Survey on Different Image Inpainting Method

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Abstract— Inpainting is the technique of filling the missing regions of an image using information from the surrounding area in a visually indistinguishable way. Image In-painting is very important and emerging field of research in image processing. Inpainting algorithm have numerous applications such as rebuilding of damaged photographs & films, heritage preservation, removal of superimposed text, removal/replacement of unwanted objects, red eye correction, image coding etc. There are numbers of method used for image inpainting. All methods have their own advantage and disadvantage. In this paper, we provide a detailed review on different techniques such as PDE based image inpainting, Exemplar based image inpainting, Texture synthesis based image inpainting, Hybrid inpainting ,Semi-automatic and Fast inpainting.

***Key words*:** Texture synthesis, PDE, Object Removal, Hybrid, Exempler method
General Terms: Inpainting, Criminisi et. al.

I. INTRODUCTION

There are lots of advantages multimedia instruments in today's world peoples are clicking lots of Picture or images of theirs and also trying to preserve their past pictures. And as the time goes on those pictures got damaged (cracks, starches, image data loss, unwanted etc.) Inpainting is the art of restoring lost parts of an image and reconstructing them based on the background information. In real world, many people need a system to recover damaged photographs, designs, drawings, art works etc. damage may be due to various reasons like scratches, overlaid text or graphics etc.
Inpainting technique has many applications such as, object removal in digital photos, removal of occlusions (date ,stamps ,logo etc.), such as large unwanted regions, red eye Correction[5], super resolution, restoration of old films and paintings etc.

Image information may be divided into three parts i.e,.shape/structure, texture and colour information. The structure inpainting usually focuses on the continuity of the geometrical structure of an image. Textures can either be homogenous (repeated texels) or stochastic (random texels).The texture to be synthesized is learned from a texture sample from the known part of the image. A number of algorithms for image inpainting continuously emerge due to extensive research and technology advancements, the basic idea of all being to improve the general quality of an image and to achieve better performance in terms of quality of the in painted images.

II. MATHEMATICAL REPRESENTATION OF INPAINTING PROBLEM [4]

We can define Inpainting problem in terms of Mathematical point of view, In a sequence say S , given only a subsequence of it, X estimate the whole S as S' such that I(S')=I(X) , where I denotes the information. Let us take a simple example to explain it more clearly. Suppose there is a sequence {1,2,3,X,5,6} where X is the unknown element. If X is derived as 4, the whole sequence looks very natural i.e., {1,2,3,4,5,6} it takes the exact value as we expected. However, if X is derived as 15, i.e.{1,2,3,15,5,6} then the whole sequence does tell us something unexpected .In case of inpainting, the generated plausible regions are commonly looks so natural which indicates that no additional information can be reproduced out of nothing related.

III. THE IN-PAINTING ALGORITHM [7] :

The image I is defined as a union of the source region 'SI' (known part of the image) and the unknown part of image, UI (Ω) i.e. I=SI ∪ UI

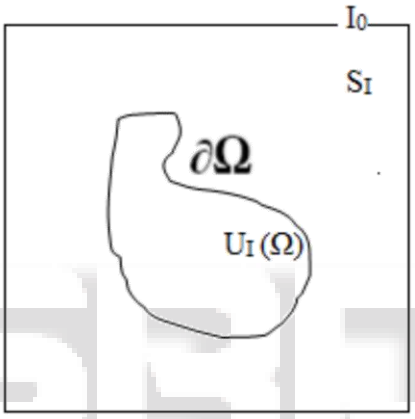


Fig.1: The image I0, the region Ω to be in-painted and its boundary ∂Ω. [7]

The general in painting algorithm can be described as:
Step I: Specify the missing region Ω.
Step II: Specify the boundary (∂Ω) of the corrupted area
Step III: Initialize the missing region (∂Ω).
Step IV: In-paint all the pixels (x, y) ϵ Ω based on the information found on the hole's edge (∂Ω).

