

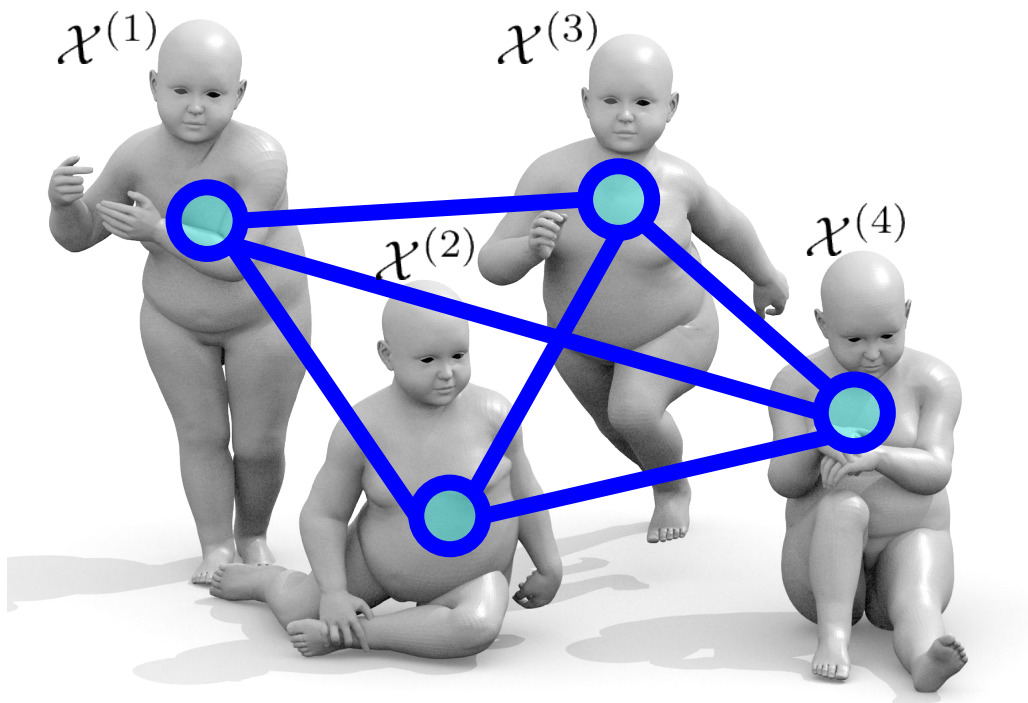
G-MSM: Unsupervised Multi-Shape Matching with Graph-based Affinity Priors

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Poster ID: THU-PM-206



Unsupervised Multi-Shape Matching



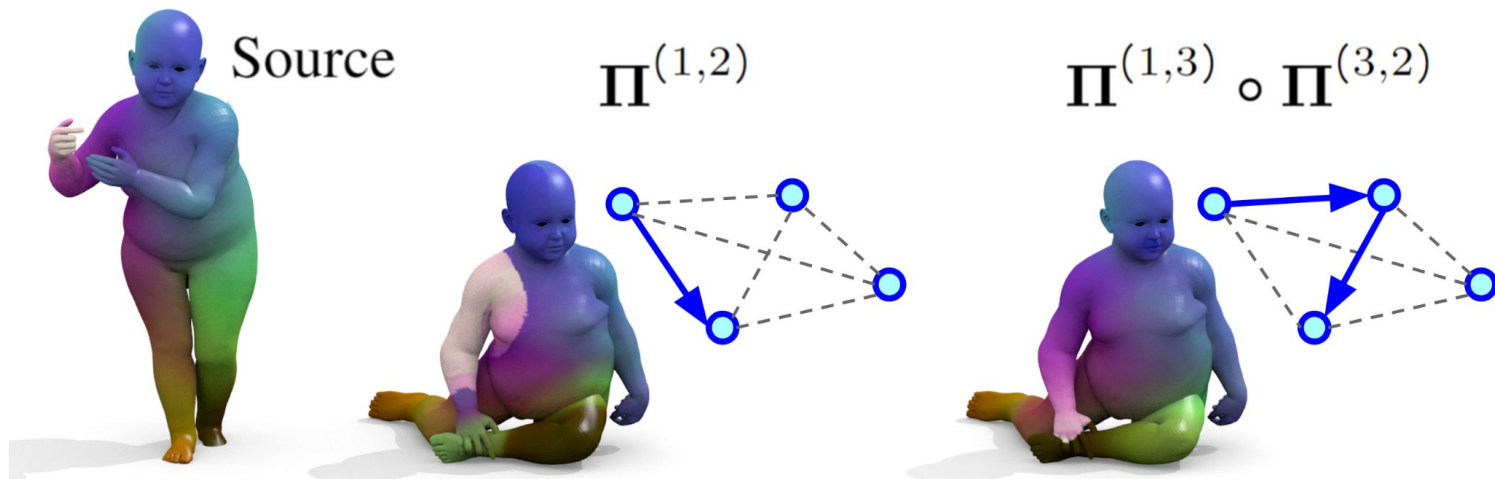
$x^{(1)}$	0.0	3.0	1.2	3.1
$x^{(2)}$	3.0	0.0	1.5	1.0
$x^{(3)}$	1.2	1.5	0.0	2.3
$x^{(4)}$	3.1	1.0	2.3	0.0
	$x^{(1)}$	$x^{(2)}$	$x^{(3)}$	$x^{(4)}$

A color bar on the right side of the table indicates the scale of the values, ranging from 0 (lightest blue) to 3 (darkest blue).

