Image inpainting using patch-based and texture synthesis algorithms

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Abstract:

Image inpainting is a art of missing value or a data in an image. The purpose of image inpainting is to reconstruct missing regions which is visible for human eyes. Image inpainting is the process of reconstructing lost part of images based on the background information. Image inpainting is a technique for restoring damaged old photographs and removing undesired objects from an image. The basic idea behind the technique is to automatically fill in lost or missing parts of an image using information from the surrounding area. It is used for restoration of old films and object removal in digital photographs. It is also applied to red-eye correction, stamped data from photographs, dust spot in film, removing objects to creative effect etc. The main goal of the Inpainting algorithm is to modify the damaged region in an image. In this paper we provide a review of different techniques used for image Inpainting. We discuss texture synthesis method and inpaint the image using masking.

Keywords:

Image inpainting, Texture Synthesis, PDE, Hybrid inpainting

1.Introduction :

"Inpainting is the process of reconstructing lost or deteriorated parts of images . For instance,in the case of a valuable painting, this task would be carried out by a skilled image restoration artist. In the digital world, inpainting(also known as image interpolation) refers to the application of sophisticated algorithms to replace lost or corrupted parts of the image data (mainly small regions or to remove little defects."[29]. There are many applications of image inpainting. It can be used in cinema and photography for "restoration", for removing effects like scratches, dust spot from images (called deterioration). It can also be used for removing some object from image or removing red eye removal. Image denoising is famous problem in image processing field. Image inpainting and image denoising are not same.Below figure shows the difference between both.
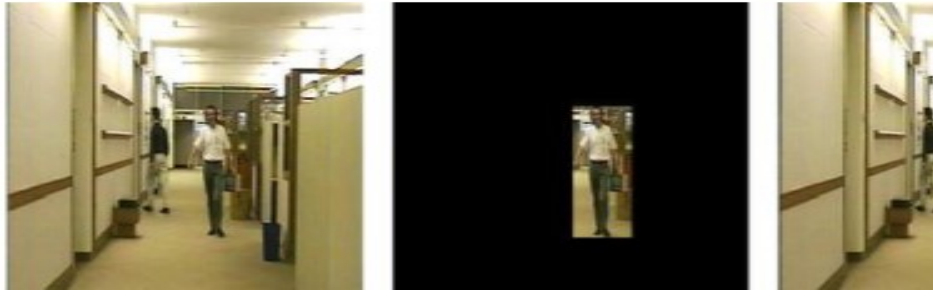
Difference between image denoising and image inpainting

Image inpainting can use for privacy protection. Many video obfuscation techniques are available [28, 13] in which one can remove objects from given video frame. Below diagram shows one such example presented in [18].

Image inpainting application for video presented in [18]

Paper is organized as follow. Section 2 contain different inpainting algorithms. In section 3 we have given a brief idea of video image inpainting, how to check or evaluate quality of inpainted image is explained in section 4, and here in section 5 we have briefly explain some of the recent work in this field. Finally section 6 contain conclusion and future work.

2. Inpainting Algorithms:

Image inpainting algorithms can be classified into different categories like texture synthesis based image inpainting, Exemplar and search based image inpainting, PDE (Partial Differential Equation) based inpainting, Fast semi- automatic inpainting and hybrid inpainting. Here in this section we have explained all of these inpainting methods.

Texture synthesis based image inpainting:

In this method, holes are filled by sampling and copying neighboring pixels[2,7,9]. Main difference between different texture based algorithms is how they maintain continuity between hole's pixel and original image pixels. This method is only work for selected number of images not with all. Yamauchi et.al presented algorithm which generate texture under different brightness condition and work for multi resolution [11].Bergen proposed algorithm. where matching texture is synthesized from target texture [7].Fast synthesizing algorithm presented in [2], uses image quilting (stitching small patches of existing images.

All texture based methods are different in terms of their capacity to generate texture with different color , intensity,gradient and statistical characteristics. Texture synthesis based inpainting method not perform well for natural images.These methods not handle edges and boundaries well. In some cases user need to enter which texture to replace with which texture. So these methods are used for small area of inpainting.Exemplar and search based image inpainting:

This method is very effective and use Isophote driven Inpainting and texture synthesis proposed by Criminisi et.al [1]. In this algorithm priority based mechanism is used to determine order of region filling. This method work very good for large number of images. It uses good texture and structure replication. Problems with this method is, curved structure are not handle properly and biasing in due to incorrect selection of patches. In [6] Fang et.al presented one algorithm by combining direction measure with texture synthesis based technique presented in [4]. In algorithm presented by drori etal[12] to find unknown region, iterative approximation used. Till now to fill the hole in image one use same image pixels only but hays et.al [14] gives the concept of using millions of

images as the database for filling hole. The nearest and perfect match for the image is obtain by database searching. Below we have shown figure adopted from [14] which given an idea how searching technique work. Position blending process can also be used with searching technique to fill hole.

