Colord Image White Cracks In-Painting Method

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Abstract:

    The gaps and cracks in an image result from different reasons and affect the images. There are various methods concerning gaps replenishment along with serious efforts and proposed methodologies to eliminate cracks in diverse tendencies. In the current research work a color image white crack in-painting system has been introduced. The proposed inpainting system involved on two algorithms. They are Linear Gaps Filling (LGF) and the Circular Gaps Filling (CGF). The quality of output image depends on several effects such as: pixels tone, the number of pixels in the cracked area and neighborhood of cracked area and the resolution the image. The quality of the output images of two methods (linear method: average Peak Signal to Noise Ratio (PSNR)=24.899 and circular method: average PSNR= 27.783). The result of correlation of images is close to the original image (horizontal = 0.894, vertical = 0.521, and diagonal =0.807). The first method is less time consuming than the circular method.

Keywords: Image In-painting, Morphology, Crack Detection, Gap filling.

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اعادة رسم صورة ملونة بتشققات بيضاء

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الخلاصة:

الفجوات أو الشقوق (التصدعات) في الصورة ناتجة عن أسباب مختلفة وتؤثر على الصور. هناك العديد من الطرق التي تتعلق بتجديد الفجوات جنبا إلى جنب مع جهود جادة واقتراح منهجيات للقضاء على الشقوق في الاتجاهات المتنوعة. في بحثنا الحالي قدمنا نظام إعادة رسم الصورة الملونة التي تحتوي على شقوق. النظام المقترح هو نظام إعادة رسم الصورة يتضمن اثنان من الخوارزميات. هي طريقة الاستكمال الخطية وطريقة الاستكمال الدائرية.

جودة الصورة المخرجة تعتمد على العديد من الآثار مثل: أسلوب (درجة اللون أو الضوء) للبكسل ، عدد البكسلات في منطقة الشقوق والمناطق المجاورة لمنطقة الشق ودقة الصورة . جودة الصورة المخرجة من الطريقتين (الطريقة الخطية: معدل نسبة إشارة الذروة إلى الضوضاء=24.899 والطريقة الدائرية: معدل نسبة إشارة الذروة إلى الضوضاء=27.783).

نتيجة معامل الارتباط للصور على مقربة من الصور الأصلية (أفقي=0.894 ، عمودي=0.521 وقطري (مائل)=0.807) . الطريقة الأولى اقل استهلاكا للوقت من الطريقة الدائرية.

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1. Introduction

    The characteristics of the satellite image are high resolution and multi spectral. The common approach of using these kind of images are military and environmental fields, there are other uses also such as a field of map production, establishment of a city plan, agriculture, forestry and planning of national land. The satellite images may be periodic data acquisition so the hyper-spectral and the high resolution satellite image make it an important source for recording the information in digital form.

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The knowledge of "environment change", "geographic information", "topography", "digital library" or "museum photography" are the interesting topics that are distinguishes by recovery of images [1]. The capturing the image causes some gaps in the digital image. There are several reasons of imagery gaps such as: instrumentation errors and transferring data, so it is necessary to complete these images with suitable values. The gap areas may be filled using other useful sources. The other is based on image pixel similarities/dissimilarity rules in the image. Hybrid techniques are representing different source or single source image for "gap filling" techniques [2]. Image enhancement is the processes used to convert the image to a better suited form, to improve the image visual appearance to human or machine analysis. The process used for image enhancement may be implemented in the gray level that represents each band such as: edge crisping "edge detection" or "edge sharpening", contrast adjusting, noise removing, image filtering "high pass filter" or "low pass filter", image pixels' interpolation and color correction. The color image may be analyzed to multi band color and each band may be considered as gray level.

2. Literature Survey

There are much work in image processing deal with satellite image in the field of image "in-painting", "crack removal", "enhancement" or "interpolation". The related work below is an important review:

o   In 2012 ***Hitoshi Yamauchi* et.al"** [3] suggested combined multi resolution texture synthesis image in-painting. The method used for crack removal, object removal, logo or subtitle removal. The method bridge the gaps between two approaches to fill the different kind of gap filling. The recovered images gained with the technique look reasonable in general and surprisingly good in some cases. This is demonstrated in a variety of input images that exhibit different kinds of defects.

o   In 2012 ***"Mohammed Jamal"*** [4] suggested a method to fill gaps in "Land sat (Enhanced Thematic Mapper Plus) ETM+ images". Several digital filters used such that "average filter", "median filter" and "midpoint filter", also different interpolation methods: "nearest neighbor", "linear" and "cubic Spline".

