

## Degrading Surround Circles for Image Inpainting

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### Abstract

Image inpainting refers to the process of reconstructing lost 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. Applications range from the reconstruction of missing blocks introduced by packet loss during wireless transmission, removing of impairments, such as cracks, scratches, and dirt, in scanned photographs and digitized artwork images, to removal of image objects such as logos, stamped dates, text, persons, and special effects on the scene. 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. This paper proposes an automatic approach for image inpainting using special method that depend on inpainting degrading closed circles around the mask in the inpainting process to improve the quality of the results. The results show that our method is more efficient when compared with genetic - based image inpainting and particle swarm optimization based image inpainting based on subjective criteria.

Keywords: Image inpainting, Damaged region, Mask region.

### Introduction

The story of inpainting begins in the art world. For centuries, people have been keenly interested in repairing missing sections of oil paintings, and doing so in a way that renders the restoration as imperceptible as possible.

Inpainting is the process of filling-in missing or damaged image information. Its applications include the removal of scratches in a photograph [1]. Digital image inpainting is relatively new area of research, but numerous and different approaches to tackle the inpainting problem have been proposed since the concept was first introduced. The challenge is to fill in the hole that is left behind in a visually plausible way.

Image inpainting is different from other general image enhancement algorithms in the sense that image enhancement assumes that the pixel in the damaged portion of image, contains both the information about real data and the noise, while in image inpainting, the pixel values are all assumed to be missing in the filling domain [1].

### Literature Review

Digital image inpainting was first proposed by Bertalmio et al. [2]. They have introduced a technique for digital inpainting based

on Partial Differential Equations (PDEs). Bertalmio filled in holes by continuously propagating the isophote (i.e., lines of equal gray values) into the missing region.

Chan et al. presented the Total Variation (TV) inpainting model in [3], it is based on the Euler-Lagrange equation, employs anisotropic diffusion based on the contrast of the isophote. This model, designed for inpainting small regions, it does a good job at removing noise, but couldn't repair large regions also. The Curvature- Driven Diffusion (CDD) model [4], extends the TV algorithm to also take into account geometric information of isophote when defining the 'strength' of the diffusion process, thus allowing the inpainting to proceed over larger areas. Although some of the broken edges are connected by the CDD approach, the resulting interpolated segments appear blurry. Zaynab R.[5] utilized a Genetic Algorithm (GA) to restore missing parts on the image and also remove undesired object from the image. The user selects the region to be inpainted, then, the GA is used to fill in the selected region in raster scan order. Sarab M. Hameed[6], adopted a Particle Swarm Optimization (PSO) for image inpainting, PSO

is a stochastic, algorithm for problem solving. A communication structure or social network is also defined, assigning neighbors for each individual to interact with for solving image inpainting problem. H. Noori, S.Saryazdi and H. Nezamabadi-pour [7] proposed convolution based image inpainting algorithms and proved that the proposed algorithm is very rapid, however in many cases, it does not provide adequate results in sharp details such as edges. Zhaoxia Wang [8] proposed an image inpainting method by using evolutionary algorithm. Its main idea is to restore the structure information and texture information separately. The proposed method is applied to restore the images with a large damaged area. Simulations indicated the high accuracy performance of the proposed method.

### The Inpainting method

This method starts with the original image and the mask image as input. Here, mask image specify the object to be removed from the original image. The object to be removed has to be marked by user because it depends on the subjective choice of user. And, given the output as reconstructed image. The main idea of the proposed method is the beginning with encircling the mask and process the outer surroundings by substitute each pixel in the outer surroundings by suitable value. When the processing of all the pixels in the outer surroundings is completed, the algorithm continues to processing the interior surroundings until reach the center pixel and repairing all the masked pixels. The proposed algorithm is illustrated in the following steps:

#### Step1: Creating the frame within the image

The mask is circles with external frame in order to minimize the time of searching, where instead of searching for the appropriate value within the whole image the search process will be within this frame to shorten the time.

