ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 2, Issue 12, December 2013

A Review of Literature On Image Inpainting And Super Resolution

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Abstract—**Inpainting is the process of reconstructing lost or deteriorated part of images based on the background information. i. e. image Inpainting fills the missing or damaged region in an image utilizing spatial information of its neighboring region. Inpainting algorithm have numerous applications. It is helpfully used for restoration of old films and object removal in digital photographs. Super resolution reconstruction produces high resolution image from sequence of low resolution images. The main aim of super resolution is to improve visual quality of available low resolution image. Also existing Low Resolution (LR) imaging can be utilized with help of super resolution reconstruction. Super resolution based inpainting 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. The gain is both in terms of computational complexity and visual quality.**

Keywords- Inpainting, super-resolution, missing areas, priority terms, *Low Resolution, High Resolution*.

I. INTRODUCTION

Image inpainting refers to methods which consist in filling-in missing regions (holes) in an image. Although tremendous progress has been made in the past years on inpainting, difficulties remain when the hole to be filled is large and another critical aspect is the high computational time in general required. These two problems are here addressed by considering a hierarchical approach in which a lower resolution of the input image is first computed and inpainted using an exemplar-based method.

Super-Resolution (SR) refers to the process of creating one enhanced resolution image from one or multiple input low resolution images. The two corresponding problems are then referred to as single or multiple images SR, respectively. In both cases, the problem is of estimating high frequency details which are missing in the input image(s). The proposed SR-aided inpainting method falls within the context of single-image SR. The SR problem is ill-posed since multiple high-resolution images can produce the same low-resolution image. Solving the problem hence requires introducing some prior information. The prior information can be an energy functional de-fined on a class of images which is then used as a regularization term together with interpolation techniques. Image Inpainting fills the missing or damaged region in an image utilizing spatial information of its neighbouring region. Inpainting algorithm have numerous applications. It is helpfully used for restoration of old films and object removal in digital photographs. It is also applied to red-eye correction, super resolution, compression etc. The main goal of the Inpainting algorithm is to modify the damaged region in an image in such a way that the inpainted region is undetectable to the ordinary observers who are not familiar with the original image. Existing methods can be classified into two main categories. The first category concerns diffusion-based approaches which propagate linear structures or level lines (so-called isophotes) via diffusion based on partial differential equations and variational methods. Unfortunately, the diffusion-based methods tend to introduce some blur when the hole to be filled-in is large. The second family of approaches concerns exemplar-based methods which sample and copy best matching texture patches from the known image neighborhood. These methods have been inspired from texture synthesis techniques and are known to work well in cases of regular or repeatable textures. The first attempt to use exemplar-based techniques for object removal has been reported in [1].

Nowadays, the image Inpainting technology is a hotspot in computer graphics. And 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. Conventionally Inpainting is carried out by professional artist and usually its very time consuming process because it was the annual process. The main goal of this process is to reconstruct damaged parts or missing parts of image. And this process reconstructs image in such a way that the inpainted region cannot be detected by a casual observer. Inpainting technique has found widespread use in many applications such as restoration of old films, object removal in digital photos, red eye correction, super resolution, compression, image coding and transmission. Image Inpainting reconstruct the damaged region or missing parts in an image utilizing spatial information of neighbouring region. Image Inpainting could also be called as modification and manipulation of an image. In image inpainting we would like to create original image but this is completely unfeasible without the prior knowledge about the image. In case of digital images we only have the image we are working on available to us and thus we are filling in a hole that encompasses an entire object.

II. RELATED WORK

A. Diffusion based Inpainting

Diffusion based Inpainting was the first digital Inpainting approach. In this approach missing region is filled by diffusing the image information from the known region into the missing region at the pixel level. Basically these algorithms are based on theory of variational method and Partial Differential equation (PDE). The diffusion- based Inpainting algorithm produces superb results or filling the non-textured or relatively smaller missing region. The drawback of the diffusion process is it introduces some blur, which becomes noticeable when filling larger regions. All the PDE based in painting models are more suitable for completing small, non-textured target region.

B. Texture Synthesis Based Inpainting

Texture synthesis based algorithms are one of the earliest methods of image Inpainting. And these algorithms are used to complete the missing regions using similar neighbourhoods of the damaged pixels. The texture synthesis algorithms synthesize the new image pixels from an initial seed. And then strives to preserve the local structure of the image [3]. All the earlier Inpainting techniques utilized these methods to fill the missing region by sampling and copying pixels from the neighbouring area. For e. g, Markov Random Field (MRF) is used to model the local distribution of the pixel. And new texture is synthesized by querying existing texture and finding all similar neighbourhoods. Their differences exist mainly in how continuity is maintained between existing pixels and Inpainting hole. 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 exture retains the statistical properties of its root texture [4].

C. PDE based Inpainting

This algorithm is the 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 [5]. This is done by propagating the information in the direction of minimal change using isophote lines. 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 proposed the Total Variational (TV) Inpainting model [6]. This model uses Euler-Lagrange equation and anisotropic diffusion based on the strength of the isophotes. This model performs reasonably well for small regions and noise removal applications. But the drawback of this method is that this method neither connects broken edges nor greats texture patterns. These algorithms were focused on maintaining the structure of the Inpainting area. And hence these algorithms produce blurred resulting image. Another drawback of these algorithms is that the large textured regions are not well reproduced.

