Fast and Enhanced Image Inpainting with a Single-Image Super-Resolution Algorithm

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Abstract— The image processing has wide applications to deal with manipulation of digital images. There are various methods and procedures for interpreting digital images for image enhancement and restoration and performing operations on images such as blurring, zooming, sharpening, edge detection. The image restoration can also be referred as image inpainting. The image inpainting is the process which used to fill-in missing areas of the input images. This process can also be used to remove an object from the image, to restore an image. As compared to existing methods, several improvements have been done. These improvements are filling order computation and the combination of K nearest neighbours. The inpainted low - resolution image from the high-resolution input image allows to reduce computational complexity, less sensitive to noise and to work with the dominant orientations of image structures. From this inpainted low-resolution image, a single-image super-resolution is applied to reconstruct the high resolution image. The image inpainting has wide applications in digital camera and the digitalization of old photos. More than scratch removing, the image inpainting methods are also used for a text removal, an object removal and other automatic modifications of images, such as cracks in photographs or scratches and dust spots in film. It is also used to remove red eye, the stamped date from photographs.

Key words: Image inpainting, Exampler-based inpainting, super-resolution, texture synthesis, object removal

I. INTRODUCTION

INPAINTING methods play very important role in various applications such as object removal, scratch removal and Image restoration. Image inpainting is a method which consists of filling-in missing regions (holes) in the image. Inpainting is a kind of art that modifies an image or video with the available information outside the region to be inpainted. It should be done in an undetectable way. We can use inpainting for the restoring the damaged paintings. It also can be used in photography for removing or replacing of selected objects. In image inpainting, we make use of super resolution algorithm. The process of creating one enhanced resolution image from one or multiple input low resolution images is known as Super-Resolution (SR).

In photography and cinema, inpainting is used for film restoration that reverses the deterioration. We can take an example of cracks in photographs or scratches and dust spots in a film. It is used for removing red-eye or the stamped date from photographs. It is used for removing the objects.

Inpainting can be used to replace the lost blocks in the coding and transmission of images .We can take an example of streaming video. It can be used for removing logos in videos.

We can take an example of museum world in case of a valuable painting. This task would be carried out by a skilled art conservator or art restorer. In the digital world, inpainting is used which contains some algorithms to replace lost or corrupted parts of the image data (mainly small regions or to remove small defects).

Fig. 1(a) and 1(b) illustrates the concept of image inpainting.

In Fig. 1(a) one woman is present we can consider it as a region of interest .Region of interest means area in the image which is to be filled. Fig. 1(b) that woman is not present .We are removing the region of interest then the remaining area will be blank so this blank region is filled with background colors of the same image.

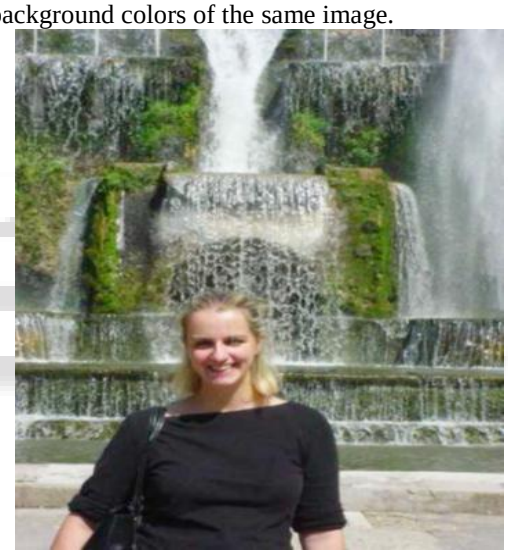

Fig. 1(a): Original photograph foreground person automatically

Fig. 1(b): The region corresponding to the foreground person has been manually selected and the removed.

There are two main existing methods for image inpainting. First method is diffusion-based method [4] which introduces some blur when the missing region to be filled is large. Second method is exempler-based method [1] which sample and copy best matching texture patches from the known image neighborhood. Both the methods work well in cases of regular or repeatable textures as these methods are inspired from texture synthesis method.

II. LITERATURE REVIEW

Image inpainting is based on two methods. Those methods are texture synthesis and diffusion based tensor techniques. In image inpainting normally focus is on the order of filling pixels. Best-first algorithm is used to fill the pixels. Calculate confidence value of the synthesized pixel. These values are used while filling the empty portion in an image [1].If there are no similar patches then it is not possible to produce satisfactory result. The curved structures not handled by this algorithm. [1] Texture synthesis is used to cover the missing large areas from image. Diffusion based image Inpainting technique is used to fill the small gaps present in the image. [1]But, while using these techniques there are some problems like how to fill the empty space of image after removing the large object from image.[1]

There are many simple resolution enhancement methods, but among those smoothing and interpolation techniques used for noise reduction. They prefer smoothing and interpolation methods because it gives better performance.[2]

The main goal of smoothing method is smoothness of image. This method works without carrying its causes, therefore the inpainted image getting blurred.[2]In smoothing and interpolation method, multiple training sets are used. All training sets are working simultaneously to generate each image patch Future work able to handle regions with primitives.

The diffusion based method which is used for filling-in missing regions in an image or to repair the damaged images, a new method which is based on the diffusion tensor. This method gives better result as compare to previous methods in the presence of complex structure images also performs well when the missing regions is small and without much textures. This method does not work with texture in-painting for large damaged area and to avoid the occlusion problem.[4]

The exampler based in-painting algorithm [4] is the algorithm in which it defines the filling order of patches using a particular formula. This algorithm is based on patch propagation by propagating the image patches. There are two methods or procedures for patch propagation first patch selection and second patch in-painting. To better understand the problem of patch selection and patch in-painting, two novels are proposed first patch structure sparsity and patch sparse representation. This algorithm showed better result infers the structure of the missing region.

