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# Analysis of Morphology Based Block By Block Image Enhancement

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## Abstract

Analysis of Morphology based block by block image enhancement was deliberated. For this, Image contrast was defined with the assistance of approximated Weber's law, which relates the perceived brightness of an object to the brightness of its background. Here, Image is divided into number of small blocks and each block was enhanced by morphological operator. This deliberated algorithm avoids the abrupt change in background illumination and gives good enhanced image. Assess with Histogram Equalization enhancement method, the methodology discussed in this paper is appropriated in enhancement and visual perception. For evaluation, enhanced images are characterized to contrast assessment through Contrast Improvement Index which exploits significant in enhanced image. Further this block by block enhancement analysis was extended in the view of divergent block size.

**Keywords:** Weber's law, Mathematical Morphology, Histogram Equalization, Contrast Improvement Index,

## Introduction

Contrast enhancement is commonly exploited in image preprocessing algorithm. Existing enhancement approaches fall into two broad categories: spatial domain methods and frequency domain methods. The spatial domain techniques have gained more popularity as they are based on direct manipulation of pixels in an image and are straightforward for visualizing the effect. Based on this objective, several spatial domain methods have been developed. Some of the methods make use of simple linear/non-linear intensity level transformation functions whereas others use complex analysis of different image features. Application of wavelets to image processing and computer vision problems are sometimes slowed down by its linearity. Coarsening an image by means of linear operators may not be well-suited with some image attributes. Hence use of linear procedures may be inconsistent in such applications. The growing understanding is, the linear approaches for image enhancement are not well suitable or even fail to solve problems involving geometrical aspects of the image. Thus there is a need for nonlinear approaches.

There are many non-linear methods were proposed. A well known technique for image enhancement is histogram processing, i.e., histogram modification and equalization. In case of gray-level image contrast enhancement, different logic has performed earlier on HE. Generally, these methods are classified into two principle categories; global and local HE. Global HE (GHE) uses the information of the entire input image for its transformation function. Hence this approach is suitable only for overall enhancement; and fails to adapt the local brightness features of the input image and shifts the mean intensity to the middle intensity level, regardless of the input mean intensity. Thus it appears to be inappropriate for consumer electronic products. Local HE (LHE) can remove the local brightness problem; but not adapted well to partial light information [5],[7], [13], still it over-enhances some portions depending on mask size, and sliding mask mechanism makes the LHE computationally expensive. With the technological advancements in processing power, the speed is no longer a problem. The LHE still faces difficulty with amplified noise and an unnatural output due to over-enhancement. Another approach is to apply a partially overlapped or non-overlapped block based HE. These two methods are widely used in various applications for global image enhancement [1]–[4], [15],[18],[19]. But its output is depends on the input. Despite its success for image contrast enhancement, this technique has a well-known drawback: it does not preserve the image background contrast. So it is not suited to implement in consumer electronics [6]. During the histogram equalization process, grey level intensities are reordered within the image to obtain a uniform distributed histogram [8]. However, the main disadvantage of histogram equalization is that the global properties of the image cannot be properly applied in a local context [9], nonetheless, most of the time; these methods produce undesirable checkerboard effects on enhanced images. Histogram Specification is used to achieve highlighted gray level ranges, i.e., the original histogram is transform into a specific histogram. However, to determine the most suitable specific histogram is not possible by general rule [10].

Mathematical Morphology (MM) is a nonlinear methodology was introduced, which successfully solve the above problems. MM considers images as geometrical objects rather than as elements of a linear (Hilbert) space. Similarly MM is a tool for extracting image components that are useful for representation and description. The technique was originally developed by Matheron and Serra. It is a set-theoretic method of image analysis providing a quantitative description of geometrical structures. Then it is evolved rapidly in to a general theory of shape and its transformations, and was applied in particularly to image processing and pattern recognition [11]. Also it is a theory and technique for the analysis and processing of geometrical structures, based on set theory, lattice theory, topology, and random functions. MM is most commonly applied to digital images, but it can be employed as well on graphs, surface meshes, solids, and many other spatial structures. Further, it can provide boundaries of objects, their skeletons, and their convex hulls. So the morphological processing could be directly interpreted in the spatial domain and more intuitive to human perception of shapes and sizes than the frequency domain analysis.

