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   REVIEW OF LITERATURE

   NEED/IMPORTANCE OF THE STUDY

   STATEMENT OF THE PROBLEM

   OBJECTIVES

   HYPOTHESES

   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

   FINDINGS

   RECOMMENDATIONS/SUGGESTIONS

   CONCLUSIONS

   SCOPE FOR FURTHER RESEARCH

   ACKNOWLEDGMENTS

   REFERENCES

   APPENDIX/ANNEXURE

   It should be in a 8 point Calibri Font, single spaced and justified. The manuscript should preferably not exceed ***5000 WORDS***.

10. **FIGURES &TABLES**: These should be simple, crystal clear, centered, separately numbered & self explained, and **titles must be above the table/figure**. **Sources of data should be mentioned below the table/figure**. It should be ensured that the tables/figures are referred to from the main text.

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- Hunker, H.L. and A.J. Wright (1963), "Factors of Industrial Location in Ohio" Ohio State University, Nigeria.

CONTRIBUTIONS TO BOOKS

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

JOURNAL AND OTHER ARTICLES

- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

CONFERENCE PAPERS

- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–22 June.

UNPUBLISHED DISSERTATIONS AND THESES

- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

ONLINE RESOURCES

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WEBSITE

- Garg, Bhavet (2011): Towards a New Natural Gas Policy, Political Weekly, Viewed on January 01, 2012 http://epw.in/user/viewabstract.jsp

COMPARISON OF IMAGE ENHANCEMENT TECHNIQUES

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ABSTRACT

Poor illumination during image acquisition leads to poor contrast and poor brightness. The resultant effect is that some features of the acquired image are obscured. Image enhancement processes an image so that the resulting image will be more suitable than the original image for a specific application. Algorithms for various image enhancement techniques are developed as digital computer programs and tested in Matlab working environment. The effects of the various image enhancement techniques are compared. The choice of the best technique is a function of input image and desired effect. Histogram processing and Linear Point Transformation (Auto-scaling) are found to improve both contrast and brightness. Logarithm and exponential transformations have opposite effects on input image. Post-processing has been used to correct the problem of poor illumination. It has helped in bringing out obscured details in images. Significant improvements in contrast and brightness have been recorded.

KEYWORDS

Illumination, Enhancement, Histogram, Transformation, Post-processing.

INTRODUCTION

The conditions under which image signals are acquired are frequently less than ideal. These non-ideal conditions may introduce noise, distortion, or other artefacts. The acquired or available image in most cases is not exactly the same as the actual or true image. Some features of the image are obscured. The image has poor contrast or poor brightness probably due to poor illumination during acquisition. Image Enhancement is required for image improvement.

The physical requirements for improved image quality are unrealizable. For instance, in x-ray imaging, improved image quality occurs with increased incident x-ray beam intensity, which is hazardous to a patient's health. In gamma-ray imaging, improved image quality occurs with increased dosage of pre-scanning radionuclide injection, which is hazardous to a patient's health. In security surveillance camera monitoring, poor illumination is inevitable at night and in dark places when and where more crimes are committed. Post-processing such as enhancement is therefore the only alternative for improved image quality.

Image enhancement processes an image so that the resulting image will be more suitable than the original image for a specific application. This suitableness is subjective and relative to each application. The image is manipulated in order to take advantage of the psychophysical aspects of the human visual system. It is hard to standardize the definition of good image as the visual evaluation of image quality is a highly subjective process (Bertero and Boccacci, 2004; Chan and Shen, 2005; Dhawan *et al*, 1986; Gonzalez and Woods 2002; Greer *et al*, 1987; Jain, 1986; Kenneth, 1996; Teuber, 1992; Tony and Jianhong, 2005; Weeks, 1999; Young et al, 1998). The objective of image enhancement is to bring out details which are obscured in an image, or simply to highlight certain features of interest in an image. One the recent algorithms for image enhancement is genetic algorithm (Hashemi *et al*, 2010).

Contrast of an image is the range from the darkest regions of the image to the lightest regions. The mathematical representation is

$$contrast = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}} \qquad (1)$$

where I_{max} and I_{min} are the maximum and minimum intensities of a region or image.

