



Practical Implementation of Image Segmentation and Enhancement Techniques Using MATLAB

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التنفيذ العملي لتقنيات تجزئة الصور وتحسينها باستخدام برنامج MATLAB

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Abstract

This paper explores various aspects of digital image processing through practical implementation using MATLAB software. The study begins with reading and converting a given image (Termal.jpg) into grayscale analysis and threshold determination using the variance growth method to isolate objects from the background. The final phase involves enhancing image contrast via histogram equalization, with previous processing steps reapplied to assess improvements. This study highlights essential techniques such as segmentation and contrast enhancement, demonstrating their effectiveness and application within MATLAB.

Keywords: image processing, variance growth method, MATLAB software .

الملخص

تستكشف هذه الورقة البحثية جوانب متعددة من معالجة الصور الرقمية من خلال التنفيذ العملي باستخدام برنامج MATLAB. يبدأ البحث بقراءة الصورة المعطاة (Termal.jpg) وتحويلها إلى صيغة التدرج الرمادي، يلي ذلك تحليل العتبة باستخدام طريقة نمو التباين لعزل الأجسام عن الخلفية. في المرحلة الأخيرة، يتم تحسين تباين الصورة من خلال تسوية المدرج التكراري، مع إعادة تطبيق خطوات المعالجة السابقة لتقييم التحسينات. يسلط هذا البحث الضوء على تقنيات أساسية مثل التجزئة وتعزيز التباين، مبرزاً فعاليتها وإمكانات تطبيقها باستخدام MATLAB.

الكلمات المفتاحية: معالجة الصور، طريقة نمو التباين، برنامج MATLAB.

1. Introduction

Researchers utilised vast quantities of data, including satellite imagery, medical imaging, video footage, and digital images. This information is retrieved via electronic and digital media. A number of algorithms and methods are developed that use this data to do different things, such getting rid of or lowering noise and improving features. And give better picture quality as a result. These characteristics led researchers to create a hybrid model that keeps brightness, cuts down on noise, and improves image quality. Maintaining the image's brightness is one of the most significant issues in low-level image processing. For instance, altering the contrast [1] makes it simple to make a picture darker or brighter. Histogram distribution, thresholding, image contamination with noise and noise-removal methodology, image enhancement (histogram equalisation), determining the histogram distribution and threshold of the after equalised image, and finally adding noise density until the noise-removal methodology is no longer effective to remove additional noise are some of the primary components of image processing that will be covered in this work [1][2]. It is harder to analyse because the quality of the images sometimes gets worse during acquisition and storage. This challenge is overcome with a new image perfect method that includes bilateral filtering and histogram equalization. This approach eliminates noise and maintains the naturalness of the image while improving global contrast. Experimental results demonstrated peak signal-to-noise ratios of 0.71 and 0.95, indicating its efficiency for enhancing image quality, supporting applications in image analysis and machine vision [3]. Image enhancement uses a range of approaches to raise the quality of photographs. Neighborhood processing exploits neighbouring pixels, whereas point processing influences

individual pixels. Brightness and contrast can be altered utilising techniques like image negative, addition, and subtraction. Techniques based on histograms enhance the appearance of an image overall. While histogram matching more successfully concentrates on select areas, histogram equalization improves the entire image. Low-pass, high-pass, median, averaging, and unsharp filters are examples of filtering processes that alter frequency components or accentuate edges. These techniques, which are applied to various images in MATLAB, enhance visual clarity. All things considered, image augmentation offers a sharper, more detailed perspective than would be possible with the original [4]. In early 2024 A novel technique for artistic image enhancement merges histogram equalization with bilateral filtering. This approach employs a multi-stage process that involves multi-band decomposition to distinguish between high and low-frequency elements, thereby enhancing the fusion of structure and texture at various scales. Bilateral filtering is applied to reduce noise in the image, and this is succeeded by histogram equalization to boost contrast and achieve consistent pixel intensity. Global tone mapping and sharpening further enhance edges and details. Experimental results show improved image quality, with an SSIM of 0.973 and an average gradient near 0.8. However, the study is limited by sample size. Future work will explore larger, more diverse datasets for broader validation and deeper insights [5].

