Analysis and implementation for image resizing algorithm based on content-aware

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Abstract

Image resizing plays an important role in digital image processing. It is widely used in various applications including image resolution adjustment, format conversion, and displaying high resolution image on the screen of PDA. In this paper, an interactive system is implemented based on the analysis of seam carving image resizing approach, which can provide some image interactive processing tools to analyze various kinds of content-aware image resizing algorithms. Furthermore, we further analyze the adaptability and limitations of these algorithms by some instance experiments in order to look for possible ways to improve efficiency.

Keywords

image resizing, seam carving, content-aware, dynamic programming.

1. Introduction

Image scaling technology is a basic and important technology in the field of digital image processing. [1,2]. Generally, the traditional technology of image zooming mainly includes nearest neighbor interpolation method, bilinear interpolation method and double cubic interpolation method. This kind of methods has many problems. For example, the scenery distortion will happen when we convert 4:3 image to 16:9 image and the image content will miss when it cuts, which are difficult to be accepted [3,4,5].

Recently, Avidan and Shamir [6,7] propose an algorithm called seam carving image resizing. It repeatedly removes or inserts horizontal and vertical seams to change the size of image with preserving the important contents in the image. Effective resizing of images should not only use geometric constraints, but also consider image content as well. It is a kind of method which is very effective.

In this paper, we firstly analyzed the seam carving technology. And then, the algorithms of content-based image cropping, image reduction and image magnification were implemented based on Microsoft Visual Studio 2013 platform and C# language [8]. Meanwhile, these algorithms were compared with conventional image scaling algorithm.

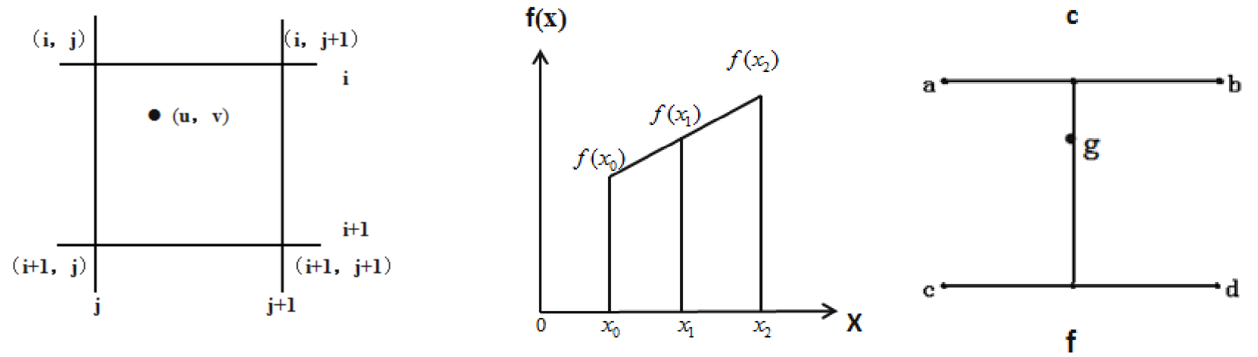
2. The analysis of image zooming technology based on content-sensed

Image zooming is a basic image processing operations. Digital image is two-dimensional matrix composed of pixels, image zooming is referred that using the known information and prior knowledge to estimate of the unknown pixel.

2.1 The current image zooming methods

The method of image zooming is divided into two categories: geometric transform scaling algorithm and keep image content scaling algorithm [9,10].

Interpolation techniques are generally used to resize image in geometric transform scaling algorithm. Unfortunately, these techniques introduce much distortion in the resulted image and there are artifacts in the result such as zigzag effects and blurring near sharp edges. Among them, the typical interpolation methods (such as nearest neighbor domain interpolation, linear interposition and bilinear interpolation) are shown in figure 1.



(a) nearest neighbor domain interpolation (b) linear interposition (c) bilinear interpolation

Fig. 1 The typical interpolation methods

Because of the simple geometric transform scaling algorithm can lead to serious distortion of images. Therefore, keep the image content scaling algorithm has a great development such as the typical seam carving algorithm which is proposed by Avidan and Shamir in 2007. The seam carving algorithm refers to zoom image by deleting or inserting eight connected pixels seam which cross the whole image horizontally and vertically. In order to keep the image characteristics, deleting or inserting the pixel lines must be the most weak of importance in image. Pixel seam is refer to the eight pixel areas, which is from top to bottom or left to right in a single picture and is defined by the energy of image function. Therefore, Seam is low energy pixels from above or from left to right path through a picture. So we can shrink or enlarge image in two directions by removing or inserting the seam, which is shown in figure 2.

Fig. 2 The image resizing based on seam carving algorithm

2.2 Image energy function

The pixel importance is determined by energy function in seam carving algorithm, which is defined as follows,

$$e_1(\mathrm{I}) = \left|\frac{\partial}{\partial_x}\mathrm{I}\right| + \left|\frac{\partial}{\partial_y}\mathrm{I}\right|$$

Energy function is actually the image gradient, when the image shrink, the smallest energy pixel line is removed to keep the main characteristics every time, and at the time of image magnification, minimal energy pixel line is inserted into the original image to magnify the image and achieve the purpose of keeping image content.

