THE CONVOLUTION ANALYZER FOR RECOGNITION AND SEGMENTATION OF WOVEN COMPOSITE STRUCTURE

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This paper presents development of analyzer for fibres searching and segmentation in hard cross section of composite. For purposes of modelling of composite mechanical properties there is absolutely necessary to know exactly where is the border of transversal fibres in internal structure of composite placed. Recently a partially automated analyzer for searching of fibre borders was developed. It is based on color channels convolution with sample color obtained from region of interest, using two dimensional gausian kernel with setable parameters. It was impossible to use a usual techniques such as tresholding in BW image because the fibres and surrounding composite filling material has very similar gray level. Not even texture based segmentation of image could be used mainly because in different cross setion the texture may be damaged after cutting. Further cleaning of segmented image is done by binar morphological functions. The analyzer is realized in Matlab GUI, using mainly image processing toolbox. Images have been obtained from destructive testing - cross-section surface - and episcopic microscanning with color CCD camera. Episcopic scanning have to be take over internal norm of Laboratory for image analysis of Research Centre Textil II at Technical University of Liberec.

Keywords: composite, fibre, segmentation, convoulution

1. Introduction

Within the industry (e.g., automotive, aerospace, shipping and railway) there is a big demand for use of very light but, very firm and durable materials. For these applications composites seems to be very suitable. Composite materials (or composites for short) are engineered materials made from two or more constituent materials with significantly different physical or chemical properties and which remain separate and distinct on a macroscopic level within the finished structure. Simply composite in our case is a structure of woven fibres which is filled under the presure with polysiloxan matrix material. These kind of textile composites are very promissing and in the previous type, CARBON CARBON composite there has been done lot of research of it. The research was mainly aimed to unveil the mechanical properties of diferent structures, diferent materials used, different fillings, and the dependance of the preassure applied during the manufacturing process. Recently main activities are focused on modeling the properties of designed and manufactured composite structure with FEM. To make a
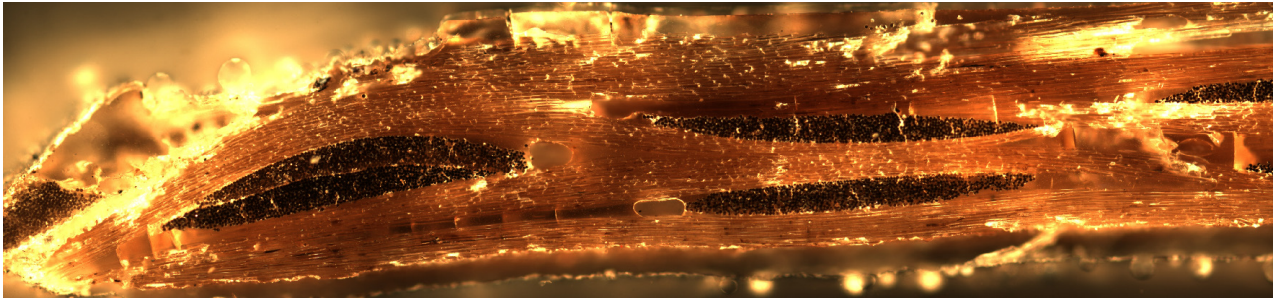
Fig 1. Part of crossection of composite structure the darkest areas are the crossection of transverzal fibres which needs to be segmented

good FEM model exact knowledge of physical propertis of internal structure is necessary. It means we have to know the properties of fibres used for woven structure, physical properties of matrix, exact positions of fibres in the composite structure after the pressing etc.. The physical properties of fibre structure, matrix and applied presure are usualy well known. The problem is to find out the exact position of fibres in internal structure of composite, their shape change after hot pressing and behaviour of voids (small bubles) in matrix. First, crossection of fibres must be obtained and precise scanning of surface of crossection must be made by the microscopic color photographs. And then the shapes of vodis and presed fibres must be find. Many samples must be meassured to get some god statistics. Previously finding the shapes of borders and position of fibres and voids has been done manualy by the hand held drawing by computer mouse technique. Because this technique was very time consuming and demanding for patience and concentration, some other automated or semiautomated techniques has been inquired. First the technique for searching for voids, based on binar matemathical morphology has been developed [1] and succesfuly tested. Semiautomated analyzer for searching for voids is working with BW image, tresholded from color BMP ima-

ges captured and put together (popis o mikroskopickopovem snimani a naslednem skladani obrazku par radek) the segmantation of voids could be done with use of binar mathematical morphology, but it is not the case where the fibres must be segmented. The fibres in crossection has very similar gray level and in the tresholding proces there is unacceptable lost of information. Some other technique has to be employed. Experiments with texture based segmentation were run, but turned void. The possible way is „color" convolution with sample color selected from region of interest.

