Data-Driven Shape Analysis
--- 3D Computer Vision

Qixing Huang
Stanford University
3D Computer Vision

• Acquisition & Modeling
  – Real-time 3D Systems
  – Image-based modeling

• Processing & Transmission
  – Analysis/Retrieval/...

• Applications
  – Robotics/Cultural heritage
  – 3D television
This lecture

• A survey of recent papers

• How data-driven ideas are designed/implemented
  – And how they can be enhanced

• Conferences
  – CVPR
  – ICCV
  – ECCV
  – 3DV
Structure from Motion from Internet images
Structure from Motion from Internet images

The Colosseum, 2,106 images, 819,242 points

Images are over-complete
-Select good images to match?

Building Rome in a Day, ICCV 2009
RGBD Stereo

Image

Scan

Stereo+Kinect for High Resolution Stereo Correspondences, 3DV 2013
RGBD Stereo

• Images
  – High-resolution
  – Hard to match

• Scans
  – Low-resolution
  – Depth information
RGBD Stereo

\[ E(f) = \sum_{p \in P} D(p, f_p) + \sum_{(p,q) \in N} V(p, q, f_p, f_q) \]

Reduce search space
Combine depth discontinuity
Combine depth information
Results

RGBD Stereo

Standard Stereo
A similar idea

\[ B = I \otimes K \]

\[ I = N_D + \Delta I \]

Image Deblurring with Blurred/Noisy Image Pairs. SIGGRAPH 2007
Projective analysis

Projective Analysis for 3D Shape Segmentation SIGGRAPH ASIA’12
Christian modifications

The present high altars and the apses were commissioned by Pope Clement XI (1700–1721) and designed by Alessandro Specchi. In the apse, a copy of a Byzantine icon of the Madonna is enshrined. The original, now in the Chapel of the Canons in the Vatican, has been dated to the 13th century, although tradition claims that it is much older. The choir was added in 1840, and was designed by Luigi Poletti.

The first niche to the right of the entrance holds a Madonna of the Girdle and St Nicholas of Bari (1686) painted by an unknown artist. The first chapel on the right, the Chapel of the

<table>
<thead>
<tr>
<th>Church of St. Mary and the Martyrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiesa Santa Maria dei Martiri</td>
</tr>
<tr>
<td>Sancta Maria ad Martyres</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Basic Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
</tr>
<tr>
<td>Rome, Italy</td>
</tr>
<tr>
<td><strong>Geographic coordinates</strong></td>
</tr>
<tr>
<td>41.6986° N</td>
</tr>
<tr>
<td>12.4788° E</td>
</tr>
<tr>
<td><strong>Affiliation</strong></td>
</tr>
<tr>
<td>Roman Catholic</td>
</tr>
<tr>
<td><strong>Year consecrated</strong></td>
</tr>
<tr>
<td>629</td>
</tr>
</tbody>
</table>
Image search
Image matching

Annunciation
Image editing

3D Object Manipulation in a Single Photograph using Stock 3D Models

Natasha Kholgade\textsuperscript{1}  Tomas Simon\textsuperscript{1}  Alexei Efros\textsuperscript{2}  Yaser Sheikh\textsuperscript{1}

\textsuperscript{1}Carnegie Mellon University \quad \textsuperscript{2}University of California, Berkeley

ACM Transactions on Graphics (SIGGRAPH 2014)
Image editing

(a) Original Photograph  (c) User Input  (e) Geometry Correction

(b) Selected Stock 3D Model  (d) 3D Object Manipulation  (f) Manipulated Object Geometry

(g) Illumination Estimation  (i) Appearance Completion

(h) Manipulated Object Illumination  (j) Final Result
Shape-driven depth estimation

Estimating Image Depth Using Shape Collections, SIGGRAPH’ 14
Label Propagation from ImageNet to 3D Point Clouds, CVPR'13
SUN3D

http://sun3d.cs.princeton.edu

Integrated Space Representation

Video

RGB-D SFM

\[
\min_{e \in \mathcal{P}, i \in \mathcal{C}} \left\| \bar{x}_p^e - K[R_i | t_i]X_p^i \right\|^2 + \left\| \bar{X}_p^e - [R_i | t_i]X_p^i \right\|^2
\]

SUN3D: A Database of Big Spaces Reconstructed using SfM and Object Labels, ICCV’13