DPC: Unsupervised Deep Point Correspondence via Cross and Self Construction

TEL AVIV UNIVERSITY אוניברסיטת תל אביב

Itai Lang*, Dvir Ginzburg*, Shai Avidan, Dan Raviv

*Equal contribution

3DV 2021 International Conference on 3D Vision Online, December 1-3, 2021

Concept

Reference shape — Our mapping result

Correspondence by construction: use latent space similarity and point coordinates to construct the shape and infer the correspondence mapping

Contributions

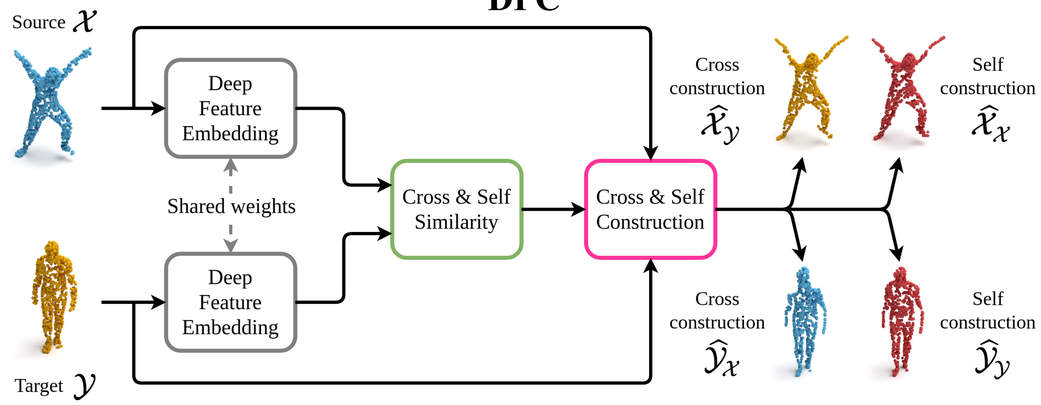
- A novel unsupervised real-time method for dense point cloud matching (38 shape pairs per-second with 1024 points per shape)
- Employ point similarity in a learned feature space and structured construction modules, rather than point regression by a decoder network as done in previous works
- Can be trained on small datasets and exhibits compelling generalization capability
- Surpasses the performance of recent SOTA methods for point cloud correspondence by a large margin for human and animal shapes

Implementation

Code is available!

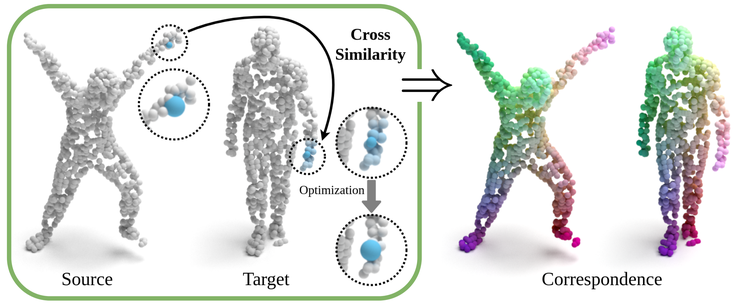
Method

DPC

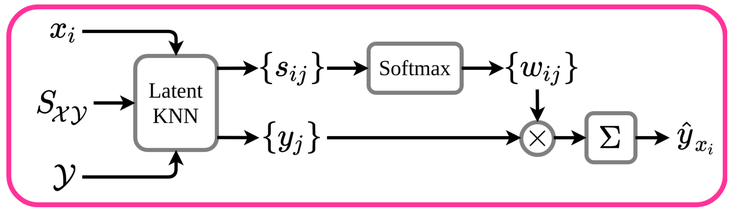


Deep Feature Embedding: learns point features by a deep neural network.
Cross/self Similarity: computes latent space similarity between points across shapes/within the same shape.
Cross construction: estimates the corresponding point as a mixture of point coordinates in the other shape, weighted according to the feature space similarity, and requires the construction of the other shape. Results in a fine-grained discriminative point representation.
Self construction: maps each point to a weighted average of its latent neighbors within the same point cloud and demands the construction of the shape. Causes close spatial points to have a smooth, similar representation.

