



A Survey on various Image Inpainting Techniques

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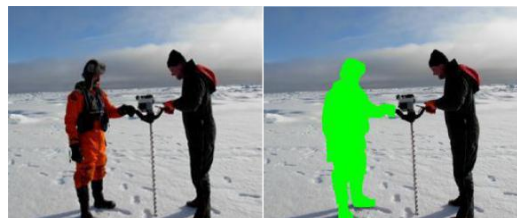
Abstract: Image Inpainting is technique, used to recover the damaged image and to fill the regions which are missing in original image in an undetectable way. The Inpainting algorithm's main goal is to modify the damaged region in an undetectable way. In this paper we have done brief survey on different image inpainting techniques. We will discuss different inpainting techniques like Exemplar based image inpainting, PDE based image inpainting, texture synthesis based image inpainting, Exemplar and search based, Wavelet Transform based, Semi-automatic and Fast Inpainting.

Keywords: Image inpainting, Exemplar, wavelet transformation, Semi-automatic and Fast Inpainting.

1. Introduction

“Inpainting is the process of reconstructing lost or deteriorated parts of images and videos. 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 or video 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).”[26].

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. Image inpainting can use for privacy protection. Many video obfuscation techniques are available [1, 2] in which one can remove objects from given video frame. Below diagram shows one such example presented in [3].



(1)

(2)



Figure.2. Ice Drill

Figure 2(1) Original Ice Drill Image.2(2) Image with mask for guiding inpainting 2(3) Result of simple Exemplar Base Inpainting 2(4) Adaptive Inpainting with patch size 10 X 10 pixels. [4]

Most Inpainting methods work as follows:-

In the first step of Inpainting method the user manually selects the portions of the image that will be restored. The image restoration is done automatically, by filling these regions in with new information coming from the surrounding pixels or from the whole image. The algorithms proposed for Inpainting use the information from surrounding portions of image to inpaint the selected region.

There are mainly three approaches for inpainting as follows:-

- A. The first approach deals with the restoration of films.
- B. The second class of algorithm deals with disocclusions.
- C. Third class of algorithm deals with restoration of textures in the image.

This paper is organized as follows. Section 2 describes the techniques for the image Inpainting which including exemplar based Inpainting, PDE based Inpainting, and Texture Synthesis based Inpainting, Wavelet Transform based and Semi-automatic Inpainting. Parameters for inpainting algorithm evaluation will be in section 3 and finally concluding remarks are given in section 4.

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2. Different approaches of image inpainting

Nowadays, there are different approaches to image inpainting are available. And we can classify them into several categories as follows:-

- 2.1 Partial Differential Equation (PDE) based
- 2.2 Texture synthesis based
- 2.3 Exemplar and search based
- 2.4 Wavelet Transform based
- 2.5 Semi-automatic and Fast Inpainting.
- 2.6 Hybrid Inpainting.

2.1 Partial Differential Equation (PDE) based

Partial Differential Equation (PDE) based algorithm is proposed by Marcelo Bertalmio et.al^[1]. This algorithm is the iterative algorithm. The algorithm is to continue geometric and photometric information that arrives at the border of the occluded area into area itself. This is done by propagating the information in the direction of minimal change using isophotelines. This algorithm will produce good results if missing regions are small. But when the missing regions are large, this algorithm will take so long time and will not produce good results.

Then inspired by this work, Chan and Shen [5] proposed the Total Variational (TV) Inpainting model. This algorithm is good due to Isophote driven Approach, we find the line of equal gray scale values which contains the more promising information and this information is used to complete the image with less time. This algorithm also have some problem, The main difficulty with this algorithm is the imitation of large texture regions. This algorithm also fail to recover Partially Degraded Image.

2.2 Texture synthesis based Image Inpainting

In this method, holes are filled by sampling and copying neighboring pixels [6,7,8]. The main difference between different texture based algorithms is how they maintain continuity between hole's pixel and original image pixels.

This method only works 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 [9]. Bergen proposed algorithm where matching texture is synthesized from target texture [7]. Fast synthesizing algorithm presented in [6], 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 don't give well result for natural images. These methods does not handle edges and boundaries well. In some cases user need to enter area of texture to replace with other texture. So these methods are used for small area of inpainting.

2.3 Exemplar and search based image inpainting

This method is very effective and use Isophote driven Inpainting and texture synthesis proposed by Criminisi et.al [10]. In this algorithm priority based mechanism is used to determine order of region filling. This method work very well for large number of images. It uses good texture and structure replication. Problems with this method is, it does not handle properly the curved structure and biasing in due to incorrect selection of patches.

In [11] Fang et.al presented one algorithm by combining direction measure with texture synthesis based technique presented in [12]. In algorithm presented by drori et.al [13] to find unknown region, iterative approximation is used. Till now to fill the hole in the 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 from

database searching. Below we have shown figure adopted from [14] which give an idea, how searching technique work. Position blending process can also be used with searching technique to fill hole.