Images with good contrast have a good representation of all luminance intensities. As the contrast of an image increases, the viewer perceives an increase in detail. This is purely a perception issue as the amount of information in the image does not increase. Human beings' perception is sensitive to luminance contrast rather than absolute luminance intensities (Chanda and Majumer, 2000; Gonzalez and Woods, 2002; Jain, 1986; Tony and Jianhong, 2005; Weeks, 1999).

Brightness of an image is defined as the average of all the pixels within the image. It is given as

$$brightness = B = \frac{1}{NM}\sum_{y=m}^{M-1}\sum_{x=n}^{N-1} g(m,n) \qquad (2)$$

where N and M are the numbers of rows and columns respectively in g(m,n) (Chanda and Majumer, 2000; Gonzalez and Woods, 2002; Jain, 1986; Tony and Jianhong, 2005; Weeks, 1999).

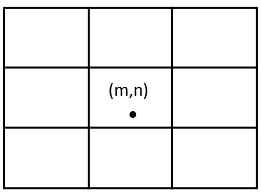
IMAGE ENHANCEMENT TECHNIQUES

POINT PROCESSING

Spatial domain enhancement procedures use the transformation of Eqn. (3). T is an operator on an input image f(m,n) defined over some neighbourhood of (m,n) to enhance the image to give a better output image g(m,n). The Neighbourhood of a point (m,n) is defined by using a rectangular sub-image area shown in Fig. 1 which is centred at point (m,n). The centre of the sub-image is moved from pixel to pixel of f(m,n) starting at the top left corner (Chanda and Majumer, 2000; Florack *et al*., 1994; Gonzalez and Woods, 2002; Jain, 1986; Tony and Jianhong, 2005; Weeks, 1999).

$$g(m,n) = T[f(m,n)] \qquad (3)$$

FIG. 1: NEIGHBOURHOOD OF POINT (M,N) DEFINED BY A RECTANGULAR SUB-IMAGE



If the neighbourhood is 1 x 1 pixel, the processing is said to be point processing or point operation. The value of g at point (m,n) depends on the value of f at point (m,n) only. It is applied in contrast stretching.

It is sometimes good to increase the dynamic range (contrast) of the gray levels in the image. Low-contrast image is a result of poor illumination, lack of dynamic range in the imaging sensor, or even wrong setting of a lens aperture for image acquisition.

Manipulation of an image's gray levels modifies the overall perception of the image, changing its brightness and contrast. There are three basic gray-level point transformation functions as presented in Table 1: Linear, logarithm and power-law transformations.

TABLE 1: BASIC GRAY-LEVEL POINT TRANSFORMATION FUNCTIONS

Basic Function	Type	Equation
Linear	Auto-scaling	$g(m,n) = mf(m,n) + d$ $m = slope$, $d = offset$ $m = \frac{g_{\max} - g_{\min}}{f_{\max} - f_{\min}}$ $d = g_{\min} - mf_{\min}$
Logarithm	Log	$g(m,n) = c\log(1 + f(m,n))$ $c \geq 0$
	Inverse Log	$g(m,n) = c\,anti\log(1 + f(m,n))$ $c \geq 0$
	Exponential	$g(m,n) = ce^{(1+f(m,n))}$ $c \geq 0$
Power-Law	$\gamma < 1$	$g(m,n) = c(f(m,n))^{\gamma}$ c and γ are positive constants
	$\gamma > 1$	$g(m,n) = c(f(m,n))^{\gamma}$ c and γ are positive constants

(Chanda and Majumer, 2000; Florack *et al.*, 1994; Gonzalez and Woods, 2002; Jain, 1986; Tony and Jianhong, 2005; Weeks, 1999)

Point processing is also useful for thresholding. In this application, a gray level image is converted to a binary image (black and white). The transformation equation is given by Eqn. (4).

$$g(m,n) = \begin{cases} 1 & \text{if } f(m,n) > th \\ 0 & \text{otherwise} \end{cases} \qquad (4)$$

where th is the threshold value.

HISTOGRAM PROCESSING

Histogram of a digital image with gray levels in the range [0, L-1] is a discrete function given as

$$h(r_k) = n_k;\ k = 0, 1, 2, \ldots, L-1 \qquad (5)$$

where r_k is the k^{th} gray level and n_k is the number of pixels in the image having gray level r_k. h is the histogram of a digital image.

