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A NOVEL ENHANCEMENT METHOD FOR COLORED ROCK ART ARCHAEOLOGICAL IMAGES

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Abstract- Rock Art Archaeology plays important role in understanding the Culture, Religious systems, Art forms, Gender relations and Belief systems of ancient times. The biggest challenge in studying the various art forms like paintings and engravings found on rocks is that they are prone to environmental degradation and vandalism. Therefore, enhancement of images acquired from Rocks becomes a prerequisite for Archaeological studies. In this study, an enhancement method based on application of Brightness Preserving Bi-Histogram Equalization (BBHE) and De-correlation Stretch (D-Stretch) is proposed. Performance Evaluation of existing enhancement methods for Rock Art images is performed and comparison is done with proposed method both subjectively and objectively using metrics PSNR, MSE, RMSE, MAE, NK, SC, AD. Experimental results demonstrate that proposed method attains the highest performance for enhancement of Rock Art images.

Keywords- Rock art Archaeology, Enhancement, HE, BBHE, D-Stretch, PSNR, MSE, RMSE, MAE, NK, SC, AD.

I. INTRODUCTION

The main aim of image enhancement is to enrich the visual quality of an image, to make the image more appealing to humans. Over the years a growing number of techniques are used to enhance Rock Art Images. Contrast enhancement is foremost concern as it can improve image for perception. Contrast is the difference in luminance or intensity level between objects or regions in an image. Low contrast causes loss of information in some areas in the image, while good contrast makes objects or scenes depicted in an image distinguishable and visually interpretable for human and machine analysis [1].

Aborigines, used rock art to represent and communicate their understanding of the world and reflect their spiritual and religious life. Their rock engravings and cave paintings are an indispensable source of information for our understanding of prehistoric living. However, most Aboriginal cave drawings are located in unprotected environments and are subject to environmental deterioration and vandalism. The surviving examples are now usually located in remote areas, which make it difficult for many to experience. It is therefore essential that rock art be accurately recorded, for conservation and studying by historians, archaeologists, the general public and future generations of aboriginals themselves. Standard recording techniques, mainly tracing and photography, do not allow a full and realistic experience. Traditional measurement techniques, like surveying and photogrammetric, cannot capture all the details of irregular surfaces [2].

A. *Need of Enhancement for Rock Art Images*

Analyzing Rock Art Images is a continuous, data intensive and turbid process. The atmospheric degradation causes both a loss in contrast and color information. Enhancement of such images is a difficult task due to the complexity in restoring both the luminance and chrominance while maintaining good color fidelity [15]. Enhancement in rock art images is used as:

- It accentuates or sharpens image features search as edges, boundaries or contrast to make graphical quality more appealing for display and analysis.
- Improve contrast, intensity, and hue and saturation transformation.
- Improves defects caused by image acquisition
- Remove unnecessary noises

Standard recording techniques, mainly tracing and photography, do not allow a full and realistic experience. Traditional measurement techniques, like surveying and photogrammetric, cannot capture all the details of irregular surfaces [2]. So, digital technique as digital image enhancement is required, which enhance the quality of such images through image enhancement techniques. There are a number of Enhancement methods available for Rock Art images but there is a lack of enhancement method which could address all challenges of Rock Art imagery. In sections 2, 3 and 4 existing enhancement methods are presented with their methodologies. Experimental results of evaluation of the enhancement methods are presented in section 5. In section 6 findings of the study are discussed. Section 7 presents conclusion of the study.

II. HISTOGRAM EQUALIZATION

Histogram equalization (HE) is primarily used because of its simplicity. HE expands the histogram by extending dynamic range of gray values to fulfill overall contrast enhancement, it has an effect of stretching dynamic range [6]. The mean brightness of resulting output image instead of input mean approach to the centered gray level, which results in uniform histogram. It is not desired where mean preservation is required. It also acts as base for many other techniques such as BBHE, MBHE, DSIHE, and RMSE

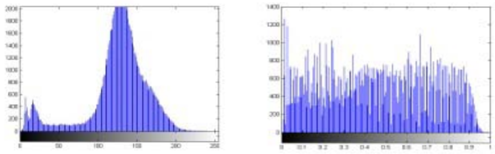


Figure 1: Example of Histogram equalization

- Let X = { X(i, j) } denote a given image composed of L discrete gray levels denoted as { X_0, X_1, ….., X_{L-1} }
- where X(i, j) represents intensity of image at the spatial location (i, j), where X(i,j) belongs to{ X_0, X_1, ….., X_{L-1}}
- Probability Density Function(PDF) for a given image is defined as:

  $p(X_k)=\frac{n^k}{n}$
- For k = 0, 1 , . . . , L – 1, where n^k represents the number of times that the level X_k appears in the input image X and n is the total number of samples in the input image.
- Note that $p(X_k)$ is associated with the histogram of the input image

  plot of n^k vs. X_k is known as the histogram of X.

