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A Comparative Study of Different Inpainting Techniques

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Abstract

The inpainting method is popular for various applications like images,videos multimedia etc. the inpainting can be helpful for the hiding the useful information from the source it can be used in security purpose, intelligence buero A lot of researchers have worked in the area of video inpainting. Most of the techniques try to ensure either spatial consistency or temporal continuity between the frames. This paper is presenting here the various inpainting methods.

Keywords: Image Inpainting; Video Inpainting; Exampler based Inpainting; Occlusion removal.

Introduction

Embedded text in associate in nursing passing video sequence provides valuable information. Texts generally appear as logos, subtitles, captions or banners among the video sequence. Such information embedded texts area unit usually largely found among the news and totally different common place and in cricket broadcastings that text might necessary components of a video. There got to be the need to erase the unwanted text from the video .The various in painting are discussed here to recover the missing pixel in an image. Inpainting is the process of reconstructing lost or deteriorated parts of images and videos. For instance, in the museum world, in the case of a valuable painting, this task would be carried out by a skilled art conservator or art restorer. In the digital world inpainting also known as image interpolation or video interpolation refers to the application of sophisticated algorithms to replace lost or corrupted parts of the image data mainly small regions or to remove small defects the global picture determines how to fill in the gap. The purpose of inpainting is to restore the unity of the work. The filling of lost information is essential in image processing, with applications as well as image coding and wireless image transmission, special effects and image restoration is to fill-in these regions with available information from their environment [1]

Types of Inpainting

Inpainting can be done in various applications but mainly over images and videos

Image Inpainting

The region of unwanted information in the bounded variation image is removed by using image inpainting.

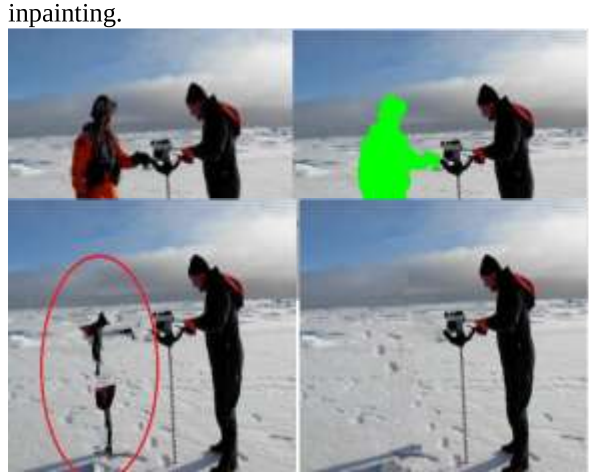

Fig.1 Person removal by using Image Inpainting

A comparative study on this all inpainting techniques includes image processing over each image to reconstruct missing parts or removal of unwanted parts from that image.

The Three types of Image Inpainting are as follows:

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1. Partial Differential Equation (PDE) based.
2. Exemplar based Inpainting.
3. Texture Synthesis based

Partial Differential Equation (PDE) based

Bertalmioetal [2] have proposed a digital image inpainting algorithm based on Partial Differential Equation (PDE) in which the direction of the lines of equal luminescence is maintained by evaluating the direction of the largest spatial change obtained by computing a gradient vector and rotating this vector by 90 radians. Bertalmioetal took the ideas from computational fluid dynamics (CFD) to continue the isophote lines into the region to be in painted [3]. It treats the image intensity as a stream function and the laplacian of the image as vorticity of the fluid which is continued into the region to be in painted by vector fields defined by stream function .PDE based algorithm is an iterative algorithm. The basic idea behind the algorithm is to propagate both the geometric information (gradient direction) and the photometric information (gray-scale values) of theimage that is available at the boundary of the occluded area into the area to be filled in (Ω). This is done by formulating a partial differential equation which propagates the information (laplacian of image) in the direction of minimal change using 'isophote lines' (the lines of equal gray value) [4],[5].This method is thus based directly on the Navier Strokes Equations for CFD. The PDE technique for inpainting produces good results if the region to be filled in is small but if the missed regions are large ,the efficiency of this algorithm decreases as it takes a long time to fill in large missing areas and the results produced will also be unsatisfactory. Inspired by the work of Bertalmio at.al, Chan & Shen forthput Total Variational (TV) in painting algorithm based on second order partial differential equation [6], [7], [8]. This algorithm uses Euler- Lagrange model as well as anisotropic diffusion based on the intensity of the isophotes. This algorithm performs quite well for noise removal applications and for filling in small regions. But the weak point of this

