Morphological Background Detection & Enhancement of Images

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Abstract- **The paper deals with detection and the enhancement of images which contains poor lighting. Using the Mathematical Morphological Transformations. If an image captured the background is not clear of that image, by using the morphological operations we can detect the background of the image and enhance the image. Weber's law is used to analyse the blocks and utilizing the opening by reconstruction to define the Multibackground notion. Some Morphological operations such as (Erosion, Dilation, Compound operation such as Opening by reconstruction, Erosion-Dilation method) and Block Analysis is used to detect the background of images. Analysis of above mention methods illustrated through the processing of images with different dark background images.**

*Keywords-***Block Analysis; Erosion-Dilation Method; Opening By Reconstruction; Opening Operation; Weber's Law Notion;**

I.   INTRODUCTION

In this Paper the concept is to detect the background in images in poor lighting. Various Mathematical Morphology [MM] is used to enhance digital images with poor lighting condition [1]. Mathematical morphology approach is based on set theoretic concepts of shape. In morphology, Objects present in an image are treated as sets. There are standard techniques like histogram equalization histogram stretching for improving the poor contrast of the degraded image. In the First method the background images in poor lighting of grey level images can identified by the use of morphological operators. Lately image enhancement has been carried out by the application based on Weber's Law [2]. Later on erosion, dilation, Opening (erosion followed by dilation), closing (dilation followed by erosion) and opening by reconstruction method is followed. In this paper, firstly we give introduction about various morphological operators and then we apply them on a bad light image and extract the background of that image and then improve contrast of that image [3].

Contrast Enhancement

The goal of Image enhancement include the improvement of the visibility and perceptibility of the various regions into which an image can be partitioned and of the detect ability of the image features inside the regions. These goals include tasks such as cleaning the image from various types of noise enhancing the contrast among adjacent regions or features, simplifying the image via selective smoothing or elimination of features at certain scales and retaining only features at certain desirable scales. Image enhancement is usually followed by (or is done simultaneously with) detection of features such as edges, peaks, and other geometric features which is of paramount importance in low-level vision. Further, many related vision problems involve the detection of a known template; such problems are usually solved via template matching [13].

Histogram Equalization

Histogram equalization method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. Histogram equalization often produces unrealistic effects in photographs; however it is very useful for scientific images like thermal, satellite and the x-ray images, often the same class of images that user would apply false-color to. Also histogram equalization can produce undesirable effects (like visible image gradient) when applied to images with low colour [8].

*Limitations:-*The main limitation of histogram equalization is that the global properties of the image cannot be properly applied, and it produces very poor performance. It may increase the contrast of background noise, while decreasing the usable signal.

II.   MORPHOLOGICAL TRANSFORMATION AND WEBER'S LAW

Morphology: - Morphology is a technique of image processing based on shapes. The value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbours. By choosing the size and shape of the neighbourhood, morphological operation can be constructed that is sensitive to specific shapes in the input image [5] [6] [7].

Mathematical Morphology: -

Mathematical Morphology is a new approach to signal/image analysis, using nonlinear pictorial transformations and functional derived from set theory and integral geometry. As a result, Morphological Filters are powerful tools for geometrical shape analysis and description and their applications in image processing and analysis are numerous.

Mathematical morphology is a set-theoretical approach to multi-dimensional digital signal or image analysis, based on shape. It is a theory and technique for the analysis and processing of geometrical structures, based on set theory, lattice theory, topology, and random functions. It is most commonly applied to digital images, but it can be employed as well on graphs, surface meshes, solids, and many other spatial structures [6].

a. *Definitions of Some Morphological Transformations:*

In mathematical morphology, increasing and idempotent transformations are frequently used. Morphological transformations complying with these properties are known as morphological filters.[17] [18] [19] The basic morphological filters are the morphological opening $\gamma_{\mu B}(f)(x)$ and closing $\varphi_{\mu B}(f)(x)$ using a given structural element. A morphological Opening smoothes only white details whereas Morphological Closing smoothes the dark details. In this paper, a square structuring element is employed, where B represents the structuring element of size 3×3 pixels, which contains its origin. While B is the transposed set $\left(\tilde{B} = \{-x : x \in B\}\right)$ and μ is a homothetic parameter .

$$\gamma_{\mu B}(f)(x) = \delta_{\mu B}(\varepsilon_{\mu B}(f))(x) \quad \text{...... (1)}$$

$$\varphi_{\mu B}(f)(x) = \varepsilon_{\mu B}(\delta_{\mu B}(f)(x) \quad \text{...... (2)}$$

Where the morphological erosion $\varepsilon_{\mu B}$ (f) (x) and morphological dilation $\delta_{\mu B}(f)(x)$ are

$\varepsilon_{\mu B}$ (f)(x) $= \bigwedge\{f(y) : y \in \mu \mathcal{B}x \}$ and

$\delta_{\mu B}(f)(x) = \bigvee\{f(y) : y \in \mathcal{B}x\}$, respectively.