2. Color convolution analyzer

In general fourier transform of convolution is product of fourier transform of image and fourier transform of kernel.

Two dimensional convolution is written as.

$$y(m,n) = x(m,n) * h(m,n)$$

it discrete form is [2]

$$y(m,n) = \sum_{k=0}^{M-1} \left(\sum_{l=0}^{N-1} \left(h(m-k, n-l) \times x(k,l) \right) \right)$$

Because the image of crossection of composite fibres has very fine texture of regions. The convolu-

tion is used for filtring and smoothing of the input image. Image is smoothed by gausian kernel. And the size of kernel is choosed in dependence of texture detail. For very precise recognition of regions of interest convolution in all three color chanels is used. The results from chanels must match othervise the pixel is not evaluated as a region of interest pixel. First user will choose the sample of region of interest. In practise there is a tool in the application for selecting of small area from composite crossection image, usualy rectangular area is selected with mouse cursor from region of fibre. Average color of selected region is computed first and it is displaed to user for visual comparison with expected average colour from fiber crossection. This then work as learning set. It can happen that sample region was selected very small and then the error from matrix (material surrounding the fibres) color can occure.
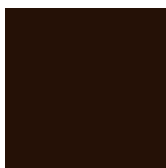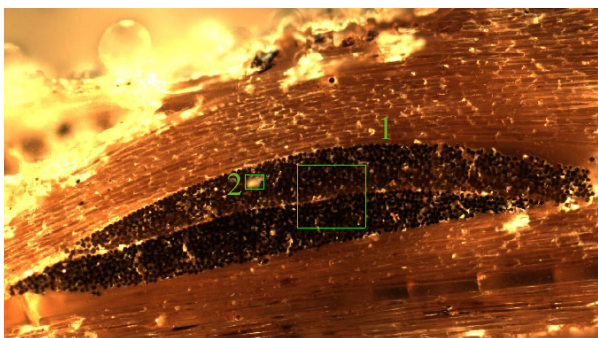

Fig. 2. The crossection of internal structure and two selected samples of averaged color first region is selected corectly, but the second is showing color which is not representativ for the region of interest.

In the case the sample color is very different from expected average color of pressed fibre crossection another selection of sample region must be made. When good sample color is obtained and approved

by user the convolution and color chanel comparison proces may begin. Gaussian kernel is used For convolution

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

We tried different values of sigma and choosed the value which matched perfectly our needs.
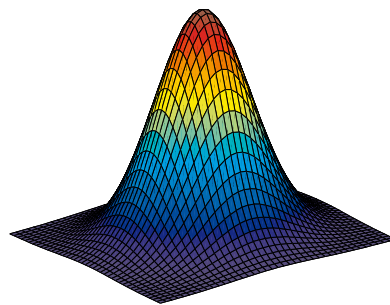
Fig. 2. Gausian kernel

Usual use of convolution would be to apply it in one step and compute it for whole image. For our needs seems to be better to compute it for every single pixel and emediatelly compare the resulting color of pixel with averaged sample color from user selection. Gausian kernel is applied to the image in such a way that it works as weight function and for every pixel of the crossection the weighted average of surounding pixels is computed. It makes in principle the information of colors in pixels level little bit blured (in dependence of sigma and size of the gausian window), but it is much beter for edge preservation, then the average. Bluring the information helps not to resolve every single detail in structure of fibres. It is the case of convolution filtering of high frequencies. As it was said the information of color weighted average is taken as a color of central pixel of gausian window in position (x, y) and is compared with sample color but there is some tolerance in its exatct RGB chanels values, just say aproximatelly ± 5 levels in 8 bit representation (0 - 255 levels).

For different kind of materials different tolerance

is used. If the weighted average color match the average color of user selection in allowed tolerance the hint is written in the (x, y) possition of correspondence matrix which has the same size as the image of crossection. The hint is one or zero. After this operation binary image of region of interest is obtained. In many cases the segmantation is not perfect and some user corections are necessary. For this purposes the analyzer is equipped with some basic functions of binar mathematical morphology. As well as possibility to erase user definable selection of image. When the whole segmentation is done perfectly. The outlines of transverzal fibres are obtained by use of morphological erosion and image subtraction.

3. Conclusion

Semiautomated software for searching for fibre outlines in crossection of polysiloxan composites was developed. It is based on RGB color comparison between sample color obtained from user selection in the region of interest and RGB color weighted average from rectangular area surrounding the representativ pixel of the segmented image. Analyzer is using convolution of segmented image of crossection with gausian kernel. It blures the spatial and color information, but on the other hand presrves partly the edges. The analyzer was sucessfully tested and now is often used for research purposes in laboratory for composite research. Where it is saving a lot of „manual" work.

References

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