A Review on Digital Image Reestablishment Techniques for Improving the Quality of Old Paintings

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***Abstract*: This Old paintings usually suffer from breaks in the substrate, the paint, or the varnish. These patterns or breaks which appear on the painting are usually called as cracks. These cracks are caused by aging, drying and other mechanical factors. The appearance of cracks on painting deteriorates the perceived paintings quality as well as it also questions authenticity of the painting. To improve the quality of such paintings the digital image processing techniques can be used. With the application of efficient image processing methods, the cracks on the digitized paintings can be detected and eliminated to considerable level. In this paper, various image processing methods are reviewed and presented in brief. Also, the approach using top hat transform, gabor wavelet and watershed transform for crack detection is explained.**

***Index Terms*: *digitized painting, craquelure, restoration, top hat transform, etc*.**

I. INTRODUCTION

In today's world, where everyday there is new advancement in the field of technology as well as new ideas are continuously evolving the advancement in the digitally equipped environment. Storage and retrieval of digital information is now possible at phenomenal speed, almost unimaginable just a decade ago. Information may contain pictorial data such as images or video sequences, as well as synthetic illustrations, diagrams, charts or computer aided graphics. Following a revolutionary trend, museums and art galleries are beginning to digitize their collections, not just to make them publicly available on the web, but also for internal use within the museums' or galleries' own environment. Digitizing the collection means providing a faster and more efficient way of recording what is available, thus giving a new dimension to methods of information retrieval within the environment itself. Instead of storing the information in a traditional manner, the ability to store it digitally opened the path for further manipulation of the technology, where digital preservation and restoration can play their part. Many paintings and artifacts were created centuries ago and are in need of preservation and restoration, to make sure that their physical appearance is maintained. Manual recording and detection of aging seem less efficient, given the increasing number of collections and electronic based approaches seems to be the best choice. Different types of materials are used for paintings and frames. For this use varnish, paint, glue, canvas, wood, metal, gilding and plaster. When both are used then it produces complex structure which can be easily damaged if knocked or dropped. Materials are damaged by different surrounding materials and they are also sensitive too. When there are changes in the heat and humidity then it changes appearance of images. Also when there is a change in environmental conditions then they also produce changes in the paintings and frames. Light and dirt also produce change in images [1]. Many paintings, especially old ones, suffer from breaks in the substrate, the paint, or the varnish. These patterns are usually called cracks or craquelure. These are produces due to no. of reasons like aging, drying, and mechanical factors. Age cracks can result from nonuniform contraction in the canvas or wood-panel support of the painting, which stresses the layers of the painting. Drying cracks are usually caused by the evaporation of volatile paint components and the consequent shrinkage of the paint. Finally, mechanical cracks result from painting deformations due to external causes, e.g. vibrations and impacts. So appearance of image get decreases image quality get reduces. The appearance of cracks on paintings deteriorates the perceived image quality [2]. So solution for this one can use digital image processing technique can be used in this process. Image processing techniques have recently been applied to analysis, preservation and restoration of artwork. Old paintings are cultural assets for country which can be preserved by computer aided analysis and processing. Digital image processing techniques used to detect and eliminate the cracks on digitized paintings. So this type of processing images are used in museum, provide clues to art historians, and the general public on how the painting would look like in its initial state, i.e., without the cracks. Furthermore, it can be used as a non-destructive tool for the planning of the actual restoration.

II. LITERATURE REVIEW

Pappas, .M, & Pitas, .I presented a paper "Digital color restoration of old paintings" [3]. This paper presented techniques for restoration of color of old wall paintings. The appearance of old wall paintings degraded due to the physical and chemical changes. Chemically, the colored regions of wall paintings were cleaned up and then patches of digital images are digitized. The main aim of this paper was to find out the color from sample images then apply the color transformation on entire image. Visual appearance of actual wall painting is estimated by using different techniques without chemical clean up treatments. For this purpose, the five color restoration methods (Mean sample matching, White point transformation, ICP approximation, linear approximation, and RBF approximation) which simulate the actual appearance of wall paintings. Different types of digital restoration techniques were used to recover the actual appearance of old wall paintings, small chemical processing of its surfaces. In this paper the best results were obtained by white point transformation and linear approximation but all methods have small computational requirements.

