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Detection and Removal of Cracks from Digital Painting

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***Abstract**: Image inpainting is the process of restoring the lost or damaged regions of a digital image. Many paintings, especially old ones, suffer from breaks in the substrate, the paint, or the varnish .In this paper, a technique for detection and removal of cracks from digitized paintings has been proposed .At first, cracks has been detected from the digital images .In the next step the brush strokes that are misclassified as cracks has been separated. Finally, cracks have been filled to get the crack free final image*.
Keywords- Digital paintings, crack detection, crack filling, brush strokes,Top-hat transform, crack restoration

I. INTRODUCTION

Image processing methods have recently been applied to analysis, preservation and restoration of of digital arts [1]. Digital image restoration can be done by using computer aided analysis and processing. Image restoration has become a very common practice. For example, we can remove the cracks from a digitized painting, visualize the effect of using different varnishes, and discover patterns that would otherwise remain unnoticed or facilitate detection of forgeries. Many paintings may suffer from breaks in the paint, varnish or substrate. The most common deteriorations in old paintings is the cracking of the paint layers. arising inevitably with aging of the material[2]. This may happen due to many factors, from mechanical stress exposure to climate changes such as variations in temperature and humidity or pressurization (e.g., during air transport). Age cracks can happen from no uniform contraction in the canvas or wood-panel support of the painting, which stresses the layers of the painting [3].Drying cracks, occurs by the evaporation of volatile paint components and the consequent shrinkage of the painting .The presence of cracks on paintings deteriorates the perceived image quality. Analysis of crack patterns can help preventing / reducing further degradations. We can use digital image processing techniques to detect and eliminate the cracks on digitized paintings. Restoration can provide clues to art historians, museum curators and the general public on how the painting would look like in its initial state, i.e., without the cracks. Also, it can be used as a non destructive tool for the planning of the actual restoration. The user can manually select a point on each crack to be restored. [12]Other research areas that are closely related to crack removal include image in painting which deals with the reconstruction of missing or damaged image areas by filling in information from the neighbouring areas i.e., recovery of object parts that are hidden behind other objects within an image.

So this type of processing 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 [2].

The technique consists of following stages.

Crack detection
Crack Classification
Crack filling

II. LITERATURE SURVEY

El-Youssef, Mouhanned [4]in his literature proposed the development of a framework for the geographical analysis of craquelure patterns. His work needs to expand on these results the intention of increasing the accuracy with rate in the classification of craquelure to their corresponding geographical origins. For the extraction of the craquelure patterns he has compared the three different thresholding methods that have been attempted and tested in his thesis. The thresholding techniques he tested were Global thresholding, segmented thresholding and offset thresholding. Out of these three techniques the offset method was deemed to be the most accurate technique. The feature extraction phase is arguably the most important phase in his thesis. The features extracted dictate how accurate the classification of the samples will be.

Volume 4 Issue VI, June 2016
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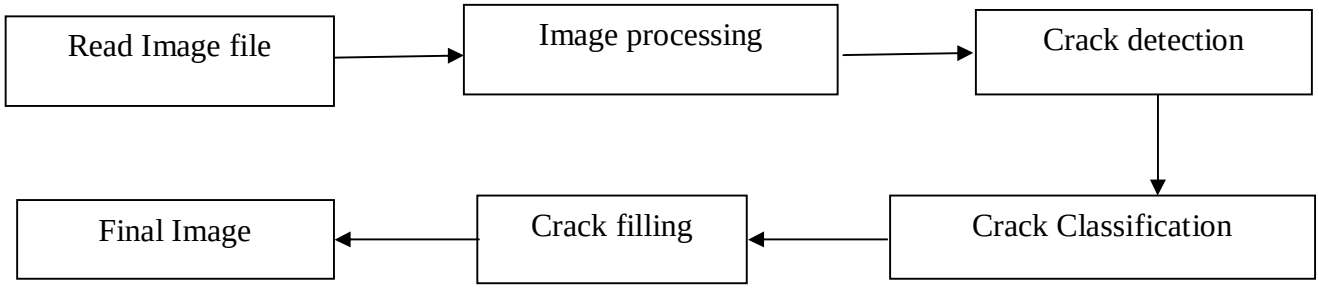
Guillermo Sapiro [8] suggested an Image Inpainting technique to fix the damage of the arts. Applications of image in painting range from the removal of an object from a scene to the retouching of a damaged painting or photograph. The basic goal is to produce a modified image in which the in painted region is merged into the image so seamlessly that a typical viewer is not aware that any modification has occurred.

