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The Pre-Processing of Images Technique for the Material Samples in the Study of Natural Polymer Composites

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ABSTRACT: *The image processing analysis is one of the most powerful tool in various research fields, especially in material / polymer science. Therefore in the present article an attempt has been made for study of pre-processing of images technique of the material samples during the images taken out by Scanning Electron Microscope (SEM). First we prepared the material samples with coir fibre (natural) and its polymer composite after that the image analysis has been performed by SEM technique and later on the said studies have been conducted. The results presented here were found satisfactory and also are in good agreement with our earlier work and some other worker in the same field.*

Keywords: *Coir fibre, composite, image, noise suppression, contrast increase, median filter.*

I. INTRODUCTION

The composites are now extensively being used for rehabilitation/strengthening of pre-existing structures that have to be retrofitted to make them seismic resistant, or to repair damage caused by seismic activity. Composites are used because overall properties of the composites are superior to those of the individual components. Advantages of composites over their conventional counterparts are the ability to meet diverse design requirements with significant weight savings as well as strength-to-weight ratio. Also, unlike conventional materials (e.g., steel), the properties of the composite material can be designed considering the structural aspects. Composite properties (e.g. stiffness, thermal expansion etc.) can be varied continuously over a broad range of values under the control of the designer. Careful selection of reinforcement type enables finished product characteristics to be tailored to almost any specific engineering requirement.

Most commonly used matrix materials are polymeric. Common fiber reinforced composites are composed of fibers and a matrix. Fibers are the reinforcement and the main source of strength while matrix glues all the fibers together in shape and transfers stresses between the reinforcing fibers. The fibers carry the loads along their longitudinal directions. Sometimes, filler might be added to smooth the manufacturing process, impact special properties to the composites, and/or reduce the product cost.

Therefore, polymeric materials, reinforced with synthetic fibres, provide advantages ratio as compared to conventional construction materials. The design of a structural component using composites involves both material and structural design. Due to this, it is essential to illustrate and record the properties of these composites and investigate new source of applications of fibres in composites.

It is known also that investigators have done chemical modification of natural fibres in order to improve them with a polymer composite [1], [2], [3]. It has been illustrated that there are many factors that can change the properties of natural fibre reinforced polymer composites [4], [5], [6]. The main objective was to find effect of chemical treatment of natural fibre.

But a property of the fiber depends on its structure, changes in the morphology of fibre before and after treatment [7], [8]. Therefore it is important to have high-quality images composites, which are made under a microscope. In the present study, the main purpose is the consideration of the application of pre-processing to enhance quality of the original image. This is necessary to study the properties of the fibers as a reinforcing agent in polymer compositions.

II. MATERIALS AND METHODS

2.1 Image Processing as an Analysis Toll

The image analysis is one of the most prevailing tools in various research fields. This is due to the fact that over 80% of information about the world around us, people tend to perceive by means of sight [9]. At the same time standards of perception can be formed in a variety of systems. One such system is a microscope:

– on the one hand, microscopic images allow a more in-depth studies of the structural component polymer composites;

– on the other hand, these are special images that differ in their visualization of microcosm objects, which necessitates the use of a variety of image processing techniques to obtain information about objects, processes, and phenomenon under study.

These circumstances impose certain features and restrictions, both on the nature of considered standards of perception, and on possibilities of their analysis, additional data accessing about outward things.

There is plenty methods for image processing. But first, use methods of preliminary image processing (noise suppression, contrast increase, localization of separate sites of the image) [10], [11]. This makes it possible to improve the image quality of perception and get the necessary information. Image preprocessing can be applied to reduce the computational cost. For this purpose usually used wavelet analysis.

Image noise suppression techniques are used to remove the noise, when it is necessary to obtain new information. For this purpose usually used filtration methods: median filter, Wiener filter, averaging filter, nonlinear filtering [12].

For the image enhancement is used increase the contrast between the foreground (objects of interest) and background. Increase of the contrast or Image smoothing usually refers to spatial filtering.