The paper is structured as follows: Section 2 presents the histogram distribution of images that used in this study, The histogram shows the number of pixels corresponding to each pixel value (ranging from 0 to 255). It can be observed that the right side of the histogram, which represents brighter pixels, contains more pixels than the left side, which represents darker pixels. This indicates that the image has more bright regions than dark ones. Section 3, describes the threshold of an image by using the variance growth method, were the aim to determine a threshold for the given image ('Thermal.jpg') to isolate the target objects (two vehicles) from the background using the variance growth method. Section 4, threshold of an image by using 'Otsu's method.

The flowchart for all steps is clearly illustrated in Figure (1):

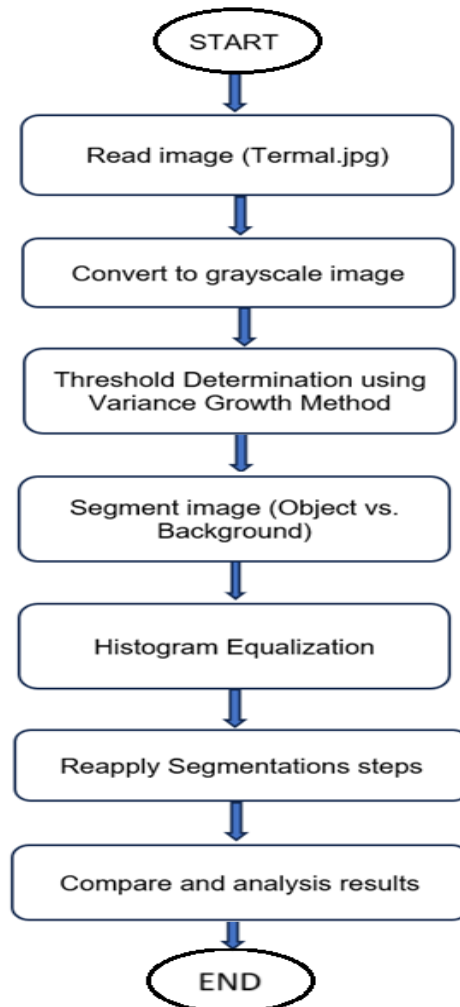


Figure 1: steps of image segmentation and enhancement techniques using MATLAB

2. picture histogram distribution.

A diagrammatic depiction of the frequency of occurrence of each greyscale in an image is known as its histogram in image processing [6].

Figure (2) displays the image ('Thermal.jpg') that I must work with in accordance with the provided excel sheet; consequently, I will use MATLAB software to work with this image in order to complete the tasks assigned. Therefore, we began by using the MATLAB tool imread to read the provided image, and then imshow to display it.

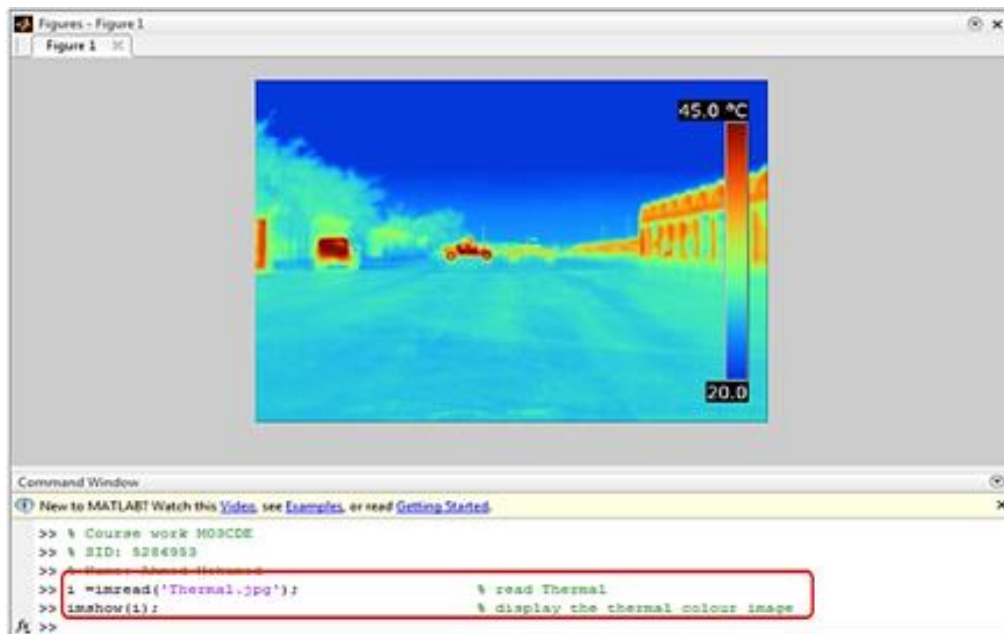


Figure 2: Shows given image ('Thermal.jpg').

