Representing Shape Collections with Alignment-Aware Linear Models

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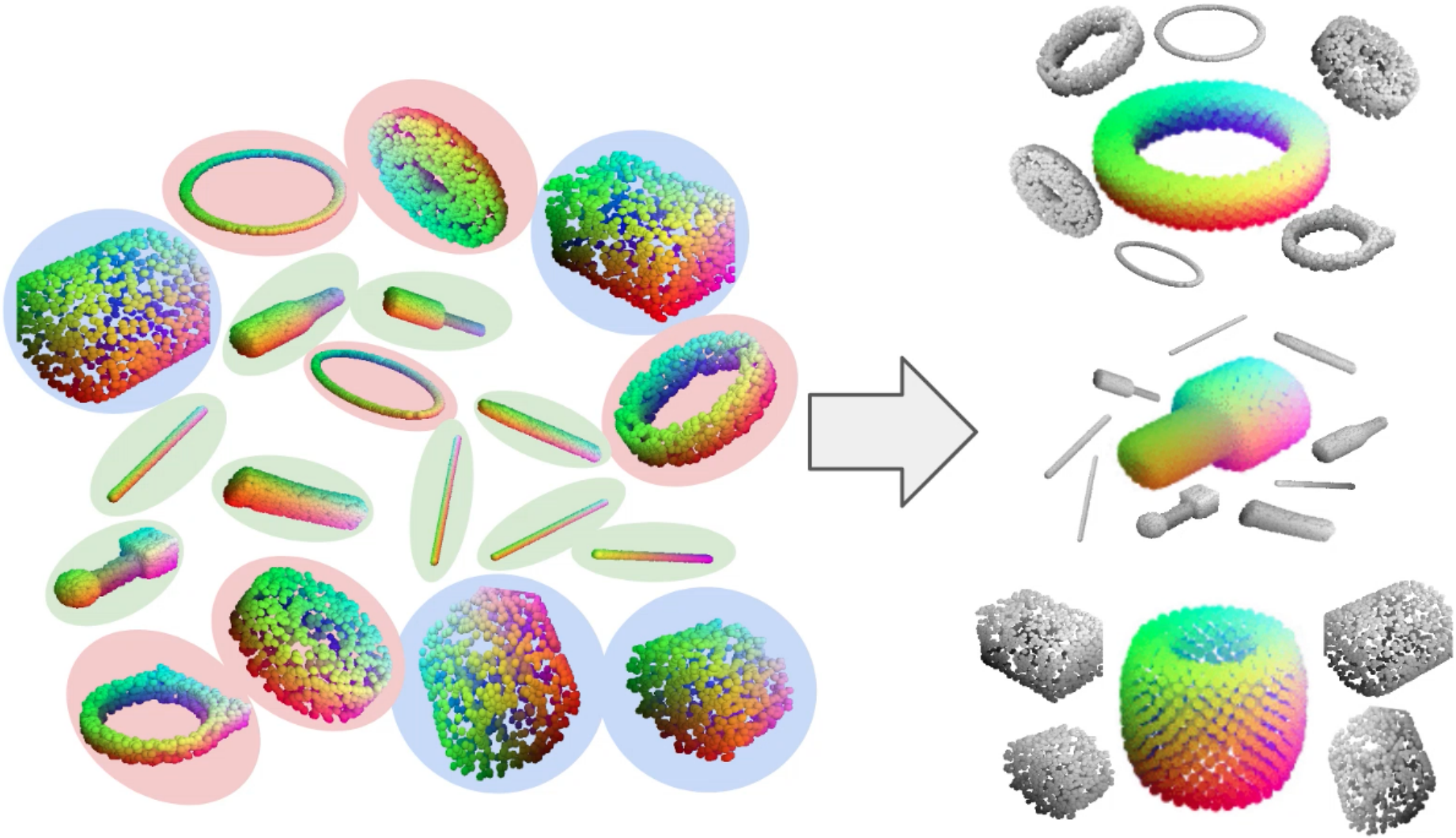
Exploring large shape collections?



