

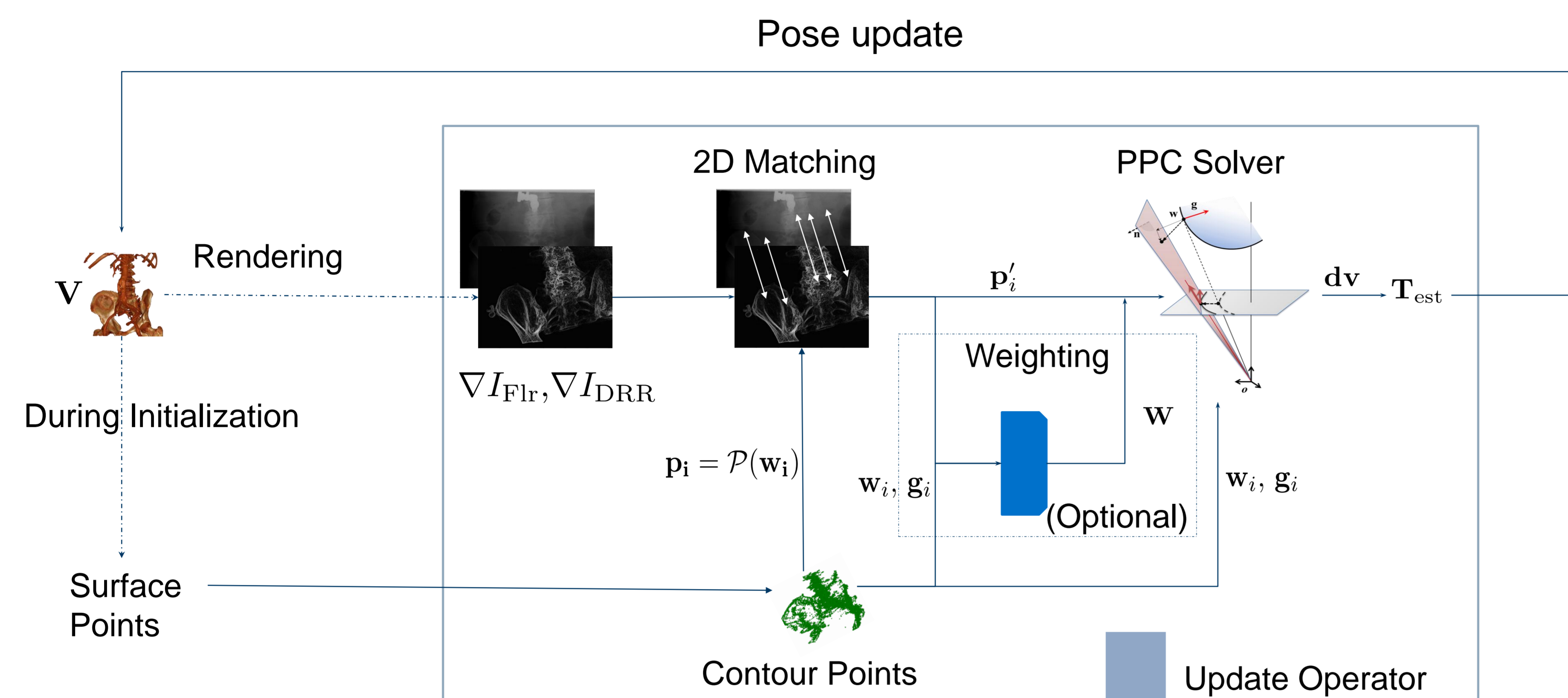
Learning the Update Operator for 2D/3D Image Registration

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2D/3D Registration Framework using Point to Plane Correspondence(PPC) Model^[1]



