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A Novel Patch Priority Estimate Method for Natural Scene Image Completion

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Abstract
Image inpainting algorithms have been widely used for removing unwanted objects in images and filling the gap produced by the object removal with plausible data. In this paper we present a novel patch priority calculation method to determine the filling order of patches. A comparison with some existing algorithms is made on a variety of scenes to demonstrate the effectiveness of the proposed method.

Keywords
Image Inpainting, Exemplar Based, Patch Priority

I. Introduction

Removing objects and restoring damaged image regions are important tasks of image processing. For a given input image with selected target region, both the geometrical property and color information should be propagated from the known area of the input image into the target region. The applications of image completion consist of restoration of photographs, films, paintings, and removal of occlusions.

A number of algorithms address this image filling issue [1-5]; these image inpainting techniques fill holes in images by propagating linear structures (called isophotes in the inpainting literature) into the target region via diffusion. They are inspired by the Partial Differential Equations (PDE) of physical heat flow, and work convincingly as restoration algorithms. The PDE-based algorithm does not perform well for texture dominated pictures. For such cases the exemplar based algorithm is used [6, 9-10].

Exemplar based image inpainting algorithms are able to inpaint even for large regions and as well as natural scene images which have complex textures and structures. Therefore recently many exemplar based inpainting methods [8-10, 12] have been developed.

In this paper we have proposed an efficient exemplar based image inpainting algorithm with an improved priority term that defines the filling order of patches in the image.

The analysis of both theoretical and experimental results of exemplar based algorithms [11] provides a good framework for us to extend our contribution to this category. This idea stems from the texture synthesis technique proposed in [6] in which the texture is synthesized by sampling the best match patch from the known region.

The rest of the paper is organized as follows: Section II presents the review of exemplar based inpainting algorithms used in the literature and section III includes a description of our proposed method. The experiment results are shown in section IV and finally the conclusion is presented in section V.

II. Review of Exemplar Based Inpainting

Image inpainting deals with repairing damaged pictures or removing unnecessary elements from pictures. Several exemplar based image inpainting algorithms are available in the literature. Criminisi proposed an exemplar-based image completion model which determined the filling order under the constraint of PDE-based data item [6].Criminisi et al [6] designed an exemplar-based inpainting algorithm by propagating the known image patches (i.e., exemplars) into the missing patches gradually. To handle the missing region with composite textures and structures, patch priority is defined to encourage the filling order of patches on the structure.

Wu [12] proposed a cross isophotes Exemplar-based inpainting algorithm, in which a cross-isophotes patch priority term was designed based on the analysis of anisotropic diffusion. Ruan [9] proposed a nonlocal means approach for the exemplar-based inpainting algorithm. The image patch is inferred by the nonlocal means of a set of candidate patches in the known region instead of a single best match patch.

Zhaolin Lu [10] proposed a PDE-based image completion algorithm in which the geometrical property of an image structure is preserved. More exemplar-based inpainting algorithms were also proposed for image completion. Compared with the diffusion based inpainting algorithms, the exemplar-based inpainting algorithms have performed plausible results for inpainting the large missing image region. In this paper we proposed an exemplar based image inpainting algorithm with a novel patch filling order method.

III. Our Proposed Image Completion Algorithm

The proposed algorithm includes the notation diagram used by Criminisi et al (6).To fill missing regions Ω with known regions Φ, there are generally two steps. Firstly, an edge patch Ψp is picked out. Ψp has part of pixels in Ω and the others are in Φ, secondly, exemplar patches Ψqi in Φ, are found, and then missing pixels in Ψp are propagated by corresponding pixels in Ψqi. Since missing pixels in Ψp has been recovered, Ψp is moved into Φ. By repeating above two steps, all pixels in Ω could be propagated.

We use a 9*9 patch, the centre point p of this patch are located at the boundary of target region. This is a target patch. Some areas of this target patch are known regions where as others need to be repaired. The priority of the target patch will decide the order of repair. The target patch which has the highest priority should be first repaired. So, we should compute the priority of target patch. When all priorities of the target patch have been computed, we find the patch Ψp with highest priority.

Our proposed Method Includes the Following Steps:

1. Initialization of Target region
   - This is done manually by marking the target region in some special colour.
2. Target region boundary Detection.
3. Patch selection from the target region for inpainting.
4. A suitable error metric called Mean Square Error is used to find the best matching patch.

