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# DIGITAL ANALYZING OF THE SEM IMAGE OF THE POROUS ANCIENT CERAMIC

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***Abstract:*** *Scanning electron microscopy (SEM) provides resolutions on the order of a nanometer. One of the problems associated with SEM images is variations in brightness due to electron imaging defects. These variations render image processing operations such as segmentation more difficult. The correction requires estimation of the global illumination field. We present a method to sharpen a non-uniformly brightness image by use of wavelet transformation. This analysis deals with the method to enhance an image to correct for non-uniform brightness, and then use the enhanced image to identify the depth of individual pores. Both the fine characteristics and object edges in the image are well enhanced without degrading the contrast. The 3D surface topography for intensity distribution of porous ceramic is presented.*
***Keywords:*** *SEM images, porous ceramic, brightness, wavelet, histogram equalization*

## 1. INTRODUCTION

Numerous ceramic objects with very aesthetic and technological qualities have been recovered by archaeological excavations. Adequate processes of restoration and conservation treatments require the accurate determination of the elemental composition and distribution within the objects, as well as the identification of the surface topology. Ideally the identification method should cause no alteration in the sample.
This study deals with the method to enhance an image to correct for non-uniform brightness, and then use the enhanced image to identify the depth of individual pores.
A method for automatically modifying the illumination of an image based on an analysis of pixel values within a selected region of interest comprising: providing a digital input image of digital pixel values; displaying the gray scale image; selecting a region of interest from the input image; computing the histogram of the pixel values within the region of interest; creating a bright light image by remapping the pixel values within the region of interest and overlaying the bright light image on the default rendered image.
So, the first step in preprocessing algorithm is correction illumination. We have used the method based on the estimation of background illumination [1].
To obtain complementary information, analysis were carried out using the scanning electron microscope (SEM) but only in the objects which could be sampled or of some fragments that were detached during their restoration process [2].
The results of this article should be enough to familiarize the readers with both the porous structure and the surface topology of ceramic objects thus avoiding the future destructive samplings of cultural heritage objects.

## 2. MATERIALS AND METHODS

### 2.1. Data visualization in MATLAB

We use Matlab 7.8.0 to process the transformation. The input image is a two-dimensional matrix with 256×256 size. We perform the transformation on the image matrix in row direction and column direction, respectively. The transformation in each direction again proceeds two times with one pixel shifted in order to detect all of the nest variations [3, 4].

We start to read and display the gray scale image .tif as 2D image (presented in Figures a) with *imshow* function as shown on Figures b.

```
>> I=imread('img.tif');
>> imshow(I)
```

In the SEM sample image, the background brightness is higher in the left side of the image. Using the MATLAB media, we proceed a morphological opening operation to estimate the background illumination. Morphological opening is an erosion followed by a dilatation, using the same structuring element for both operation. The opening operation has the effect of removing objects that cannot completely contain the structuring element:

```
>> background=imopen(I,strel('disk',15));
```

Another possibility is to use the 3D imaging with *surf* function and others function for defining the view, light, render method and so forth. This step will permit to create a surface display of the background. We create a colored parametric surface that enable us to view mathematical function over a rectangular area (presented in Figures c). The Matlab code for this imaging is presented here:

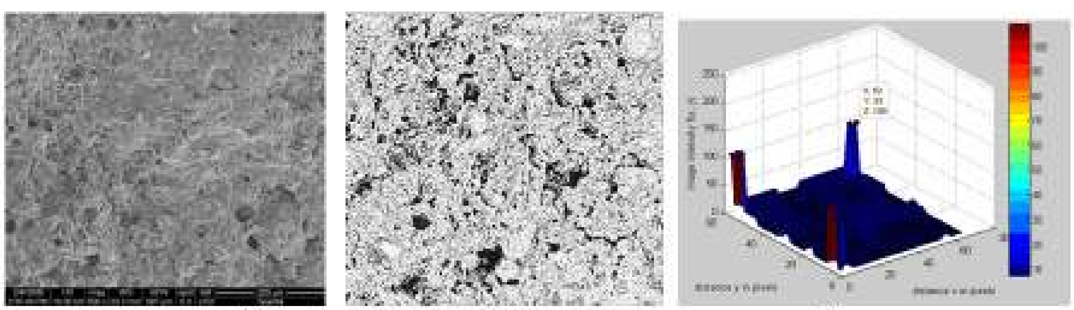
```
>> figure,surf(double(background(1:8:end,1:8:end))),zlim([2 255]);
>> set(gca,'ydir','reverse');
```