Normalized histogram is obtainable as

$$h_n(r_k) = \frac{n_k}{n};\ k = 0, 1, 2, \ldots, L-1 \qquad (6)$$

where n is the total number of pixels in the image.

A histogram of the frequency or number of times that a pixel with a particular gray-level occurs within an image provides a useful statistical representation of the image. An image whose histogram shows a uniform distribution over the range of gray levels is the best, since this enables the eye to comprehend the contribution made by all the gray levels to the image. In practice, however, the resulting histogram is often non-uniform, with a few gray levels dominating over others to the extent that full image interpretation by the eye cannot be achieved.

It is necessary to put in place a transformation process that will increase the dynamic range (the ratio between the minimum and maximum) of intensities to include more gray scale; with the result that the overall contrast is enhanced relative to the original image. This transformation process is called "histogram processing" or "histogram equalization". Histogram processing is basic for numerous spatial processing techniques. It is used effectively for image enhancement. Information inherent in histograms also is useful in image compression and segmentation. Statistical theory shows that use of a transformation function equal to the cumulative distribution of the gray level intensities in the image generates another image with a gray level distribution having a uniform density (Chanda and Majumer, 2000; Gonzalez and Woods, 2002; Greer *et al.*, 1987; Jain, 1986; Kim *et al*, 1997; Tony and Jianhong, 2005; Weeks, 1999). The histogram of the image is first obtained. The cumulative distribution of the gray levels is then obtained and is used to replace the original gray level intensities. This process is the transformation T in Eqn. (3) for histogram processing.

Although the above method enables the redistribution of gray levels over a uniform range, circumstances may arise where certain specific levels need to be highlighted relative to others. For example, even after application of the equalization process, certain levels may still dominate the image to the extent that the contribution of the other levels cannot be interpreted by the eye. One way to overcome this is to specify a histogram distribution which enhances selected gray levels relative to others and then reconstitute the original image in terms of the new distribution. The process of histogram equalization is first applied to the image. Histogram specification (a gray level distribution) which enhances certain levels relative to others is then considered and used.

MODELLING AND PROGRAMMING

Digital computer programs for the evaluation of minimum intensity, maximum intensity, contrast and brightness of an image were developed in Matlab working environment in accordance with Eqns. (1) and (2). A digital computer program was also developed for the evaluation and plotting of the histogram of an image. Histogram plot is a plot of frequency (no of pixels) versus intensity I. I is an integer between 0 and 255.

Point processing operations were also modelled as described in Fig. 2 and were coded into digital computer programs in Matlab working environment. The point processing functions include auto-scaling, logarithm, exponential and power-law transformations as presented in Table 1. Histogram processing was modelled as described in Fig. 3 and coded into a digital computer program. It has four basic steps. The histogram of the image is determined first. The histogram is converted to cumulative frequency which is then normalized by dividing by total no of pixels in the image. The intensity of every pixel is swapped with the product of corresponding cumulative frequency and 255 as shown in Fig. 3.

FIG. 2. MODEL FOR POINT PROCESSING

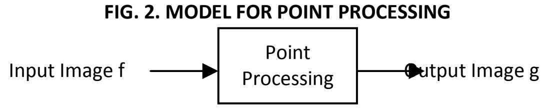
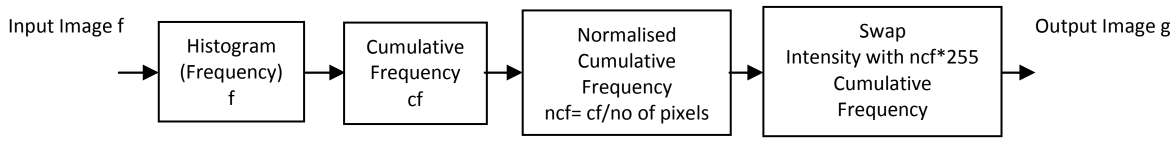


FIG. 3: HISTOGRAM PROCESSING



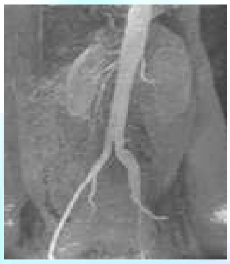
The programs developed in this work are adaptable for both gray-level images and red-green-blue (rgb) colour images. The various programs were tested with gray-level and colour images.

