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Implementing Seam Carving in Digital Image: The Fractal Way

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Abstract

In this paper, we propose a new method to implement seam carving by inducing the fractal concept. The fractal concept, based in geometry and dimension theory, is one of the areas widely attracting the researcher's interest. The fractals now-a-days is considered to be the key for many scientific and artistic developments. 'Self-similarity' is one of the essential property of the objects which are fractal in nature. Whereas, Seam carving, is one of the most popular techniques for digital image retargeting, with the concept of 'systematic removal of less important pixels' in the core. The technique works by removing seams, which are the paths of least importance, from the digital image. In our work we capitalized the 'self-similarity' properties of fractals to build the seam to be further removed for the purpose of colored digital image retargeting. Our result shows the increased number of seams, which in turn results in efficient image resizing.

Keywords: Fractals, Algorithm, Digital Images, Pixel, Seam, Seam Carving

INTRODUCTION

Working and dealing with digital images now-a-days, is a common practice, which comes across in our routine activities. Scaling and cropping are among the various techniques available for retargeting a digital image[1]. In the said two techniques, retargeting digital images may results in damage or loss of valuable information content. To overcome the stated damage or loss, content aware retargeting techniques in digital images evolved.

Seam Carving [2] is one of the popular content aware retargeting technique, which works by removing or inserting the chain of pixels (seams) in the digital image. The selection of the seam depends on the algorithm, thus resulting in a pixel content known resizing of digital image. The fractal concept [3, 4] deals with mathematically defining the complex shapes that exists in nature. In this work we use the fractal property of 'self-similarity' in determining the seams, while implementing seam carving in colored digital images.

THE FRACTALS

The term fractal was coined by Benoit B Mandelbrot, in 1975 to denote his generalization of complex shapes [3, 4, 5, 6]. Fractal is derived from Latin word 'fractus' which describes the appearance of broken stone: irregular and fragmented. A fractal is made by repeating a simple process again and again. Fractals essentially have the property of 'self-similarity' i.e., a fractal is a never ending pattern that repeats itself at different scales either strictly or statistically. In simple words by Jampala [6], strictly self-similar fractals do not change their appearance significantly when viewed under a microscope of arbitrary magnifying power, whereas for statistically self-similar fractals, when a small portion of it is magnified, results into a fractal, which is seemingly but not exactly similar to the original fractal itself.

Seam Carving

Seam Carving, also known as liquid rescaling [2], is an algorithm for content-aware image resizing of the digital images, developed by Shai Avidan of Mitsubishi Electric Research Laboratory and Ariel Shamir of The Interdisciplinary Center & MERL. The seam carving technique [2, 7] supports content-aware image resizing for both reduction and expansion. The digital image is retargeted by finding out seams, a connected path of low energy pixels in

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an image, and removing/inserting it in one direction to change the aspect ratio of the image.

The Seam carving implementation methodology

The generalized methodology to implement the seam carving is described in following steps [1, 7, 8, 9]:

1. Select a colored digital image
2. Calculate energy of each pixel of the image
3. Calculate the cumulative energy of each pixel of the colored digital image
4. Generate list of the seams based on cumulative energy of the pixel in the last row
5. Remove seams from the image to reduce the size

We in our work had taken the colored digital image with the reduced dimension (93 X 137 pixels) to make computation easy. We opted to find out and remove the vertical seams. The energy of each pixel is calculated as follows:

Let we have to compute the energy of a pixel E surrounded by pixels A to I, the arrangement of pixels looks like:

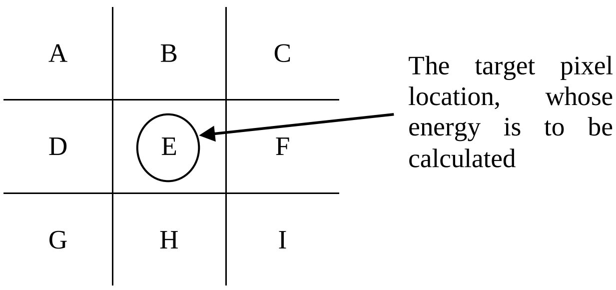

Figure 1: Arrangement of pixels in the provided digital image, as per the statement

