DIGITAL IMAGE PROCESSING TECHNIQUES IN MEDICAL IMAGING

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ABSTRACT: In this paper we will present a few techniques for processing medical digital images using an open sourced software program for processing and analyzing images – ImageJ.

KEYWORDS: image processing, medical imaging, histogram, analizyng images.

1. INTRODUCTION

Until a few years ago the image processing community consisted of a small group of people, fortunately, the situation has drastically improved today, when most programming languages (C, C++, Java) all come with libraries for processing images or other types of media.

The digital image is a numeric replica of its optical counterpart. The process of capturing the image is quite laborious, with millions of optical sensors converting light into electrical impulses, which are further converted into bits. All this plus the optics of the camera lead to image distortions, and the introduction of artifacts such as digital noise.

To fix these issues the images are modified in diverse ways, getting them ready for further image processing techniques.

In this paper we will present a few techniques for processing medical digital images using an open sourced software program for processing and analyzing images – ImageJ.

2. IMAGEJ PROCESSING PROGRAM

ImageJ is and open sourced image processing program, developed in Java by the National Institute of Health [SRE12]. ImageJ was conceived as open sourced software, thus offering numerous ways of extending its functionality using Java plugins and registered macros [GV04]. This architecture that supports plugins and macros has made ImageJ very popular in image processing. While the ImageJ API makes using the program very straightforward, its underlying base – the programming level – is very complex and includes a lot of libraries, some of them unique to ImageJ, while others are standard Java libraries (AWT) or derived from standard libraries [BB08].

ImageJ can be used online in the form of an applet, or as a standalone application, only requiring that a java virtual machine version 5 or later to be installed on the computer.

3. IMAGE PROCESSING OPERATIONS

To enhance images you make use of a wide range of tools and functions whose purpose is to improve the detection of image components. In the following paragraphs we will describe a few image processing operations:

3.1 Making a grayscale image

When color is irrelevant to the end result of our image processing (in determining the contours of objects for example), you can transform the original color image into its grayscale counterpart (the image thus becoming simpler, with less information contained in it, and with more processing options available after the transformation).

In ImageJ the following steps are necessary: Image / Type / 32-bit.

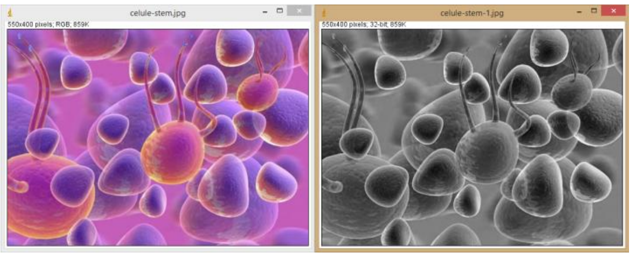
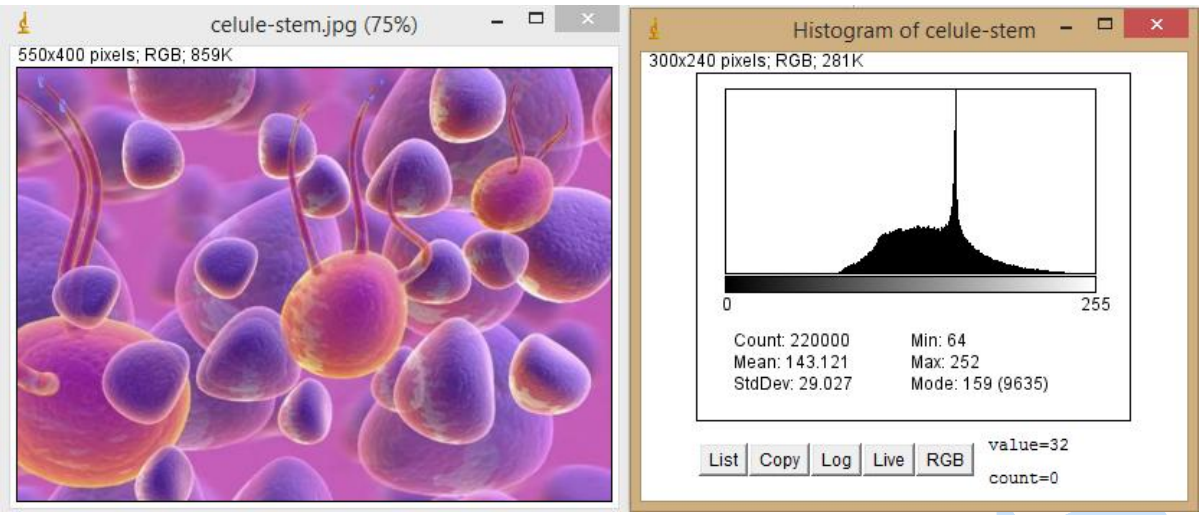


