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Enhancement of Shadow Region in an Image using Artificial Neural Network

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Abstract: ***Image captured in darker region increases complexities in processing and extracting vital information. Enhancement of such images helps us to retrieve important data and various tools are available for the same. Proposed system uses multi layer feed forward artificial neural network. Error Back Propagation algorithm is used in training process. Desired data is obtained using log transformation method. The proposed model is trained to enhance only shadow part of an image. The results shows enhancement in the darker region and is expected to improve more by changing different parameters in the above methodology.***

Keywords: Shadow Region, Error Back Propagation Training, Image Enhancement, Multi Layer Perceptron.

I. INTRODUCTION

Low contrast and brightness are the major issues in images captured in darker region. Computer power of vision like object identification and site understanding is more proper with high quality image. So image enhancement plays an important role in image processing. Image enhancement techniques help in quality improvement of an image. Resultant parameters or features of an enhanced image are better as compared to the original image. Various methods are available for digital image enhancement which includes Log Transform, Directional Wavelet Transform, Algebraic Reconstruction Model, Partial Differential Equation, Histogram Equalization, Cellular Neural Networks, Adaptive Interpolation Method, Contrast Stretching, Range Compression, Alpha Rooting and Spatially Adaptive Iterative Filtering and Multi-Frame Super Resolution [1].

Various shadow detecting schemes where introduced for image enhancement like real time shadow detection scheme RGB ellipsoidal region technique [3], convolutional neural network based shadow detection in images using visible light camera sensors was proposed in [4], double-threshold pulse coupled neural network approach [5], hypothesis test and energy function available in matlab for shadow detection and removal is used [6] and Enhanced streaming random tree (ESRT) algorithm/model [7] where also used.

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An Artificial Neural Network (ANN) based image enhancement technique is a topic in research now a days. Back-Propagation (BP) neural network based enhancement technique was proposed in [8]. Combination of Artificial neural network and fuzzy logic based approach can also be used for image enhancement [9]. Back-propogation based neural network approach for removing impulsive noise was introduced in [10]. Neural network based adaptive filters where designed to gather high level knowledge of an image [11].

A neural network based log transformed image enhancement is still an area of research to be carried out. In Feed-forward neural network information is processed in the form of interconnected neural cells present inside the brain. This neurons learn and processes the information whenever required [2].

The dark pixels in an image are expanded as compared to the higher pixel values during log transformation. In this, the higher pixel values are somewhat compressed. If such log transformed based image enhancement training is provided to such neurons then it can help us for better image enhancement gradually after learning. Therefore, multi layer artificial neural network with back propagation training algorithm is implemented in c programming language, shadow region enhancement is observed in this process.

II. METHODOLOGY

Fig. 1 depicts the block diagram of the implemented work flow. Following are the steps being followed for multi layer perceptron based image enhancement:

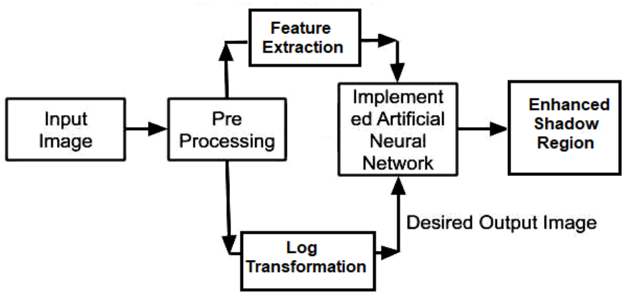

Fig. 1.Block diagram of proposed system

Image Acquisition and Pre-Processing

Image acquisition is done using an optical 12 mega pixel camera. Original jpg image provided as an input to the model for preprocessing. The original RGB image is transformed into Gray scale image. An appropriate part of image is selected (cropped) using GIMP software. Image pixel values are normalized and stored into a text file for further processing.

Log transform of these pixel values is taken using equation 1 and stored again into another text file for further processing. Both the original image pixel text file and log transformed pixel value files are used during training process.