## 2.2. Sample preparation

No special preparation is required for SEM analysis. It was used small fragments detached from the samples. All images are taken directly in digital form.

# 3. RESULTS AND DISCUSSION

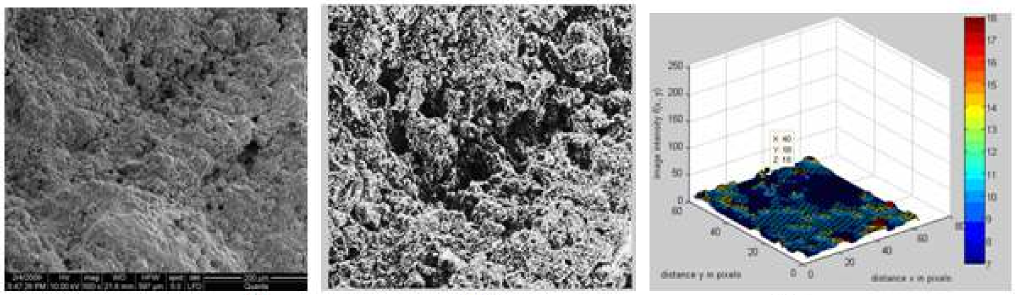
Image enhancement techniques are used to improve an image, where "improve" is sometimes defined objectively (e.g., increase the signal-to-noise ratio), and sometimes subjectively (e.g., make certain features easier to see by modifying the colors or intensities).



(a) (b) (c)

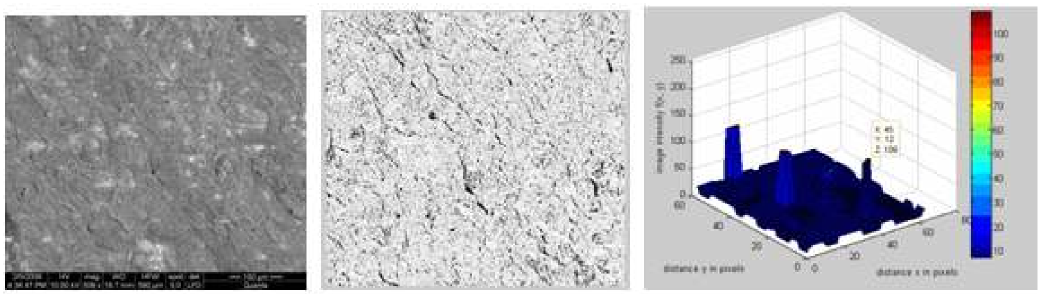
**Figure 1:** (a) SEM image in .tif extention of a highly porous ceramic sample;
(b) The crop image with 256×256 pixels size showing an uniform brightness;
(c) The parametric images shown as in 3D space for the positions of maximal values.

In the surface display, the point [0, 0] represents the origin or upper-left corner of the image. The highest part of the curves indicate that the highest pixel value of image occur near the upper-right corner of the surface.
The lower pixel values occur at the top of the image and are represented in the surface plot by the lowest part of the curves.