Here, $\bigwedge$ is the inf operator and $\bigvee$ is the sup operator. On the other hand, throughout the paper, we will use either size 1 or size for the structuring element. Size 1 means a square of 3×3 while size means a square of $(2\mu + 1)(2\mu + 1)$. For example, if structuring element is size 3, then the square will be 7×7 pixels, to render an analysis of 49 neighbouring regions. For any size of the structuring element, the origin is located at its centre.

b. Weber's Law:
The luminance of an object (the amount of light that passes through or is emitted from a particular area)

is independent of the luminance of the surrounding objects. [12][14].

In psycho-visual studies, the contrast C of an object with luminance L_{max} against its surrounding luminance L_{min} is defined as follows:

$$c = \frac{L_{max} - L_{min}}{L_{min}} \qquad (3)$$

If $L = L_{max}$ and $\Delta L = L_{max} {}_{-L_{min}}$ can be written as

$$C = \frac{\Delta L}{L} \qquad (4)$$

The above equation indicates that $\Delta(log\, L)$ is proportional to C; therefore, Weber's law can be expressed as [5].

$$C = k log L + b \qquad L>0 \qquad (5)$$

Where 'k' and 'b' are constants, 'b' being the background.

In this case, an approximation to Weber's law is considered by taking the luminance L as the grey level intensity of a function 'f'(Image).
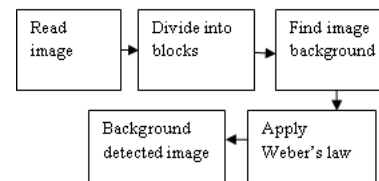
III. IMAGE BACKGROUND APPROXIMATION BY BLOCKS

Fig1: Block Diagram of Background Detection by Block Analysis.

In block analysis approximation the image f is divided into several blocks, the each block is the sub-image of the original image. Considering D as the digital space under study, with $D=Z^2$ and Z is the integer set. In this way, let D be the domain of definition of the function.

The image f is divided into n blocks of size $l_1 * l_2$.

$$m_i = \bigwedge w^i(x) \qquad \forall_x \in D_{w^i} \subseteq D \qquad (6)$$

$$M_i = \bigvee w^i(x) \qquad \forall_x \in D_{w^i} \subseteq D \qquad (7)$$
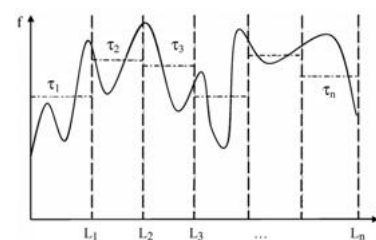

Fig2: Background Criteria Obtained by Block Analysis.

For the each analyzed block the maximum M_i and minimum m_i intensity values will be used to determine the Background Criteria as follows.

$$\tau_i = \frac{m_i + M_i}{2} \qquad \forall_i = 1,2......,n \qquad (8)$$

$$\Gamma_{\tau i}(f) = \begin{cases} k_i \log(f+1) + M_i, & f \le 1 \\ k_i \log(f+1) + m_i, & otherwise \end{cases} \qquad (9)$$

The value τ_i represents a division line between clear and dark intensity levels. This value is used to select the background parameter associated with the analyzed block. If $f \le \tau_i$ (dark region), the background parameter takes the value of the maximum intensity M_i, within the analyzed block, and the minimum intensity m_i, value otherwise. By equation 10 we will be able to detect the background of the image.

$$k_i = \frac{255 - m_i^*}{\log(256)} \qquad \forall i = 1,2,......,n \qquad (10)$$

Where $\quad m_i^* = \begin{cases} m_i, & f > \tau_i \\ M_i, & f \le \tau_i \end{cases} \qquad (11)$

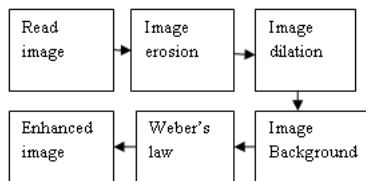## IV. IMAGE BACKGROUND ANALYSIS USING OPENING BY RECONSTRUCTION

Fig3: Background approximation by opening by reconstruction.

Image Erosion: It is used to reduce objects in the image and known that erosion reduces the peaks and enlarges the widths of minimum regions. So it can remove positive noises but affect negative impulsive noises little.The erosion of the binary image *A* by the structuring element *B* is defined by:
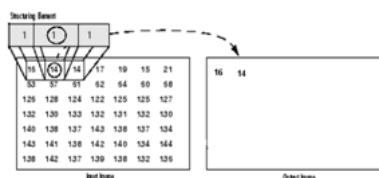
$$A \oplus B = \underset{b \in B}{\cup} A_b$$

Fig4: Erosion of a Grayscale Image.

