Detection And Discrimination Of Cracked Digitized Paintings Based On Image Processing Methodology

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***Abstract*— With the passage of time, paintings can be damaged, and common deteriorations found in ancient paintings include cracking. Cracks can be caused by many factors, such as ageing, drying, and mechanical factors. The detection and restoration of crack formation on the earliest digitized paint surface concede great significance and safety for cultural heritages. particular, this paper is based on image processing methodology to detect and discriminate cracks. First, images are enhanced in the preprocessing stage for further processing. Then two proposed algorithms are employed to detect and separate medium and thin crack images. The experiments show better results compared with previous work. This study also confirms that the proposed image processing algorithms are an efficient and robust tool for the detection and discrimination of cracks.**

Keywords—Detection, Discrimination, Cracked Paintings, Image Processing Methodology

I. Introduction

Technology has progressed exponentially in the past few decades. Every day, a huge amount of data is generated due to the rapidly increasing size of the digital storage space. Information could contain images or video sequences, as well as synthetic illustration diagrams, charts, or computer aided graphics. Many institutions, such as museums, libraries, galleries, and archives are digitizing their collections to simplify public access. Creating and maintaining the best possible environment for storing or displaying artefacts help prevent damages and increase longevity [1].

One of the most prevalent deteriorations in ancient master paintings is cracking, which is brought on by a variety of things such the materials' natural age. the shrinkage of the paint as a result of volatile paint component evaporation. Last but not least, the visual quality is harmed by external factors such as vibrations and impacts. and serves as a record of their degrading condition. Cracks are the common name for these patterns. The method of restoring a digitized painting image involves using image processing to restore the ancient paintings original appearance. Old artworks that have been digitally captured are restored using a variety of technology and methodologies [2].

The structure of this paper is as follows. The literature on detection techniques is covered in Section II. The suggested methodological design is described in Section III in depth, and the proposed algorithm is covered in Section IV. Section V shows the experimentations, while Section VI discuss their findings. and Section VII presents the concludes.

II. Literature Review

Researchers are currently creating new methods and algorithms for the goal of repairing damaged paintings, cracks can be automatically recognized and discriminates with the use of image processing techniques through the application of a number of cutting-edge algorithms.

Authors in [3] proposed a technique that uses spatial maps to investigate how to discriminate between painted and unpainted areas. To train and validate the suggested method, an inpainted image dataset produced using the exemplar-based image inpainting technique is used. A hybrid encoding-decoded architecture is suggested, using a section of the DenseNet-121 architecture as an encoder, and a convolution neural network-based model for the identification of inpainted regions.

In [4] a writers suggested a book Automatic weld picture segmentation using a semi-supervised Transfer learning based Multi-domain learning (ST-MDL) network. The suggested ST-MDL approach has been compared to six conventional segmentation models built on the U-net architecture. To determine and measure the weld porosity inside a weld image, the best performing model is used for semantic segmentation of weld images.

Authors in [5] introduce a study of the logarithmic entropy's operation time is discussed. Then the pair is

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replaced with the exponential entropy. Improvements are made to both the two-dimensional maximum entropy approach and numerical entropy. The information about the gray level of the four nearby pixels is combined utilizing the Otsu method. The experimental findings demonstrate that the method may efficiently reduce computation time, highlight edge characteristics, and improve the accuracy and robustness of threshold automatic selection.

Researchers in [6] Describe a dark image enhancing strategy that involves doing local pixel transformations. To obtain the desired histogram, they apply a transformation algorithm to various portions of the input image's histogram. The input image was then subjected to the histogram specification technique utilizing the altered histogram. The effectiveness of the suggested strategy has been assessed, and the results demonstrate that, when compared to the alternatives, the suggested method increases image quality with the fewest unanticipated artefacts.

Authors in [7] a sophisticated system capable of conducting quality control evaluations in an industrial manufacturing line. Using the transfer learning methodology, deep learning methods are used and successfully demonstrated in a real application for the inspection of welding flaws on a fuel injector manufacturing line [8]. The system is also set up to take advantage of fresh information that is gathered while in use, extending the current dataset and enhancing performance. The created system demonstrates that deep neural networks are capable of handling responsibilities for quality assessment that are typically assigned to people.

The researchers in [8] introduce five main printing technologies—FDM (Fused Deposition Modeling), SLA (Stereo Lithography Apparatus), DLP (Digital Light Processing), LCD (Liquid Crystal Display), and SLS (Selective Laser Sintering)—are used in the authors' methodology for processing the restoration of a Charter on the preservation of digital heritage. The missing piece of the digital legacy is then recreated using modeling software. The 3D fragment reconstruction is then finished, printed, and chromatically reintegrated. Different printing materials are utilized for testing in order to optimize this restoration procedure to produce the best aesthetic result similar to the appearance of the porcelain bowl.

