Analogy-Driven 3D Style Transfer

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Shape Analogies

source

exemplar

? = target

output

(1)

(2)

(3)
Shape Analogies

source

exemplar

? 

target

output

(1)

(2)

(3)
Style Transfer

source

exemplar

target

output
Style Transfer

source

exemplar

target

output
Shape Analysis

• Symmetry detection
  – [TW05, MGP06, PMW*08, MBB10]

• Full/partial mapping
  – [SAPH04, vKZHCO11, KLM*12, HZG*12, SNB*12]

• Shape analogies for retrieval
  – [ROA*13]
Part-based Shape Synthesis

• User-assisted assembly
  – [FKS*04, CKGK11]

• Randomized from shape grammars
  – [BWS10, TYK*12]

• Automatic from pre-segmented database
  – [KCKK12, XZCOC12, SFCH12]
Deformation/Style Transfer

- Deformation Transfer
  - [SP04]
  - Continuous mapping, no structural difference
Deformation/Style Transfer

• Deformation Transfer
  – [SP04]
  – Continuous mapping, no structural difference

• 2D Style Transfer
  – [HJO*01, HOCS02, FTP03, LZW*13]
  – Not applicable to 3D
Deformation/Style Transfer

• Deformation Transfer
  – [SP04]
  – Continuous mapping, no structural difference

• 2D Style Transfer
  – [HJO*01, HOCS02, FTP03]
  – Not applicable to 3D

• 3D Part-Scale Transfer
  – [XLZ*10]
  – Require pre-segmentation and one-to-one mapping
Pre-Processing

• Consistently scale and align input models
  – Bounding boxes
  – Upright orientation

• Uniformly sample model surface
  – Point sample set \( \{s\} \)
  – Sample position \( p(s) \) and normal \( n(s) \)
Algorithm Overview

source

exemplar

output
Algorithm Overview

**Source-Exemplar Correspondence**
Algorithm Overview

Input

Source-Target Possible Transformations
Algorithm Overview

Input

source  

exemplar

→

target

Analogy Optimization
Algorithm Overview
Source-Exemplar Correspondence

• Pair-wise sample distance

\[ d(s_e, s_s) = |\hat{\mathbf{p}}(s_s) - \hat{\mathbf{p}}(s_e)|^2 + \lambda \cdot \cos^{-1}(\mathbf{n}(s_s) \cdot \mathbf{n}(s_e)) \]

• Minimize sum of pair-wise distance
  – Hungarian algorithm [Kuh55]
Transformation Selection

• Initial candidate set
  – Votes from all pairs of source and target samples
  – Best align local coordinate systems

• Selected transformations \( \{Q\} \) [MGP06]
  – Dominant modes from mean-shift clustering
  – Associated subsets of target samples \( \{s_t\} \)

\[
|Q(p(s_t)) - p(s_s)| < \delta_p, \quad Q(n(s_t)) \cdot n(s_s) > \delta_n
\]
Analogy Optimization

• Source-to-target analogy
  – A subset of selected transformation
  – Each target sample associated to one transformation

• Multi-label energy optimization
  – Simplicity: unary term
  – Compactness: pairwise term
  – Continuity: regularization term
Analogy Optimization

- Source-to-target analogy
  - A subset of selected transformation
  - Each target sample associated to one transformation

- Multi-label energy optimization
Algorithm – Scan Completion

partial scan  template  source  exemplar
Algorithm – Scan Completion

- partial scan
- template
- exemplar
- source
Algorithm – Scan Completion

partial scan  template  source  target  exemplar
Algorithm – Scan Completion

- partial scan
- template
- source
- target
- exemplar
Algorithm – Scan Completion

- partial scan
- template
- source
- exemplar
- target
- output
Algorithm – Scan Completion

- partial scan
- template
- source
- exemplar
- target
- output
Algorithm – Scan Completion

- Partial scan
- Template
- Source
- Exemplar
- Target
- Output
- Reconstructed result
Results – 2D Style Transfer

source

target

exemplar

output
Results – 2D Style Transfer

source

exemplar

target

output
Results – 2D Style Transfer

source

exemplar

target

output
Results – 2D Style Transfer

source
exemplar

output
Results – 3D Style Transfer
Results – 3D Style Transfer
Results – 3D Style Transfer

source | target 1 | target 2 | target 3
--- | --- | --- | ---
exemplar A | output 1A | output 2A | output 3A
exemplar B | ? | ? | ?
Results – 3D Style Transfer
Results – 3D Style Exchange
Results – 3D Style Exchange

source
target 1
target 2
exemplar
Results – 3D Style Exchange

source

exemplar

output 1

output 2
Results – 3D Style Exchange

target 1
source
target 2
exemplar
Results – 3D Style Exchange

target 1  source  target 2
output 1  exemplar  output 2

?
Results – 3D Style Exchange
Results – Scan Completion

- template
- partial scan
- output
Results – Scan Completion

template

exemplar

output
Comparison

Style transfer based on anisotropic part scaling

source  exemplar  target

[XLZ* 2010]  our result
Comparison

Template based scan completion

exemplar  template  [KS05]  our result
Conclusion

• A analogy-driven shape synthesis framework
  – Automatically transfer diverse style characteristics between 3D shapes

• A multi-label optimization algorithm
  – Assemble simple, compact and continuous shape analogies
Limitations

• Symmetry between source and target only
  – No constraints for self-symmetric target
Limitations

• Overlapping mesh patches
  – No stitching
Limitations

- One reasonable solution only
  - Ambiguity
Future work

• Free-form deformation
  – Organic shapes

• Automatic input alignment
  – Shape matching and analysis tools

• Infer a source shape
  – Given only the target and exemplar
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