o   In 2012 "***Carlos Ramirez* et.al"** [5] suggested the principle of sparse representation for image in-painting. The suggested method depends on minimizing the structured image. The method considers an endlessly different curved estimated function. The numerical experiments are conducted on real data to solve sub problem.

o   In 2013 "***Ravi P. Gupta* et.al"** [6] suggested a linear gaps filling using Principle Component Transform (PCT) the method provides straight forward logical method for image interpolation.

o   In 2013 ***"Faisel G. Mohammed"*** [7] suggested a linear method of high resolution satellite image in-painting. The method combined nearest neighbor with bilinear interpolation method as a concept of replaced missed pixels

o   In 2013 ***"S.M. Ali* et.al"*** [8] suggested several methods to restore the ETM+ image. Initially "Arithmetic Mean filter", "Median filter", "Mid- Point filter", secondly "Nearest-Neighbor interpolation", "Linear interpolation" and "Spline interpolation" that not essential a sequential scene for gaps filling as self-sense dependent methods. The second type used different temporal viewed sense for estimation.

o   In 2013 ***"M. Mohammdy* et.al**" [9] suggested a "Local Linear Histogram Matching(LLHM) method" for gaps filling in the ETM+ satellite image. The suggested method measured that pixels neighboring Scan Line Corrector (" SLC"-off) gaps as a sequential patterns of change and similar spectral characteristics with the missing pixels. The information of the same-class adjacent pixels is used to recover missing pixels.

3. Problem Statement and Motivations

The image gaps or cracks may be caused by instrumentation error and the loss of image during data transmission. The main problems could be summarized in the next few points:

 1.   The cracks in the image may be noisy or not clearly missed pixels (i.e., its pixel's values have only zero values).
 2.   The cracks in image involved in two types: - a) pure gaps (i.e., all its pixel's value be zero/missed pixels), or b) impure gaps (i.e., its pixel's value diverse btw. 0 and 255). Thus the challenges are how to design a system have ability to fill these two types.
 3.   Also the above (b) type could be classified into white or black cracks.

4. These cracks/gaps may be wide or thick pixels and caused by fully objects removal.
5. The values of image pixels and the verities of noise in the image, the challenges are represented in a changes to discover the missing pixel and to interpolate these missing pixels.

The main motivation behind current research work is how to overcome some of the previous problem, which is summarized in the following

1. Detect white cracks within the old color images.
2. Introduce an efficient gap filling algorithm to fill out the detected cracks.

4. Proposed Image In-painting System (IIS)

The proposed in-painting system involved in two steps. The first step was dedicated to detect white cracks (convert it to black pixels, i.e., gap), while the second step was dedicated to interpolate/fill these detected cracks (black pixels) by using a new gap filling algorithm called circular gap filling CGF method and linear gap filling LGF method implemented previously by [10]. The main differences between these methods depend on quality of cracked filling and time consuming.

The proposed system uses a processing unit (such as, PC) to process and analyze images to find the crack and try to fill this crack with a suitable value. The cracked image should be the first processes to detemin the cracked area by defining a mask (binary image) that represents the cracked pixels with white color and other area with black color.

| White Crack image detection | → | Gap filling | → | In-paint   Image |

Figure 1- The proposed system main diagram

The layout of proposed image gaps filling system consists of two modules (the linear gaps filling module, circular gaps filling module). Each module has its own method (filling methods) to complete the gaps in the images. Figure-2 shows the system layout.
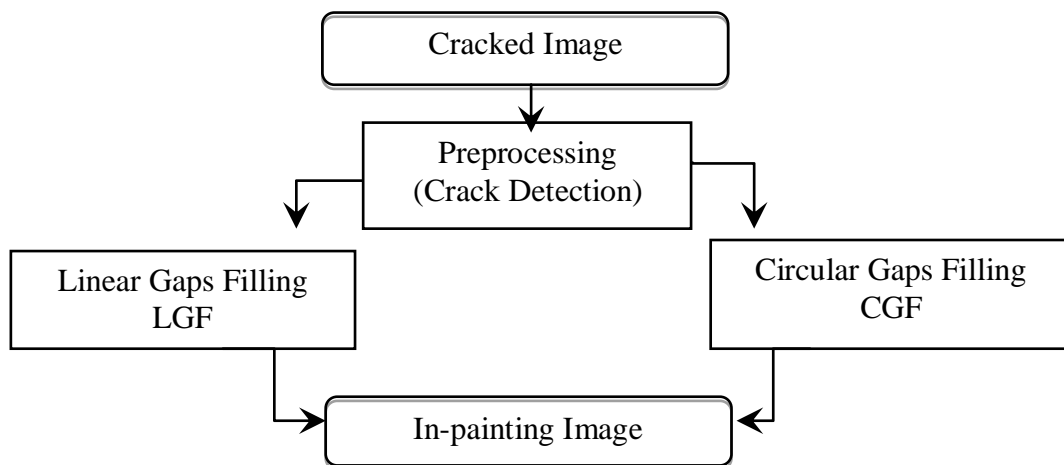
Figure 2- The block diagram of proposed system layout