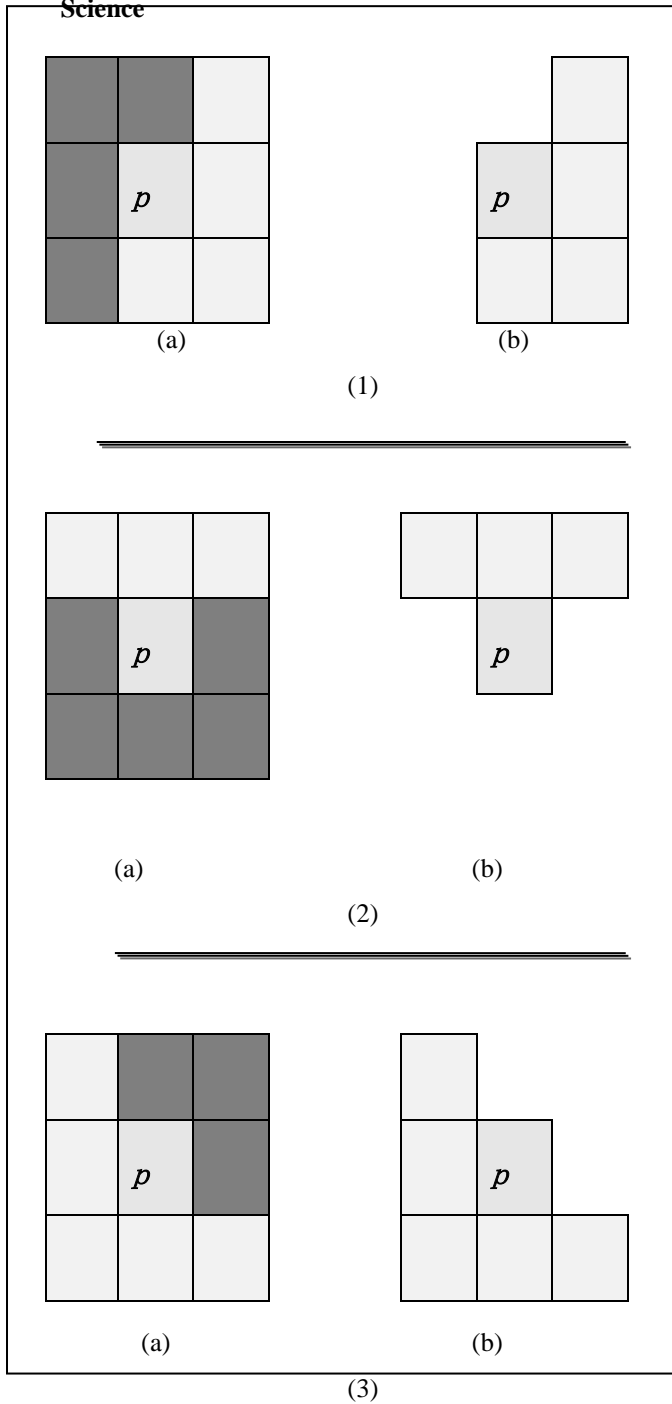
The algorithm can give the freedom to the user to determine the limits of the frame or can be fixed frame for all images. This freedom is because the inpainting process is vary depending on the size of the image, size and shape of the mask.

#### Step2: inpainting algorithm detect the outer encircling and build a matrix

- 1- The inpainting process search the entire image to detect the pixels that located within the boundary of the mask.
- 2- Build a matrix that contain the coordinates of each pixel located at the boundary plus it's number of neighbors that contain true color (pixels not fall in the mask).
- 3- Sort the matrix (pixels located at the boundary) in descending order according to their number of neighbors for each pixel stored in this matrix.

#### Step3: Substitute with suitable value

- 1- Choosing pixels stored in the matrix from top to bottom that means we will begin to process the pixel in the matrix which owns the highest neighbors having real color, assume that pixel it's  $p$  at coordinate  $(i,j)$ .
- 2- For each pixel on the boundary, determine the number of neighbors that have true color, this process allow us to determine template's shape according to the existence of neighbors. For that, the shape of the template is varying for each pixel in the boundary's mask.