- Cumulative Density Function is defined based on PDF as

  $c(x)=\sum_{j=0}^{k} P(X_j)$

  Where X_k =x, for k = 0, 1. . . L – 1.
- HE maps the intensity values of input image to entire dynamic range{ X_0, X_{L-1}} using CDF as a transform function.
- Transform function f(x) is defined as

  $f(x) = X_0+(X_{L-1}-X_0)c(x)$
- then the output image of the histogram equalization = {Y(i, j)} , can be expressed as y = f(X)

III. BRIGHTNESS PRESERVING BI-HISTOGRAM EQUALIZATION

Brightness Preserving Bi-Histogram Equalization (BBHE) is an extended version of HE. Y.-T. Kim put HE forward to BBHE to overwhelm the downside (change in brightness) of HE. The utmost goal is to maintain the mean brightness of input image while contrast enhancement is done. As it preserves mean value, it is also known as Mean Preserving Brightness Histogram Equalization. BBHE works by splitting the input image into two parts on behalf of its mean value, one part is the set of pixel values which are less than or equal or to mean whereas the second part is one having values greater than mean. After splitting BBHE applies HE to both parts of image independently with a constraint that values in the first part is equalized over the range up and in second part, from mean to maximum gray level based on their respective histograms. The output equalized partitioned images are bounded by input mean, which preserves the mean brightness [6].

- The input image(X) is partitioned into two sub images X_L and X_U, based on mean value as

  $X=X_L \cup X_U$
- Where X_m is mean of input image X, $X_L=\{X(i,j)|X(i,j)\} \le X_m, \forall X(i, j)\in X$
- $X_U = \{X(i, j)\ l\ X(i,j) > X_m, \forall X(i, j)\in X\}$
- X_L is composed of $\{X_0, X_1, \ldots, X_m\}$ and X_U is composed of $\{ X_{m+1}, X_{m+2}, \ldots, X_{L-1}\}$
- PDF for X_L and X_U is defined as

  $p_L(X_k) =\frac{n_L^k}{n_L}$, where k= 0,1, ….,m and $p_U(X_k) = \frac{n_U^k}{n_U}$, where k= m+1,m+2, ….,L-1
- n_L^k and n_U^k represent the respective numbers of X_k in X_L, and X_U
- $n_L= \sum_{k=0}^{m} n_L^k$, $n_U= \sum_{k=m+1}^{L-1} n_U^k$, $n=n_L+n_U$
- CDF for X_L and X_U are defined as

  $c_L(x) = \sum_{j=0}^{k} p_L(X_j)$ and $c_U(x) = \sum_{j=m+1}^{k} p_U(X_j)$
- where X_k =x .Note that $c_L(X_m)$= 1 and $c_U(X_{L-1})$=1 by definition
- Transform functions defined using CDF as

  $f_L(x)=X_0+(X_m - X_0)c_L(x)$ and $f_U(x)=X_{m+1}+(X_{L-1} - X_{m+1})c_U(x)$
- Transformation function is applied to both images X_L and X_U, these images are then concatenated to have the final output image Y of BBHE method.

  $Y= f_L(X_L) \cup f_U(X_U)$

  Where $f_L(X_L)=\{f_L(X(i, j))|\forall X(i, j)\in X_L\}$ and $f_U(X_U)=\{f_U(X(i, j))|\forall X(i, j)\in X_U$

IV. DE-CORRELATION STRETCH

D-stretch method is very helpful for archaeologists, historians, interested scholars and others for study and documentation of rock arts. This method brings out the details from faded pictographs which are not visible to naked eyes. Obscureness in hue is enhanced to inkling superimposed images. D-stretch diagonalize correlation matrix of color channels, then contrast stretching is performed to equalize color variation. Colors are uncorrelated at this point to fill the color space. To map back the approximate original colors inverse transformation is used. A 3*3 transformation matrix is produced that is applied to the colors in image. The common color types (red, black, and white, mainly red) of pictographs cause consistency in enhancement of De-correlation Stretch. The resultant enhanced image is of false colors, i.e. colors are extreme from original [7].

