Feature Sensitive Bas Relief Generation

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Motivation

- **Aim**
  - Compress depth-interval size of height field
  - No loss of important features

- **Applications for Bas-Reliefs**
  - Coinage
  - Packaging
  - Shape Decoration
    - Embossment
    - Engraving
    - Carving
  - Displacement Maps

SMI 2009, Tsinghua University, Beijing, China

1 http://www.cachecoins.org/
2 Real-time relief mapping on arbitrary polygonal surfaces
  Policarpoo F., Oliveira M., Comba J. L. D., SIGGRAPH 2005
Naïve Approach

- Linear Rescaling
Related Work

- Automatic generation of bas-reliefs from 3D shapes
  W. Song, A. Belyaev, H.-P. Seidel, SMI 2007 (short paper)
    + Introducing the problem and attempting to solve it

- Digital Bas-Relief from 3D Scenes
    + Impressive results       - Much user interaction required, computationally expensive

- Feature Preserving Depth Compression of Range Images
  J. Kerber, A. Belyaev, H.-P. Seidel, SCCG 2007
    + Simple and fast       - Spherical parts not well reproduced, problems with noise

- Bas-Relief Generation Using Adaptive Histogram Equalization
  X. Sun, P. Rosin, R. Martin, TVCG 2009
    + Very good results       - Time consuming

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Pipeline

I

Gradient Extraction  Silhouette Removal  Outlier Detection  Attenuation

R

Rescaling  Re-assembling  Re-weighting  Decomposition

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Silhouette Treatment

- Gradient of the Background mask = 1 ?
Outlier Detection

- Tollerance parameter
  - Deviation to mean gradient value
Signal Decomposition

- Base-layer and Detail-layer
- Detail Enhancement
- Base Compression

\( \frac{1}{\lambda} \cdot \text{Base + Detail} \)
Bilateral Filter

Gradient domain
- Edge preservation
- Gradient extrema preservation

Spatial Domain
- Preservation of ridges and valleys
- Curvature extrema preservation
Reweighting

- X-Gradient

- Y-Gradient
Poisson Reconstruction

- Given \( I_x, I_y \)

- Compute \( I_{xx} + I_{yy} = \Delta I \)

- Partial Differential Equation

- Well studied Problem

- Multi-Grid-Solver
  - Assumption: Frame equals background

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Results
Cubism

- Ancient technique in art
- Combine multiple viewpoints in a single painting

- Aim: extend this effect from 2D to sculpting

http://picasso.tamu.edu/picasso/
Height Field Capturing

- Open GL Application
- 180° in 15° steps
- Composition in 2D

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Transition Problems

- Transition areas
  - Seams are automatically detected as outliers
  - But set to 0
  - Flat transitions would emphasize the impression of having two different parts
Transition Problems (ctd.)

- 0-Gradient affects 3x3 neighborhood
- Re-fill affected area
- Weighted average (Gauss) excluding masked entries

- Seamless results
Results
### Performance

<table>
<thead>
<tr>
<th>Model</th>
<th>Resolution / pixel</th>
<th>Time / seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lucy</td>
<td>950x800</td>
<td>6.2</td>
</tr>
<tr>
<td>Lion-Vase</td>
<td>950x800</td>
<td>6.8</td>
</tr>
<tr>
<td>XYZRGB Dragon</td>
<td>980x1700</td>
<td>13.5</td>
</tr>
<tr>
<td>David Cubism 1</td>
<td>1200x1200</td>
<td>17.2</td>
</tr>
<tr>
<td>David Cubism 2</td>
<td>800x800</td>
<td>8.1</td>
</tr>
</tbody>
</table>

- Intel 4x2.6 GHz, 8GB, Matlab64 Implementation
- Bottleneck
  - Bilateral Filter
  - Poisson Reconstruction
- Not optimized yet, possible acceleration
**Conclusion**

- **Contribution**
  - Little user intervention
  - Preservation of fine and sharp structural details
  - More artistic freedom
  - Potentially Fast
  - Independent of complexity
  - Commercial applications
Future work

- Dynamic extension
  - Video

- Thank you for your attention!