It is also useful for many pre- and post-processing techniques. Digital image processing is subjected to filtering processes during the pre-processing. Morphological techniques are significantly faster than linear filtering techniques [12]. It reduces the memory requirements for hardware implementation. Similarly linear filtering processes could have undesired effects on the resultant images and the Natural Image Quality (details) Evaluation may be lost. Morphological processing preserves the same. In this review process, Section II elaborate Weber's Law in Image Processing and defines contrast of an object in image. At section III, block by block Image Enhancement was carried. In section IV, Morphology based block by block Image Enhancement was analyzed with different aspect. Further discussions are made based on the visual perception and some referred assessment parameters.

## Weber's Law

It describes the relationship between the physical magnitudes of stimuli and the perceived intensity of the stimuli. Alternatively, this law can define by measuring the difference between two visual stimuli. It is similar to Fechner's law which states that subjective sensation is proportional to the logarithm of the stimulus intensity. This law suggests that for a stimulus, the ratio between the smallest perceptual change and the background is constant. i.e., $\Delta I_{\min}/I$ is constant. From this assistance, the contrast $C$ of an object with its maximum luminance ($L_M$) against its surrounding luminance ($L_m$) is defined [10] as:

$$C = (L_M - L_m)/L_m \quad (1)$$

If $L_m = L, \quad \Delta L = L_M - L_m;$

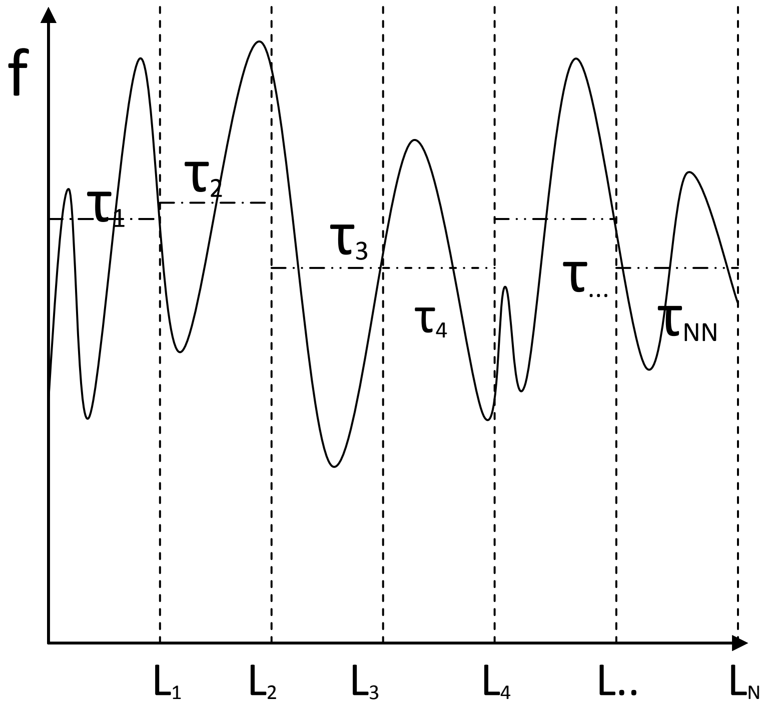
Then (1) can be written as $C = \Delta L/L$, By taking the luminance L as the grey level intensity of a function (image); $\Delta(\log L)$ is proportional to $C$ ; then with the logarithmic relation, Weber's law is approximated as

$$C = k\log(L) + b \qquad L > 0 \quad (2)$$

Where C is the contrast, k and b are constants, b being the background parameter and k being the scaling factor for enhancement. In our case, consider luminance L as a grey level intensity function *f* (image); in this way, expression (2) is written as

$$C = k\log(f) + b \qquad f > 0 \quad (3)$$

This contrast definition is used in image enhancement method to preserve the background information effectively.