Figure 1. Transforming a color image into grayscale

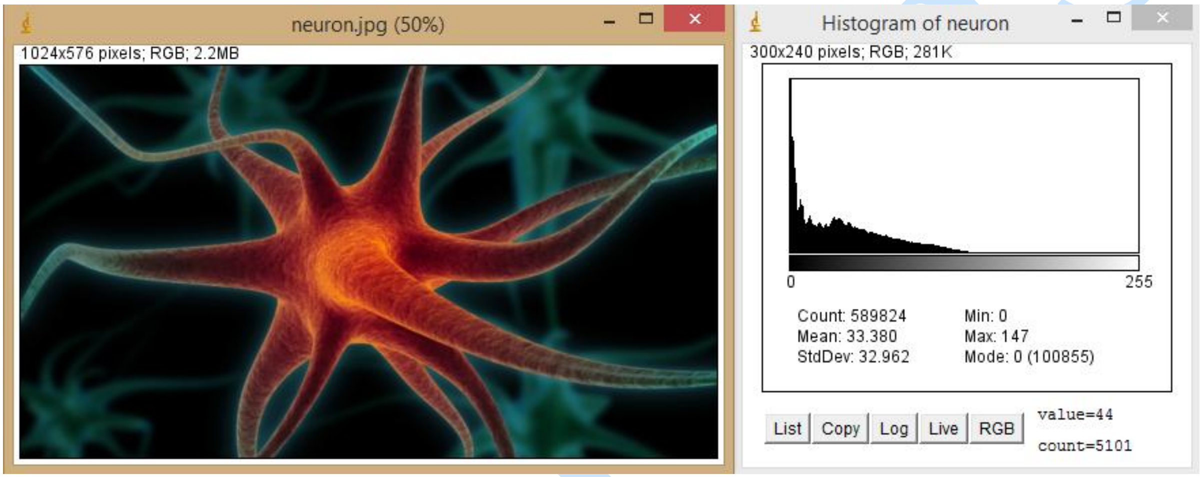
3.2 Adjusting the tonal distribution

The number of pixels (frequency) for each tonal value are represented in the Image Histogram.



Count: 220000 Min: 64
Mean: 143.121 Max: 252
StdDev: 29.027 Mode: 159 (9635)
value=32
count=0

Figure 2. Image Histogram *celule-stem.jpg*



Count: 589824 Min: 0
Mean: 33.380 Max: 147
StdDev: 32.962 Mode: 0 (100855)
value=44
count=5101

Figure 3. Image Histogram *neuron.jpg*

The brightness and contrast of an image can be modified thus: Image / Adjust / Brightness-Contrast:

