A Survey on Different Inpainting Algorithms

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Abstract— **Image inpainting was historically done manually by painters for removing defect from paintings and photographs. It is the art of filling missing data in an image. The purpose of inpainting is to reconstruct missing region in a visually plausible manner so that it seems reasonable to the human eye. In Image inpainting region filling of missing information from a signal using surrounding information and re-form signal is the basic work of inpainting algorithms. There have been several approaches proposed for the same. Here, a novel approach is proposed to implement adaptive image inpainting algorithm. Propose algorithm automatically inpaint the selected area according to the background information. The image can then be saved, algorithm will be modified by changing values of variable and adaptively using fminsearch algorithm. The algorithm is implemented in the software tool MATLAB**

***Key words*— Image inpainting, Structure synthesis, Exemplar, PDE, MATLAB**

I. INTRODUCTION

"Inpainting is the art of restoring lost parts of an image and reconstructing them based on the background information. Image inpainting was historically done by painters for removing defect from paintings and photographs. It is the art of felling missing data in an image. The purpose of inpainting is to reconstruct missing region in a visually plausible manner so that it seems reasonable to the human eye."

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.

Figure1. Difference between image denoising and image inpainting

II. EXEMPLAR BASED IMAGE INPAINTING

The user selects a target region, Ω, to be removed and filled. The source region, Φ, may be defined as the entire image minus the target region (Φ = I- Ω), the boundary of the target region is define as δΩ. Our algorithm iterates the following three steps until all pixels have been filled:

1. Find computing patch priorities
2. Texture synthesis
3. Filling order

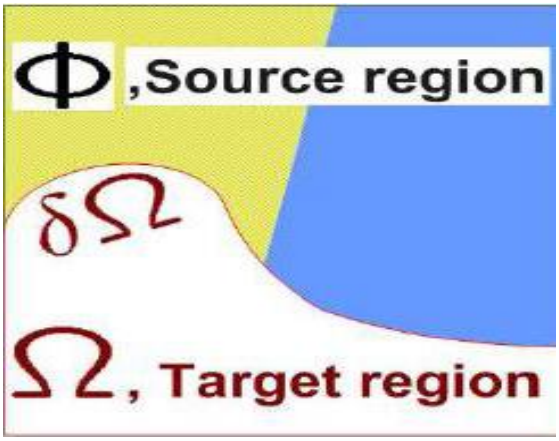

Figure2. Structure propagation by exemplar base texture synthesis [3]

2.1 Find computing patch priorities

An algorithm performs the synthesis task through a best-first filling strategy that depends entirely on the priority values that are assigned to each patch on the fill front. The priority computation is biased toward those patches which: (i) are on the continuation of strong edges and (ii) are surrounded by high confidence pixels. Given a patch p centered at the point p for some p Є δn , we define its priority P(p) as the product of two terms:

$$P(p) = C(p)D(p) \quad (1)$$

C(p) the confidence term and D(p) the data term:

$$C(p) = \frac{\Sigma q \in \Psi p \cap \Phi c(q)}{|\Psi p|} \quad (2)$$

$$D(p) = \frac{|\nabla Ip^{\perp}.np|}{|\gamma|} \quad (3)$$

The confidence term C (p) may be thought of as a measure of the amount of reliable information surrounding the pixel p. The confidence value for all pixels in the source region is to be 1 and the confidence value for all the pixels in target region is to be 0. The confidence value does not change once the pixel has been filled.

Patches that include corners and thin tendrils of the target region will tend to be filled first, as they are surrounded by more pixels from the original image. These patches provide more reliable information against which to match. Conversely, patches at the tip of "peninsulas" of filled pixels jutting into the target region will tend to be set aside until more of the surrounding pixels are filled.

2.2 Texture Synthesis

Once all priorities on the fill front have been computed, the patch Ψp with highest priority is obtained. We then fill it with data extracted from the source region. In traditional inpainting techniques, pixel-value information is propagated via diffusion. As noted previously, diffusion necessarily leads to image smoothing, which results in blurry fill-in, especially of large regions. Formally,

$$\Psi q = \arg\min d(\Psi p, \Psi q) \quad (4)$$
$$\Psi q \in \phi$$

2.3 Adaptive approach for Filling order

A novel propose algorithm is capable of propagating both texture and structure information. This section demonstrates that the quality of the output image synthesis is highly influenced by the order in which the filling process proceeds. As it can be observed, the ordering of the filled patches produces the horizontal boundary between the background image regions to be unexpectedly reconstructed as a curve. A concentric-layer ordering, coupled with a patch-based filling may produce further artefacts. Another desired property of a good filling algorithm is that of avoiding "over-shooting" artefacts that occur when image edges are allowed to grow indefinitely.