The authors in [4], presented three applications of digital image processing. First was crack restoration. Second was the restoration of color and third was mosaicing of images which are partial. Linear approximation and the white point transformation methods were

used for color restoration of old wall paintings. Linear approximation was used for the effective choice of transformation function. In white point transformation the object under different lighting conditions look different and the dirty samples was obtained easily. In this database management system was introduced which was helpful for achieving and classification of paintings. Crack detection was done by morphological top- hat transformation. The thresholding operation was used to eliminate cracks from background. Crack filling was done by applying the median filters.

In [5], author introduced a technique in which the wall painting excavated in fragments then fragments was photographed. The image of fragments introduced to computer then its contours was obtained. After that the fragments contours was compared to proposed technique. The authors define a approach which extract maximum information from the contours of fragmented parts to achieve the estimation of initial image. In this paper, a novel general methodology was introduced for the computer-aided reconstruction of the impressive wall paintings of the Greek island Thera (Santorini), that were painted in the middle of the second millennium B.C. These wall paintings have been excavated in fragments, and as a result, their reconstruction may be a scrupulous and a long process. Therefore, in order to facilitate and expedite this method, a proper system has been developed based on the introduced methodology. According to this technique, every fragment is photographed, its image is introduced to the computer, its contour is obtained, and, later on, all of the fragments contours are compared in a manner proposed herein.

The aim of the paper presented in [6] was to introduce a methodology to determine whether a handmade shape fitted into given geometrical prototype. To achieve that three mathematical criteria are introduced, two of them being of statistical in nature and another one is based on fuzzy logic. In this paper the methodology was introduced together with a set of original criteria to show the specific shape in a painting that has probably been drawn by using geometrical method. Pattern recognition methods and related criteria were introduced in this paper. It employed thus far only on the tharan wall paintings which can be applied to any painted shape. The main aim of this paper was to determine the geometrical shapes or curves, which adjust a given equation in paintings.[7]

In [8], the authors presented an integrated strategy for crack detection and filling in digitized paintings. An integrated methodology for the detection and removal of cracks on digitized paintings is presented in this paper. The cracks are detected by thresholding the output of the morphological top-hat transform. Afterward, the thin dark brush strokes which have been misidentified as cracks are removed using either a median radial basis function neural network on hue and saturation data or a semi-automatic procedure based on region growing. Finally, crack filling using order statistics filters or controlled anisotropic diffusion is performed. The methodology has been shown to perform very well on digitized paintings suffering from cracks. The methodology has been applied for the virtual restoration of images and was found very effective by restoration experts. However, there are certain aspects of the proposed methodology that can be further improved.

In [9], image segmentation and pattern analysis was used for the reconstruction of wall paintings. They used color image segmentation method to decay many problems which provide the good estimation of initial fragments which were depicted. For reconstruction of wall paintings, pattern matching techniques were used. The wall paintings typically reconstructed from the thousands of fragments which are scattered within excavated sites. In fragments of wall paintings, many depictions are occur which manifests non uniform color decay and cracks. Sometimes extraneous material is also added in fragments of wall paintings. The image segmentation technique is used which provide the good approximation of depiction of fragments. This technique defines the color region and region border of depicted fragments.

In [10], several methods have been proposed for detection and removal of cracks in digitized paintings. Cracks not only deteriorate the quality of painting but also question its authenticity. In this paper, a morphological methodology (MAO) is proposed which is a variant of recently published morphological methods to identify cracks. After detecting cracks, a modified adaptive median filter (MAMF) is used to fill the cracks. The order of the median filter to be applied on crack pixels is computed on the basis of the number of crack pixels in its neighborhood. This methodology of detection and elimination of cracks in digitized paintings is shown to be very effective in preserving the edges also.