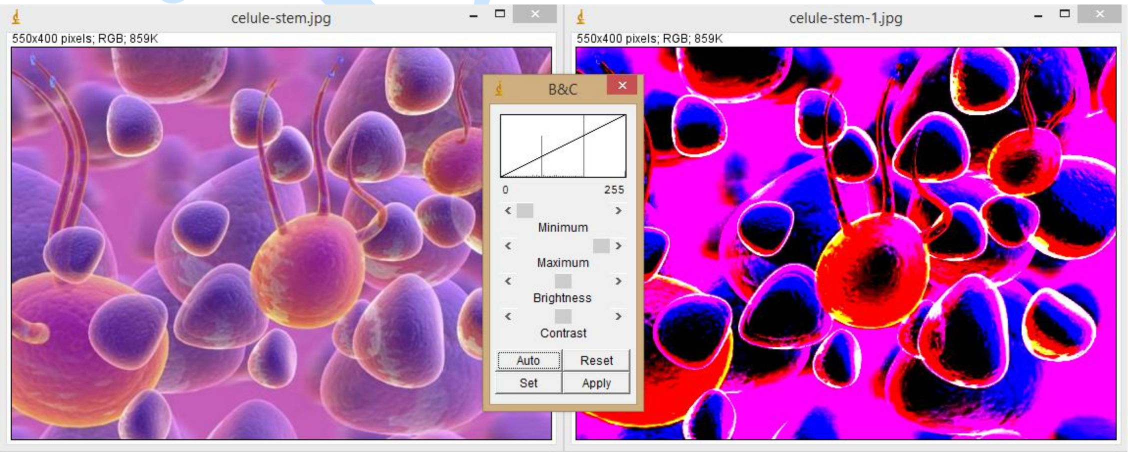
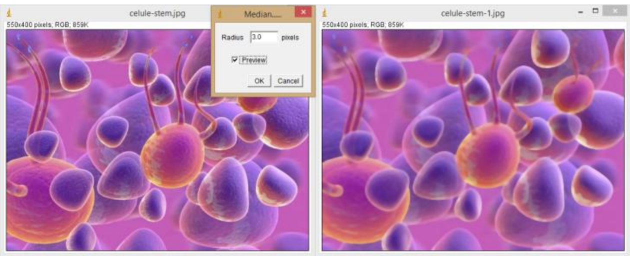


Figure 4. Adjusting the tonal distribution

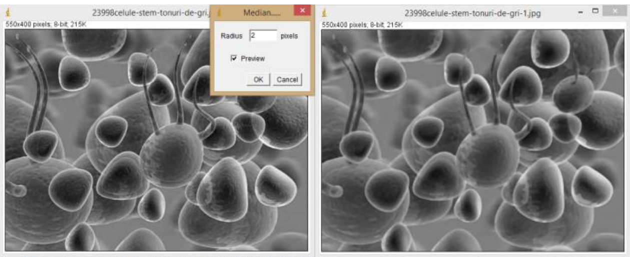
3.3 Image filtering

Some images contain a lot of digital noise. Digital noise is the result of errors that manifest when the original image is captured. The errors come in the form of wrong tonal values for some pixels that do not reflect the actual image. Digital noise can appear in the image in multiple ways, dependent on the way the picture was created. To remove the noise you replace every pixel that has a bad tonal value with the median tonal value of its neighbors. Filtering the image by determining the median tonal value is a method for smoothing an image (Gaussian Linear Filter). For a moderate level of noise this method represents an ideal way to remove noise, while preserving contours, thus leading to it being widely used in image processing.



Radius 3.0 pixels
☑ Preview

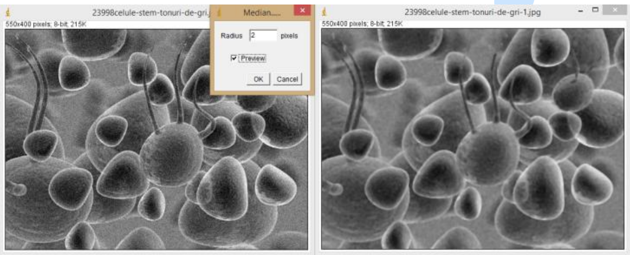
Figure 5. Applying a median filter with a radius of 3px


23998celule-stem-tonuri-de-gri.j
550x400 pixels; 8-bit; 215K
Median.....
OK
Cancel
23998celule-stem-tonuri-de-gri-1.jpg
550x400 pixels; 8-bit; 215K

Radius 2 pixels
☑ Preview

Figure 6. Applying a median filter with a radius of 2px

In the process of creating the grayscale image some Gaussian noise with a standard deviation of 15 appeared in the image, after which a median filter was applied.

