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CONTENTS

Sr. No.	TITLE & NAME OF THE AUTHOR (S)	Page No.
1.	ROLE OF IT IN COMMERCE EDUCATION IN INDIA: A KEY TO ACHIEVE INCLUSIVE GROWTH AND SUSTAINABILITY <i>DR. SONAL SHARMA & DR. M. K. SINGH</i>	1
2.	AGRIBUSINESS POTENTIAL IMPACT OF HORTICULTURE CROPS: AN AGRICULTURAL ECONOMIC ANALYSIS OF CASHEW NUT IN TAMIL NADU <i>DR. R. LOGANATHAN & DR. M. CHANDRASEKARAN</i>	8
3.	REAL IMPACT OF IMPACT FACTOR RESEARCH JOURNALS ON RESEARCH PAPERS <i>SHUBHANGI JAIN & DR. PRATEEK SHARMA</i>	13
4.	GREEN CONSUMERISM: AWARENESS OF ENVIRONMENTAL ISSUES AMONG CONSUMERS IN TAMILNADU <i>DR. K. SALEEM KHAN, DR. A. MOHAMED SALI & K. SHARIFA NIZARA</i>	21
5.	REFINED HR SCENARIO IN INDIAN IT INDUSTRY <i>U. JEYASUTHARSAN & DR. N. RAJASEKAR</i>	27
6.	AN ANALYSIS OF FACTORS AFFECTING POST-HARVESTING FOOD LOSS IN PERISHABLE CHAIN <i>N. ARUNFRED & DR. D. KINSLIN</i>	32
7.	ANALYSIS OF LIQUIDITY AND PROFITABILITY IN TEXTILE INDUSTRY IN INDIA <i>DR. T. MADHU SUDANA & DR. B. PHANISWARA RAJU</i>	35
8.	TECHNOLOGICAL DEVELOPMENTS IN INDIAN BANKING SECTOR <i>N. SURESH BABU & DR. G.V. CHALAM</i>	43
9.	FOREIGN DIRECT INVESTMENT IN MULTIBRAND RETAILING IN INDIA: FROM STAKEHOLDERS PERSPECTIVES <i>DR. P. SANTHI</i>	48
10.	COMPARATIVE STUDY OF IMAGE ENHANCEMENT TECHNIQUES <i>SANJEEV KUMAR & NAVNEET GOLCHHA</i>	53
11.	IMPLEMENTATION OF SHORTEST PATH ALGORITHM FOR RECTILINEAR STEINER TREE PROBLEM <i>SAKSHI RAJPUT</i>	57
12.	A STUDY ON FAST MOVING CONSUMER GOODS MARKETING WITH SPECIAL REFERENCE TO SAKTHI MASALA PRODUCTS <i>R. BUVANESWARI, B. BHARATHI & MAHALAKSHMI VENKATESH</i>	61
13.	A STUDY ON CONSUMER BEHAVIOUR TOWARDS RETAIL STORES WITH REFERENCE TO BIG BAZAAR IN COIMBATORE CITY <i>B. DEVIPRIYA & DR. M. NANDHINI</i>	64
14.	ROLE OF MARKET ORIENTATION IN PERFORMANCE OF SMALL-SCALE INDUSTRIES: A STUDY OF UNISOPENT PVT. LTD. <i>NISHU MARWAH</i>	67
15.	STRATEGIC THINKING: A KEY FOR COMPETITIVENESS IN SMALL BUSINESS OPERATING IN NIGERIA <i>ONYEAGHALA OBIOMA, H. & UKPATA, SUNDAY IJUO</i>	70
16.	IS SMALL SCALE IRRIGATION A SOLUTION FOR ALLEVIATING RURAL POVERTY IN TIGRAY? (CASE STUDY IN HINTALLO WAJIRAT) <i>TEFERA KEBEDE LEYU</i>	77
17.	ENVIRONMENTAL CORRELATES OF SCIENCE, TECHNICAL, VOCATIONAL AND BUSINESS EDUCATION FOR ECONOMIC TRANSFORMATION IN NIGERIA <i>UKPATA, SUNDAY IJUO & DR. ONYEUKWU, PAULINE EBERE</i>	85
18.	EMPLOYEES PERCEPTION TOWARDS HRD CLIMATE IN THE BANKING SECTOR: A CASE STUDY OF JAMMU AND KASHMIR BANK <i>RAFIA GULZAR</i>	90
19.	POVERTY REDUCTION: A PREDICATE OF HUMAN CAPACITY DEVELOPMENT IN NIGERIA <i>ONYEAGHALA, OBIOMA, H., KAPPE, MAMMAN, P. & DIBAL, HYLADI STANLEY</i>	95
20.	A STUDY ON LEADERSHIP STYLES OF SELECTED ENGINEERING UNITS LOCATED IN GIDC, VITTHAL UDYOGNAGAR, GUJARAT <i>SAMIR P RATHOD & MEHUL J MISTRY</i>	101
21.	ADOPTION OF THE TECHNOLOGY ACCEPTANCE MODEL TO DETERMINE THE FACTORS THAT DRIVE TO SHOP ONLINE <i>ANKUR SANGWAN</i>	107
22.	TO ASSESS THE EFFECT OF INTELLECTUAL CAPITAL ON ORGANIZATIONAL PERFORMANCE IN THE MANUFACTURING SECTOR <i>JOHN WEKESA WANJALA</i>	113
23.	THE ANALYSIS AND DERIVATION OF A NEW FRAMEWORK TO INVEST IN GOLD <i>ANKUR SANGWAN</i>	119
24.	THE FINANCIAL STATEMENT ANALYSIS OF TAMIL NADU NEWSPRINT AND PAPERS LIMITED, KARUR <i>OMBEGA OGUTA KEPHAR</i>	127
25.	NATURAL RESOURCE AND CIVIL WARS: A CRITICAL ANALYSIS <i>SIDDHARTH RATHORE</i>	136
26.	EMERGENCE OF HEDGE FUNDS: IMPLICATIONS ON THE INDIAN CAPITAL MARKET <i>ANINDITA CHAKRAVORTY</i>	140
27.	TRAINING AND DEVELOPMENT PROGRAMMES IN TAMILNADU STATE TRANSPORT CORPORATION LIMITED, KUMBAKONAM <i>D. PAUL DHINAKARAN</i>	146
28.	INDIGENIZATION OF MILITARY HARDWARE: A NECESSITY FOR INDIA? <i>SIDDHARTH RATHORE</i>	150
29.	A STUDY ON THE STATUS OF FACULTY DEVELOPMENT ACTIVITIES IN ENGINEERING INSTITUTIONS <i>S. MURALI</i>	153
30.	WIRELESS MONITORING AND RECORDING OF ENVIRONMENTAL PARAMETERS BASED ON XBEE AND PIC <i>ARAVIND.S</i>	158
	REQUEST FOR FEEDBACK & DISCLAIMER	163

