Exemplar Based Image Inpainting Algorithm Using Structure Tensor

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Abstract: **Image inpainting is a technique to fill the missing area in the image, to recover the damaged area in the image and to remove unwanted area in the image in an undetectable way. After applying inpainting method to an image the output image should look like original image and The viewer should feel that the image is never altered before. In this paper the proposed algorithm is based on image structure tensor to tackle the problems of criminisi's algorithm. Image gradients with image structure have been employed to help image structure detection. Performance analysis of the structure tensor is shown in result section comparing with crimnisi's algorithm by using PSNR and SSIM and also the runtime of the both algorithms.**

Keywords: **image inpainting, criminisi's algorithm, structure tensor, image gradient, structure analysis.**

I. INTRODUCTION

In real world, image Inpainting is very hottest topic in the image processing to fill the missing area in the image, to recover the damaged area in the image and to remove unwanted area in the image. the viewer cannot find the image is altered by Inpainting technique. The Inpainting algorithm is based on known area of the image image look like there is no visual differences between original image and Inpainted image. Inpainting algorithm has several applications such as removing unwanted objects from image, image compression, restoration of an image, filling missed region. techniques of image Inpainting are texture synthesis based image Inpainting[13] algorithm is the earliest techniques of image Inpainting in image processing. To fill the missing areas texture synthesis based algorithms utilize same neighborhoods of the damaged pixels in the image. The earlier Inpainting techniques make use of texture synthesis methods to fill the damaged area by sampling and copying pixels from the neighboringpixel. PDE based image Inpainting[13] the main goal of partial differential equation (PDE) algorithm is to inpaint the image partial differential equation algorithms outputs are good if inpainting area is small for large inpainting area it will take more time and output will look like blurry image . hybrid Inpainting technique is combining of both old algorithm texture synthesis and partial differential equation based Inpainting for inpainting the unwanted area . hybrid Inpainting technique process divides the image into two separate parts, texture region and structure region. Semi-automatic image Inpainting technique needs user in the form of guide. there are two-steps in this technique, In the first step user draws missing area by using sketching object boundaries from the known area to the unknown area and then a patch based texture synthesis is used to produce the texture. Semi-automatic image Inpainting technique may take much time to Inpaint that depends on the size of the missing area to Inpaint. The fast Inpainting techniques are not applicable for filling the large missing areas and blurry effect in the output image [13]. The exemplar based image Inpainting method is based on the mask selected by the user. Exemplar based Inpainting consists of two steps first is, selection of mask to Inpaint by user second is, Inpainting technique to get original image. The main purpose of exemplar based Inpainting is to repair the mask portion of an image selected by the user and fill the missing area of an image by the priority order of patches [1]. This algorithm iteratively synthesizes the target region filling starts in missing area by using nearest neighbouring regions. The advantage of Exemplar based method algorithm is suitable for large selected area by the user to Inpaint. So in this paper the proposed method is based on exemplar based image Inpainting method.

II. LITERATURE SURVEY

In paper [1], author enhanced the method of exemplar based Inpainting method based on fast global optimal searching. Framework entails four processes; first, the initialization is performed fastly by layer by layer. Second, Patch-Match algorithm is incorporated to search the comparative patch for patches in the mislaided region. Third, a weighted mean oriented image reconstruction tactic is executed iteratively. Forth, is to contend the interpretation of mislaided portion to have real image look by Poisson editing. This paper shows the verdicts that effectively conserve the texture and structure attributes of the missing portion. In paper [2], author enhanced a tactic for object scrapping using exemplar image inpainting. Here, image is formalized to column and each pixel priorities are evaluated. The pixel is superseded with maximum priority pixel and is unceased till all the adequate objects are eliminated from patches. The Inpainted image portion of an image is masked by user and copy the highest priority patch from source region.

In paper [3], author enhanced a Inpainting method using image structure tensors algorithm to speculate the desperate target image parts by harnessing the left image portion. To tackle the criminisi's problem structure tensors are employed. To get the effective structures a conflation of structure tensors and image inclinations has been employed and structure image is strengthened.

