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### STUDY OF EXEMPLAR BASED IMAGE INPAINTING TECHNIQUES

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#### ABSTRACT

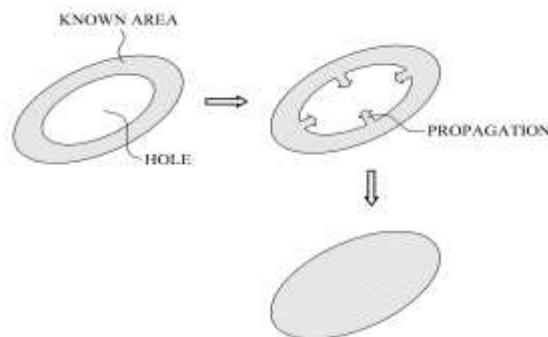
Image Inpainting refers to filling up the missing area (hole) of an image by using the information from surrounding's (known area) such that the resultant image is logically accepted. OR it is a technique of altering the given image in such a way that the resultant image is undetectable by the ordinary observer. Image In-painting is very important and emerging field of research in image processing. It is the technique of repairing the disrupted /missing part of an image plus elimination of unwanted objects. It has wide range of applications-used in restoring the ancient paintings, removal of superimposed text like dates, subtitles, logos or publicity, repairing the damaged parts of photographs and films. In this paper we have discussed various inpainting techniques such as Texture synthesis, PDE based image inpainting, Exemplar based image inpainting, Semi automatic image inpainting, Hybrid inpainting.

**KEYWORDS:** Image inpainting: exemplar-based, Texture synthesis, Object removal.

#### INTRODUCTION

In present image inpainting techniques has gained very high popularity in the field of image processing and computer graphics. It has important value in a heritage preservation, film and television special effects production, removing redundant objects etc. In the fine art museums, this Inpainting concept is used for degraded paintings. Its only purpose is to reconstruct the deteriorated/damaged part of the image by utilizing the spatial information of the neighbouring region. Image inpainting is widespread in several applications like reformation of old images/films removal of objects in digital images. The idea of image inpainting is to repair the damaged portions, remove the unwanted objects of an image or fill in the holes.

This uses the known image information to fill up the missing region such that the texture as well as structure of the image is preserved.



**Image Inpainting:** Image inpainting has been used to fill in small holes in the image, by propagating structure information from image to the region to be filled. So the aim of the inpainting algorithm is not only reconstruct what used to be in that hole, But instead to create a visually pleasing continuation of the data around the hole in such a way that it is not detectable by ordinary observer.

The mixture of texture synthesis technique and inpainting technique produces a new inpainting technique known as **exemplar based image inpainting technique**. That's why exemplar based image inpainting can rebuild texture part as well as structural part of an image .

*Fig.1 filling of missing/damaged areas*



(a) (b)

In Figure (a) some missing /disrupted areas are filled up and restored version Fig.(b) is the result of image inpainting.

*Fig.2 Removal of super imposed text*



(c)

(d)

In Fig (c) text has been superimposed on the image .Fig (d) is the required result in which the superimposed text has been removed in order to have greater insight into the image.

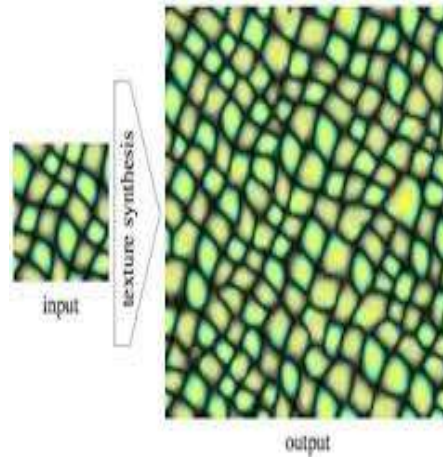
The underlying methodology of image inpainting is as follows:

- The sole purpose of inpainting is to restore the unity of the work.
- The structure of the gap surroundings is supposed to be continued into the gap. Contour lines that arrive at the gap boundary are prolonged into the gap.
- The different regions inside a gap, as defined by the contour lines, are filled with colours. matching for those of its boundary.
- The small details are painted, i.e. “texture” is added.

## EXISTING TECHNIQUES

### Texture Synthesis

Texture synthesis has been used to fill large image regions with texture pattern similar to given sample. Texture is the most repetitive pattern of the image. So this can be used for generating large image regions from sample texture.



There are different approaches of Texture synthesis Technique

Statistical (parametric), pixel-based and patch- based (non-parametric).

#### ***Statistical Method***

Statistical methods are useful in reproducing irregular textures, but are less useful for regular textures.

#### ***Pixel-based Method***

Pixel-based methods reproduce 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 regular textures.

#### ***Patch-based***

Patch-based methods reproduce the sample texture patch-by-patch as opposed to pixel-by-pixel, thus they give faster and more better results for regular textures.

#### **Partial Differential Equation**

Partial Differential Equation based method is to continue the geometric and photometric information that appears at the border of disrupted area. The focus of partial differential equation based algorithms is mainly on maintaining the structure of the inpainting area. It is good if missing area is small. But results blurred if missing area is large. Another problem with these algorithms is that the large textured areas are not well regenerated. 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.