Approach – Summary

For a given collection of shapes $\mathcal{A}^{(i)}$:

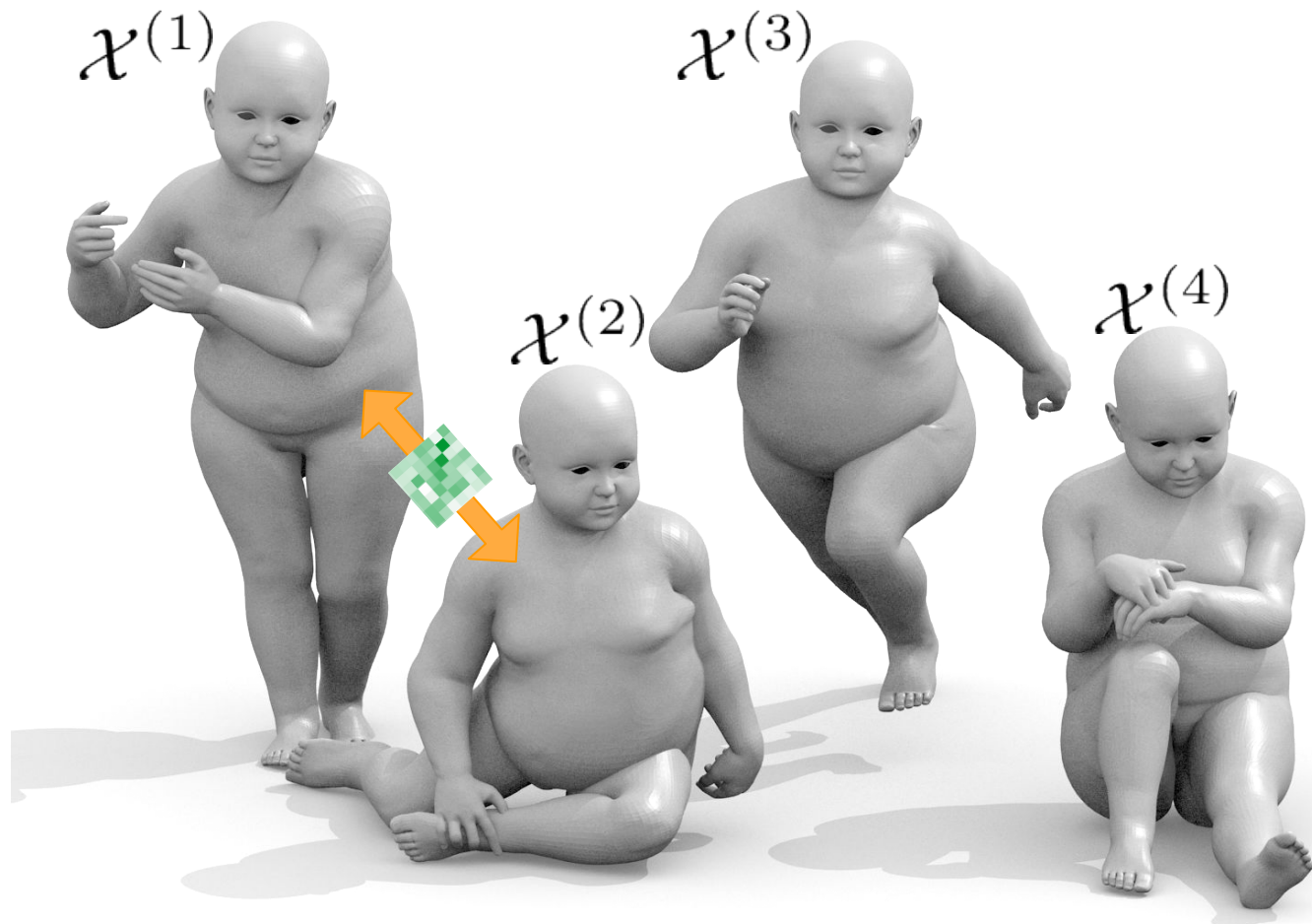
1. Predict putative, pairwise matches.
2. Define self-supervised affinity scores $w^{(i,j)}$.
3. Extract multi-shape correspondences $\Pi^{(i,j)}$.