model is that it neither greats texture patterns nor connects the broken edges. The TV model was then extended to the Curvature Driven Model (CDM) which also included the geometric information of the isophotes in order to handle the curved structures in a better way thus allowing this inpainting technique to proceed over large areas [9]. Although CDM connects the broken edges but also results in some blur. Then Telea [10] proposed a Fast Marching Method (FMM) which in-paints the near pixels to known areas first and also maintains a narrow band of pixels which distinguishes the unknown pixels from the known pixels. The drawback of this method is that it produces a post inpainting blur which becomes noticeable when the area to be in painted is larger than ten pixels .This method computes the smoothness of an image and is considered as a PDE method which is simpler as well as faster to implement as compared to other PDE based techniques. PDE being an iterative method is very time consuming, requires difficult implementation process and is not applicable to large textured areas, the results for which are often blocky. PDE based technique has numerous applications such as restoration, image segmentation etc. Partial Differential Equation (PDE) based algorithms focuses on maintaining the geometric structure of the area to be inpainted.

Exemplar Based Inpainting:

As natural images (paintings) are composed of both structures and textures (regions with regular patterns), more complex inpainting techniques are required for faithfully reconstructing the corrupted regions. Because of this distinguishing feature of natural images, a technique that is designed strictly for texture synthesis will not provide satisfactory results.Exemplar based in painting inspired by local region growing techniques that grow texture using one patch or one pixel at a time perform well for a wide range of images and are able to produce reasonably better quality results by combining texture synthesis with isophote (lines of equal gray value) driven inpainting methods. Exemplar based methods have proved to be very effective for reconstructing large target regions. The basic idea behind Exemplar based image interpolation is the use of a set of image exemplars/ blocks that are derived either from the same image that needs to be in painted or from other images that are related to the representative images. Exemplar based approach consists of two basic steps: Firstly, priority assignment is done. Each pixel p belonging to the patch ψp has a patch priority given by the product of the confidence term C(p) and the data term D(p) . The confidence term tells us about the number of existing pixels in this patch. The data term tells us about the strength of the isophote that hits the boundary and is important since it maintains the structure of an edge at the target patch and focuses on the linear structure to be synthesized first

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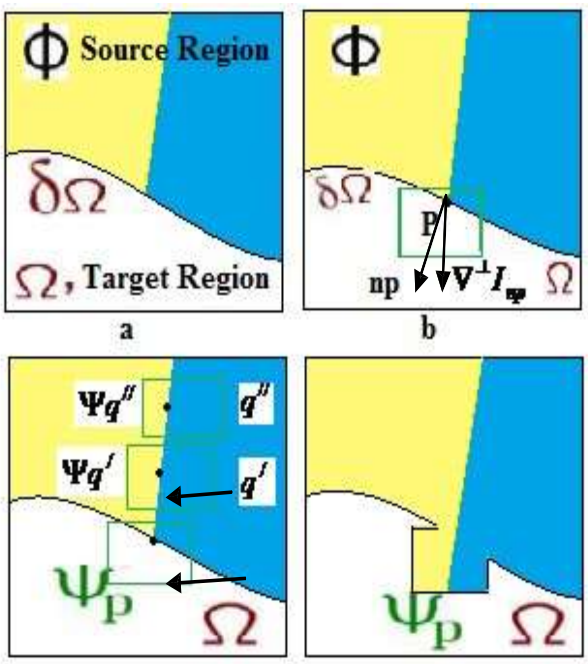
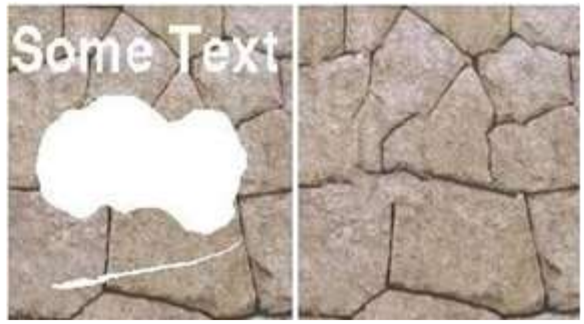