III. THE METHODOLOGY

Fig. 1 illustrates the block diagram for the method of detection and discrimination of medium and thin cracks , which is includes several steps.

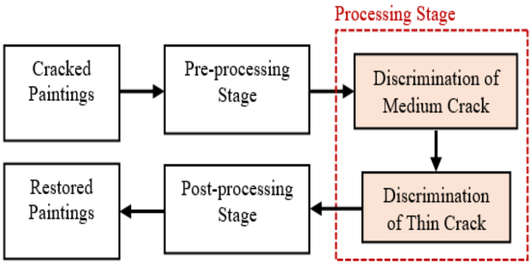

Fig.1. Crack detection separation medium and thin crack.

A. Cracked Paintings

From several sources, digitized paintings and manuscripts were obtained (shot with a digital camera at high resolutions), and the files were compressed to require less storage. Row photos typically aren't good candidates for detection and discrimination of cracks due to the noise-pixels that surroundings and undesired background. As a result, the preprocessing processes that follow include all of the necessary phases.

B. Pre-processing Stage

In the detection and restoration methods using color images, the pre-processing stage is crucial. These photos must be transformed into standard color formats, like a colored grayscale image. In order to build an image map. Noise during processing or transmission is the main cause of image data corruption. The noise may be removed or added. To retain the true image information and boost contrast, these sounds must be eliminated from the image. By selecting an ideal 3x3 window size that slides towered the image and can precisely identify the noise pixel that controls the outcome. The central pixel is recognized as the processing pixel.

C. Processing Stage

This stage is a critical one. Two steps make up its discrimination of medium cracks is step one and the thin cracks is step two. The current approach divided the image into two meaningful regions. It discriminates the crack from the obtained image set. Also, dark medium and thin cracks regions are observed and are expected to be obtained

D. Post-rocessing stage

The post-processing stage is the last step after detecting and classifying all of the image's fissures, which were filled with the color of their nearby pixels.

E. Restored Paintings

This module will restore the image's original appearance by removing the noise and unwanted cracks and after it has been damaged by mechanical and natural forces.

IV. PROPOSED ALGORITHMS

The goal of this study is to create a model that can detect and discriminates cracked digitized old paintings byn using image processing methods. Fig.2 illustrate the architecture of the proposed Algorithms. There are two main steps are involved in the processing stage which is discriminate of medium and the thin cracks. These algorithms are mostly used for historical paintings and have proven to be effective in classifying the cracked paintings.

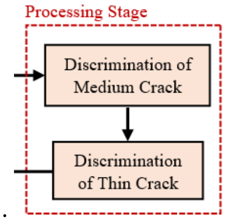

Fig.2. crack detection separation medium and thin crack

A. *Descrimination of Medium Crack*

The proposed algorithm process is a zero-value; the number of pixels represents the background of the image, and value one represents the fact that the object is enlarged, which is indicated in the background image. Threshold operation applied for cracks detection which is exploited as well as some other objects. Similarly, with a higher luminance pixel can be identified as a background. Therefore, the result of thresholding is binary image which is zero present black color and 255 present white color. A window size of 3x3 was selected to determine the medium scratch pixels values between greater than or equal to 111 and less than or equal to 121 pixels. It also fills the holes in persistent objects. The opening operation smooths the outline of an object, clears the narrow bridges, and eliminates minor extensions present in the object. However, the closing operation smooths the contour sections and blends little breaks and thin gaps. This helps the algorithm uncover medium-size patterns and fill gaps in the boundaries of the objects. The pseudocode for If. Else statements for separation of the medium cracks are:

Algorithm 1: applying proposed algorithm on gray scale image.

Input	**image map (medium crack)**
Output	**image map (discrimination of medium crack)**
Begin	
Step1:	ws=ones (3,3) %create window size
Step2:	% read the image. K=imread(“dilation.png”);
Step3:	% define the structuring element. SE=strel(‘disk’,5);
Step4:	% apply the separation of medium crack operation. D=imdilate(k,3x3);
Step5:	%display all the images. Imtool(k,[]); imtool(d,[]);
Step6:	% medium crack condition. im= 121 ≥ separation of medium crack≤ 111 displayimage; end

B. *Descrimination of Thin Crack*

The proposed morphological operations extract patterns from background images based on an efficient and mature method. The methodology of the proposed algorithm works by enlarging the number of pixels with a value of zero, representing the background of the image, and rendering the number of pixels the objects with values less than one which is devoted to the foreground. The proposed algorithm operation removes structures with a slight reduction in the size of the elements. A window size of 3x3 was selected to determine the thin scratch pixels value between less than or equal to 114 pixels and greater than or equal to 111 pixels. In binary, the operation of every image pixel has only two possible values. The number of neighbours considered depends on the size of the applied structural element.