D. Exemplar based Inpainting.

The exemplar based approach is an important class of inpainting algorithms [1]. And they have proved to be very effective. Basically it consists of two basic steps: in the first step priority assignment is done 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, 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. According to the filling order, the method fills structures in the missing regions using spatial information of neighboring regions. This method is an efficient approach for reconstructing large target regions.

E. Non-uniform Interpolation SR Technique

The basis of non-uniform interpolation super-resolution techniques is the non-uniform sampling theory which allows for the reconstruction of functions from samples taken at non-uniformly distributed locations. Early super-resolution applications used detailed camera placement to allow for accurate interpolation, because this method requires very accurate registration between images. The advantage of this approach is that it takes relatively low computational load and makes real-time applications possible [7]. However, in this approach, degradation models are limited they are only applicable when the blur and the noise characteristics are the same for all LR images.

F. Sparse Representation Method

This method is based on single-image super resolution, which is based on sparse signal representation. Researchers in imaging field suggest that image patches can be well represented as a sparse linear combination of elements from an appropriately chosen over-complete dictionary. Learning an over-complete dictionary capable of optimally representing broad classes of image patches is a difficult problem [8]. It is difficult to learn such a dictionary or using a generic set of basis vectors (e.g., Fourier), so for simplicity one can generate dictionaries by simply randomly sampling raw patches from training images of similar statistical nature. Researchers suggest that simple prepared dictionaries are already capable of generating high-quality reconstructions, when used together with the sparse representation prior [9].

G. Super Resolution through Neighbor Embedding

This method is used for solving single-image super-resolution problems [10]. Given a low resolution image as input, objective is to recover its high-resolution counterpart using a set of training examples. In a recent neighbor embedding method based on Semi-nonnegative Matrix Factorization (SNMF) only nonnegative weighs are considered. In LLE the weights are constrained to sum up to one, but no constraints are specified for their sign. This might explain the unstable results, since possible negative weights can lead to having subtractive combinations of patches, which is counterintuitive. This method is based on assumption that small patches in the low- and high-resolution images form manifolds with similar local geometry in two distinct spaces. In this method each low- or high-resolution image is represented as a set of small overlapping image patches. Each patch is represented by a feature vector. The feature may be contrast, correlation, entropy, variance, sum of average, sum of variance, homogeneity, variance of difference, sum of entropy, difference of entropy, change of luminance.

H. Frequency Domain Method

The frequency domain approach makes explicit use of the aliasing that exists in each LR image to reconstruct an HR image [11]. Tsai and Huang first derived a system equation that describes the relationship between LR images and a desired HR image by using the relative motion between LR images.

The frequency domain approach is based on the following three principles [7], [11]: (1) the shifting property of the Fourier transform, (2) the aliasing relationship between the continuous Fourier transform (CFT) of an original HR image and the discrete Fourier transform (DFT) of observed LR images, (3) and the assumption that an original HR image is band limited.

These properties make it possible to design the system equation relating the aliased DFT coefficients of the observed LR images to a sample of the CFT of an unknown input image [11]. For example, let us assume that there are two 1-D LR signals that are sampled below the Nyquist sampling rate.

I. Projection onto Convex Sets

This method is based on a linear model describing the relation of HR and LR images, a cost function is introduced and the HR image is obtained [7]. POCS algorithm has many advantages like simplicity; it can be applied to the occasion with any smooth movement, and can easily join in the prior information, so this method is widely used. But POCS algorithm is strict to the accuracy of movement estimation [7]. So in order to improve the stability and performance of the algorithm, the relaxation operator will be used to replace ordinary projector operator, at the same time it is not contributing to the resumption of the edge and details of images.

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However, the linear model used in this method is an ill-posed problem in the sense that its transformation matrix may be singular and so a unique solution cannot be obtained. The advantage of POCS is that it is simple, and it utilizes the powerful spatial domain observation model [7]. It also allows a convenient inclusion of a priori information. These methods have the disadvantages like non-uniqueness of solution, slow convergence, and a high computational cost.

III. CONCLUSION AND FUTURE SCOPE

In this paper we review the existing techniques of image Inpainting and super resolution. We discussed a variety of image Inpainting techniques such as texture synthesis based Inpainting, PDE based Inpainting, Exemplar based Inpainting, Diffusion based Inpainting techniques. For each technique we have provided a detailed explanation of the techniques which are used for filling the missing region making use of image. From this analysis, a number of shortcomings and limitations were highlighted of these techniques. It is observed that the PDE based Inpainting algorithms cannot fill the large missing region and it cannot restore the texture pattern. The theoretical analysis proved that exemplar based Inpainting will produce good results for Inpainting the large missing region also these algorithms can inpaint both structure and textured image as well.

As different methods of super-resolution have been developed using models with unequal
assumptions of the existing problem, and because the results provided have been primarily based on subjective measurements, it is difficult to find an unbiased comparison on what super-resolution methods are more appropriate for a given task. There must be considerations like if more than one input images are present then use multi frame super resolution approach and if one or more high resolution training images are available then use single image super resolution approach.

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