



Enhanced Technique for Exemplar Based Image Inpainting Method

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Abstract. Image Inpainting expertise in reconstructing mislaid image parts. It is the technique for filling an unknown area or scratched area of an Image developed on the nearby information present in the image that is not recognizable by ordinary viewer. In proposed method two Inpainting algorithms, the traditional exemplar-based Image Inpainting and structure tensor inpainting technique has been used. The traditional Criminisi's Image Inpainting method is simple and fast but veracity of the image is weakened and the output image results in blurriness's. To resolve this issue structure tensor Inpainting method has been introduced in the proposed method. The structure tensor algorithm gives more accuracy of the image by using Image structure tensor information. The experimental results are obtained by comparing the Criminisi's method and the proposed method by PSNR, SSIM, MSE and SNR. Structure tensor method significantly improves Inpainting quality compared with traditional Criminisi's method.

Keywords: Image Inpainting · Criminisi's algorithm · Structure tensor

1 Introduction

Nowadays, people are much more interested in clicking pictures, images which are stored as memories and lots are the sources of valuable information. With the age, the images, photographs often get damaged. A technique in the Image Processing field which solves this kind of problem known as the Image Inpainting Technique. This technique helps in the reconstruction of the damaged region of images as similar to the original image and used for removing unrequired objects, scratches, superimposed text like dates, subtitles from the image in an undetectable way. The Image Inpainting idea is first proposed by author Criminisi in 2006. Image Inpainting is the algorithm that shows there is no visual discrepancy among the Inpainting and original image and it gives better results. Applications of image inpainting are the recovery of a picture, eliminating an object, compression, restoration, rebuilding the missing places in the photograph, etc. Various categories of image inpainting techniques exist. The primitive method that is Texture synthesis incorporated to consummate the lost portion in the image. This algorithm utilizes similar neighborhoods of damaged pixels imitation and sampling from the nearest region to fill the missing area. Partial Differential Equation (PDE)

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Based Image Inpainting is used to endure geometrical and photometrical informatics seems at the edge of the damaged region. This method gives better results for the small destructive regions and if that region is large then the output results in blurriness. Hybrid Inpainting technique cooperate with two techniques such as texture synthesis and Partial Differential Equation-Based method. Semi-Automatic and Fast Inpainting technique has two steps in the process first is, the user provides mislaid details in the aperture by drawing object edges then texture emulsion is performed. Semiautomatic tactics consume more time from minutes to hours to complete the inpainting of the image. Exemplar based inpainting technique is more efficient for image inpainting than other methods. The algorithm consists of a selection of the unwanted object to be removed and recovering the selected area. It selects the best matching patch in the image apart from the selected area. It consists of steps as figuring the target portion, calculating patch priorities, finding greatest identical patch, and updating in-painted area. When a person takes a snapshot, there might be some unwanted objects in between so to remove such unwanted objects and can fill that area using surrounding patches of the image the software is needed. The proposed method has been used to solve this issue. Where Criminisi's algorithm is improved by adding a structure tensor method. In traditional Criminisi's inpainting method image veracity decreases and the output image results in blurriness's. To resolve this issue structure tensor Inpainting method has been introduced in the proposed algorithm. The structure tensor algorithm gives more accuracy of the image by using Image structure tensor information. Compared to the traditional Criminisi algorithm this proposed improved method gives better results.

2 Literature Review

Criminisi et al. [1] have come up with the Exemplar based image Inpainting method to eliminate huge unrequired portion from the image and to remove small cracks by merging texture synthesis and inpainting technique. The method results in speed efficiency and accuracy of synthesis of texture. Bing Yu and Ding [2] have improved exemplar-based image inpainting algorithms with fastened global optimal search which can effectively maintain the texture and structure characteristics of the lost region. Vidya Krishnamoorthy et al. [3] upgrades the method used for elimination of unrequired portion from the photograph by applying exemplar-based image inpainting techniques and is suitable for images with linear patterns, complete preferred objects. S. Zahra Siadati et al. [4] proposed inpainting algorithm that uses tensor to tackle convoluted structures. This algorithm gives better results in the image accuracy than other methods and information about gradient directions and their coherence. Liu Ying et al. [5] have proposed an improved algorithm that provides a greater advantage in the exactness of figure structure contrast with the Criminisi method. Also, progresses in visual effects. Seema Dixit et al. [6] have proposed an exemplar based image inpainting technique that splits the images and search the region. This proposed clustering method reduces time complications and improves image fidelity. Jayesh Patel [7] have proposed the method where searching pixels procedure reduced to the neighbouring regions rather than exploring the whole image. The user chooses the region to be inpaint and the algorithm automatically starts filling the portion. The process is based on pixel priority. Higher the priority of the pixel

region filling is faster. Huaming LIU [12] have proposed a method of screen window propagation for image inpainting. Where the higher layer leads the bottom layer inpainting for various resolution reduction. The priority calculation is upgrade using higher improve results can lead to acquire a superior repair order.