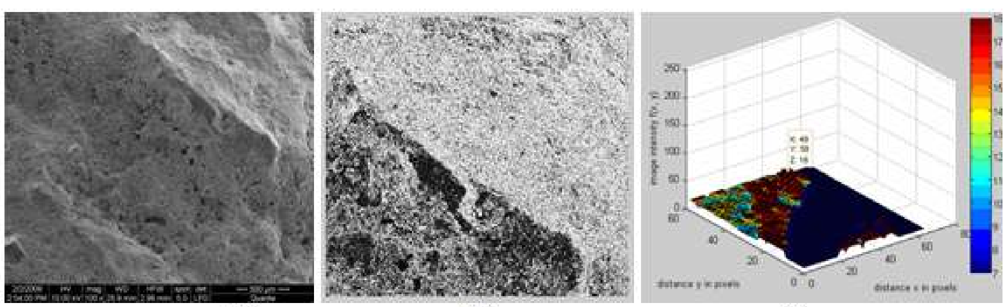
(a) (b) (c)

**Figure 2:** (a) SEM image in .tif extention of a moderate porous ceramic sample;
(b) The crop image with 256×256 pixels size showing an uniform brightness;
(c) The parametric images shown as in 3D space for the positions of maximal values.



(a) (b) (c)

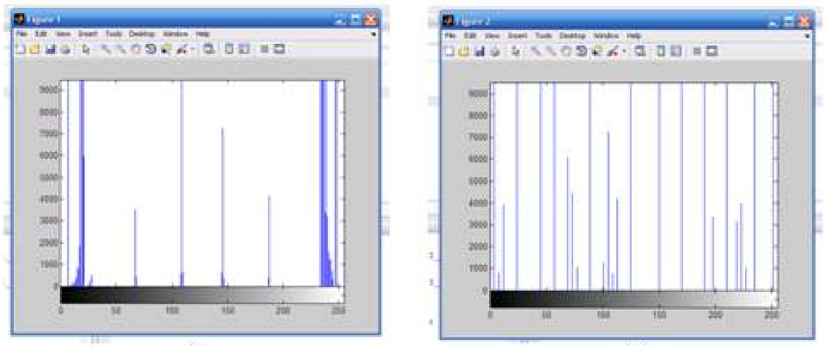
**Figure 3:** (a) SEM image in .tif extention of a low porous ceramic sample;
(b) The crop image with 256×256 pixels size showing an uniform brightness;
(c) The parametric images shown as in 3D space for the positions of maximal values.



(a) (b) (c)

**Figure 4:** (a) SEM image in .tif extention of a ceramic sample with inhomogeneous porosity distribution;
(b) The crop image with 256×256 pixels size showing an uniform brightness;
(c) The parametric images shown as in 3D space for the positions of maximal values.

Figures 1 to 2, respectively, show the spatial intensity distribution for a ancient ceramic with high and moderate porosity. Figures 3 to 4, respectively, show the spatial intensity distribution for a ancient ceramic with low porosity and with inhomogeneous porosity distribution. Also, the plots clearly indicate the same high spatial frequency power in the SEM images of the porous regions, compared with non-porous area.
Intensity adjustment is an image enhancement technique that maps an image's intensity values to a new range. To illustrate, the figure 5 shows the histograms for low-contrast image presented in figs. 4. Notice in the histogram of the image how all the values gather in the center of the range. Histogram equalization is a technique which consists of adjusting the gray scale of the image so that the gray level histogram of the input image is mapped onto a uniform histogram. The histogram equalization scheme, which tends to over enhance the image contrast, often leads to a noisy appearance of the input image [5]. If we remap the data values to fill the entire intensity range [0, 255], then it can increase the contrast of the image.



a) b)

**Figure 5:** Histogram equalization for the SEM image presented in figures 4a and 4b.
a) for figure 4a the histogram is not equalized ; b) histogram of the equalized image from figure 4b

## 4. CONCLUSION

A method to enhance an image and to correct for non-uniform brightness from data visualization has been presented. Then, we used the enhanced image to identify the depth of individual pores. The algorithm can be summarized as follows:
1. Illumination correction - background illumination model;
2. Data extraction;
3. Visualization - Matlab routines for 2D/3D imaging;
4. Histogram equalization.

The presented results show the effectiveness of Matlab for data visualization.

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