- First, a grid of pixels is selected that is expected to form a representative sample of all “good” surface pixels found within the scene.
- The requester may optionally specify a rectangular subarea for statistics gathering, rather than use the entire image. This option would permit a greater diversity of color within the region of interest, at the expense of overall scene diversity.
- Using the sampled pixels, the nine sums that are needed to calculate the covariance matrix for the three channels are accumulated.
- These sums are:

  For l=1, 3; m=1,l, and sampling n pixels,

  $SUM_{l,m}=\sum_{k=1}^{n} P_{k,l} * P_{k,m}$

  Where $P_{k,l}$ is the value of the k^{th} pixel for Channel l
- The covariance and the correlation matrices are computed, using the following formulas:
- The elements of the covariance matrix are computed as follows:

$Cov_{l,m} = \frac{1}{n-1}[SUMX_{l,m} - \frac{1}{n} * SUM_l * SUM_m]$

- For the correlation matrix elements:

$Corr_{l,m} = \frac{Cov_{l,m}}{(Cov_{l,l} * Cov_{m,m})^{1/2}}$

- The matrix of eigenvectors described by the correlation matrix (or, optionally, of the covariance matrix) is referred to as the rotation matrix, R, in subsequent steps.
- The "stretching vector" (or Normalization vector), s, is formed by taking the reciprocal of the square root of each element in the eigenvalue vector, and multiplying it by the desired standard deviation for the output image channels.
- The final transformation matrix, T, is composed from the rotation matrix and the stretching vector. This is done by the following matrix multiplication: $T = R^t s R$
- Before applying transformation on image, it is applied to vector of the means of the input channels. Result is used to compute the offsets needed to reposition the output image values to the 0 to 255 dynamic range of eight bit data. For each pixel in the scene, the output pixel vector (3 valued) is computed by applying the final transformation matrix, and then the offset vector [7].

V. BPDS METHOD FOR ENHANCEMENT

A method Brightness Preserving De-correlation Stretch (BPDS) is proposed for color image enhancement of Rock Art Images based on BBHE and DS methods. These methods have not been used for Rock Art Images. Proposed procedure is presented below and flow chart is represented in figure2

Proposed Procedure:

- Load a color image in Matlab.
- Calculate the mean of input image.

Mean=round (mean (input image (:)));

- Divide the image into two halves on behalf of mean value(1st half from 1st value to mean value, second half from mean+1 to end)

1st half= input image (:, 1:Mean, :);

2nd half= input image (:, 1:Mean+1: end,:);

- Apply De-correlation stretch on both images

Ds=decorrstretch(1st half);

Ds1=decorrstretch (2nd half);

- Concatenate the resultant images of D-stretch

Output image=cat (2,Ds,DS1);