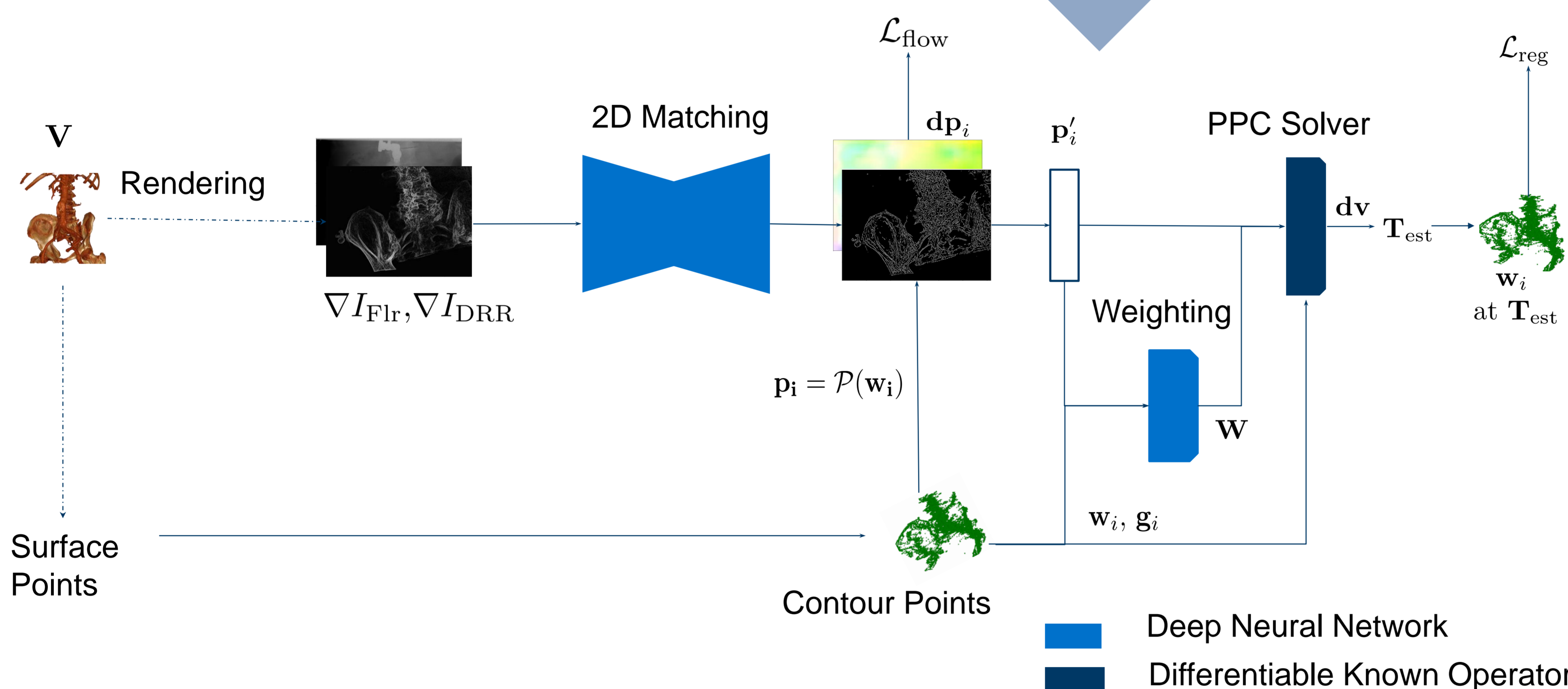
Goal: Learn the update operation of the registration framework proposed in [1].

The update operation consists of

- 2D Matching
- Correspondence Weighting (optional)
- Solve for 3D motion with PPC solver

PPC solver is **differentiable** and can be used as **known operator**^[2] to train DNN.

Learning the Update Operator



Models considered:

Flow (Baseline) ^[3]:

- Learn correspondence estimation in isolation.

PPC Flow - Known Operator Learning

- Uses PPC solver as known operator in addition to Flow to learn correspondence.

