

Watershed Segmentation using Otsu based Thresholding in R Tool

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ABSTRACT: Acquisition of Images with the help of mathematical operations makes an enhanced way to extract meaningful insights in the field of imaging. Improvements in machine learning have made even more greater improvements to study the morphological characteristics by means of visualization, image sharpening, image restoration, image segmentation, image retrieval, pattern recognition & image recognition, etc., Image segmentation has been a most promising approach that distinguishes the input original image into meaningful pixel information such as features, objects, contents. An image is always characterized or formed based on the super pixel information (i.e. computationally they determine the morphological characteristics of other pixels). Considering the super-pixel as a consistent unit, R tool provides a four-dimensional view where one can get hyper spectral, volumetric, geography & normalized cuts. Since image is a semi-structured data, to study the morphological characteristics R promises a peculiar way of data analysis to gain more meaningful insights. To proceed with this, different images have been chosen and a comparison upon different segmentation approach using R has been proposed.

KEYWORDS: Image Segmentation, Super-pixel. Normalized Cuts, Watershed Segmentation, Otsu Thresholding, R tool.

I. INTRODUCTION

Computer analysis of image objects starts with finding them-deciding which pixels belong to each object. This is called image segmentation, the process of separating objects from the background, as well as from each other [9]. Image processing has undergone massive transformations and advancements from a low-level to high-level descriptions and data pattern analysis which has made data analytics to a new level with enhanced machine learning capabilities. To segment the image based on high & low intensity pixels a promising approach has to be made. In case of image processing, there are several methodologies like image segmentation, image restoration, image recognition, and pattern recognition & image retrieval, etc. Extensive research has been focused on image segmentation and image recognition approaches. Image segmentation techniques consist of histogram thresholding, feature space clustering, region-based segmentation, edge detection & so on [9]. Image segmentation has been the most promising approach to study the morphological characteristics where it opens a wide area of research. Image Segmentation can be divided into different forms such as: i) Region growing based Segmentation ii) Texture based Segmentation iii) Color based Segmentation. Clustering plays a major role in the arena of image segmentation where research has been widespread with respect to different factors such as color, intensity, pixel range, value etc. Watershed segmentation is a transformation defined on a grey-scale image. There are three different approaches with which watershed transformation proceeds: i) Watershed by flooding ii) Watershed by the topographic distance iii) Watershed by the drop of water principle. Image thresholding is the simplest form of segmentation where it is used to create binary

images. In thresholding, the pixels are partitioned based on their intensity value. There are different kinds of thresholding such as i) Local Thresholding ii) Global Thresholding iii) Adaptive Thresholding iv) Multiple Thresholding v) Variable Thresholding etc. Thresholding can be defined as the function of applying mathematical operations of functions on light objects in dark background. Not all different thresholding techniques can be applied to grey-scale or color based images. The focus of the paper is to study the effect of how R tool reacts while applying thresholding to both grey-scale & color-based images. Images such as parrot, baboon, Lena, vegetables has been chosen to analyse how R tool reacts to image thresholding while proceeding to image segmentation. The proposed outcome has been organized as follows: i) Introduction ii) Image Segmentation and its Approaches iii) Image Thresholding and its Significance iv) R tool Compatibility v) Comparison study of both Grey-scale & Color-based images vi) Performance comparison plots for grey & color-scale images using R vii) Conclusion.

II. IMAGE SEGMENTATION AND ITS APPROACHES

Image segmentation can be defined as the process of dividing an image into clusters of regions [6] whereby the objects that forms the morphological operations can be analysed. There are different forms of image segmentation viz. i) Thresholding methods such as Otsu’s method ii) Color based segmentation such as k-means clustering iii) Transform methods such as watershed segmentation iv) Texture methods such as texture filters. The aim of the study is to project the performance of R tool in addition to MATLAB in Watershed Segmentation.