## Block By Block Image Enhancement:

In this technique, Image is divided into number of blocks and each block was enhanced based on Weber's law based contrast definition. In block by block enhancement technique [14], the background parameter in (3), was computed by considering the average between the maximum and minimum intensity. The image *f(x)* is divided into 'n' blocks (Each block is a sub image of original image). The minimum (smallest minimum- $m_i$) and maximum (largest maximum- $M_i$) intensity values in each sub-image are used to determine the background parameter in the following way:

$$\tau_i = \frac{M_i + m_i}{2} \qquad \forall i = 1,2,,3.....n. \tag{4}$$

In each block, once $\tau_i$ is calculated, this value is used to select the background parameter associated with the analyzed block. Then contrast was enhanced by

$$\Gamma_{\tau_i}(f) = \begin{cases} k_i \log(f+1) + M_i & f \le \tau_i \\ k_i \log(f+1) + m_i & else \end{cases} \tag{5}$$

Note that the background parameter depends on the $\tau_i$ value. If $f \le \tau_i$ (dark region), the background parameter takes the maximum intensity value within the analyzed block, otherwise minimum intensity value. Also, the unit was added to the logarithm function in (5) to avoid indetermination. Since grey level images are used in this paper, the constant $k_i$ is obtained as follows:

$$k_i = \frac{255 - m_i^*}{\log(256)} \quad \forall i = 1,2,3,\ldots\ldots n$$

$$m_i^* = \begin{cases} M_i & f \le \tau_i \\ m_i & else \end{cases} \tag{6}$$

However, this enhancement procedure was carried by the following way. Initially test image was divided into four sub-images. Each sub images are enhanced by the said procedure. As a result, the contrast is not correctly enhanced for poor lighting image background, so considerable changes occur in the image background due to abrupt changes in luminance. As well as this enhancement process is similar to a contrast mapping [12].

## Morphology Based Block By Block Enhancement:

Let the grey level intensity function *f* be a function on $Z^2$, and *B* is a fixed structuring element. Erosion and Dilation are the basic operation in MM. Then remaining operations are derived from the combination of basic operation. The morphological erosion and dilation defined by the order-statistical filters [16,20]. Erosion of *f* by a flat structuring element *B* at any location *(x, y)* is defined as the minimum value of the image in the region co-incident with *B* when the origin *B* is at *(x, y)*. Therefore the erosion at *(x, y)* of an image *f* by a structuring element *B* is given by *x* and *y* are incremented through all values required so that the origin of *B* visits every pixel in *f*.

$$\varepsilon(f(x)) = \min_{s,t \subseteq B} \{ f(x+s, y+t) \} \tag{7}$$

That is, to find the erosion of *f by B* we place the origin of the structuring element at every pixel location in the image. The erosion is the minimum value of *f* from all values of *f* in the region of *f* coincident with *B*. Dilation of *f* by a flat structuring element *B* at any location *(x, y)* is defined as the minimum value of the image in the region co-incident with *B* when the origin *B* is at *(x, y)*. Therefore the dilation at *(x, y)* of an image *f* by a structuring element *B* is given by *x* and *y* are incremented through all values required so that the origin of *B* visits every pixel in *f*.

$$\delta(f(x)) = \max_{s,t \subseteq B} \{ f(x-s, y-t) \} \tag{8}$$

That is, to find the dilation of *f by B* we place the origin of the structuring element at every pixel location in the image. The dilation is the maximum value of *f* from all values of *f* in the region of *f* coincident with *B*. Thus $M_i, m_i$ values are obtained [17] by morphological erosion and dilation and (4) is proposed as

$$\tau(x) = \frac{\varepsilon(f(x)) + \delta(f(x))}{2} \tag{9}$$

By this extended procedure, contrast operator in (5) is define as [21],

$$\Gamma_{\tau(x)}(f) = \begin{cases} k_{\tau(x)} \log(f+1) + \delta(f)(x) & f \leq \tau_i \\ k_{\tau(x)} \log(f+1) + \varepsilon(f)(x) & else \end{cases} \quad (10)$$