G Schirripa Spagnolo, F Somma [9] explained the cracks are detected by thresholding the output of the morphological top-hat transform. Afterwards, the thin dark brush strokes which have been misidentified as cracks are removed using automatic procedure. Finally, crack filling using texture synthesis algorithms.

III. PROPOSED METHOD

The central idea of proposed work is same as the painters use for restoration of old cracked paintings. First of all they find cracks and then fill them with colors by most appropriate color information available. They do the whole painting for more visually pleasing result. In this work, firstly identification of the cracks is done and then fills them by the using improved exemplar based inpainting. This is some kind of Image processing with retouching or we can say repairing the images .In the proposed system detection method is employed which contains multi-scale morphology and then for filling or restore the image the improved exemplar based inpainting method.

The concept used in this is image processing techniques for analysis, preservation and restoration of artwork. The method proposed for detection and removal of cracks can be applied to remove scratches and other artifacts from any kind of image.

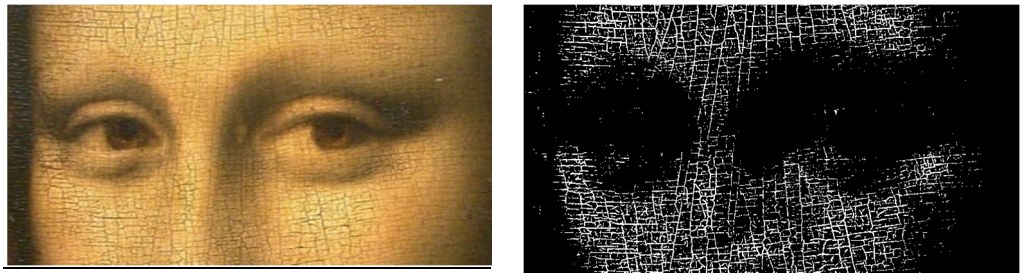


Block diagram of crack detection and removal process

A. Cracks detection

Cracks are the low luminance component of the image, that is, the dark details in the bright background. Therefore they can be considered as the local intensity minima and elongated structures. A crack detector can be applied on the luminance component of an image and should be able to identify such minima was presented in the image. The detection of the cracks can be done with the implementation of morphological filter.

Here we have used Black-Hat morphological transformation which includes the difference of closing of the source image and the source image itself. Two basic operations Dilation and Erosion has been used. So, after applying black hat transformation technique on our cracked picture we get.



(a) (b)

Fig 1: (a) Original Image with cracks , (b) Image after Black- Hat Transformation

