Applying Retinex Filters to Microscopic Images

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Abstract: We will discuss, in a series of papers, the several applications that Retinex filters can have for enhancing images. Applications are ranging from the images obtained by microscopes to the images coming from satellites. However, we can find also interesting uses for the increase of the visibility of objects in dark, foggy and underwater images, such as for increasing details in medical imaging and for fault- and face-detection. Besides these applications, others are possible such as in the studies of painting masterpieces and for the digital restoration of cultural heritage. Here we discuss the first application of Retinex, that for enhancing the images coming from microscopy.

Keywords: Image Processing, Image Segmentation, Texture Analysis, Entropy, Microscopy, Kerr Microscopy, SEM imaging, Optical Microscopy,

Introduction

Retinex methods of image processing had been developed to solve some problems concerning the automatic vision, coming from experimental observations. Experiments evidence the fact that it is easy to note discrepancies between an image that we have recorded by a camera and the real scene that we have observed. The reason is in the fact that humans are able to see details both in the shadows and in the nearby illuminated areas, whereas a photograph of the same scene is showing either the shadows as too dark or the bright areas as overexposed [1]. In fact, some peculiar features of human vision concerning colours, brightness and contrast of a scene, are quite different from those of the recording devices [2,3].

Several methods and algorithms of image processing had been developed, inspired by the human vision biological mechanism to adapt itself to these conditions. Actually, these methods are known as the Retinex models. The first algorithm was conceived by Edwin H. Land, an American scientist and inventor, best known as co-founder of Polaroid Corporation [4-8]. As explained in Ref.1, through the years, Land evolved several models, until his last one proposed in 1986. The term "retinex" was coined by Land himself, combining the words "retina" and "cortex", to indicate the results of his researches, that human colour perception is involving all levels of vision processes, from the retina to the cerebral cortex.

Several Retinex approaches exist [3,9]: the single-scale Retinex (SSR), the multiscale Retinex (MSR), and, for colour images, the MultiScale Retinex with Colour Restoration (MSRCR). GIMP Retinex is a freely available tool of this last family, developed by Fabien Pelisson [10]. The resulting image of this filter can be adjusted selecting different levels, scales and dynamics. In the GIMP tool, we have three "levels". The uniform level tends to treat both low and high intensity areas fairly, the low level "flares up" the lower intensity areas on the image, and high level tends to "bury" the lower intensity areas in favor of a better rendering of the clearer areas of the image. A "scale" parameter determines the depth of the Retinex scale filtering, and a "scale division" determines the number of iterations used by the filter. A "dynamic" slider allows adjusting colour saturation contamination around the new average colour. For what concerns the results of the GIMP Retinex filtering, we have shown, by means of a method based on the generation of a bulk set of images with selection and ranking, and using entropy too, that the information in the image is changed, in particular for dark and foggy images [11-14].

Here, we will start a discussion of the several applications of Retinex filtering. We will use GIMP Retinex again for the proposed examples. Applications are ranging from the images obtained by microscopes to the images coming from satellites. However, we can find also interesting uses for the increase of the visibility of objects in dark, foggy and underwater images, such as for increasing details in medical imaging and for fault- and face-detection. Besides these applications, others are possible such as the use of Retinex in the studies of painting masterpieces and in the digital restoration of cultural heritage. Here we discuss the first application of Retinex, that to the enhancement of the images from microscopy.

Microscopy

In a previous article [15], we have shown some examples of the use of GIMP Retinex. Therefore here we mention only some of them. Of course, we have applications for biology, medical imaging and materials sciences. In [15], the reader can find examples from the microscopy of liquid crystals and images involved in the Kerr microscopy. An example of the use of GIMP Retinex for SEM microscopy is also proposed. Other case studies and filtering are proposed in [16-25].

In [16], an image processing is given for the contrast and brightness enhancement, by means of a technique based on Cuckoo Search (CS) and Multi-scale Retinex (MSR) algorithm. Examples are given for biology. In [17], the biological samples are concerning the embryos viability, for the optimization of in vitro fertilization treatment outcome. In this study, the authors propose a fully automatic method for segmentation and measurement of blastocysts. The researchers have eliminated the inhomogeneities of the blastocysts surface using the Retinex filtering.

Multi-Scale Retinex (MSR) algorithm in used in [18], for an automated approach to image enhancement. MSR is associated to a Flower Pollination Algorithm (FPA) to select the optimal weights to the different scales of Gaussian filters for MSR. The experiments are carried out using blood cell microscopic imaging. In [19], Retinex is used for the processing of the images obtained by high-speed panoramic light-sheet microscopy in the study of the endodermal cell dynamics. Other biological applications of Retinex are in [20-22].