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COMPARATIVE STUDY OF IMAGE ENHANCEMENT TECHNIQUES

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ABSTRACT

Image Enhancement is one of the important aspects of image processing to improve the interpretability of the information present in images for human viewers. An enhancement algorithm is one that yields a better-quality image for the purpose of some particular application which can be done by either suppressing the noise or increasing the image contrast. Image enhancement algorithms are employed to emphasize, sharpen or smoothen the image features for display and analysis. This paper presents a review of some image enhancement algorithms. The performances of algorithms are evaluated both qualitatively and quantitatively.

KEYWORDS

Image Enhancement, contrast stretching, Slicing, Histogram equalization, Filters, SNR.

INTRODUCTION

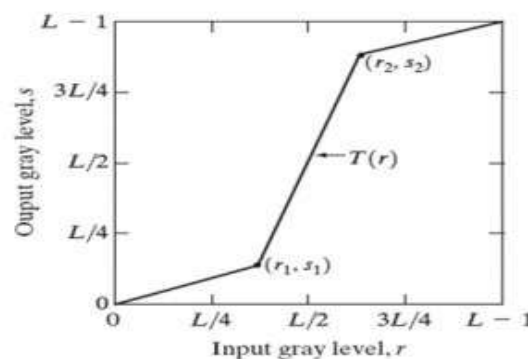
The objective of image enhancement is to improve the quality of image as perceived by human beings through enhancement algorithms. Digital images play an important role in daily life applications such as satellite television as well as in areas of research and technology such as geographical information systems[2]. Whenever an image is converted from one form to other, some form of degradation occurs at output. Improvement in quality of degraded images can be achieved by applying one of the enhancement techniques. Enhancement methods are application specific. Image enhancement techniques emphasize specific image features to improve the visual perception of an image. Image enhancement produces an output image by changing the pixel's intensity of the input image.

Generally, image enhancement enlarges the intensity differences among objects and background. There are many image enhancement techniques that have been proposed and developed[1]. In this paper some image enhancement techniques have been discussed with their mathematical understanding[3]. This paper will provide an overview of underlying concepts with focus on spatial domain techniques and spatial filtering.