Exploring large shape collections?

Summarizing large shape collections

- Understanding collections
  - Clustering
  - Semantic segmentation
- In an unsupervised manner
- With easy annotation and visualisation

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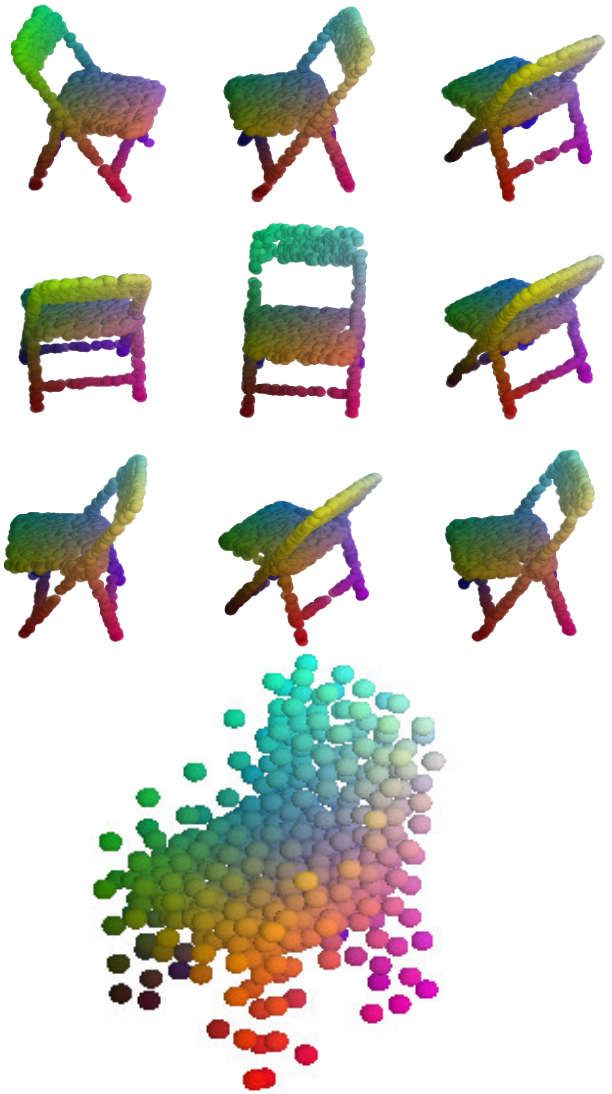
Common problems/Issues

- Distance between shapes?
- Unaligned shapes?
- Average of shapes?

