

Digital Image Inpainting: A Review

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Abstract – *Image Inpainting is an ancient art and is a research topic in image processing. It fills the corrupted and the lost data in an undetectable manner. Image inpainting finds numerous applications like red eye correction, restoration of old damaged films, compression etc. There are several algorithms proposed for Image Inpainting. This paper reviews the work done by various authors in this field and a comparative study of their techniques. We discuss the different techniques of inpainting like PDE based inpainting, Exemplar based inpainting, bilateral filter inpainting, fast digital inpainting. The lost information can be reconstructed by propagating the known information in the direction of isophote lines. Isophote lines are the lines of equal intensity. Image Inpainting can be achieved by convolving with the weighted average kernel.*

Key Words: *Image Inpainting, Diffusion, Exemplar, Bilateral filter, Laplacian operator.*

1. INTRODUCTION

Sometimes it is required to remove the unwanted objects and scratches from an image. The unwanted object can be a logo, text etc. Removal can be done manually but it's an tedious task. The unwanted objects and scratches cannot be just erased, as erasing leaves a white patch behind in that area. By using the neighboring spatial information the unwanted and white patch is filled. This methodology is referred as Image Inpainting.

Image Inpainting is a technique which fills the regions that are missing or damaged using the spatial information available in the neighboring region. Image Inpainting is an ancient method of restoring the images which are damaged due to scratches on it and are old. Image Inpainting is an important research subclass of image processing. It's an ancient art of restoration. It plays an

important role in computer graphics, in preserving the historical heritage and eliminating the unwanted objects. Image Inpainting refers to manipulation of an image in an undetectable manner.

Using Image Inpainting we can remove the hole with its background as if the omitted object never existed. Thus Image Inpainting is aimed at filling the hole to create a pleasing continuation of information such that the editing cannot be easily identified by a neutral observer. Inpainting does not reconstruct the original image but fills the lost or unwanted objects by a part that has close resemblance to the original image. Marcelo Bertalmio was the first person to propose the notion of Image Inpainting. The inpainting methods are classified as:

A. Diffusion based inpainting

This was the first approach for image inpainting in which the information from the known image is diffused into the unknown region at pixel level. It utilizes the variational methods concept and PDE (Partial Differential Equation). This method does not give the convincing results for textured images and creates blur. This approach can be used if the area to be inpainted is small.

B. Exemplar based inpainting

In Exemplar based inpainting approach the missing region is filled with the information from surrounding known region at patch level. It follows three steps:

1. Priorities of each patch is computed
2. Selection of the best patch
3. Filling order.

This approach overcomes the drawbacks of Diffusion algorithm.

All the proposed Image Inpainting algorithms follow the following steps

1. Restoration of the image is the main purpose of the Image Inpainting and the way to fill the hole is determined from the global picture.
2. The hole is packed by continuing the structure of the region surrounding the gap into the hole. Prolongation of the contour lines arriving at the boundary of the hole is done.
3. The contour lines define different regions in inpainting domain and are filled with the colors the match the boundary of the hole.

4. Finally, the texture is added by filling the small regions. Image inpainting algorithms find the widespread applications which include

Object removal: The objects indicated by the user can be removed by using inpainting techniques in a visually plausible way.

Scratch removal: Old images damaged by scratches can be recovered by applying image inpainting algorithms at the part containing the scratch.

Correction of corrupted images during transmission: Image gets often corrupted in wireless transmission. By considering the lost part as inpainting domain the original image can be restored.

Generating visually stunning effects: In an image we can produce the required stunning effects by using inpainting technique.

Text removal: Inpainting algorithms can be used to eliminate the unwanted texts on the image.

2. LITERATURE SURVEY

In paper [1] author has proposed an algorithm for Image Inpainting in structured zone. The ideology used by author is to fill the hole region by propagating the available information about surrounding region in the direction of isophote lines. In this algorithm, only the zone to be filled is indicated by the user and no need to specify "What to put where". The result of this algorithm is an inpainted image without color artifacts and is sharp. The drawback of this algorithm is that it cannot reproduce images with large textured regions.

In paper [2] author proposed an simple algorithm which reconstructs the corrupted and missing portions which are small in size in an image. This approach is based on the isotropic diffusion model. In this approach the image is convolved with the weighted average kernel which considers the contribution only from the neighboring pixels. It is suitable for filling the parts which are small.