Image Dilation:

Dilation is a transformation that produces an image that is the same shape as the original, but is a different size. It stretches or shrinks the original figure. The dilation of *A* by the structuring element *B* is defined by:
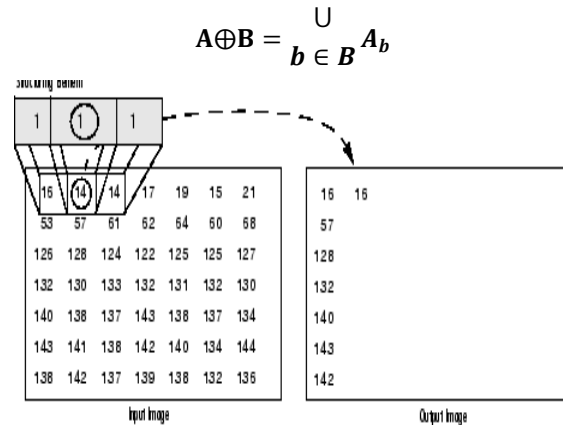
$$A \oplus B = \underset{b \in B}{\cup} A_b$$

Fig5: Dilation of a Gray scale Image.

Structuring Element:

An essential part of the dilation and erosion operations is the structuring element used to probe the input image. A structuring element is a matrix consisting of only 0's and 1's that can have any arbitrary shape and size.

The pixels with values of 1 define the neighbourhood. Two-dimensional, or flat, structuring elements are typically much smaller than the image being processed. The centre pixel of the structuring element, called the origin, identifies the pixel of interest the pixel being processed. The pixels in the structuring element containing 1's define the neighbourhood of the structuring element. These pixels are also considered in dilation or erosion processing.

Image Opening: Removes pixels on object boundaries (the morphological erosion is called opening). The opening of *A* by *B* is obtained by the erosion of *A* by *B*, followed by dilation of the resulting image by *B*.

$$AoB = (A!B) \oplus B$$

Image Closing: Adds pixels to the boundaries of objects in an image (the morphological dilation is called opening). The closing of *A* by *B* is obtained by the dilation of *A* by *B*, followed by erosion of the resulting Structure by *B*:

$$A \bullet B = (A \oplus B)! \, B$$

In our case, let $I_{max}(x)$ and $I_{min}(x)$ be the maximum and minimum intensity values taken from one set of pixels contained in a window (B) of elemental size (3×3 elements), $x \in D$. Notice that the window corresponds to the structuring element B. For the sake of simplicity, let us consider

$$I_{max}(x) = \max\{f(x+b): b \subseteq B\} \text{ and}$$

$I_{min}(x) = \min\{f(x+b): b \subseteq B\}, x \in D$.Then, from (9), a new expression is derived

$$\tau_{(x)} = \frac{I_{min} + I_{max}}{2} \qquad (12)$$

Where $I_{max}(x)$ and $I_{min}(x)$ values correspond to the morphological dilation and erosion defined by the order-statistical filters. Thus, (12) is expressed as

$$\tau_{(x)} = \frac{\varepsilon_{\mu B}(f)(x) + \delta_{\mu B}(f)(x)}{2} \qquad (13)$$

If morphological erosion or dilation is used with large sizes of to reveal the background, inappropriate values may be obtained. However, in Mathematical Morphology, there is other class of transformations that allows the filtering of the image without generating new components; these transformations are called transformations by reconstruction. In our case, the opening by reconstruction is our choice because touches the regional minima and merges regional maxima.[20][21].

$$\tau_{(x)} = \check{\gamma}\mu B \,(f)(x) \qquad (14)$$

In the below figure the background touches only regional minima, while the other regions contain local information of the original function. From these extreme points and the local information provided by the original function (in other words the background), important information about the image can be acquired. When considering the opening by reconstruction to detect the background, one further operation is necessary to detect the local information given by the original function. The morphological transformation proposed for this task is the erosion size μ=1, i.e.