In [23], the authors focussed on the properties of the geo-materials, because greatly affected by the internal micro structure system. The study is made by means of a Retinex scale optimized image enhancement algorithm. Some soil specimens in South China are analysed, by means of a threshold segmentation of the enhanced image too. In [24,25], we used Retinex followed by image segmentation for the study of the fly ashes and the measurement and prediction of pore size distribution of freeze-dried solutions in vials.

Examples Here we show some examples just to illustrate some possible uses of GIMP Retinex. Let us start from the capillary already investigated in [15]. On the left, the SEM image and on the right, with the inside of the capillary enhanced by means of the Retinex.

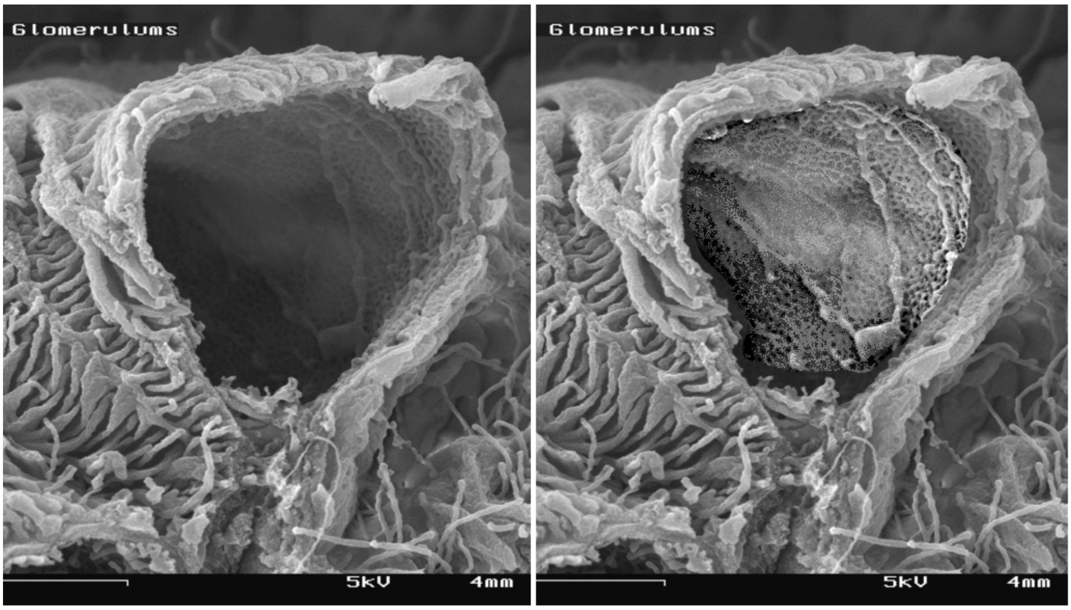

Figure 1: The left image shows a glomerulus of mouse kidney with a broken capillary, in a SEM image, magnification 10,000x (courtesy SecretDisc, on Wikipedia). GIMP Retinex allows observing details in the shadow of the capillary, as we can see in the right panel. The endothelial surface of the capillary contains numerous pores and some structures that represent localized thickening of the surface.

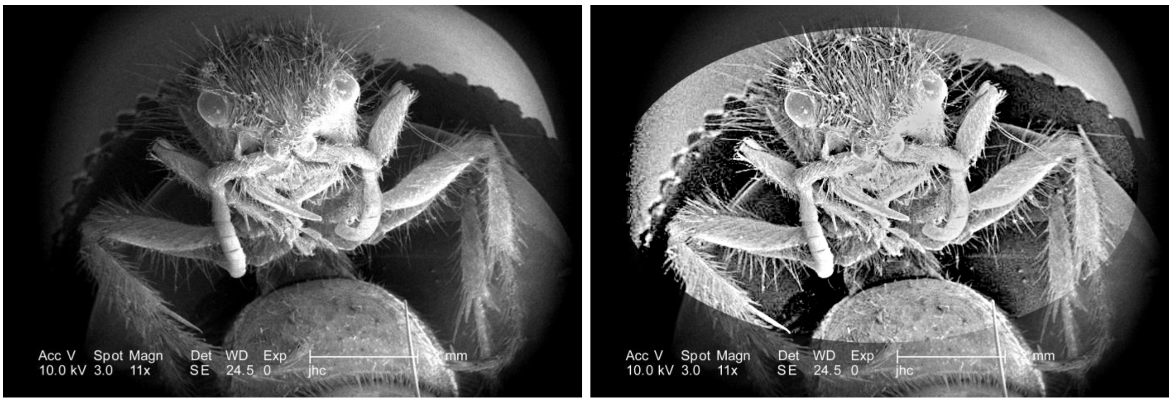

Figure 2: Scanning electron micrograph (SEM) of a female velvet ant. On the right, a part of the image enhance by means of GIMP Retinex. Creators: CDC/ Michael and Paula Smith. Source: Public Health Image Library. Image and details are available at the web page of the Library: http://www.publicdomainfiles.com/show_file.php?id=13544112011538