$$where \qquad k_{\tau(x)} = \frac{255 - \tau(x)}{\log(256)}$$

A restricted examination was carried to enhance the image by (10). In this proposed method, the structuring element *B* allows set of neighboring pixels at each pixel. So that, this procedure avoids the abrupt changes in background illumination. Here enhanced images were obtained with square structuring element with size 3*X*3. Here also, initially image function *f* is divided into four and enhanced using the above said morphology based transformation. As a result, the abrupt changes are eliminated in image background.

**Figure 1a:** Input Test Image (Image ID 71b.pgm)

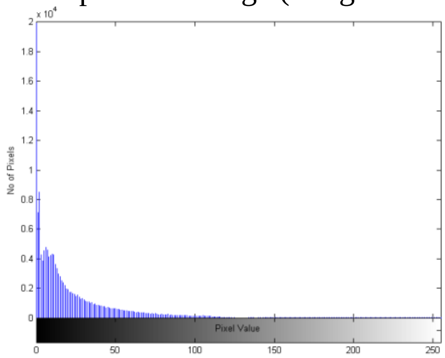
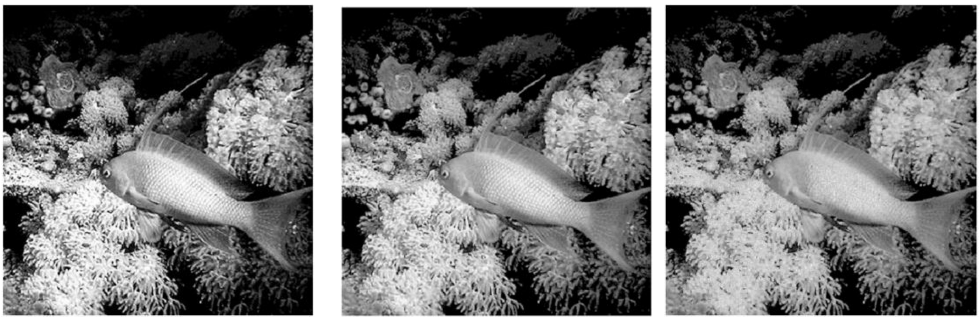



**Figure 1b:** Histogram of Test Image

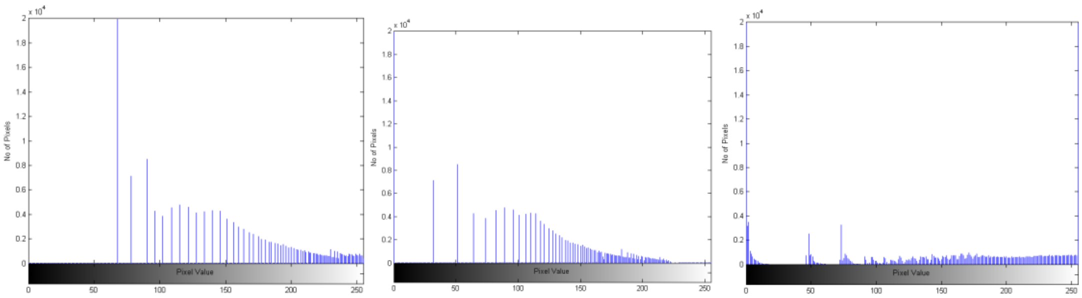
## Result and Discussion:

In this section, analysis of the proposed, histogram equalization (HE), and simple Weber's law based block by block methods are presented. A subjective assessment to compare the visual quality of the images is carried out. Natural image quality evaluator (NIQE) index and Contrast Improvement Index (CII) were used to evaluate the effectiveness of the proposed method. The test images used for the experiments are available on the website http://decsai.ugr.es/cvg/dbimagenes/. Notice that, the input test image (Image Id 71b.pgm) and the relevant histogram are given in given in figure 1(a) & 1(b). Figure 2 is the follow-on images obtained by the existing methods and proposed method for the same test image.