Volume 4 Issue VI, June 2016
ISSN: 2321-9653
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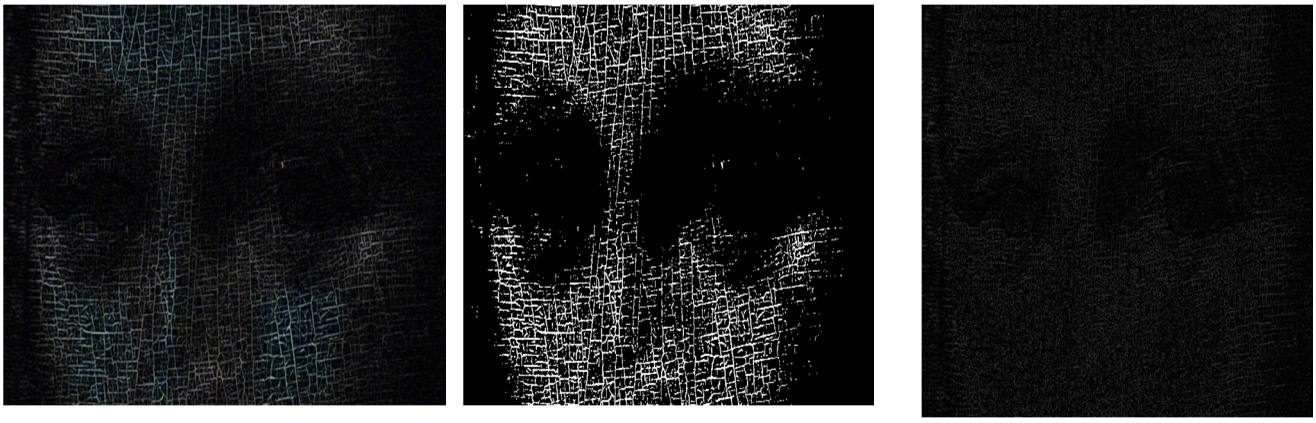
B. Crack Classification

In some paintings, certain areas exist where brush strokes have almost the same thickness and luminance features as cracks. For example hairs of a person in a portrait could be such an area. Thus, in order to avoid these undesirable alterations to the original paintings, it is very important to separate these brush strokes from the actual cracks, before implementing crack filling procedure. There are several crack classification procedures that are needed to discuss.

We have used Selective thresholding operation to differentiate the crack from the thin brush stroke. This method works on grey scale images. so we have to convert the picture in to grey scale before applying the process. This method works with the intensity value of the pixel which start from 0 and ends in 255. After several attempt I have found that the intensity value of brush strokes ranges 0 to 50. And the higher intensity values are taken as crack.

Here thresholding operation has been used to differentiate cracks from the thin brush strokes and after applying this process the result is:



(a) (b) (c)

Fig. 2 : (a) Cracks + Brush Strokes (after Black-Hat Transformation),(b) Cracks we got after thresholding operation , (c) The brush strokes that are separated from the cracks.

C. Filling the Cracks

After identifying cracks and separating misclassified brush strokes, the final task is to restore the image using local image information (i.e., information from neighboring pixels) to fill the cracks. Here we have used the idea of median filtering technique to fill the cracks of the image, to fill the crack we have developed several algorithms from selecting the co-ordinate of the cracked pixel to filling those cracks by getting the approximate colour from its neighboring pixels.

1) *Selecting the pixel co-ordinates of the cracks:* Selective thresholding have been on the cracked image and the output is a grey scale image that contains only cracks as brighter than its surroundings with more intensity value.

Procedure:

{ image Im is the cracked image from which we will get the pixel co-ordinate. Crack_loc is a matrix where the x_o-ordinates will be mapped. i, j, k are the integer variable in memory }

Step 1: Read the height and width of the image Im.
Step 2: Allocate a 2D array Crack_loc of the size of (height*width) X 2.
Step 3: Set i=0 and j=0.
Step 4: If the intensity value of image (i, j) lies in crack and any of its surrounding pixel lies in crack then execute step 5 & 6.
Step 5: Crack_loc (c, 0) <-certain height value and crak_loc (c, 1) <- certain width value
Step 6: Increment c.
Step 7: Increment j .
Step 8: Repeat step 4 to step 7 until j is the width of the image.
Step 9: Increment i.
Step 10: Repeat step 4 to step 9 until i is he height of the image Im.
Step 11: Stop.

