Pop-Out Motion: 3D-Aware Image Deformation via Learning the Shape Laplacian
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Introduction

Objective
We aim to enable 3D-aware image deformation with minimal restrictions on shape category and deformation type.

Motivation
For 3D-aware deformation, it is necessary to reconstruct the object in a 2D image to 3D space; however, it is not sufficient in general.

→ Modeling deformation often requires the shape Laplacian [1].
→ However, most of existing methods of image-based 3D reconstruction produce a surface without proper consideration about intrinsic shape properties.

We propose to take a supervised learning-based approach to predict the shape Laplacian of the underlying volume of a 3D reconstruction.

Quantitative Evaluation

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<tbody>
<tr>
<td>Weight L1 (x 100)</td>
<td>3.86</td>
<td>3.46</td>
<td>4.32</td>
<td>2.66</td>
<td>3.26</td>
<td>3.53</td>
<td>3.34</td>
<td>2.10</td>
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<tr>
<td>Shape CD (x 100)</td>
<td>3.84</td>
<td>3.04</td>
<td>3.83</td>
<td>2.61</td>
<td>4.00</td>
<td>3.16</td>
<td>4.04</td>
<td>1.81</td>
<td></td>
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<tr>
<td>Shape HDS (x 0.1)</td>
<td>1.81</td>
<td>1.31</td>
<td>1.73</td>
<td>0.48</td>
<td>2.85</td>
<td>1.13</td>
<td>0.42</td>
<td>0.43</td>
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Dataset: DFAUST [11] • Evaluation Metric: Deformation Weight Error (L1 Distance), Deformed Shape Error (Chamfer Distance, Hausdorff Distance)

References

3D-Aware Image Deformation

Deformation Weight Visualization

User-Defined Control Handles

Dataset

Please visit our project page (QR code above) for more results, including motion videos generated using our image deformation method.

Images from [1]

Laplacian-Based Deformation Weights [1]

Bounded Biharmonic Weights [1]

\[
\begin{align*}
\arg\min_{w_k} & \sum_{k=1}^{m} \frac{1}{2} w_k^t W_k w_k \\
\text{subject to:} & \begin{cases}
w_k = 1 & \text{for } k \text{ associated with handle } \cdot \\
0 & \text{otherwise}
\end{cases}
\end{align*}
\]

- \( w_k \): deformation weights associated with \( k \)-th handle
- \( W_k \): deformation weights for \( k \)-th handle

\( L = \nabla^2 \): cotangent Laplacian

\( M = \nabla^2 \): inverse mass

Desired properties:
- positive semi-definiteness /
- symmetry /
- sparsity

\[
A = L^{-1} \nabla^2
\]

Ours

""