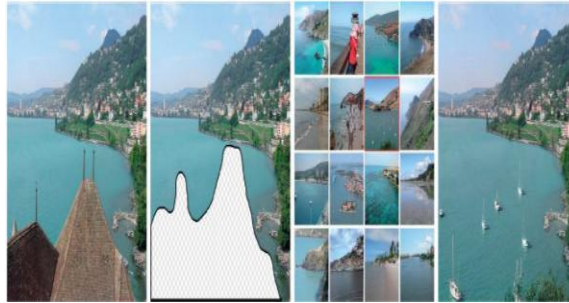


Figure 3. Search based inpainting [14]

2.4 Wavelet Transform based

The algorithm [15] presented the technique with the help of the wavelet transform. Here we expect the best global structure estimation of damaged regions in addition to shape and texture properties. If we consider the fact of multi-resolution analysis, data separation, compaction along with the statistical properties then we have to consider the wavelet transform due to its good image representation quality. Wavelet transform try to satisfy the human visual system (HVS). The algorithm decomposition of incomplete image is done with the help of wavelet and after that wavelet and scaling coefficients is found. The image inpainting process is applied in the wavelet domain by considering both scaling and wavelet coefficient from coarse to fine scales in the target region. Using this algorithm one benefit is that it utilizes inter and intra scale dependency to maintain image structure and texture quality using Wavelet Transform. But difficulties in this algorithm is masking for regions are defined manually.

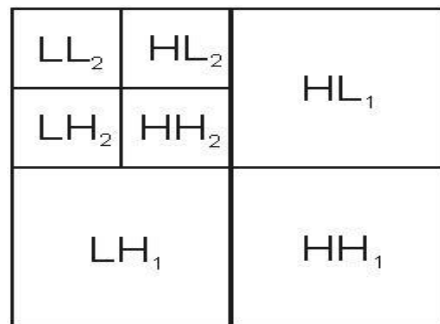


Figure.4. Wavelet transform decomposition of image [16]

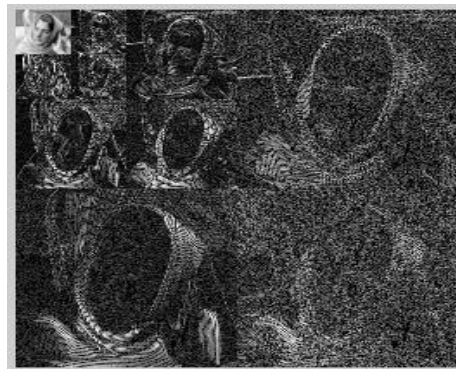


Figure.5. Result of Wavelet Transform [16]

2.5 Fast semi-automatic inpainting

A two step process is proposed by Jian et al[17] called inpainting with Structure propagation. A fast inpainting method is proposed by Oliviera et al[18] which do inpainting using iterative convolving inpainting region with diffusion kernel. Another method which uses FMM (Fast Marching Method) for image information propagation. This method is not suitable for images with large size holes as for edge region no specific method is used.

2.6 Hybrid Inpainting.

Hybrid inpainting technique[23] is also called as Image Completion. It is used for filling large target (missing) regions. And also preserves both structure and texture in a visually plausible manner. The hybrid approaches combine both texture synthesis and PDE based Inpainting for completing the holes. The main idea behind these approaches is that it decomposed the image into two separate parts, Structure region and texture regions. The corresponding decomposed regions are filled by edge propagating algorithms and texture synthesis techniques. These algorithms are computationally intensive unless the fill region is small. One important direction we believe is more natural to the inpainting process is by structure completion through segmentation. This technique uses a two-step approach: the first stage is structure completion followed by texture synthesis. In the structure completion stage, segmentation, using the algorithm of, is performed based on the insouciant geometry, color and texture information on the input and then the partitioning boundaries are extrapolated to generate a complete segmentation for the input using tensor voting. The second step consists of synthesizing texture and color information in each segment, again using tensor voting.

3 Parameters for inpainting algorithm evaluation

For finding 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.[19]. Sometime images are converted in RGB in order to compare their visual quality. In [20] they have used PSNR (Pick signal to noise ratio) and MSE (Mean squared error) for comparing inpainting algorithms. Sometime domain of original image is also considered for comparison. Below figure adopted from [21] shows domain shape based quality checking. Nowadays parameter used to check the quality of inpainting algorithm is to check how inpainted image are closer to original image. Ardi [22] analyze the visual salience map generated by a computational vision model [23]). They relate it to the perceptual quality of image inpainting.



Figure 6. Domain shape based quality[22]

4 conclusion

In this paper we review the existing techniques of image Inpainting. We discussed a variety of image Inpainting techniques such as texture synthesis based Inpainting, PDE based Inpainting, Exemplar based Inpainting, , and semi-automatic and fast Inpainting techniques. For each technique we have provided an explanation of the techniques which are used for filling the missing region. From this analysis, number of limitations were highlighted of these techniques.

It is observed that the PDE based Inpainting algorithms cannot fill the large missing region and it cannot restore the texture pattern. Exemplar based Inpainting will produce good results for Inpainting the large missing region also these algorithms can inpaint both structure as well as textured image. But they work well only if missing region consists of simple structure and texture.

Further study includes development of efficient algorithm which reduce computational cost and the time required for Inpainting as well .

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