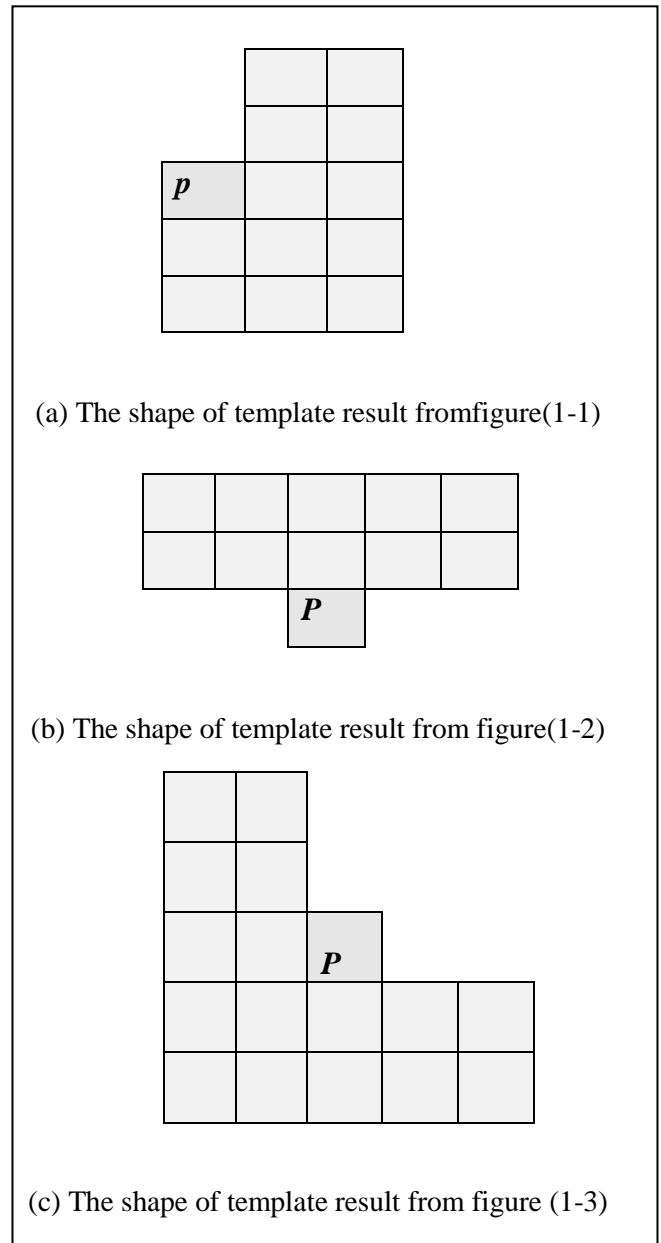
**Fig.(1) Initial shape of the template.**

- Pixel within the mask region
- Pixel has true color

- (a) -Examples of the neighbors around the pixel  $p$
- (b)- The plate shape of existence neighbors of  $p$ .

3- Enlarge the shape of the template, this means duplicate each existence pixel in the neighbors, the neighbors that located in the corner take full angle's pixels (three pixels around the corner's pixel), where for the shape shown in Fig.(1) it will be as below in

Fig.(2) and this final template shape will be used in searching for the appropriate value.



**Fig. (2) Final shape of the template.**

The shape of the template used in searching for the appropriate value

- 4-With these templates, the algorithm search for the appropriate value that best fit to  $p$  in scan order.
- 5- Best fit means the shortest path between pixel  $p$  in the mask region and pixel  $q$  at source region (in the frame region), that is the minimum sum of Euclidean distance between source pixels and their

corresponding target pixels. Formally speaking:

$$D(p,q)=\sum \text{sqrt}\{(R(p)-R(q))^2+ (G(p) - G(q))^2 + (B(p) - B(q))^2 \} \dots\dots\dots(1)$$

Where

R, G, and B are Red: Green, and Blue channels.

*p*: pixel to be filled (i.e. pixel in the masked region)

*q*: pixel in the original image (within the frame).