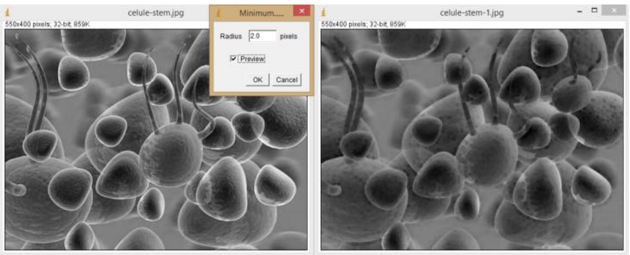

23998celule-stem-tonuri-de-gri.j
550x400 pixels; 8-bit; 215K
Median.....
OK
Cancel
23998celule-stem-tonuri-de-gri-1.jpg
550x400 pixels; 8-bit; 215K

Radius 2 pixels
☑ Preview

Figure 7. Median filter

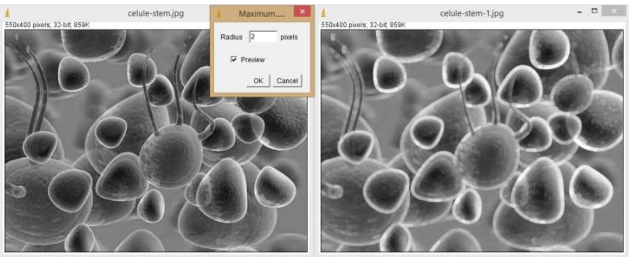
3.4 Morphologic operations

Morphologic processing of images is a technique used for extracting or modifying information specific to the shape and structure of object from the image. Morphologic operators (dilation, erosion), are generally used in analyzing binary images, but can also be used to analyze color or grayscale images. In the case of erosion, every pixel that belongs to the object and touches the background becomes a pixel of the background. In the case of dilation, every pixel that belongs to the background and touches an object, becomes a pixel of the object. The border is established with the help of neighboring pixels.
Using ImageJ you can erode an image by: Process/Filters/Minimum, while you can dilate an image by: Process/Filters/Maximum.



Radius 2.0 pixels
☑ Preview

Figure 8. The operation of Erosion



Radius 2 pixels
☑ Preview

Figure 9. The operation of Dilation

The two morphologic operators can be used together resulting in morphologic closing when using dilation – erosion, and morphologic opening when using erosion – dilation.

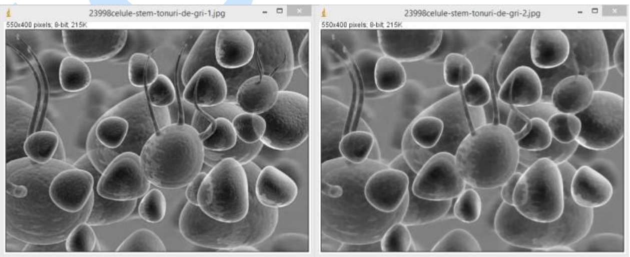

23998celule-stem-tonuri-de-gri-1.jpg
550x400 pixels; 8-bit; 215K
23998celule-stem-tonuri-de-gri-2.jpg
550x400 pixels; 8-bit; 215K

Figure 10. Morphological closing (dilation-erosion)

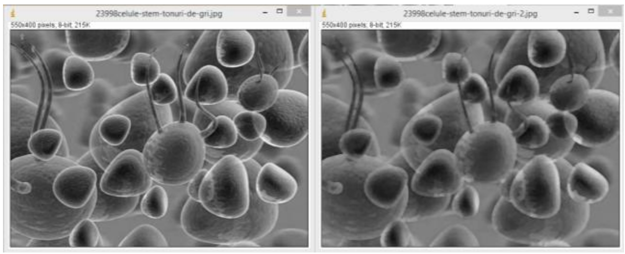

23998celule-stem-tonuri-de-gri.jpg
550x400 pixels; 8-bit; 215K
23998celule-stem-tonuri-de-gri-2.jpg
550x400 pixels; 8-bit; 215K

Figure 11. Morphological opening (erosion-dilation)

3.5 Image segmentation

Segmentation is one of the most important steps in image analysis [Bra03]. The process of segmentation is considered to be a process of classifying the objects from an image. By partitioning in regions the goal of segmentation is achieved, which is the representations of the images as useful information. The image segmentation method is used to locate certain objects and contours from the image. The contour or perimeter of an object is the assembly of pixels from the object which have at least one neighboring pixel which is outside of the object.

In ImageJ you can find contours by using: Process -> Find Edges.