The energy [10, 11] of the pixel E is calculated as:

$$\text{energy (E)} = \text{sqrt} (\, xenergy^2 + yenergy^2 \,)$$

where,

$$xenergy = a + 2d + g - c - 2f - i$$
$$yenergy = a + 2b + c - g - 2h - i$$

(each lowercase letters represents the brightness (sum of red blue and green values of the corresponding pixel), to compute the energy of edge pixels, we consider that the image is surrounded by a 1 pixel wide border of black pixels (with 0 brightness)).

The induction of fractal concept in seam carving

Here we induced the fractal concept while implementing seam carving. We utilized the statistically self-similarity property of fractals while generating the seams in the energy matrix of digital image. In the energy matrix, while calculating the cumulative energy of a particular pixel, we compare the target pixel's energy to the energies of three pixels, exactly above (n-1,m), above right(n-1,m+1) and above left(n-1,m-1) respectively, in order to find most self-similar energy values. The most nearer energy value to the target pixel is taken into consideration for calculating the cumulative value and thus the seam. After having the seam determined, we remove all the pixels of the seam from the image and shift the rest of the pixels towards the removed pixels. The procedure is illustrated as follows:

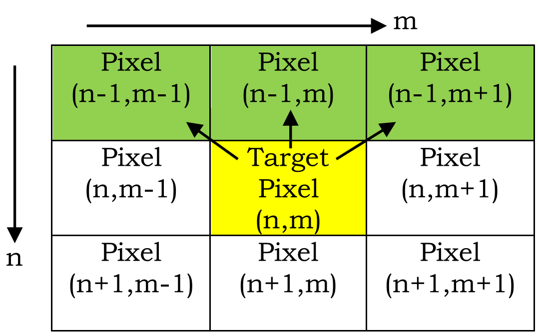

Figure 2: The target pixels is compared with the above three pixels cumulative energy value, to find the most self-similar pixel

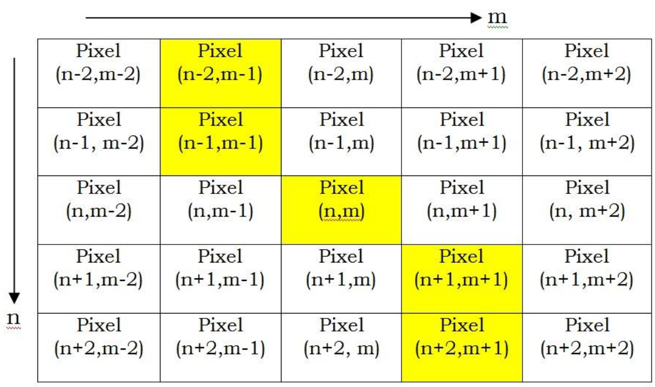

Figure 3: The formation of vertical seam in the cumulative energy matrix of the image

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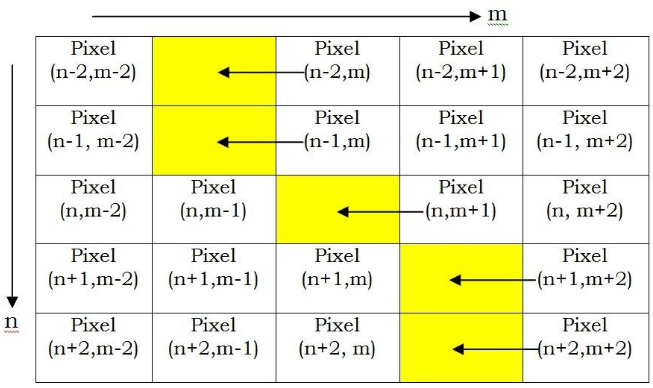

