

KINOVIS Hybrid Capture Platform

Kinovis capture platform

- 10 video cameras (4 Mpix)
 - 3D surface motion
 - Up to 100fps
- 2 X-ray C-arms (1 Mpix)
 - In-depth motion
 - Up to 30 fps
 - Low radiation dose
- Capture volume: 30x30x30cm



Motivation

Objectives

- Capture dense model of moving samples
- Study correlation between surface and in-depth structure motion

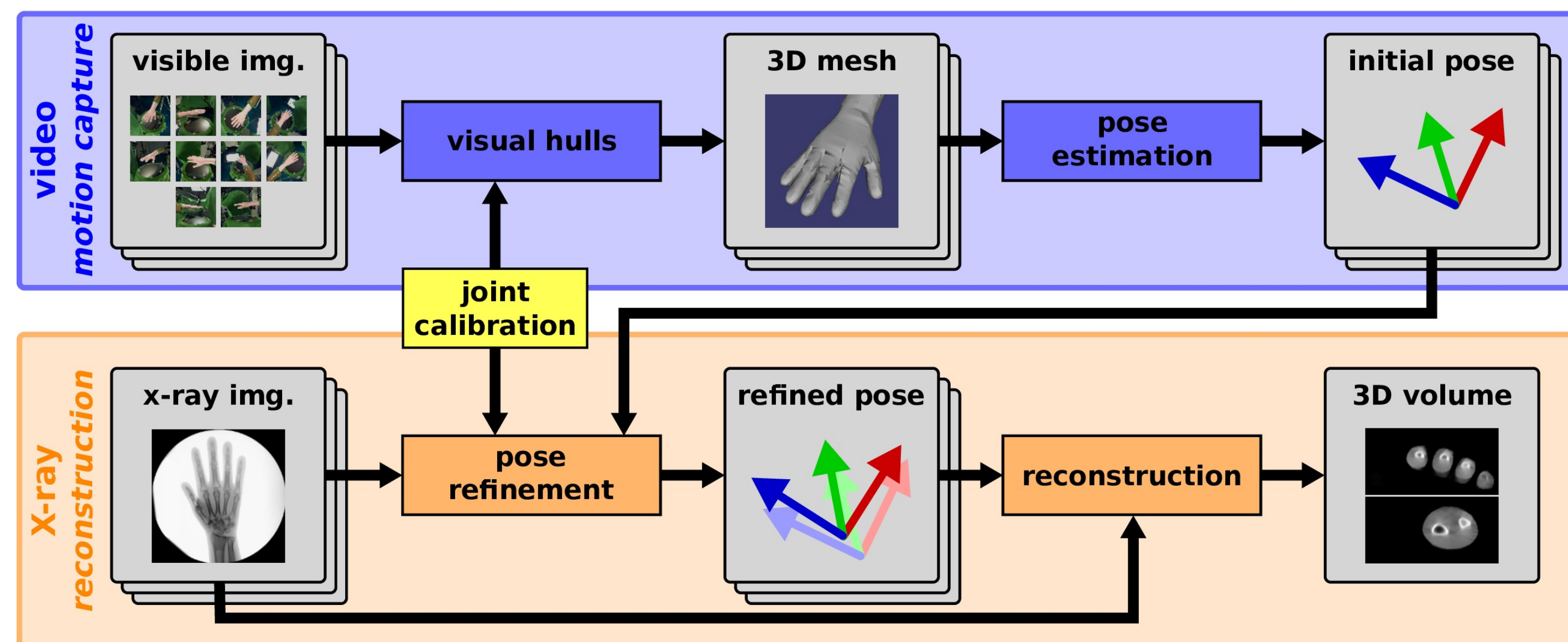
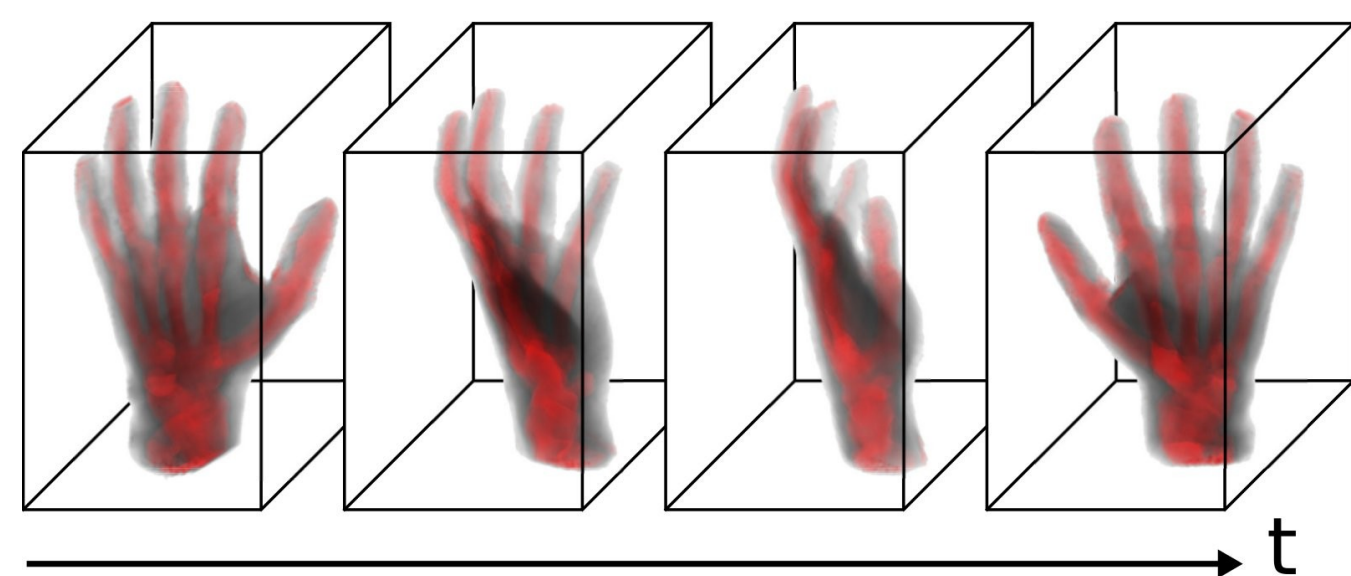
Benefits compared to regular CBCT

