Image Resizing Using Seam Carving

John Entrieri
Jiaheng Fu
Background

Image Resizing
- Shrinking – Data must be removed
- Enlarging – Data must be added
Conventional Methods

- Cropping
  - Loss of Quality – None
  - Loss of Content – High
Conventional Methods

Scaling

- Loss of Quality – High
- Loss of Content – None
Problem Statement

- How can we resize an image in a way that minimizes losses in both quality and content?

SOLUTION

- Seam Carving
Seam Carving

- Seam – Path across an image either horizontally or vertically

- Calculate and remove the least “important” seam, reducing Height or Width by 1 pixel
Energy Function

- How can we define the “importance” of a pixel?
- How can we represent it quantitatively for mathematical use?

Which pixels are “important”?

Energy of a pixel:

\[ e(I) = \left| \frac{\partial}{\partial x} I \right| + \left| \frac{\partial}{\partial y} I \right| \]
Image Gradient

- Convolve each image channel (RGB) with one of several differentiation operators and average them.

<table>
<thead>
<tr>
<th>-1</th>
<th>-1</th>
<th>-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>-1</td>
<td>-2</td>
</tr>
</tbody>
</table>

Original  Prewitt Operator  Sobel Operator  Roberts cross Operator
Path Detection

- Using this new “energy matrix” how can we determine which seam to remove?

- Straight Forward Approach – Compare the sums along every potential path
  - Far too “expensive”

- Dynamic programming – Create “energy map” or matrix of minimum possible path sum at a given location
Creating an Energy Map

Energy of Image: \( E(x,y) \)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>3</th>
<th>2</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Copy first row or column

Energy Map of Image: \( EM(x,y) \)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>3+1</th>
<th>-</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>3+1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

\[ EM(x,y) = E(x,y) + \text{minimum possible touching EM value (options highlighted)} \]

Energy Map viewed as an image
Using an Energy Map

- Work Backwards
  - Find smallest value in final column
  - Find minimum touching, previous value
  - Continue until edge is reached

- Remove chosen locations from original image matrix and shift

- Result is a successfully resized (by 1px) image
The Seam Carving Algorithm
Results

- Quality retained
- Nothing meaningful lost
More Results

- Algorithm runs out of unimportant seams and distorts meaningful parts of the image.

- Scaling is the better method for these “high energy” images.
## Even More Results

- Computers are “dumb”, cannot infer what we want
- High energy trees, grass, and rocks cause chosen seams to cut through the houses
Possible Solutions

- In some cases, the energy function disagrees with what the user wants.
- The user can highlight areas they wish to not be tampered with.
- High energy values are injected into the section’s pixels.
Conclusions

- For certain images, seam-carving blows alternatives away
- In some cases, scaling may be superior
- Sometimes, the user must provide extra input to obtain the desired output.
Future Applications

- **Real-time Processing**
  - Web browsers
  - Image editing tools
  - Office suites

- **Image Completion**
  - Similar to solution on previous slide
  - Remove unwanted sections of an image
  - Highlight areas to be removed, and low energy values are injected
References


Questions?

Thank you for your time