Images Processing
Resizing

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Resizing Definition

- Scaling up and down while preserving aspect ratio

- Changing aspect ratio = retargeting
Resizing Using Scaling

- How can scaling be done gracefully?
  - Scaling up
  - Scaling down
  - Scaling non-uniformly

- All share the same problems: **aliasing**
  (since they are similar to sampling)
Non Uniform Resizing
Sampling Vs. Reconstruction
Comparison
Still, non-uniform artifacts!
Retargeting

- Changing the aspect ratio!
- Given the original media in size $m \times n$
  resize it to size $m' \times n'$
  where $m' \neq m$ or $n' \neq n$ or both.
Retargeting

- Simple scaling creates artifacts
- Simple cropping loses information at the edges, and cannot support enlarging an image:
Cropping?
Enlarging?
Seam Carving
Key Idea: Content Aware

- Remove (or Insert) “less important” parts and preserve more important ones
- In effect this means we are creating ... content aware resizing

- Key questions: what is important?
  - Edges are important
What Is Important?

- Edges Carry most information in the scene:
Seam Carving
A Local Operator!
Finding the Seam?
The Optimal Seam

\[ E(I) = | \frac{\partial}{\partial x} I | + | \frac{\partial}{\partial y} I | \quad \rightarrow \quad s^* = \arg \min_s E(s) \]
How Many Seams?

- An image has $n$ columns and $m$ rows
- Start from any pixel at top row ($n$)
- For each one choose between 3 possible pixels in the next row
- For each one of those, choose between 3 in the next row...
- $n \times 3^{m-1} = \text{exponential!} 😞
Pixel Attribute → Dynamic Programming

\[ M(i, j) = e(i, j) + \min(M(i-1, j-1), M(i-1, j), M(i-1, j+1)) \]
Dynamic Programming

\[ M(i, j) = e(i, j) + \min(M(i-1, j-1), M(i-1, j), M(i-1, j+1)) \]

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Dynamic Programming

$$M(i,j) = e(i,j) + \min(M(i-1,j-1), M(i-1,j), M(i-1,j+1))$$

\[
\begin{array}{cccc}
  5 & 8 & 12 & 3 \\
  9 & 7 & 3+3 & 9 \\
  7 & 3 & 4 & 2 \\
  5 & 4 & 7 & 8 \\
\end{array}
\]
Dynamic Programming

\[ M(i, j) = e(i, j) + \min(M(i-1, j-1), M(i-1, j), M(i-1, j+1)) \]
Searching for Minimum

\[ M(i, j) = e(i, j) + \min(M(i-1, j-1), M(i-1, j), M(i-1, j+1)) \]
Backtracking the Seam

\[ M(i, j) = e(i, j) + \min(M(i-1, j-1), M(i-1, j), M(i - 1, j+1)) \]

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Backtracking the Seam

\[ M(i, j) = e(i, j) + \min(M(i-1, j-1), M(i-1, j), M(i - 1, j+1)) \]
Backtracking the Seam

\[ M(i, j) = e(i, j) + \min(M(i-1, j-1), M(i-1, j), M(i-1, j+1)) \]
Inserting a Seam

Duplicate
Enlarging by Seam Insertion?
Duplicate Seams in Order
Duplicate Seams in Order
Enlarged or Reduced?
Not Always a Success
Find the Missing Shoe!
Solution
Changes in Energy
Changes in Energy

- Energy Reduced
- Energy Increased
Tracking Inserted Energy

- Three possibilities When Removing Pixel $P_{i,j}$:

```
  $p_{i-1,j-1}$     $p_{i-1,j}$     $p_{i-1,j+1}$
  $p_{i,j-1}$     $p_{i,j}$     $p_{i,j+1}$
```
Pixel $P_{i,j} :$ Left Seam

$$C_L(i, j) = |I(i, j + 1) - I(i, j - 1)| + |I(i - 1, j) - I(i, j - 1)|$$
Pixel $P_{i,j}$: Right Seam

$$C_R(i, j) = |I(i, j + 1) - I(i, j - 1)| + |I(i - 1, j) - I(i, j + 1)|$$

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Pixel $P_{i,j}$: Vertical Seam

$$C_V(i, j) = |I(i, j + 1) - I(i, j - 1)|$$
New **Forward Looking** Energy Function

\[
M(i, j) = E(i, j) + \min \left\{ \begin{array}{l}
M(i - 1, j - 1) \\
M(i - 1, j) \\
M(i - 1, j + 1)
\end{array} \right. 
\]
New **Forward Looking** Energy Function

\[ M(i, j) = \min \left\{ M(i - 1, j - 1), M(i - 1, j), M(i - 1, j + 1) \right\} \]
Backward (SIG 07)
Forward (SIG 08)
Backward
Forward
Backward
Forward

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