As observed, the original image ('Thermal.jpg') is in color (RGB). Therefore, to compute its histogram, the image must first be converted to grayscale. This conversion is performed using the MATLAB command rgb2gray, as illustrated in Figure (3). The figure also displays the corresponding MATLAB commands used in the process.



Figure 3: original image after using MATLAB tools to convert it to a greyscale image

As seen in figure (4) below, which also displays the MTALAB commands used to do so, we can now determine the histogram distribution for the coloured picture ('Thermal.jpg') after it has been converted to a grey image using the MATLAB program (mishist).

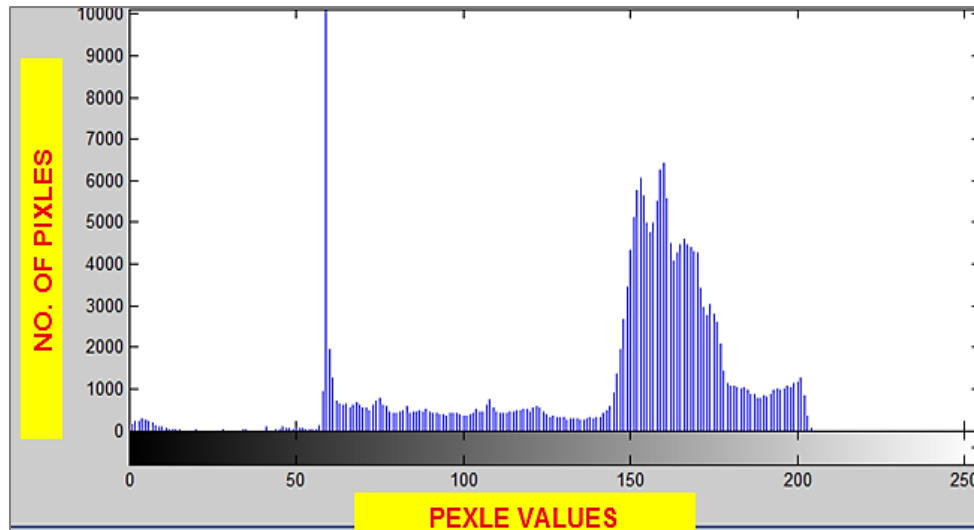


Figure 4: Histogram distribution graph of original image in greyscale.

The number of pixels for each pixel value (ranging from 0 to 255) is shown in the above histogram. Since the left region represents dark pixels and the right region represents brighter pixels, observers may see that there are more pixels in the right region than in the left, indicating that the brighter region is greater than the dark region. (Readthedocs.org/OpenCV-python-tutroals, 2015) [7].

3. Threshold of an image by using the variance growth method

Selecting an appropriate greyscale threshold is crucial in image processing in order to separate target items from their background. In this regard, a variety of approaches, including the variance growth method, have been presented. There is 256 (28) intensity scaling in 8-bit greyscale images that can be assigned to individual pixels. Although a pixel with an intensity of 0 is black and one with a value of 255 is white, everything in the middle is rendered as grey. Thresholding, also known as "segmentation," works by distinguishing pixels that fall within a desired rate of intensity values from pixels that do not. Furthermore, a crucial component used to distinguish an object from its background is the threshold. The threshold value, which ranges from 0 to 1, can be found using a variety of methods that will be covered later. Additionally, thresholding can be a very useful method for assessing complicated or fragmented elements in an image [8].

then we have a threshold concept. Using the variance growth method, a straightforward technique for determining an image's threshold using a variance graph that can be obtained manually or with the aid of MATLAB commands, we will determine the threshold for a given image ('Thermal.jpg') in order to separate the necessary objects (two vehicles) from its background. However, because the matrix size of the provided image ('Thermal.jpg') is so huge, we will utilise MATLAB to plot the variance graph because it is simpler than the usual method (manually)

following the acquisition of the variance graph, as illustrated in figure 5 below. The X axis is represented by the threshold level value, while the Y axis is represented by the number of pixels that would pass. As we can see in figure 5, there are two shoulders, one of which is situated in the dark area at threshold value 0.22 proximately. This is because the variance growth approach states that the threshold value that can isolate the objects should be situated between shoulders. The second shoulder, on the other hand, is located in the white region, at a threshold value of 0.68 close by. As shown below, we may calculate the threshold for a given image that separates the necessary objects (vehicles) from the image backdrop by averaging the threshold values of two shoulders.