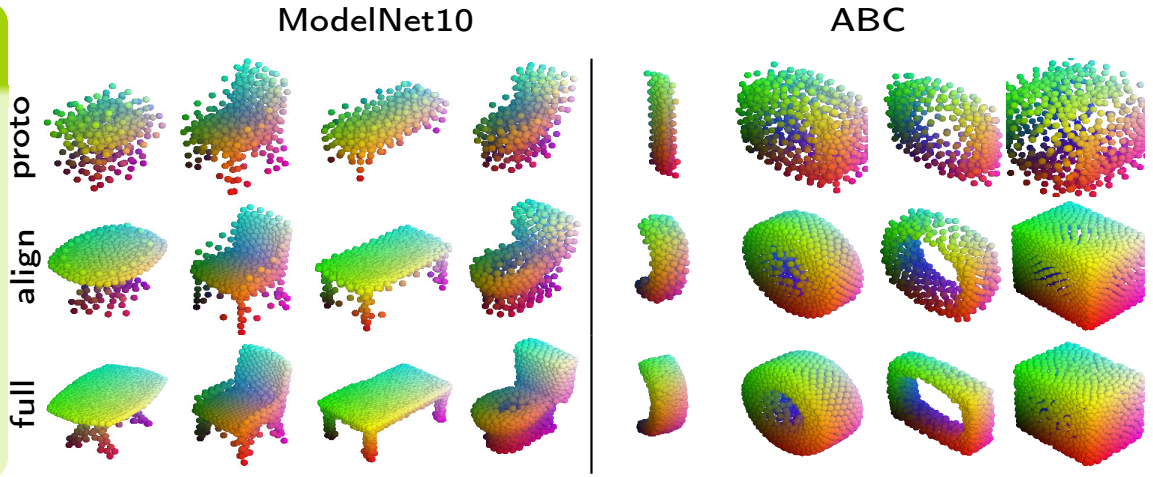


Linear Shape Models

Linear Shape Models

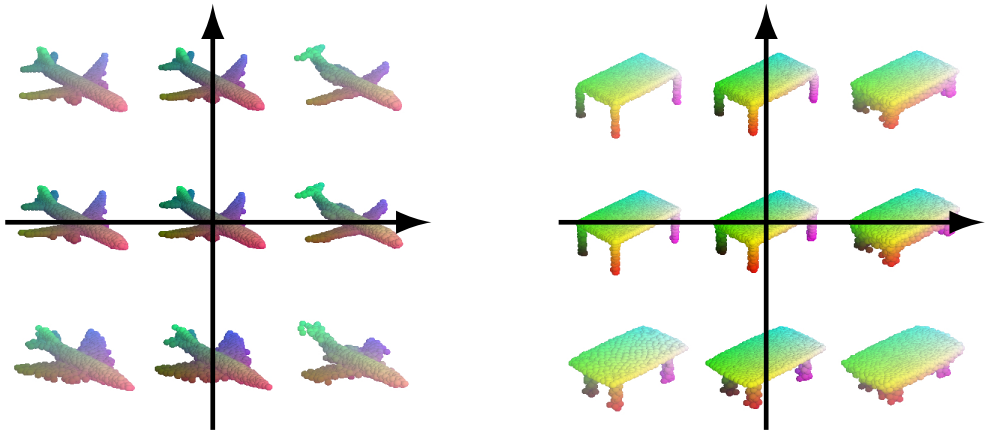
- a center shape $c \in \mathbb{R}^{M \times 3}$
- an alignment network $\mathcal{A}$
- displacement fields $v_i \in \mathbb{R}^{M \times 3}$

$$\mathcal{R}_{\text{full}}(x) = \mathcal{A}(x)\left[c + \sum_{i=1}^{D} a_i \cdot v_i\right]$$



Unsupervised loss

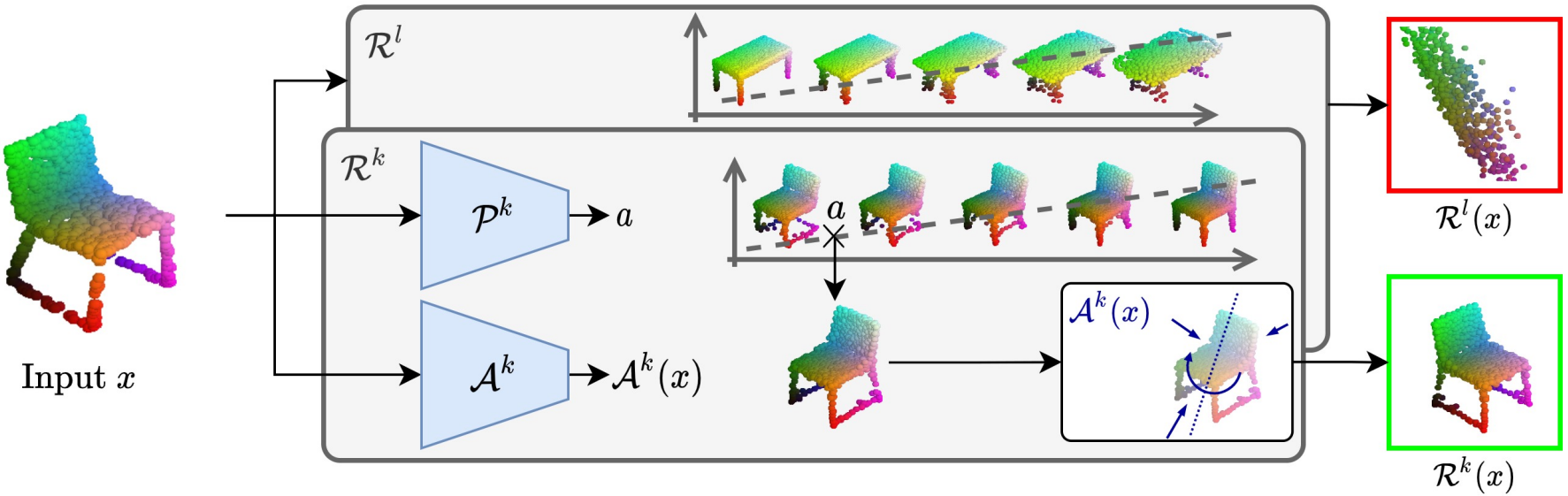
$$\mathcal{L}(\mathcal{R}) = \min_{k=1}^{K} d\left(x, \mathcal{R}^k(x)\right)$$



