

# Detection and Removal of Cracks in Digitized Frescoes using Neighboring Transfer Technique

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**Abstract**— Ancient frescoes are important art heritage. Cracking is one of the most prominent impairments found in wall paintings. This research introduces a computer-aided automatic repair system for crack detection and removal. The framework can be separated into crack detecting procedure and pixel transfer-based inpainting. In the crack detection process, thresholding-based segmentation and morphological based operations are performed and the result is the mask image that indicates the locations of cracks. After that, crack removal stage is processed by our neighboring pixel transfer method. This research paper is experimented on the Myanmar mural painting of Po-Win-Daung (A.D. 1301 – 1800) and Kyauktawgyi (A.D. 1801 - 1900). The experiment shows that the proposed method for crack detection and restoration is effective for our ancient frescoes' dataset.

**Keywords**— Crack Detection, Ancient Frescoes, Inpainting, Neighboring Pixel Transfer method, Image Processing

## I. INTRODUCTION

The murals are original documents from the ancient time, therefore information about history can be learned. Mural paintings can be observed on several pagodas in Myanmar. However, some of the temples have nearly been completely destroyed, and the interior walls of the temples have suffered severe deterioration. One of the most prominent forms of deterioration found in ancient murals is cracking. The primary objective of the proposed work is to develop a restoration strategy that's capable of effectively preserve our historical murals from Myanmar.

## II. RELATED WORKS

J. Salinee et al. [1] proposes a computer aided semi-automatic repair framework to detect and restore cracks from Thailand frescoes. The framework consists of two procedures, scratch detection procedure and model optimization based inpainting procedure. Users have to give a small number of seed points for region growing method and morphological operation are utilized to find out the scratches from image. After that different variational methods are used for inpainting process. The paper shows that LBM inpainting method performs more effective than other methods when the image is not complex.

Abdulwahab et al. [2] develops the proposed work for the detection of small patterns and preservation of cracks in digitized old painting. Crack identification is accomplished through the use of morphology and thresholding operation. For the separation of actual cracks and mistakenly recognized strokes, region growing is applied. For the restoration approach, median filter and weighted median approaches are utilized. Results show that for images with very dark regions,

the crack identification procedure is not particularly effective since the image's intensity values become similar causing crack detection impossible.

Cornelis B et al. [3] suggests a novel technique for virtually restoring gaps in digitized paintings by crack detection and removal. Three new detection techniques are integrated to identify cracks with various sizes and brightness. Objects that were incorrectly labeled as cracks are removed using semi-supervised clustering for post-processing. A patch-based technique is used for the subsequent inpainting stage to deal with the noisy character of the images and to enhance crack elimination performance..

## III. DATASET

Myanmar's ancient paintings originated in 11th century, Bagan period and developed very well in different periods. A different kind of heritage in the country's suburban areas can be found, including Po-Win-Daung in the 14th to 18th centuries, and Kyauk Taw Kyi Pagodas in the late 18th century [4]. Ancient murals from Po-Win-Daung and Kyauktawgyi are shown in Fig. 1.

### A. Po-Win-Daung (AD 1301 ~ 1800)

Po-Win-Daung is a location where Myanmar's artistic culture and historic landscape are preserved. One can find more than 900 man-made caves with some of the best-preserved Buddhist mural paintings from the 14th to the 18th centuries.

### B. Taung Ta Man Kyauktawgyi (AD 1801 ~ 1900)

Among the beautiful paintings that have been created on the interiors of historic temples around Myanmar, the paintings from Amarapura were particularly prominent among researchers. In the temple, the walls and ceilings of the four halls are covered with paintings which highlight the story of Bagan Min's benevolence to religion.



Fig. 1. Ancient Wall Paintings from Dataset

#### IV. PROPOSED SYSTEM

Existing solutions from the literature have shown to be insufficient for these images due to the complex texture and heterogeneous nature. The proposed system is divided into two groups: crack detection and crack removal.