Search based inpainting

PDE based inpainting:

First PDE base approach given by Bertalmio et.al [21]. It uses the concept of isophotes (linear edges of surrounding area) and diffusion process. Main problem with this method is that due to blurring effect of diffusion process replication of large texture is not perform well. Pixels on edges are also not handled properly. TV (Total Vibrational) model is proposed by Chan and Shen which uses anisotropic diffusion and Euler-Lagrange equation. From TV model, another algorithm presented based on CDD (Curvature Driven Diffusion model) which include curvature information of the isophotes. Another PDE based technique known as vector valued regularization under anisotropic diffusion framework presented by Tschumperle et.al.

Hybrid Inpainting:

In this method, PDE and texture synthesis based inpainting methods are combined for filling holes. Here main goal is to decompose image into texture and structure region. Then corresponding regions are filled by texture synthesis and edge propagating algorithms respectively [22]. It require more computational time for large holes. Structure completion through segmentation based inpainting technique is found in [16]. Segmentation algorithm used in this method is presented in [31].

3. Parameters for Inpainting Algorithm Evaluation:

For find out or compare the quality of different inpainting algorithms, not much research has been done. Initially algorithms were compared based on their capability to handle big fill areas, how good algorithm in curved structures, texture replication capability, time taken and algorithm work for how many images etc.[21]. Some time images are converted in RGB to compare their visual quality. In [8] they have used PSNR (Pick signal to noise ratio) and MSE (Mean squared error) for comparing inpainting algorithms. Some time domain of original image is also considered for comparison. Below figure adopted from [27] shows domain shape based quality checking. Nowadays parameter used to check the quality of inpainting algorithm is to check how inpainted image closer to original image. Ardi [25] very recently analyze the visual salience map generated by a computational vision model[20]). They relate it to the perceptual quality of image inpainting.

Domain shape based quality[27]

4. Recentwork:

We have studied some recent research paper in detain. In this section we have describe all that and show the results achieved by these papers. In [24] authors presented TV based texture inpainting algorithm which simultaneously inpaints structures and textures of damaged images. Their algorithm decomposes image into two parts. They inpaint the cartoon image part firstly using boundary reconstruction. Then they use texture synthesis to texture image part guided by boundary reconstruction. Their algorithm gives good results for texture with complex structure. Below we have shown the result produce by their algorithm. They have compare it with M.Bertalmio(indicated "[1]" in figure) and with crimini.

Result and comparison of algorithm presented in [24]

Inpainting algorithm based on directional mean filters is presented in [10]. They have proposed iterative algorithm. The algorithm works as follow. "First iteration calculate median value of known pixels' in each direction and then damaged pixel is replaced by the median of the obtained values. In latter iterations, median of all pixels' values in each direction is calculated then median of obtained values is copied in place of the damaged pixel. This algorithm is fast and provides adequate results in sharp edges regions." Below figure shows the results and comparison of proposed method.
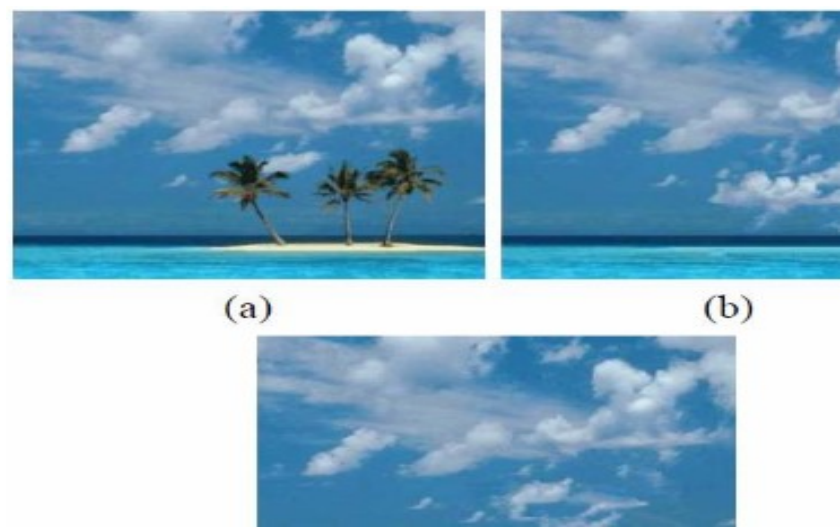
Result and comparison for algorithm presentedin [10]

