Point MixSwap: Attentional Point Cloud Mixing via Swapping Matched Structural Division

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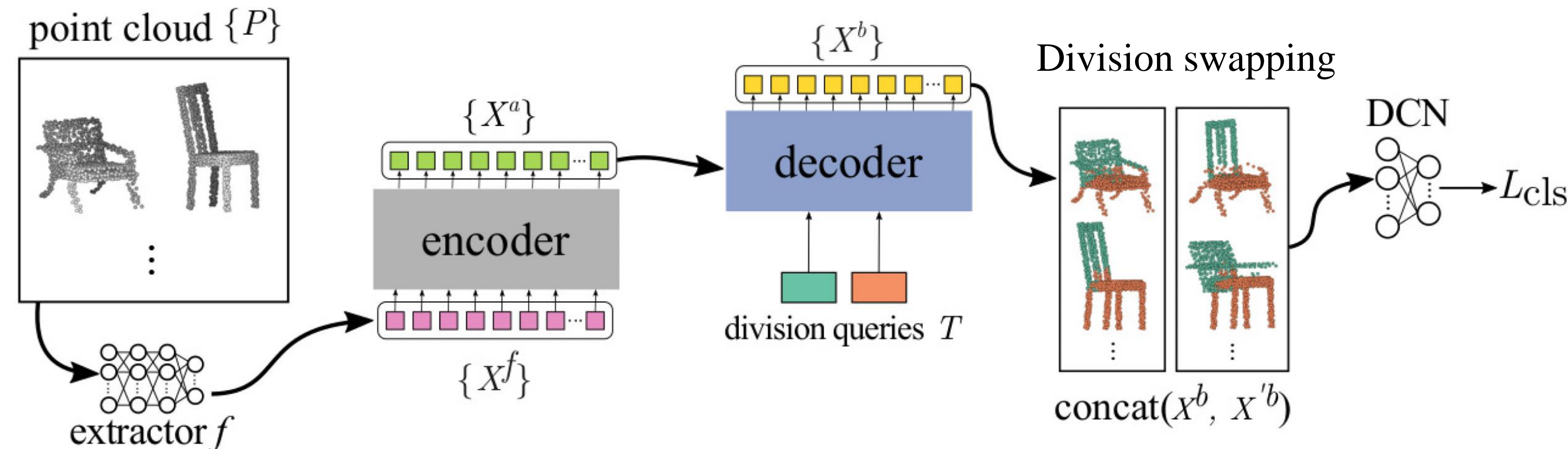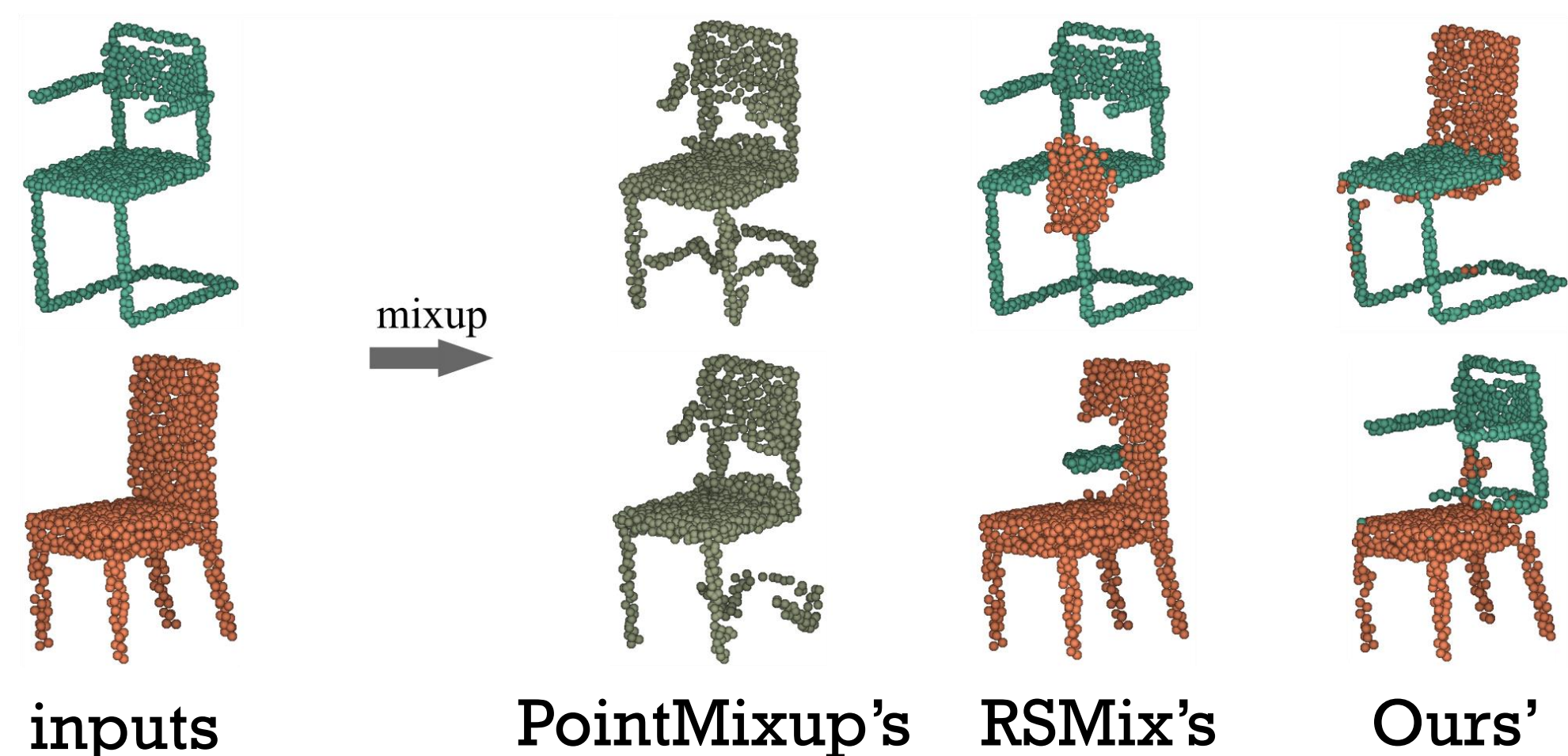
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Contributions:

