# Non Uniform Illumination Reduction Using Morphological Dilation and Erosion for Area Based Statistics Computation

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***Abstract*—Non Uniform Illumination in an image often leads to diminished structures and inhomogeneous intensities of the image due to different texture of the object surface and shadows cast from different light source directions. This effect is adverse in case of biological images. Techniques such as segmentation, edge detection and contrast or brightness enhancement using Histogram Equalization could not differentiate between some of the particles and their background or neighbouring pixels. This paper is aimed to remove these problems in microscopic image processing by removing the problem of non-uniform background illumination from the image using Morphological Opening, Adaptive Histogram Equalization and Edge detection techniques for particle analysis , a comparative study have been shown and a new algorithm is proposed for removing the problem of non-uniform background illumination in biological images such as visualizing and estimation of growth of a fungus in a particular sample to transform the input image to its indexed form with maximum accuracy involving morphological openings and structuring element design using Morphological Opening**

***Index Terms*—morphological opening, thinning, skeletonization, histogram equalization, thresholding, structuring element**

## I. Introduction

Image processing is utilized to alter pictures to enhance them (enhancement, rebuilding), remove data (investigation, acknowledgment), and change their structure (arrangement, image altering). Images can be handled by optical, photographic, and electronic means, however image processing utilizing computerized PCs is the most widely recognized strategy on the grounds that advanced strategies are quick, adaptable, and exact. Image processing innovation is utilized via planetary researchers to improve images of Mars, Venus, or different planets. Specialists utilize this innovation to control CT sweeps and MRI images. Image Enhancement enhances the nature of images for human survey. Evacuating obscuring and commotion, expanding difference, and uncovering points of interest are cases of enhancement operations. Image Processing fundamentally incorporates investigation, controls, stockpiling and show of graphical images from sources, for example, photos, drawings et cetera. Image processing traverses a grouping of 3 stages, which are the image obtain, processing and show stage. The image procures stage changes over the distinctions in shading and shading in the photo into double values that a PC can prepare. The enhancement stage can incorporate image enhancement and information pressure. The last stage comprises of show or printing of the handled image. The term morphology implies shape and structure of a question. Now and then it alludes to the courses of action and between connections between the parts of a protest. Morphology is identified with the shapes and advanced morphology is an approach to depict and dissect the state of a computerized question. In science, morphology relates all the more specifically to state of a living being, for example, microscopic organisms. Morphological opening is a name particular innovation that makes a yield image to such an extent that estimation of every pixel in the yield image depends on an examination of the relating pixel in the information image with its neighbors. By picking the size and state of the area, one can develop a morphological operation that is delicate to particular shapes in the information image. Morphological capacities could be utilized to perform basic image processing assignments, for example, differentiate enhancement, commotion expulsion, thinning, skeletonization, filling and division.

## II. Non-Uniform Background Illumination and Effects

Non-uniform illumination can have many sources: maturing fibers, broken reference voltages, defiled gaps, or non-uniform bolster film creation. Unpretentious electron illumination asymmetries are more clear at direct to-low amplifications and are regularly coincidentally upgraded by computerized differentiate modification. This Effect is like the force inhomogeneity issue saw in MRI. The MRI Intensity inhomogeneity issue is showed as a gradually shifting multiplicative impact in the gained images. Essentially, the non-uniform illumination can be demonstrated as a multiplicative impact. The watched image is given as $f(x; y) = s(x; y) I(x; y) + n(x; y)$; (1.1) , where s is the genuine flag, I is the non-uniform illumination field and n is added substance clamor. The I-field fluctuates gradually over the image; at the end of the

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day, it doesn't have any high recurrence content. Evacuation of non-uniform illumination impacts is vital for later processing stages, for example, image enlistment in view of relationship measurements and division in view of power thresholding. Molecule Analysis is a system that figures the points of interest of the segments introduce in the image, their shape, estimate (region) and number and different attributes of the particles or articles show in an image. This issue is serious if there should be an occurrence of minuscule images caught with the end goal of bio-medicinal research where it is hard to discover the correct shape, size and number of minute particles because of non-uniform illumination and affectability to even little variances in light.