Figure 4: Removal of vertical seam from the digital image

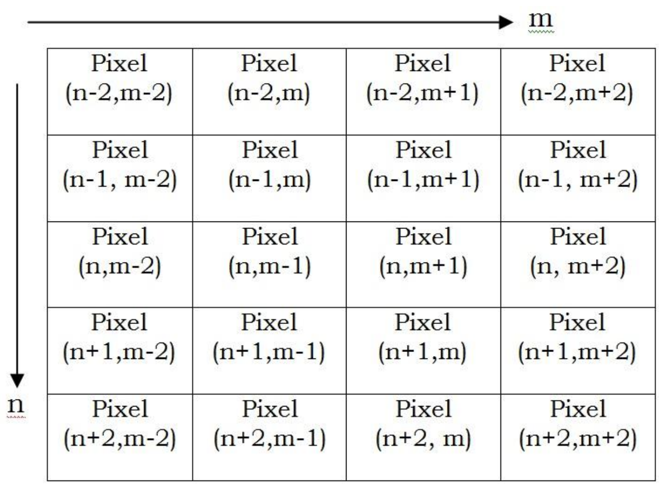

Figure 5: The shifted pixel positions after removal of vertical seam from the digital image

The proposed fractal-based algorithm for determining seam

1. If first row, then
2. cumulative energy value of pixel(n,m) = energy of the pixel(n,m)
3. else,
4. if first column, then
5. value1 = energy of current pixel(n,m) + cumulative energy of the pixel(n-1,m)
6. value2 = energy of current pixel(n,m) + cumulative energy of the pixel(n-1,m+1)
7. compare the two values (value1and value2) to find most similar value to the energy of current pixel(n,m)
8. cumulative energy of the current pixel = result of above comparison
9. else
10. value1 = energy of current pixel(n,m) + cumulative energy of the pixel (n-1,m-1)
11. value2 = energy of current pixel(n,m) + cumulative energy of the pixel (n-1,m)
12. value3 = energy of current pixel(n,m) + cumulative energy of the pixel (n-1,m+1)
13. compare all three values (value1, value2 and value 3) to find most similar value to the energy of current pixel(n,m)
14. cumulative energy of the current pixel = result of above comparison
15. end if
16. end if
17. backtrack to determine seam

(start with the pixel with a minimum value in cumulative energy matrix, then from above three pixel choose the one with minimum cumulative energy value, and so on)

RESULTS

Figure 6: The orignal colored digital image (93 X 137 pixels)

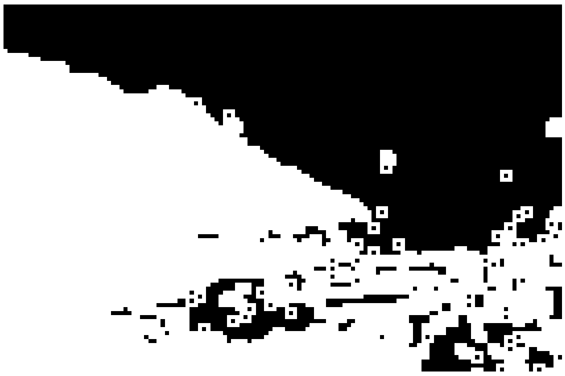

Figure 7: The energy function applied on the orignal image (93 X 137 pixels)

Figure 8: The Intermidate seam determined and carved away (seam 08) by new proposed algo

Figure 9: The Intermidate seam determined and carved away (seam 42) by new proposed algo

Figure 10: The final seam carved image (93 X 95 pixels) using the normal algorithm

Figure 11: The final seam carved image (93 X 88 pixels) using the proposed fractal based algorithm

CONCLUSION & FUTURE SCOPE

The result shows that the seam carving implemented using the proposed fractal-based algorithm for determining the seam, while computing the cumulative energy of the provided digital image, produces comparatively higher number of seams. This results in better image resizing by reducing the image size. The proposed algorithm can have many future scopes. We would like to test its implementations in video resizing. Content-aware enlargement of the digital images could be one another possible future aspects.

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