4.1. The White Crack Detection

This phase is handled by the system initiation and mask, which is presented in Figure-3 and Algorithm (1), it requires the following steps: sharpening Image, convert color image to grayscale image, is grayscale image histogram equalization, is image morphology (Dilation gray level), image morphology (Erosion gray level) and gray scale image (binary conversion). After extracting the binary image (binary mask) the white pixel represents cracked pixel and black pixel represents a source pixel. The last operation of pre-processing is to mark the crack pixel with the black color to fill later.
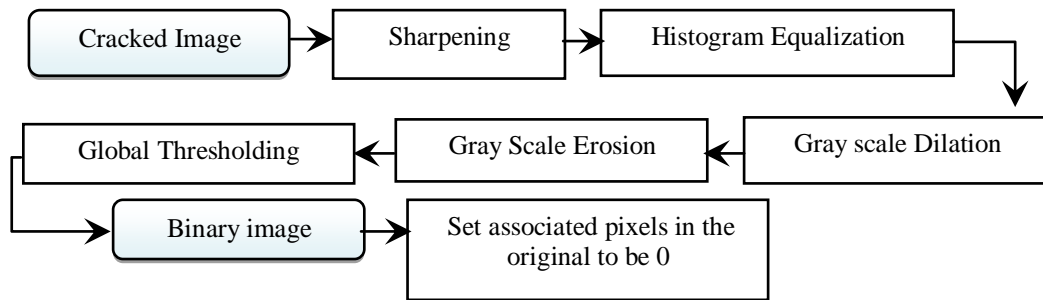
```
Cracked Image → Sharpening → Histogram Equalization
                                                    ↓
Global Thresholding ← Gray Scale Erosion ← Gray scale Dilation
        ↓
Binary image → Set associated pixels in the original to be 0
```

Figure 3- The block diagram of white crack detection step.

Algorithm (1): White Crake detection

Input: Crack colored image (RGB)
Output: Binary cracked image

Begin
  Step1:   Image sharpening using Laplacian filter (filter mask showed in figure (4))
  Step2:   Histogram equalization of the step1 output
  Step3:   Gray dilation of the step2 output
  Step7:   Gray erosion with defined structure element
  Step8:   Define threshold
  Step9:   Extract binary mask using defined threshold
Step10:   Put zero value (black) to crack pixel on crack image
End

0	-1	0
-1	5	-1
0	-1	0

Figure 4- Laplacian sharpening mask.

4.2 Linear Gaps Filling (LGF)

The first method of proposed system (Image In-painting System (IIS)). This method depends on the neighborhood pixels to fill the gaps. The quality of filling depends on the similarity of cracked pixel with the neighbors (mean of sources neighbors pixels). The general steps of this method are explained in algorithm (2). The method counts the cracked pixel in cracked image and to process them one by one until processing all pixels.

Algorithm (2): Linear Gaps Filling (first method)

Input: Crack Image, Binary Mask
Output: In-paint Image

Begin
Step1:   Count the number of crack pixel in the mask that equal to one (white pixel)

Step2:   Select (3,3) window for sliding on mask

Step3:   Slide the window on the mask until reach of crack pixel the center of window equal to one (white pixel)

Step4:   Find the no. of pixel that is not a crack pixel in the window(8 neighborhood)

Step5:   If (no. of Pixel more than 1) then find the average of these pixel in window to replace the center of window in original image (crack image)

Step6:   Put center of window equal to zero
             Reduce no. of cracked pixel by one