##### A. Crack Detection

Detecting cracks in complicated texture images are very challenging. Applying spatial filtering rather than contrast adjustments is more suitable for the crack detection process. Therefore, an approach to reduce noise is applying non-linear spatial median filtering because it removes smaller details while preserving the stronger edges. In order to improve the thresholding process, image smoothing process is applied beforehand. For thresholding, Global thresholding is used to segment images into foreground and background images.

$$g(x,y) = \begin{cases} 1, & \text{if } f(x,y) > T \text{ (foreground)} \\ 0, & \text{if } f(x,y) \leq T \text{ (background)} \end{cases} \quad (1)$$

Where  $g(x,y)$  is the thresholding output image,  $T$  is the global thresholding value, and  $f(x,y)$  is the input image.

Fixing and refining the imperfections of segmented results (masks) are done with morphological processing. After analyzing the nature of crack, region properties of Bounding Box, Eccentricity, Major Axis and Minor Axis Length are used to highlight the region of interest (crack).

##### B. Crack Removal

For the crack removal, pixel neighboring transfer approach is used. This approach fills the cracks by copying from their neighboring regions like a patch-based approach. In Patch-based method, it tries to find the candidate patch that is similar with the target region. Unlike patch-based method, pixel neighboring transfer approach uses only neighboring pixels, no need to find the similar patch in the whole image. So, the time of the searching the similar patch is reduced. The general form of the neighboring pixel transfer equation can be written as:

$$I'(x,y) = I(x+i,y+j) \quad (2)$$

Where  $I'(x,y)$  is the inpainted value of the pixel at position  $(x,y)$  and  $I(x+i,y+j)$  represents the neighboring pixels around  $(x,y)$ .

#### V. EXPERIMENTAL RESULTS

The experiments show that applying only the morphological operations is not suitable for Myanmar frescoes because Myanmar painting has many brush strokes and has low luminance properties as the same as the cracks. Therefore, we applied the crack detection method to extract cracks from Myanmar painting images. The original image with crack is shown in Fig. 1 (a). In order to improve the crack detection process, pre-processing step is needed. It is to be known that ancient murals are complicated in both structure and texture, therefore spatial median filtering is pre-processed in order to remove smaller details while preserving the stronger edges. The resultant image is illustrated in Fig. 1 (b). From the image, it can be seen that edges are stronger than the original image and it can support for crack segmentation step.

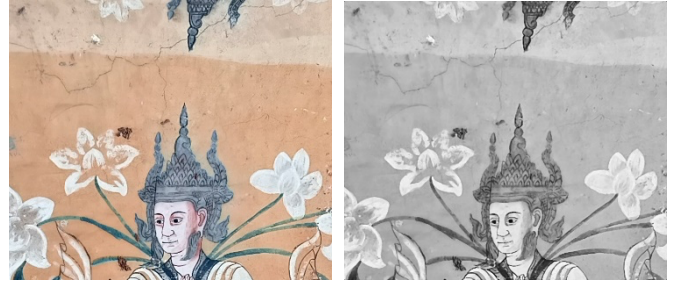
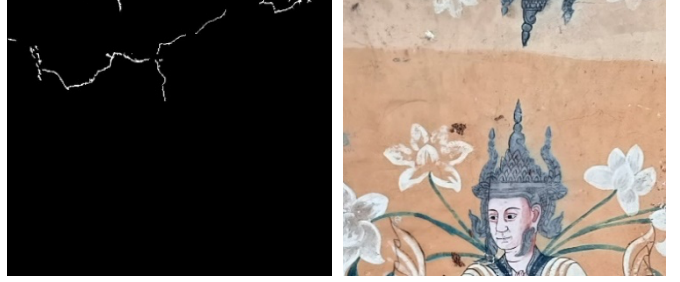


Fig. 1. (a) Original Image

(b) Filtered Image



(c) Mask Image

(d) Restored Image After Crack Removal

The output of the crack detection process is the binary mask that indicates which parts of the image need to be filled or inpainted. The crack detection is processed mainly upon the Global thresholding. And the experiments shows that it is still challenging problem because of their uniqueness in color, structures and so on. The output of the thresholding method include brush strokes that are misclassified as cracks. Therefore, to get the final mask image, morphological processing and region properties are used to classify the cracks from the other noises. Fig. 1 (c) shows the final refine mask image of the crack detection stage. The result image of the crack removal process is illustrated in Fig. 1 (d). The result image shows that although the pixel neighboring transfer approach is simple to implement, it can also give the outstanding result in inpainting background of the image which are coherent. And it shows that the pixel neighboring transfer method can achieve great visual result in the restoration of cracks.

