Seam Carving

Shai Avidan

Ariel Shamir
Miki Rubinstein
Seam Carving
Image Retargeting

Page layout

From Wikipedia, the free encyclopedia

Page layout is the part of graphic design that deals in the arrangement and style treatment of elements (content) on a page. Beginning from early illuminated pages in hand-copied books of the Middle Ages and proceeding down to intricate modern magazine and catalog layouts, proper page design has long been a consideration in printed material. With print media, elements usually consist of type (text), images (pictures), and occasionally place-holder graphics for elements that are not printed with ink such as die/laser cutting, foil stamping or blind embossing.

Since the advent of personal computing, page layout skills have expanded to electronic media as well as print media. The electronic page is better known as a (GUI) graphical user interface when interactive elements are included. Page layout for interactive media overlaps with (and is often called) interface design. This usually includes interactive elements and multimedia in addition to text and still images. Interactivity takes page layout skills from planning attraction and eye flow to the next level of planning user experience in collaboration with software engineers and creative directors.

A page layout may be designed in a rough paper and pencil sketch before producing, or produced during the design process to the final form. Both design and production may be achieved using hand tools or page layout software. Producing the most popular electronic page (the web page) may require knowledge of markup languages along with...
Image Retargeting
Seam Carving

Cropping

Scaling
A Seam
Seam Carving
General Scheme

1. Define an energy function $e(I)$ (interest, importance, saliency…)

2. Use some operator(s) to change the image $I$

Setlur et al. [2005]

Recompose

Santella et al. [2006]

Crop

Gal et al. [2006]

Warp

Seam Carving
Seams in Images

- Efros & Freeman [2001] – Texture synthesis
- Kwatra et al. [2003] – Image and video synthesis
- Agarwala et al. [2004] – Digital Photomontage
- Perez et al. [2003] – Poisson Image Editing
- Jia et al. [2006] – Drag-and-Drop Pasting
- Rother et al. [2006] – Auto-Collage

Mostly used for composition of two (or more) images…
Finding the Seam?
Finding the Optimal Seam

\[ s^* = \arg \min_s E(s) \]
Dynamic Programming
Computing the seam: Dynamic Programming

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Computing the seam: Dynamic Programming

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13 14 15 16
Computing the seam: Dynamic Programming

5  8  12
9  7  12
14 10  8
14 15 16
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Computing the seam: Dynamic Programming

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\begin{array}{ccc}
5 & 8 & 12 \\
9 & 7 & 12 \\
14 & 10 & 8 \\
13 & 15 & 16 \\
\end{array}
\]
Seam Carving
Energy Preservation

While resizing: remove *as many* low energy pixels and *as few* high energy pixels!
Reduce Width

Average Pixel Energy

Image Reduction

crop  column  pixel  optimal
Alternative Error Functions

- $L_1$
- Entropy
- HoG
- Seg.+$L_1$
L₁ Error Function
Aspect Ratio Correction
Aspect Ratio Correction

Original  Retarget  Resize

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Aspect Ratio Correction

Original

Retarget

Resize
Aspect Ratio Correction

Original

Retarget

Resize

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Image Retargeting

Original

Retarget

Resize

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Sub Pixel Seam Carving
Content Enhancement
Seam Carving in the Gradient Domain
Optimal Order?
## Optimal Order Map

### Remove vertical seams

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# Optimal Order Map

## Remove vertical seams

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Remove horizontal seams
Optimal Order Map

Remove vertical seams

Remove horizontal seams

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Optimal Order Map

alternate  vert. first  horiz. first  optimal  rescale

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Seam Insertion
Seam Insertion:
Duplicate Seams in Order
Seam Insertion
Enlarge or Remove?
How to change the aspect ratio?
Using Face Detection
Adding User Constraints
Object Removal
Object Removal
Find the Missing Shoe!
Solution
Consistent maps
Consistent Index Maps

2 1 3 4
1 2 4 3
2 1 3 4
3 2 1 4

2 3 3 3
1 2 4 2
3 1 2 1
4 4 1 4

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**Consistent Index Maps**

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Consistent Index Maps

- Use rows/columns

- Use seams in one direction, rows/columns in the other direction

- Use seams in one direction and use them to constraint seams in the other direction.

Can you do that?
Limitations

Content

Structure
Content driven video retargeting (Wolf et al. 2007)
Bidirectional Similarity

**Completeness:**

(a) The bidirectional spatial (image) similarity:
Input image Output image
(source) (target)

(b) The bidirectional space-time (video) similarity:
Input video Output video
(source) (target)
When does it fail and why?
Forward Energy
Results
Results
Results
Graph Cuts

Seam (cut) must be monotonic and connected
Graph Cuts

Not monotonic
Graph Cuts

Monotonic, Not Connected
Graph Cuts

Forward Energy

Backward Energy

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Results

Backward Energy

Forward Energy
Class Projects

- GPU implementation
- Incremental Graph Cut
- Relative Vs. Absolute
- Consistent Seam maps
- Bidirectional Seam Carving
- Seam Scaling