Measurement of Electro Spun PVA nano fiber diameter distribution using Image Processing and comparison with manual method

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ABSTRACT:- The measurement of electrospun nanofiber diameter has been developed by using image analysis processing method. The development of the fiber diameter, scanning electron microscopy (SEM) images of electrospun nanofiber have been prepared and applied to the individual measurement and the traditional manual methods. In this measurement the average value of the diameter nanofibers found to be similar in both manual and image processing method, but the variance is higher than the manual methods. SEM images are converted to binary image using local thresholding method, skeleton and distance transformed image are generated. The results show the accurate automated measurements of electrospun nanofibre diameters. The effectiveness of the proposed method is shown by comparing automatically and manually measured nanofiber diameter values.

Keywords — Fiber diameter, Skeleton and distance transformed ,Image processing.

I. INTRODUCTION

Electro spinning is a straightforward method for manufacturing nanofibers that combines the benefits of a controlled fiber diameter with the possibility for large scale automated production. Electro spinning is one of the most efficient processes for nanofiber production by charging high voltage to polymer solutions or melts. Electro spinning is a process that offers unique capabilities for producing novel synthetic fibers of unusually small diameter and good mechanical performance (“nanofibers”), and fabrics with controllable pore structure and high surface area[1, 2]. One of the most significant drawbacks is that the fiber diameters and its distribution were measured from SEM images in most of researches. The physical properties of the morphological parameters are fiber diameter, pore and fiber orientation show critical effect. The various image analyses have developed for each parameter are characterized and simulate the morphology[3]. To measure the fiber diameter the SEM images are taken from Nanofibers as an acquired for image processing techniques. Automatic calculation of the fiber diameters is a relatively new research topic. The effect of the physical properties and its applications has morphological parameters such as fiber diameter, pore and fiber orientation show in critical. The various image analyses were developed for each parameter are characterized and simulate the morphology [4-8]. We developed a fiber diameter measuring process for nanofiber web using image analysis method from SEM images, in order to provide more precise characterization of the electrospun web morphology and structure. By separating the desirable layer from the image, the

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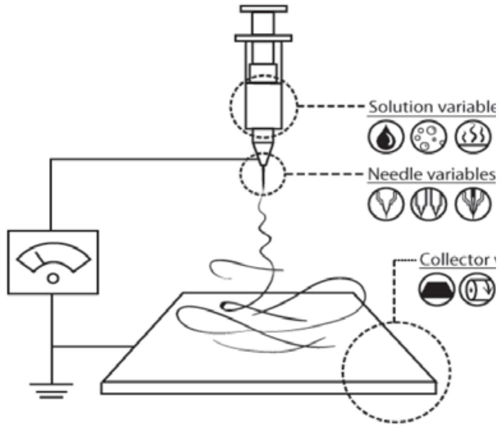
development method can estimate the fiber diameter from thick web. The objective of the current research is thus to develop an image analyses based method to serve as a simple, automated and efficient alternative for electrospun nanofiber diameter measurement.



THERSHOLDING:

In the simplest thresholding technique, called global thresholding, the image is segmented using a single constant threshold. One simple way to choose a threshold is by trial and error. Each pixel is then labeled as object or background depending on whether its gray level is greater or less than the value of the threshold, respectively [9&10] .The main problem of global thresholding is its possible failure in the presence of non-uniform illumination or local gray level unevenness. An alternative to this problem is to use local thresholding instead. In this approach, the original image is divided into sub images and different thresholds are used for segmentation.

MORPHOLOGICAL:

Determination of fiber diameters, fiber diameters distribution and the compactness of electrospun nanofibers are the important characterization process which are necessary for optimization of electrospinning process in different applications. Routine measurements of fiber diameters and its distribution were carried out manually by selecting 100 fibers and measuring their respective diameters which was a very time consuming method and is completely based on the operator's accuracy. In this work, we utilized the modified method which is previously reported by [11& 12].The following paragraphs describes the various steps of image analysis.The Original image showed in figure.1 the Original image is acquired by a scanning electron microscope (SEM), which produces images of a sample by scanning it with a focused beam of electrons. Nanofiber webs were prepared using electro spinning process.

IMAGE CONVERSION

The following steps are used for image conversion are in grayscale image each pixel is shade of gray, which have value normally 0 [black] to 255 [white]. This means that each pixel in this image can be shown by eight bits that is exactly of one byte. Other grayscale ranges can be used, but usually they are also power of 2. The gray scale image shows in figure 2. The gray scale images have been calculated from the original images figure 1. It produces a binary image from a gray-scale image. The object within the image is based upon its pixel values. Thresholding is the simplest method of image segmentation. From a gray scale image figure .2, Thresholding can be used to create binary images. The threshold images are shown in figure .3. The inverse filtering is a restoration technique for deconvolution, i.e., when the image is blurred by a known low pass filter, it is possible to recover the image by inverse filtering or generalized inverse filtering. However, inverse filtering is very sensitive to additive noise. It not only performs the deconvolution by inverse filtering (high pass filtering) but also removes the noise with a compression operation (low pass filtering). Threshold Images can be filtered have been shown in figure.4