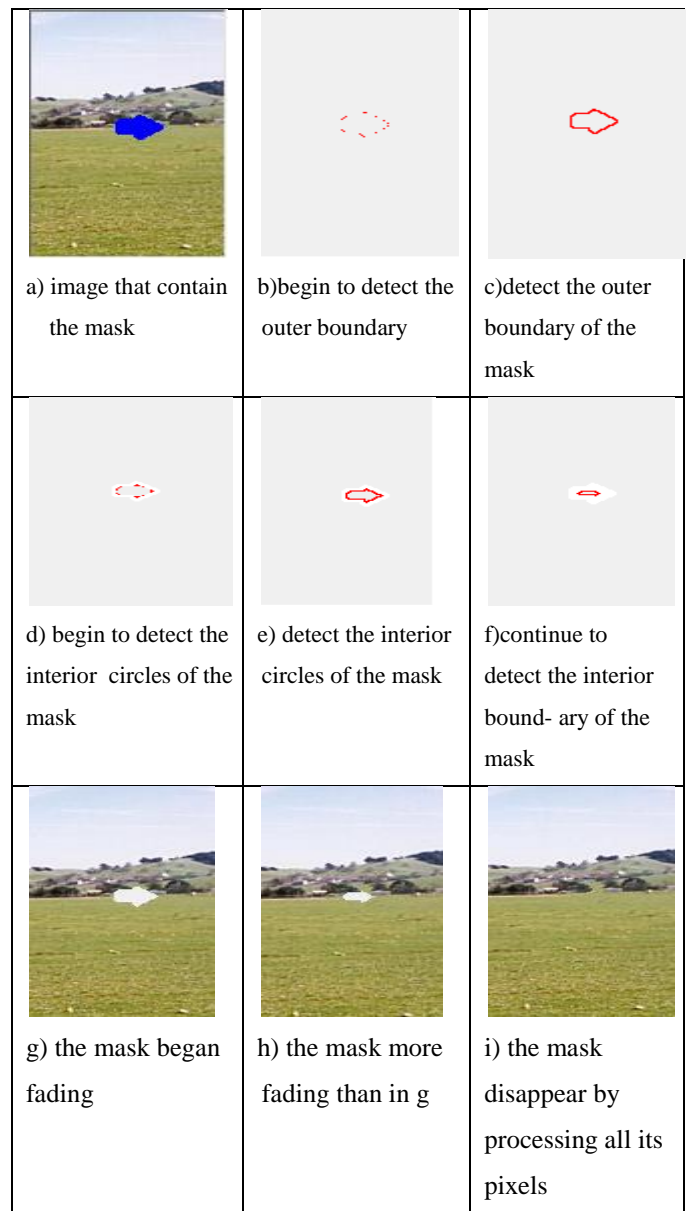
6- Substitute the value of *p* by the value of *q* that has the minimum sum.