A. Artificial Neural Network

Pre-processed input and desired log transformed output image is used in the implemented machine learning model during training. We have selected back propagation neural network training algorithm to implement a multi layered neural network.

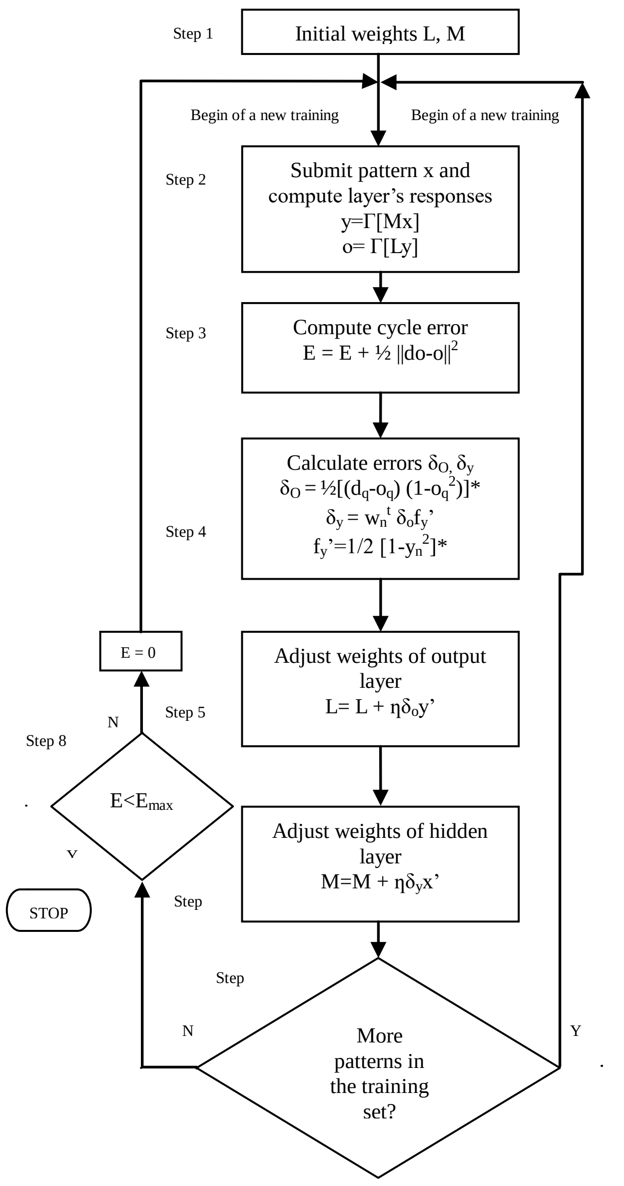

Fig. 2.Error back-propagation training algorithm [2]

B. Error Back-Propagation Training Algorithm:

It is a supervised learning method for training multilayer feed-forward neural network that models the function of log transformation as shown in the equation 1, by modifying the weights of input signals to generate an expected output signal at different layers of ANN. Here the error is calculated by finding the difference between system's output and a known expected output in order to back propagate it to the network and to modify the internal weights of the same [2].

$$o = c \log(x + 1) \qquad (1)$$

A standard network structure implemented in this paper is of input layer, one hidden layer, and an output layer. Below are the steps involved in error back-propagation training algorithm as shown in Fig. 2.

Steps in Error Back-Propagation Algorithm [2]:

$$\{x_1, do_1, x_2, do_2, \ldots, x_t, do_t\},$$

where x_p is $(P \times 1)$, do_p is $(Q \times 1)$, and $p = 1, 2, \ldots, t$.

Note that each x_p component value is taken as -1. Hidden layer of size N-1 having outputs y is selected. Note that each y_p is of value - 1; y is $(N \times 1)$ and o is of size $(Q \times 1)$.