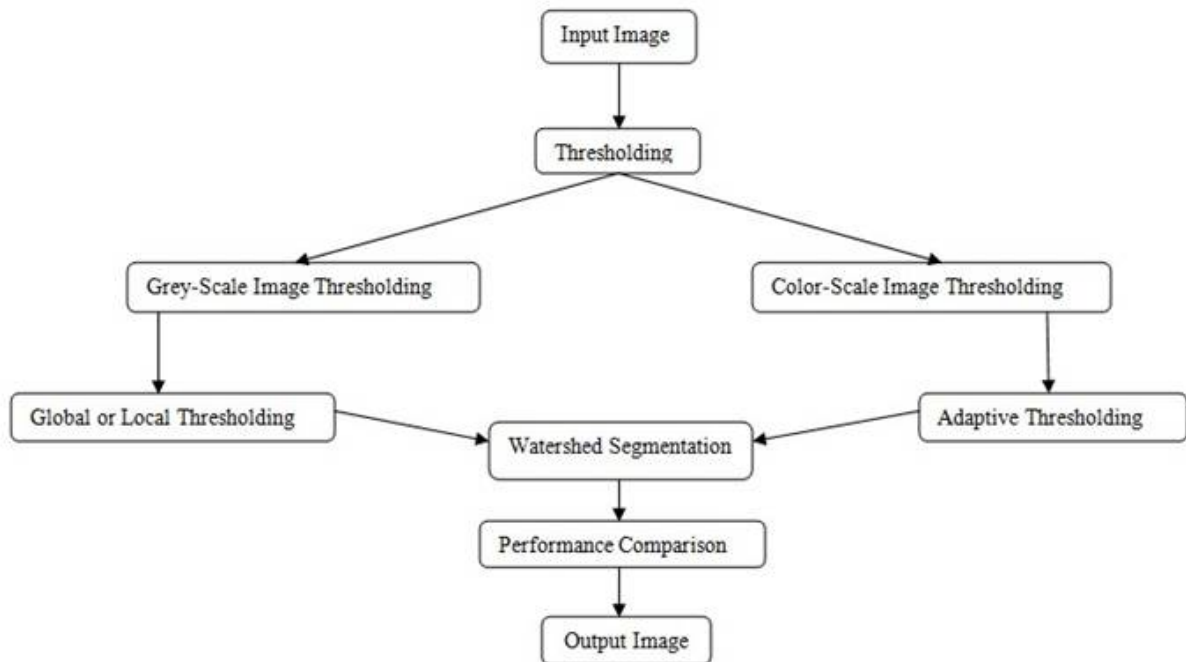


Fig.1 Process of Image Segmentation

III. IMAGE THRESHOLDING AND ITS SIGNIFICANCE

Image Thresholding is an essential region based approach where it is mainly used when dark images rests solely on a light background. It is computationally simple and never fails to define disjoint regions with closed, connected boundaries. Thresholding in image segmentation computationally makes all or some of the pixels above or below the threshold in order to identify the objects of interest. Segmenting an image having different grey-levels does not provide adequate information for what the researcher looks for. Also, some grey levels may behave differently in light background and in dark background or vice-versa. Hence thresholding makes the super-pixelation values to be uniform

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over all the backgrounds. Thresholding is ultimately performed to get the binary values of the corresponding input image.

A. Local Thresholding

Upon thresholding methods, the thresholding constant computationally replaces the value of the object of interest either to or above or below the threshold constant. The thresholding depends upon the thresholding function where $f(x,y)$ is a function and x, y denotes the 2-dimensional variable of a pixel in an image and their interlink or inter connection with the lower range pixels. However, both the super-pixels and the lower-range pixels are of much importance which forms the objects of interest of an image.

B. Working of Local Thresholds

Step 1: Image is partitioned into regions

Step 2: Computation of threshold for each region in order to find the objects of interest.

C. Global Thresholding

In case of global thresholding, grey-level pixels are given lower significance which are made constant by using the global function $F(x, y)$ where x, y are the two-dimensional pixel value of an image after applying the threshold. The light weight pixels are correctly identified without specifying inadvertently without discriminating the dark pixels.

D. Adaptive Thresholding

Both the local & global thresholding concentrates only on the grey-scale images whereas it cannot be applied to color-scale images in case of R tool. Hence Adaptive thresholding is preferred. Since Otsu method [4] is predominantly preferred a separate package is not present in an R tool to utilize the Otsu method for color images which paves the way for adaptive thresholding. Anything that is greater than 127 in the greyscale, can be set to 1 in the binary image and anything that is less than or equal to 127 in the greyscale image can be set to 0 in the binary image. This process is called fixed thresholding as our threshold value is set to 127. In adaptive threshold unlike fixed threshold, the threshold value at each pixel location depends on the neighboring pixel intensities. In adaptive thresholding the weighted average mean value is chosen as a threshold where all the lower range pixels that contribute the major morphological characteristics of an image can be distinguished.