Fig.2- Criminisi et.al Exemplar based Texture synthesis Algorithm.(a)Original image with target region (Ω) , its source region ϕ and boundary d Ω. (b) Area to be synthesized delimited by the patch ψp centred at point p.(c) Most likely candidate patches (ψq/ ,ψq// lying in the source region ϕ . (d)Best matching patch among candidate patches copied to the position occupied by ψp, thereby achieving partial fill-in in target region Ω.

Texture Synthesis Based Inpainting:

PDE based techniques are well suited for filling in small gaps, text overlays etc. but PDE technique usually fails if applied to areas containing regular patterns or to a textured area. This failure is because of the following reason:

1. Mostly high intensity gradients are present in textures which may be interpreted wrongly as edges and falsely transported into the region to b in painted.
2. In case of PDE based in painting, the information used is only the boundary condition that is present within a narrow band around the region to be in painted. Thus, it is impossible to recognize structures, textured areas or regular patterns from such an insignificant amount of information. Texture synthesis based algorithms are based on the concept of synthesizing artificial texture from an (typically small) initial seed, striving to preserve the appearance structure and color) in a way that the synthesized texture Markov Random Field (MRF) is utilized for modeling the local distribution for pixel is local pixel distribution after which a new texture is created by inquiring existing texture and retrieving information from similar neighbourhoods. Their difference mainly lies in the way continuity is maintained between the already existing pixels and the in painting domain (hole). This pixel based texture synthesis performs very well on set of selected images. Synthesis based approaches are well suited for only a selected set of images where completing the missing region with homogenous textures results in nature completion. Since the filling- in of the in painting domain is done pixel by pixel, this scheme is very slow



a) Input Image b)Texture Synthesis

Fig.3 Example of texture synthesis (a) Input Corrupted Image (b) In-painted output using texture synthesis

Efros & Freeman proposed a way to greatly improve the speed by using more simpler fragment based algorithm. Fragment based algorithms can be considers as generalized texture synthesis. Here, instead of copying pixels one by one entire blocks are transferred into the inpainting hole that results in smoothness and the changes in the in painted area seem undetectable to the Human Visual SystemCriminisiet.al [11], introduced an algorithm specific for texture in painting that uses the same technique as proposed by Efros- Leung [12], the only difference being that the high priority is given to the filling of pixels placed along the edges. Priority of a pixel is dependent on the gradient magnitude of its surrounding areas and the confidence term. Pixels lying close to the edges have high gradients and thus edges are given high priority. This slight modification was sufficient to give even better results as depicted in [11]. Later, this technique was extended to fast synthesizing algorithm. It works by stitching small patches of the images together referred to as image quilting. A recent study on patch based texture synthesis methods has stated that special purpose algorithms are required to develop for handling different types of textures Innumerable texture synthesis methods for creating textures with different statistical characteristics are available other than fore cited but here we shall confine ourselves

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only to those synthesis techniques specifically used for in-painting.