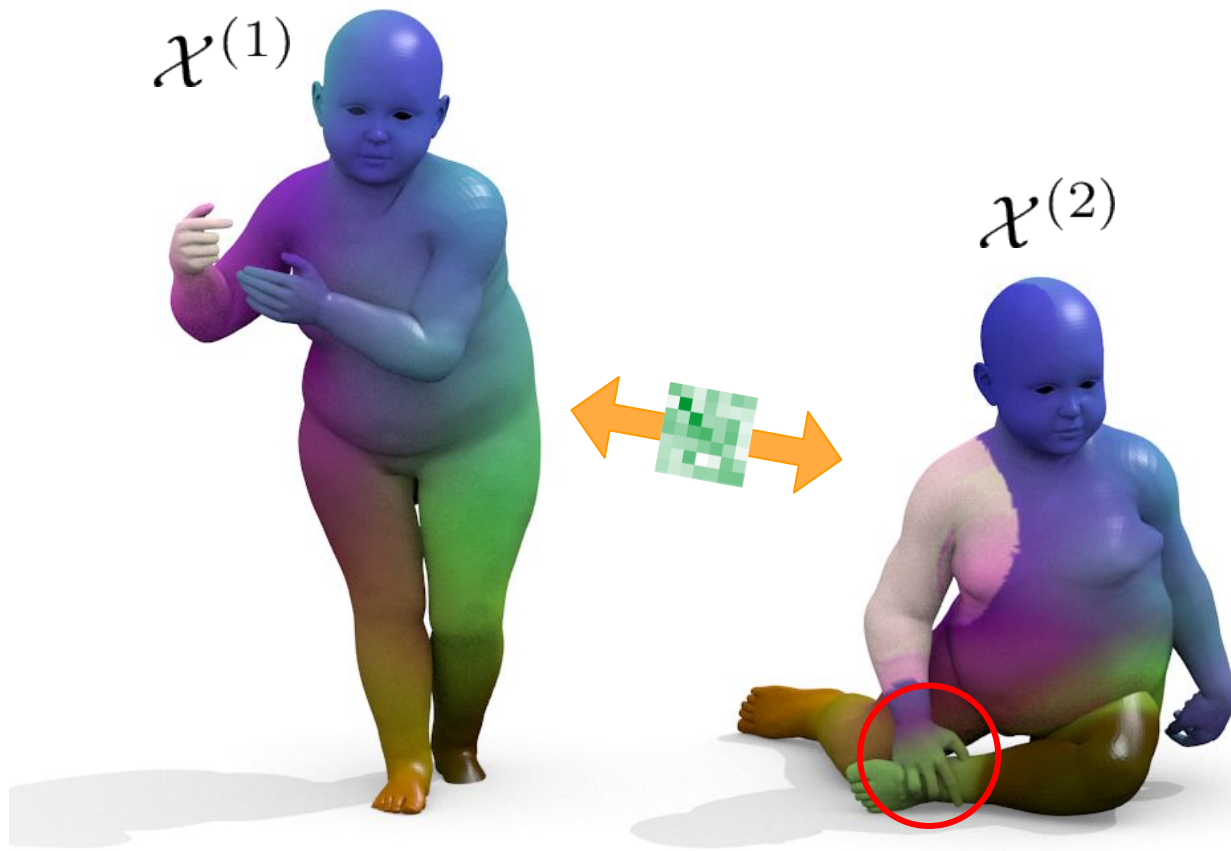
Code



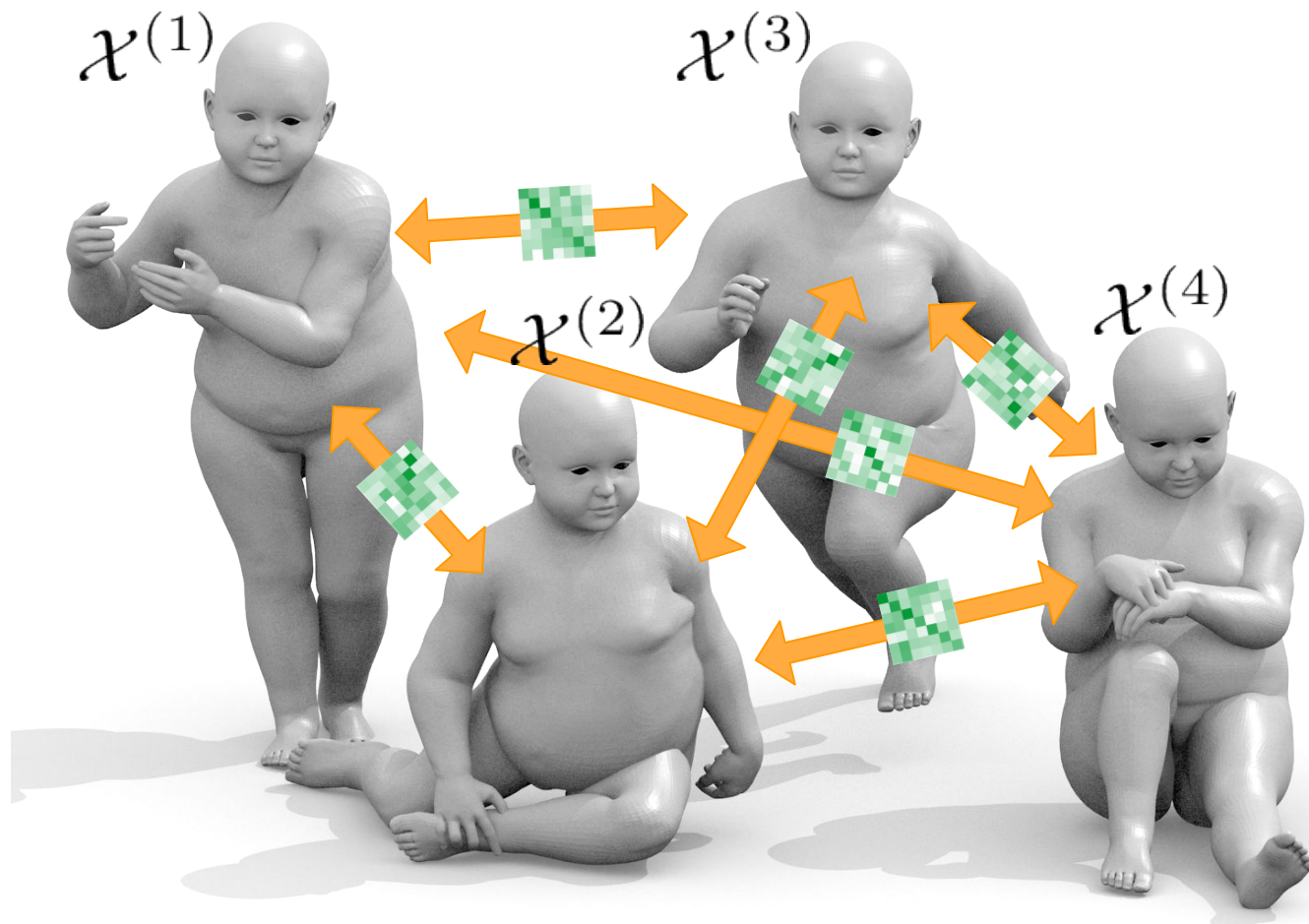
Multi-Shape Matching



Multi-Shape Matching



Multi-Shape Matching

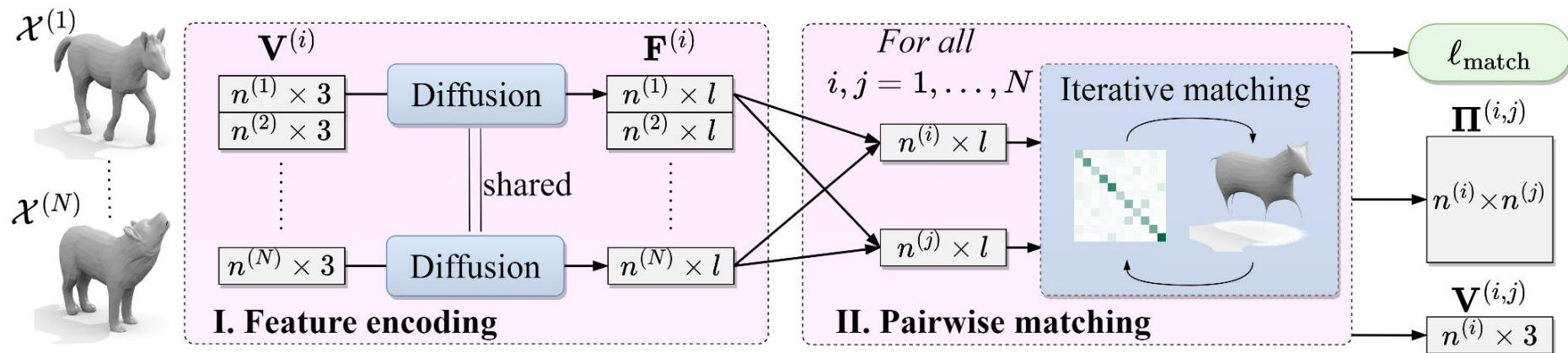


Approach

For a given collection of shapes:

1. Predict putative, pairwise matches.
2. Define self-supervised affinity scores.
3. Extract multi-shape correspondences.

1. Pairwise Matching



[1] Sharp, Nicholas, et al. "Diffusionnet: Discretization agnostic learning on surfaces." ACM Transactions on Graphics (2022).

[2] Eisenberger, Marvin, et al. "Deep shells: Unsupervised shape correspondence with optimal transport." NeurIPS (2020).