IV. DIFFERENT APPROACHES OF IMAGE INPAINTING TECHNIQUES TO RESTORE IMAGE

So many methods have been proposed for image inpainting so far and we can classify them into several categories as follows:

1) Texture synthesis based image inpainting
2) PDE based image inpainting
3) Exemplar based image inpainting
4) Hybrid Inpainting
5) Semi-automatic and Fast Inpainting.

A. Texture Synthesis based Inpainting Method:

Texture Synthesis based Image Inpainting algorithms are used to complete the missing regions using similar neighborhoods of the damaged pixels. These algorithms synthesize the new image pixels from an initial seed. And then strives to preserve the local structure of the image. All the earlier Inpainting techniques utilized these methods to fill the missing region by sampling and copying pixels from

the neighboring area. For e. g, Markov Random Field (MRF) is used to model the local distribution of the pixel. Texture synthesis approaches can be categorized into three categories: Statistical (parametric), pixel-based and patch-based(non-parametric).

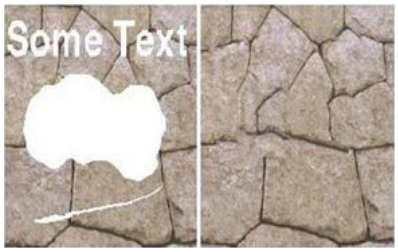


Fig.2: Example of texure Synthesis (a) Input correpted Image (b) Inpainted output using texure synthesis[4]

Statistical Method: Statistical methods are more likely to succeed in reproducing stochastic/irregular textures, but usually it fails to reproduce structured/regular textures.

Pixel-based Method: 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.

Patch-based: 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.

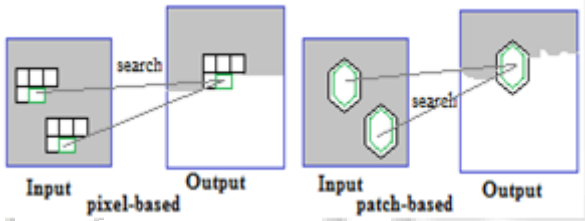


Fig.3: Difference between pixel-based and patch-based Texture Synthesis.

B. Partial Differential Equation (PDE):

PDE is a differential equation contains one or more variables, relating the values of the function itself and its derivatives of various orders[4]. Consequently, a PDE is a differential equation that uses partial derivatives. Bertalmio et.al (2000) proposed Partial Differential Equation based algorithm. It is iterative algorithm. The main idea behind this 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 "isophote lines". This algorithm will produce good results for small inpainted regions. And if the missed regions are large this algorithm will take so long time and it will not produce good results.

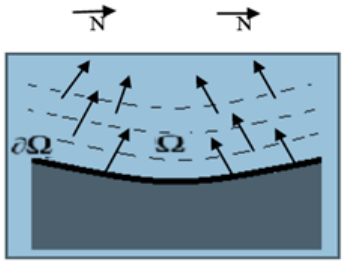


Fig.4: Direction of the lines of equal gray value (isophote lines). [4].

C. Exemplar based Inpainting:

The exemplar based consists of two basic steps 1.priority assignment is done and the 2. The selection of the best matching patch. The exemplar based approach samples the best matching patches from the known region, whose similarity is measured by certain metrics, and pastes into the target patches in the missing region. Exemplar- based Inpainting iteratively synthesizes the unknown region i. e. target region, by the most similar patch in the source region. The method fills structures in the missing regions using spatial information of neighboring regions.

Generally, an exemplar-based Inpainting algorithm includes the following four main steps:[1]

1) Initializing the Target Region, in which the initial missing areas are extracted and represented with appropriate data structures.

2) Computing Filling Priorities, in this a predefined priority function is used to compute the filling order for all unfilled pixels p∈δΩ in the beginning of each filling iteration.