There are two methods previously used. (i.e. diffusion based tensor and criminisi method) These methods have some disadvantages. Diffusion based approaches introduce some blurs when the hole to be filled-in is large that is the region which is to be filled is of large scale. This is the reason that the image is looking blur after inpainting. In criminisi method, inpainting is based on matching texture patches from the known image neighborhood. Criminisi method work well in case of regular or repeatable textures. [1] That means at the time of fill-in the patch, criminisi method checks only the neighbourhood patches to fill-in the unknown patch. So, there is also possibility of image getting blur-in.

Following Table I shows the comparative study of previous algorithms and the algorithm which we are going to implement. It shows the comparative study based on some parameters. The table shows that how exempler based image inpainting method is better than previously used methods.

Parameters	**Exempler based image inpainting**	**Non liner diffusion tensor**	**Exempler based on color distribu-tion analysis**	**KNN Exempler based method**
Structure and Texture synthesis	Yes	No	Yes	Yes
Approach	Patch based filling	Non linear diffusion n based	Patch based filling	Patch based filling
Patch priority	Based on highest priority patch	No	Based on color distribution	Based on K-NN with highest priority
Result of complex structure image	Good	Does not give best result	-	Preserve the structure of complex structure images
Image quality	better	good	better	better

Table 1: Comparative Study of algorithms

III. METHODOLOGY

Image restoration of large missing regions is a challenging task. In the previous section, we have seen a number of solutions for the image inpainting. This section represents the main ideas of a single-image super-resolution algorithm. This proposed method is new and innovative.

A single-image super-resolution algorithm has two main components. These two components are the inpainting & the super-resolution algorithms. It consists of three main steps. In first step, a low-resolution image is built from the original high-resolution image. In second step, an inpainting algorithm is then applied to fill-in missing region of the low-resolution image. In third step, the image quality is improved by a single-image SR method.

The Fig. 2 illustrates the concept of a single-image SR method.

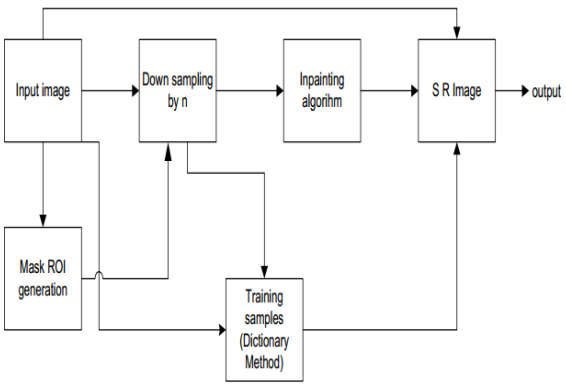

Fig. 2: The block diagram of a single-image SR method

A. Exampler-Based Image Inpainting of Low-Resolution Images:

The Exampler-based image inpainting method is used to fill-in the low-resolution images. The Exampler-based method has two classical steps as described in [1]: the filling order computation and the texture synthesis. These steps are described as follows:

B. Patch Priority and Filling Order:

In order to distinguish the structures from the textures, the filling order computation defines a priority for each patch. High priority means the presence of structure. The priority of a patch centered on 'p' is given by a data term.

There are three different data terms: gradient-based priority [1], sparsity-based priority [3] and tensor-based priority [6]. In a search window, a template matching is performed between the current patch and neighboring patches that belong to the known part of the image. By using a non-local means approach [7], a similarity weight (wp and wpj) between the two patches centered on p and pj is computed for each pair of patches

The sparsity term is defined as:

$$D(p) = ||wp||2 \times \sqrt{\frac{|Ns(p)|}{|N(p)|}}$$

Where, D(p) represents the data term. N_s and N represent the number of valid patches and the total number of candidates in the search window.

Fig. 3: Inpainting of LR images with different gradient-based priority [1](first row), tensor-based priority [6](second row) and sparsity-based priority [3](third row).

From Fig 3, it is clear that the sparsity-based priority is more robust and visually improves the final result compared to the gradient-based and tensor-based priority. Therefore, we use this method to compute the filling order.

C. Texture Synthesis:

The filling process in the missing region starts with the patch having the highest priority. To fill in the missing part of the current patch, k-coherence algorithm is used. According to this algorithm, a set of k-most similar patches located in the neighbourhood of the current patch is composed first. The use of k-coherence candidates used to improve the quality of the pictures.

D. Super-Resolution Algorithm:

A single-image super resolution algorithm is used to reconstruct the high resolution image from the inpainted low-resolution image. The low-resolution inpainted areas are used to guide the texture synthesis at the higher resolution. As in [8], the problem is to find a patch of high-resolution from a database of examples.

There are four main stages which are used to reconstruct the high-resolution image. The first stage is Dictionary Building in which the correspondences between low and high resolution image patches is maintained. The second stage consists of filling order of the HR picture. The filling order is similar as described in section patch priority and filling order. Filling process starts with patch having the highest priority. In third stage, a set of the k-most similar patches in the neighbourhood of the current patch is composed by using k-coherence algorithm and the last stage consists of the stitching process in which the HR patch is pasted into the missing areas. The stitching process is used only when all the pixel values in the overlapping region are known or synthesized. Otherwise; the stitching process is disabled.

The above mentioned processes are iterated while there is an existence of missing region.

IV. Conclusion

There are many existing methods for an image inpainting. The existing methods have some problems like blurs in an image, occlusion problems, cannot preserve the structures of the complex images. Therefore, the proposed method aims to give the better result, to minimize the blurs in an output image. By inpainting the low-resolution image rather than high-resolution input image, reduces the computational speed. The proposed method also preserves the structures and textures of the image, while filling in large missing areas.

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