In this paper, the performance of the crack detection stage is measured by comparing with the region growing method proposed by J. Salinee et al. [1]. The result images are compared in Fig. 2. The region growing method is the semi-automatic approach that users need to specify the seed points to get the accurate result. Our proposed framework is the automatic approach that do not need user interaction. In the comparison, there is no significant different in the two images. But the region growing method can give the more accurate result because it needs user interaction to get the great result. In compare with, although the proposed crack detection method is the automatic method that is based on thresholding and region properties, it can also give the good result that can approximately detect the damaged cracks regions of the image.

As the limitation, the crack removal method is good when cracks are found in homogeneous regions. For heterogeneous regions, it is difficult to blend.

For the further study, the older murals that are created in Bagan period (AD1044 – 1287) will be further analyzed and

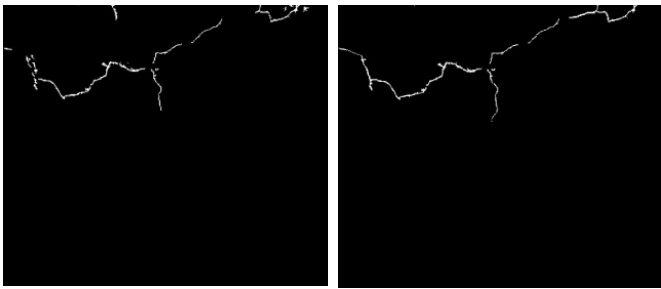


Fig. 2. (a) Proposed System (b) Region Growing

compared the damage rate. Besides the cracks, other degradation types that are found in murals will be restored in the future research work.

## VI. CONCLUSION

Digitized murals have noises that can vary the resulting image, therefore non-linear spatial median filtering is applied in order to remove noises. After analyzing the pixel values, the nature of the crack is elongated, small region, narrow and long. Therefore, the proposed pixel transfer method can give the outstanding result in the removal of cracks. In the later study, the old murals around AD 1000 that are more ancient and degraded will be analyzed and experimented. The mural paintings are invaluable cultural treasures that portray the history of successive era. Hence, the ancient frescoes should be kept in a state of good preservation.

## REFERENCES

- [1] Salinee Jaidilert, & Ghulam Farooque, "Crack Detection and Images Inpainting Method for Thai Mural Painting Images", 2018. <https://doi.org/10.1109/icivc.2018.8492735>.
- [2] Abdulwahab Farajalla Ali, N., Fakhri Taha Al-Shaikhli, I., & Hasan, R. "Detection and Restoration of Cracked Digitized Paintings and Manuscripts Using Image Processing", *International Journal of Engineering & Technology*, 7(2.34), 39, June 2018. <https://doi.org/10.14419/ijet.v7i2.34.13907>
- [3] Cornelis B., Ružić T., Gezels, E Dooms, A., Pižurica, A., Platiša, L., Cornelis, J., Martens, M., De Mey, M., & Daubechies, I, "Crack detection and inpainting for virtual restoration of paintings: The case of the Ghent Altarpiece", *Signal Processing*, 93(3), 605–619, March 2013. <https://doi.org/10.1016/j.sigpro.2012.07.022>.
- [4] Thu Maung, W. T. (n.d.). "A STUDY ON MURAL PAINTINGS IN THE SAKU (SAGU)AREA". Academia.edu. November 2019
- [5] Buddhas and Murals at the Po Win Caves, Monywa. (n.d). <https://www.photodharma.net/Myanmar/Po-Win-Daung/Po-Win-Daung.htm>
- [6] [https://www.tripadvisor.com/sg/Attraction-Review-g641717-d2668545/Reviews-Phowintaung-Monywa\\_Sagaing\\_Region.html](https://www.tripadvisor.com/sg/Attraction-Review-g641717-d2668545/Reviews-Phowintaung-Monywa_Sagaing_Region.html)