E. Multiband Thresholding

In color images to perform thresholding a separate thresholding function has to be designed according to the RGB components of the image and combine them with an AND operation. Circular Thresholding or Hue transformation is preferred in terms of color scale images.

IV. WATERSHED SEGMENTATION USING R

Different images have been chosen to analyse the performance comparison using watershed segmentation algorithm. In watershed segmentation approach, after the region gets partitioned thresholding is the important feature in order to extract the objects of interest [1]. Watershed segmentation for grey-scale & color-based images has been performed in order to analyse the morphological characteristics and different plots has been taken as reference for the image analysis part. In R tool, it is not possible to use Otsu based image thresholding technique proceeding to watershed segmentation for color-scale images.

A. Watershed Segmentation for Color-Scale Images

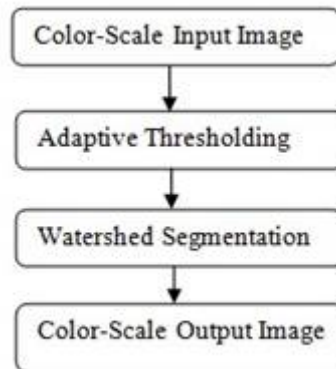


Fig.2 Watershed Segmentation Approach for Color-Scale Images using Otsu-based Image thresholding

Otsu method can't be applied to color-scale images due to the highly varying intensity of pixels. To compensate the issue, a separate thresholding function which can segregate and pacify the thresholding intensity value of all the pixels in both the foreground and the background has to be devised and designed. There are number of thresholding techniques such as adaptive thresholding with weighted average mean, hue saturation, histogram, thresholding, etc.

B. Watershed Segmentation for Grey-Scale Images

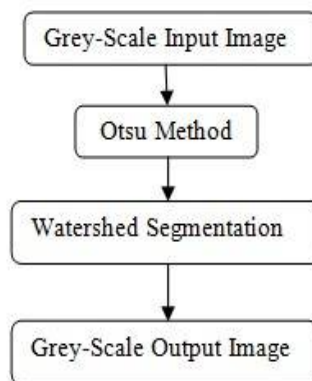


Fig.3 Watershed Segmentation Approach for Grey-Scale Images using Otsu-based Image thresholding

Otsu based watershed segmentation is meant only for grey-scale images which can't be applied to color-based images respectively. Since the pixel intensity of the color images vary with respect to the topography and texture, Otsu method can be applied only to pixels having uniform intensities. Hence this method can't be applied to color-scale images. Adaptive thresholding can also be applied to grey- Scale images whereas it does not yield desirable results in case of baboon and parrot images due to highly varying intensity of pixels.

V. COMPARISON STUDY OF BOTH GREY-SCALE & COLOR-SCALE IMAGES IN R & MATLAB

A. Segmentation Results for Grey-scale & Color-scale Images using R

Different images such as parrot, lena, vegetable, baboon have been chosen in both grey-scale & in color scale images where the watershed segmentation has been applied. Since the study has been made to analysis & performance

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of the R tool experiments are carried out for both the grey-scale & color-scale images respectively. Each image is given as a input which has gone through the above mentioned watershed segmentation approach as follows:



Fig.4 i) Lena-grey scale input image ii) Otsu based threshold image iii) Watershed Segmented image

The above fore-mentioned approach is followed in order to compare & analyse the grey-scale image where process has been followed as input image, threshold image & Watershed segmented image. The same approach is then repeated in order to compare & analyse the grey-scale image where process has been followed as input image, threshold image & Watershed segmented image.



Fig.5 i) Baboon-grey scale input image ii) Otsu based threshold image iii) Watershed Segmented image



Fig.6 i) Lena-color scale input image ii) Otsu based threshold image iii) Watershed Segmented image



Fig.7 i) Baboon-color scale input image ii) Otsu based threshold image iii) Watershed Segmented image

VI. SEGMENTATION RESULTS FOR GREY & COLOR-SCALE IMAGES USING MATLAB



Fig.8 i) Lena-color scale input image ii) Otsu based threshold image iii) Watershed Segmented image