5. Updating the image information according to step 4.

The proposed method is described in detail as follows:

A. Patch Priority Estimation and Patch Selection

Instead of using the multiplicative definition by Criminisi, we have proposed the addition of weights to the priority term as

P (p) = a*RC (p) +b*D (p) for 0≤a, b≤1and a+b=1

where a is the component weight for C(p) and b is the component weight for D(p). The regularized confidence term RC (p) is denoted as

RC (p)= (1-ω)*C(p)+ω for 0≤ω≤1

where ω is the regularizing factor for controlling the curve smoothness. By changing the priority for the patches on the δΩ now we are able to find a patch ψ_p with the highest priority.

The exemplar patches are selected from the sum of squared difference (SSD) measure between Ψ_p and a patch Ψ_q in ϕ.

μ_i is pixel mask function and defined as

$$\mu_i = \begin{cases} 1, if\ \Psi_p(i) \in \phi \\ 0. If\ \psi_p(i) \in \Omega \end{cases}$$

B. Search Time Reduction

Most often, the patch that most resembles the selected patch lies very close to the patch selected to be inpainted. Based on this assumption, we provide an approach on how to reduce the computational complexity of the algorithm.

For the patch ψp with highest priority, we would find the best matched patch of it in Φ. To increase the robustness of the similarity between exemplar patch and matching patch based on the square of Euclidean distance we design a new similarity matching function. The diameter of the surrounding region to search is calculated at run time by taking into account the region to be inpainted

An exemplar patch Ψq is a patch with the lowest SSD value. We must update the confidence C (p) for every iteration. Update pixel information (as known pixel) and then fill another unknown pixel in Ψp by the same method until there is no unknown pixel in Ψp.

IV. Experiment Results

Our algorithm has been applied to a number of natural images. In this section, we do some experiments to evaluate the performance of our proposed method. To validate the proposed image inpainting algorithm, the results are compared with some of the existing algorithms. The experimental results demonstrate that images generated by our algorithm have satisfactory results compared with Criminisi et al's algorithm [6].

Since the quality of the results apparently corresponds to the human perception of the appearance in the completed images, we visually demonstrate the results and comparisons without giving any quantified measurements.

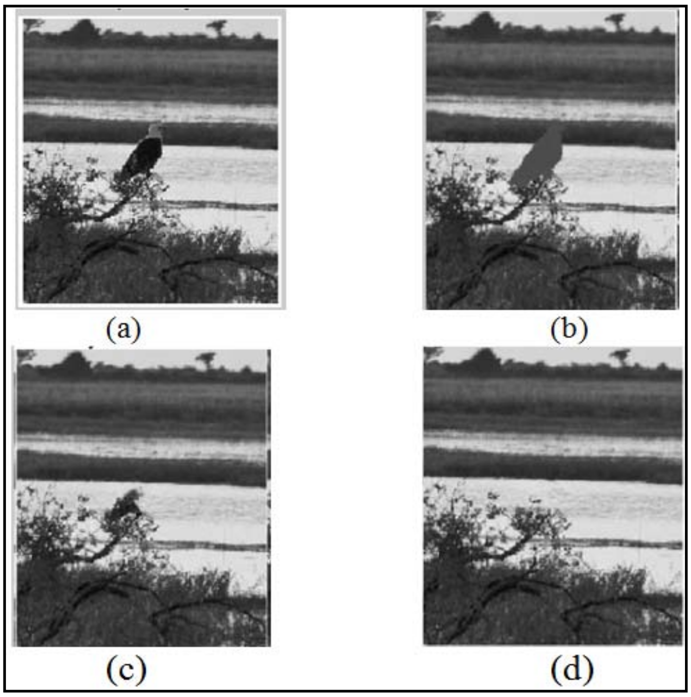

Fig. 1: Reconstruction of bird occluded region of image. (a) Original Image. (b) The target region has been blanked out. (c) The final image in which the occluded area is reconstructed using Criminisi et al's algorithm. (d) Reconstructed image using proposed algorithm

