OVERVIEW OF AN IMAGE INPAINTING TECHNIQUES

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Abstract: Image in-painting is the art of restoring lost and selected parts of an image based on the background information in unfamiliar way. Inpainting algorithm have numerous applications such as rebuilding of damaged photographs & films, removal of superimposed text, removal of unwanted objects, removal of noise, image compress etc. The main aim of the Inpainting algorithm is to restore or complete the image. This proposed work presents a brief survey of different techniques and relative study of these techniques. The basic idea behind the technique is to automatically fill in lost or missing parts of an image using information from the neighbouring area. In this paper, we provide a detailed review on different techniques used for image inpainting such as PDE based, Exemplar based, Texture synthesis based, Hybrid, Semi-automatic and Fast, wavelet transformation based and discrete cosine transform based image inpainting.

I. INTRODUCTION

Image in-painting is an active area in research in image processing. Image inpainting is also known as image restoration or completion. The main goal of this process is to fill the missing region of an image based on the background information/neighbouring area and this process reconstruct image in such a way so that the change cannot be detected by an observer. The mostly used in-painting methods are PDE based method, Patch based method and Sparse based method. PDE based method also known as diffusion based method. Patch based method also known as exemplar based method.

Inpainting technique has set up an extensive use in many applications such as restoration of old films, object removal in digital photos, super declaration, compression, image coding and communication. In image inpainting would like to create original image but it is absolutely not visible without the prior knowledge about the image. The basic idea at the back of the algorithms that have been proposed in the literature is to fill-in these regions with available information from their environment.

Different Approaches of Image Inpainting Techniques
A. Partial Differential Equation (PDE) based
B. Texture synthesis based
C. Exemplar based
D. Hybrid based
E. Semi-automatic and Fast
F. Wavelet transformation based
G. Discrete cosine transform based inpainting.

A. PDE based Image Inpainting

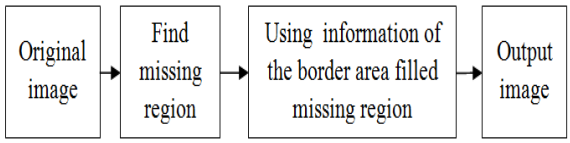


Fig 1(a) PDE based inpainting Block diagram

Partial Differential Equation (PDE) is a differential equation contains one or more variables, relating the values of the function itself and its derivatives of various orders. Consequently, a PDE is a differential equation that uses partial derivatives. Bertalmio et.al (2000) [4] proposed Partial Differential Equation based algorithm. It is iterative algorithm. Diffusion based Inpainting was the first digital Inpainting technique in which missing region is filled by diffusing the image data on or after the identified region into the missing region at the pixel point. Fundamentally these algorithms are based on the variational method and Partial Differential equation (PDE). The algorithm is to continue geometric and photometric information that arrives at the border of the occluded area into area itself. This algorithm will produce good results if missed regions are small one. But when the missed regions are large this algorithm will take so long time and it 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 used to complete the image with less time. This algorithm also provide some problem. The main difficulty with this algorithm is imitation of large texture regions. This algorithm also unable to recover partially degraded image. Then CDD (Curvature Driven Diffusion) [6] model used in which it included the curvature information of the isophotes to handle the curved structures in a better manner. PDE based technique has been widely used in various applications such as image segmentation, restoration etc.

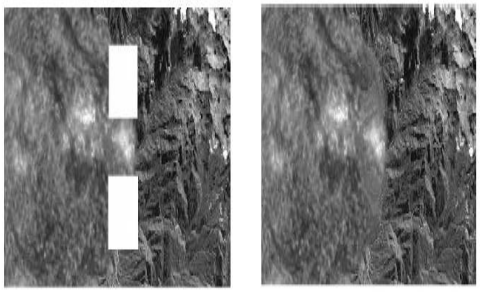
(b) (c)

Fig 1(b) Image with small dots, (c) Inpainted image [18]