3 Methodology

Implementation of the proposed method shown in following Fig. 1.

3.1 Input Image

Input Image is a photograph, natural image for processing that contain both coloured, black and white images of different sizes. The input image should be in JPG and PNG format. The uploaded image is displayed in the Matlab GUI window to carry out inpainting processes.

3.2 Perform Cropping

The selected image contains unwanted objects or unrequired portions to be eliminated. In Perform Cropping Module, the unwanted region of image is cropped by using “imfreehand” function in MATLAB. It creates mask on selected portion with desired colour.

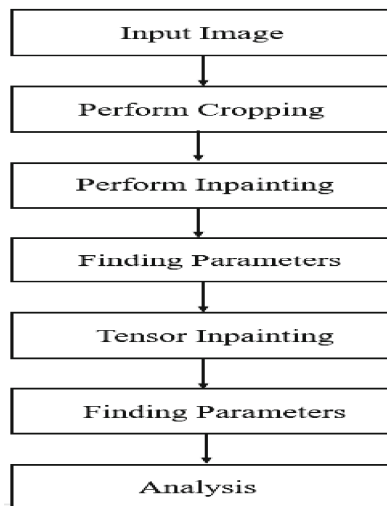


Fig. 1. System Overview

3.3 Perform Inpainting by Criminisi Method

Criminisi’s algorithm combines the avails of both texture emulsion and inpainting techniques. The method eliminates unrequired portion from the image by creating a mask known as target region. Pre-setting the priorities for the target part based on image structures and textures. The higher priority pixel is elected as a patch centre with size $9 * 9$ for each iteration. The most same patch with the least discrepancies is selected to load the required portion. During this, the patch in the source region content will be imitated into the selected inpainted region. Loading the selected inpainted region by patch degrades the running time (Fig. 2).

The masked object is eliminated by the traditional Exemplar based method. It contains the following steps:

Step1: Computing the Target Region of given Input Image

The user is allowed to select the image to be inpainted. The area that is not required or to be removed is selected and that is made visible by the mask of desired color that is green color (Fig. 3).

Step2: Calculating patch Priorities:

Reconstruction of inpainted portion in the desired image takes place by calculating the pixel priority $Pr(p)$ over damaged region’s edge.

The patch priority is obtained by multiplication of confidence term and data term as shown below:

$$Pr(p) = Cr(p) * Dr(p) \tag{1}$$

where, $Cr(p)$ – confidence term

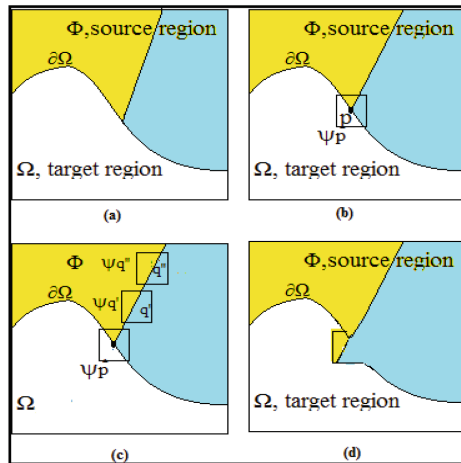


Fig. 2. Patch-based Inpainting, (a) Input Image contains Source region (Φ), Target region (Ω) and the boundary contour ($\partial\Omega$) (b) Patch with highest priority (c) Candidate patches $\Psi_{q'}$ and $\Psi_{q''}$ located approximately either on the same edge or same coloured edge. (d) The patch $\Psi_{q'}$ is the matching patch.

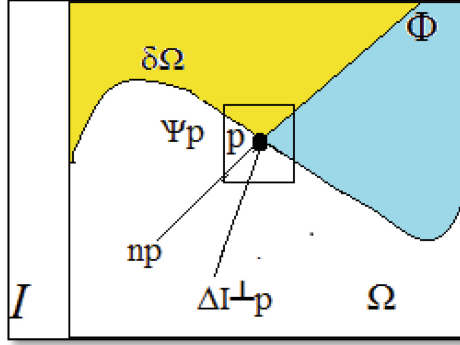


Fig. 3. The image is denoted as I while Φ is the source region, Ω is the target region and $\partial\Omega$ is the borderline between the source and target region. Consider the patch p , normal to the outline of target region is denoted as n_p and ΔI^\perp_p is the gradient at point p .