(a) (b) (c)

**Figure 2:** Simulation results of Test Image (Image ID 71b.pgm). (a) Histogram Equalization Method, (b) Block by Block Enhancement Method, (c) Morphology based Block by Block Enhancement Method



(a) (b) (c)

**Figure 3:** Histogram of Simulated Test Image (Image ID 71b.pgm). (a) Histogram Equalization Method, (b) Block by Block Enhancement Method, (c) Morphology based Block by Block Enhancement Method

Figure 3 represent the histograms of all resultant images. Figure 2(a) is HEed image gives enhancement with noise and visual inferiority. Figure 2(b) illustrates block by block analysis with block size is 4, In this procedure, the intensity levels are stretched with respect to the behavior of logarithm function and the background parameter. In block based analysis, the abrupt changes in background illumination are avoided but over enhancement produce poor NIQE. Figure 2(c) the proposed block analysis with block size 4, is prove that the proposed morphology based block by block enhancement has more natural looking and provide significant improvement in image contrast enhancement. Additionally a better local analysis was achieved in this procedure and the resultant images are appropriated in quality metrics. The histograms of all resultant images are illustrated in Figure3, The output histograms of Figure 3 (a) HEed and Figure 3(b) Block by Block Enhancement are fail to achieve distribution at low and high gray levels. Thus, the enhancement results of HEed and Block by Block Enhancement are visually unpleasing. By visually inspecting, Figure 3(c) proposed method achieves a smoother and uniform distribution at gray values. So that, Morphology based block by block image enhancement leads to superior visual representation in visual comparison. This method was tested with several gray scale images and had been compared with other conventional methods.

**Table 1:** NIQE Value for enhanced images

| Method | Histogram Equalization | Bl. by Block enhancement | Morphology Based |
|---|---|---|---|
| flight | 9.5484 | 10.1615 | **7.7638** |
| Fish | 10.3041 | 10.1789 | **7.7540** |
| Build | 7.2801 | 7.2755 | **6.9577** |
| Girl | 6.8395 | 6.4087 | **5.5197** |
| Tower | 6.8303 | 6.4738 | **6.1125** |
| Man | 5.6081 | 7.1241 | **5.3062** |

**Table 2:** CII Value for enhanced images

| Method | Histogram Equalization | Bl. by Block enhancement | Morphology Based |
|---|---|---|---|
| flight | 0.7260 | 1.3572 | **1.3572** |
| Fish | 0.7692 | 1.0119 | **1.0616** |
| Build | 0.9959 | 1.0036 | **1.0430** |
| Girl | 0.9588 | 0.8620 | **1.6667** |
| Tower | 0.9388 | 1.2712 | **1.2829** |
| Man | 0.8168 | 0.8000 | **0.9124** |