2. Affinity Weights

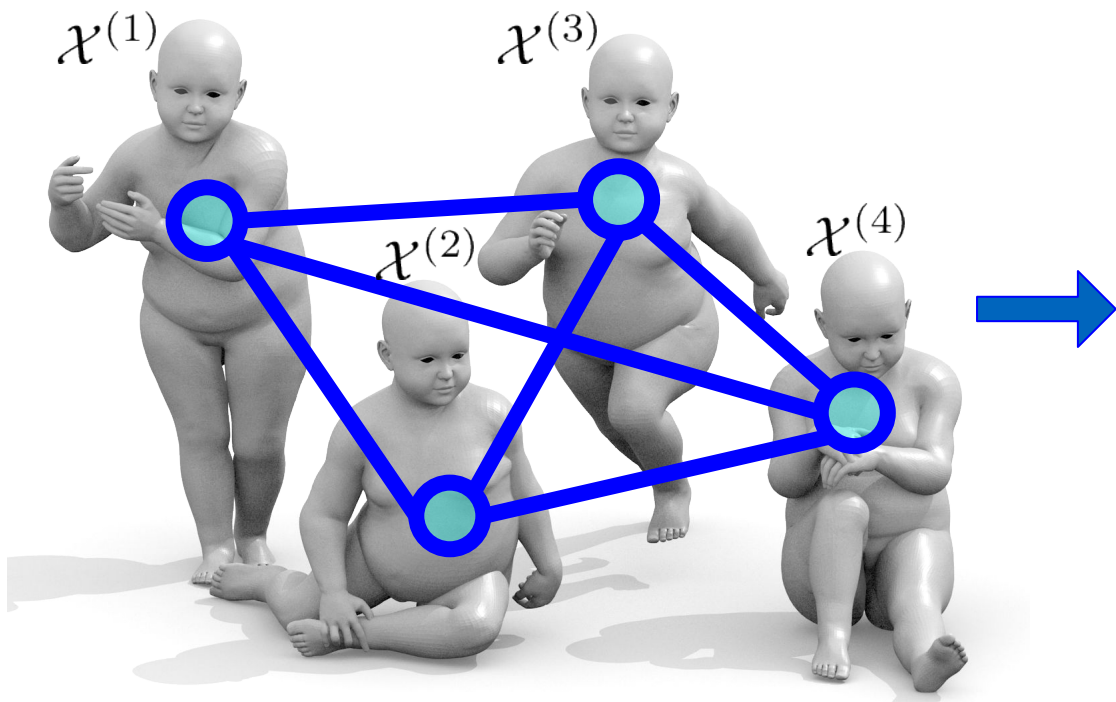
→ We use the optimal transport matching distance:

$$E_{\text{match}}(\mathbf{F}, \mathbf{G}; \mathbf{\Pi}) := \sum_{i'=1}^m \sum_{j'=1}^n \mathbf{\Pi}_{i',j'} \|\mathbf{F}_{i'} - \mathbf{G}_{j'}\|_2^2$$

→ For each pair of shapes, define an affinity score:

$$w(\mathcal{X}^{(i)}, \mathcal{X}^{(j)}) := \min \left\{ E_{\text{match}}(\mathbf{\Pi}^{(i,j)}), E_{\text{match}}(\mathbf{\Pi}^{(j,i)}) \right\}.$$

2. Affinity Weights



A 4x4 matrix showing the affinity weights between the four baby figures. The rows and columns are labeled $x^{(1)}$, $x^{(2)}$, $x^{(3)}$, and $x^{(4)}$. The diagonal elements are 0.0. The off-diagonal elements represent the affinity weights between pairs of figures. A color scale on the right indicates the magnitude of the weights, ranging from 0 (lightest blue) to 3 (darkest blue).

$x^{(1)}$	0.0	3.0	1.2	3.1
$x^{(2)}$	3.0	0.0	1.5	1.0
$x^{(3)}$	1.2	1.5	0.0	2.3
$x^{(4)}$	3.1	1.0	2.3	0.0
	$x^{(1)}$	$x^{(2)}$	$x^{(3)}$	$x^{(4)}$

3. Multi-Matching

→ Concatenate maps along shortest paths in the shape graph:

$$(i, s_1, \dots, s_{M-1}, j) := \text{Dijkstra}(\mathcal{X}^{(i)}, \mathcal{X}^{(j)}; \mathcal{G})$$

$$\mathbf{\Pi}_{\text{mult}}^{(i,j)} := \mathbf{\Pi}^{(i,s_1)} \circ \mathbf{\Pi}^{(s_1,s_2)} \circ \dots \circ \mathbf{\Pi}^{(s_{M-1},j)}.$$

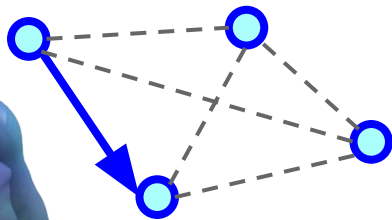
→ Enforce cycle-consistency during training

3. Multi-Matching

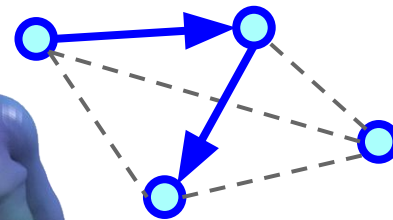
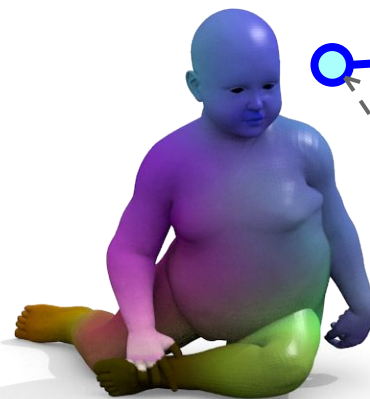