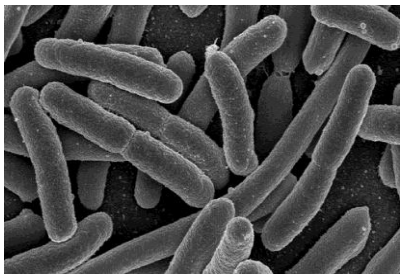


Figure 1. Dim scale Image demonstrating a cluster of bacteria present in a liquid having non-uniform surface, brighter on the top and focus partitions and darker at the base.

Along these lines, a specific characterized region of a photographic plate is taken and uncovered by the particles the qualities of which are to be figured. Along these lines, the strategy utilized is make a calculation to at last look at each molecule of the image, to see obviously every protest in the image, and evacuate any of the issues, for example, non-uniform illumination, less shine and so forth that make it hard to separate between the particles on the tiny image appeared in Fig. 1. Various methods and basic ways to deal with take care of the issue of molecule distinguishing proof are Histogram Equalization, Image Filtering, Boundary identification, Edge Detection, Linear Filtering, Segmentation, Morphological operations: Dilation and Erosion and so on. Yet, the majority of these procedures alone neglect to precisely decide the articles genuine limits because of the issue of non-uniform illumination out of sight of the image because of which the greater part of the particles give off an impression of being either dull or light in an image and utilizing methods, for example, histogram leveling, division, edge recognition and general image processing calculations in view of 'area of intrigue' couldn't separate between a portion of the particles and their experience or neighboring pixels and limits and states of the subsequent question changes. Notwithstanding when the particles are removed, there are changes to their shape and size which prompts to defective readings in the calculations of zone of such particles. In this way, propelled image processing and image enhancement devices must be utilized for most extreme exactness of the outcomes and to distinguish the particles precisely from the image without missing a solitary protest.

## III. Techniques for Non-Uniform Background Reduction in Particle Analysis and Results

Different regular strategies, for example, Histogram balance and edge recognition have been contemplated by altering the information picture of minute bacteria as appeared in Fig. 1. Related issues with these current advancements are considered on the nearness of non-uniform illumination field out of sight of the image and a calculation in view of morphological opening and organizing component configuration have been examined keeping in mind the end goal to expel the issues of non-uniform foundation by foundation estimation procedures. Accessible procedures are recorded beneath.

### *A. Histogram Equalization and Contrast Enhancement*

Histogram of an image speaks to the relative recurrence of event of dark levels inside an image. Histogram displaying systems alter an image so that its histogram has a coveted shape. Histogram evening out is utilized to improve the differentiation of the image with the end goal that it spreads the force values over full range. Under Contrast modification utilizing histogram balance, general gentility or obscurity of the image is changed, i.e. in this procedure, pixel values beneath determined qualities are mapped to dark and pixel values over a predetermined esteem are mapped to white. The outcome is straight mapping of a subset of pixel qualities to whole scope of show powers for instance given beneath.

Figure 2. Grey scale image with low

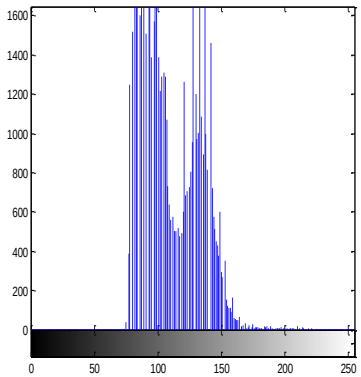



Figure 3. Histogram plot of the Input Image contrast

Performing histogram equalization on the above image the results are shown below in Fig. 4 and its histogram in Fig. 5.