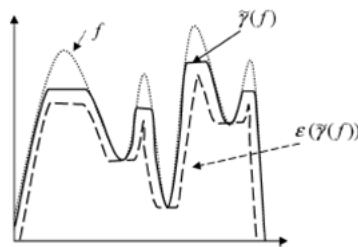*Fig6: Image background obtained from the erosion of the opening by reconstruction.*

$$b(x) = \varepsilon_1[\check{\gamma}\mu(f)]x \qquad (15)$$

It can be observed from the above equation that opening by reconstruction first erodes the input image and uses it as a marker. Here marker image is defined because this is the image which contains the starting or seed locations. For example, here the eroded image can be used as the marker. Then dilation of the eroded image i.e. marker is performed iteratively until stability is achieved. The following expression derived from equation 5 is proposed to enhance the contrast in images with poor lighting.

$$\xi\check{\gamma}_\mu(f) = k_x \log(f + 1) + \varepsilon_1[\check{\gamma}\mu(f)]x \qquad (16)$$

$$k_{(x)} = \frac{maxint - \varepsilon_1[\check{\gamma}\mu(f)]}{\log(maxint+1)} \qquad (17)$$

In our case, the maximum grey level is

$$maxint = 255.$$

If the background image increases, the image tends to become lighter due to the additive effect of the image background. Formally, we have

$$\lim_{\varepsilon_1[\check{\gamma}\mu(f)]x \to maxint} \xi\check{\gamma}_\mu(f) = maxint \qquad (18)$$

The objective of opening by reconstruction to maintain the shape of the image components that remains after erosion.

V.   IMPLEMENTATION RESULTS

By considering the structuring element 'μ' value in the above equations like 16 and 17 and we will get the desired output, taking different values of 'μ' the changes are observed. If 'μ' value is 20,50 and 100 the output is given below
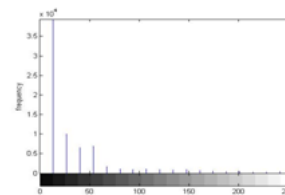

Fig 7(a): Original Image with μ=20.

Fig 7(b): Histogram of the original Image with μ = 20.
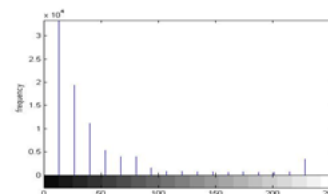

Fig 7(c): Background Detected Image with μ=20

Fig 7(d): Histogram of the Background Detected Image with μ = 20.

Fig 7(e): Enhanced Image with µ=20.

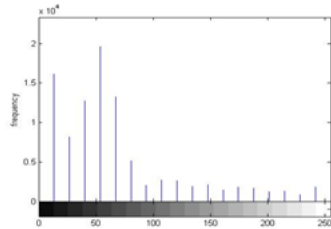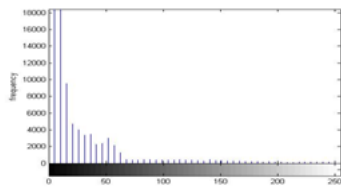*Fig 7(f): Histogram of the Enhanced Image with µ = 20.*

Fig 7(g): Original Image with µ=50.

Fig 7(h): Histogram of the original Image with µ = 50.

Fig 7(i): Background Detected Image with µ=50.

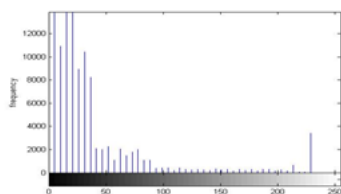

Fig 7(j): Histogram of the Background Detected Image with µ = 50.
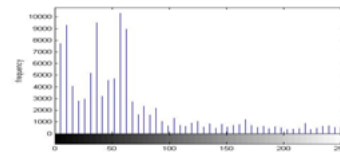

Fig 7(k): Enhanced Image with µ=50.

Fig 7(l): Histogram of the Enhanced Image with µ = 50.

Fig 7(m): Original Image with µ=100.

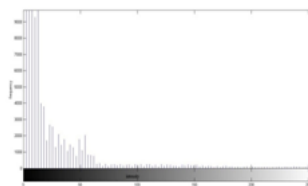*Fig 7(n): Histogram of the original Image with µ=100.*
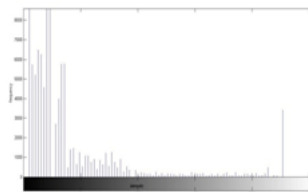

Fig 7(o): Background Detected Image with µ=100.

Fig7 (p): Histogram of the Background Detected Image with µ=100.

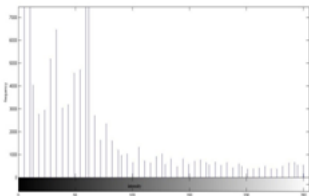***Fig 7(q): Enhanced Image with µ=100.***

Fig 7(r): Histogram of the Enhanced Image with µ=100.

VI.   CONCLUSION

For detecting the background images and to enhance the contrast in grey level with poor lighting conditions, various methodologies were introduced. Based on Weber's law notion, firstly Image detection is carried out by simple block analysis. Finally Opening by reconstruction is used to analyze multi background definition of images and to enhance the background images.

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