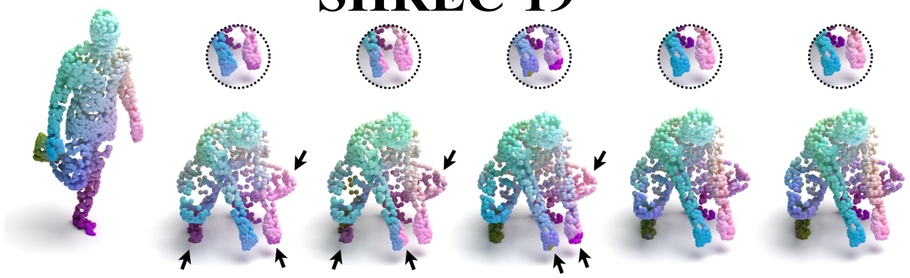
Cross Similarity



Cross Construction

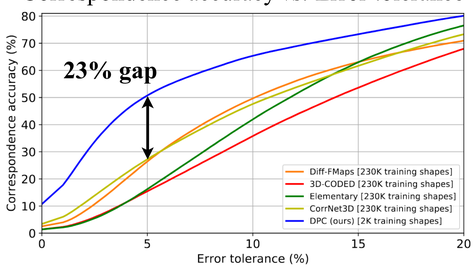


SHREC'19



Reference target — 3D-CODED [3] — Elementary [1] — CorrNet3D [6] — DPC (ours) — Ground-truth

Correspondence accuracy *vs.* Error tolerance



Acc@1% tolerance and Matching err [cm]

Method	Input	SURREAL/ SHREC *acc* ↑	SURREAL/ SHREC *err* ↓	SHREC/ SHREC *acc* ↑	SHREC/ SHREC *err* ↓
SURFMNet [5]	LBO	4.3%	0.3	5.9%	0.2
GeoFMNet [2]	LBO	8.2%	0.2	*	*
Diff-FMaps [4]	Point	4.0%	7.1	*	*
3D-CODED [3]	Point	2.1%	8.1	*	*
Elementary [1]	Point	2.3%	7.6	*	*
CorrNet3D [6]	Point	6.0%	6.9	0.4%	33.8
DPC (ours)	Point	**17.7%**	**6.1**	**15.3%**	**5.6**

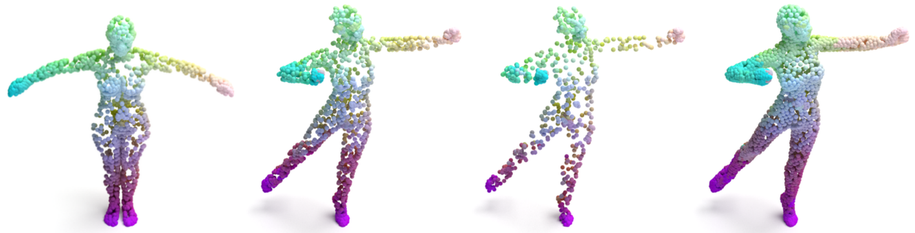
Processing Time Analysis [ms]

Method	Pre-process	Inference	Total
SURFMNet [5]	1593	163	1756
GeoFMNet [2]	1997	215	2212
Diff-FMaps [4]	0	121.7	121.7
3D-CODED [3]	0	32.1	32.1
Elementary [1]	0	35.3	35.3
CorrNet3D [6]	0	175.4	175.4
DPC (ours)	0	**26.3**	**26.3**

✓ DPC **outperforms** baseline point-based correspondence methods by a large gap while trained on only 1% of the training data

✓ DPC is approximately **100x faster** than the compared LBO-based spectral techniques

Robustness



Target 1024 points — Source 1024 points — Source 512 points — Source 4096 points

DPC is robust to the point cloud resolution. The same model that was trained for 1024 points successfully aligns point clouds with either lower or higher resolution.

TOSCA

Reference target — 3D-CODED [3] — Elementary [1] — CorrNet3D [6] — DPC (ours) — Ground-truth

Out method is versatile and can be applied to animal shapes. While the compared methods result in high correspondence errors, DPC computes a smooth and accurate point mapping.

[1] Deprelle *et al.*, Learning Elementary Structures for 3D Shape Generation and Matching, *NeuralIPS 2019*.
[2] Donati *et al.*, Deep Geometric Functional Maps: Robust Feature Learning for Shape Correspondence, *CVPR 2020*.
[3] Groueix *et al.*, 3D-CODED: 3D Correspondences by Deep Deformation, *ECCV 2018*.
[4] Marin *et al.*, Correspondence Learning via Linearly-invariant Embedding, *NeuralIPS 2020*.
[5] Roufosse *et al.*, Unsupervised Deep Learning for Structured Shape Matching, *CVPR 2019*.
[6] Zeng *et al.*, CorrNet3D: Unsupervised End-to-end Learning of Dense Correspondence for 3D Point Clouds, *CVPR 2021*.