Step 1: $\eta > 0$ and set maximum error E_{max}. Initialize weights L and M to some small random values; L is of size $(Q \times N)$ and M is $(N \times P)$. Initialize r = l, s = l, E = 0

Step 2: Input is presented and the layers output is computed using following formulas:

$_x = x_p$, do = do_p

$$y_n = f(l_n^t z), \text{ for } n = 1, 2, \ldots, N$$

where m_n is a column vector of M at n^{th} row and

$$o_k = f(m_k^t y), \text{ for } q = 1, 2, \ldots, Q$$

where l_k is a column vector of L at k^{th} row and Bipolar Activation Function used in (2) is

$$f(net) = \left(\frac{2}{1 + \exp(-\lambda net)}\right) - 1 \qquad (2)$$

And f(net) = +1, if net > 0 or f(net) = -1, if net < 0

Step 3: Error Calculation

$$E \leftarrow \frac{1}{2}(do_q - o_q)(do_q - o_q) + E, \; for q = 1,2,\ldots Q$$

Step4: δ_o and δ_y (error signal vectors) of both the layers are calculated. δ_o vector is of size $(Q \times 1)$ and $_y$ is $(N \times 1)$. The output layers error signal terms are

$$\delta_{ok} = 1/2(do_k - o_k)(1 - o_k^2), \text{ for } q = 1, 2, \ldots, Q$$

The hidden layers error signal terms are

$$\delta_{yn} = ½ (1 - y_n^2) \Sigma^K_{k=1} \delta o_k \times l_{kn} \quad \text{for } n = 1,2,\ldots, N$$

Step 5: Weight adjustments at Output layer:

$$l_{kn} = l_{kn} + \eta \, \delta_{ok} \, y_n, \text{ for } q = 1, 2, \ldots, Q \text{ and } n = 1, 2, \ldots, N$$

Step 6: Weight adjustments at Hidden layer:

$$m_{np} = m_{np} + \eta \, \delta_{yn} x_p, \quad \text{for } n = 1, 2, \ldots, N \text{ and } p = 1, 2, \ldots, P$$

Step 7: If s < t then increment s = s + 1 and r = r + 1 , and return back on Step 2 else jump on Step 8.

Step 8: Here the training cycle gets complete. If $E < E_{max}$ then end the training session and Output weights L, M, r, and E.

else If $E > E_{max}$, then initialize E = 0 and s = 1. Now start executing the new training cycle by returning back on Step 2.

II. EXPERIMENTATION RESULTS

Pixel value of a darker image and corresponding pixel value of the enhanced image is used as a dataset for error back propagation training. Sliding window of size 3×3 is used during feature extraction process. The multi layered neural network consist of an input layer with nine input nodes plus bias neuron, one hidden layer with three hidden nodes and an output layer with nine output nodes. Following are the steps carried out for generating the sample dataset:

Step 1: (3×3 sliding window sample)
144, 164,152
150,164,153
153,161,154

Step 2. Corresponding 3× 3 Log transform values for the given input vector using equation 1

24.88366871210287, 25.5297273695029,
25.15218960696217
25.08639918407462, 25.5297273695029,
25.18476301206815

25.18476301206815, 25.43798167616192,
25.21712558459623

Step 3. Matrix of 3×3 total nine values and its respective log transformed values are given as an input to algorithm as input vector and expected output vector respectively.

Step 4. Repeat step 3 iteratively to obtain all the input vectors and its desired log transformed output vectors.

A. Training and Testing

The first original RGB input image is shown in fig. 3 of size 375×500. Fig. 4 is the 8 bit gray scaled input image and fig. 5 is provided as a desired output image to the machine learning algorithm for training. Total 20750 input vectors each of size nine are generated and applied to the machine learning algorithm. Fig. 6 shows the output received from the implemented machine learning algorithm (using C programming language) after a rigorous training for about 300 iterations for 3×3 moving window size. The learning constant η is selected as 1.0, gain factor λ of the continuous bipolar activation function is selected as 1.0 and used for the experimentation. Error graph showing error value for different levels of iteration is shown in fig. 7.