- Limit patient radiation
- Reduce costs
- Ability to capture motion

Proposed Approach

Overall idea

- Move sample rather than X-ray device
- Recover sample rigid motion using video
- Volumetric reconstruction from X-ray
 - Generative image formation model
 - Inspired by super-resolution approaches [1]



Generative Image Formation Model

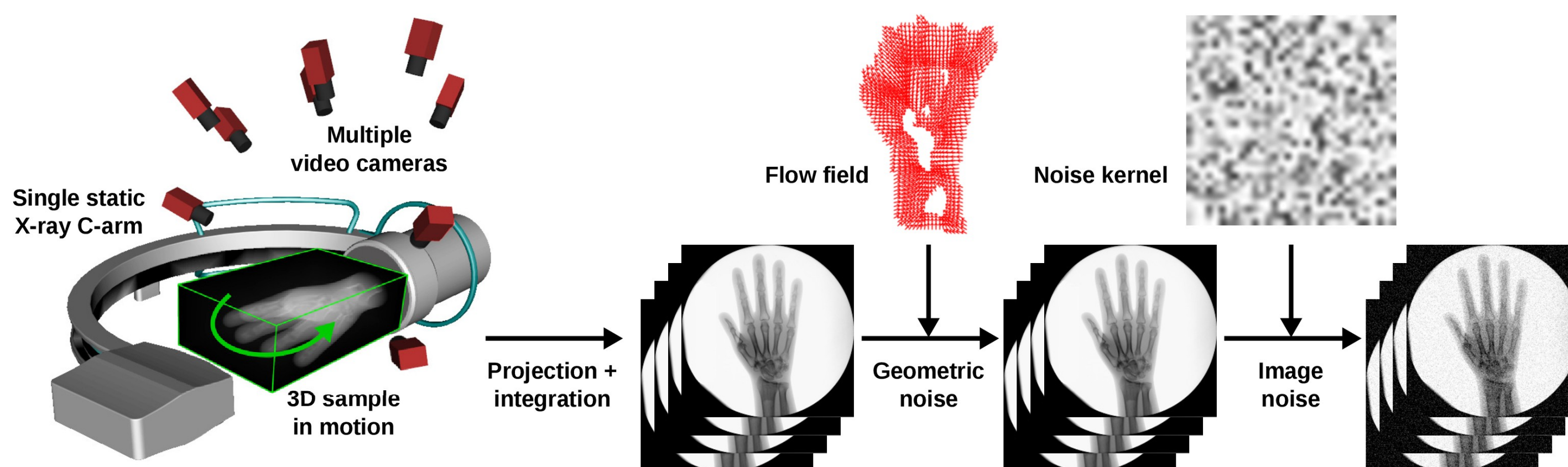


Image formation model composed of:

- Known projection/integration matrix
- 2D image noise (light source, amplifier, sensor, ...)
- 3D geometric noise (motion, projection, ...)