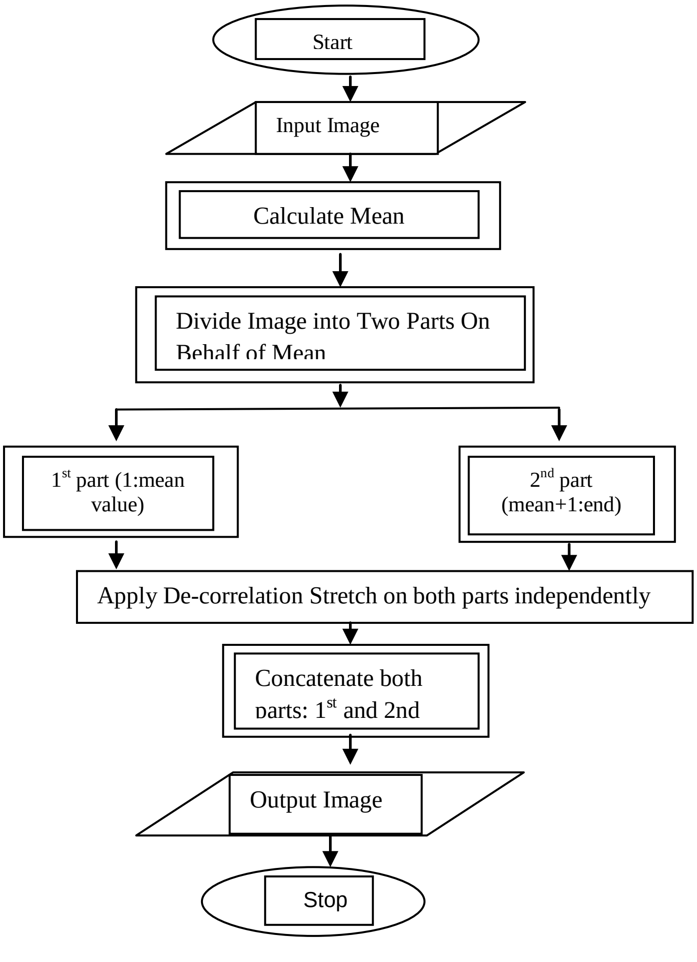


Figure2: Flow Chart for BPDS method

VI. EXPERIMENTAL RESULTS

To demonstrate the efficiency of proposed algorithm, performance evaluation of proposed method BPDS and existing methods is done both subjectively and objectively. Objective performance evaluation is done using metrics like MSE, PSNR, Average Difference, SC, and NK. Graphical outputs are presented in Table1 and results of performance metrics are presented Table2.

Results for images on regular surface, irregular surface, images having multiple colors, image with single color, having high and low brightness are computed. As we can see in last row of table 1 results of BPDS, preserves the brightness as well texture details, in image 2 the texture details are more visible in lower left corner, by equalizing the color variation in D-Stretch it degrades the quality of edges, as we can see in 5^{th} row and 2^{nd} column of table1 the image 1 has some grass, D-Stretch results in blur effect, whereas with BPDS the blur effect is lesser as compared to D-Stretch. The objective results of BPDS outer perform than other techniques as shown in table 2, the change in Structural content in BPDS is lesser than D-Stretch.

Table1: Experimental Results for Enhancement Methods

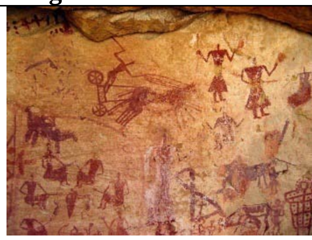
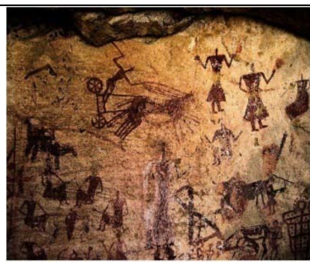
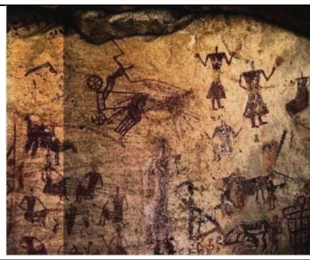
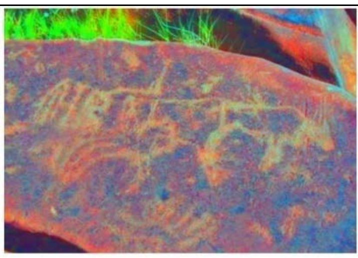
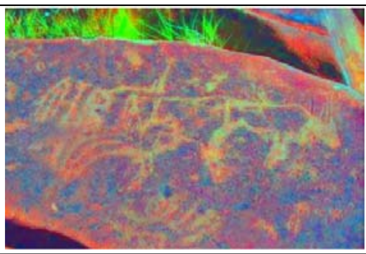
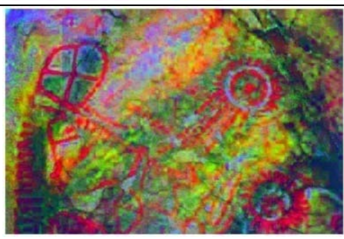
	Image 1	**Image 2**	**Image 3**
Original image			
HE			
BBHE			
DS			
BPDS			

Table 2: Quantative Results for Enhancement Methods

TECHNIQUES USED	QUALITY PARAMETERS						
	PSNR	**MSE**	**RMSE**	**MAE**	**NK**	**AD**	**SC**
	IMAGE 1						
HE	5.7850	17162.5240	131.0058	153807.3747	0.0036	1.2216	0.0000
BBHE	5.7850	17165.4419	131.0055	153807.3747	0.0036	1.2216	0.0000
D-STRETCH	18.1283	10000.5709	31.6318	153806.1524	1.0006	-0.0007	1.0012
BPDS	18.1462	996.4547	31.5667	206504.8020	0.3424	0.4195	0.1172
	IMAGE 2						
HE	6.8581	13405.2548	115.7811	182200.3496	0.0041	-0.4788	0.0000
BBHE	6.8580	13405.3158	115.7813	182201.5844	0.0041	0.7561	0.0000
D-STRETCH	16.0244	1624.2002	40.3014	182200.8266	1.0023	-0.0017	1.0045
BPDS	15.9206	1663.4774	40.7857	206505.2663	0.7735	0.0982	0.2831
	IMAGE 3						
HE	5.6030	17897.1542	133.7802	230619.1957	0.0030	0.7485	0.0000
BBHE	5.6026	17898.5673	133.7855	230619.1957	0.0029	0.7485	0.0000
D-STRETCH	18.8686	843.7609	29.0476	230618.4461	1.0015	-0.0011	1.0031
BPDS	19.3537	757.5806	27.4696	230618.4464	1.0010	-0.0008	1.0021