Fast exemplar based algorithm presented in [3]. Their approach can inpaint large regions. Algorithm presented in paper is "is to find examples (i.e. patches) from the image and replace the lost data with it". Their technique can be used in restoring old photographs or

damaged film. It can also remove superimposed text like dates, subtitles etc.; or even entire objects from the image like microphones or wires to produce special effects. Result is given below. In figure "[3]" represent A. Criminisi, P. Perez, and K. Toyama, "Region Filling and Object Removal by Exemplar- Based Image Inpainting," IEEE Transactions on Image Processing, 13(9), 1200-1212, 2004.

Result and comparison for algorithm presentedin [10]

In [5] algorithm based on multiscale salient structure propagation is proposed. The brief of algorithm is "approach consists of four stages, namely, (1) detection of salient structure(s), (2) inpainting of salient structure(s), (3) inpainting of surrounding areas of salient structure(s) by modified ant colony optimization (ACO), and (4) inpainting of remaining missing regions." Below we have shown result of proposed algorithm. In below figure "[b]" is M. Bertalmío, "[e]" is Y. Chen, Q. Luan, H. Li, and Oscar Au, "Sketch-guided texture-based image inpainting," and "[gs]" is J. Shen, X. Jin, C. Zhou, and C. C. L. Wang, "Gradient based image completion by solving the Poisson equation,".

Result and comparison of algorithm presented in [3].

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Result and comparison of algorithm presenter in [26]

a. original image

b. the result o
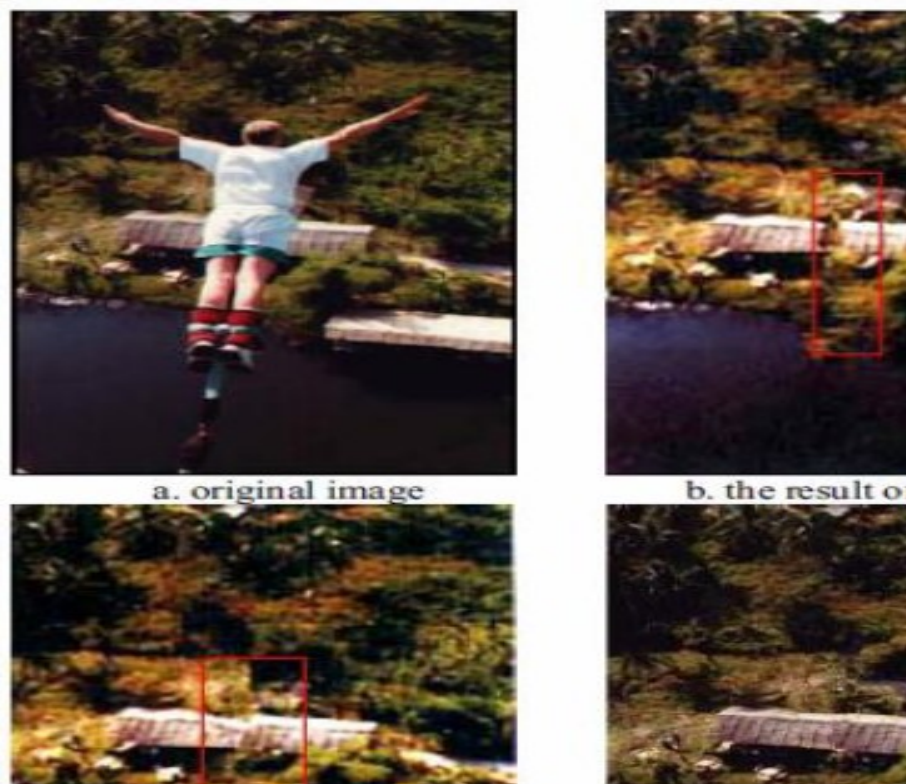
5. Conclusion And Feature works:

Image inpainting is recently very important research area in the field of image processing. Still many work on images can be done. The applications as we have listed are many of inpainting algorithms. In future we would like to implement all recent algorithm presented by us and would like to compare them. We would like to improve those algorithm if possible and would like to propose our new inpainting algorithm.

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