Figure 4. Grey scale image with histogram equalization (contrast enhancement)

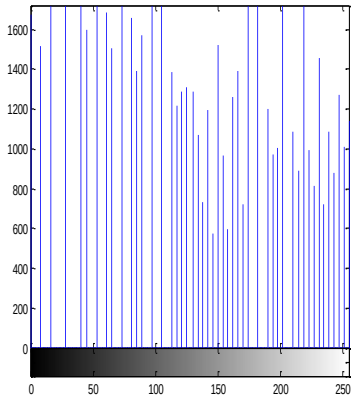



Figure 5. Histogram of output image after global histogram equalization (dynamic range)

So, histogram equalization technique basically compares every pixel in the input image with a predefines pixel value that sets all the pixel values above the threshold values to be 1 i.e. white in colour and others below this value to be 0, or black. Considering this approach, histogram equalization technique was studied over the required image with non-uniform background as shown in Fig. 1.The resultant image is shown in Fig. 6.

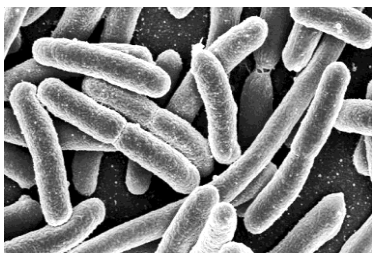


Figure 6. Resulting image after histogram equalization for contrast enhancement on the input image

As showed in Fig. 6, obviously histogram evening out strategy can't be utilized for images experiencing non-uniform illumination in their experiences. The histograms of both the images got appeared underneath in Fig. 7 and Fig. 8.

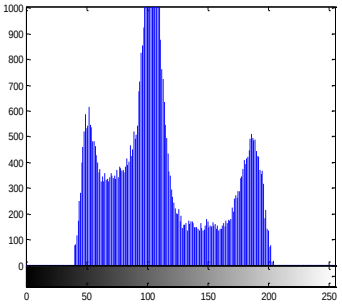



Figure 7. Histogram of input image (less dynamic range and high frequency variation)

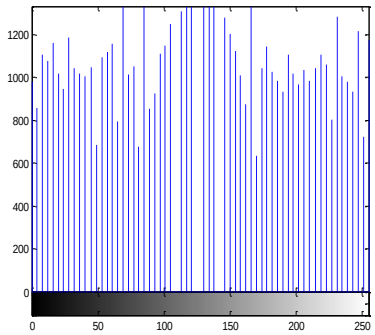



Figure 8. Histogram of the image as shown in fig 7 (high dynamic range and increased amplitudes)

Above histograms for the two methods demonstrate that the dynamic range for the whole image is however enhanced yet the amplitudes for different pixels close to the focal point of the image with light foundations have been intensified bringing about unreasonable splendor close to the particles show in determined areas making the subsequent image inadmissible for Particle distinguishing pieces of proof and investigation.

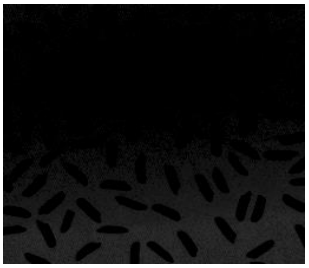


Figure 9. Approximated non-uniform background image extraction using histogram equalization