PPC Flow Attention

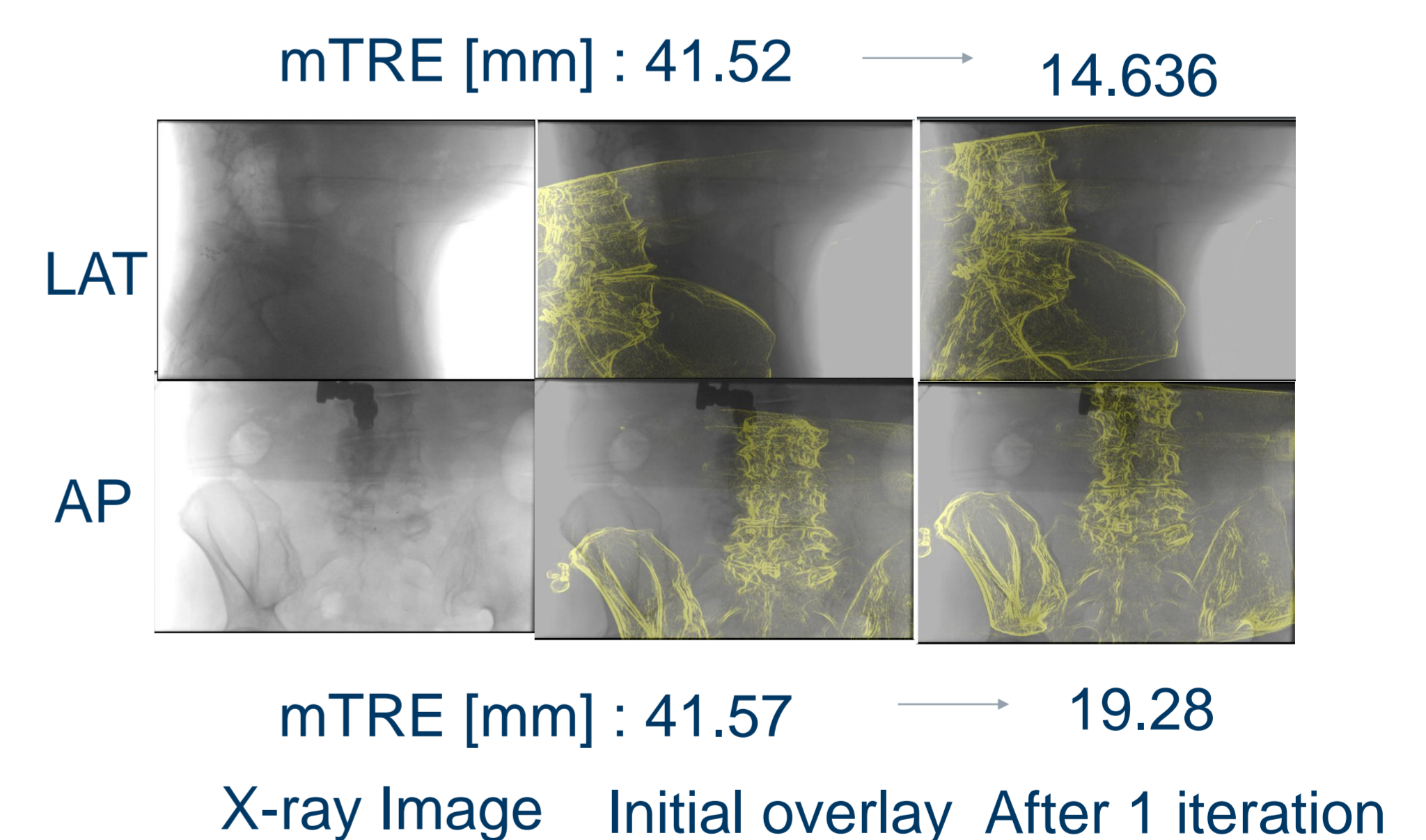
- Combines correspondence weighting (PointNet Attention^[4]) and PPC Flow model.

Results

	Percentile mTRE [mm]			mTRE [mm]	Reduction Factor
	50 th	75 th	95 th	$\mu \pm \sigma$	$\mu \pm \sigma$
Initial	20.18	30.09	39.75	20.59 ± 11.76	
Flow	7.45	15.20	34.59	11.27 ± 11.66	0.47 ± 0.38
PPC Flow	5.03	8.80	15.41	6.21 ± 4.70	0.68 ± 0.17
PPC Flow Attention	4.70	8.31	14.68	5.88 ± 4.50	0.69 ± 0.17

Evaluation of the models computed on the test data set after one registration update. We used CBCT reconstruction data set with 38 patients for training, 5 patients for validation and 12 patients for testing.

1. PPC Flow improves the performance by a **factor of ~2** and requires **no additional learnable parameters** compared to Flow.
2. Additionally, joint learning of correspondence estimation and weighting is possible and this improves the performance even more compared to PPC Flow.



Overlay after one update step for AP and LAT views from one patient on test data set of the best performing model (PPC Flow Attention)

References

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- [2] Maier AK, Syben C, Stimpel B, et al. Learning with known operators reduces maximum error bounds. Nature machine intelligence. 2019;1(8):373–380.
- [3] Schaffert R, Weiß M, Wang J, et al. Learning-Based Correspondence Estimation for 2-D/3-D Registration. In: Proc BVM. Springer; 2020. p. 222–228.
- [4] Schaffert R, Wang J, Fischer P, et al. Learning an Attention Model for Robust 2-D/3-D Registration Using Point-To-Plane Correspondences. IEEE Trans MedImaging. 2020;39(10):3159–3174.

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