$$\text{The mean value of threshold} = \frac{0.68+0.22}{2} = \mathbf{0.45}$$

Threshold value of variance growth T=0.45

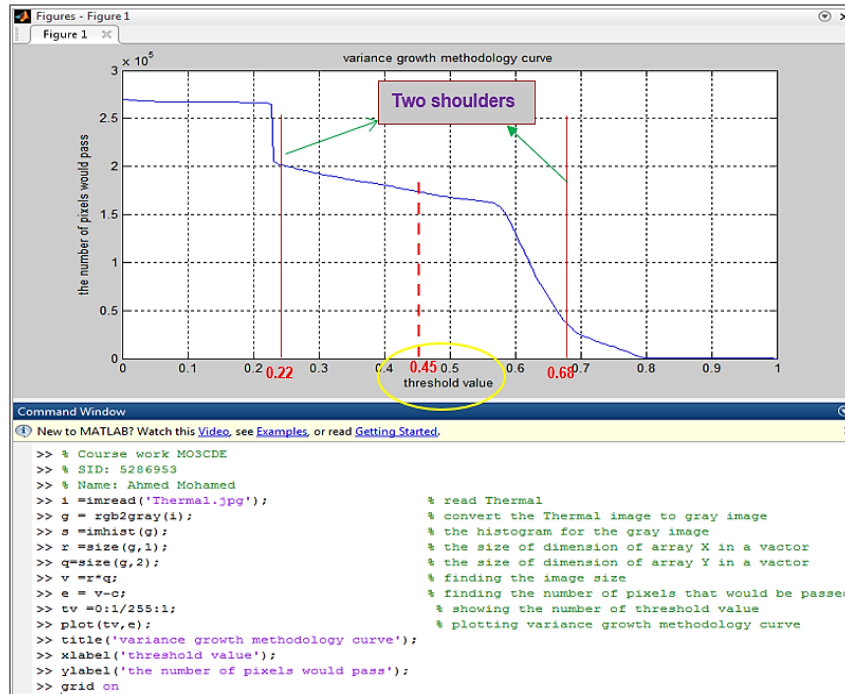


Figure 5: Variance Growth Method Graph.

The threshold value derived using the variance growth method will be applied to the original grayscale image to segment the desired objects from the background. To apply the threshold value to the image, the grayscale image must first be converted into a binary image using the following MATLAB function:

$t = \text{im2bw}(g, \text{level});$

Where is,

g =gray image

Level is equal to the threshold value, which in this instance is 0.45.

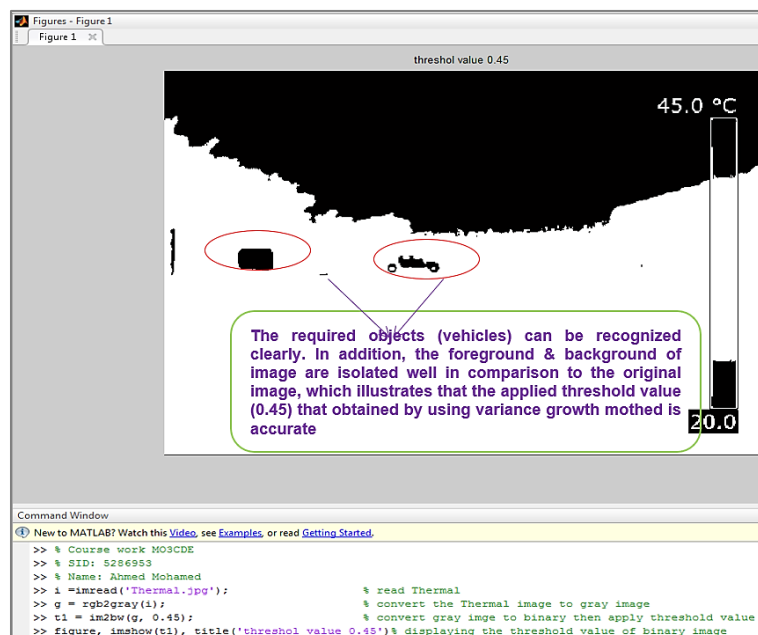


Figure 6: Applying the image's threshold value (0.45) that was determined using the variance growth method.