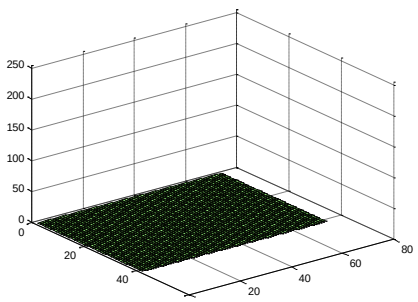


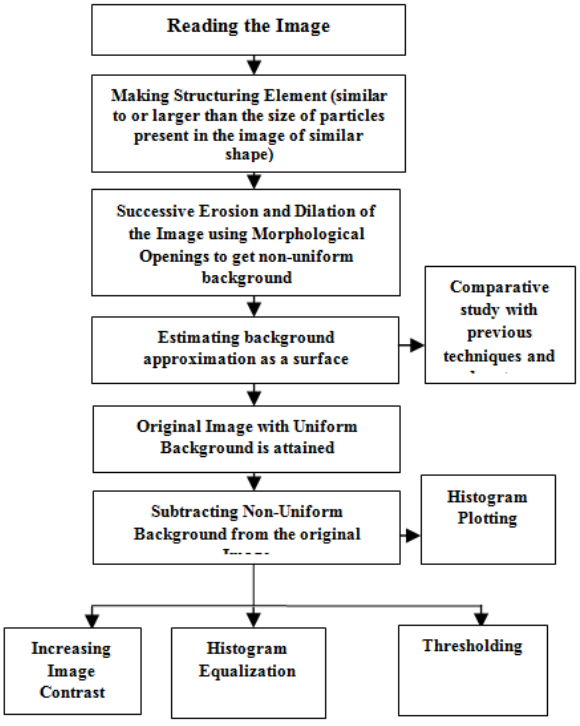

Figure 10. Surface approximation of the background attained using histogram equalization

Approximated foundation image assessed by the method of histogram adjustment is appeared in Fig. 10 and its surface estimation in Fig. 10. The surface show [0, 0] speaks to the root, or upper left corner of the image. Surface estimate demonstrates the most noteworthy pixel values as a curvier segment and lower pixel values as a level locale. In any case, the above district delineates a considerable measure of abnormalities out of sight accomplished because of a great deal of dim part achieved at the highest point of the image out of sight. It is clear from the above diagram plotting that histogram evening out alone couldn't have the capacity to make an image of uniform foundation from non-uniform foundation because of the expansion of substantial abundancy qualities to the lighter areas around the items if there should arise an occurrence of molecule investigation and consequently brings about defective figurings toward the end to decide every molecule exclusively.

### B. *Proposed Algorithm and Work for Non-Uniform Illumination Removal for Particle Analysis Using Morphology*

We have proposed an algorithm with morphological opening at first to first estimate the background of the image and then remove the non- uniform background illumination.

Algorithm Designed for non-uniform background removal for particle analysis and image enhancement




This is finished by making an organizing component of the size and shape like the particles introduce in the image (for this situation, plate formed: as indicated by state of bacteria) and morphological opening of the image with this organizing component. Foundation estimatiohn have been taken as the criteria to decide the nearness to the non-uniform foundation extraction utilizing different systems, for example, Histogram Equalization, Linear Filtering and our new procedure in view of morphological procedures and progressive expansion and disintegration took after by complexity enhancement for the exact molecule extraction for parallel image processing.

### C. *Results*

Image commands of Image Processing toolbox is used for computing the background of the image and enhancing the contrast, thresholding and computing the object statistics present in the image. Stepwise Results from the above operations are shown in Fig. 1.

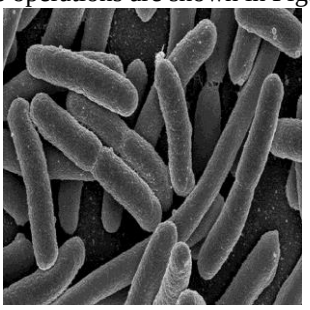


Figure 11.a) Original Microscopic Image with non-uniform background in which particle analysis is to be performed (bright in center, slightly bright in top and dark at the bottom)

Designing of a disk type organizing component was done and it was utilized as a part of the progressive widening and disintegration of the above image so as to perform morphological opening and non-uniform foundation field was assessed.

Figure 11. b) Non-Uniform background extraction by morphological operations in the above image

### D. *Background Approximation as A Surface*

The strategy utilized for tackling the issue is evaluating exact foundation guess as a surface to extricate the non-uniform foundation from the image and afterward developing the new image by subtracting this assessed foundation from the first image. In the surface show [0, 0] speaks to the starting point, or upper left corner of the image. Surface estimate demonstrates the most astounding pixel values as a curvier part and lower pixel values as a level area. The exactness of non-uniform illumination lessening and execution of the image enhancement for further molecule examination relies on the element s(x,y) to be extricated from the Image , I(x,y) where