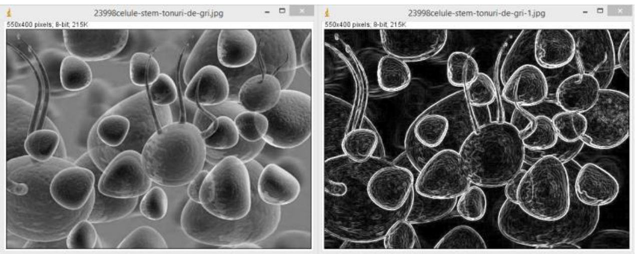

23998celule-stem-tonuri-de-gri.jpg
550x400 pixels; 8-bit; 215K
23998celule-stem-tonuri-de-gri-1.jpg
550x400 pixels; 8-bit; 215K

Figure 12. Finding contours in a grayscale image (celule-stem.jpg)

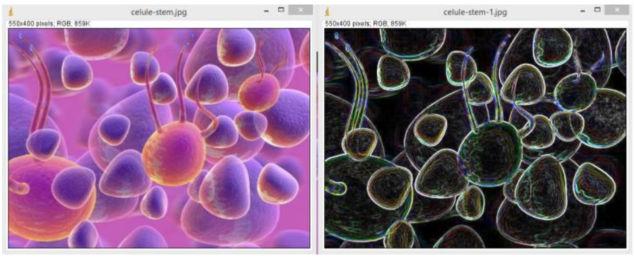


Figure 13. Finding contours in a color image (celule-stem.jpg)

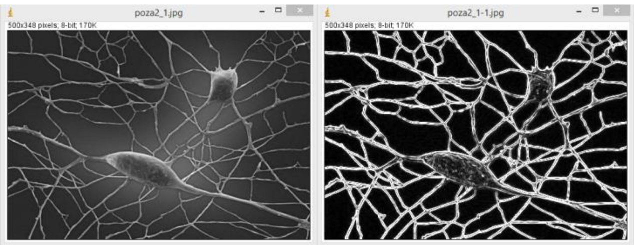


Figure 14. Finding contours in a grayscale image (poza2_1.jpg)

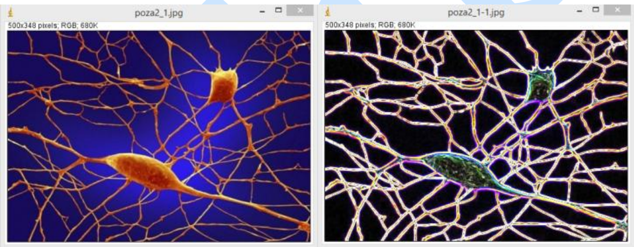


Figure 15. Finding contours in a color image (poza2_1.jpg)

The detection of contours is best achieved using black and white images. For this, the first step is the convert the picture to black and white (binarize the image), after which you find the contours.

In Figure 17 there are presented a few image processing operations, with the purpose of finding the contour of the object of interest from the image.

