DIGITAL IMAGE INPAINTING USING DIFFUSION TENSOR FOR OBJECT REMOVAL

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ABSTRACT

Inpainting is a technique of correcting a damaged image in an imperceptible form. The main application of Inpainting is reconstruction of damaged paintings and elimination of chosen objects from photographs to the extent that they appear normal and original to an observer. Image Inpainting algorithm is used to interpolate the misplaced or unknown regions in an image by making use of spatial information of its neighboring region. In this paper, we propose an efficient method to inpaint a damaged image based on a non linear diffusion tensor. The method perfectly tracks the local geometry of the damaged image and allows diffusion only in the isophotes curves direction. In this paper we have concentrated on object removal application of Image Inpainting. A large number of experiments show that the algorithms can efficiently remove the selected objects from the image in less time with good perceptual quality.

Index Terms: Digital Image Inpainting, Diffusion Tensor

I. INTRODUCTION

The field of image processing deals with the study of image restoration/enhancement such as image denoising, image deblurring, and image Inpainting. Furthermore, it is well known that the performance of these studies has been rapidly improved in recent years. Missing area reconstruction is one of the most attractive topics for study in the field of image restoration since it has a number of applications. Unwanted object removal, missing block reconstruction in an error-prone environment in wireless communication, and restoration of damaged old films are important applications. Image Inpainting is an important topic in both computer technology and computer vision and has great application value [1]. Digital image Inpainting techniques face great challenges in actual cases and also require constant improvement and development. Although some popular image processing software's such as Photoshop, CorelDraw, etc can also repair the damaged image, but demand professional skills on the users. And users must be careful to fill the color and texture and follow a complex and tedious manual, which makes it more difficult to do image Inpainting automatically and easily. Extensive research has been carried out in the field of digital Inpainting. Depending on the approach they take towards image completion, digital Inpainting algorithms can be categorized into two main categories. Partial differential equation based algorithms(PDE), like the ones proposed in [2],[3],[4],[fill in missing regions in an image by extending lines of equal luminance values, from the source region into the target region, via diffusion. The main drawback of this type of Inpainting algorithms consists of introduces blur artifacts that become more visible when larger areas are Inpainted. The second category comprises exemplar-based Inpainting algorithms [6][7][8][9][10][11]. Methods in this category try to overcome the drawback exhibited by PDE based techniques, by reconstructing large missing image regions from sample textures. Exemplar-based texture algorithm reconstructs the damaged part of an image by finding patches in the rest of the image which are similar to the known parts of the image patch to be filled, and then copying the missing information over. In image Inpainting technique the user selects the target region which is to be restored then algorithm automatically starts filling in that region using the available information from the source region. Filling proceeds based on the pixel's priority, higher the priority sooner the pixel gets filled. Priority of pixel is high if pixel lies on isophotes lines arriving at the regions‟ boundaries. [12]. In paper [13], a robust method for noise removal of image sequence based on coupled spatial and temporal anisotropic diffusion is proposed. The idea is to achieve an adaptive smoothing in both spatial and temporal directions, by solving a nonlinear diffusion equation. This allows removing noise while preserving all spatial and temporal discontinuities. The aim of paper [14] is occlusion removal and reconstruction of the image. An image mainly consists of two parts, structure and texture. The image is decomposed into structure and texture by morphological component analysis (MCA) decomposition method. They are processed separately. Structure image is processed using sparse Inpainting method. Texture image is processed using anisotropic diffusion.

In order to understand the algorithms we need to understand the terms used in image Inpainting literature. The original image is described as I, the area that has to be Inpainted is denoted as Ω, the border of this region and the known region also known as source region is indicated by ф. This is shown in Figure

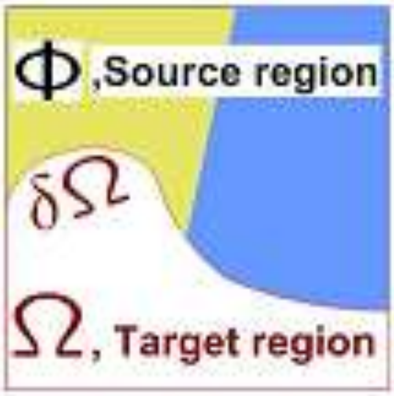

Figure1. Notation Diagram

Given an image and a region Ω inside it, the Inpainting problem modifies the image values of the pixels in Ω so that this region does not stand out with respect to its surroundings. The region Ω is always given by the user, so the localization of Ω is not part of the Inpainting problem. Almost all Inpainting algorithms treat Ω as a hard constraint, whereas some methods allow some relaxing of the boundaries of Ω.