Fig. 3.First Original Input Image

Fig. 4.First original image to gray scale image

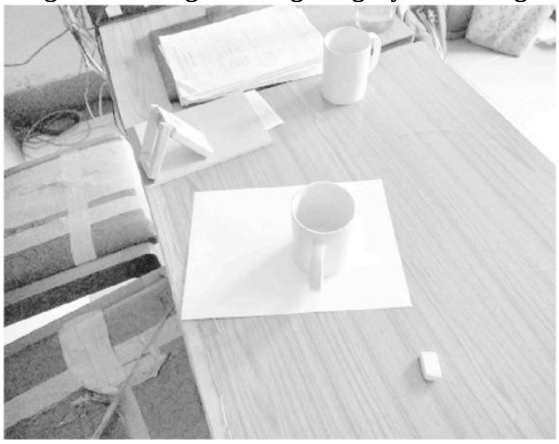

Fig. 5.Desired Log Transformed output image for first input image

Fig. 6.Output of implemented ANN for first input image

The Signal to Noise Ratio (SNR) between input image fig.4 and desired output image fig.5 is noted as 0.7121 where as 0.3813 between input image fig.4 and current output image fig.6.

Mean Square Error (MSE) between input and desired output image is noted as 1.3132e+04 where as MSE between input and current output image is noted as 1.3574e+04.

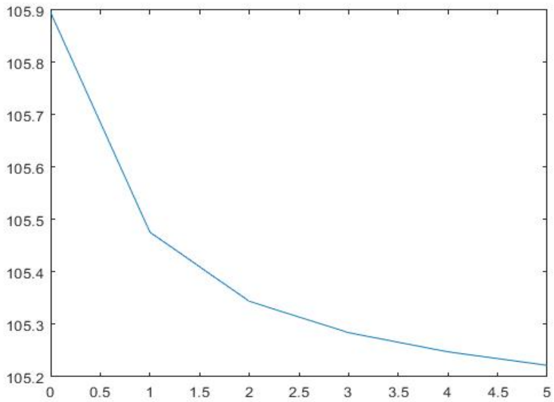

Fig.7. Error graph for first input image

The second original RGB input image is shown in fig. 8 of size 153 × 204. Fig. 9 is the gray scaled input image and fig. 10 is provided as an expected output image to the ANN for training. Total 3468 input vectors each of size nine are generated and applied to the machine learning algorithm. Fig. 11 shows the output received from the implemented machine learning algorithm (using C programming language) after a rigorous training for about 300 iterations for 3 × 3 moving window size. The learning constant η is selected as 1.0, gain factor λ of the continuous bipolar activation function is selected as 1.0 and used The error graph showing error values with respect to each iteration is shown in fig. 12.

Fig. 8.Second Original Input Image

Fig .9.Second original image to gray scale image

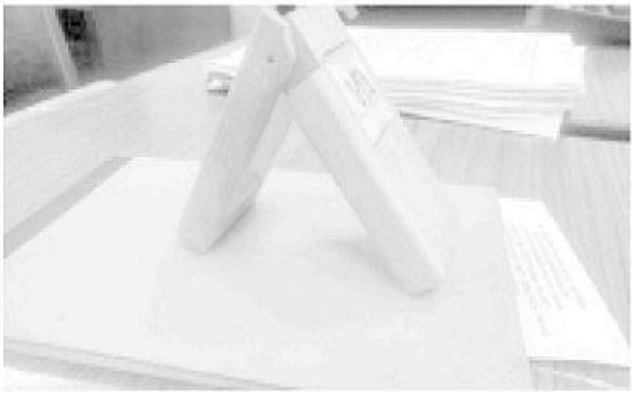

Fig. 10.Desired Log Transformed output image for second input image

Fig. 11.Output of implemented ANN for second input image

The Signal to Noise Ratio (SNR) between input image fig.9 and desired output image fig.10 is noted as 0.6206 where as 0.3985 between input image fig.9 and current output image fig.11. Mean Square Error (MSE) between input and desired output image is noted as 2.2663e+04 where as MSE between input and current output image is noted as 2.3172e+04.