Linear family parametrization

- Pointwise: $v \in \mathbb{R}^{D \times (M \times 3)}$
- Implicit: $[v_i]_p = \mathcal{V}_i([c]_p)$
  - $\mathcal{V}_i^k : \mathbb{R}^3 \mapsto \mathbb{R}^3$

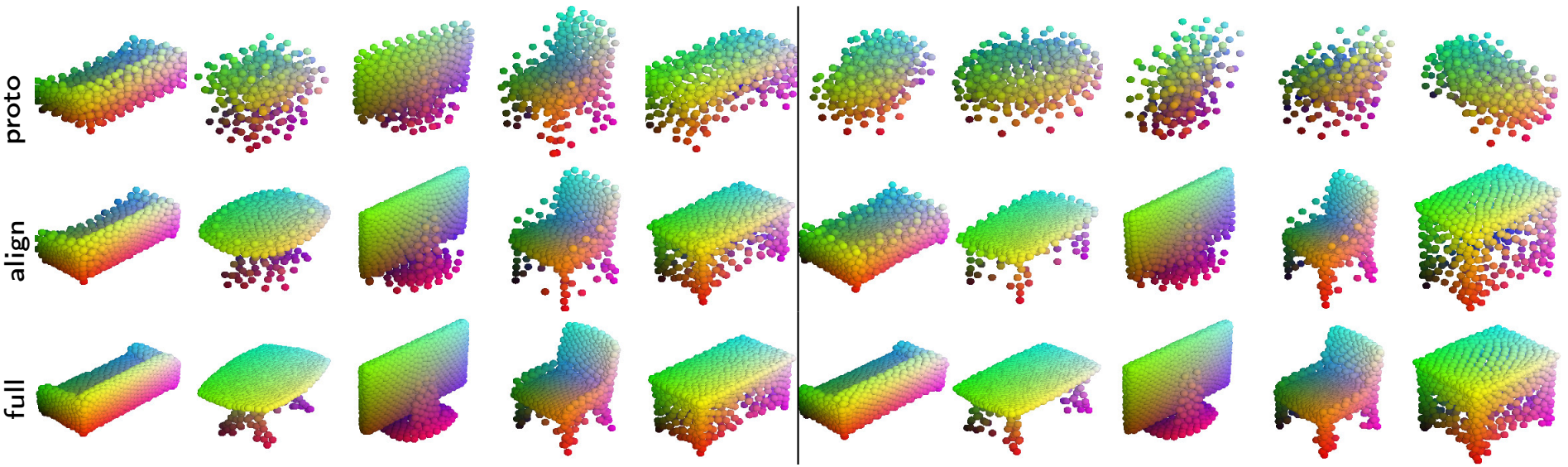
Method overview



Unsupervised clustering loss

- $\mathcal{L}(\mathcal{R}) = \min_{k=1}^{K} d\left(x, \mathcal{R}^k(x)\right)$
- Curriculum training $\mathcal{R}_{\text{proto}}; \mathcal{R}_{\text{align}}; \mathcal{R}_{\text{full}}$