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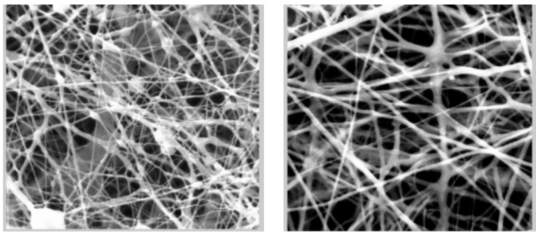

Figure.1 Original image

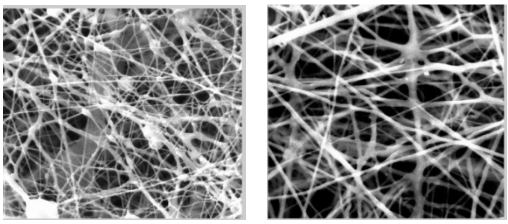

Figure.2 Grayscale image

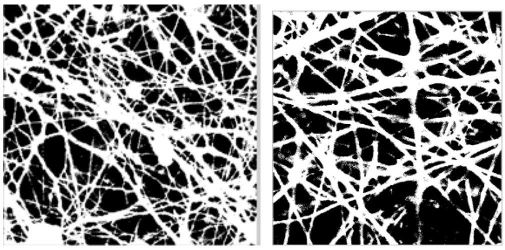

Figure.3 Threshold image

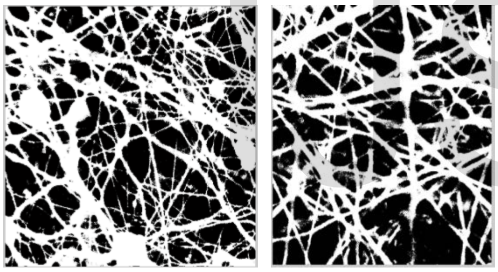

Figure.4 Noise Eliminated image

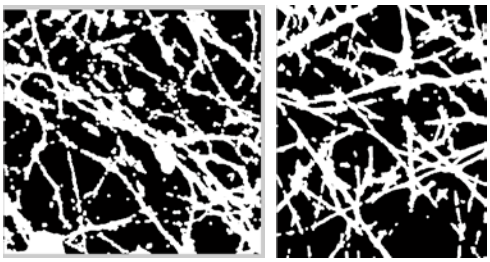

Figure.5 Morphological image

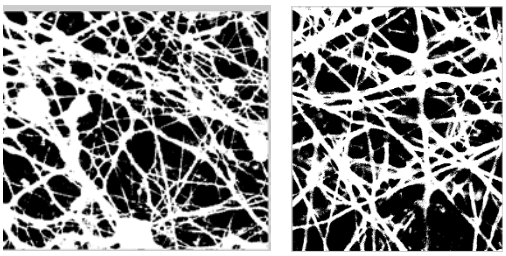

Figure .6 Inversed Image

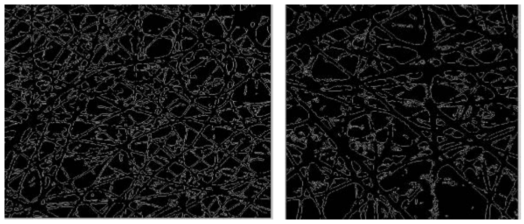

Figure.7 Canny Edge Detection

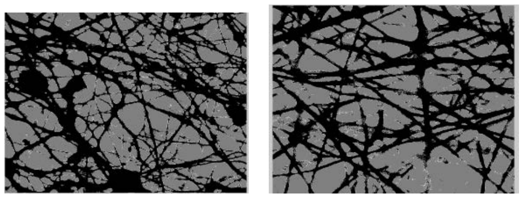

Figure .8 Merged Image

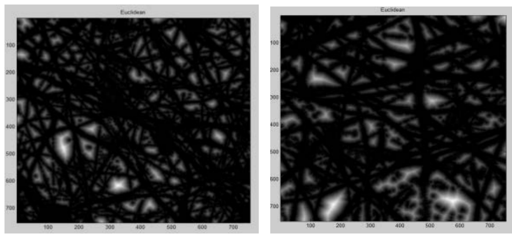

Figure.9 Euclidean distance transform image

MORPHOLOGICAL IMAGE PROCESSING

Morphology is the study of the shape and form of objects. Morphological image analysis can be used to perform Object Extraction Image filtering operations, such as removal of small objects or noise from an image. Image segmentation operations, such as separating connected objects, measurement operations are texture analysis and shape description. Figure 5. show the Morphological images, which has been taken from the filtered images.

INVERSION

Inverts the image binary image, the (black) background pixels become (white) foreground and vice versa. Logical NOT gate is used for the INVERSION processing .For a single input, the block applies the operation (except the NOT operator) to all elements of the vector. The output is always a scalar. The NOT operator accepts only one input, which can be a scalar or a vector. If the input is a vector, the output is a vector

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of the same size containing the logical complements of the input vector elements.

