Content Aware Image Resizing

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Abstract

The goal of this project is to effectively resize images. I implemented an image operator named seam carving that support content-aware image resizing.

Introduction

Displaying images on devices with various sizes (cell phones, tablets) increase the need for a good image resizing algorithm. Also HTML and other document standards support dynamic changes in page layout and text , but not the image size.

Scaling and cropping are simple ways of resizing the image. With both techniques, some important details may be eliminated from images. Effective image resizing algorithm should consider image content.

Shai Avidan and Ariel Shamir's seam carving algorithm is a content-aware image resizing. Importance of pixels computed by energy function such as gradient magnitude, entropy, visual saliency, eye-gaze movement.A seam is a connected path of low energy pixels crossing the image from top to bottom, or from left to right. Image size will be increase or decreased by adding or removing low energy seams from the image.

Technical Part

1.Image Energy

The idea of seam carving is to remove pixels with less information, pixels that are similar to their neighbors and blend with them. Energy function, sum of image gradient in x and y direction, is a good operator for this purpose.

$$e_1(I)=\left|\frac{\partial}{\partial x}I\right|+\left|\frac{\partial}{\partial y}I\right|$$

2. Seam

One way to resize image is to remove equal numbers of pixels with lowest energy from every row/column. This will create a zigzag issue as pixels removed from random positions.

One good solution is to define seams for carving pixels. Seam is is an 8-connected path of pixels in the image from top to bot-tom/left to right, containing one, and only one, pixel in each row/column of the image.

$$(s^x)_i = (i, x(j)) \ s.t. \ \forall i, |x(i) - x(i-1)| \leq 1$$

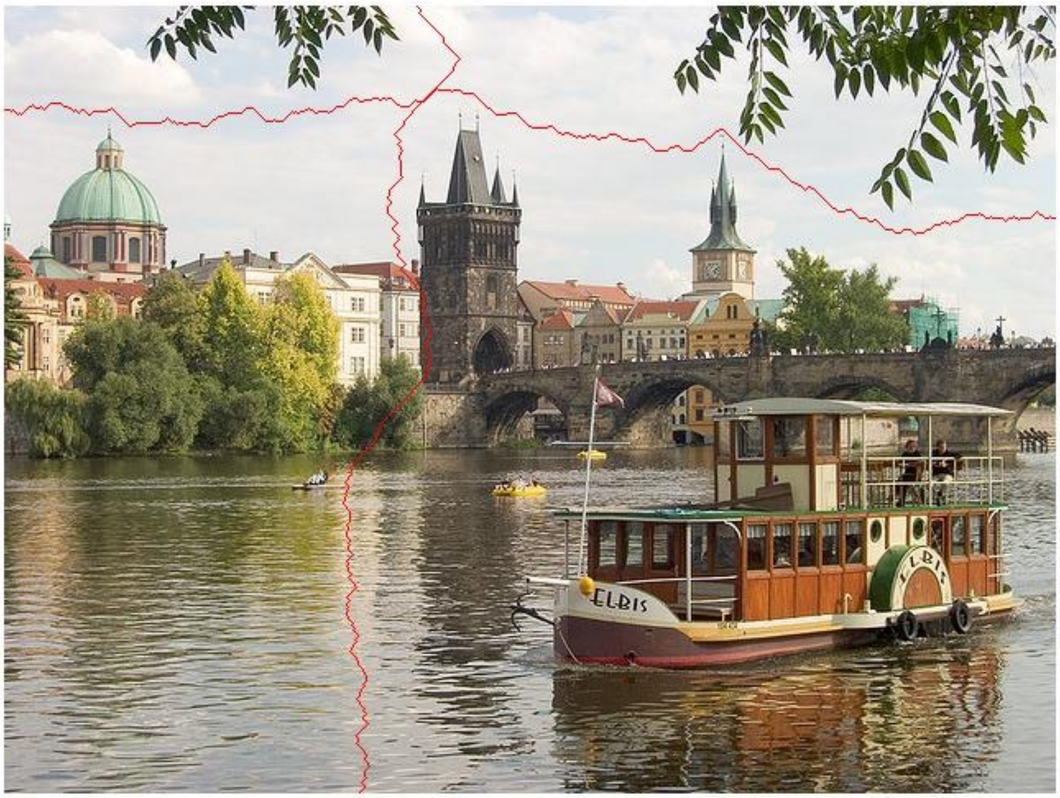
optimal seam is the seam minimizes energy function which can be find by dynamic programming.

First, find minimum cumulative energy of all possible seams for pixel at location(i,j).

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

second, find the minimum value in the last row and backtrace from this pixel to find the best seam.

Finding horizontal seam is similar to vertical seam, just need to transpose image and repeat same steps.



3.Optimal seams order

Changing image size in both vertical and horizontal direction $(m \times n) \text{-->} (m' \times n')$ begs the question of what is the correct order of seam carving?

Optimization of below function gives the optimal order of seam carving.

$$min_{\alpha, s^y, s^x} \sum_{i=1}^{k} E\left(\alpha_i s_i^x + (1-\alpha_i) s_i^y\right)$$

where $k = r - c, r = n - n', c = m - m'$ and α_i is used to determine if at each step vertical or horizontal seam should be removed.

Optimal order is found using a transport map T.T specifies cost of optimal sequence of horizontal and vertical seam carving. Each entry at T(r,c) has the minimum energy needed to resize image to n-r x m-c. T is computes using functional programming.

$$T(r,c)=min\Big(T(r-1,c)+E\big(s^x(I_{n-r-1\times m-c})\big),T(r,c-1)+E\big(s^y(I_{n-r\times m-c-1})\big)\Big)$$

T(0,0) is set to 0 and for each T(r,c), we choose either removing a horizontal seam or a vertical seam is the best operation. Then we backtrace from T(r,c) to T(0,0) and apply the corresponding carving operation.

4.result

I tested the seam carving algorithm on an image from Prague.

(a)

(b)

(c)

(d)

(a) is the original image (b) image is resized horizontally (c)image is resized vertically (d) image resized in both direction.

References

[1]Seam Carving for Content-Aware Image Resizing. Shai Avidan, Ariel Shamir, 2007.

[2]DALAL, N., AND TRIGGS, B. 2005. Histograms of oriented gradi- ents for human detection. In International Conference on Com- puter Vision & Pattern Recognition, vol.
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