Effect of alignment between shapes



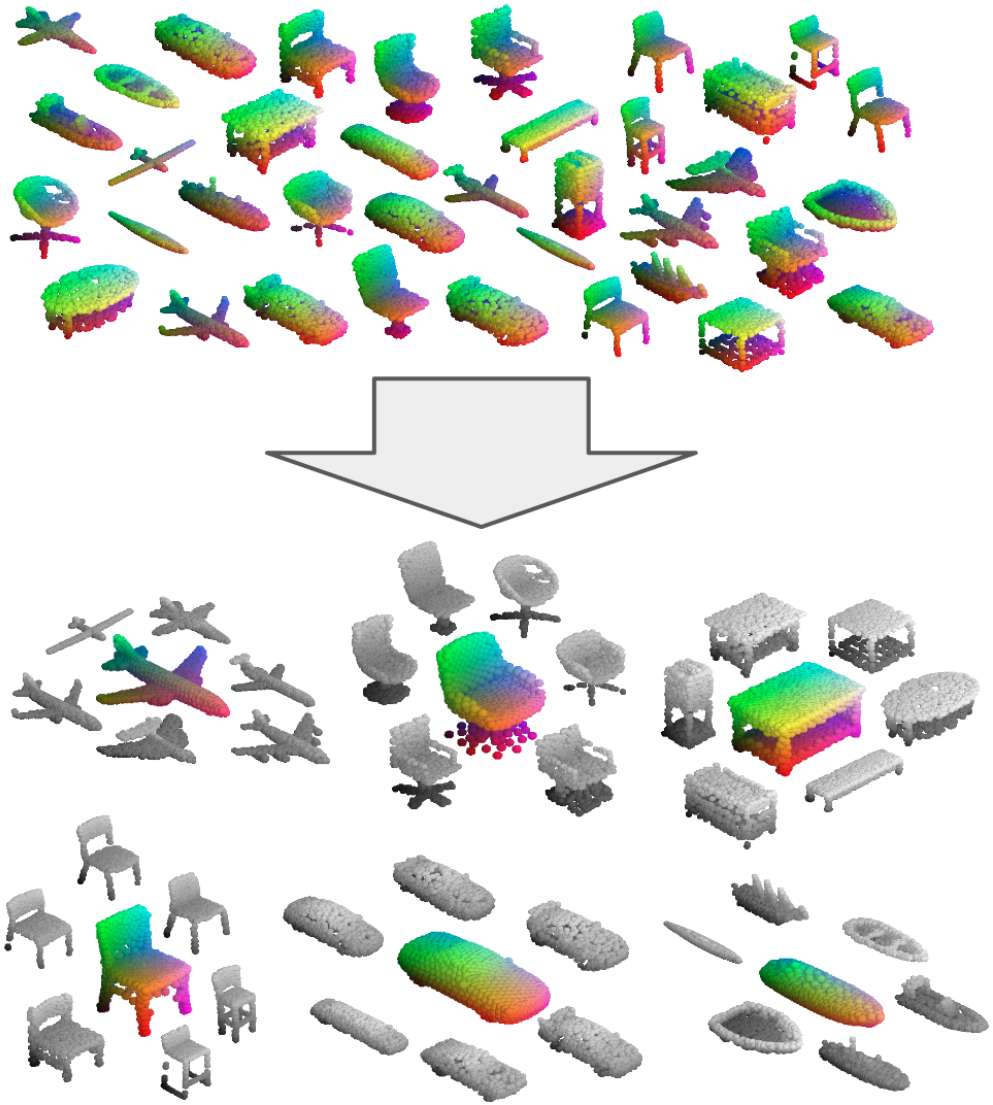
Linear Shape Models

- $\mathcal{R}_{\text{proto}}(x) = c$
- $\mathcal{R}_{\text{align}}(x) = \mathcal{A}(x)\,[c]$
- $\mathcal{R}_{\text{full}}(x) = \mathcal{A}(x)\left[c + \sum_{i=1}^{D} a_i \cdot v_i\right]$