➤ Introduce an effective technique for synthesizing diverse and realistic point clouds by swapping matched structural division, without any part-segmentation labels
  – Develop a novel encoder-decoder structure to decompose point cloud with cross-cloud correspondence

➤ Mix the point clouds to generate augmented data utilizing division queries, leading to significant improvement on point cloud classification task
  – Augment the point clouds by swapping matched divisions cross different clouds

➤ Evaluated on both synthetic and real-world datasets
  – ModelNet10, ModelNet40, ScanObjectNN
 – Experiment with all data (100%) and reduced data (20%)

Observations:

➤ Existing point cloud mixup methods does not consider the semantic structural information while performing mixup:
  – We generalize the encoder-decoder model to explores inter-cloud division correspondence for division swapping
  – Through the learned division queries, we can divide the point cloud into R divisions and synthesize the new point clouds

inputs   mixup   PointMixup's   RSMix's   Ours'

point cloud $\{P\}$ — extractor f — $\{X^f\}$ — encoder — $\{X^a\}$ — decoder — $\{X^b\}$ — division queries T — Division swapping — concat(X^b, X'^b) — DCN — L_{cls}

Designed encoder-decoder architecture:

➤ The learnable division queries jointly decompose point cloud into R disjoint subsets, for further division swapping

➤ The query and key-value pairs will be switched in the second layer and jointly produce point-specific features
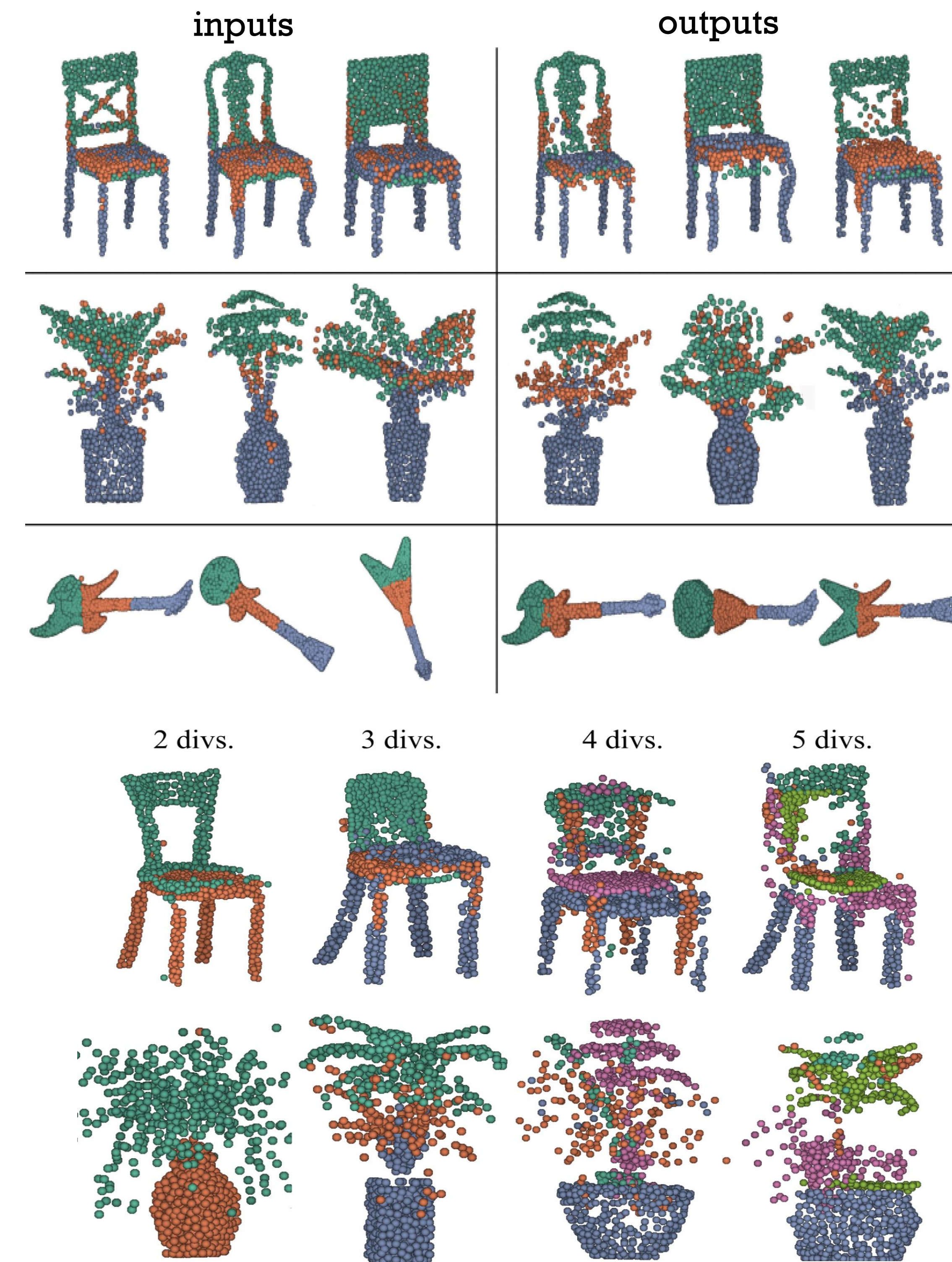