Source

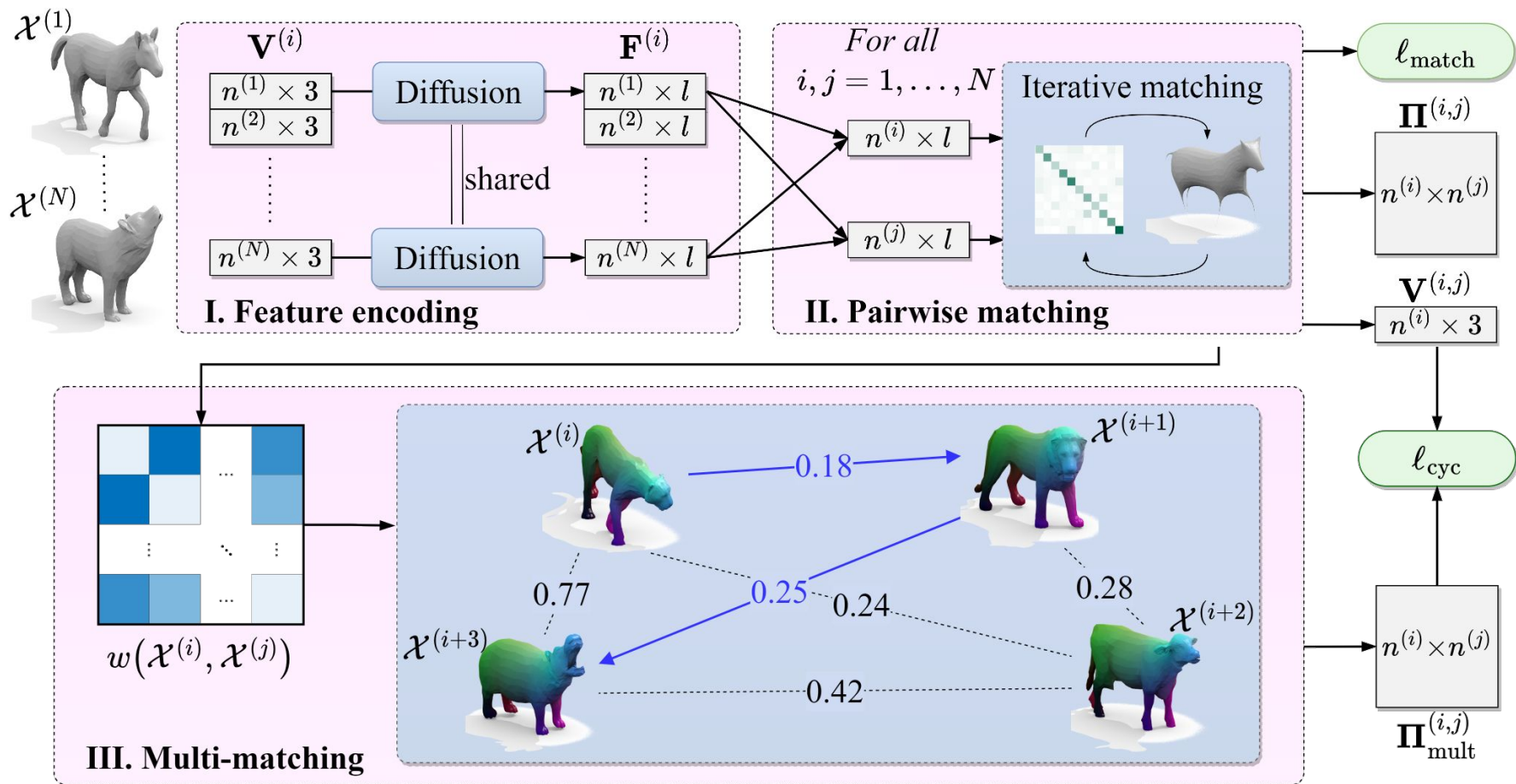
$\Pi^{(1,2)}$



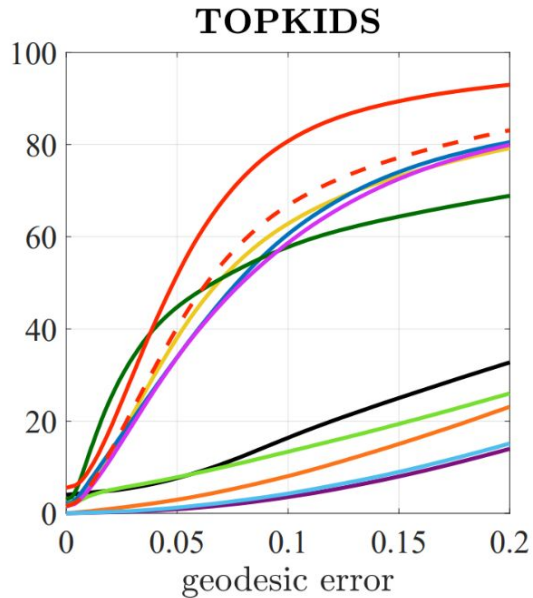
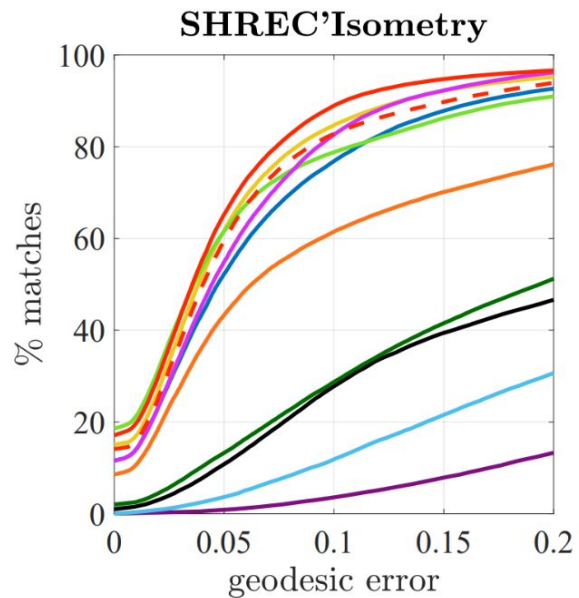
$\Pi^{(1,3)} \circ \Pi^{(3,2)}$