In order to determine the proper threshold value using the variance growth method, I have selected different values for shoulders 1 and 2, which are 0.22 and 0.59, respectively, as indicated in the variance. graph below. The new threshold value can then be obtained by averaging the values between the two points (shoulders), as illustrated below.:

New.threshold value of variance growth

$$T = \frac{0.22+0.59}{2} = 0.405$$

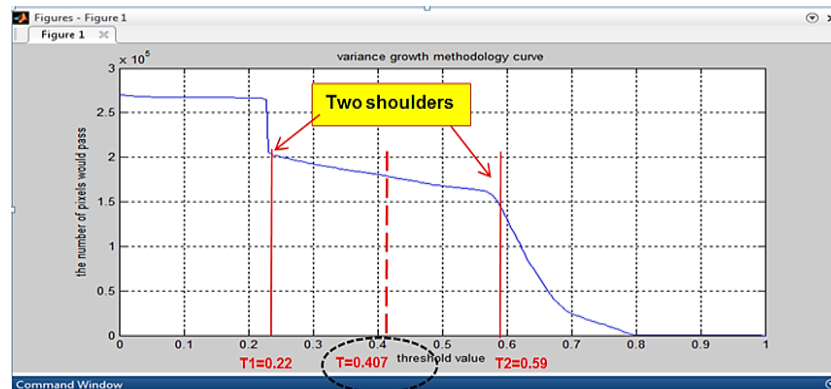


Figure 7: The new threshold value that obtained by variance growth method.

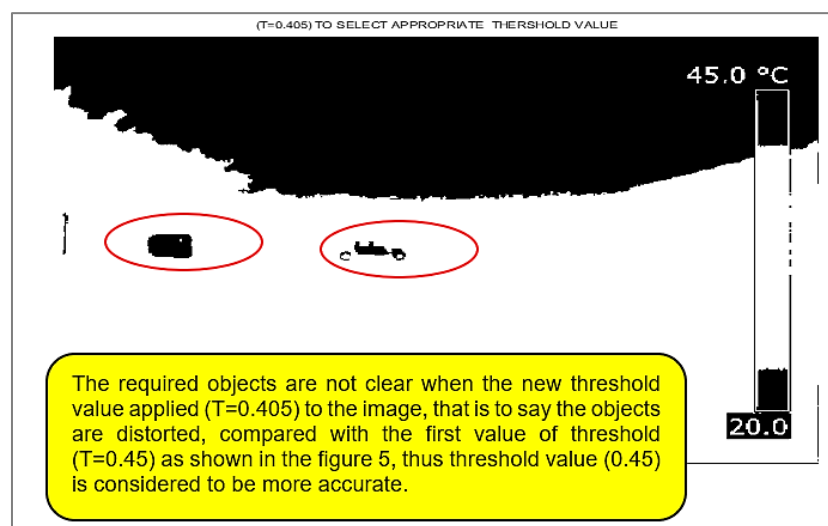


Figure 8: Applying new threshold value (0.405) that obtained by variance growth method to the image

4. Threshold of an image by using 'Otsu's method':

The new "Otsu method," which is based on selecting the lowest point between two peaks, will be utilised to support the threshold value that was determined using the variance growth method. The following MATLAB toolbox must be used with this procedure.:

$T = \text{graythresh}(A)$

Where is :

- T = the threshold value between 0.0 and 1.0.
- Graythresh = Global image threshold utilizing 'Otsu's method'

To apply the. value of threshold. that obtained by 'Otsu method' to image in order to isolate its foreground from background MATLAB function (im2bw (gray image, T)) is required to be used. The threshold value that was automatically calculated using the "Otsu method" is 0.4471.

The outcome of applying the threshold value (0.4471) that was acquired by applying the "Otsu method" to the original greyscale picture is displayed in figure (9) below.

