MoSculp: Interactive Visualization of Shape and Time

Xiuming Zhang\textsuperscript{1}
Tali Dekel\textsuperscript{1,2}
Tianfan Xue\textsuperscript{1,2}
Andrew Owens\textsuperscript{1,3}
Qiurui He\textsuperscript{1,2}
Jiajun Wu\textsuperscript{1}
Stefanie Mueller\textsuperscript{1}
William T. Freeman\textsuperscript{1,2}

\textsuperscript{1} MIT CSAIL
\textsuperscript{2} Google Research
\textsuperscript{3} UC Berkeley
Video Courtesy of Tom Buehler (MIT CSAIL)
Outline

• Related Work
• System Walkthrough
• User Studies
• Approach
• Results
• Conclusion
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Motivation

Muybridge, *The Human Figure in Motion*, 1901
Motivation

Muybridge, *The Human Figure in Motion*, 1901

Edgerton, *Back Dive*, 1954
Motivation

Muybridge, *The Human Figure in Motion*, 1901

Edgerton, *Back Dive*, 1954

Duchamp, *Nude Descending a Staircase, No. 2*, 1912
Related Work

Edgerton, *Stroboscopic Photography*, 1927–1931

2D
Related Work

Edgerton, *Stroboscopic Photography*, 1927–1931

Freeman & Zhang, *Shape-Time Photography*, CVPR ’03

2D

Requires a depth camera
Related Work vs. Ours

Edgerton, *Stroboscopic Photography*, 1927–1931

2D

Freeman & Zhang, *Shape-Time Photography*, CVPR ’03

Requires a depth camera

MoSculp

3D w/ an RGB camera
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System Walkthrough
2D Keypoints

Body Parts
- Body (Leather)
- Left Upper Arm (Leather)
- Left Lower Arm (Leather)
- Right Upper Arm (Leather)
- Right Lower Arm (Original)
- Left Upper Leg (Leather)
- Left Lower Leg (Leather)
- Right Upper Leg (Leather)
- Right Lower Leg (Leather)

Part Material: Right Lower Arm
- Leather
- Tarp
- Wood
- Original

Lighting
- Left
- Middle
- Right

Keyframe Density 0
Sculpture Transparency 0
Sculpture Specularity: On
Synthetic Background: Off
2D Keypoints

Body Parts
- Body (Leather)
- Left Upper Arm (Tarp)
- Left Lower Arm (Leather)
- Right Upper Arm (Leather)
- Right Lower Arm (Original)
- Left Upper Leg (Leather)
- Left Lower Leg (Leather)
- Right Upper Leg (Leather)
- Right Lower Leg (Leather)

Part Material: Left Upper Arm
- Leather
- Tarp
- Wood
- Original

Lighting
- Left
- Middle
- Right

Keyframe Density 0
Sculpture Transparency 0
Sculpture Specularity: On
Synthetic Background: Off
Body Parts
- Body (Leather)
- Left Upper Arm (Tarp)
- Left Lower Arm (Tarp)
- Right Upper Arm (Tarp)
- Right Lower Arm (Leather)
- Left Upper Leg (Leather)
- Left Lower Leg (Leather)
- Right Upper Leg (Leather)
- Right Lower Leg (Leather)

Part Material: Right Lower Arm
- Leather
- Tarp
- Wood
- Original

Lighting
- Left
- Middle
- Right

Keyframe Density 0.0
Sculpture Transparency 0.0

Sculpture Specularity: On
Synthetic Background: Off
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User Studies: Design Choices

With Floor Reflections
 Preferred by 82%

Without
User Studies: Efficacy in Conveying Motion

Baseline 1 (Stroboscopic)
Baseline 2 (Shape-Time)
MoSculp Preferred by 75%
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Overview

Input Video

3D Shape & Pose Estimation

Motion Sculpture Generation

Depth-Preserving Compositing
Overview

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Approach: 2D Keypoint Detection

Time: $t$

[Cao et al., CVPR '17]
Approach: 2D Keypoint Detection

Time: $t + 1$

[Cao et al., CVPR '17]
Approach: 3D Estimation

• Solve for the best shape and poses jointly for the clip
Approach: 3D Estimation

• Solve for the best shape and poses jointly for the clip
  • Small reprojection error

[Image of 2D Image and 3D Model]

[Reference: Loper et al., ToG ’15]
Approach: 3D Estimation

- Solve for the best shape and poses jointly for the clip
  - Small reprojection error
  - Large probability of the poses

\[ p(\text{left}) > p(\text{right}) \]
Approach: 3D Estimation

• Solve for the best shape and poses jointly for the clip
  • Small reprojection error
  • Large probability of the poses
  • Smooth evolution of poses
Approach: 3D Estimation

- Solve for the best shape and poses \textit{jointly} for the clip
  - Small reprojection error
  - Large probability of the poses
  - Smooth evolution of poses

Original Camera View  
Novel View

Per-Frame Optimization
[Bogo et al., ECCV '16]
Approach: 3D Estimation

• Solve for the best shape and poses *jointly* for the clip
  • Small reprojection error
  • Large probability of the poses
  • Smooth evolution of poses
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Approach: Sculpture Generation
Overview

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Approach: Compositing

• **Key challenge:** how to “put together” 3D sculpture and 2D video?
Approach: Compositing

• **Naive Compositing:** sculpture on top of the frames
Approach: Compositing

• **Full 3D Rendering:** texturing the 3D models

Skirt Not Covered by 3D Model
Approach: Compositing

• **Solution:** depth-preserving composite

Rendered Depth (Refined)
Approach: Compositing

- **Solution**: depth-preserving composite
Approach: Before Refinement
Approach: After Refinement
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Federer
Single-Frame Shape and Pose Estimation
Our Joint Estimation
Input Video

Jumping
Texture from Original Frames

Input Video

U-Walking
Handling a Moving Camera

Dunking
Run, Forrest, Run!
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Limitation: Repeated, Localized Motion
Conclusion
http://mosculp.csail.mit.edu

Please come to our demo D-12 for more!

Thank you!

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