B. Texture synthesis based image inpainting

Fig 2(a) Texture synthesis based inpainting Block diagram

The Texture synthesis is a field of study independent from, but related to inpainting. In the general definition of this problem, an input sample of a texture is given, and the goal is to produce more of that texture. The main objective of texture synthesis based inpainting is to generate texture patterns, which is similar to a given sample pattern, in such a way that the reproduced texture retains the statistical properties of its root texture. Texture synthesis approaches (Efors et al.1999) [7] can be categorized into three categories: Statistical (parametric), pixel-based and patch-based (non-parametric). Statistical methods are more likely to succeed in reproducing stochastic/irregular textures, but usually it fails to reproduce structured/regular textures. On the other hand, pixel-based methods "build" on the sample texture pixel-by-pixel instead of applying filters on it, and their final outputs are of better quality than those of statistical methods, but they usually fail to grow large structured textures. Finally, patch-based methods "build" on a sample texture patch-by-patch as opposed to pixel-by-pixel, thus they yield faster and more plausible regular textures. The texture synthesis is based Inpainting perform well in approximating textures. These algorithms have difficulty in handling natural images as they are composed of structures in form of edges. Also they have complex interaction between structure and texture boundaries.



(b) (c)

Fig 2(b) Original image with multiple textures, (c) Result of Texture Synthesis[17]

C. Exemplar based image inpainting

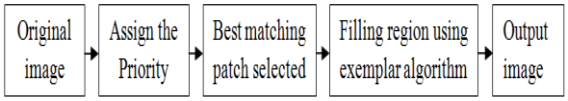


Fig 3(a) Exemplar based inpainting Block diagram

It is an important class of inpainting algorithms. It overcomes the drawback of PDE based inpainting and it is used for reconstructing large target regions. Basically it consists of two basic steps: priority assignment is the first step and the second step consists of the selection of the best matching patch. The exemplar based approach samples the best matching patches from the known region and pastes into the target patches in the missing region. According to the filling order, the method fills structures in the missing regions using spatial information of neighboring regions. Numbers of algorithms are developed for the exemplar based image Inpainting. Such as, Criminisi [8] proposed a single efficient algorithm for Region filling and object removal by exemplar based image in-painting. Most of the new exemplar-based algorithms adopt the greedy strategy, so these algorithms suffer from the common problems of the greedy algorithm, being the filling order (namely priority) is very critical. Exemplar based Inpainting will produce good results only if the missing region consists of simple structure and texture and if there are not enough samples in image then it is impossible to synthesize the desired image.

(b) (c) (d)

Fig 3(b) Butterfly image with patch in white, (c) Butterfly image with mask in black, (d) Result using proposed approach [13]

D. Hybrid based image inpainting

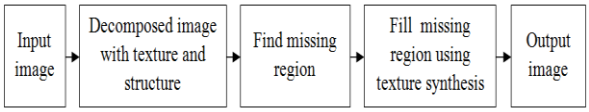


Fig 4(a) Hybrid based inpainting Block Diagram

Hybrid inpainting technique is also known as Image Completion. It is used for filling large target (missing) regions. 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, one for Structure region and another for texture regions. The corresponding decomposed regions are filled by edge propagating algorithms and texture synthesis techniques. Structure completion uses two step methods: First a texture based segmentation on the input image and extrapolating the boundary regions by tensor voting to generate a complete image segmentation and second by using tensor voting missing colors are synthesized. Tensor voting method is good for maintaining curvature, but cannot perform well on complex structures and image segmentation of natural images is also a difficult task to perform.

(b) (c) (d)

Fig 4(b) Original image, (c) Structure and Texture image, (d) Structure and Texture image [14]

E. Semi-automatic and Fast image inpainting

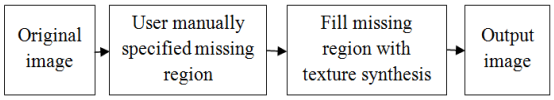


Fig 5(a) Semi automatic based inpainting Block diagram

This image in painting requires user assistance the in the form of guide lines to help in structure completion has found favour with researchers. The method by Jian et.al [9] proposed inpainting with Structure propagation, this perform two-step process. First a user manually specifies important missing information in the hole by sketching object boundaries from the known to the unknown region and then a patch based texture synthesis is used to generate the texture. The missing image patches are synthesized along the user specified curves by formulating the problem as a global optimization problem under various structural and consistency constraints. Effortless dynamic programming can be used to obtain the optimal reply if only a single curve is in attendance. Intended for multiple objects, the optimization is immense deal with more difficult and proposes approximated answer by means of certainty propagation. To speed up the conventional image Inpainting algorithms, new classes of fast Inpainting techniques are being developed. A new method which treats the missing regions as level sets and uses Fast Marching Method (FMM) to propagate image information has been proposed by Telea in [10]. These fast techniques are not suitable in filling large hole regions as they lack explicit methods to inpaint edge regions. This technique results in blur effect in image.