P (p) =C (p) D (p) (1)

We call *C* (p) the *confidence* term and *D* (p) the *data* term, and they are defined as follows:

$$C(p) = \sum_{q \in \Psi_p \cap \bar{\Phi}} C(q) \Big/ |\Psi_p| \qquad (2)$$

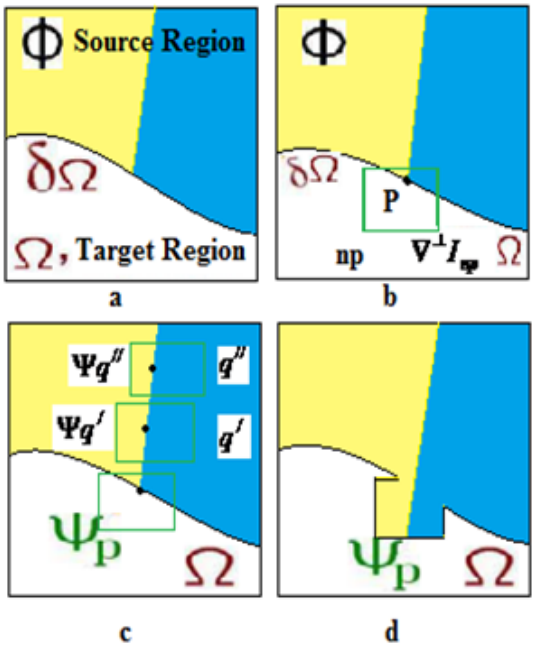
and

$$D(p) = \left|\nabla I_p^{\perp} \cdot n_p\right| \Big/ \alpha \qquad (3)$$

3) Searching Example and Compositing, in which the most similar example is searched from the source region Φ to compose the given patch (of size N×N pixels) centered On the given pixel p.

$$\Psi q = \text{Euclidian distance}(\Psi p, \Psi q) \quad (4)$$

4) Updating Image Information, in which the boundary δΩ of the target region Ω and the required information for computing filling priorities are updated. Replace Ψp with Ψq.



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D. Hybrid Based Image Inpainting:

Hybrid inpainting technique is also known as Image Completion. It is used for filling large target (missing) regions. It 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, one for Structure region and another for texture regions. The corresponding decomposed regions are filled by edge propagating algorithms and texture synthesis techniques. One important direction we believe is more natural to the inpainting process is by structure completion through segmentation. This technique 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.

E. Semi-Automatic and Fast Image Inpainting:

Semi-automatic image inpainting with user assistance, require in the form of guide line to help in structure completion has found favor with researchers. The method by termed as inpainting with Structure propagation follows a two step process. In the first step, a user manually specifies important missing information in the hole by sketching object boundaries from the known to the unknown region. In the second step, 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. Simple dynamic programming can be used to derive the optimal answer if only a single curve is present. For multiple objects, the optimization is great deal more difficult and the proposers approximated the answer by using belief propagation. Depending on the size of the inpainting area, all the methods take minutes to hours to complete and hence making it unacceptable for interactive user applications. Limitation of that algorithem is that these fast techniques are not suitable in filling large hole regions as they lack explicit methods to inpain edge regions. This technique results in blur effect in image.

Image Inpainting Methods	**Advantages**	**Disadvantages**
Texture Synthesis based Inpainting	The texture synthesis based Inpainting perform well in approximating textures.	Not suitable for large objects Not applicable for curved structure
Partial Differential Equation Based inpainting	– Algorithm will produce good results if missed regions are small one. – Fine Outcome & produce structural information	If missing region are large this algorithm will take so long time and it will not produce good results • unable to recover partially Degraded Image
Exemplar based Inpainting	• faster completion and use of multiresolutionbased method to help in more natural texture synthesis.	• the bias caused by selection of few incorrect patches in the priority based filling mechanism
Semi-automatic and Fast Inpainting	• Enhance speed of inpainting	• Not suitable in filling large hole regions • Results in blur effect in image

Table 1. Comparison of different image inpainting methods

V. CONCLUSION

This survey gives theoretical knowledge about various image Inpainting techniques 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 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 & 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 The main objective of this survey is to help the researchers to select best technique for image inpaitning.

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