EXPERIMENTAL RESULTS

LINEAR POINT PROCESSING (AUTO-SCALING) RESULTS

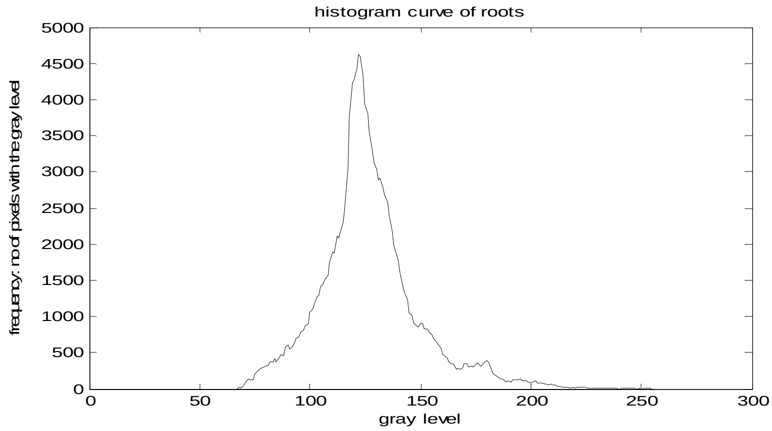
Experimental results for linear point transformation (Auto-scaling) are presented in Figs. 4 and 5 for gray level and rgb colour images respectively. Auto-scaling improves both contrast and brightness.

FIG. 4: LINEAR POINT TRANSFORMATION (AUTO-SCALING) RESULTS FOR ROOTS

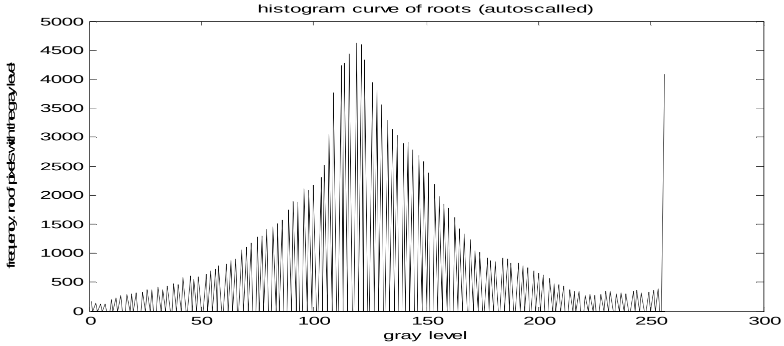


Contrast = 0.58
Brightness = 125.70
(a) Roots (Original)

Contrast = 1
Brightness = 127.78
(b) Roots (Enhanced by Auto- scaling)

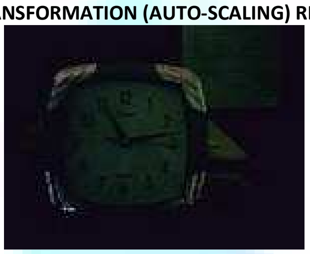


(c) Histogram of Roots (Original)



(d) Histogram of Roots (Enhanced by Auto-scaling)

