Seam Carving: Content Aware Image Resizing

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1 Introduction

Changing image dimensions by croping or by rescaling can often result in a loss of information or distorted image content. The SeamCarving package provides an implementation of the Seam Carving algorithm to solve this task. Seam Carving is the process of calculating an energy and cost value for every pixel of a given image and removing an 8-connected path of pixels, vertical or horizontal, to reduce the dimensions of the given image with respect to the content of the image. The algorithm consists of three major parts:

- Generate an energy map of the image
- Calculate a cost map, where each value represents the minimal cost to reach a pixel from the image top
- Remove lowest cost seam by:
  - Finding least cost value in bottom pixel row
  - backtrack least cost seam
  - remove all pixels in that seam
  - Reshape image to fit new dimensions

A more indepth description of the algorithm can be found in Shai Avidan et al. (2012).

2 Process

The SeamCarving package supports RGB, three channel, PNG, JPG and TIF files. In this example, an image provided by the EBImage package will be used:

```
> imagePath <- system.file("images", "sample-color.png", package="EBImage")
> img <- readImage(imagePath)
> dim(img)

[1] 768 512   3

> display(img)
```

Figure 1: Original Image: 768x512 pixels and 3 channels

First, an energy map needs to be calculated. For that, a vertical and horizontal Sobel kernal is used which provides a good estimate about contrasts and edges in the image. The cost of a pixel inside a high contrast area will be higher and therefore more likely effect the primary content of the image. The energy map for figure 1 can be seen in the following figure:

```
> energy_map <- sc_mark_leastCSeam(imagePath)$energy_map
> display(energy_map)
```

Figure 2: Energy Map

The cost map can now be generated in the following manner:

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

Where M is an Array with the minimum cost of all pixels, i is the current row, j is the current column and $e(i,j)$ is the energy of the current pixel. Essentially, the cost of any given pixel is the energy value of said pixel and the minimum value of the three pixels above it.

The resulting cost map can be used to find the least cost seam, the pixel path with the lowest calculated impact on the content of the image:

```
> seam_image <- sc_mark_leastCSeam(imagePath)$seam_image
> display(seam_image)
```

Figure 3: Energy Map

The marked pixel seam in figure 3 can be removed and the image can be resized to fit the reduced dimensions.

This whole process has to be conducted for every iteration of removing a seam because once a connected path of pixels is removed from the image, the enrgy map and the cost map are no longer accurate and have to be calculated again. The introduced process focused on vertical seam removal and works for horizontal seam removal by rotating the image by 90°. The final reduction, using the SeamCarving package, looks like this:

```
> image_reduced <- sc_reduce(imagePath, 10, 5)$reduced_img
> dim(image_reduced)

[1] 758 507   3

> display(image_reduced)
```

Figure 4: Image with reduced dimensions: 758x507 pixels and 3 channels

References

[1] Shai Avidan & Ariel Shamir: *Seam Carving for Content-Aware Image Resizing*. CMU Graphics, 2012
`http://graphics.cs.cmu.edu/courses/15-463/2012_fall/hw/proj3-seamcarving/imret.pdf`