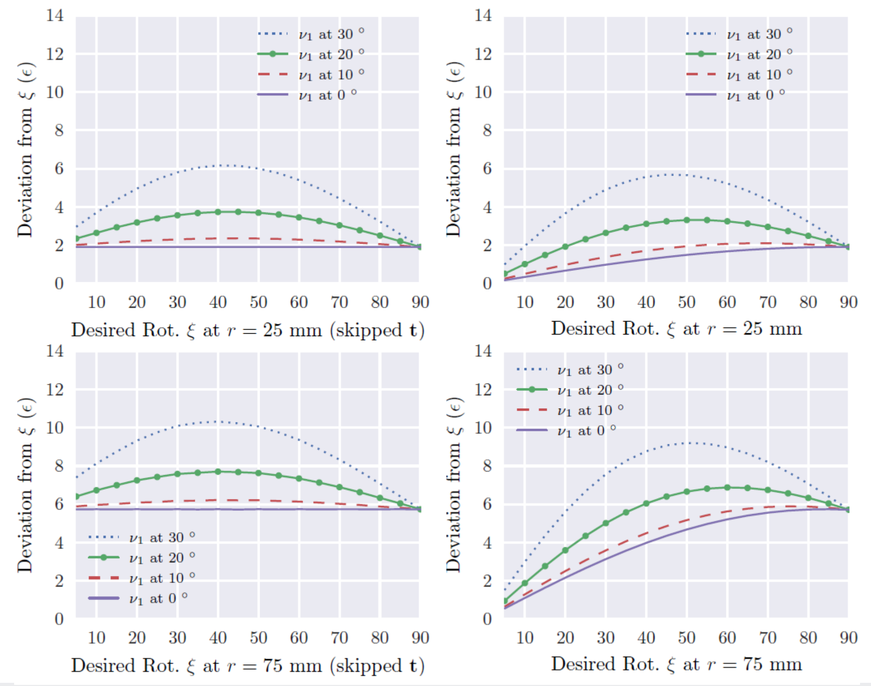
Evaluation of Foreshortening

Figure 3: Heatmap showing the maximal foreshortening in the second view for vessels having an initial foreshortening of $\nu_1 = 30°$.

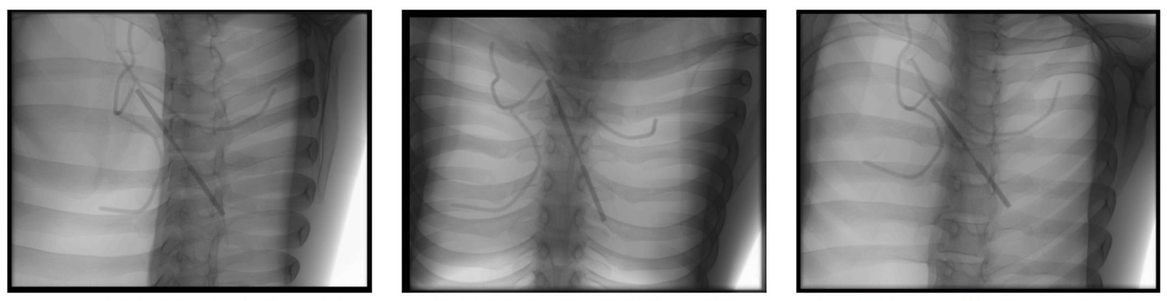


Angular Precision

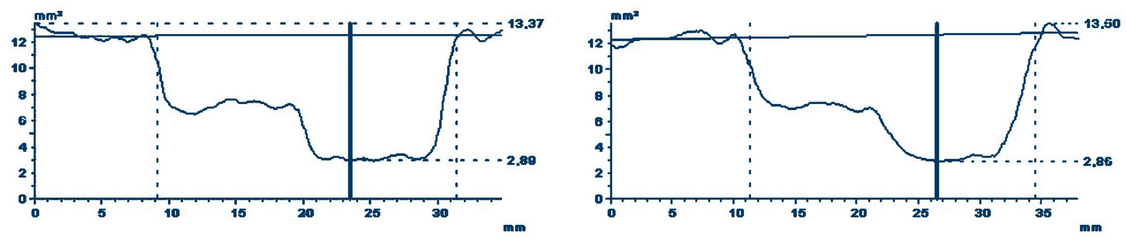
Figure 4: Plots depicting ϵ as a function of ξ. The two plots in the left column correspond to the algorithm with skipped translation, and the two plots in the right column correspond to the full algorithm.



Phantom Study



(a) RAO: 27, CAUD: 11. (b) LAO: 6, CAUD: 30. (c) RAO: 15, CRAN: 13.



(d) QCA using 5(a) and 5(b) as inputs. (e) QCA using 5(a) and 5(c) as inputs.

Figure 5: Top Row: input views for QCA generation. The initial view (a), a second view generated using the proposed viewpoint planning with $\xi = 35°$ (b), and a manual selected view (c). Bottom: Area curves deduced from a 3-D QCA using two input views.

Discussion and Conclusion

- **No need** for **3-D models** as necessary for all previous methods
- Workflow **seamlessly integrates** into current **clinical workflow**
- **Standardizes viewpoints** to guarantee high quality QCA
- Helpful **navigation** tool especially for novice physicians

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