$$f(x; y) = s(x; y)\, I(x; y) + n(x; y); \qquad (1.1)$$

where f is the watched image, s is the genuine flag, I is the non-uniform illumination field and n is added substance commotion. Here, the capacity s is non-uniform illumination field that is variable and relies on the many components. N(x, y) is the outside clamor, an added substance amount and can be evacuated effortlessly with the assistance of histogram balance and brilliance control strategies. In any case, S(x, y) is a multiplicative amount with the image and is hard to expel as it is factor. With the assistance of foundation guess from the first image, non-uniform field could be effectively ascertained and expelled from the first image. S capacity is resolved with the assistance of foundation guess strategy and with the assistance of our new philosophy, precise foundation has been evaluated when contrasted with past outcomes from histogram balance and straight separating procedures.

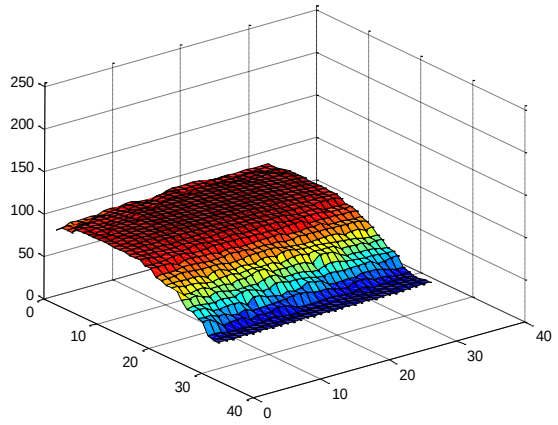



Figure 12. Background approximation as a surface in 3-d view

In the surface display, [0, 0] represents the origin, or upper left corner of the image. The highest part of the curve indicates that the highest pixel values of background (and consequently input image in Fig. 1) occur near the middle rows of the image. The lowest pixel values occur at the bottom of the image and are represented in the surface plot by the lowest part of the curve. This background approximation obtained is exactly similar to the original non-uniform background field and is a uniform 3-D graph with no-sudden changes in the surface plot as it was in case of other techniques such as histogram equalization. Resulting Image obtained after morphological opening is the difference of this background approximation from the original image with removal of non-uniform background problems. Further after the final image is obtained, there is still a remaining problem of noise in the image that is extracted by histogram equalization and contrast adjustment techniques. The modification performed uses the image enhancement after the removal of background illumination for the lateral stages whereas in older algorithms, these enhancement methods were used in staring stages but also multiplied the effect of noise and non-uniform background. Image obtained after subtracting the non-uniform field from the original image results in the required image with uniform background that is suitable for particle analysis as shown in Fig. 13.

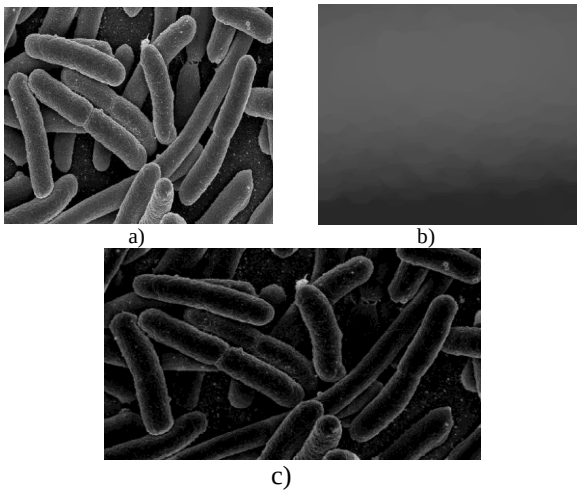



Figure 13. a) Original Image with Non-Uniform Background. b) Non-uniform Background extraction from original image using morphological opening and successive erosion and dilation techniques and structuring element approach. c) Iout = I – B, where Iout is the image obtained after the removal of non-uniform background (B) from original image (I) uniform background throughout the image

After non-uniform illumination have been removed, we observe that the resulting image have the problem of less brightness than the original image due to morphological opening and the particles appear to be slightly less bright than their original view. In order to remove these problems, we performed image enhancement techniques at the output of the image including the contrast and brightness adjustment and finally thresholding was done. Image obtained after the image enhancement step results in the final image as shown in Fig. 14 that is computed to be suitable for applications in particle analysis.