#### **Exemplar based image inpainting**

The exemplar based image inpainting is an important category of inpainting algorithms. The exemplar based image inpainting is an efficient technique of reinstallation of big target regions. The exemplar based image inpainting consists of two stages:

1. First priority assignment: Priority function is utilized to compute the filling order for all unoccupied pixels in the starting of each filling iteration.
2. Choice of the best matching patch: The exemplar based image inpainting selects the best matching patches from the well-known area, and insert into the target patches in the missing area. According to the filling order, the technique 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) 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 in the beginning of each filling iteration.
- 3) Searching Example and Compositing, in which the most similar example is searched from the source region to compose the given patch.

- 4) Updating Image Information, in which the boundary of the target region and the required information for computing filling priorities are updated.

### Hybrid Inpainting

It is also known as image completion. As it preserves both structure and texture in a visually plausible manner. Hybrid approach is a combination of both texture synthesis and partial differential equation based inpainting for completing the missing area. It produces good results for large missing areas. This technique uses a two-step approach: the first stage is structure completion followed by texture synthesis. In the structure completion stage, segmentation, is performed based on the geometry, colour and texture information on the input. The second step consists of synthesizing texture and colour information in each segment.

### Semi-automatic and Fast image inpainting

Semi automatic inpainting method demand user intervention in the form of guidelines to assist in the structure completion. This approach follows a two step process. In the first step the user gives the essential missing information in the gap by sketching object boundaries from the known to the unknown region. In second step a patch based texture synthesis is utilized to produce the texture.

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 algorithm is that 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.

## LITERATURE SURVEY

1. Christine Guillemot and Olivier Le Meur, Image Inpainting  
This paper introduces methods which are based on the assumption that pixels in the known and unknown parts of the image share the same statistical properties and geometrical structures. This assumption translates into different local or global priors, with the goal of having an inpainted image as physically plausible and as visually pleasing as possible [1].
2. Olivier Le Meur, Mounira Ebdelli Christine Guillemot, Hierarchical super-resolution based inpainting  
This paper introduces a novel framework for exemplar based inpainting. It consists in performing first the inpainting on a coarse version of the input image. A hierarchical super resolution algorithm is then used to recover details on the missing areas. The advantage of this approach is that it is easier to inpaint low-resolution pictures than high resolution ones [2].
3. A.Criminisi, P.perez and K.Toyama, Region Filling and Object removal by Exemplar based Image Inpainting  
This paper introduces a new algorithm for removing large objects from digital images. It addresses two classes of algorithms.
  - 1) Texture Synthesis algorithms for generating large image regions from sample textures and
  - 2) Inpainting techniques for filling in small image gaps [3].
4. Lixin Yin, Chen Chang, An effective Exemplar-based Image inpainting Method  
In this paper, the author introduces an improved method for exemplar based image inpainting. By considering the isophote curvature as a new ingredient to compute patch priority and matching cost function, this method performs well when the target region contains linear structure with significant changes in curvature [4].
5. Raut Bhaskar, Ritesh Thakur, Survey on Exemplar Based image Inpainting  
This paper explains the work of filling the missing part in the video by using exemplar based method. First an image is taken from the video and then exemplar based inpainting is applied to reconstruct the video by removing the obstacle from the video [5].
6. Ashish Dewangan and Indu Sahu, Survey on Exemplar Based Super Resolution Based Inpainting  
This paper introduces a novel framework for exemplar based inpainting. This paper presents a novel combination of patch based inpainting and single image super resolution algorithm. The advantage of this approach is that it is easier to inpaint low resolution images than high resolution ones [6].
7. Chaitali P.Sathe and Dr.Shubhalaxmi P.Hingway, Image Restoration using Inpainting  
This paper presents comparison between two methods of image inpainting for image restoration. A coarse version of the input image is inpainted using CDD and TV inpainting algorithm. These methods will be applied to grey scale and RGB images [7].

**COMPARATIVE ANALYSIS OF VARIOUS IMAGE INPAINTING TECHNIQUES**

| <b>Image Inpainting Methods</b>                | <b>Advantages</b>  | <b>Disadvantages</b>  |
|--|--|---|
| Texture Synthesis based Inpainting             | The texture synthesis based Inpainting perform well in approximating textures.                       | Not suitable for large objects.<br>Not applicable for curved structure                        |
| Partial Differential Equation Based inpainting | Not suitable for large objects Not applicable for curved structure & produce structural information  | Unable to recover partially Degraded Image  |
| Exemplar based Inpainting                      | Rapid completion and use of multi resolution based 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.<br>Results in blur effect in the image.           |

**CONCLUSION**

In this paper we have studied various techniques for exemplar based image inpainting technique. Various algorithms related to inpainting techniques have been discussed. It is concluded that no technique can inpaint the image correctly due to image variations. It is required to develop an algorithm that can inpaint the images correctly in an efficient time. In future we are planning to develop an algorithm that can inpaint masked images as well as blurred images in an efficient time and with accuracy.

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