In paper [3] author has introduced a modified Oliveira inpainting algorithm. The proposed model is similar to the Oliveira but differs only in filling method. The method takes the image after the inpainted region is convolved with averaging filter having a zero weight at the bottom right corner instead of having in centre. This method reduced the time required for inpainting, produced results without blur as it does not involve repetition in convolution. Suitable for removing the large objects without blur.

In paper [4] author presents an inpainting method which uses bilateral filter. A bilateral filter is a smoothing filter which preserves the edges. A bilateral filter is used as it utilizes both domain and range filters. This algorithm does the convolution with the bilateral averaging filter. In this algorithm the kernel value is calculated at each pixel level

by making use of surrounding neighbors in both space and domain zone. This algorithm is an iterative algorithm and for better performance the number of iterations required is determined by the region type by using local variance. The edges are preserved well and the noise is eliminated by using this scheme.

In paper [5] author proposed an method which is based on preserving the effectiveness of rehabilitation which shortens the inpainting time greatly. The neighborhood of a pixel is set of pixels that touch the pixel and share vertex or edge with the pixel. It shows that there is an increase in the image inpainting rate for small regions. The important concern of the algorithm is establishing and maintaining the symbol distance function to the level set method. Algorithm does 4 scans on all the available grid points and does a simple operation that completes the establishment of symbol distance. This algorithm gives better, fast and feasible results when compared with Bertalmio's algorithm.

In paper [6] author has presented an algorithm which uses the spatial contextual correlation for inpainting. The inpainting is done by selecting the hole region automatically or semi automatically. In this algorithm the image to be inpainted is initially preprocessed using the Gaussian filter to eliminate noise and distortion. Using the merge split with max-difference growing region area segmentation is done. The region of inpainting is selected. Then the object and the real images are compared. The object is marked with different color. At last the image mating is done using contextual correlation and self data information. In semi- automatic approach the algorithm remains same only difference is segmenataion is carried out using drag shape method and the input is given manually. The omitted region is packed using the correlation information supplied by the neighbors and the information that is supplied in the borders is eventually proceeded towards the centre. Using this algorithm single and multiple regions can be inpainted.

In paper [7] author has introduced an approach in which the image to be inpainted is decomposed as structure and texture and based on their characteristics repairing is done. The texture image is repaired using the using the Exemplar based method. For the structure repairing the structure is enhanced using the Laplacian operator. Then the Laplacian image is inpainted using Exemplar based algorithm followed by reconstruction based on the Poisson equation. Finally both the repaired images are combined to get the inpainted image. This algorithm gives visual effects for large inpainting area.

In paper [8] author has designed a novel model to assign the priority and guidelines for filling order. Instead of using the basic isophote driven priority method, author has used the novel scheme of assigning the priority based

on color distribution analysis. This method distinguishes between the texture and structure and assigns highest priority to the structures in a more robust manner. This algorithm is capable of maintaining the consistency of texture and continuity at edges for a better visual quality.

In paper [9] author has introduced an Exemplar based Image inpainting by using the concept of extended wavelet transform. The algorithm consists of 2 steps: decomposition of the sub bands and directional transform. Firstly to capture the point discontinuities a Laplacian filter bank is used then to link the discontinuity into the linear structure directional filter bank is used. This algorithm gives promising results for edge enhancements in natural image.

In paper [10] author proposed an efficient scheme for repairing the damaged images using a non linear diffusion tensor. This scheme avoids the isotropic smoothing that is caused due to the diffusion by tracking the geometry of the corrupted image perfectly and then the diffusion is done only in the isophote curves direction which leads to the coherent color completion in the holes. This algorithm gives promising results in terms of repairing the corrupted zones and preserves discontinuities.

3. CONCLUSIONS

All the proposed algorithms have their own advantages and disadvantages. Using Bertalmio's algorithm large textured regions cannot be reconstructed. Isotropic diffusion based algorithm is suitable only for packing the regions which are small. Modified Oliveira algorithm packs the unwanted objects which are large without blur. Bilateral filter based approach preserves the edges and removes the noise. 8 neighborhood fast sweeping algorithm gives better results than Bertalmio's algorithm. Single and multiple regions can be inpainted by using spatial contextual correlation algorithm. Poisson equation based approach gives good visual effects for large inpainting area. Using color distribution analysis, consistency of texture and continuity at edges for a better visual quality can be obtained. Edges can be enhanced by using the extended wavelet transform. Non linear diffusion tensor method repairs the corrupt zones and preserves discontinuities.

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BIOGRAPHIES



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