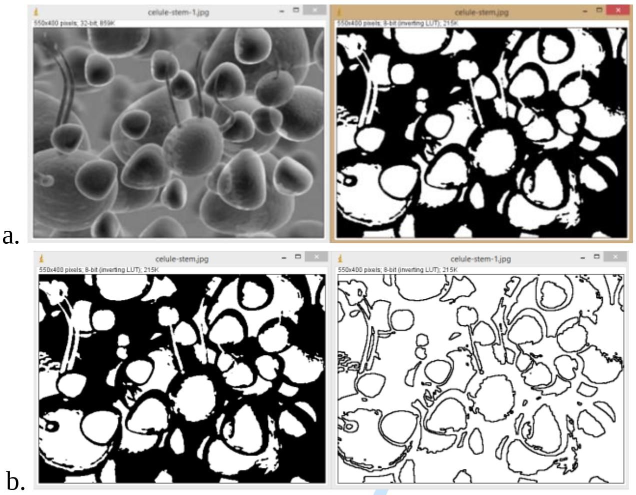


Figure 16. a. Binarizing, b. Finding the contours

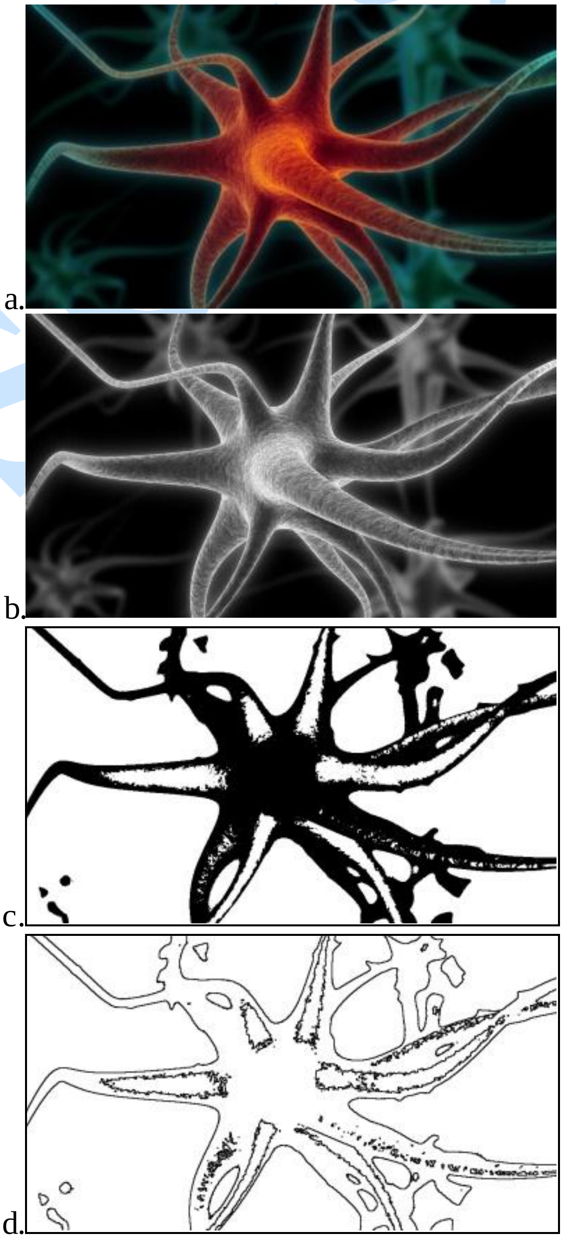


Figure 17. a. Original Image, b. Grayscale image, c. Binarization, d. Finding the contour

In Figure 18 some image processing operations are presented, in the order proposed by the authors, with the purpose of obtaining the best and most succinct contour of the object of interest from the image neuron.jpg.