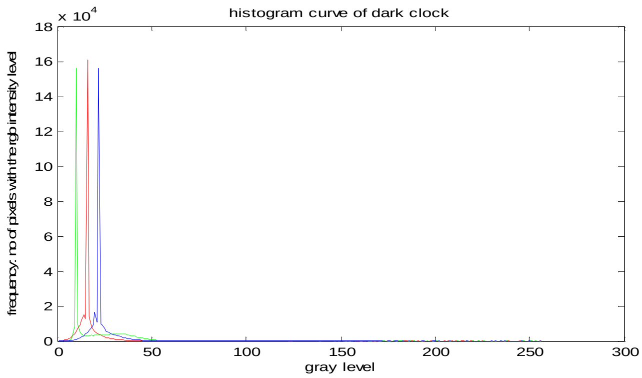
FIG. 5: LINEAR POINT TRANSFORMATION (AUTO-SCALING) RESULTS FOR DARK CLOCK



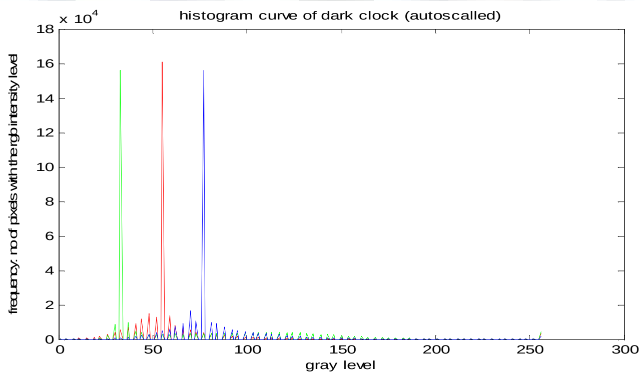
Mean Contrast = 1
Mean Brightness = 19.18
(a) Dark Clock (Original)

Mean Contrast = 1
Mean Brightness = 68.78
(b) Dark Clock (Enhanced by Auto-scaling)

FIG. 5: LINEAR POINT TRANSFORMATION (AUTO-SCALING) RESULTS FOR DARK CLOCK

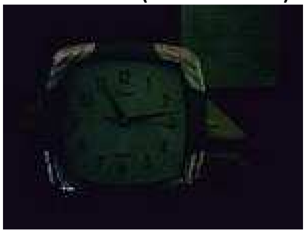


(c) Histogram of Roots (Original)



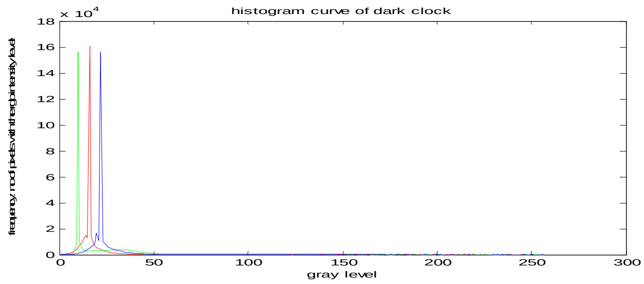
(d) Histogram of Roots (Enhanced by Auto-scaling)

FIG. 5: LINEAR POINT TRANSFORMATION (AUTO-SCALING) RESULTS FOR DARK CLOCK

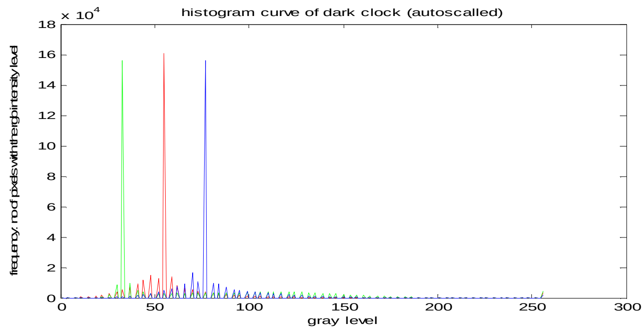


Mean Contrast = 1
Mean Brightness = 19.18
(a) Dark Clock (Original)

Mean Contrast = 1
Mean Brightness = 68.78
(b) Dark Clock (Enhanced by Auto-scaling)



(c) Histogram of Roots (Original)

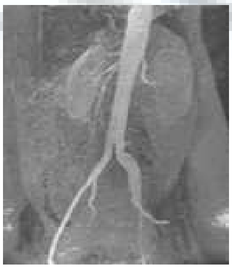


(d) Histogram of Roots (Enhanced by Auto-scaling)

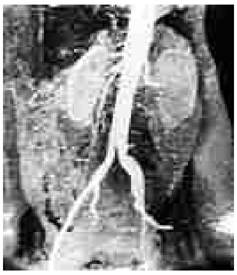
HISTOGRAM PROCESSING RESULTS

Experimental results on histogram processing are presented in Figs. 6 and 7 for gray level and rgb colour images respectively. Histogram processing improves both contrast and brightness.

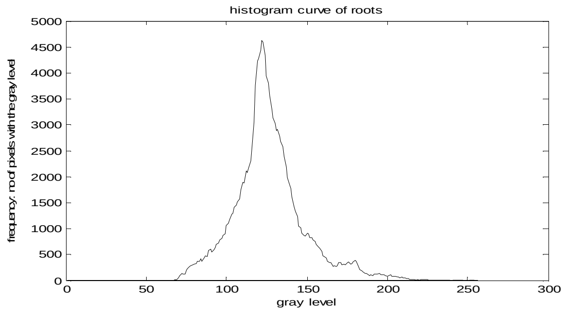
FIG. 6: HISTOGRAM PROCESSING RESULTS FOR ROOTS.



