Image In-Painting using Improved Exemplar based Approached

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Abstract— In-painting is a type of art that rebuilt the missing data in an image. There are several proposed algorithms for this purpose in which exemplar based approach is the most broadly used. The objective of in-painting is to synthesize the missing part of an image in such a way that it looks suitable to the eye of viewer who is known to the original. Image inpainting is widely used to restore a damaged paintings and photographs or remove unwanted objects. Criminisi's exemplar-based inpainting combined "texture synthesis" and PDE-based inpainting that showed great efficiency on removal of large objects. However, this approach has certain weakness such as high time cost, visual inconsistency in some cases. In this paper, we improve the Criminsi's exemplar-based inpainting based on search strategy and color transfer. This new method is also suitable to all exemplar-based methods and the results show its effectiveness.

Key words: Exemplar based inpainting, Color transfer, Search strategy

I. Introduction to Inpainting

A. *Introduction*

In-painting is a type of art that rebuilt the missing data in an image. It modifies the image in such a way that the observer who is not familiar with original image is not able to detect the modification. Nowadays inpainting is used in the field of image processing and computer graphics where it finds lots of applications like reconstructing old films and images, removal of objects in digital photos , image compression , image coding and image transmission.

B. *Inpainting Problem*

The purpose of inpainting might be to restore damaged portions of an image or to remove unwanted elements presents in the image. The problem which we can see basically as an interpolation task is called image inpainting. The question of how to construct an image I′ in the domain Ω (called the hole) using the information taken from outside the hole is treated in inpainting problem. So the outside known region I is called source region and the unknown region I′ will be called as target region throughout the thesis. The target region is filled using the information in the source region.

C. *Image Inpainting Techniques*

There are numbers of image inpainting techniques used in literature, some of them are: Texture synthesis based imageinpainting, PDE (Partial Differential Equation) based image inpainting, exemplar based image inpainting, Hybrid inpainting, Semi-automatic and Fast Inpainting.

1) Texture synthesis based image inpainting:

Texture synthesis based image inpainting algorithm is one of the earliest techniques of image inpainting. To complete the missing areas these algorithms utilize similar neighbourhoods of the damaged pixels. To create the new image pixels the texture synthesis algorithms use an initial seed. All the earlier inpainting techniques make use of these methods to fill the missing area by sampling and copying pixels from the neighbouring region. Texture synthesis based image inpainting algorithms be able to fill large textured areas, but depends on users selection on sampling position and content.

2) PDE based image inpainting:

Partial Differential Equation (PDE) based algorithms are iterative algorithms which are proposed by MarceloBertalmioetal. The main purpose of this algorithm is to continue geometric and photometric information that looks at the border of the occluded/obstructed area into area itself and this is made through propagating the information in the direction of minimum change using isophote lines. Partial differential equation algorithms will generate good outcomes if missed areas are small one, but when the missed areas are big partial differential equation algorithms will take so much time and will not generate good outcomes. There are number of applications of partial differential equation based algorithms like image reinstatement, image segmentation etc.

3) 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 is consists of two stages:

1) First priority assignment is made and then
2) Choice of the best matching patch.

The exemplar based image inpainting selects the best matching patches from the well-known area, whose similarity is determined by certain metrics, 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. The exemplar based image inpainting consists of the following steps:

1) 1) Initializing the Target Region: In this step initial missing areas are removed and represented with suitable data structures.
2) Computing Filling Priorities: In this a prescribed priority function is utilized to compute the filling order for all unoccupied pixels in the starting of each filling iteration.
3) Searching Example and Compositing: In this the most analogous pattern is found from the source area to compose the given patch, which centered on the given pixel.
4) Updating Image Information: In this the boundary of the target area and the necessary information for computing filling priorities are changed numbers of algorithms are created for the exemplar based image Inpainting.

4) Hybrid Inpainting:

Hybrid inpainting technique is also known as Image Completion. Hybrid inpainting technique is combination of both texture synthesis and partial differential equation based inpainting for completing the missing areas. The core thought behind hybrid inpainting technique is that it divides the image into two separate parts, texture region and structure region. The consequent decomposed areas are filled by edge propagating techniques and texture synthesis techniques. Hybrid inpainting technique is used for filling large missing/target areas.

5) Semi-automatic and Fast Inpainting:

Semi-automatic image inpainting technique needs user's assistance in the form of guide lines to help in structure completion has found favor with researchers. In a method proposed by Z. Xu and S. Jian, present inpainting with Structure propagation, this technique shows a two-step process. In the first stage a user manually gives essential missing information in the gap by sketching object boundaries from the well-known to the unknown area andthen a patch based texture synthesis is utilize to produce the texture. Semi-automatic image inpainting technique takes much time from a minute to hours for completion; it depends on the size of area to in paint. To make up the conventional image inpainting algorithms fast, a new class of image inpainting technique is being developed. Fast image inpainting technique based on an isotropic diffusion model which performs inpainting by repeatedly convolving the inpaintingarea with a diffusion kernel.

II. CRIMINISI'S EXEMPLAR BASED INPAINTING ALGORITHM

Exemplar based object removal is based on texture synthesis algorithm. It is an isophote driven sampling problem that do not use separate mechanism for texture and structure synthesis.

A. Terminology Used

The image is defined by a function I. Let pixel be the position of the pixels in image and pixel value refers to the value taken by the pixel at this position. A pixel is mapped to a scalar(d=1) for gray level image and (d=3) for a color image.

$$I: \Omega \rightarrow \{0.....,255\}^{d}$$

$$p \rightarrow I_p$$

Ω is the region which is to be filled and is denoted by target region. The known region from which information is to be sampled is known as the source region and is denoted by Φ .It is the area which surrounds the target region in form of a dilated band. The boundary which separates these two regions is denoted by ∂ Ω. It is the contour of target area and as the algorithm proceeds this contour evolves inward.