Video Inpainting

The process of removing and reconstructing the specific area in video is known as video Inpainting. Most of the automatic techniques of video Inpainting are computationally intensive and unable to repair large holes.To overcome this problem, exemplar based video Inpainting method is extended by incorporating the Sparsity of natural image patches using background registration technique.Video Inpainting refers to a field of Computer Vision that aims to remove objects or restore missing or tainted regions present in a video sequence by utilizing a technique of patch Sparsity to fill-in the missing parts of video sequence taken from a static camera using background registration method. The overriding objective is to generate an inpainted area that is merged seamlessly into the video so that visual coherence is maintained throughout and no distortion in the affected area is observable to the human eye when the video is played as a sequence. Inpainting technique is the modification of the images in an undetectable form Video is considered to be the display of sequence of framed images. Normally twenty five frames per second are considered as a video. Less than twenty five frames per second will not be considered as a video since the display of those will appear as a flash of still image for the human eye. The main difference between the video and image inpainting methods using texture synthesis is in the size and characteristics of the region to be inpainted. For texture synthesis the region can be much larger with the main focus being the filling in of two-dimensional repeating patterns that have some associated stochasticity Removing unwanted objects or art effects from videos is a common task in professional video and movie productions. For instance, when filming in public locations, it is often necessary to remove walking people and other objects that accidentally occlude the scene. Objects may also have to be erased from a video sequence due to copyright issues. In other cases, the film crew needs to be in a scene for technical reasons, and needs to be removed in post-processing. Bertalmio [13] is the first pioneer to video inpainting. The author repaired a video using image inpainting frame by frame. A user-provided mask specifies the portions of the input image to be retouched and the algorithm treats the input image as three separate channels (R, G and B).For each channel, it fills in the areas to be inpainted by propagating information from the outside of the masked region along level lines (isophotes). Isophote directions are obtained by computing at each pixel along the inpainting contour a discredited gradient vector and by rotating the resulting vector by 90 degrees. This intends to propagate information while preserving edges to handle the missing region with composite textures and structures, patch priority is defined to encourage the filling-in of patches on the structure. Wexler [14] defined an optimal function to search the best matching patch in a foreground and use the found patch to repair the moving foreground. This algorithm filled the video frame patch by patch. Space-time completion of video (Wexler, Shechtman, & Irani, 2007) , Wexler et al. consider video inpainting as a global optimization problem, which inherently leads to slow running time due to its complexity.

Fig.4- Video Inpainting Example

Video inpainting meant for repairing damaged video was analysed in [15] which involves gamut of different techniques which made the process very complicated. These works combine motion layer estimation and segmentation with warping and region filling-in.Finally, there is a very interesting paper by Patwardhan [16] et al.(Patwardhan, Sapiro, & Bertalmio, 2007), which proposes a pipeline for video inpainting. However, the pipeline is so simple that it failed to perform well in many cases. [17] zhang uses a motion layer segmentation algorithm to separate a video sequences to several layers according to the amount of motion. Each separate layer is completed by applying motion compensation and image completion algorithms. Except for the layer with objects to be removed, all of the remaining layers are combined in order to restore the final video. However, temporal consistency among inpainted areas between adjacent frames was not taken care of in [17].

Analysis and discussion

Digital image in-painting has become a hotspot and as received a lot of attention since a decade .Several approaches have been introduced with varying applicability in disocclusion, texture synthesis, object removal, text removal, and image reconstruction. These techniques are based on various approaches and include basic as well as improved and more recent methods to fill-in the corrupted regions in a visually plausible manner so that the in-painted area mimics the source region in appearance. Table1 shows various inpainting techniques Diffusion based methods perform well if the area to be in- painted is uniform. The performance is high for noise removal applications and when the area to be in-painted is small. But the drawback of this method is that it neither connects the broken edges nor synthesizes texture, the results for which often produce blur. Also, PDE being an iterative method is very time consuming. Texture synthesis based methods are well suited for only a selected set of images where completing the missing region with homogenous textures results in nature completion. This technique performs well for in-painting large areas but founds difficulty with natural images as they contain geometric structures (edges). Exemplar based methods faithfully reconstruct both the structure and the texture and give impressive results for a wide range of images as it combines texture synthesis with diffusion driven methods. The disadvantage of this method is that it gives unsatisfactory results if the patch size is small and if the target region is spread along most of the image area.

Conclusion

In this paper we are discussed about various inpainting methods which are useful for image processing research Image in-painting is a relatively young and active research area. This study provides estimable contextual information about different types of image in-painting techniques with an So one has to rely on the human visual comparisons for the quality assessment.

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