Contrast is one of main characteristics of image because it is directly related to the brightness of pixels that are the sources of information about the objects in the image. By increasing the contrast of the image (pixels - individual image points) highlights become lighter and dark image regions become darker. When reducing image contrast there is an expansion of the average gray-level range. Dark pixels become lighter, and light pixels become darker and partially transform into the midtones. Thus, modifying the contrast of the image makes some of its details more distinct. It allows improving both image perception accuracy, as well as the accuracy (efficiency) of its further processing. It is very important for microscopic images, an example of which are images of natural polymer composites.

The following methods can be used to change the contrast of the image [13]:

– histogram equalization of brightness values (luminance),

– non-linear stretching of dynamic range of brightness values,

– masks filtering,

– fuzzy masking,

At the same time, the main task of image analysis of natural polymer composites is to define the area of individual objects. Then the use methodology pre-processing of image in the study polymer compositions includes the following steps:

Step 1: noise suppression (we will use the median filter);

Step 2: contrast increase (we will use all of the above methods);

Step 3: calculation of the area of objects which defined in advance (we use the threshold segmentation. Then we determine the area of the object).

Consider the application of methodology pre-processing of image in the study polymer compositions for the specific images.

2.2 Data for Analysis

For analysis, we use images that are obtained by means of scanning electron microscopy (**Fig. 1** and **Fig. 2**). The scanning electron microscopy of the test samples were done by JSM 6390A (JEOL Japan).

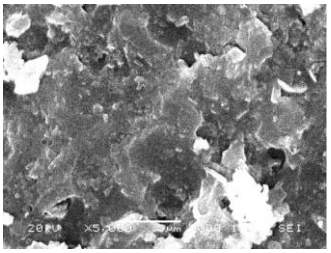


Figure 1: The first part of the sample

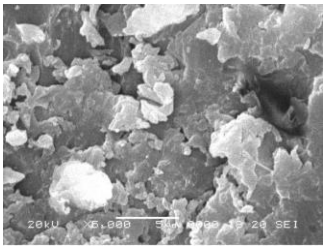


Figure 2: The second part of the sample

In this way we have different portions of one sample, which is regarded.

III. RESULT OF IMAGE PROCESSING

Initially we point objects, the area that should be calculates.
For **Fig. 1** this:

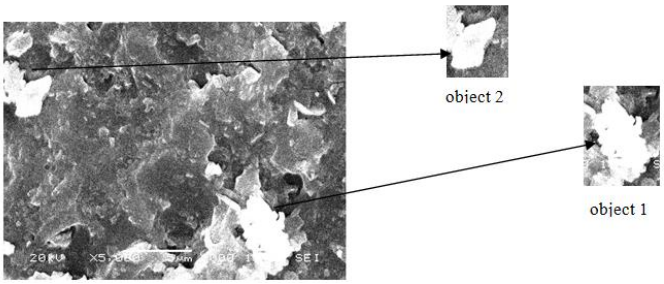


Figure 3: The objects that require to define their area (for **Fig. 1**)

For **Fig. 2** this:

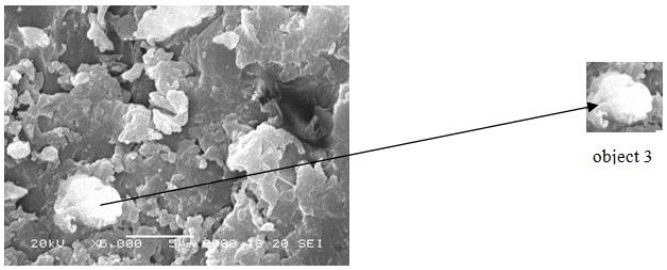


Figure 4: The objects that require to define their area (for **Fig. 2**)

