SEMI-SUPERVISED CO-ANALYSIS OF 3D SHAPE STYLES FROM PROJECTED LINES

FENGGEN YU, NANJING UNIVERSITY
YAN ZHANG, NANJING UNIVERSITY
KAI XU, NATI UNIV OF DEFENSE TECHONOLOGY
ALI MAHDAVI-AMIRI, SIMON FRASER UNIVERSITY
HAO ZHANG, SIMON FRASER UNIVERSITY

© 2018 SIGGRAPH. All Rights Reserved
Distinctive features which permit the grouping of objects into related categories

Eric Fernie. Art History and its Methods: A critical anthology
Style

Chinese Style

European Style
Style

Byzantine

Greek

Gothic
Style-Aware Mesh Simplification
Style-Aware Shape Clustering
Related Work

[Li et.al., 2012]  [Xu et.al., 2010]

Hand Crafted Rules
Related Work

Supervised Style Ranking

[Lun et.al., 2015]  [Liu et.al., 2015]
Related Work

[Hu et.al., 2017]
Expert Annotated Dataset
Semi-Supervised Method

Heterogenous objects
Main Operations

Shape Clustering

Patches Identification
Line Drawing

3D shape

Feature Line Images
Line Drawing Advantages

Reduces visual clutter
Line Drawing Advantages

Reduces visual clutter

Not affected by poor illumination
Line Drawing Advantages

- Reduces visual clutter
- Not affected by poor illumination
- Robust under shape imperfection
Challenges

How to distinguish stylistic patches?
Challenges

How to combine features at multiple views?
Challenges

How to bring human in the loop to have semi-supervised learning?
Pipe-Line

- Style Patch Pre-Selection
- Per View Feature Encoding
- Semi-Supervised Style Clustering
Style Patch Pre-Selection

Input 3D shape

Feature Line Images

Mid-level Patches
Style Patch Pre-Selection

Input 3D shape

Feature Line Images

Mid-level Patches
Style Patch Pre-Selection

Input 3D shape

Feature Line Images

Mid-level Patches
Style Patch Pre-Selection

Input 3D shape

Feature Line Images

Mid-level Patches
Per-View Feature Encoding

Patches as convolution Kernel
Per-View Feature Encoding

Feature Per Patch
Per-View Feature Encoding
Per-View Feature Encoding

View 1

View N

Feature for Shape
Semi-Supervised Style Clustering
Semi-Supervised Style Clustering

Partially Shared Latent Factor (PSLF)

supervision
Technical Details
Pipe-Line

Style Patch Pre-Selection

Per View Feature Encoding

Semi-Supervised Style Clustering
Patch Sampling

3D shape → Projected image → Projected lines

Back project

Same location
Sampled patches

Candidate style patches

k-means
Pipe-Line

- Style Patch Pre-Selection
- Per View Feature Encoding
- Semi-Supervised Style Clustering
Patch Convolution

Kernels → Patch convolution → Projected lines → Feature encoding → Activation pyramid → MAX POOLING → Feature vector
Pipe-Line

- Style Patch Pre-Selection
- Per View Feature Encoding
- Semi-Supervised Style Clustering
Motivation of PSLF

**Consistent:** decorative style are generally shared over all views

**Complementary:** distinctive stylistic features in each view
Feature Fusion by PSLF

Nonnegative matrix factorization

Input feature Matrix

Latent factor

Special part

Common part

View 1

View N

Shape 1

Shape M

© 2018 SIGGRAPH. All Rights Reserved
Fuse feature from our method

Fuse feature from VGGNET16
Style Clustering

Clustering with label constraints

\[ V_l = W \times Y_l \]

\[ W^T \times V_u = Y_u \]

Labeled feature \( V_l \)
Cluster centers \( W \)
Label indicator \( Y_l \)
Chinese
European

Unlabeled feature \( V_u \)
Cluster indicator \( Y_u \)

Fused feature \( V \)
Extraction

VS1
VS2
VC
Style Clustering

\[ A' = Y^T \times S \times Y \]

Similarity with constraints

Cluster centers

Cluster indicator

Clustering with style-rankings constraints
Datasets

<table>
<thead>
<tr>
<th>Object Collection</th>
<th>Numb Shapes</th>
<th>Numb Style Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed Furniture 1</td>
<td>120</td>
<td>4</td>
</tr>
<tr>
<td>Mixed Furniture 2</td>
<td>400</td>
<td>5</td>
</tr>
<tr>
<td>Building</td>
<td>329</td>
<td>4</td>
</tr>
<tr>
<td>Chair</td>
<td>516</td>
<td>9</td>
</tr>
<tr>
<td>Car</td>
<td>1050</td>
<td>6</td>
</tr>
<tr>
<td>Vase</td>
<td>194</td>
<td>5</td>
</tr>
</tbody>
</table>
Style Clustering

Proportion of user style labels

Number of style ranking triplets
Patch Selection

Candidate patches

Patch-shape support

Cluster1, Cluster2

Shape-cluster indicator

Patch-cluster indicator
Style Patch Localization
Style Aware Simplification

⚠️ Style preserved

⚠️ Without Style preserved
Style Aware View Selection
Style Aware View Selection
Style Aware View Selection

© 2018 SIGGRAPH. All Rights Reserved
Limitation

- symmetries and repetition style
- insufficient stylistic elements
Conclusion

- The first semi-supervised co-analysis of 3D shape styles

- We focus on projective feature lines, and achieve improvements on previous works.

- Our method combines local feature learning and global discriminative style extraction.

- We can locate stylistic shape elements without user involvement to mark any style patches.
THANK YOU!

Web App: http://180.209.64.32:8080/Style_analysis/style_web.jsp
Code & Data: https://github.com/FoggYu/proj_style
The Graphics Replicability Stamp Initiative (GRSI)
http://www.replicabilitystamp.org/

Acknowledgement