CONTRAST STRETCHING

Contrast stretching is to enhance image contrast. Contrast is enhanced between the various parts of the original image, the basic idea is to improve the image processing gray level dynamic range, that is, the original image by increasing the intensity of a two dynamic range between the value achieved[4]. A typical change in contrast enhancement, can be seen from the Figure 1:

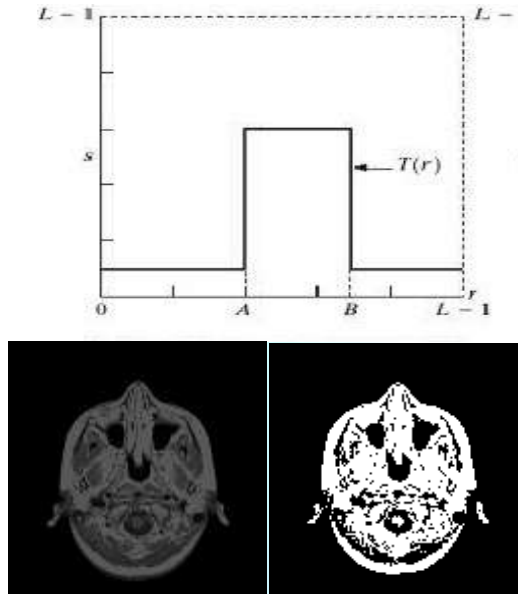
FIGURE 1: SHOWS THE RESULT OF CONTRAST STRETCHING OBTAINED USING A SIMULATION TOOL MATLAB



GREY LEVEL SLICING

A grey level slicing technique enhances all the gray levels in the range of interest using high values and all other gray levels using low values. This function is particularly useful to enhance flaws in X-ray images and enhancing features such as masses of water in satellite imagery. Figure 2 shows the transformation function for the range of pixels of interest and also showing the effect on image.

FIGURE 2: SHOWING EXAMPLE OF GREY LEVEL SLICING



HISTOGRAM PROCESSING

The histogram of a digital image with intensity levels in the range [0, L-1] is a discrete function

$$h(r_k) = n_k$$

r_k \leftarrow k^{th} intensity value
 n_k \leftarrow Number of pixels in the image with intensity r_k

Histograms are frequently normalized by the total number of pixels in the image. Assuming an $M \times N$ image, a normalized histogram.

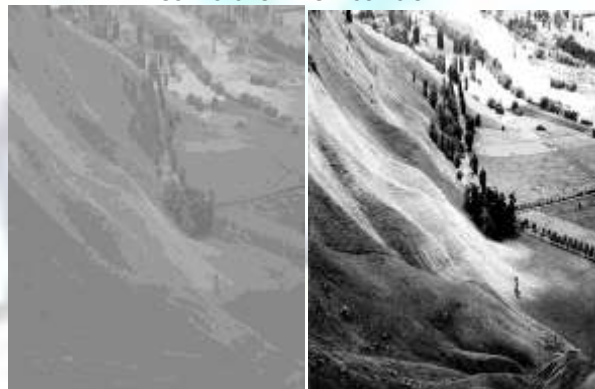
$$p(r_k) = \frac{n_k}{MN}, \quad k = 0, 1, \dots, L - 1$$

is related to probability of occurrence of r_k in the image.[2].

HISTOGRAM EQUALIZATION

Histogram equalization is a technique by which the dynamic range of the histogram of an image is increased. It flattens and stretches the dynamic range of the image's histogram and resulting in overall contrast improvement [7]. Histogram equalization assigns the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities. It improves contrast by obtaining a uniform histogram. This technique can be used on a whole image or just on a part of an image[5].

FIGURE 3: SHOWING RESULTS OF HE



LOCAL ENHANCEMENT TECHNIQUES

The Histogram Equalization discussed above is a global method, which means it increases the overall contrast of the image. So this method is suitable for overall enhancement. This method can be easily adapted to local enhancement. The procedure is to define the neighbourhood and move the center of this area from pixel to pixel. At each location, calculate histogram of the points in the neighborhood. Obtain histogram equalization/specification function. Finally this function is used to map gray level of the pixel centered in neighbourhood[6]. It uses new pixel values and previous histogram to calculate next histogram[3].

FIGURE 4: SHOWING RESULTS OF LHE



IMAGE SUBTRACTION

The primary use of image subtraction includes background removal and illumination equalization. The image difference between two images $f(x,y)$ & $g(x,y)$ can be expressed as

$$Z(x,y) = f(x,y) - g(x,y)$$

A common use is to subtract background variations in illumination from a scene so that the foreground objects in it may be more easily analyzed.