2.3 Sobel algorithm

For color images, it usually is converted into grayscale firstly, and then we use Sobel operator to calculate image gradient,that is $e_1(I)$. The the common Sobel operator is shown in figure 3.

-1	**0**	**+1**
-2	**0**	**+2**
-1	**0**	**+1**

Gx

+1	**+2**	**+1**
0	**0**	**0**
-1	**-2**	**-1**

Gy

Fig. 3 The common 3x3 matrix Sobel operator

In figure 3, Gx(x,y) indicates the gray-scale changes in the horizontal direction of image, and Gy(x,y) indicates the gray-scale changes in the vertical direction of image. The corresponding calculation formulas are as follows,

$$e_1(\mathrm{I}) = |G_\chi(\chi, y)| + |G_y(\chi, y)|$$

$$G_\chi(\chi,y) = [\mathrm{I}(x+1,y-1)+2\mathrm{I}(x+1,y)+\mathrm{I}(x+1,y+1)]-[\mathrm{I}(x-1,y-1)+2\mathrm{I}(x-1,y)+\mathrm{I}(x-1,y-1)]$$

$$G_y(\chi,y) = [\mathrm{I}(x-1,y-1)+2\mathrm{I}(x,y-1)+\mathrm{I}(x+1,y-1)]-[\mathrm{I}(x-1,y+1)+2\mathrm{I}(x,y+1)+\mathrm{I}(x+1,y+1)]$$

In order to make the minimum energy value of each seam, an optimal seam can be found by using dynamic programming approach. the minimum energy M of each seam is as follows,

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

3. The implement of image scaling algorithm based on content-aware

This section describes the realization of the image scaling algorithm based on content-aware in detail. The data flow diagram and function module diagram of image scaling system are shown in figure 4-5.

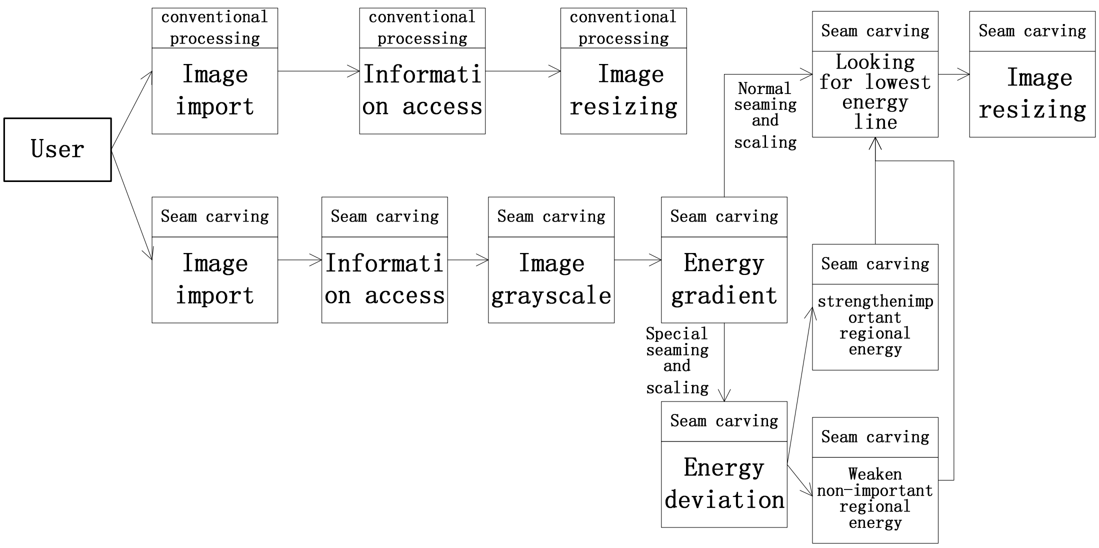


Fig. 4 The data flow diagram of image scaling system

3.1 Bitmap images generation

Bitmap is an array of bits, which sets the color of each pixel in the pixel matrix. Bitmap is Windows standard format graphics files, which defines that the image is made up of point (pixel), and each point may be expressed by a variety of colors, including 2, 4, 8, 16, 24 and 32 bit color.

In the programing aspect, firstly, Using the function OpenFileDialog in C# to access file, and then using Bitmap (Image) class to initialize the existing image to a new instance of the Bitmap class, that is Bitmap [11].

