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A Review of Image Inpainting Techniques

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Abstract: Image inpainting is the process of filling in missing regions in an image. The objective of inpainting is to reconstruct the missing regions in a visually plausible way. Several algorithms are available in the literature for the same. In this paper we introduce a literature review of some latest exempler based image inpainting techniques. We also discuss their advantages and disadvantages. An overview of image inpainting is also given at the beginning.

Keywords: Partial Differential Equation (PDE)

I. INTRODUCTION

Image inpainting is the research area in the field of image processing whose goal is to remove some objects or restore the damaged regions in a way that observers cannot notice the flaw. There are many applications of image inpainting such as photo editing, video editing, image compression and imagetransmission. Generally image inpainting techniques can be categorized into two approaches; Diffusion-based and Exemplar-based approaches. Diffusion-based approach is the fundamental approach in which information diffuses from known region into missing region. The problem is usually modeled by Partial Differential Equation (PDE), so sometimes it is called a PDE-based approach. Diffusion-based approach works well for non-texture image, in which the missing region must be small and thinner than the surrounding object. In the case that the missing region is large or containing texture, this approach gives a blurry result.

Exemplar-based approach is originated from the Exemplar- based texture synthesis in [1]. In that work, the texture is synthesized by copying the best match patch from the known region. However, as there are both structures and textures in natural images, directly applying Exemplar-based texture synthesis to image inpainting problem may not provide satisfactory result. Bertalmio [2] proposed to decompose the image into structural and textural images, then apply Diffusion- based inpainting to the structural image and texture synthesis to the textural image separately. The result of combining restored structural and textural image is better than restoration by only Diffusion-based inpainting or texture synthesis alone. For Exemplar-based texture synthesis to determine the fill-in order Criminisi et al. [3] introduced patch priority, which is defined by isophote direction and the known region in the target patch, Comparing with Diffusion-based inpainting, Exemplar- based approach gives a better result even in the large missing region case.

II. LITERATURE SURVEY

At present there are very few accepted technologies for carrying out the work of image inpainting. This is still in the beginning stage and a lot of researches are being carried out to explore this area. The restoreInpaint [12] is an open source library which provides functionalities to detect and automatically restore cracks from damaged photographs. The Software currently available for this task is named Photo-Wipe [11] by Hanov Solutions. Also provides tools for selecting the region to be inpainted and then provides several options to carry out the inpainting process with varying time and quality.

Algorithm at first sight may seem to be something similar to noise removal from images. The De-noising is focused towards modifying individual pixels whereas inpainting aims at modifying larger regions from the image. The Denoising also differs from inpainting in the way that in inpainting there is no information about the image in the region to be inpainted as opposed to noise removal where pixels may contain information about both the real data and noise [1]. The noise removal will in general not work for filling-in large missing portions in an image.

The most of the inpainting methods work as follows: user selects the region to be inpainted. It is usually done as a separate process and may require the use of separate image processing tools. Image restoration is then carried out automatically. To produce a visually plausible reconstruction, an inpainting technique must try to reconstruct the isophotes as smoothly as possible and also propagate two dimensional textures. On the basis of these two requirements, all the inpainting algorithms are classified as in the following way.

Mainly there are three classes of algorithms employed for inpainting. The first class of algorithms is for restoring

films or videos, but it is not very useful for image inpainting as there is limited information for inpainting images as opposed to film inpainting where the information may be extracted from various frames. Second class of algorithms deals with the reconstruction of textures from the image [4]. Algorithms utilize samples from the source region to rebuild the image. By using this approach, the most of the texture of the image can be rebuilt. Third class of algorithms tries to rebuild the structural features such as edges and object contours etc. Authors of paper [1] presented a pioneering work in this respect. This was able to recover most of the structural features from the image but failed while recovering very large regions. One more algorithm proposed in paper [10] involved the use of mask to achieve inpainting. Mask that they choose for inpainting is decided interactively and requires user intervention. Method prepare the mask such that the centre element in the mask is zero. It means that no information about a pixel is extracted using its own value. Algorithm uses the values of its neighboring pixels to determine its value. It also works only for small regions and cannot inpaint large regions in the image.

One more algorithm for recovering small regions and noise in an image is proposed in paper [5]. This can inpaint images with very high noise ratio. Method uses Cellular Neural Networks for the same. The noises inside the cell with different sizes are inpainted with different levels of surrounding information. This method achieved a high accuracy in the field of de-noising using inpainting techniques. Mehod provides results that show that an almost blurred image can be recovered with visually good effect. It is not suitable for the larger regions.

The [13] propose an algorithm using Cahn-Hilliard fourth order reaction equation to achieve inpainting in gray-scale images. This paper [2] extends the earlier mentioned paper [13] by introducing a total-variation flow for images.

Method in [4] proposed an inpainting algorithm to fill in holes in overlapping texture and/or cartoon image synthesis. This algorithm is a direct extension of morphological component analysis that is designed to separate linearly combined texture and cartoon. The approach differs from the one proposed by Bertalmio et al. [1]. Bertalmio considered decomposition and filling-in stage as two blocks. On the other hand, their approach [4] considers these as one unified task.

A very few algorithms that utilize the advantages of both the image inpainting methods i.e. the structure recreation and texture synthesis algorithms. One such algorithm was proposed in the paper by Criminisi et al. [3]. Authors proposed a pioneering approach in this field that combined structural reconstruction approach with the texture synthesis approach in one algorithm by combining the advantages of both approaches. Method used the fact that the result of inpainting process depends (in general) on the order of filling-in the hole. Traditional concentric-layer filling (onion-peel) algorithm [15] for defining the region filling order failed to reconstruct structural features.

The work done in [14] proposed an algorithm for video inpainting by implanting objects from other frames. The improved exemplar based algorithms for the same. Another approach for video inpainting employs information from adjacent frames and performs interpolation based on those frames to achieve inpainting [7]. The work done in [6] present an algorithm to inpaint videos using the exemplar based approach. Authors focus their research towards the restoration of old movies and particularly scratch removal. Method use the block based exemplar based approach and extend it using motion estimation.

III. CONCLUSION

This paper contains an overview of image inpainting. The review of some modern image inpainting technique is presented. Their merits and demerits are discussed in brief. The common problems of modern image inpainting techniques have been identified. In our next research paper, we will propose a new technique for exempler based image inpainting. In the proposed method, we will try to overcome all these common problems of image inpainting.

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