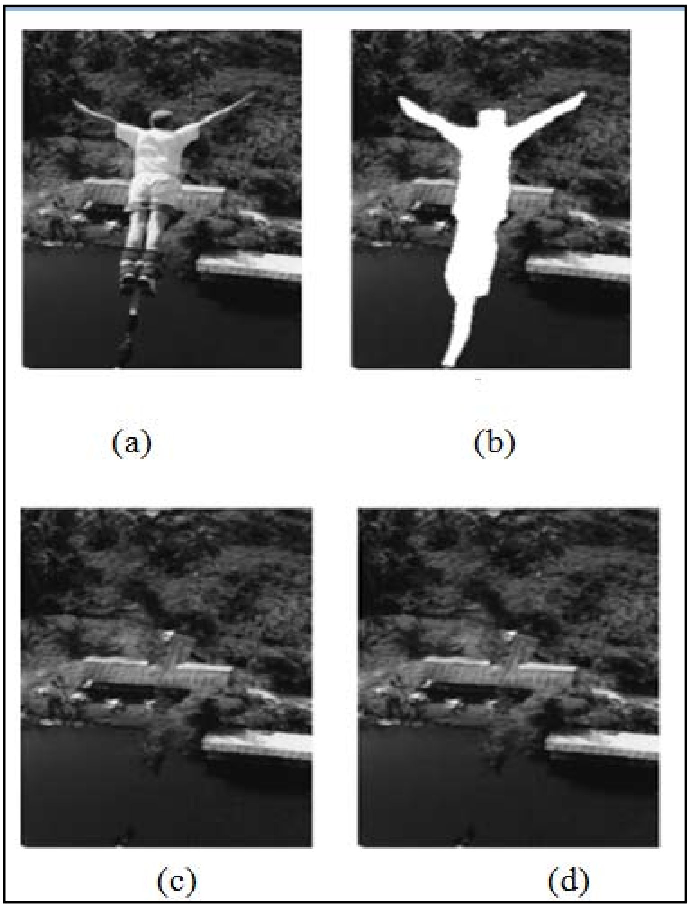

Fig. 2 Reconstruction of man occluded region of image. (a) Original Image. (b) The target region has been blanked out. (c) The final image in which the occluded area is reconstructed using Criminisi et al's algorithm. (d) Reconstructed image using proposed algorithm

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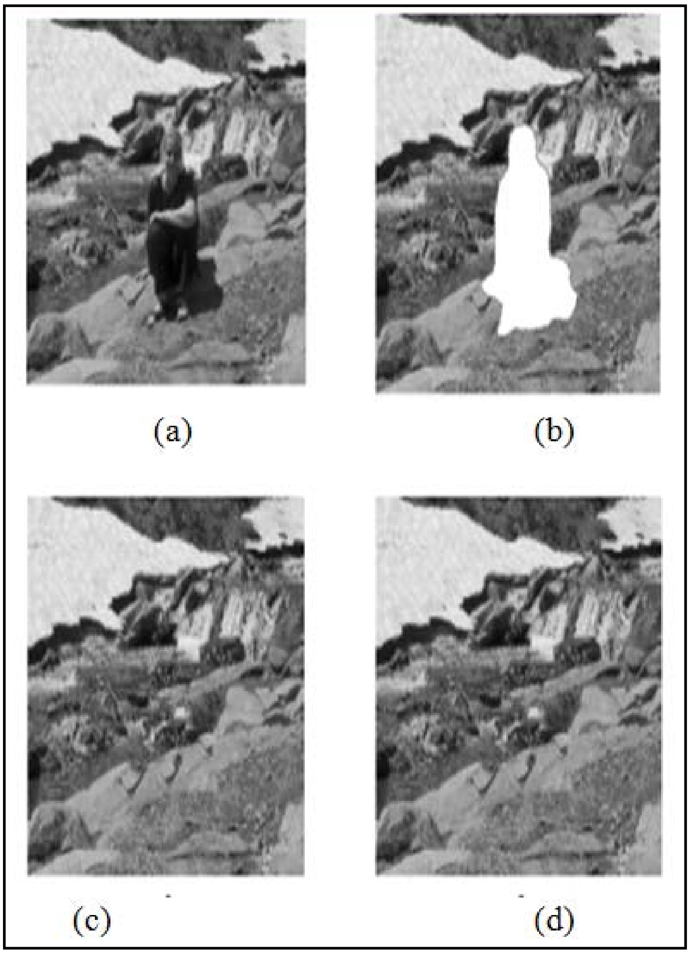

Fig. 3 Reconstruction of lady occluded region of image. (a) Original Image. (b) The target region has been blanked out. (c) The final image in which the occluded area is reconstructed using Criminisi et al's algorithm. (d) Reconstructed image using proposed algorithm

V. Conclusion

The existing image completion algorithms are time consuming, and the results are not satisfactory. The experimental results show its potential in comparison with the state of the art inpainting techniques. The major novelty of this work is that an improved patch priority term is introduced into the exemplar based inpainting algorithm. The results obtained are preferable to those obtained by other similar methods. The examples presented demonstrate the effectiveness of the modified algorithm. While this paper addresses inpainting of still photographs, it can also be extended to inpainting of video frames.

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