**Step4: Update certain pixels and process all the boundary pixels**

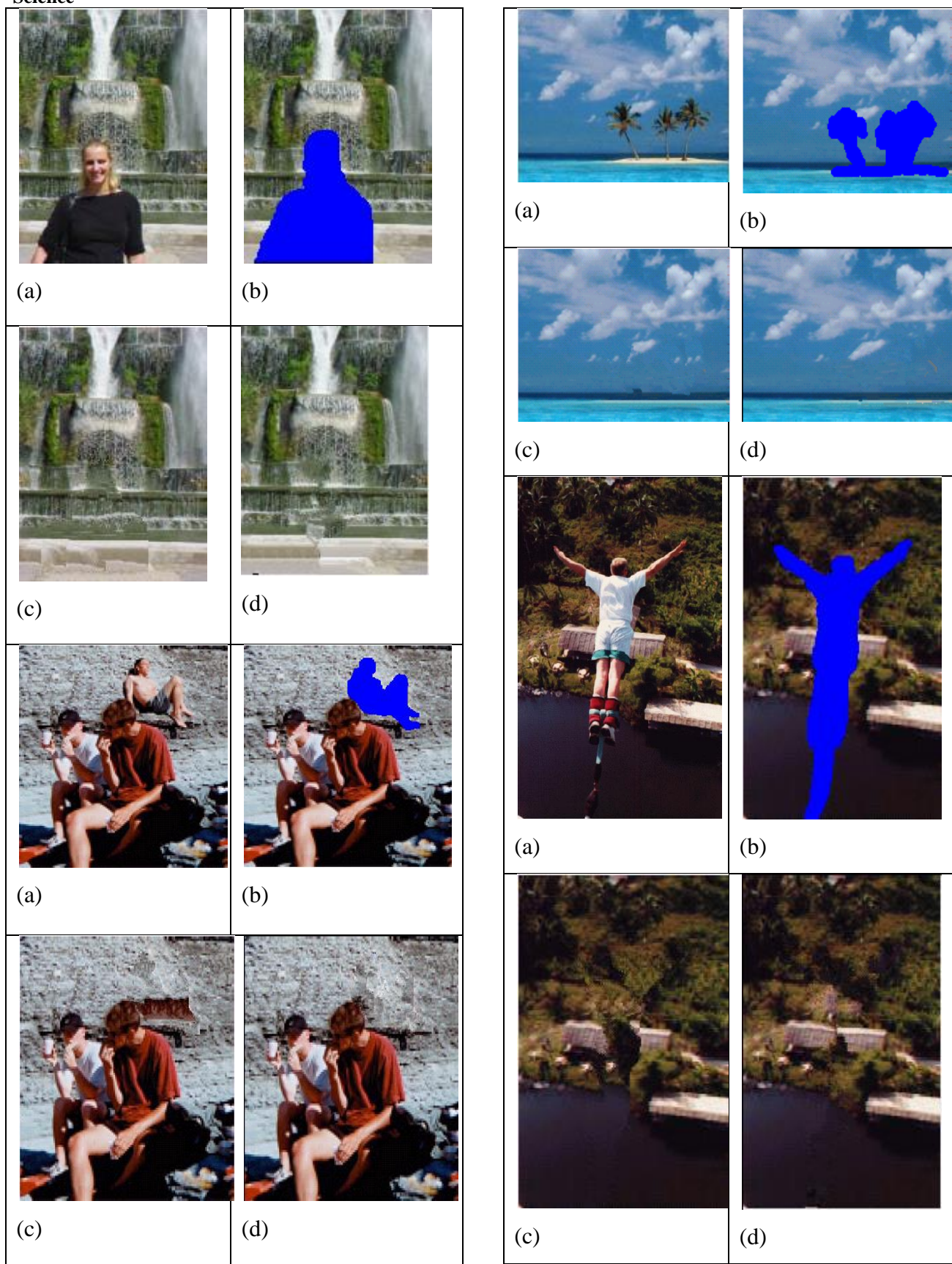
After choosing the best value for pixel *p* update the number of neighbors in the matrix for each pixel located with the neighbors of pixel *p* that have been processed, then rearrange the matrix with new update in descend order, the algorithm will continue to processing the rest of the pixels in the matrix till they completed, and in such case all the pixels located in the boundary of the mask, (this means the steps from 3to 5 will be iterated until all pixels located in the boundary processed).