$D_r(p)$ – data term

$$Cr(p) = \sum_{q \in \varphi p \cap (1 - \Omega)} \frac{c(p)}{\varphi p} \quad (2)$$

where, (p) equals zero for target region and $Cr(p)$ equals one for source region

$$D_r(p) = \frac{\Delta I^\perp \cdot n_p}{\alpha} \quad (3)$$

where, gradient of pixel is ΔI^\perp_p and n_p is unit vector perpendicular to the border $\partial\Omega$.

Step3: Finding the greatest identical patch.

The identical priority area in the source region is searched and priority of each pixel is obtained. The pixel having largest priority among them assimilated with the targeted portion over the source area and produced as follows.

$$\varphi_{qr} = \arg \min_{\varphi p \in \Phi} d(\Psi p, \Psi q) \quad (4)$$

Step4: Updating selected inpainting region.

The obtained best match patch of an image is copied and enhances the target region.

Repetition of all the steps arises till the target part of image is completely processed and produces the inpainting image which is similar to original image.

3.4 Finding Parameters

In this module, the Mean Squared Error (MSE), Signal-to-Noise Ratio (SNR), Peak Signal-to-Noise Ratio (PSNR), and Structural Similarity Index Measure (SSIM) is calculated between original image and inpainted image that is Criminised image (Fig. 4).

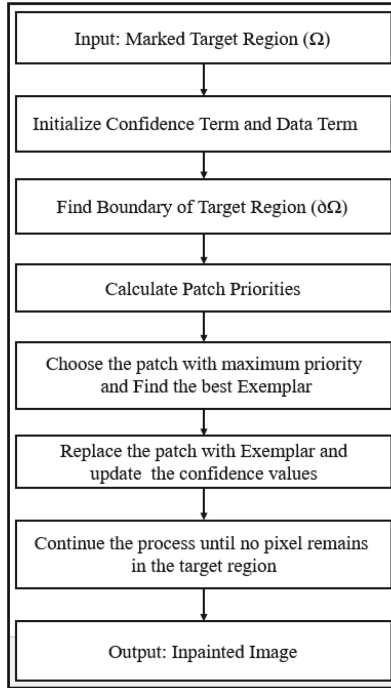


Fig. 4. Flow Chart

3.5 Perform Tensor Inpainting

In this module, same traditional Criminisi algorithm is used with some modification. The product of the confidence and data term in algorithm increases the pixel counts which affects the loading order. If the confidence term is nearly zero for pixel p in the equation of confidence term and data term, the maximum priority will be close to zero. This verdict smaller value of priority. The structure content is added prior to the data term explained by structure tensor algorithm as the data term cannot provide the structure details of an image.

Structure tensor, a second moment-matrix is invented by Forstner and Glush that provides gradients directions and consistency of pixel in the image. The image structure analysis can be obtained by Eigen values. The neighbouring structure content is added to the data term prior the calculation of Patch priorities.

Let I represent the image and the gradient vector is given as follows,

$$\nabla I = \begin{pmatrix} I_x \\ I_y \end{pmatrix} \quad (5)$$

The structure tensor is shown as,

$$J\rho = g\rho \otimes J\rho \quad (6)$$

where,

$$J_o = \begin{matrix} Ix^2 & IxIy \\ IxIy & Iy^2 \end{matrix} \quad (7)$$

Gaussian kernel is defined as follow,

$$gp = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (8)$$

where, Image I contains Ix and Iy as horizontal and vertical vector gradient components of each pixels respectively. The σ represents the breath of the Gaussian kernel and the square of it, σ^2 is the variance and \otimes denotes the convolution operator.

The structure control function is represented as shown,

$$h = (e(1) - e(2))^2 \quad (9)$$

$$F_s(p) = k \cdot h + \exp(-h) \quad (10)$$

The patch priorities is shown as,

$$P(p) = C(p) * (D(p) + F_s(p)) \quad (11)$$

Eigen values of structure tensor provides valuable data for structure analysis. The attributes of tensors are important in the algorithm. Where searching for the matching patch in the image reduces error in matching rate and ensures higher similarity for the target region of the image.