In [11], authors mainly discusses scale invariance at three aspects of essence, representation and application. a natural image always contains the same contents of different scales and dually the same contents of same scale exist throughout scales of the image. GMM based scale invariance model was used into the proposed image restoration algorithm. In this algorithm, natural image scale invariance and nonlocal self-similarity were utilized simultaneously. More specifically, multi-scale similar patches were searched, adjusted by GMM and then 3-D transformed. In regularization based framework, local total variation regularizer and nonlocal adaptive 3-D scale invariant sparse representation regularizer are introduced into the minimization function. Experimental results show that the proposed algorithm achieves more significant performance than the current state-of-the-art schemes.

In [12], authors implemented an integrated system which restores missing parts of various sizes and shapes that appear in Theran wall paintings. In this, the missing area was stitched by applying the seamless image stitching algorithm and the total variation inpainting was used for area extraction and repair. The non-local inpainting mechanism was used for elimination of minor defects on the retrieved parts. The graph cuts were used for missing area with complicated boundaries. In this paper, the authors proposed an integrated system that restores missing parts of assorted shapes and sizes that seem in Theran wall paintings. At first, a mathematical morphology algorithm was used that additionally incorporates edge information for detecting missing areas.

III. Summary And Discussion

After studying the various techniques of wall painting re-establishment, it is found that there are various problems in the existing techniques. Different types of digital restoration techniques were used to recover the actual appearance of old wall paintings, small chemical processing of its surfaces. The use of chemical processing is very critical process. Most of the approached used to fragment the wall paintings. Making fragments of wall painting is quite a long, time consuming and difficult task. Morphological algorithm detects only the cracks and missing area in the wall painting. For filling the cracks, different methods to be used which also takes time. To overcome these limitations a new algorithms need to be introduced which are fast and accurate to detect the cracks without fragmenting the wall painting. So the quality of the wall painting images can be improved. For more improvement in the quality of digital wall painting, another deformity need to be considered which can be improved by increasing the contrast and saturation.

IV. Proposed Approach

In the proposed system, the digital images older paintings are collected and stored in JPEG format.

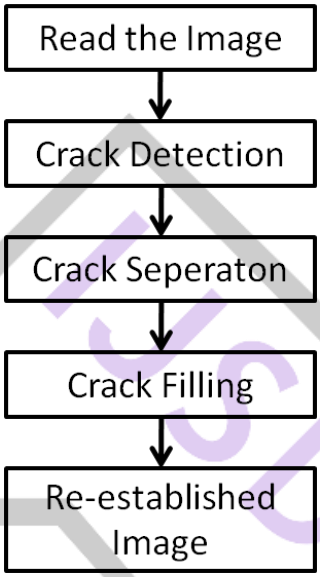

Fig. 4.2 Block Diagram of Proposed System

All the processing will be done on this stored image for the re-establishment and improvement in the appearance of the images. For the processing various image processing techniques will be applied and the modified output image will be obtained. Firstly, the image in the JPEG format will be read and made available in the form of RGB image matrix with the MATLAB. Then, three different crack detection methods will be applied to the available image matrix namely Multiscale Top Hat Transform, Watershed Transform and Gabor Filters. The cracks detected by the above mentioned approaches consists of all types edges in the image including the desired cracks and inconsistencies. Then, with the help of proper thresholding algorithms the exact cracks are extracted removing the edges belonging to the art in the images. Then, either the best results of detected crack map or the fusion of the crack map obtained by all three methods can be used to obtain the improved crack map of the image. This crack map now contains the cracks as well as brush strokes. The information about the brush strokes need to be removed from the crack map. This is done with the help of the classifiers such as Gaussian or Neural Network. After separation of crack and brush strokes, now the crack map will have the pixels belonging to desired cracks only. Now, this cracks need to be interpolated with the neighboring pixels to make the image more smooth and uniform and to provide the crack free-established image.

V. Conclusion

In this paper, detailed survey of literature related to Improving Quality of Older Paintings using Digital Image Re-establishment Techniques has been done and presented along with their merits and demerits.

Most of the work used the morphological operation for finding the cracks and used the filters to fill the cracks by the surrounding pixels. But such operations are not sufficient to re-establish the good quality of the paintings. Hence, in the proposed approach the combination of Mustiscale Top Hat Transform, Gabor Filters and Watershed algorithm is used to find the exact crack pixels and then used various filters to fill the cracks which will enhance the quality of the painting.

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