Algorithm 2: applying proposed algorithm on gray scale image.

Input	image map (thin crack)
Output	image map (discrimination of thin crack)
Begin	
Step1:	ws=ones (3,3) %create window size
Step2:	% read the image. K=imread(“dilation.png”);
Step3:	% define the structuring element. SE=strel(‘disk’,5);
Step4:	% apply the separation of thin crack operation. N=imdilate(L,3x3);
Step5:	%display all the images. Imtool(k,[]); imtool(d,[]);
Step6:	% thin crack condition. im= 114 ≥ separation of thin crack≤ 111 displayimage; end

V. Experemental

The performance is done at three different algorithms Gabor, Nearest Neighborhood, and edge detection have been compared the results with the proposed algorithm in this experiment. The comparison is done by computing the MSE and PSNR of each image with respective to their corresponding ground truth images.

The PSNR measures the peak signal-to-noise ratio between the images. This ratio is often used as a quality measurement between the original and repaired image[2], and is defined in Eq.(1)[2].

$$PSNRf = 10\log 10(\frac{R}{MSE}) \quad (1)$$

Where Mean Square Error (MSE) is the most straightforward objective measure for evaluating image quality as shown in Eq.(2)[2][12].

$$MSE = \frac{1}{N}\sum_{i=1}^{N}(xi - yi)2 \quad (2)$$

VI. Results and Discussion

Table 1 shows the PSNR and MSE results of the proposed algorithm that discriminate medium cracked of nine old test images and compared with existing algorithms Gabor, Nearest Neighbourhood, Edge Detection. It can be observed from the numerical results that Gabor present highest average MSE. Whereas the proposed algorithm shows least average MSE among the three tested algorithms. On the other hand, the proposed algorithm presents the highest PSNR comparing to other three algorithms.

Tested Images	Gabor		Nearest Neighborhood		Edge Detection		Proposed Algorithm	
	MSE	*PSNR*	*MSE*	*PSNR*	*MSE*	*PSNR*	*MSE*	*PSNR*
Img1	2.684	33.25	3.681	38.12	3.988	29.14	0.981	87.82
Img2	2.461	34.21	3.462	36.74	3.726	41.24	0.721	84.22
Img3	2.468	33.24	3.298	35.74	3.601	40.41	0.652	84.19
Img4	2.465	29.22	2.311	31.27	3.513	33.42	0.357	83.15
Img5	2.437	19.28	2.911	20.27	3.371	23.11	0.479	82.17
Img6	2.397	16.93	2.744	17.34	3.153	23.51	0.275	75.23
Img7	2.371	14.22	2.601	19.45	2.881	20.56	0.913	73.26
Img8	2.085	13.25	2.382	11.25	2.618	13.27	0.783	74.28
Img9	1.736	11.12	2.136	12.14	2.406	11.14	0.518	71.14

Fig1 present the accuracy percentage of performance evaluation for nine cracked paintings had an of more than 97.67% as shows below It is important to note the proposed algorithm capable of detecting medium scratched comparing to existing algorithms.

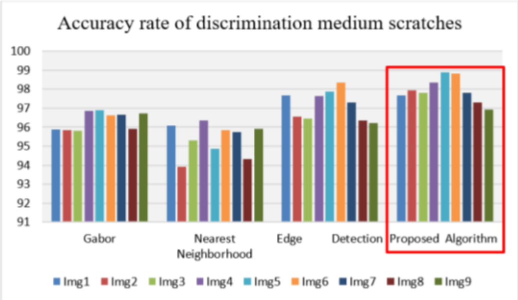

Fig.1 The accuracy rate of proposed algorithm comparing with the existing algorithms

The numerical results in table 2 reveal the discrimination of thin cracked of nine old test images then compared with three existing algorithms Gabor, Nearest Neighbourhood, and Edge Detection that expose upper average MSE values. Whereas the proposed algorithm has the lowest average MSE. Furthermore, the existing algorithms present highest PSNR besides the proposed algorithm shows lower PSNR values.