Architecture



Results: Topological changes



Method	SH'Iso	KIDS
UFM [23]	13.4	38.5
SURFM [50]	45.6	48.6
WFM [55]	38.0	47.9
DiffNet [56]	26.5	35.7
DS [20]	6.3	13.7
NM [19]	7.7	13.8
CZO [27]	7.6	39.3
UDM [10]	23.6	18.2
SyNoRiM [25]	6.2	13.8
Ours w/o III	6.3	12.0
Ours	5.2	7.9

Results: Topological changes

Target

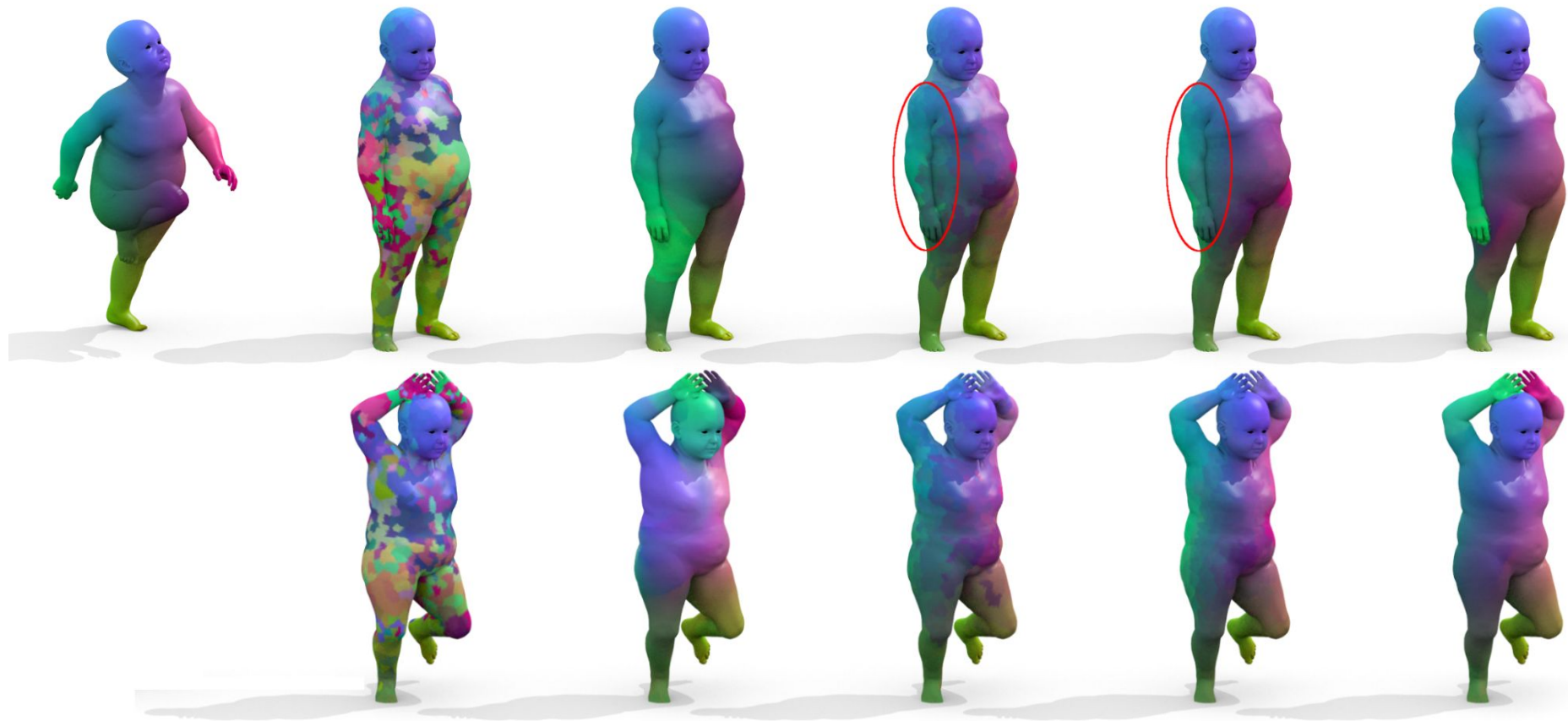
UDM [10]

DS [20]

NM [19]