II. DIFFUSION BASED IMAGE INPAINTING

The term of digital Inpainting was first introduced by Bertalmio et al 2000 [15]. In this paper, a third order PDE is solved only inside Ω with proper boundary conditions in δΩ. Its purpose is to propagate image laplacians in the, line of constant intensity directions. The edges recovered with this approach are smooth and continuous at the boundary of the hole. However, it cannot deal with texture and when the area to be Inpainted is too big, the result exhibits a lot of blur. Diffusion based Inpainting was the first digital Inpainting technique in which missing region is filled by diffusing the image data into the missing region at the pixel point. In this section, we will review the mathematical formalism of the PDEs, and the concept of isotropic and anisotropic diffusion applied to the still grayscale image [13].

2.1 Isotropic Diffusion

The isotropic diffusion finds its origin in the well known heat equation and is defined according to the following equation

$$\frac{\partial g(x,y,t)}{\partial t} = div(\nabla g(x, \quad (1)$$

Where t is the time of diffusion; **∇** g: is the gradient of the grayscale image g,

The parabolic linear PDE equation (1) can be interpreted as a diffusion process of pixel (x,y)'s brightness around the neighboring pixels , during a time t. It is shown that this approach is not efficient, because the diffusion operates in all directions leading to edge degradation.[13]

2.2 Anisotropic Diffusion

To overcome the problem of the isotropic diffusion, the anisotropic diffusion has been proposed in which smoothing is only performed in low gradients areas in homogeneous areas, the idea is to introduce a function that controls the force of the diffusion making it possible to retain edges.

2.3 Non Linear Diffusion Tensor

The non linear diffusion (anisotropic) does not give reliable information in the presence of flow-like structures .It would be desirable to rotate the flow towards the orientation of interesting features. This can be easily achieved by using the structure tensor, also referred to the second moment matrix. A structure tensor is a matrix representation of partial derivatives information. In the spatial domain, it is typically used to represent the gradient or edge information of an image since it provides a more powerful description of local patterns compared with the directional derivative. The structure tensor is given by the matrix:

$$J_\rho = K_\rho * \begin{bmatrix} J_{11} \\ J_{21} \end{bmatrix} \quad (2)$$

$$J_{11} = K\sigma \quad (3)$$

$$J_{12} = J_{21} = K\sigma * \quad (4)$$

$$J_{22} = K\sigma \quad (5)$$

$$U_i^{n+1} = U_i^n + \Delta t \quad (7)$$

$$D = div(J_\rho \quad (8)$$

Where I is the original image, is the gradient of image I in x direction, is the gradient of image I in y direction. K_σ is the Gaussian kernel used to smoothened the gradient. The parameter σ determines the size of the resulting flow like patterns. Increasing σ gives an increased distance between the resulting flow lines. These new gradients features allow a more precise description of the local gradient characteristics.

K_ρ is a Gaussian kernel of standard deviation ρ. The integration scale ρ averages orientation information. Therefore, it helps to stabilize the directional behavior of the filter. The convolution with the Gaussian kernels, make the structure tensor measure more coherent. D is the diffusion tensor; div is divergence and is gradient of image I.

III. IMPLEMENTATION

In this paper we have implemented Digital Image Inpainting using Diffusion Tensor The algorithm is as stated below.

Step1. The region of the gray scale image to be Inpainted is marked manually by the user.

Step2. A mask image is generated with one in the region to be filled and zero in the remaining region.

Step3. The region to be Inpainted is filled with zeros (unknown values).

Step4.The edges of the image to be Inpainted are identified.

Step5. Find J11, J12, J21 J22 using equation 3 to 5.

Step6. Find using equation 2.

Step7.Find D using equation 8.

Step8. Find u^{n+1} using equation 7.

Step9. Repeat steps 4 to 8 for several iterations.

IV.RESULTS

The discussed algorithms are tested on a variety of images to investigate the performance of Inpainting. The proposed algorithm is implemented in MATLAB 7.7.0.471 R2008b.Evaluation of Inpainting by perceptual quality is subjective in nature. However, this is a difficult task and there is no common method for evaluating Inpainting algorithms. Hence, we have to rely on qualitative evaluation. The contours are well reconstructed and recovered with a good track of the local geometry image and isophotes. Figure 2 and Figure 3 show the input and output image of the algorithm. In figure 2 we can see that the object to be removed is marked by the user and that region is initialized to zero pixel value. Figure 3 we see that the pixels are filled with the neighboring pixels proceeding in the line of equal intensities.

Figure1 Original Image with Object Marked

Figure2 Inpainted Image with Object Removed

IV. CONCLUSION

In this paper, we have proposed an efficient method for image Inpainting based on the non linear diffusion tensor. This is more appropriate than the use of a simple diffusion gradient since it gives reliable information in the presence of complex structures images. The algorithm results are obtained for several images. The performance can be compared on the basis of PSNR and time required for Inpainting. Experimental results are very promising in removing the selected objects. Future work will include Inpainting for highly textured images.

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