Step7:   Repeat step3 to step6 until no. of pixel equal to zero

Step8:   Save the process image
**Step9:**   End

4.3 Circular Gaps Filling (CGF)

The second method of the proposed system (Image In-painting System), this method depends on the neighboring pixels to fill the gaps. The differences in the first methods are that each position have the direction of the next pixel. The direction makes the filling of circular order. The quality of filling also depends on the similarity of cracked pixel with the neighbors. The general steps of this method are explained in algorithm (3). The method counts the cracked pixel in cracked image and try to process them one by one until processing all pixels.

|	
Algorithm (3): Circular Gaps Filling (second method)	
Input: Crack Image, Binary Mask	
Output: In-paint Image	
Begin	
Step1:	Count the number of crack pixel in the mask that equal to one (white pixel)
Step2:	Select (3,3) window for sliding on mask
Step3:	Slide the window on the mask until reach of crack pixel the center of window equal to one (white pixel)
Step4:	Move to the left neighborhood pixel and find tmpx and tmpy and set dr for each cases of tmpx and tmpy from 1 to 8
Step5:	If (no. of Pixel more than 1) then find the average of these pixel in window to replace the center of window in original image (crack image)
Step6:	Increment dr
	Put center of window equal to zero
	Reduce no. of cracked pixel by one
Step7:	If dr>8 then dr =1
Step8:	Repeat step3 to step7 until no. of pixel equal to zero
Step9:	Save the process image
Step10:	End

5. Experimental Results

The tested images are shown in Figure-1. They are most often used to display images. These all types may contain white cracks and the proposed system tries to retrieve the better values of cracked pixel. The second requirement is a software such as windows form application or visual studio (visual basic 6). The third requirement is hardware requirements for implementation of the proposed system and the same characteristic of personal computer (PC) such as Pentium four as a minimum requirement.

The proposed system implements different types of image (file types use in the proposed system in BMP, PNG, JPEG, PGM and GIF formats). Figure-5.b explains the two method implementation of the first image, Figure-5.c explains the two method implementation of the second image.

a.   Original cracked image   b.   Cracks detection/allocation   c.   in-paint image
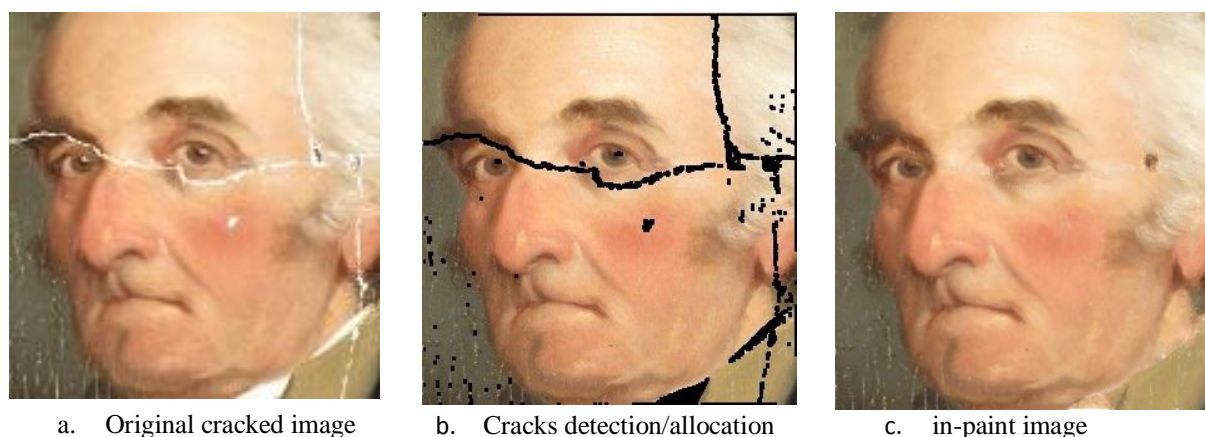
Figure 4- Crack detection
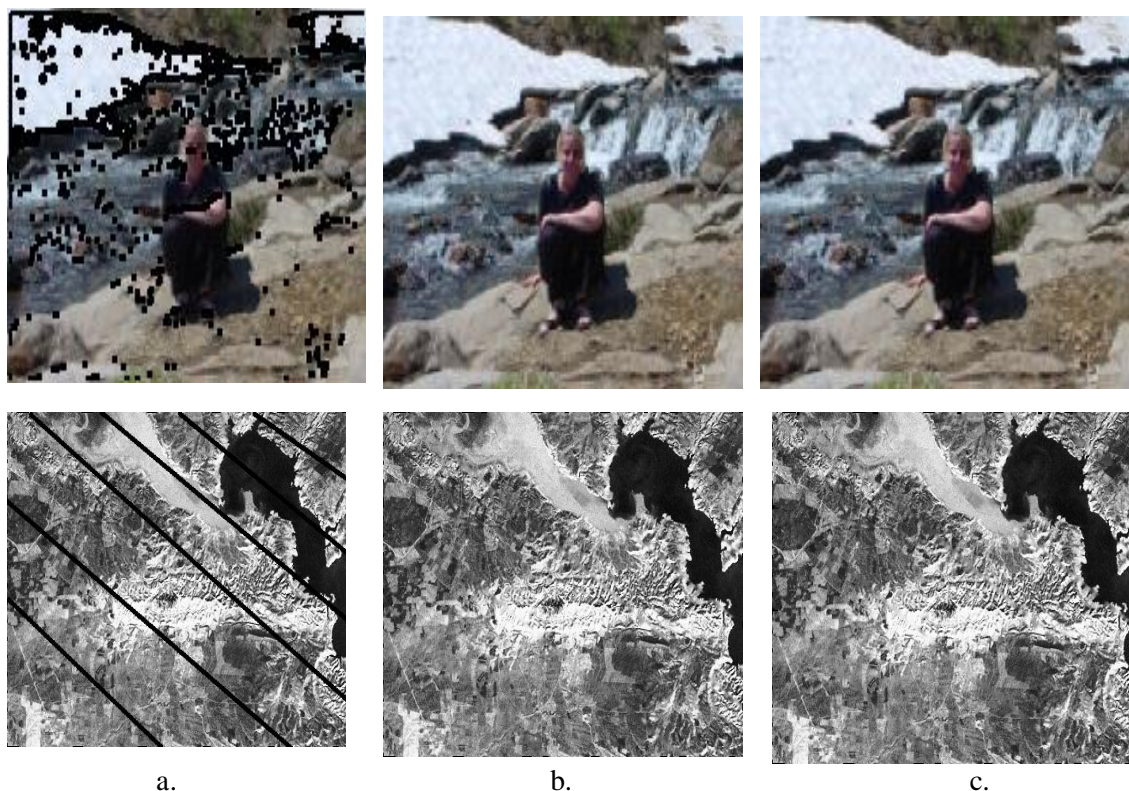
Figure 5- the implementation of proposed system on images
a. cracked image after crack detection   b. linear gap filling   c. circular gap filling