VII. CONCLUSION

In this study, a method for enhancing the details covered in rock art images is proposed, which maintains the mean brightness of input image as well as stretch the contrast of image by equalizing color variation. The proposed method is referred to as BPDS (Brightness Preserving De-correlation Stretch), which is a novel extension of BBHE and D-Stretch. The goal is to uncover the hidden details of rock art by preserving the mean brightness and equalize color variation. Experimental results of performance evaluation of proposed method and other methods demonstrate that BPDS attains highest performance for enhancement of Rock Art Images. The proposed algorithm is complex then existing ones, an effort to reduce the complexity should be made to effectively use this algorithm.

VIII. REFERENCES

[1] Ojo J.A, Solomon I.D., and Adeniran S.A., “Contrast enhancement algorithm for color images.” Science and Information Conference(SAI),pp. 555-559, 2015

[2] Clarke, J., “ Deterioration analysis of rock art sites, Proc. Int.” Workshop Conservation of Rock Art. Perth, Australia, pp. 54-63, 1977.

[3] Robert Mark, Evelyn Billo, “Computer assisted photographic documentation of rock art” Coalition,11,pp. 10-14, 2006

[4] B.N. Chatterji, R.Narshima Murthy, “Adaptive contrast enhancement for color images” International conference on Information, Communication and Signal Processing *ICICS’97*, pp. 1537-1541, 1997

[5] Vasile Buzuloiu Mihai Ciuc, Rangaraj M. Rangayan and Constantin Vertan, “Adaptive-neighborhood histogram equalization of color images” Journal of Electronic Imaging, vol. 10(2), pp. 445-459, 2001.

[6] Yeong-Taeg Kim, “Contrast enhancement using brightness preserving bi-histogram equalization” IEEE Transactions on Consumer Electronics, vol. 43(1), pp. 1-8, 1997.

[7] Ronald E. Alley, “Algorithm theoretical basis document for decorrelation stretch ast06”, pp. 1-18, 1996.

[8] Nicholas Sia Pik Kong Haidi Ibrahim, “Color image enhancement using brightness preserving dynamic histogram equalization*.*” IEEE Transactions on Consumer Electronics, vol. 54(4), pp. 1962-1968, 2008.

[9] Gyu-Hee Park, Hwa-Hyun Cho and Myung-Ryul Choi, “A contrast enhancement using dynamic range separate histogram equalization.” IEEE Transactions on Consumer Electronics, vol. 54(4), pp. 1981-1987, 2008.

[10] Soo-Chang Pei, Yi-Chong Zeng, and Jian-Jiun Ding, “Color images enhancement using weighted histogram separation.” IEEE International Conference on Image Processing (ICIP), pp. 2889-2892, 2006.

[11] Yusra A.Y. Al-Najjar, Dr. Den Chen Soong, “Comparison of image quality assessment: PSNR,HVS,SSIM,UIQI.” International Journal of Scientific & Engineering Research, vol. 3(8), pp. 1-5, 2012.

[12] M.Aarthy, P.Sumathy, “A comparison of histogram equalization method and histogram expansion.” International Journal of Computer Science and Mobile Applications, vol. 2(3), pp. 25-34, 2014.

[13] Sukhjinder Singh, R.K Bansal, and Savina Bansal, “Comparative study and implementation of image processing techniques using matlab.” International Journal of Advanced Research in Computer Science and Software Engineering, vol. 2(3), pp. 244-250, 2012.

[14] Jaya V.L, R. Gopikakumari, “IEM: A new image enhancement metric for contrast and sharpness measurements.” International Journal of Computer Applications. vol. 79(9), pp. 1-9, 2013.

[15] KokKeong Tan and John *P.* Oakley, “Enhancement of color images in poor visibility conditions.” IEEE Transactions on Consumer Electronics, pp. 788-791, 2000.