Volume 4 Issue VI, June 2016
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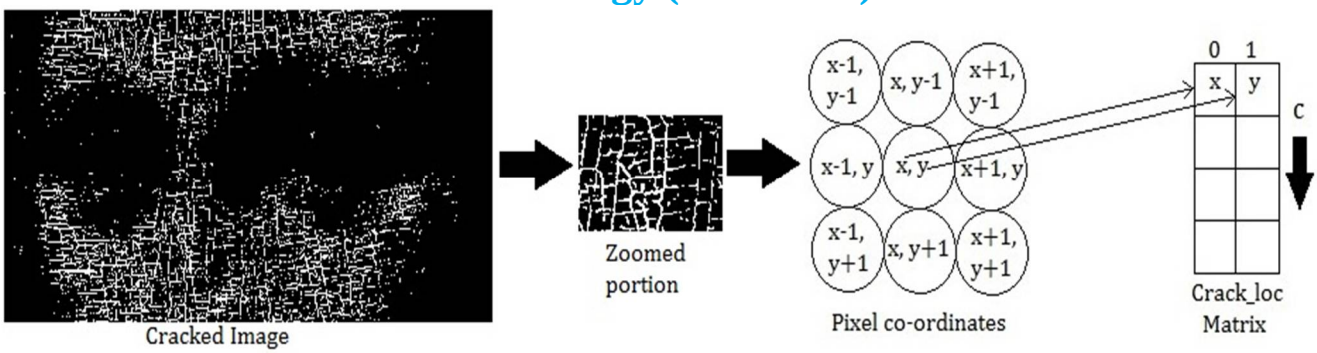

Fig3 : 8 –Connected method

2) *Procedure to set the colour value of the cracked pixel*: Before starting filling process I have realised that the intensity value of the cracks in the main picture can cause problem while calculating the average intensity value of the neighboring pixels because they contain a low intensity value which will give unwanted intensity value and that can reduce the quality of the final image. That is why I have developed a process which will substitute the cracked pixel with any other crack free pixel from the image.

Procedure:

{Image Im is the user inputted picture which contains crack, Crack_loc is the matrix the contains the coordinate value of the crack. b, g and r are integers in which color values are stored temporarily, c is the number of rows of the Crack_loc matrix, i is an integer in the memory}

Step 1: Set i=0.

Step 2: Set x and y as the co-ordinate of the cracked pixel respectively from Crack_loc (i, 0) and Crack_loc (i, 1).

Step 3: If coordinate x-10 lies in the image then execute step 4 else step 5.

Step 4: Take the respective color intensity value of the $(x-10)^{th}$ pixel as blue, red, green in b, g,r.

Step 5: If coordinate x-5 lies in the picture then execute step 6 else step 7.

Step 6: Select the colour intensity value of the $(x-5)^{th}$ pixel in b, g, r.

Step 7: Select the colour intensity value of the $(x-1)^{th}$ pixel in b, g, r.

Step 8 : Substitute the value of x, y with the new b, g and r value.

Step 9 : Increment i.

Step 10: Repeat step 2 to step 9 until i=c.

Step 11: Stop.

Process to fill the cracks:

After substituting the cracked pixel in the image the final work is left to remove the cracks. Here for this process we have developed an algorithm which takes the color intensity value of the eight neighboring pixels and by averaging them calculates the approximate color value of the selected cracked pixel and substitute the value with the previous one.

Procedure:

Step 1: set i=0.

Step 2: set b = g = r = 0.

Step 3: Set x and y as the co-ordinate of the cracked pixel respectively. from Crack_loc (i, 0) and Crack_loc (i, 1).

Step 4: If co-ordinate (x-1) lies in the image then execute step 5.

Step 5: Select the respective color value of blue, red and green from image (x-1, y) and add the respective value with b, g, r.

Step 6: If co-ordinate (x-1) and (y-1) lies in the image then execute step 7.

Step 7: Select the respective color value of blue, red and green from image (x-1, y-1) and add the respective value with b, g, r.

Step 8: If co-ordinate (y-1) lies in the image then execute step 9.