Clustering and segmentation

Visualize large collections of shapes

- Unsupervised clustering with a single clustering loss



Clustering and segmentation

Visualize large collections of shapes

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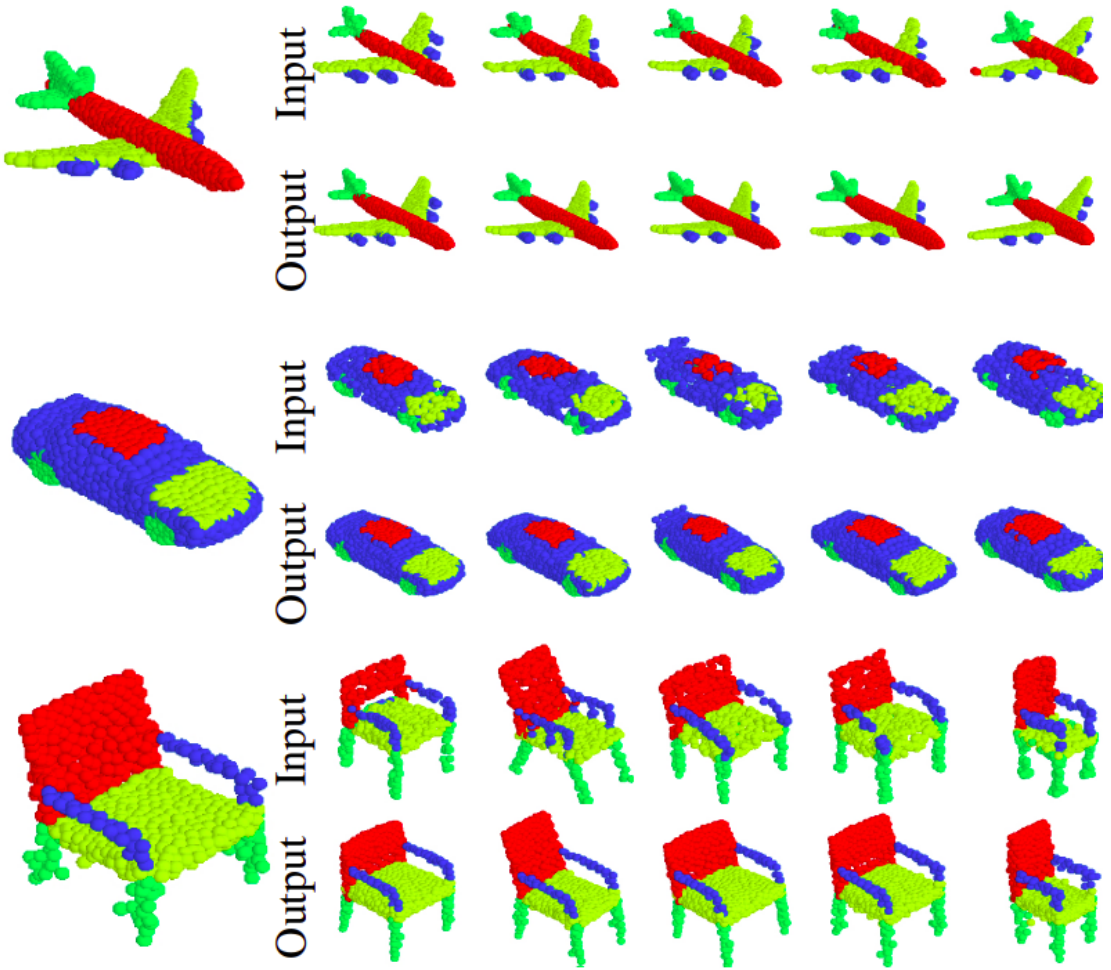
Low shot segmentation

- Easy manual annotation or using a few samples to annotate linear shapes
- From a single annotated model we can propagate labels
- **State of the art on low-shot segmentation**



Conclusion

Contributions

- Unsupervised method to represent large point cloud collections
- Extension of the DTI clustering framework to learn linear shape models
- State-of-the-art few-shot segmentation performance

romainloiseau.github.io/
deep-linear-shapes

Thanks for your attention!