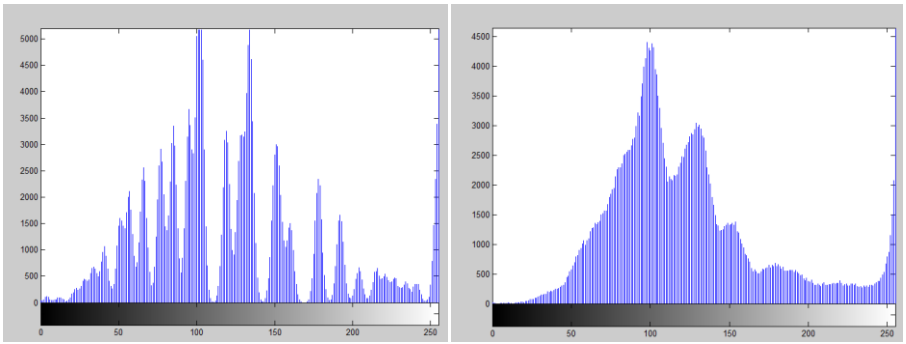
The areas of objects have been defined by experts (area has been calculated without the use of image processing methods):

object 1 – 8441 pixels,
object 2 – 4001 pixels,
object 3 – 4838 pixels.

We also define the area of objects without the use of methodology pre-processing of image (we use the threshold segmentation):

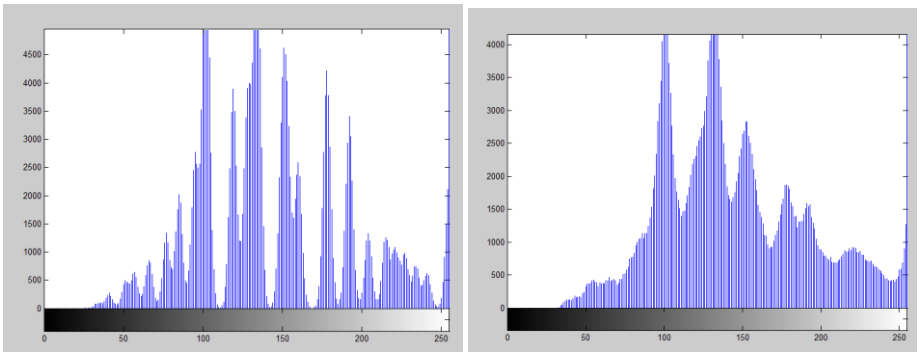
object 1 – 8563 pixels,
object 2 – 3912 pixels,
object 3 – 4902 pixels.

Step 1: To remove the noise, we used median filter (filtering mask has a size of 3x3 pixels). The results of application of median filtering can be clearly seen on **Fig. 5** and **Fig. 6**, which shows the histogram of the original and processed images.



a) the histogram of the original image b) the histogram of the image after filtering

Figure 5: Histogram of the original image and the image after filtering (for image **Fig. 1**)



a) the histogram of the original image b) the histogram of the image after filtering

Figure 6: Histogram of the original image and the image after filtering (for image **Fig. 2**)

Step 2: To change contrast, we use all of the above methods. At the same time:

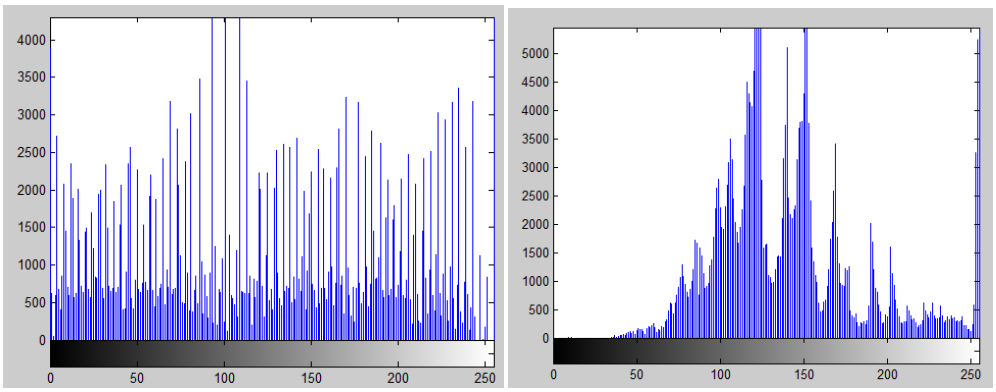
we use the nonlinearity coefficient with a parameter of 0.8 (for non-linear extension of dynamic range of brightness values);

we use the filter mask (h), which increases the sharpness of the image (for masks filtering):