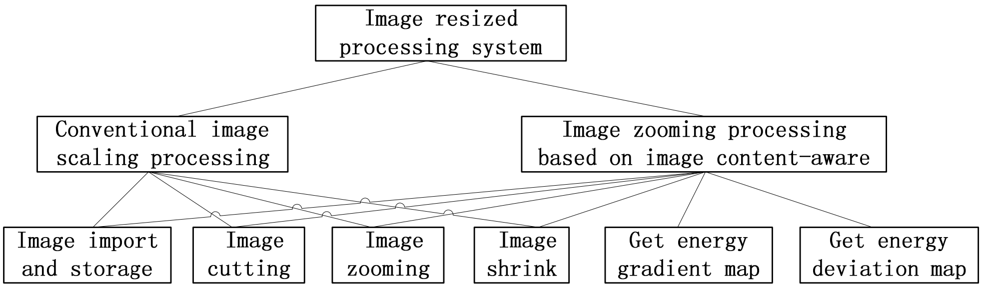


Fig. 5 The function module diagram of image scaling system

3.2 Grayscale images generation

Generally, each pixel of one 24-bit color images is described with 3 bytes, which corresponds to the brightness of the R, G, B component respectively. When RGB component values are different, it shows as a color image, when RGB component values are equal, it shows as a gray image. Two kinds of common calculation method for image grey value are as follows,

(1) the average method: f(i,j)=(R(i,j)+G(i,j)+B(i,j))/3.

(2) the weighted average method: According to importance and other indicators, the three components in different weights to the weighted average. Due to the human eye is sensitive to the green is highest, lowest sensitive to blue, therefore, f(i,j)=0.30R(i,j)+0.59G(i,j)+0.11B(i,j).

3.3 Gradient calculation

The steps of calculating the gradient value ($e(I)$ matrix) of the original image through the Sobel operator are as follows:

(1) Get the energy value of FX and FY in X and Y direction;

(2) Take matrix absolute value |FX| and |FY|;

(3) Return the matrix addition |FX|+|FY| (that is $e(I)$ matrix).

3.4 Energy matrix and optimal cutting seam calculation

For vertical cutting seam, M(i,j)=e(i,j)+min(M(i-1,j-1),M(i-1,j), M(i-1,j+1)). For horizontal cutting seam, M(i,j)=e(i,j)+min(M(i-1,j-1),M(i,j-1), M(i+1,j-1)). Implementation steps are as follows,

(1) Input matrix $e(I)$ which is calculated in 3.3 section;

(2) Create an image energy matrix M with the function GenerateEnergyMapBitmap of Bitmap class in C#;

(3) Return the energy M matrix after it is processed with dynamic programming method;

(4) Save and return the optimal seam path (that is the least energy cutting seam) with an array according to energy M matrix.

3.5 Removing the minimum energy cutting seam

According to optimal cutting seam, we can remove the vertical or horizontal cutting kerf from image to reduction image. Implementation steps are as follows,

(1) Input image and optimal vertical seam path arrays (taking an example of vertical cutting seam);

(2) Assign the pixels value near cutting seam to the pixels in the position of optimal cutting seam, Taking an example of vertical cutting seam, the right side pixels of cutting seam overall left shift one unit pixels to the optimal vertical seam, and then the width of image will reduce 1;

(3) Return the image whose optimal cutting seam has been removed.

3.6 Increase the minimum energy cutting seam

According to optimal cutting seam, we can increase the vertical or horizontal cutting kerf into image to enlarge image. Implementation steps are as follows,

(1) Input image and optimal vertical seam path arrays (taking an example of vertical cutting seam);

(2) Insert average pixel values of two adjacent pixel values on the left and the right of the minimum energy cutting seam into the original image;

(3) Return the image whose optimal cutting seam has been increased.

4. Algorithm experimental analysis

This section mainly analyzes the advantages and limits of image zooming system (algorithm) through several specific examples.

4.1 The applicability

Image scaling method based on seam carving technique is not suitable for all types of images, which is mainly suitable for this kind of image of image content uniform, image structure balance and high image texture, a concrete example is shown in figure 6.

Original image (100%) Image reduces 20% Image reduces 50%

Fig. 6 The The application types of the seam carving algorithm

4.2 The limitation

Through example analysis (as shown in figure 7), the application of seam carving in the processing of image should consider the following constraints:

(1) The first limiting factor is the amount of image content. When the content of original image is too dense, the image doesn't possibly contain less important content area. Therefore, the seam cutting technology based on the content-aware is difficult to effective adjust the image size.

(2) The second limitation factor is image distortion. When all important areas of the original image is bigger than the final output target, this approach will inevitably produce serious distortion, especially, the excessive extension and zooming will cause image distortion. Therefore, only in terms of the image zoom processing is not enough to achieve the ideal result.

(a)Original image (b)Scaling in ratio (c)Distortion (d) Effect (e)Important degree

Fig. 7 The limitation of the seam carving algorithm

5. Conclusion

This paper implemented a complete image scaling processing prototype system based on the analysis of the seam carving technology. The analysis and experimental results show that seam carving technology and prototype system can achieve better effect on the whole. But, this method has some limitations in respect of the image content amount and the image content layout. Therefore, the best way of image processing is the combination of various kinds of algorithms in practice.

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