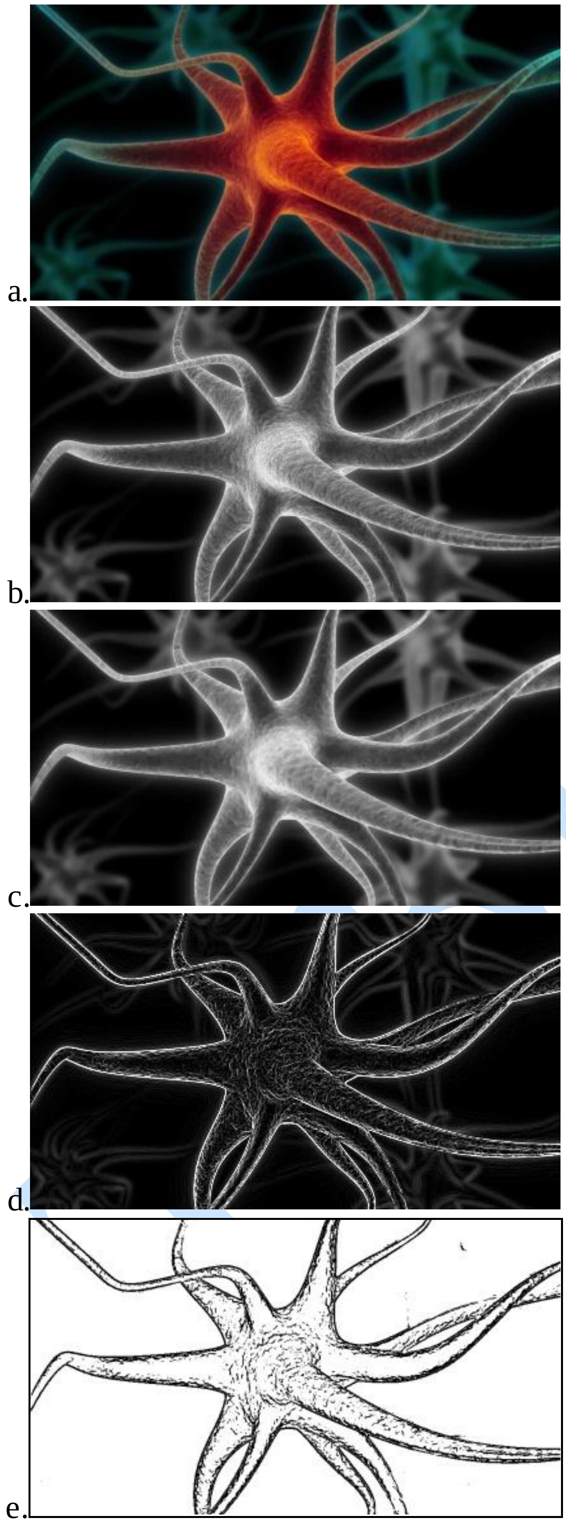
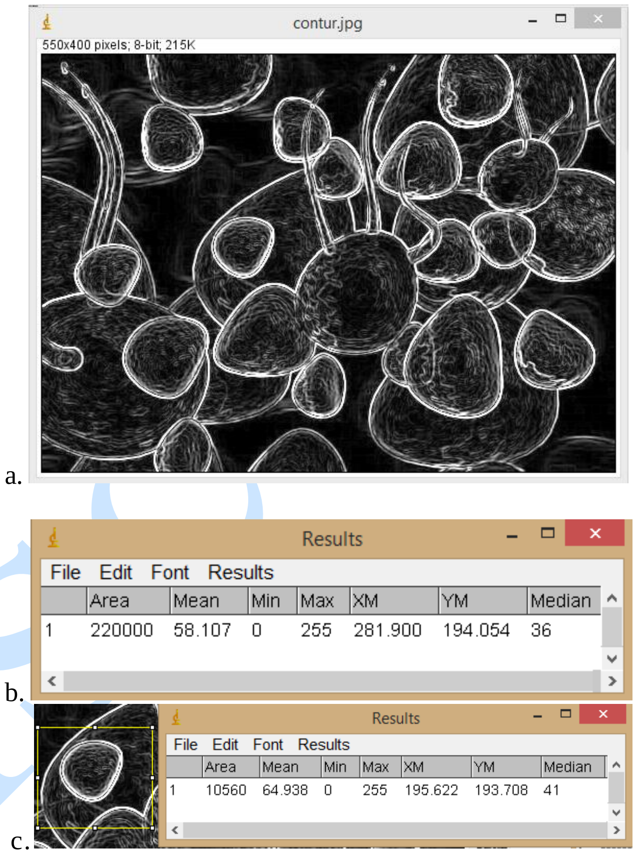


Figure 18. a. Original Image, b. Grayscale, c. Morphologic closing, d. Finding contour, e. Binarization

3.6 Statistic measurements

ImageJ can also assist the user in making a set of statistic measurements in an image, depending on the current selection. Result regarding area computations, line lengths, coordinates, angle size are displayed in a table, the measurements thus made can be selected from a separate window.



	Area	Mean	Min	Max	XM	YM	Median
1	220000	58.107	0	255	281.900	194.054	36

	Area	Mean	Min	Max	XM	YM	Median
1	10560	64.938	0	255	195.622	193.708	41

Figure 19. a. Original Image, b. Display measurements for whole image, c. Display measurements for selection only

CONCLUSIONS

ImageJ is a tool used with success both in the academic and research spheres, for processing (segmenting and binarization) biological as well as medical images.

ImageJ has a unique position, not only because it is open sourced (the source code is available for anyone and it is free), but it can also run on any operating system. What makes it attractive is the ease of use, it can perform a complete set of image processing operations and it have a large community of users. Thus it can be easily used in schools, high schools, universities, with very little financial cost.

The evolution of program development will be a very interesting experience and full of satisfaction for both users and developers.

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