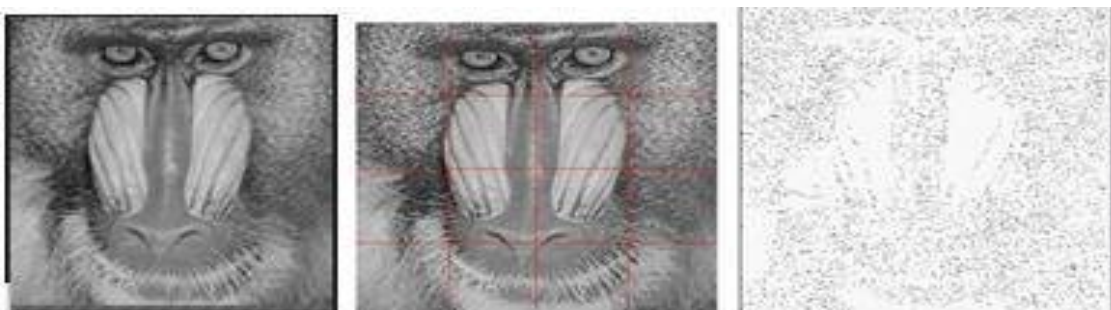


Fig.9 i) Baboon grey-scale input image ii) Otsu based threshold image iii) Watershed Segmented image

From the above two images such as lena and baboon, it is concluded that MATLAB has more features which will comprehend the intrinsic & the extrinsic properties of an image. R tool is comparatively better whereas MATLAB gets the best out of the worst of about 98% accuracy in the segmentation respectively. For color image segmentation, R tool

provides the compatibility which can't be gone through using MATLAB where the color images have to get converted into grey-scale images which is necessary a single step that introduces a computational overhead as well.

A. HISTOGRAM RESULTS FOR THE SELECTED IMAGES

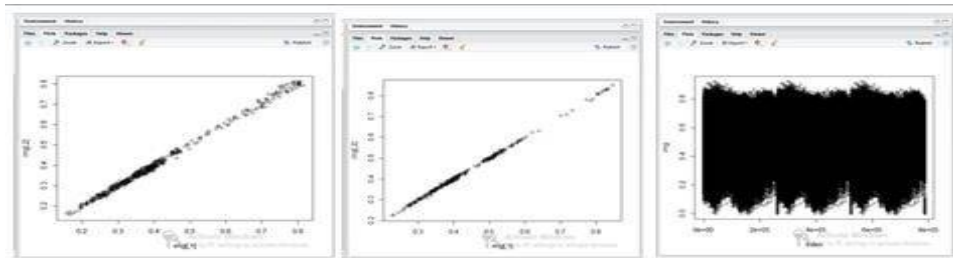


Fig.10 i) Histogram results for the selected grey-scale images (Parrot, Lena, Baboon, etc.)

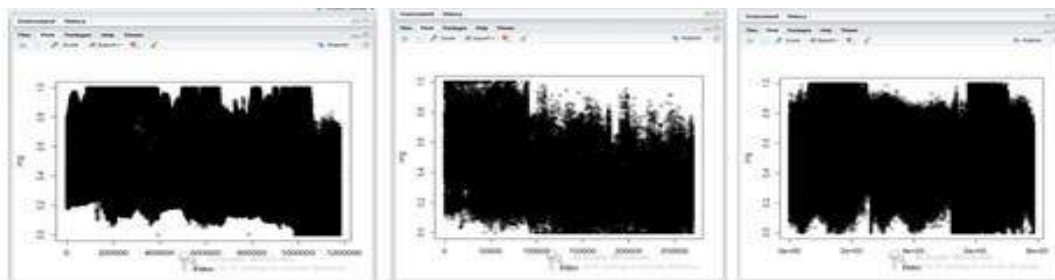


Fig.11 i) Histogram results for the selected color-scale images (Parrot, Lena, Baboon, etc.)

The histogram results that the segmented images yield perfect segmentation with respect to higher background super-pixel intensities. These intensities vary with respect to the image illumination and super-pixels present in the image.

VII.CONCLUSION

The disadvantages of existing otsu based thresholding methods is that selecting a threshold on the unequal pixel super pixel values yields different maximas which may not be the determining characteristic of an image. It soles not corresponds to an optimum value with varying images. It is evident that R needs more tool & package which have to support different features similar to that of MATLAB. Extensive research has been progressing in R programming, where the image analytics will be a future of scope providing a opportunity to explore.

FUTURE WORK

Image thresholding algorithms & methods can be enhanced in order to improve the quality of the watershed segmentation transformation which yields better results with more accuracy for medical diagnosis as well[7]. Improvements have to be made in case of variable illumination where pixel level thresholding and probabilistic approach may yield higher segmentation results.

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