In paper[4], the exemplar image Inpainting algorithm implemented to figure out error remedy accumulation, high time intricacy in Criminisi's method. by acquainting the structure tensor tactic and patch priority this algorithm improves the results in visual effect and set the priority in to sum form instead of multiplication to expel error removal in Inpainting and structure tensor is incorporated to constitute a structure control event and Eigen values of the structure reduces random similar block, it improves the accuracy in similairty.

In paper [5], traditional exemplar method may cause the transparency of texture when it proliferates the time. To solve this two steps are proposed, first it is proposed an algorithm that is adaptive sample algorithm based on patch sparsity. The sample patch size is very eminent in Inpainting. An adaptive function is introduced to decide the size that is patch sparsity. The value of patch sparsity represents the location of patch that is based on whether the value is large (edge) or small (texture). Second it is presented a candidate patch method to enrich the patch match rate, it selects several candidate patches rather than most similar patch and then selects three connate patches and calculates the difference among patches.This proposed method can give better result compared to traditional method.

In paper [6], author enhanced a method that is advanced exemplar inpainting algorithm to solve the problem such as arithmetic complexes, brawl and image reconstruction. This method includes image gradient function and extra similarity metric for measuring how image is altering. The traditional method can occur blurry effect while filling bigger holes so this proposed method can easily fill the bigger holes.

In paper [7], proposed a method that combines advantages both texture and structure. It is based on image texture by sampling the source portion to dredge the most analogous patch to highest priority patch. This is enough to achieve the propagation of both structure and texture information from the source region to the target region

In paper[8], the proposed method improves and extends traditional method instead of searching the entire image for ,patch the proposed method has reduced search region by searching the nearby pixels since in most cases the similar information patch lies nearby pixels this algorithm reduces time to complete Inpainting.

In paper [9], the proposed method has a further parameter to which patches entropy be similar and is a measure of edge content. To solve the mystery of erroneous edge propagation that is occurred by slight mismatch out of source patch and best patch match entropy of a patch is accustomed. If the patch and matching patch are smooth that verdicts valid good entropy. The patch with edge entropy is high hence data is non-uniform. PSNR of the image gives better results than the other methods.

In paper [10], This paper introduce a new image inpainting method, includes 2 steps salient structure completion step and texture propagation step. In firststep, finish incomplete unpronounced structures by content warped image retrieval technique. In second step, first alloys texture content of inacted salient structures. Further texture content is deliberated into remaining lost regions by patch inpainting tactic.

III. METHODOLOGY

A. Exemplar Based Image Inpainting Algorithm:

The main aim of an Exemplar based Image Inpainting method is to remove unwanted objects in the image and recovery of the damaged area in the image by creating a mask for the unwanted region that is called as target region and then selecting pixels from the boundary of the target region and search for the highest priority matching patch from the surrounding region of the target region that is called as source region. After finding match patch copy and update it in the target region.

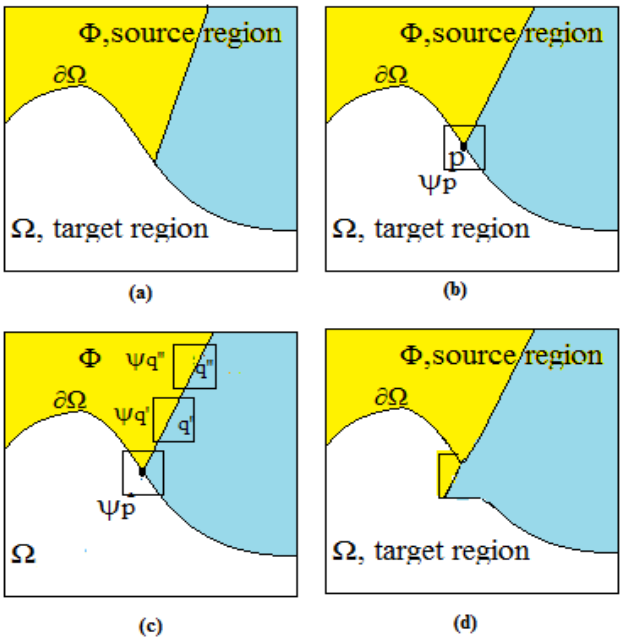


Fig1:Visualization of patch-based inpainting operation. (a) Original image shows sources and target area as well as the boundary contour (b) Patch that was given the highest priority (c) Candidate patches ψq' and ψq'' (d) The patch ψq' is filled in with the best matching patch

Exemplar based Image Inpainting algorithm includes four main steps:

Step1: COMPUTING THE TARGET REGION: Inpainting algorithm starts from this basic step, to remove unwanted object or area in the image and the damaged area in the image select the unwanted area by using mask this is done by user.