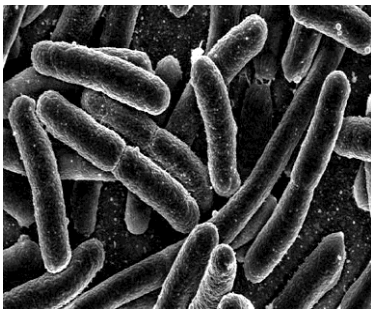


Figure 14. Final Image obtained for Particle Analysis application with full accuracy and non-uniform illumination removal and contrast enhancement obtained with new algorithm

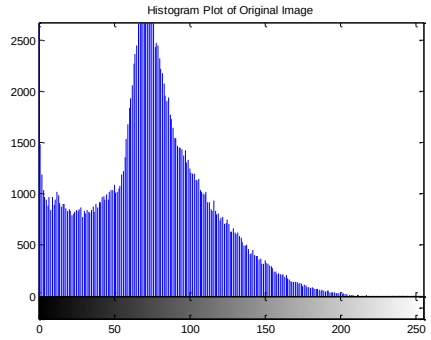



Figure 15. x) Histogram plot of original image in 24.a)

Histogram plot for the progressive stages in Fig. 13 a), c) and Fig. 14 images have been thought about and comes about have advocated in taking after figure x, y, z of Fig. 15 correspondingly.

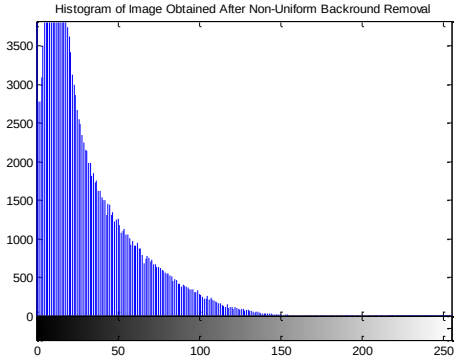



Figure 15. y) Histogram plot after the removal of non-uniform background indicating uniform variation in the image corresponding the equal distributions of probability at the output.

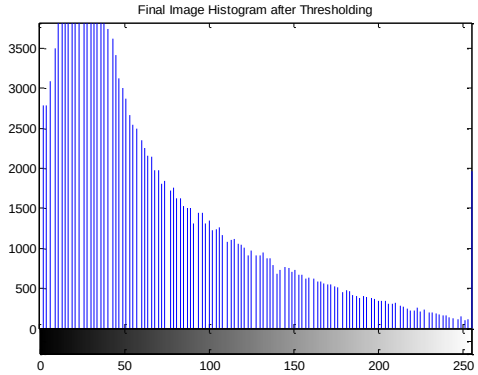



Figure 15.(z) Histogram plot of the final image indicating uniform distribution of graph (uniform background) and Wide Dynamic Range for effective brightness of the image

## IV. Conclusions and Future Work

It has been presumed that strategies, for example, division, edge identification and difference or shine enhancement utilizing Histogram Equalization couldn't separate between a portion of the particles and their experience or neighboring pixels. For applications, including particles/articles to be considered or investigated, these methods give broken outcomes because of changes in real shapes and sizes of the particles in the subsequent image. However the proposed strategy created ideal outcomes. Histogram plots acquired from new calculation demonstrates uniform appropriation of powers in the image alongside complexity enhancement and wide element extend showing clear perceivability of the image alongside compelling non-uniform foundation expulsion. After non-uniform illumination have been evacuated, we watch that the subsequent image have the issue of less brilliance than the first image because of morphological opening and the particles seem, by all accounts, to be marginally less splendid than their unique view. With a specific end goal to expel these issues, we performed image enhancement strategies at the yield of the image including the complexity and brilliance modification lastly thresholding was finished. In future the proposition is to discover qualities of every molecule, register its region and to show brings about territory based insights and histogram evening out.

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