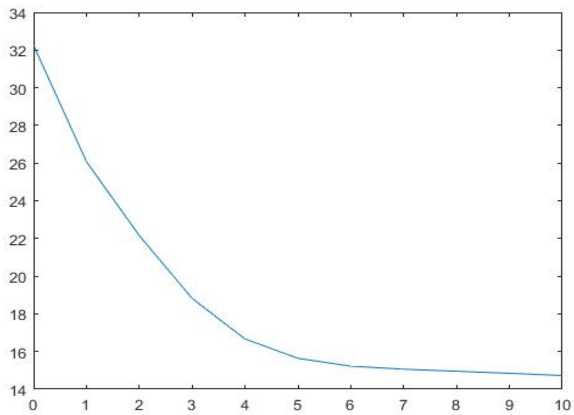

Fig. 12.Error graph for second input image

The Third original RGB input image is shown in fig. 13 of size 225 × 400. Fig. 14 is the gray scaled input image and fig. 15 is provided as an expected output image to the ANN for training. Total 9975 input vectors each of size nine are generated and applied to the machine learning algorithm. Fig. 16 shows the output received from the implemented machine learning algorithm (using C programming language) after a rigorous training for about 300 iterations for 3 × 3 moving window size.

The learning constant η is selected as 1.0, gain factor λ of the continuous bipolar activation function is selected as 1.0 and used for the experimentation. Error graph showing error values per iteration is shown in fig. 17.

Fig. 13.Third Original Input Image

Fig. 14.Third original image to gray scale image

Fig. 15.Desired Log Transformed output image for third input image

Fig. 16.Output of implemented ANN for third input image

Table I: Performance Measures

Sr. no.	Output Images	SNR	MSE
1	First Output Image	0.3813	1.3574e+04
2	Second Output Image	0.3985	2.3172e+04
3	Third Output Image	0.3945	2.2068e+04

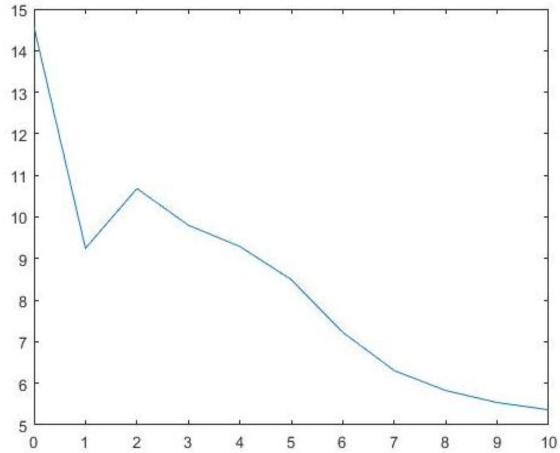

Fig. 17.Error graph for Third input image

The Signal to Noise Ratio (SNR) between input image fig.14 and desired output image fig.15 is noted as 0.6135 where as 0.3945 between input image fig.14 and current output image fig.16. Mean Square Error (MSE) between input and desired output image is noted as 2.1590e+04 where as MSE between input and current output image is noted as 2.2068e+04. Table I depicts all the performance measures drawn out for all the output images.

III. CONCLUSION

This research paper demonstrates ability of log transformation in non parametric way to improve dark/ shadow region in an image. This proposed novel approach to enhance shadow region has the generalization ability and hence suitable for different type of image performance of the proposed framework can be improved by using additional hidden layers as well as more optimized parameters. This technique is more suitable as a pre-processing methodology by information extraction of dark/shadow portions of an image under consideration.

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