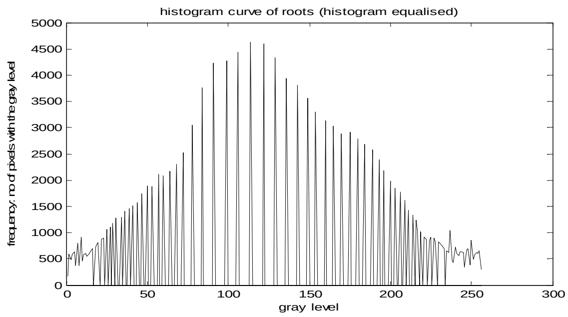
Contrast = 0.58
Brightness = 125.70
(a) Roots (Original)



Contrast = 1
Brightness = 129.53
(b) Roots (Enhanced by Histogram Processing)

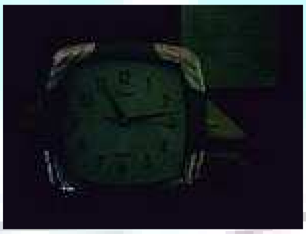


(c) Histogram of Roots (Original)



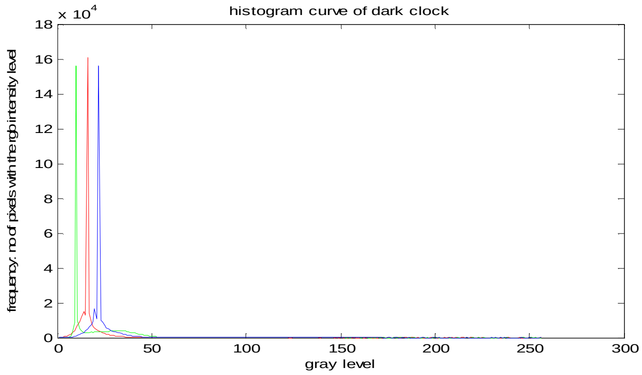
(d) Histogram of Roots (Enhanced by Histogram Processing)

FIG. 7. HISTOGRAM PROCESSING RESULTS FOR DARK CLOCK

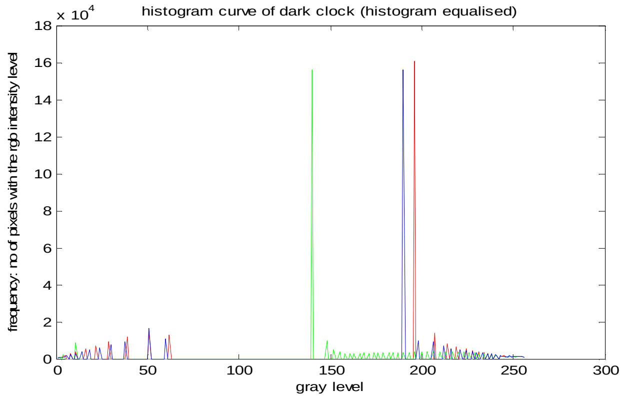


Mean Contrast = 1
Mean Brightness = 19.18
(a) Dark Clock (Original)

Mean Contrast = 1
Mean Brightness = 162.01
(b) Dark Clock (Enhanced by Histogram Processing)



(c) Histogram of Roots (Original)



(d) Histogram of Roots (Enhanced by Histogram Processing)

COMPARISON OF RESULTS

Comparison of Auto-scaling and Histogram processing results are shown in Figs. 8 and 9 for gray level and rgb colour images respectively. The results obtained by different techniques for the same image are compared and presented in Figs. 10 to 13. The techniques are Histogram processing, Auto-scaling, Logarithm transformation, Exponential transformation, and Power Law transformation. The observed opposite effects of Logarithm and Exponential Transformations are illustrated in Fig. 14. The different techniques affect input image in one way or the other. The choice of the best technique is a function of input image and desired effect. For instance, contrast increased from 0.58 to 1 (maximum) in the result of Fig. 8 and brightness increased from 19.18 to 162.01 in Fig. 9.