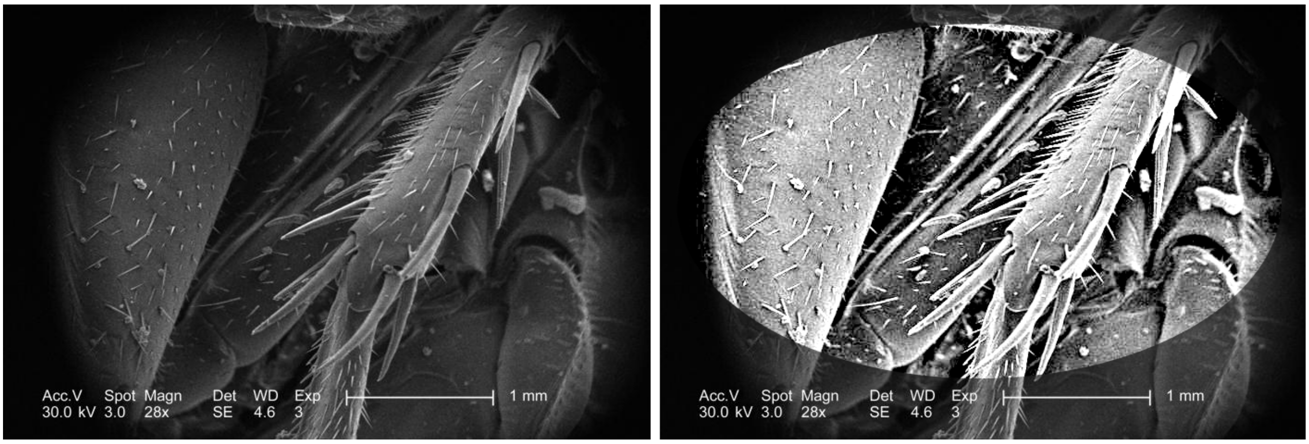

Figure 3: SEM image of the anatomical morphology found in the exoskeletal configuration of a roach. On the right, a part of the image is enhance by means of Retinex. Creator: CDC/ Janice Carr. Source: Public Health Image Library. Source: Public Health Image Library. Image and details are available at the web page of the Library: http://www.publicdomainfiles.com/show_file.php?id=13540178417244