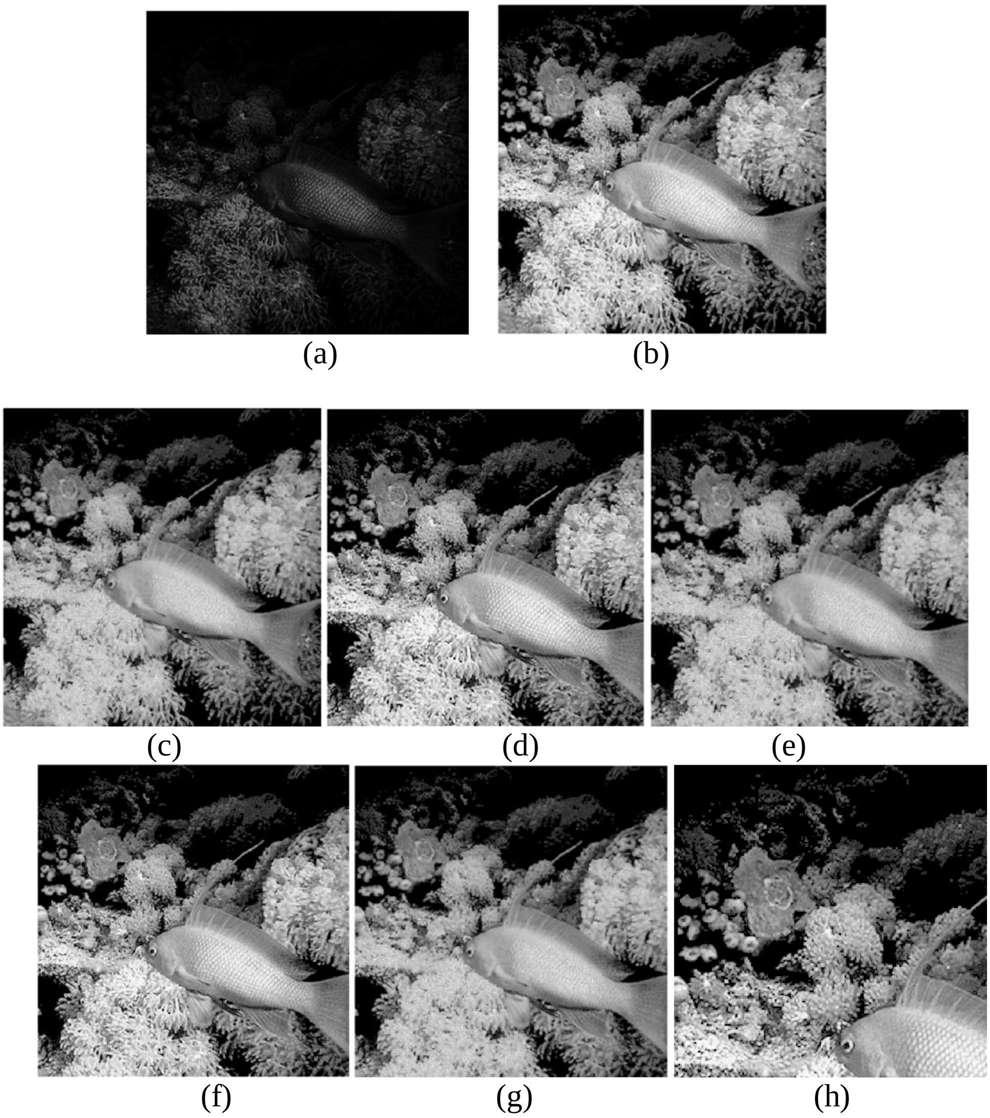



**Figure 4:** (a) Input Test Image (Image ID 71b.pgm ), (b)-(h) Simulation results of Enhanced Test Image with various block size. (b)Size-2. (c) Size-4. (d) Size-8. (e) Size-16. (f) Size-32. (g) Size-64. (h) Size-128.

From the table 1&2, the morphology based Block by Block image enhancement provide good visual perception and enhanced contrast. This may be defensible from the lesser NIQE value and larger CII value. Further, this block by block enhancement analysis was extended in the view of block size variations. From fig.4, If block size was increased which leads to more information content in the resultant image. But higher block size enhancement procedure increases the resultant image size. If consumer's electronic goods reconstruct the enhanced image in a same memory size, which may produce loss of information content. With reference to figure 4, Enhanced with smaller block size, producing almost same result. When the size is comparatively high, the tail end portions are eliminated in enhanced image. In a lower block size, dividing an image by four is simple procedure. So in all the cases, the given image is divided into four sub images and performs the morphology based block by block image enhancement.

## Conclusion

This Morphology based block by block procedure was suitable in image enhancement and good in local analysis too. This enhancement method gives sharp natural looking for resultant images. Further it does not introduce any artifacts. Experimental result shows that the morphology based method is effective for grayscale images. The simulation over large number of test images shows that, this procedure preserves content and gives natural appearance of the images. Due to these desirable reasons the morphology based method is suitable for consumer electronic equipments. This method can be used for medical images, remote sensing satellite images, microscopic images and photographic pictures suffer from poor contrast problems during its acquisition.

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