In matlab, creating mask is done by using a tool called imfreehand.

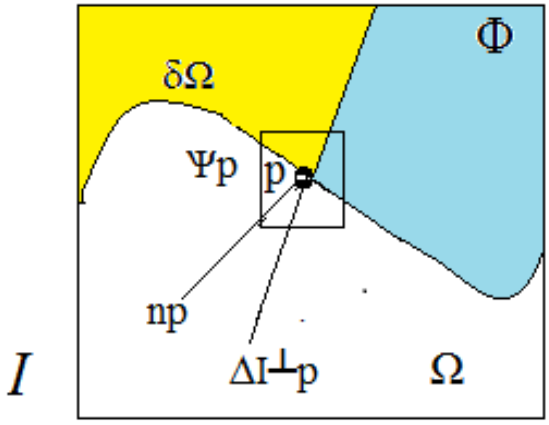


Fig2: Notation diagram. Given the patch p Ψ, np is the normal to the contour δΩ of the target region and $\nabla I\, p\perp$ is the isophote (direction and intensity) at point p . The entire image is denoted with I while Φ to be the undamaged area and Ω to be the damaged area.

Step2: COMPUTING THE PRIORITIES: To recover the target region (masked region) in the image calculate the priority P(p) of each pixel on the boundary of damaged region.

Priority is defined by the product of two terms

$$Pr\,(p) = Cr\,(p) * Dr\,(p) \qquad (1)$$

Where $Cr\,(p)$– confidence term

$Dr\,(p)$ – data term

$$C_r(p) = \sum_{q\in\varphi_p\cap(I-\Omega)} \frac{C(p)}{|\varphi_p|}$$

$Cr\,(p)$=0 for target region

$Cr\,(p)$= 1 for source region

$$D_r(p) = \left|\frac{\nabla I^{\perp}.n_p}{\propto}\right|$$

ΔI⊥p –gradient of the pixel p

np- unit vector orthogonal to the edge $\partial\Omega$

Step3: SEARCHING FOR THE BEST MATCHING PATCH:

To choose best matching patch compare the calculated priority of each pixel and find out the highest priority patch compared with target region throughout the whole known region or source region. This process is defined as the follows

$$\varphi_{qr} = arg\min_{\varphi_p\in\Phi} d(\Psi p^{-},\Psi q)$$

The d(x,y)is the sum of squared differences of the already known pixels in the two patches

Step4: UPDATING THE BEST MATCHING PATCH:

After finding the best matching patch in the source region of the image copy and update the patch to the target region.

And Repeat the above steps until the masked image is fully restored.

B. Structure Tensor Algorithm:

Criminisi's algorithm adopts the multiplication of only data term and confidence term and this inpainting process increases the known pixel counts, and encounters causes in structure proc and loading order. According to equation of confidence term and data term for pixel p, if the confidence is nearly zero while the another term with high priority value will be near to zero. This verdicts less priority value because of this a patch may reserve to be loaded misses its hit at the start itself of the inpainting. Data term is illustrated by isophote values that cannot fully detail the image structure information but structure tensor can explain the structure content.