CANNY EDGE DETECTION

The canny edge detector is a popular method for detecting edges that begin by smoothing an image by convolving it with a gaussian of a given sigma value . Based on the smoothed image , derivatives in both the x and y direction are computed, these in turn are used to compute the gradient magnitude of the image. It takes as input a gray scale image and produces as output an image showing the positions of tracked intensity discontinuities. The Gaussian smoothing in the Canny edge detector fulfills two purposes: first it can be used to control the amount of detail that appears in the edge image and second, it can be used to suppress noise. Canny edge detection images shown in figure .7

MERGED IMAGE

Image merging or the processing of blending two images into a single image, can be done in many ways. The merged processing is combining two or multiple images into single image. The Merge block combines its inputs into a single output image whose value at any time is equal to the most recently computed output image of its driving blocks. The two images have been combined figure 6 and 7, gives the result of merged images shown in the figure 8.

DISTANCE TRANSFORMATION

The original (binary) image is converted into feature and non-feature elements. The feature elements belong to the boundary of the object. The distance map is generated where each element gives the distance to the nearest feature element. The ridges (local extremes) are detected as skeletal points. The distance map resulted by the distance transformation depends on the chosen distance. The distance transformation can be executed in linear on time in arbitrary dimensions, but the topological correctness is not guaranteed. The Euclidean transform shown in figure .9

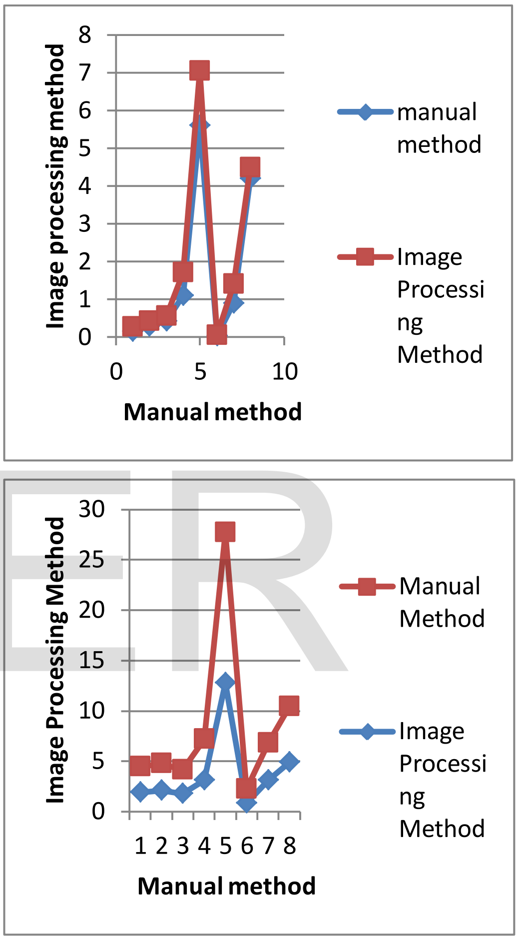

Figure 10.a) The Fiber Diameter Mean Between Manual And Image Processing Method.b) The fiber diameter variance between manual and image processing method.

That means the developed method as well as the manual measurement can equally be good estimating tools for fiber average diameter. However, due to large sampling number, the developed method is supposed to be a better estimating tool for population variation. For close comparison, the fiber diameter distributions of samples were measured using the two methods as shown in Figure 10.a).

Both the manual and the developed methods showed similar fiber diameter distributions. The modes of each distribution were found in similar values and the shapes of the distribution were almost same. The measured diameter by the developed method showed broader distribution than those by the manual method.. Due to the orientation, the fiber boundaries were not clearly distinguished by Canny edge detection. Figure 10.b) shows the linear regression result between the fiber average diameters obtained by the two methods.

Table I. Comparison of Results from the Two Methods for Samples

samples	Manual method		Image processing method	
	Mean (nm)	variance(nm)	Mean (nm)	variance(nm)
1.	0.15	1.92	0.2783	2.5029
2.	0.28	2.1	0.4285	2.6680
3.	0.43	1.8	0.5605	2.3263
4.	1.1	3.1	1.7038	4.0803
5.	5.6	12.8	7.039	14.875
6.	0.03	0.8	0.0466	1.4222
7.	0.9	3.1	1.4103	3.7212
8.	4.2	4.9	4.8418	5.5184

The average diameters from both methods gave similar values for every case. It revealed that the new method can determine the average fiber diameter in correct. However they showed small difference in their variance. It can be explained in terms of sample number used for population variation estimation. While small number of sample was used in manual analysis, the developed process used at least 500 measurement for the various estimations.

CONCLUSION

The developed method using image analysis technique successfull, estimate the fiber's diameter produced by electro spinning. The developed method and the manual method did not show significant difference in the fiber diameter distributions. Both the methods provide similar fiber average diameters, while the variances from the image analysis were 50-200% larger than those from the manual method. The regression analysis confirms that two methods give the same values. It reveals that the developed method can be used as a practical tool to estimate the fiber diameter of electro spun web.

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