Filling is done by searching for the best match patch in the source region to that of the target region. Patch is a group of pixels which are in the form of a square window around a central pixel. A patch size is chosen such that it is larger than the most distinguishable texture in the image. For every pixel that belongs to the boundary ∂ Ω patch of 9x9 window is made. In this patch there are some filled and some unfilled pixels .The pixels of the patch in the source region which has maximum similarity with this patch are copied in the unfilled pixels of this patch. This method is iterated until all the missing region is filled.

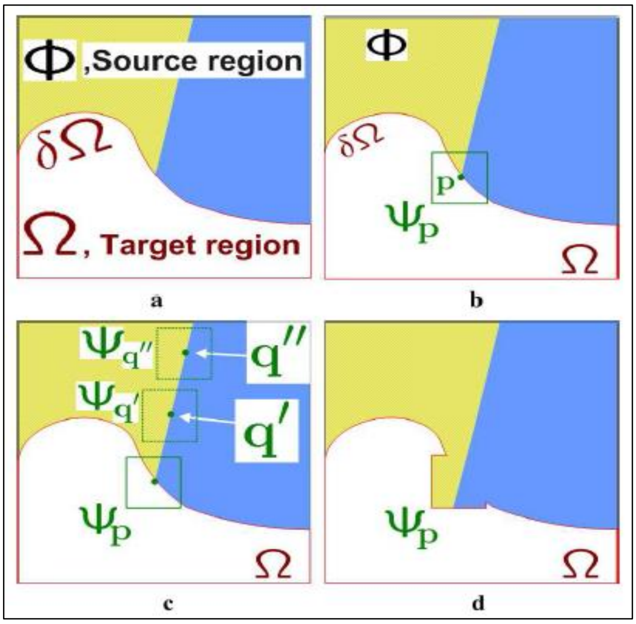

Fig:- Structure propagation by exemplar-based texture synthesis.(a) Original image, with the target region Ω, its contour ∂Ω, and the source region Φ clearly marked. (b) the area delimited by the patch $\Psi_p$centered on the point p € ∂Ω is to be synthesized (c) The most similar candidate patch for $\Psi_p$lie along the boundary between the two textures in the source region (d) The best matching patch in the candidates set has been copied into the position occupied by Ψ_p, thus achieving partial filling of Ω.

The most similar patch Ψ_q is likely to be found in the neighborhood of the target patch Ψ_p. We can see in the figure that if patch $\Psi_p$lies on an edge in the image then Ψ_q will also lie on the same edge. So exemplar based method has preserved isophote orientation automatically. In the thesis instead of searching one similar patch k similar patches are searched.

B. Importance of Filling Order

Filling order plays a very critical role in Exemplar based inpainting as it influences the quality of the synthesized image to a great extent. It decides which pixels of the image are to be synthesized first and which later ..

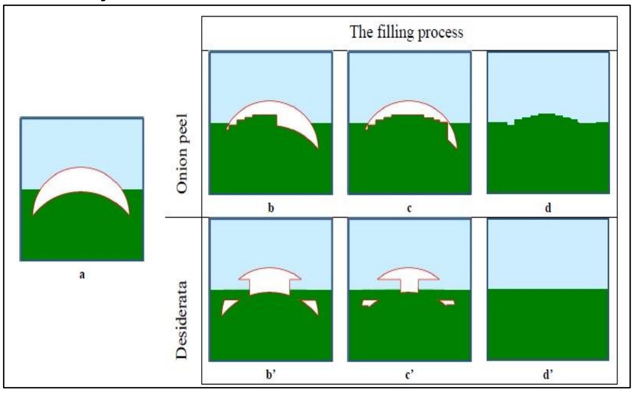

Fig. : Comparison between Concentric Layer filling and desired filling order(a) Image with its target region shown in white. (b, c, d) Concentric layer filling. (b', c',d') Target region filled with an edge driven filling order

In figure:- A comparison between concentric layer filling (i.e. onion peel strategy) and the desired filling behavior has been shown . In fig, b, c the filling of a concave target region via an anticlockwise onion peel strategy is being shown. As it can be seen when filling is done by this order, the horizontal boundary between the two regions is not constructed expectedly. It has been regenerated as a curve which is undesirable.

A better filling algorithm would be one that gives higher priority of synthesis to those regions of the target area which lie on the continuation of edge structures as shown in figure. Besides propagating the linear structures the latter algorithm would be more robust towards variations in the shape of the target region. Exemplar based algorithm overcomes the issues that characterizes the traditional concentric layer filling approach and achieves the desired properties of

1) propagating linear structures correctly
2) robustness to change in shape of target region maintaining balance in propagation of structure and texture simultaneously

III. Results and Conclusion

A. Results

In this chapter, the simulation results of proposed algorithms are presented. The result is compared with earlier works. The simulation results compared with Criminisi and [6] have been shown. Different images from synthetic to natural images have been taken to implement the algorithm. The experiments have been performed in MATLAB version 2010 on an Intel Celeron B830 1.8 GHz CPU Windows 8 (64 bit) environment.
The algorithm removes the objects very efficiently.

Fig. : Removal of object(a) Original Image (b) Processed image

(a) Oiginal Image

(b) Reconstructed Image
Fig. : Example of Real Life Image

IV. Conclusion

In the thesis an image inpainting algorithm has been proposed which can reconstruct linear edged as well as texture efficiently. The results have been compared with that of previous algorithms. For region segmentation I have taken the threshold value as a constant value to reduce computational cost. A more robust method can be found for this region segmentation.