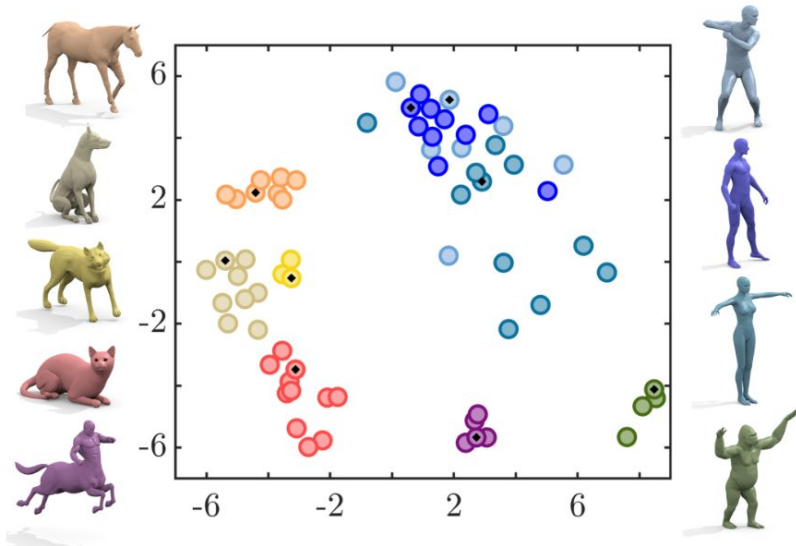
SyNoRiM [25]

Ours



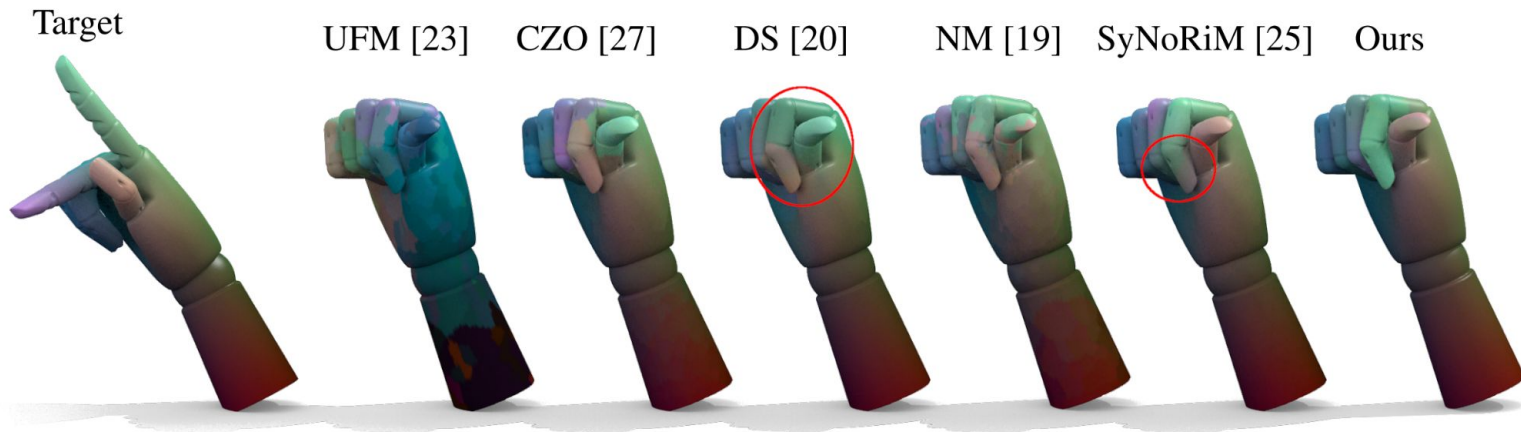
Results: Inter-class matching

	SH'20 on		SH'20 on TOSCA					
	SH'20	SMAL	Cat	Centaur	Dog	Horse	Human	Wolf
UFM [23]	39.8	32.9	39.4	39.2	37.5	34.1	49.6	4.4
SURFM [50]	53.4	37.7	54.0	57.7	57.9	57.0	65.8	55.3
WFM [55]	31.4	20.2	20.6	21.9	16.7	22.4	38.1	5.7
DiffNet [56]	40.5	18.2	14.2	8.3	13.6	9.1	24.5	2.6
DS [20]	35.0	10.8	7.6	9.1	5.5	2.5	10.1	2.1
NM [19]	10.0	9.9	16.8	12.7	14.6	11.2	29.7	1.5
CZO [27]	21.7	-	-	-	-	-	-	-
UDM [10]	52.6	25.5	40.7	34.3	43.6	43.0	45.8	34.3
SyNoRiM [25]	10.4	5.7	12.8	11.6	10.6	7.1	28.2	2.0
Ours w/o III	11.1	3.4	6.3	6.0	4.9	2.6	20.1	2.2
Ours	10.6	2.6	5.2	2.0	3.0	2.2	8.3	1.4



Conclusion

- Introduce shape graphs, self-supervised affinity weights.
- Predict multi-shape matches, enforce cycle consistency.
- SOTA performance on several non-isometric benchmarks.



Code



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