The structure tensor is the basic notion in image processing and invented by Forstner and Gulch and it is a second moment-matrix it provides gradients directions and coherence of pixelin the image. and eigen values provide image structure analysis[5]. So adding local structure information to the data term before multiplying the confidence term and data term.The second moment matrix is obtained as follows, let I be the two dimensional image and the

gradient vector is defined as:

$$\nabla I = \begin{pmatrix} Ix \\ Iy \end{pmatrix} \qquad (5)$$

The structure tensor is defined by Jρ, is shown as

$$Jo = \begin{bmatrix} {I_x}^2 & IxIy \\ IxIy & {I_y}^2 \end{bmatrix} \qquad (6)$$

$$J\rho = g\rho \otimes Jo \qquad (7)$$

gρ is gaussian kernel is defined as following ,

$$g\rho = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma}} \qquad (8)$$

where I represents the image and Ix and Iy are horizontal and vertical constituents of the each pixels vector gradient. The σ determines the width of the Gaussian kernel and the square of it, $\sigma 2$ is the variance. In this structure tensor equation sigma of

Gaussian kernel is taken as 1 and ⊗ denotes the convolution operator.

The structure control function is defined as follows:

$$h = (e(1) - e(2))\text{^}2 \qquad (9)$$

$$F_s(p) = k.h + \exp(-h)) \qquad (10)$$

Where, constant K accurately recovers structure attributes of the damaged image and improvise visual effect at K=0.8 and H(p) upgrades the structure proportion in remedy process and verdicts an accurate discernment for structure tensor algorithm.

The improved priority after calculating the structure control function is as defined as follows:

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

The eigen values of Jρ outsource valuable data for structure analysis. The tensor has peak magnitude and more coherence extant image edges and magnitude is trivial in smooth image portions. The attributes of tensors are important in structure publicization in Criminisi's algorithm. So searching for the matching patch ensures higher similarity for the target region and reduces error in matching rate.

IV. EXPERIMENTAL RESULTS

To evaluate the outputs of the Criminisi's algorithm and structure tensor algorithm are exploited. The original images are given as input images and outputs are shown one as Criminisi's method and other one as structure tensor method and evaluated the inpainted images by taking PSNR and SSIM and run time of the both methods. The results are shown below are for object removal in the image and also damaged area recovery in the image.

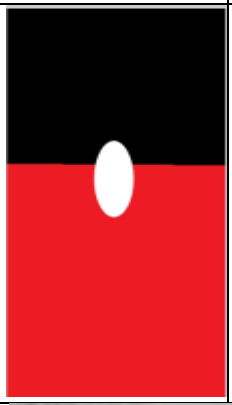
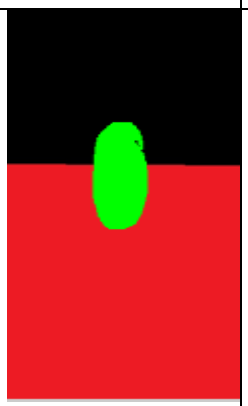
Object removal in the image:

ORIGINAL IMAGE	**MASKED IMAGE**
	

CRIMINISI'S ALGORITHM	**STRUCTURE TENOSR ALGORITHM**
	

ORIGINAL IMAGE	**MASKED IMAGE**
	
CRIMINISI'S ALGORITHM	**STRUCTURE TENOSR ALGORITHM**
	

Damaged area recovery in the image:

	ORIGINAL IMAGE	DAMAGED IMAGE	MASKED IMAGE	CRIMINISI'S ALGORITHM	STRUCTURE TENSOR ALGORITHM
Image1					
Image2					

Numerical analysis for damaged area recovery in the image:

Criminisi's algorithm	PSNR	SSIM	SNR	TIME(s)
Image1	26.3302	0.9916	18.78	22.38
Image2	42.611	0.9814	39.24	15.92

Proposed Method	PSNR	SSIM	SNR	TIME(s)
Image1	49.2815	0.9998	41.79	84.388
Image2	44.2685	0.9845	40.90	55.63

V. CONCLUSION AND FUTURE WORK

Image Inpainting method plays a major role in Image Processing. It is a method of removing unwanted object based on surrounding area of the image or restore damaged area in the image, in this work the exemplar image inpainting and also improved version of it by habituating structure tensor has been proposed. This method gives better verdicts compared with crimini's image inpainting method. The future scope for this algorithm is improving the method by automatic detects the object and inpaint instead of creating a mask for object and also reduces the runtime of the algorithm.

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