FIGURE 5: SHOWING RESULTS OF IMAGE SUBTRACTION



By analyzing the image obtained by subtraction, we are able to get the better & more clear image of the text which was badly illuminated.

SPATIAL FILTERING

The purpose of these filters is to remove unwanted noise from the image. It is one of principle tools used in this field for a wide range of applications[2]. Spatial filters can be broadly classified into two types:

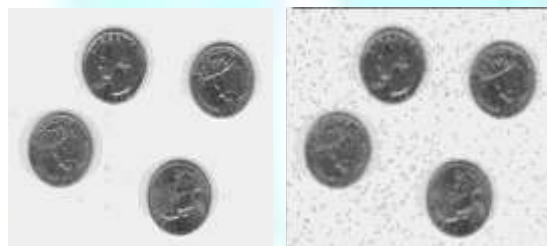
- 1 Smoothing Spatial Filters
- 2 Sharpening Spatial Filters

1 Smoothing Filters: They are used for blurring and for noise reduction.

SMOOTHING LINEAR FILTERS

This is simply the average of pixels contained in the neighbourhood of filter mask. They are also called averaging or low-pass filters. It reduces the noise such as bridging of small gaps in the lines or curves in the image[6].

FIGURE 6: SHOWING RESULTS OF LOW-PASS FILTER



ORDER-STATISTICS (NON-LINEAR) FILTERS

Their response is based on ordering the pixels contained in the image area encompassed by the filter, and then replacing the center with the value determined by the ranking result[2]. The well known median filter is a Non-Linear filter.

FIGURE 7: SHOWING RESULTS OF MEDIAN FILTER



A median filter smoothens the image by utilizing the median of the neighborhood. Median filter performs the following tasks to find each pixel value in the processed image:

- 1) All pixels in the neighborhood of the pixel in the original image which are identified by the mask are stored in the ascending (or) descending order.
- 2) The median of the stored value is computed and is chosen as the pixel value for the processed image.

2 Sharpening Spatial Filters: The principle objective of sharpening is to highlight transitions in intensity. Its applications ranging from electronic printing and medical imaging to industrial inspection[2]. It can provide more visible details that are poor, hazy and of obscured focus in the original image[6].

FIGURE 8: SHOWING RESULTS OF HIGH-PASS FILTER



The well known sharpening filter is High pass filter. High-pass filtering[9],[10] is used for sharpening the image. The objective of high-pass filtering or image sharpening is to high light fine details in the image through enhancing the high frequency components. The spatial filter or spatial mask which performs image sharpening is given below:

The spatial mask which performs image sharpening is given as

$$1/9 \times \begin{pmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{pmatrix}$$

The sum of all the weights is zero; this implies that the resulting signal will have zero dc value.

EXPERIMENTAL RESULTS

A comparison between various spatial domain techniques has been done by implementing these methods in MATLAB. The parameters considered for comparison are SNR, PSNR

Signal-to-Noise Ratio(SNR): It is defined as

$$\frac{\sum_{x=0}^{M-1} \sum_{y=0}^{N-1} \hat{f}(x,y)^2}{\sum_{x=0}^{M-1} \sum_{y=0}^{N-1} [f(x,y) - \hat{f}(x,y)]^2}$$

Here, \hat{f} is the enhanced image and f is the original image [8] and higher value is always desired for SNR.

Peak Signal-to-Noise Ratio (PSNR): It is defined as

$$10 \log_{10} \left(\frac{R^2}{MSE} \right)$$

The PSNR computes the peak signal-to-noise ratio, in decibels, between two images. This ratio is often used as a quality measurement between the original and an enhanced image. The higher the PSNR, the better the quality of the enhanced image.

Visual Quality: By looking at the enhanced image, one can easily determine the difference between the input image and the enhanced image and hence, performance of the enhancement technique is evaluated.

TABLE 1: COMPARISON OF VARIOUS PARAMETERS FOR IMAGE

parameters	SNR	PSNR
Contrast Stretching	8.8708	18.0356
Gray level Slicing	2.9857	9.1104
Histogram Equalization	9.5603	14.2634
Local Enhancement	5.7577	9.4291
Image Subtraction	-8.4707	7.2335

CONCLUSION

In this paper, various image enhancement techniques are discussed. These techniques have been implemented and compared. From the experimental results, it is found that all the discussed techniques yield different outputs for different parameters. In future, more images can be taken from the different application fields for the enhancement purpose so that it becomes clearer that which particular technique is more suitable for which application.

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