7.1 Mean Squared Error Test

MSE is the mean of the squared of the difference between the original image and degraded image. The difference occurs because of the in-painting images don't match the original images. The method to calculate MSE. Table-1 explains the implemented results of three images in the proposed system.

Table 1- The MSE of images in the proposed system

Tests Images		MSE		
		Original and Cracked Image	Linear Gap Filling	Circular Gap Filling
Original image 1	In-painting Image1	507.5162	66.5282	37.7214
Original image 2	In-painting Image2	772.93	90.212	77.293
Original image 3	In-painting Image3	1337.11	1256.21	1251.52

The results in Table-1 show that the values of MSE between the cracked image and the original image have high value and after image in-painting, these images of the MSE are reduced. The MSE values have different values depending on the kind of images, the satellites image (image 3) have high MSE values and these become reduced after image in-painting.

The PSNR of Images is the test that measures the degradation in images with respect to the original image. Table-2 explains the results with respect to the original images. The implementation of linear gap filling result less PSNR while the circular gap filling result.

Table 2- The PSNR of In-painting images with original images

Tests Images	Original and Cracked Image	Linear Gap Filling	Circular Gap Filling
image 1	21.076	29.934	32.109
image 2	19.249	20.251	23.013
image 3	16.869	24.899	27.783

The results in Table-2 show that the values are between the in-paint images and the original images. The method 2 (Circular Gap Filling) have better PSNR than method 1 (Linear Gap Filling).

6. Conclusions

The gap filling is related to size of gaps and the result enhanced when the gaps are of small size. The quality of filling depends on whether the techniques (linear gaps filling are less in more quality than circular gaps filling). As mentioned previously, the developing proposed methods need some enhancements to improve performance and to override some of the weaker aspects. Therefore, it is recommended that future work should be developed. There is an ability for using any of the two methods in video gaps filling with the same attribute. The ability to combine any of the two methods with the interpolation methods for gaps filling. Use of the methods in auto-correction in satellite image to enhanced the image. The proposed techniques are tested using MSE and PSNR of the filling technique with respect to the original images.

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