FIG. 8: COMPARISON OF AUTO-SCALING AND HISTOGRAM PROCESSING RESULTS FOR ROOTS

(a) Roots (Enhanced by Auto-scaling) Contrast = 1 Brightness = 127.78

(b) Roots (Original) Contrast =0.58 Brightness = 125.70

(c) Roots (Enhanced by histogram processing) Contrast = 1 Brightness = 129.53

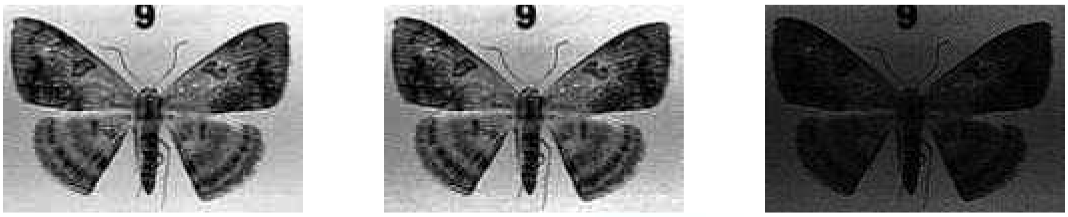
FIG. 9: COMPARISON OF AUTO-SCALING AND HISTOGRAM PROCESSING RESULTS FOR DARK CLOCK

(a) Dark Clock (Enhanced by Auto-scaling)
Mean Contrast = 1
Mean Brightness = 68.78

(b) Dark Clock (Original)
Mean Contrast = 1
Mean Brightness = 19.18

(c) Dark Clock (Enhanced by histogram processing)
Mean Contrast = 1
Mean Brightness = 162.01