MAP estimation:

- Volumetric attenuation
- 2D & 3D noise parameters
- Regularisation: TV L_1 prior

Bayesian Model Estimation

Iterative independent estimation of:

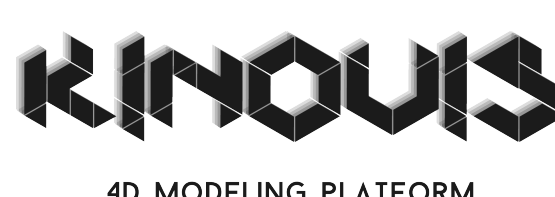
- Attenuation given 2D & 3D noise using Iteratively Reweighted Least Squares (IRLS) with TV L_1
- 2D image Gaussian noise variance based on residual error (gamma distribution)
- 3D geometric warp based on residual optical flow

Video link



Acknowledgements

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References

- [1] C. Liu and D. Sun. **On Bayesian adaptive video super resolution**. TPAMI 36(2), 346-360 (Feb 2014).
- [2] J. Pansiot, L. Reveret, and E. Boyer. **Combined Visible and X-ray 3D Imaging**. MIUA, pp. 13-18, London, 2014.

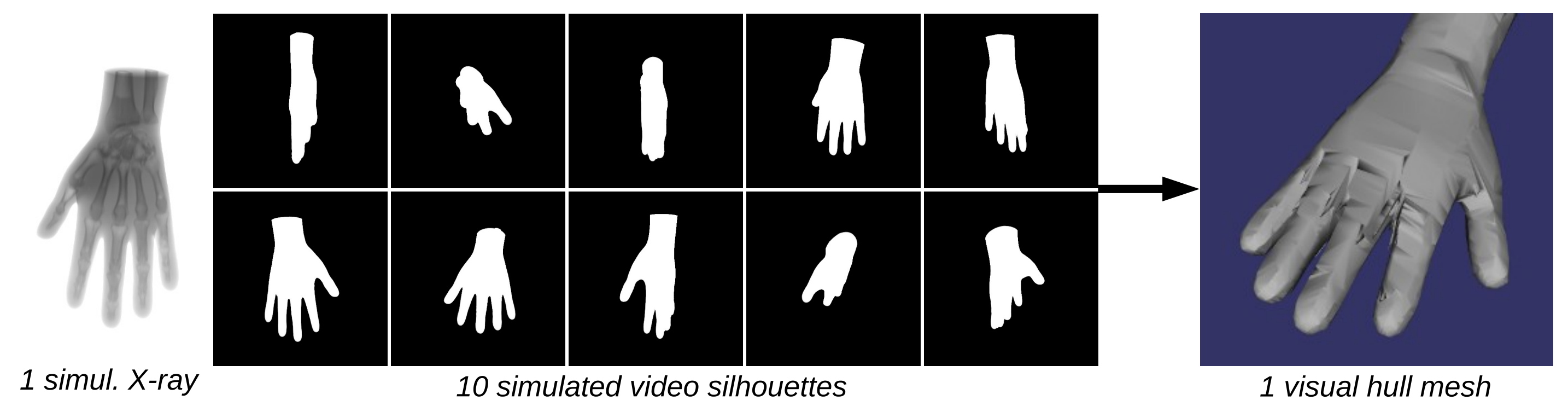
Simulated Forearm Phantom

Forearm phantom CT scan rendered as:

- 10 video silhouettes (thresholding)
- 1 X-ray image (raycasting)

