Representing Shape Collections with Alignment-Aware Linear Models

Romain Loiseau\textsuperscript{1, 2} Tom Monnier\textsuperscript{1} Mathieu Aubry\textsuperscript{1} Loïc Landrieu\textsuperscript{2}

\textsuperscript{1}LIGM, Ecole des Ponts, Univ Gustave Eiffel, CNRS, France
\textsuperscript{2}LASTIG, Univ. Gustave Eiffel, ENSG, IGN, F-94160 Saint-Mande, France
Exploring large shape collections?
Visualize and understand large collections of shapes
Introducing Deep Linear Shapes
Applications: clustering and segmentation

Exploring large shape collections?

Summarizing large shape collections

• Understanding collections
  • Clustering
  • Semantic segmentation
• In an unsupervised manner
• With easy annotation and visualisation
Visualize and understand large collections of shapes
Introducing Deep Linear Shapes
Applications: clustering and segmentation

Exploring large shape collections?

Summarizing large shape collections

• Understanding collections
  • Clustering
  • Semantic segmentation

• In an unsupervised manner
• With easy annotation and visualisation

Common problems/Issues

• Distance between shapes?
• Unaligned shapes?
• Average of shapes?
Linear Shape Models

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

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

Unsupervised loss

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

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

- $\mathcal{L}(\mathcal{R}) = \min_{k=1}^{K} d(x, \mathcal{R}_k(x))$
- Curriculum training $\mathcal{R}_{\text{proto}}; \mathcal{R}_{\text{align}}; \mathcal{R}_{\text{full}}$
Visualize and understand large collections of shapes
Introducing Deep Linear Shapes
Applications: clustering and segmentation

Effect of alignment between shapes

Aligned ModelNet10

Un-aligned ModelNet10

proto

align

full

Linear Shape Models

• \( R_{\text{proto}}(x) = c \)

• \( R_{\text{align}}(x) = A(x) [c] \)

• \( R_{\text{full}}(x) = A(x) \left[ c + \sum_{i=1}^{D} a_i \cdot v_i \right] \)
Clustering and segmentation

Visualize large collections of shapes

- Unsupervised clustering with a single clustering loss

Applications: clustering and segmentation

Visualize and understand large collections of shapes
Introducing Deep Linear Shapes

Romain Loiseau
3DV 2021
Visualize and understand large collections of shapes
Introducing Deep Linear Shapes
Applications: clustering and segmentation

Clustering and segmentation

Visualize large collections of shapes

- Unsupervised clustering with a single clustering loss

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

Thanks for your attention!

romainloiseau.github.io/deep-linear-shapes