**Step 5: Termination**

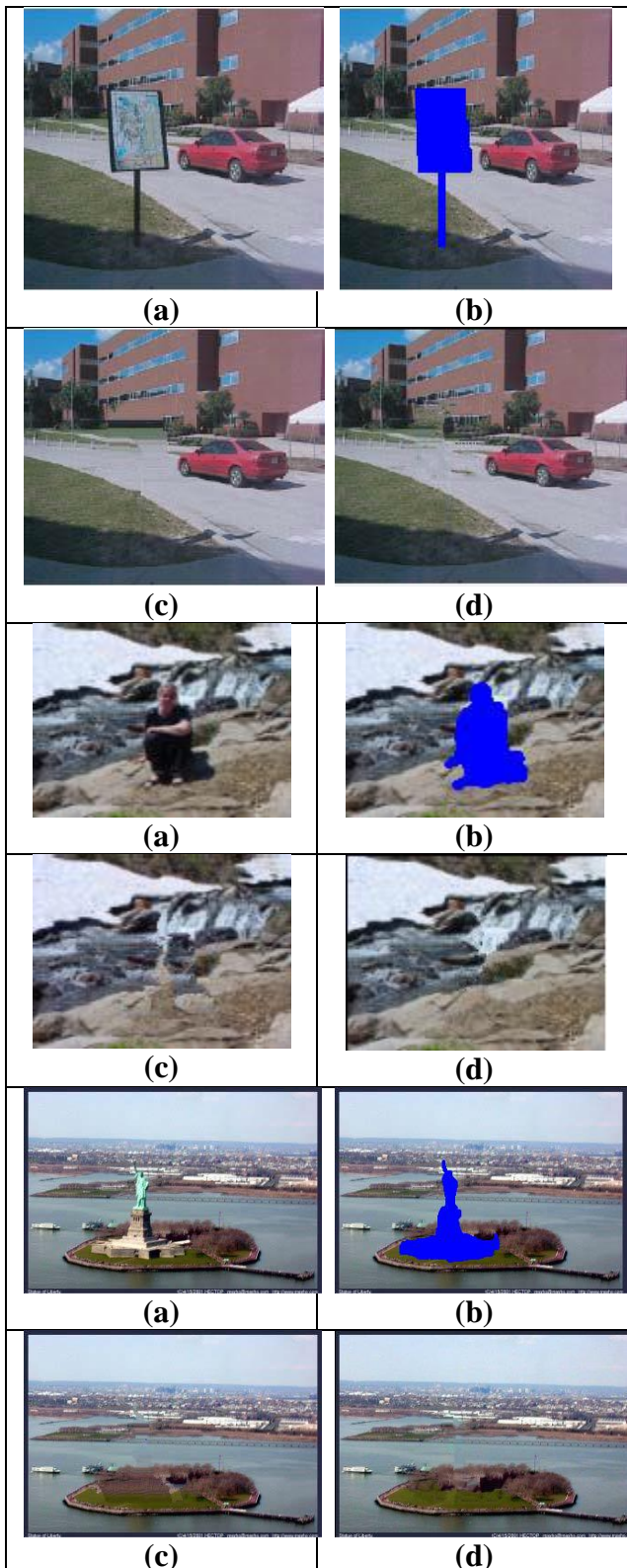
Steps 2 to step 4 are repeated until all the boundaries are processed and no pixel within the mask still not processed. After termination, the image will be in painted using the proposed algorithm.



*Fig.(3) The steps of interior inpainting process.*



**Fig.(4) Comparison the results of proposed method and GA.**  
**(a) Original image. (b) Mask image.**  
**(c) The result image using GA inpainting algorithm.**  
**(d) The result image using the proposed algorithm.**



**Fig.(5) Comparison the results of proposed method and GA.**

**(a) Original image. (b) Masked image.**

**(c) The result image using PSO algorithm.**

**(d) The result image using the proposed algorithm.**

## Conclusion

This paper propose a new algorithm for removing objects from images and inpainting damaged image using degrading surrounded circles for image inpainting. The algorithm is detect the boundary of an object selected by the user and removes it from the image in a visually pleasant way using pixel based inpainting for each pixel in the boundary of the mask and continue with the same way for all boundaries until process the center pixel of the mask. The time required for the inpainting process depends on the size of the image and the regions to be inpainted, and it ranges form few seconds to several minutes for large images.

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### الخلاصة

طلاء الصورة يشير الى عملية إعادة بناء الجزء المفقود او المخرب من الصورة بناءً على معلومات الخلفية المحيطة بالجزء. إن صبغ الصورة له تطبيقات عديدة حيث انه يستفاد منه لاستعادة الاجزاء المفقودة خلال عملية البث اللاسلكي، وازالة التشوهات في الصور مثل الخدوش والاوساخ في الصور التي اجري لها مسح ضوئي والصور الرقمية وازالة عناصر من الصورة مثل الشعارات والتاريخ المطبوع والنصوص والاشخاص وغيرها. ان الهدف الرئيسي من طلاء الصور هو تعديل المنطقة النالفة في الصورة بطريقة مرضية. النتائج اثبتت ان الطريقة المقترحة هي اكفاً عند مقارنتها مع طلاء الصورة المعتمد على الخوارزمية الجينية وطلاء الصورة بالاعتماد على افضل سرب طيور (بالنسبة للعين البشرية).