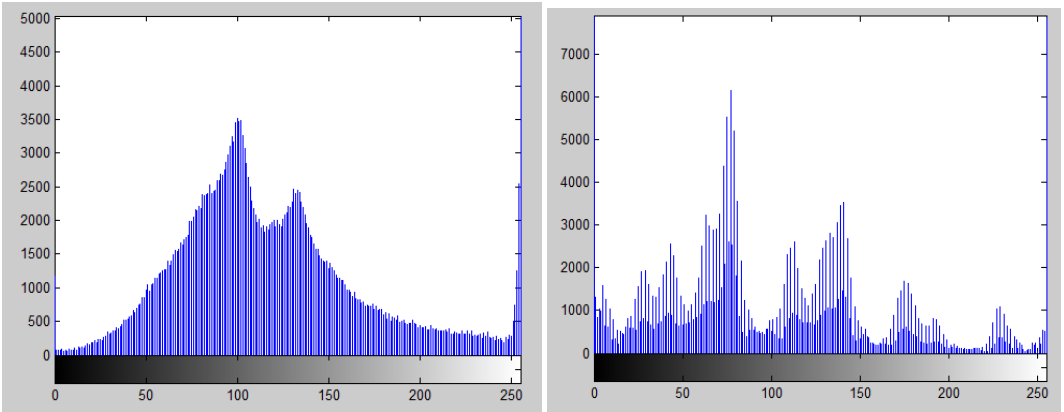
$$h = \frac{1}{(1+a)}\begin{bmatrix} -a & a-1 & -a \\ a-1 & a+5 & a-1 \\ -a & a-1 & -a \end{bmatrix},\ a = 0.2;$$

we use the average values and blurring coefficient 2 (for fuzzy masking).

The results of change contrast can be clearly seen in **Fig. 7** and **Fig. 8**, which shows the histogram processed images (in comparison with **Fig. 5** and **Fig. 6**).

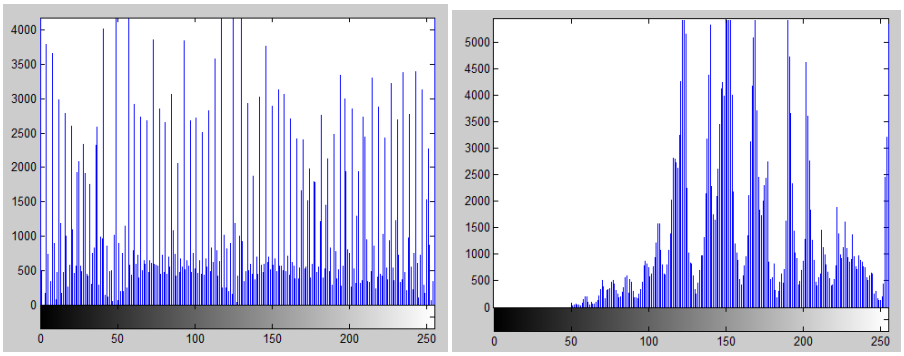


a) histogram equalization of brightness values b) non-linear stretching of dynamic range of brightness values

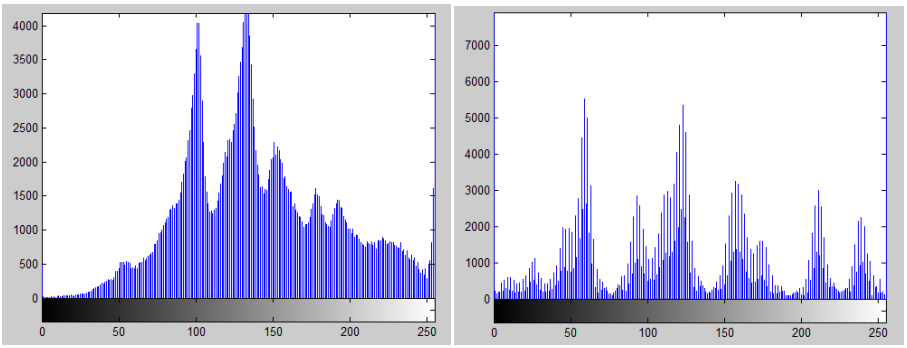


c) masks filtering d) fuzzy masking

Figure 7: Histogram of the image after change contrast (for image **Fig. 1**)