(b) (c)

Fig 5(b) Missing region in structure based image, (c) Complete structure in image [9]

F. Wavelet transformation based image inpainting

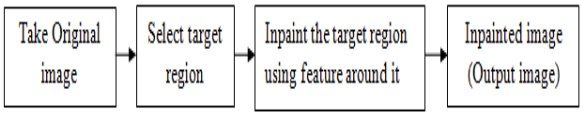
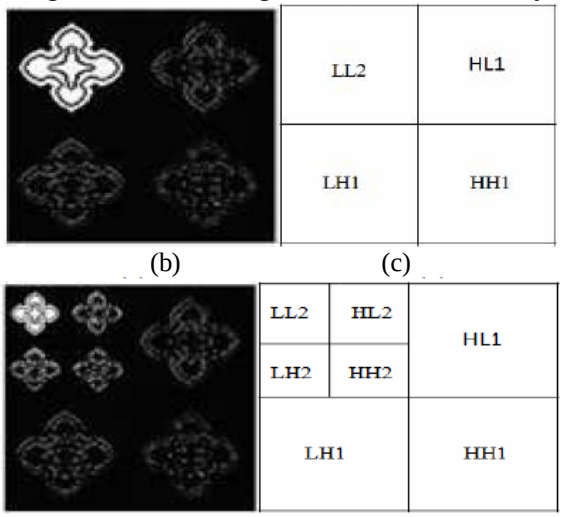


Fig 6(a) Wavelet based inpainting Block diagram [15]

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 this utilizes inter and intra scale dependency to maintain image structure and texture quality using Wavelet Transform. But difficulties In this algorithm mask for regions are defined manually.



(b) (c)

(d) (e)

Fig 6(b) 1-Level DWT image (c) 1-Level DWT Resolution (d) 2-Level DWT image (e) 2-Level DWT Resolution [15]

G. Discrete cosine transform based Inpainting

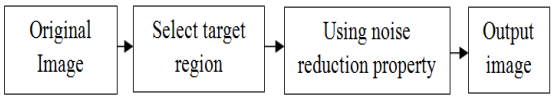
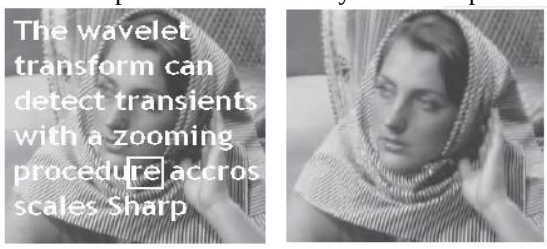


Fig 7(a) Discrete cosine transform based inpainting Block diagram

A discrete cosine transform (DCT) expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies. The DCT as an orthogonal transform is used in various applications. DCTs are important to numerous applications in science and engineering,from lossycompression of audio (e.g. MP3)and i mages (e.g. JPEG) (where small high-frequency components can be discarded), to spectral methods for the numerical solution of partial differential equations. In particular, a DCT is a Fourier related transform similar to the discrete Fourier transform (DFT), but using only real numbers. DCTs are equivalent to DFTs of roughly twice the length, operating on real data with even symmetry, where in some variants the input and/or output data are shifted by half a sample.



(b) (c)

Fig 7(b) Test image with text, (c) Output image removing text and noise [16]

II. CONCLUSION

In this paper a variety of image Inpainting techniques such as texture synthesis based Inpainting, PDE based Inpainting, Exemplar based Inpainting, semi-automatic and fast, wavelet transformation and discrete cosine transform based Inpainting techniques are studied. For every technique we have provided a detailed explanation which is used for filling the missing region based on the surrounding information of the image. From this study, a number of advantages and disadvantages were highlighted of these techniques. The performance of different techniques is evaluated on the basis of area to be inpainted. Most of the algorithms work well for small scratch regions or small regions to be inpainted such as PDE and texture synthesis based Inpainting algorithms. It cannot fill the large missing region and also it cannot restore the texture pattern. The theoretical analysis proved that exemplar based Inpainting will produce good results for the large missing regions and also these algorithms can inpaint both structure and textured image as well. But they work well only if missing region consists of simple structure and texture. Discrete cosine transform suitable for inpainting problem including impulsive noise removal.

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