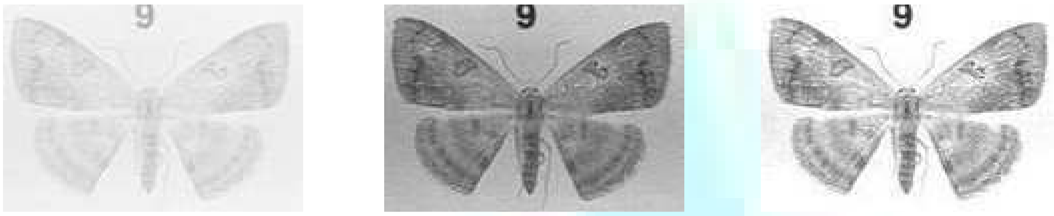
FIG. 10: COMPARISON OF ENHANCEMENT TECHNIQUES FOR INSECT



(a) Insect (Enhanced by Auto-scaling)
Contrast = 1; Brightness = 139.2

(b) Insect (Enhanced by Histogram processing)
Contrast = 1; Brightness = 128.66

(c) Insect (Enhanced by Exponential transform)
Contrast = 1; Brightness = 36.32

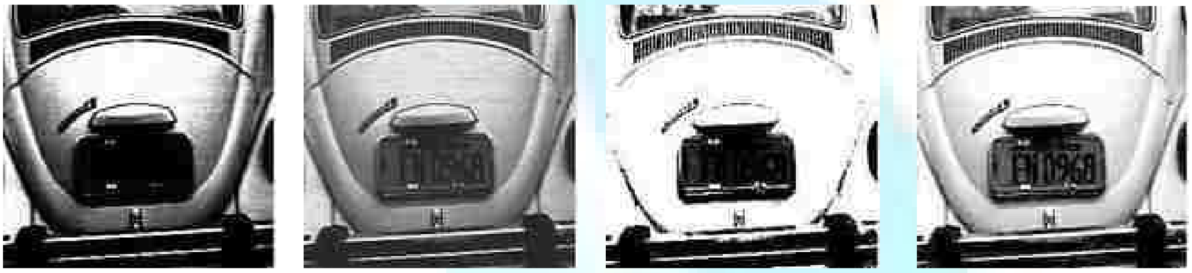


(d) Insect (Enhanced by Logarithm transform)
Contrast=0.19; Brightness=230.56

(e) Insect (Original)
Contrast = 0.70; Brightness=155.41

(f) Insect (Enhanced by power law transform)
Contrast =0.67; Brightness=218.53

FIG. 11: COMPARISON OF ENHANCEMENT TECHNIQUES FOR CAR



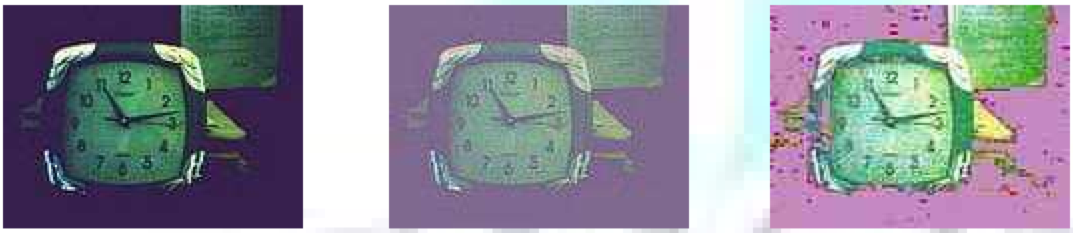
(a) Car (Original)
Mean Contrast = 1
Mean Brightness = 104

(b) Car (Enhanced by histogram processing)
Mean Contrast = 0.70
Mean Brightness = 130.10

(c) Car (Enhanced by power transformation; c=1;y=2)
Mean Contrast = 1
Mean Brightness = 176.16

(d) Car (Enhanced by logarithm transformation)
Mean Contrast = 1
Mean Brightness = 160.45

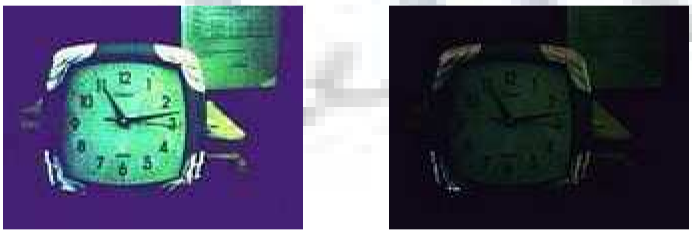
FIG. 12: COMPARISON OF ENHANCEMENT TECHNIQUES FOR DARK CLOCK



(a) Dark Clock (Enhanced by Auto-scaling)
Mean Contrast = 1
Mean Brightness = 68.78

(b) Dark Clock (Enhanced by logarithm transform)
Mean Contrast = 0.90
Mean Brightness = 132.35

(c) Dark Clock (Enhanced by histogram processing)
Mean Contrast = 1
Mean Brightness = 162.01



(d) Dark Clock (Enhanced by power law transform)
Mean Contrast = 1
Mean Brightness = 98.28

(e) Dark Clock (Original)
Mean Contrast = 1
Mean Brightness = 19.18

FIG. 13: COMPARISON OF ENHANCEMENT TECHNIQUES FOR CHEST X-RAY

(a) Chest (Enhanced by histogram processing)
Mean Contrast = 1
Mean Brightness = 128.34

(b) Chest (Original)
Mean Contrast = 0.83
Mean Brightness = 114.36

(c) Chest (Enhanced by logarithm transformation)
Mean Contrast = 0.30
Mean Brightness = 206.13

Fig. 14. Comparison of Logarithm and Exponential Transformations for Clock.

(a) Clock (Enhanced by logarithm transform)
Mean Contrast = 0.97
Mean Brightness = 182.99

(b) Clock (Original)
Mean Contrast = 1
Mean Brightness = 88.26

(c) Clock (Enhanced by exponential transform)
Mean Contrast = 1
Mean Brightness = 19.67

CONCLUSIONS

Both Histogram processing and Linear Point Transformation (Auto-scaling) are found to improve both contrast and brightness. Histogram processing, Auto-scaling, Logarithm transformation, Exponential transformation and Power law transformation are compared. These different enhancement techniques are found to affect image in one way or the other. The choice of the best technique is a function of input image and desired effect.

Logarithm and exponential transformations have opposite effects on input image. A dark image acquired with poor illumination requires Logarithm transformation to improve brightness. An extremely bright image acquired with excess illumination requires Exponential transformation to improve contrast. Post-processing has been used to correct the problem of poor illumination. It has helped in bringing out obscured details in images. Significant improvements in contrast and brightness have been recorded.

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