TABLE I. COMPARISION OF MSE AND PSNR OF DIFFERENT ALGORITHMS FOR DISCRIMENATION THIN CRACK

Tested Images	Hue and saturation		Region growing		Hit and miss clearing		Proposed Algorithm	
	MSE	*PSNR*	*MSE*	*PSNR*	*MSE*	*PSNR*	*MSE*	*PSNR*
Img1	22.27	25.53	24.01	27.23	25.99	29.45	21.81	39.25
Img2	21.64	29.18	26.85	31.41	23.44	34.24	21.69	39.33
Img3	19.37	20.41	24.61	31.42	22.52	35.12	21.46	38.91
Img4	16.92	29.33	22.17	32.27	21.76	35.423	20.99	36.52
Img5	14.27	24.12	21.01	27.34	20.39	29.15	19.88	31.72
Img6	11.85	13.33	19.39	14.53	18.23	19.51	17.69	24.32
Img7	15.69	12.23	16.66	14.15	15.05	16.23	14.18	18.62
Img8	13.92	13.21	12.45	14.17	11.68	15.41	11.39	16.82
Img9	11.52	13.68	11.55	12.68	12.36	11.41	12.33	12.25

Fig. 2 show the accuracy percentage of discrimination thine crack from nine old cracked images of more than 97.88%, comparing to the performance evaluation. It is clearly seen that the proposed algorithm shown the best result for discrimination thin crack as compare to existing algorithms.

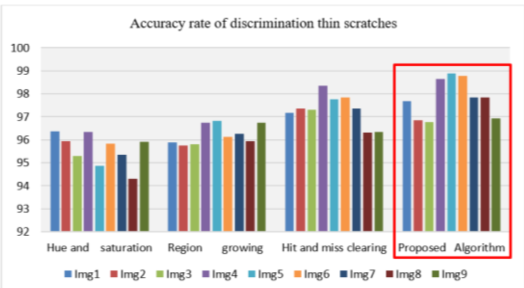

Fig.2 The accuracy rate of proposed algorithm comparing with the existing algorithms

VII. CONCLUSIONS

This paper present a proposed algorithm consists of three main stages for discrimination medium and thin crack. Where nine cracked digitized paintings where tested and measurements that used for evaluation are Mean Square Error and Peak Signal to Noise Ratio. Comparison with other literature algorithms done to evaluate the experimental results and to provide better outcomes. Which is considered the proposed algorithm is produce the highest accuracy rate around 97.67% in crack edge detection for medium scratches and approximately 97.88% for detection thin scratches that excellent relative to the value of other algorithms. Furthermore, one of the factors that affect the accuracy of the results is the processing of the data used in the discrimination task. The future scope will be to study the reason of discrimination crack from old painting and improve this proposed algorithm in a broader scope.

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REFERENCES

[1] S. P. Arun Mohan, "Crack detection using image processing: A critical," Alexandria Engineering Journal, vol. 57, no. 2, p. 12, 2018.

[2] I. F. T. A. S. Nawafil Abdulwahab Farajalla Ali, "Detection and Restoration of Cracked Digitized Paintings and Manuscripts using Image Processing - A Survey," International Journal on Perceptive and Cognitive Computing, vol. 3, no. 2, p. 6, 2017.

[3] T. M. Nitish Kumar, "Encoder–decoder-based CNN model for detection of object removal by image inpainting," Journal of Electronic Imaging, Vols. 32(4),, no. 042110, p. 11, 2023.

[4] C. F. a. Y. Z. a. Y. G. Dheeraj Dhruva Kumar a, "Semi-supervised transfer learning-based automatic weld defect detection and visual inspection," Engineering Structures, vol. 292, p. 116580, 2023.

[5] Y.-a. X. Rong Chen, "Threshold optimization selection of fast multimedia image segmentation processing based on Labview," Multimedia Tools and Applications, vol. 79, p. 9451–9467, 2019.

[6] S. R. M. M. R. S. M. K. M. A.-A. W. M. A. H. K. &. M. S. Khalid Hussain, "A histogram specification technique for dark image enhancement using a local transformation method," Transactions on Computer Vision and Applications, vol. 10, no. 3, p. 15, 2018.

[7] P. Sassi, P. Tripicchio and C. A. Avizzano, "A Smart Monitoring System for Automatic Welding Defect Detection," Transactions on Industrial Electronics, vol. 66, no. 12, pp. 9641 - 9650, 2019.

[8] E. A.-C. E. N. D. Y. Zhou, "3D PRINTING TECHNOLOGY AND ITS APPLICATION IN THE CONSERVATION AND RESTORATION OF PORCELAIN," Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, p. 7, 2023.

[9] S. Athar and Z. Wang, "A Comprehensive Performance Evaluation of Image Quality Assessment Algorithms," IEEE Access, vol. 7, no. 2169-3536, pp. 140030 - 140070, 2019.

[10] I. A. S. Nawafil Abdulwahab, "A Proposed De-noising Algorithm," International Journal on Perceptive and Cognitive Computing , vol. 6, no. 2, p. 7, 2020.

[11] "Image De-noising Techniques: A Comparative Study," Journal of Advanced Computer Science and Technology Research, vol. 10, no. 2, p. 8, 2020.

[12] P. Wojciechowski, "Detection of Critical Infrastructure Elements Damage with Drones," 10th International Workshop on Metrology for AeroSpace (MetroAeroSpace), pp. 341-345, 2023.