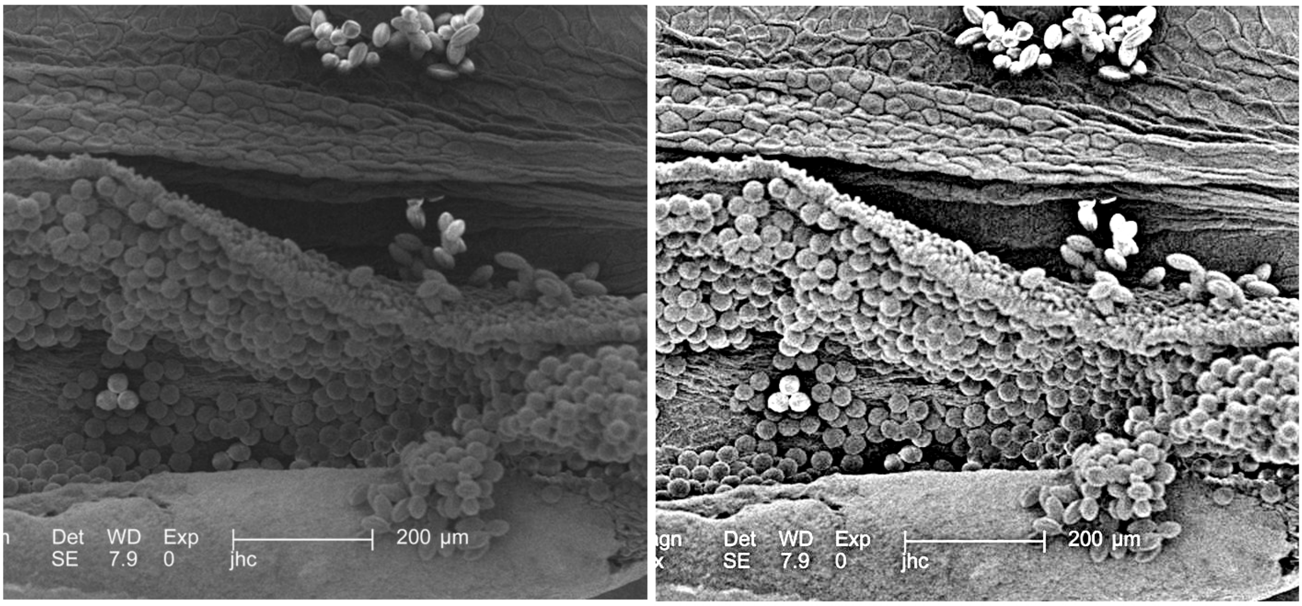

Figure 4: SEM of a morphologic ultrastructure found amongst a collection of pollen Creator: CDC/ Janice Carr, Betsy Crane. Source: Public Health Image Library. On the right, the GIMP Retinex is applied to all the image. Available at the web page of the Library: http://www.publicdomainfiles.com/show_file.php?id=13540258212645

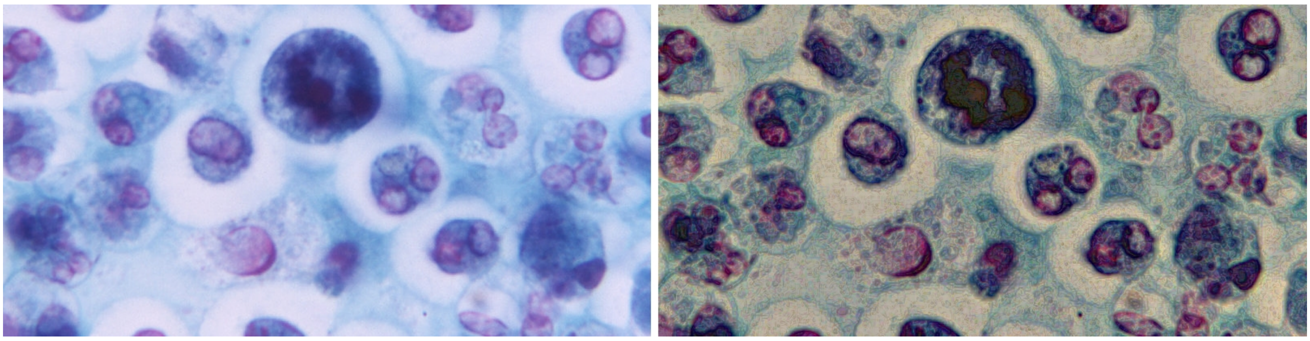

Figure 5: A detail of a micrograph showing a blood smear. Magnified 1125X. Creator: CDC, Source: Public Health Image Library. http://www.publicdomainfiles.com/show_file.php?id=13533841213859

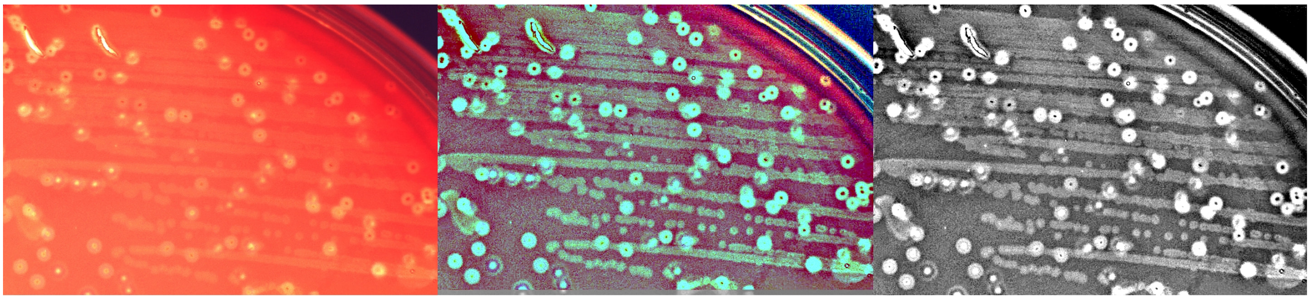

Figure 6: A Petri dish filled with trypticase soy agar medium containing 5% defibrinated sheep's blood. No magnification was used here. Creator: CDC/ Richard R. Facklam, Ph.D. Source: Public Health Image Library. Retinex is made on the colour and on the grey-scale images. http://www.publicdomainfiles.com/show_file.php?id=13540082411418

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