attention layer 1   attention layer 2   division map S
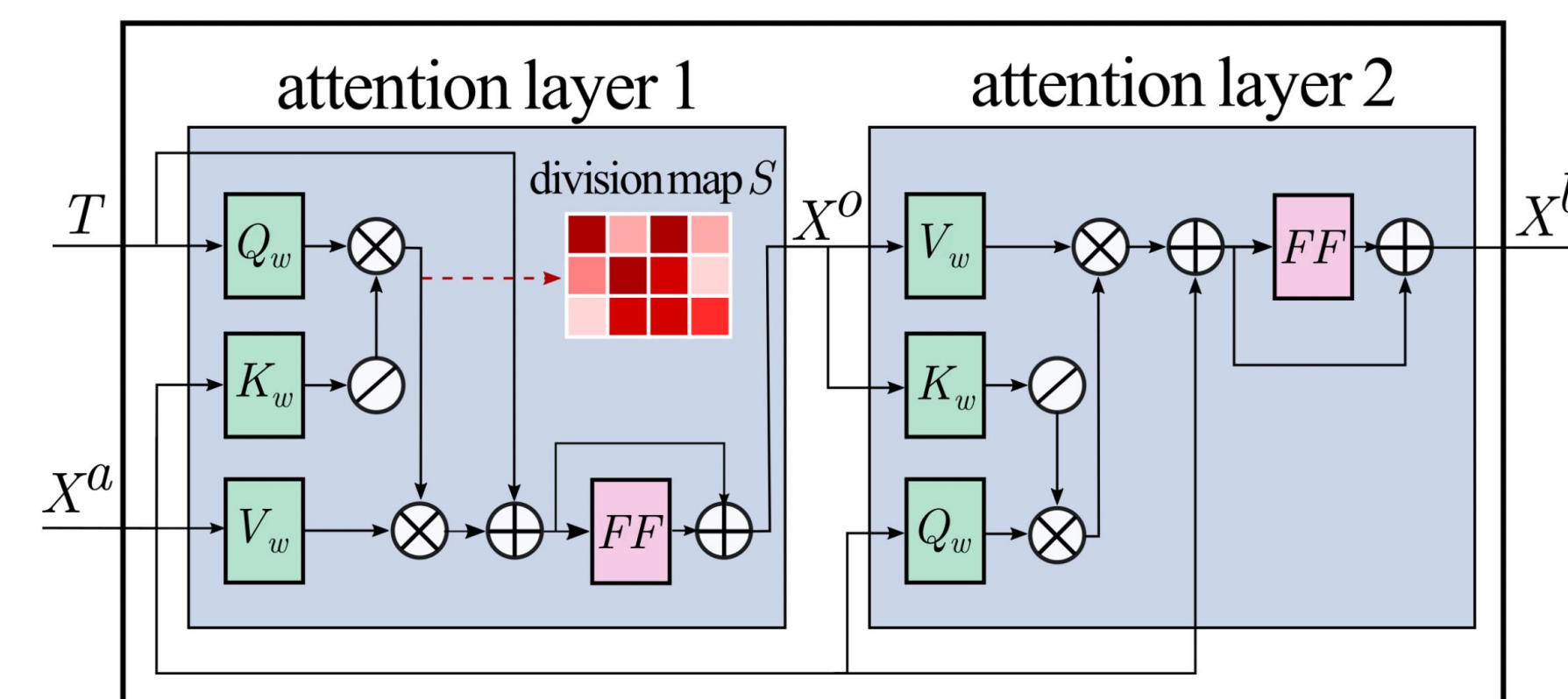
Quantitative results:

➤ Different SoTA methods and training data usage are compared

Method	Rate 20%		Rate 100%	
	M40	M10	M40	M10
DGCNN	87.5	93.2	92.6	94.8
DGCNN + PointMixup [3]	89.0	93.8	93.1	95.1
DGCNN + PointAugment [12]	88.6	92.8	93.4	95.2
DGCNN + RSMix [11]	90.1	93.7	**93.5**	95.9
DGCNN + PointWOLF [9]	89.3	93.5	93.2	95.1
DGCNN + Ours	**91.3**	**94.6**	**93.5**	**96.0**

Divisions	Level	M40	M10	SON
2	Input	91.0	94.6	75.9
	Feature	91.1	**94.7**	76.2
3	Input	91.2	94.5	76.1
	Feature	**91.3**	94.6	**76.3**
4	Input	91.0	94.4	75.7
	Feature	91.2	94.6	76.1
5	Input	91.0	94.3	75.5
	Feature	91.2	94.6	76.0

Visualization:

inputs   outputs

2 divs.   3 divs.   4 divs.   5 divs.

Source code available: