ShaRPy: Shape Reconstruction and Hand Pose Estimation From RGB-D with Uncertainty

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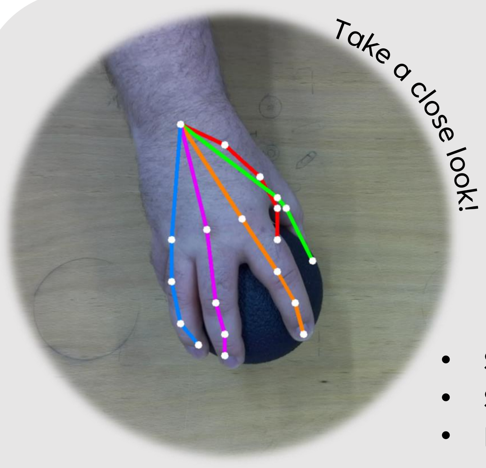
Contributions

First markerless RGB-D approach tailored to medical applications



Focus on **plausibility** of motions

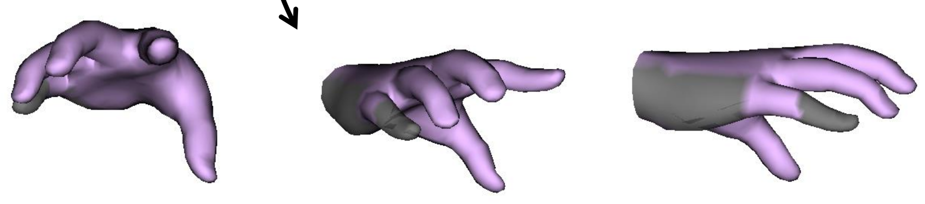
- Speculated hidden parts
- Speculated skeleton
- Misclassified predictions

Keypoint-based SOTA [2,3]

Focus on **reliability** of motions with **Uncertainty Estimation**

ShaRPy

Single RGB-D Camera (arbitrary model)

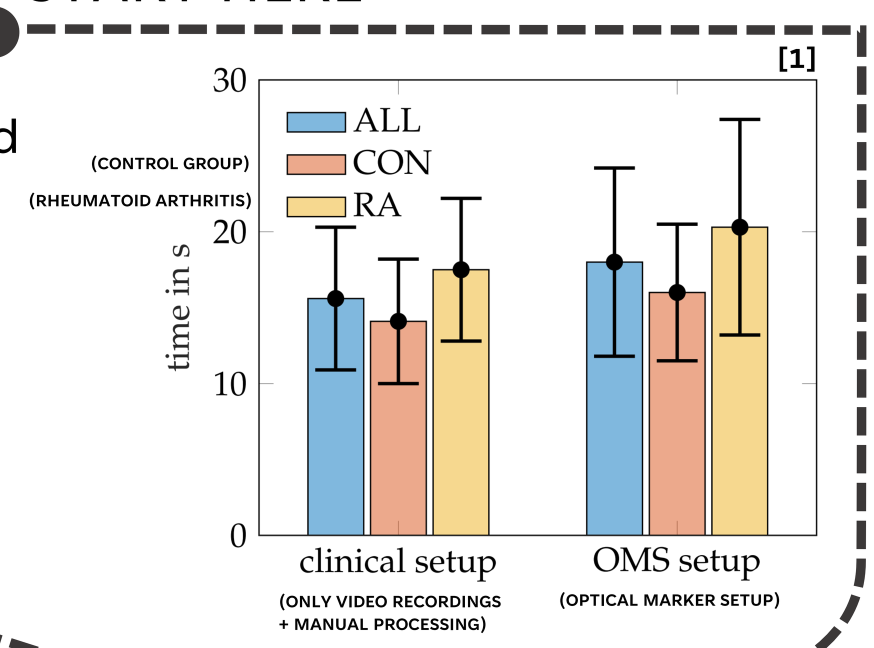


Intuitive 3D visualization of **pose** and **personalized** hand **shape**

Motivation

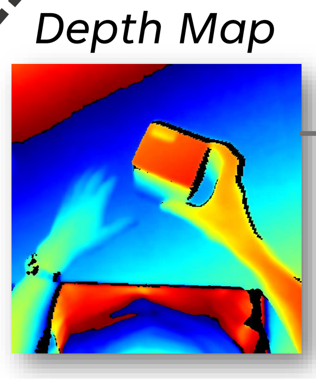
START HERE

Musculoskeletal **diseases** on the hand can be detected through **motion**.
How can we objectively evaluate the hand function of a patient?
Current SOTA with **OMS is time-consuming and not intuitive**
→ **Markerless methods**

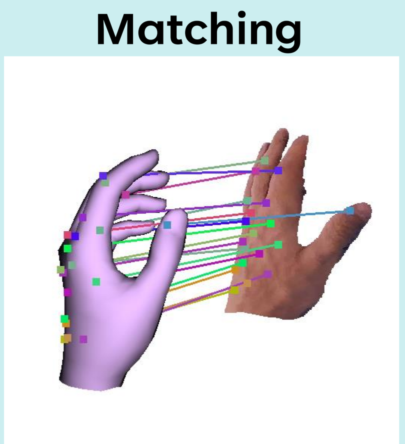


Methods

Neural Object Detector

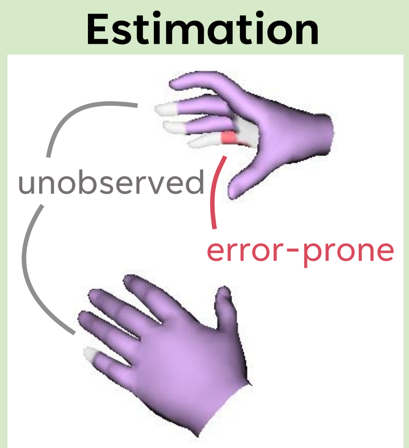


Correspondence Matching

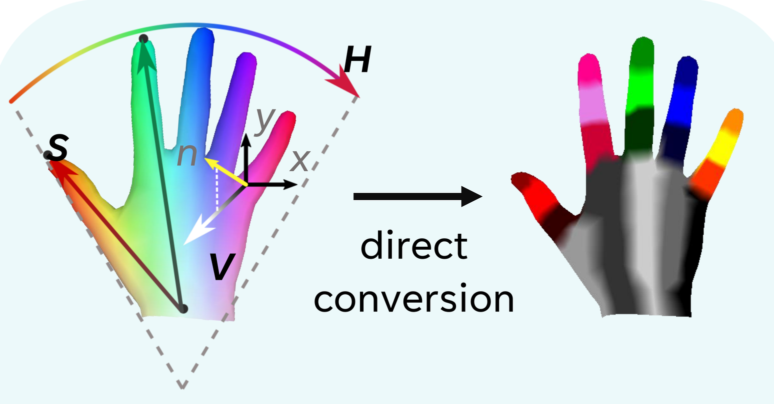


Pose and Shape Tracking

Uncertainty Estimation



re-use temporal information $k-1 \rightarrow k$



Anatomically aligned canonical correspondence space (H, S, V)

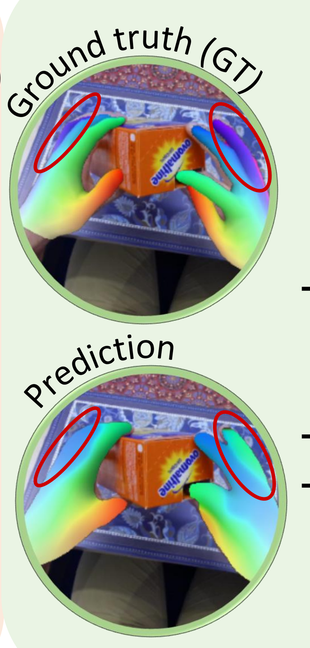
Segmentation map

Optimal Params

$$\Omega^k = (R^k, t^k, \theta^k, \beta^k)$$

$$\underset{\Omega^k}{\arg\min} \begin{bmatrix} E_{3d}(\mathcal{C}_{3d}) \\ + \; E_{2d}(\mathcal{C}_{2d}) \\ + \; E_{shape}(\beta) \\ + \; E_{pose}(\theta) \\ + E_{temp}(\theta^{t-1}, \theta^t) \end{bmatrix}$$

data



Predicted Inconsistencies yield high or no residuals

→ Cluster residuals per segment

→ Thresholding

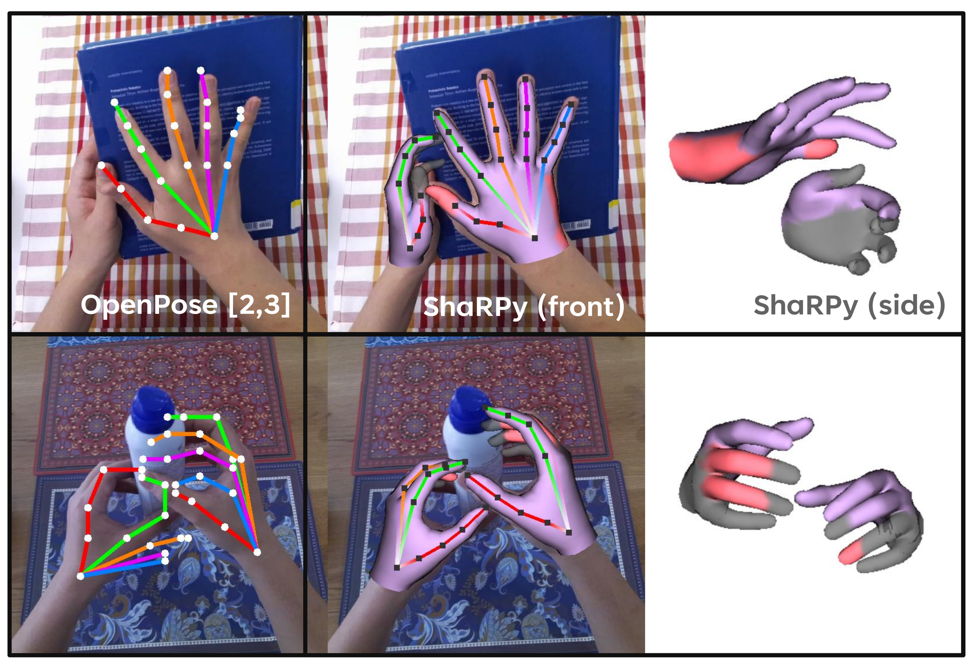
→ Error-prone & unobserved segments

Results

Evaluation on **H2O** Pose Estimation

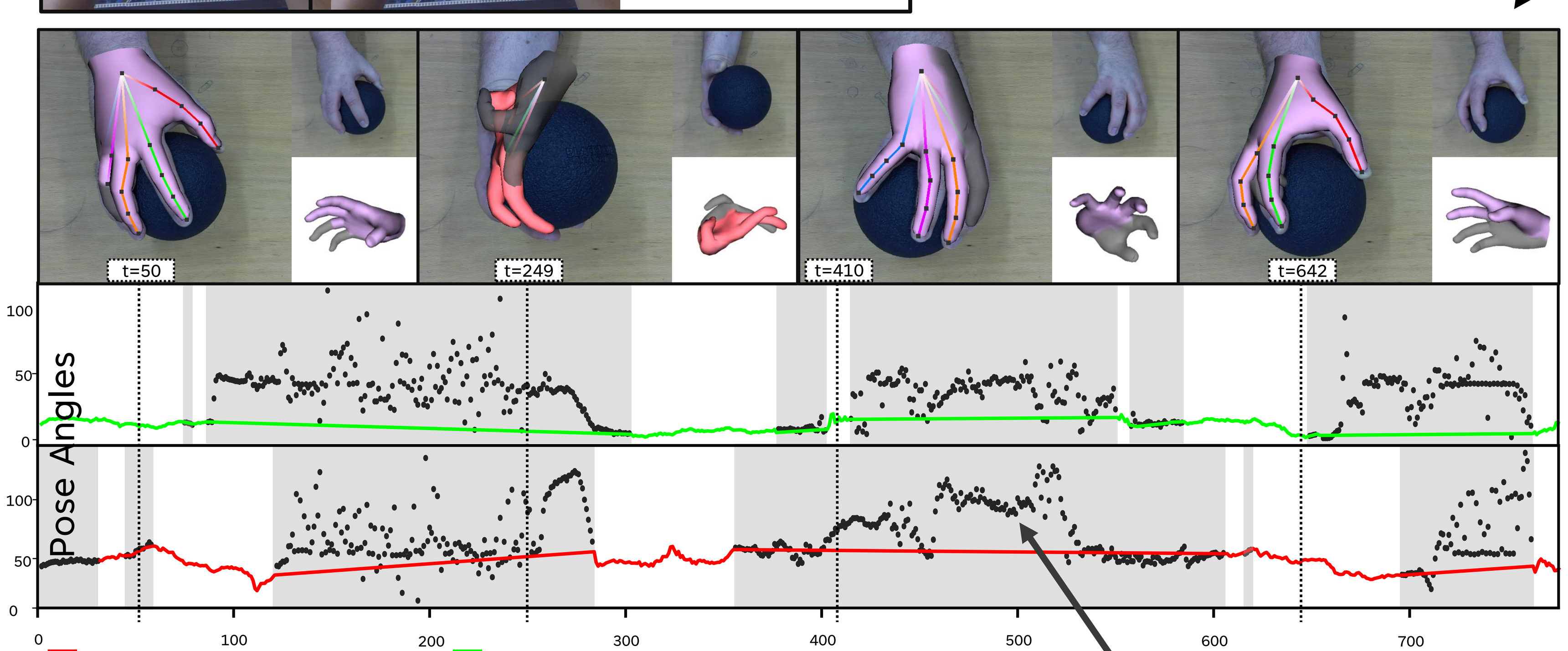
ShaRPy achieves **2nd place** w.r.t. MEPE

	MEPE (mm) ↓		3D PCK@15mm ↑	
	Left	Right	Left	right
Hasson et al. (CoRR 2020)	39.56	41.87	-	-
Tekin et al. (CVPR 2019)	41.32	38.86	-	-
Kwon et al. (ICCV 2021)	41.45	37.21	-	-
Aboukhandra et al. (WACV 2023)	36.80	36.50	-	-
Cho et al. (CVPR 2023)	24.40	25.80	-	-
Wen et al. (CVPR 2023)	35.02	35.63	12.67	2.98
Cho et al. (HBHA@ECCV 2022)	14.40	15.90	70.75	54.61
Luo et al. (HBHA@ECCV 2022)	20.80	24.70	40.77	32.29
Ours	**20.47**	**19.07**	**21.04**	**27.81**



Qualitative Evaluation with **OpenPose**

Hand function tests on PsA patient → discard unreliable poses



THE END

[1] **U. Phutane et al.:** *Evaluation of Optical and Radar Based Motion Capturing Technologies for Characterizing Hand Movement in Rheumatoid Arthritis—A Pilot Study (Sensors 2021)*
[2] **Z. Cao et al.:** *OpenPose: Realtime Multi-Person 2D Pose Estimation using Part Affinity Fields (TPAMI 2019)*
[3] **T. Simon et al.:** *Hand Keypoint Detection in Single Images using Multiview Bootstrapping (CVPR 2017)*

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