Simulated motion

- Moved over 32 frames
- Rotation over $\sim 180^\circ$



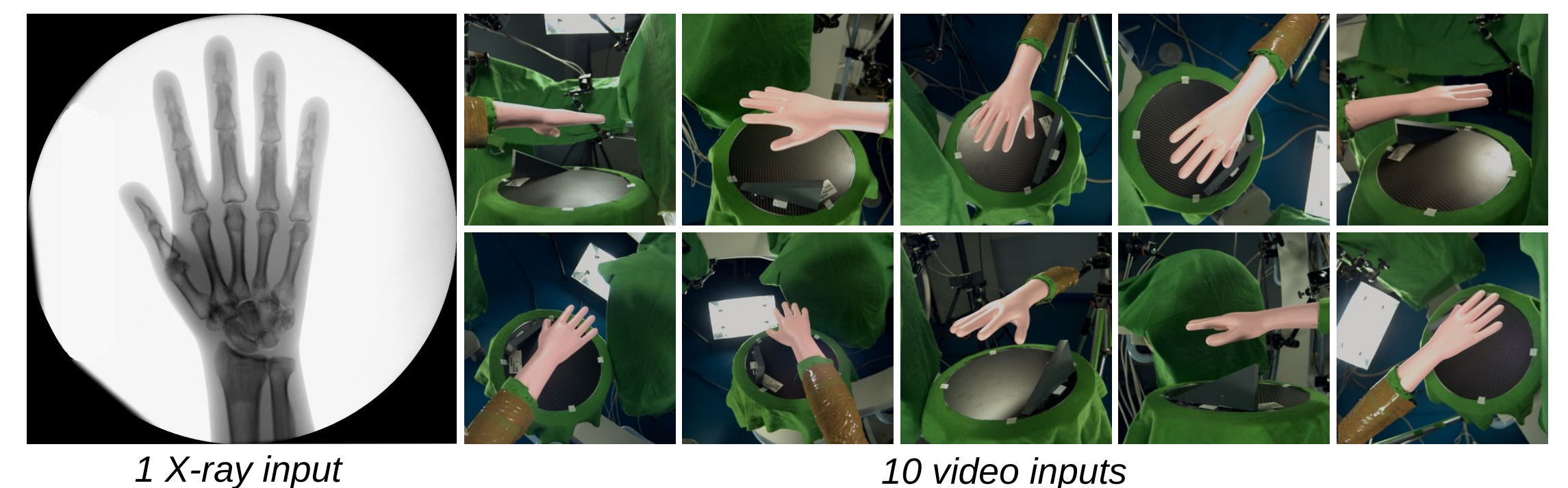
Results

Ground truth CT	Proposed method	Without optical flow	Without TV L_1 prior	ART [2]
RMS Error	0.125	0.134	0.180	0.072
MI score	0.338	0.318	0.177	0.309

In-situ Forearm Phantom

Forearm phantom

- 10 video cameras
- 1 X-ray C-arm
- 20 frames
- Rotation $\sim 180^\circ$



Results

Ground truth CT	Proposed method	Without optical flow	Without TV L_1 prior	ART [2]
MI score	0.146	0.137	N/A (failed)	0.094

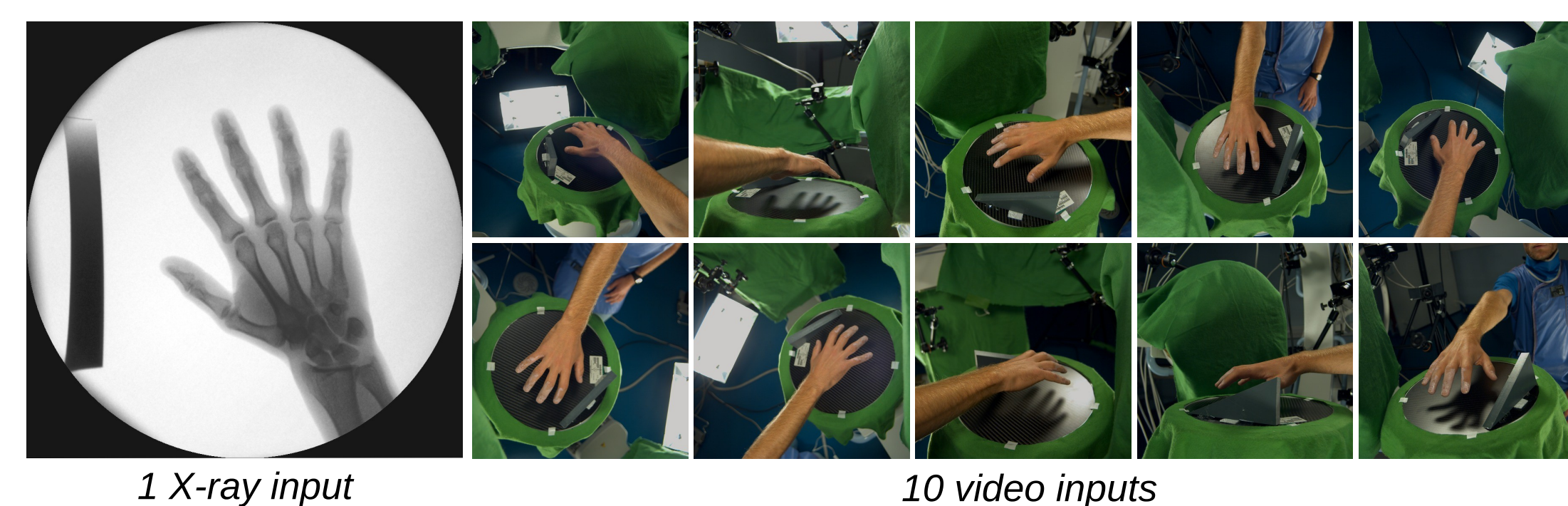
In-vivo Human Hand

In-vivo human hand data

- 10 video cameras (sensor: 4 Mpix - utilised: 1MPix)
- 1 X-ray C-arm (1 Mpix)
- Volumetric resolution: 0.8mm/voxel

Actual motion

- Moved over 20 frames at 10 fps
- Free wrist rotation over $\sim 180^\circ$
- Near-rigid



Results

Proposed method	Reduced TV L_1 prior	Without TV L_1 prior	Without optical flow	ART [2]

Cone-beam planar integration rendering over time