Step 9: Select the respective color value of blue, red and green from image (x, y-1) and add the

Volume 4 Issue VI, June 2016
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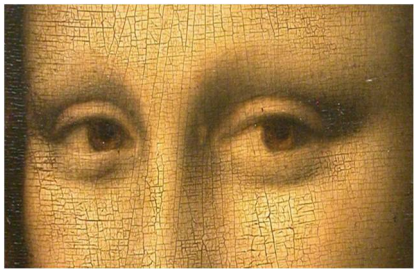
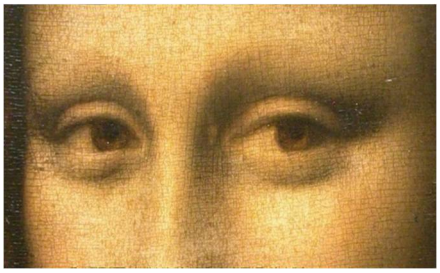
respective value with b, g, r.
Step 9: If co-ordinate (x+1, y-1) lies in the image then execute step 10.
Step 10: Select the respective color value of blue, red and green from image (x+1, y-1) and add the respective value with b, g, r.
Step 11: If co-ordinate (x+1) lies in the image then execute step 12.
Step 12: Select the respective color value of blue, red and green from image (x+1, y) and add the respective value with b, g, r.
Step 13: If co-ordinate (x+1, y+1) lies in the image then execute step 14.
Step 14: Select the respective color value of blue, red and green from image (x+1, y+1) and add the respective value with b, g, r.
Step 15: If co-ordinate (y+1) lies in the image then execute step 16.
Step 16: Select the respective color value of blue, red and green from image (x, y+1) and add the respective value with b, g, r.
Step 17: If co-ordinate (x-1, y+1) lies in the image then execute step 18
Step 18: Select the respective color value of blue, red and green from image (x-1, y+1) and add the respective value with b, g, r.
Step 19: Get the average value of the color intensity by dividing by eight respectively for blue, green and red and store them at b, g, r.
Step 20: Substitute the value of x, y with the new b, g and r value.
Step 21: Increment i.
Step 22: Repeat step 2 to step 21 until i=c.
Step 23: Stop.

IV. RESULTS

The below is the result that has found after the first iteration of the filling algorithm. It is observed that the best result comes out after several iteration of the filling process. Here four iteration have been used which seems to give the optimized result. After using fourth and final iteration basic median Blur process has been used to smooth the image. And final outputs are shown in fig. 4 below:


(a)Image with Cracks


(b)Image after first iteration


(c)Image after second iteration


(d)Image after third iteration


(e)Image after final iteration


(f)Image after smoothing using Median Blur

Other results

Volume 4 Issue VI, June 2016
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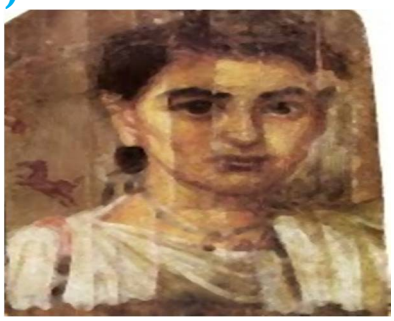
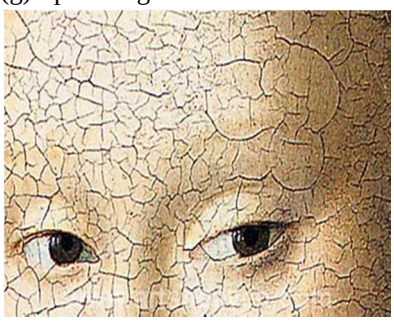
(g)Input Image


(h)After selective Thresholding


(i)Final Output Image


(j)Input Image with Cracks


(k)After Black-Hat and Selective Thresholding


(l)Final Output Image

Fig. 4

V. CONCLUSION

In this paper, a technique for the crack detection and filling in digitized paintings has been proposed. cracks were identified by top transform is an operation that extracts small elements and details from given images. I have used black hat transform that generates an output image where the thin dark brushes strokes, which are misidentified as cracks. Therefore, a thresholding operation is required for multiple times to separate cracks from the rest of the image. Finally, in order to restore the cracks, we used the idea of median-filtering algorithm. For implementing the median filter, the pixels in the chosen mask need to be sorted in the ascending order then center pixel of the mask is replaced by the median pixel value from the sorted list. Using the information from the neighboring pixels we are successful to restore the images by filling all the cracks in the old digital paintings. Experiments were performed on different cracked images to evaluate the accuracy of the result. Using the information from the neighboring pixels we are successful to restore the image to fill all the cracks in the old digital paintings.