Steps for Region Filling Algorithm

1. Select an image then find all boundary points.
2. Find data pattern & confident for each boundary point
3. Multiply data pattern & confident of each boundary point (It is total point/strength/priority of particular pixel)
4. Find the pixel on boundary point which one having highest priority
5. Create patch window by keeping that highest priority pixel as central one
6. Match this window with entire image from (0, 0) th pixel to (x, y) th pixel and identify the matched window
7. Collect all the matched window position and again find data pattern & confident for each matched window, and multiply data pattern & confident
8. Find highest priority matched window then replace the patch window, which has been created in point number (5), with currently got matched window
9. Repeat the above steps unless there is no further inpainting needed.

III. EXEMPLAR AND SEARCH BASED IMAGE INPAINTING

This method is very effective and use Isophote driven Inpainting and texture synthesis proposed by Criminisi [1]. In this algorithm priority based mechanism is used to determine order of region filling. This method is 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 [5] Fang presented one algorithm by combining direction measure with texture synthesis based technique presented in [4]. In algorithm presented by drori [8] to find unknown region, iterative approximation used, now to fill the hole in image one use same image pixels only but hays [9] gives the concept of using millions of images as the database for filling hole. The nearest and perfect match for the image is obtained by database searching. Below we have shown figure adopted from [9] which given an idea how searching technique work. Position blending process can also be used with searching technique to fill hole.

Figure3. Search based inpainting [15]

3.1PDE based inpainting

PDE base inpainting approach given by Bertalmio [12]. It uses the concept of Isophote (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[5]

3.2Fast semi-automatic inpainting

There are two step process is proposed by Jian[10] called inpainting with Structure propagation. A fast inpainting method is proposed by Oliviera [14] which do inpainting using iterative convolving inpainting region with diffusion kernel. A method for image, FMM is used for information propagation. This method is not suitable for images with large size holes as for edge region no specific method used.

3.3Hybrid Inpainting

In this method, PDE and texture synthesis based inpainting methods are combined for filling holes. Here, the main goal is to decompose image into texture and structure region. After that region is filled first by texture synthesis and then after by edge propagating algorithms [13]. It require more time for large holes. Structure completion through segmentation based inpainting technique is found in [11]. Segmentation algorithm used in this method is presented in [18].

IV. RECENT WORK

We have studied some research paper, so in this section we have described some of work done and show the results achieved by papers.

In [25] authors presented TV based texture inpainting algorithm, 'Thangka' image is used as experimental subjects in this paper. Inpainting effectiveness have two ways: objective

evaluation and subjective evaluation. In this paper, widely used objective evaluation methods are: mean square error(MSE)measurement, signal to peak signal to noise ratio (PSNR) measurement and improved signal to noise ratio (ISNR) measurement and so on. In this paper, peak signal to noise ratio (PSNR) was used to evaluate the inpainting results. Below we have shown the result produce by their algorithm.

(a)Damaged Image (b) Inpainting result of TV algorithm (c) Result of propose algorithm (d) Original image

Figure4. Result and comparison for propose algorithm [17]

Inpainting algorithm based on directional mean filters is presented in [7]. They have proposed iterative algorithm. The algorithm works as follow. "First calculate the median value of known pixels in each direction and the replace by obtain median value. After that median of all pixels values in each direction is calculated, then the damage pixel is replace by obtain value. This algorithm is very fast and use for getting results in sharp edges regions." Below figure shows the results and comparison of proposed method.

Figure5. Result and comparison for propose algorithm [7]

Here, present the comparison of this approach with the one presented by Criminisi et al. in [4]. The image in Figure 6 (a) was an input image for inpainting process, that used approach as well as implementation of the Criminisi"s approach. This gives better results as compare to Criminisi algorithm. Algorithm presented in paper is "is to find examples (i.e. patches) from the image and replace the lost data with it".

(a) (b) (c)

Figure6. Result and comparison for propose algorithm [3]

This algorithm based on multiscale salient structure propagation is proposed. Figure 7(a) shows the target region, figure 7(b) indicate the blurred image of target region while figure 7(c) shows the salient structure extraction result of target region.

(a) (b) (c)

Figure7. Result and comparison for propose algorithm [16]

New image inpainting method based on exemplar- based image inpainting idea by Curvature-Driven Diffusion (CDD) model is presented. Results are shown below. This is the method for improve object remove by exemplar-based inpainting method.

Figure8. Result and comparison for propose algorithm [1]

V. CONCLUSION

Image inpainting is recently very important research area in the field of image processing. We discussed a variety of image Inpainting techniques such as texture synthesis based Inpainting, PDE based Inpainting, Exemplar based Inpainting. This analysis shows that exemplar based Inpainting will produce well results for Inpainting the large missing region. In future Researchers can make this algorithm adaptive so the quality of result increase, as well as efficiency is also going to be increase and timing for inpaint object will decrease. Researchers go for video base image inpainting.

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