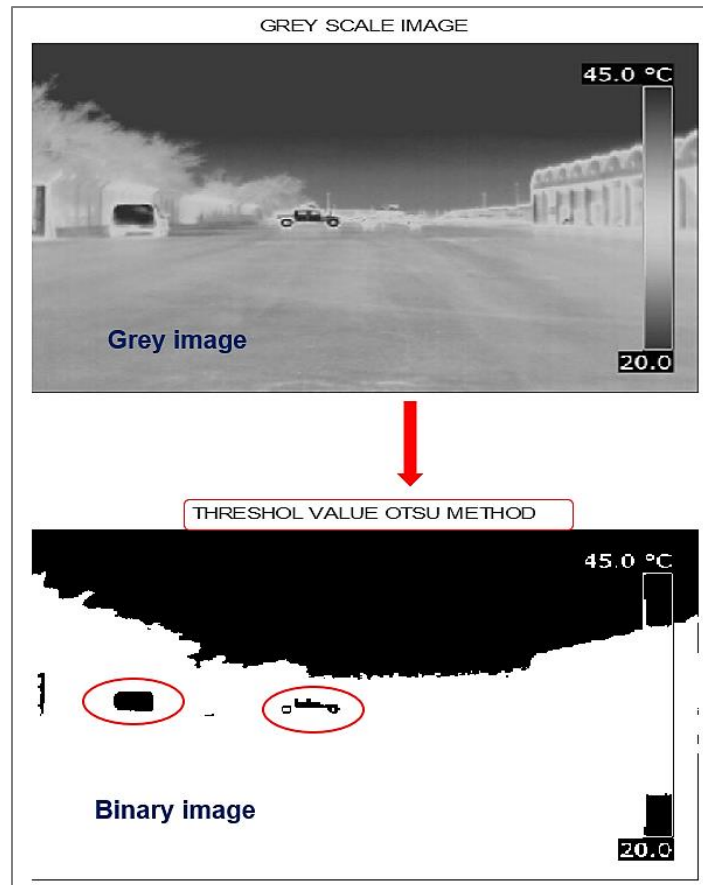


Figure 9: Applying threshold value (0.4471) that obtained by 'Otsu's method' to the image

When comparing the threshold value of 0.45 applied to the image in Figure (6) obtained using the variance growth method with the threshold value of 0.4471 applied to the image in Figure (9) determined using Otsu's method a slight difference between the two results can be observed. This suggests that the variance growth method is a practical and effective approach for determining the threshold value in image segmentation.

Conclusion

Some facets of digital image processing have been discussed and examined in this study. Additionally, MATLAB software was used to complete all of the practical activities needed for this study. In the first section of this task, we began by interpreting the provided image (Termal.jpg), which was then transformed into a greyscale image using the variance growth approach to determine its histogram and threshold. The acquired threshold value was then applied to the greyscale image in order to separate the necessary items from the image's backdrop. Applying the threshold value (0.4471) that was discovered by the "Otsu method" to the original greyscale image yields the desired outcome. We now know more about various aspects of image processing and how to work with images using MATLAB software thanks to this research.

References

- [1]. Ahirwar, V., Yadav, H. and Jain, A. (2013). An Assessment on Brightness Preservation Techniques Over Digital Image Processing. *International Journal of Computer Applications* 68 (12), 12-17
- [2]. Russ, John C., and J. Christian Russ. *Introduction to image processing and analysis*. CRC press, 2017.
- [3]. Wu, M., and Zhong, Q. (2024). Image enhancement algorithm combining histogram equalization and bilateral filtering. *Systems and Soft Computing*, 6, 200169.
- [4]. Kaur, G., and Kumar, R. (2020). Analysis and implementation of image enhancement techniques using matlab. *Int J Eng Appl Sci Technol*, 5(1), 194-200.
- [5]. Zhang, W. (2024). The feature enhancement method of artistic images based on histogram equalization and bilateral filtering. *PeerJ Computer Science*, 10, e2109.
- [6]. Marques, O. (2011) *Practical Image and Video Processing Using MATLAB*. Hoboken, NJ: Wiley-IEEE Press
- [7]. [Opencv-python-tutroals.readthedocs.org](https://opencv-python-tutroals.readthedocs.org/en/latest/py_tutorials/py_imgproc/py_histograms/py_histogram_begins/py_histogram_begins.html), (2015) Histograms - 1: Find, Plot, Analyze !!! "Opencv-Python Tutorials 1 Documentation [online] available from <http://opencv-python-tutroals.readthedocs.org/en/latest/py_tutorials/py_imgproc/py_histograms/py_histogram_begins/py_histogram_begins.html> [27 March 2015]
- [8]. McNaughton, A. *ImageJ Thresholding*, (2010), Microscopy Otago. Notes.