a) histogram equalization of brightness values b) non-linear stretching of dynamic range of brightness values



c) masks filtering d) fuzzy masking

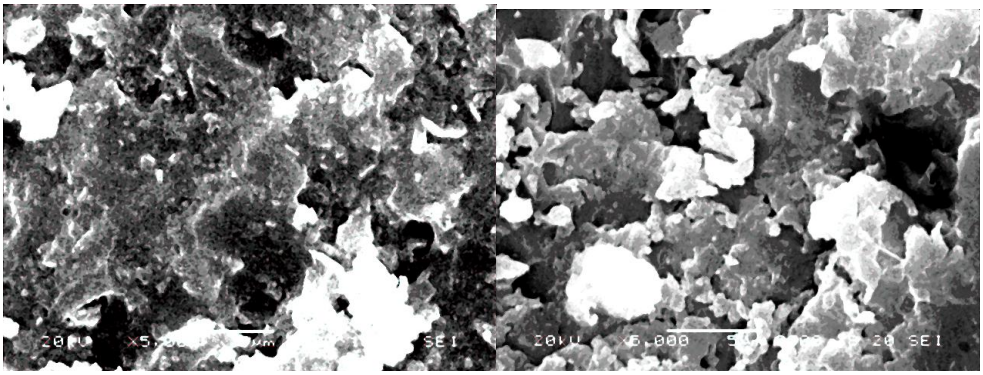
Figure 8: Histogram of the image after change contrast (for image **Fig. 2**)

We see that the histogram form for **Fig. 1** and **Fig. 2** is approximately the same (after contrast changes).
Step 3: In the table shows the area of objects which are studied.

Table: Area objects (pixels)

Objects	expert opinion	the original image	histogram equalization of brightness values	non-linear stretching of dynamic range of brightness values	masks filtering	fuzzy masking
1	8441	8563	8372	8643	9702	9971
2	4001	3912	3917	3985	3673	4734
3	4838	4902	4724	4903	5012	5437

We see that the experts' estimate coincide with the result when is used to change the contrast - histogram equalization of brightness values or non-linear stretching of dynamic range of brightness values. At the same time, the results for the object 3 are better than an object 1 and object 2 (when is used for changing the contrast - masks filtering or fuzzy masking). This is due to the fact that the object merges with the background (see **Fig. 9**, in comparison with **Fig. 1** and **Fig. 2**).



a) for **Fig. 1** (object 1 and object 2) b) for **Fig. 2** (object 3)

Figure 9: Change contrast using fuzzy masking

For use masks filtering or fuzzy masking is necessary to correctly choose the mask or the conditions for image blur. For this purpose necessary to take into account the properties of the objects, which are investigated and the properties of the entire image. Great importance is the ratio of the brightness of the background and the object, which are investigated. Thus, for the analysis of images of natural polymer aggregate should be chosen simple methods to improve the contrast. Since we have images, in where is dominated by black and white colors. It is also important to apply a local change in contrast.

IV. CONCLUSION

Some significant results have been obtained for the pre-processing of images technique in the present research work, therefore based on it one can draw the following conclusions:

One can predicts that there is change in the morphology of the coir fibre and its composites in comparison to the images of the prepared samples (natural coir fibre and its polymer composites), those were taken at the plane polished surface. From of these images we can see, that the cluster of coir fibre have inhomogeneous and deformed at microscopic level and therefore can be, for example, the reason for resistive ac conduction. Uneven and cracked surface may be due to the presence of impurities in the coir fibre. We also see the crystalline nature of the samples.

The present study also shows that successful fabrication of natural fibre / polymer composites by simple hand lay-up technique as well as pre-processing of images technique. This allows to someone for the better perceive the differences between uneven and cracked surface in polymer compositions. And this approach is not only enough for the contemporary need of engineering judgment but also requires a rigorous mathematical model to obtain optimal process settings.

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