4 Experimental Results

The images that need to be inpainted are selected. The result yields in two output images as Criminisi's method and the proposed method. The evaluation of inpainted images is done by taking MSE, SNR, PSNR and SSIM of both methods. The proposed method compares with to the traditional Criminisi's method as shown in the Fig. 5. The results of proposed approach is tabulated in Table 1. The observation concludes the SSIM values and other calculated values like MSE, SNR; PSNR for proposed approach provides greater results than traditional Criminisi's method. The results are displayed for removing unwanted region in the image with Criminisi's method and proposed method (Tables 2, 3 and Fig. 6).

Table 1. Result images with proposed method and Criminisi’s Method






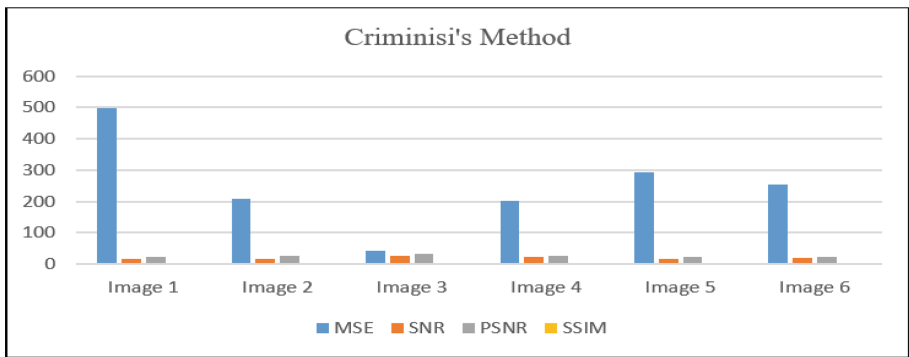
Images	Original Image	Mask	Criminisi’s Method	Proposed Method
Image 1				
Image 2				
Image 3				
Image 4				
Image 5				
Image 6				

Table 2. Numerical Analysis of Inpainted Images by Criminisi method

Criminisi's Method	MSE	SNR	PSNR	SSIM
Image 1	497.323	15.6158	21.1644	0.931838
Image 2	209.608	17.4746	24.9167	0.938022
Image 3	43.7815	25.4941	31.7179	0.987476
Image 4	203.134	21.8653	25.053	0.971146
Image 5	293.503	17.4769	23.4547	0.967412
Image 6	253.533	18.4988	24.0905	0.958178

**Fig. 5.** Graph representation of Numerical analysis by Criminisi Method**Table 3.** Numerical Analysis of Inpainted Images by Proposed Method

Proposed Method	MSE	SNR	PSNR	SSIM
Image 1	473.599	15.8281	21.3767	0.940647
Image 2	187.305	17.9631	25.4053	0.938073
Image 3	56.6925	24.3717	30.5955	0.987959
Image 4	140.482	23.4669	26.6546	0.979732
Image 5	326.579	17.0132	22.9909	0.973922
Image 6	190.847	19.7323	25.324	0.964334

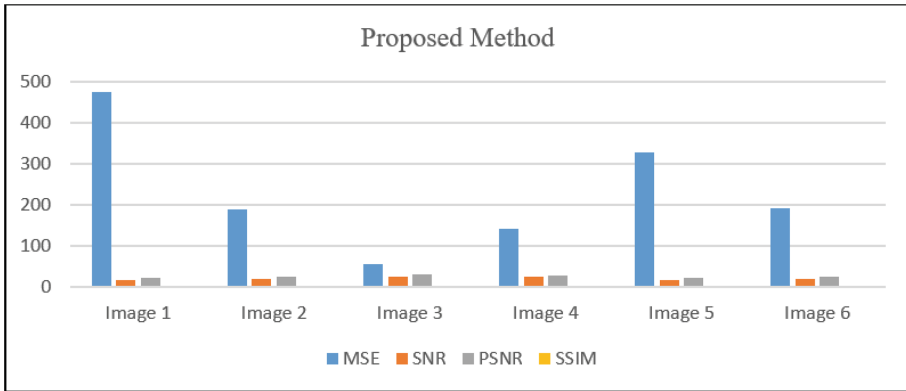


Fig. 6. Numerical Analysis of Inpainted Images by Proposed Method

5 Conclusion

Image Inpainting method perform a measure part in Image Processing. It is a procedure of eliminating unwanted regions or restoring damage area based on surrounding area in the image. The proposed inpainting algorithm provides greater verdicts compared with the traditional Criminisi's method. That is shown by using the Mean Square Error (MSE), Signal-to-Noise Ratio (SNR), Peak Signal-to-Noise Ratio (PSNR), and Structural Similarity Index Measure (SSIM). The future scope for this approach is to reduce the runtime of the algorithm to get more faster results.

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