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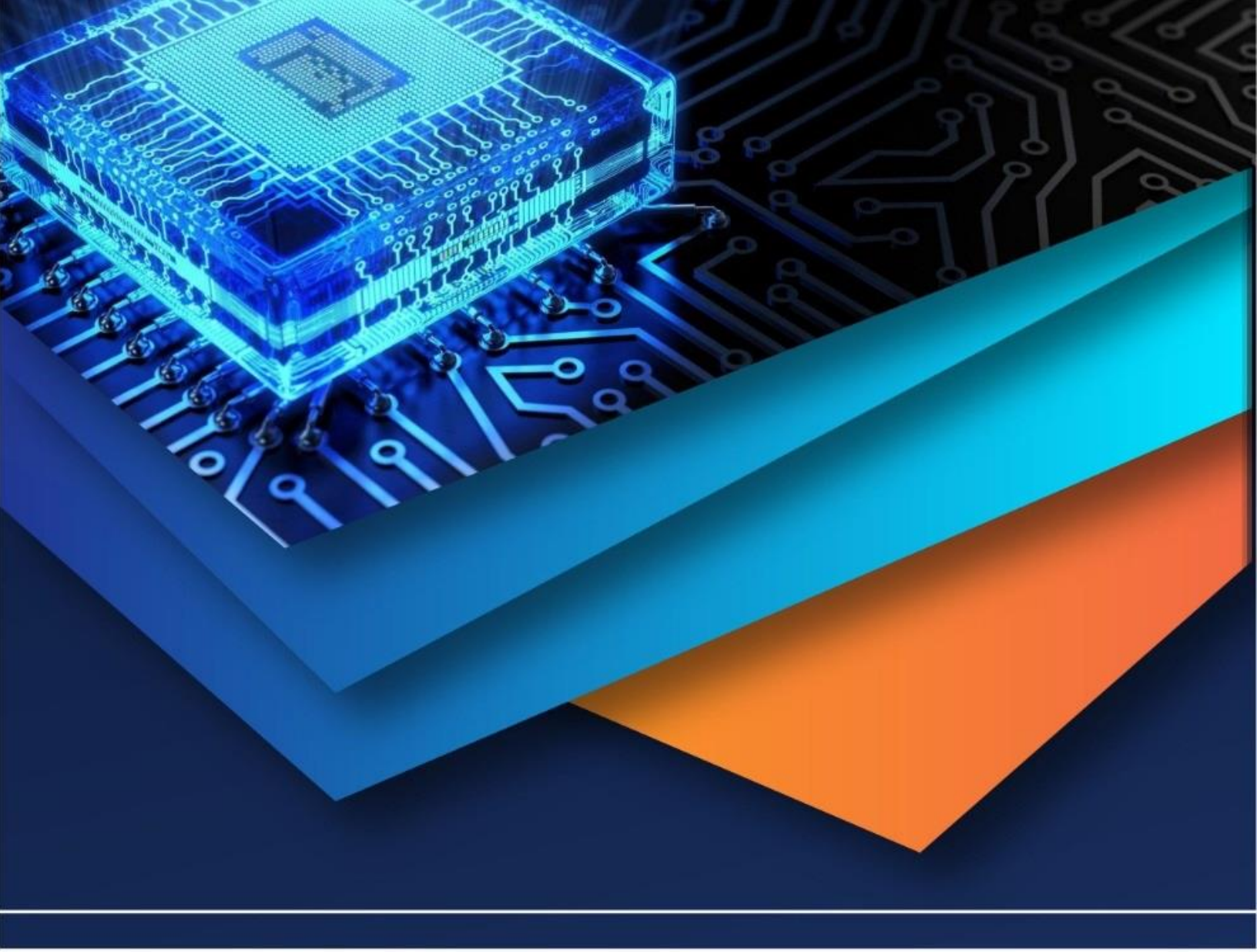

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