APPLICATION OF FRACTAL ANALYSIS IN TEXTILE PRODUCTION PROCESSES

E.Chrpova
Department of Mechanical Technologies, Technical University of Liberec, Czech Republic

ABSTRACT
This paper presents a method developed for the automatic detection and identification of defects on flat fabrics. The work was intended to develop monitoring system for random processes based on video image during the production phase. Our developed modular system consist of hardware equipment, data evaluation implemented in software and determination of acceptable tolerances related to final product quality. There were investigated applications of the developed methods in a paper production process, a carding process and a weaving process. The modular system is based on image understanding algorithms that imitate the human visual mechanism. A 3 CCD camera receives the reflected light, the intensity and colour variation of which deviates noticeably in the presence of a defect. Automatic system adapts to a variety of applications and can be positioned “in-line” as part of a production process, or “stand-alone” as a separate inspection unit. For the solution we use a fractal analysis that allows on-line evaluation. Method for estimating fractal dimension is described in the following text.

1 INTRODUCTION

The primary objective is to produce specifications for a developed modular system [1] that can be used in the monitoring and controlling of a wide variety of industrial processes, based on the use of fractal and other measurements. The basic principle will be presented on the wet-laying process (paper production process) that is similar to the basic principle of the textile production process. The principle for monitoring the process, for the generation of time series, for the estimation of a fractal dimension of the series and for analysis of the fractal dimension we can name “NOVISCAM Technique”. The technique can be divided into "hardware" and "software"[1].

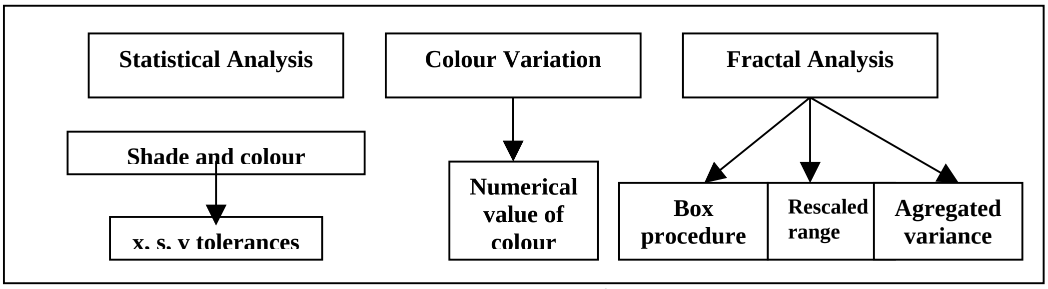

Figure 1: Analysis of the data

There are two distinct requirements for all used algorithms. Firstly, they must be flexible enough to enable the best parameters for analysis to be selected and compared with other methods. Secondly, they must be fast enough for on-line and in real time control. There are for the monitoring and obtaining parameters of analysis are used three various algorithm (software tools) as is shown on figure 1. The investigation considered new approach using fractal analysis, numerical value of colour and conventional statistical method.

2 METHOD FOR ESTIMATING FRACTAL DIMENSION

The computer shows the data record as single images. The images in digital form are represented as matrices with values of pixels, and windows are created from the images. The windows are located in important positions of the production process. This means that only some parts of the scanned production process are critical for production process (for quality of process, for obtaining a required product). Average values of pixels in the windows are read from the images. The values are saved, and these create a time series. The fractal dimension from the time series can be estimated, for example, by using an "iso-gray set". The "iso-gray set" can be generated by setting a suitable brightness threshold and making the time at which the brightness of the set average crosses this threshold. The fractal dimension of the points set, so generated, can be estimated using the Box Procedure or another procedure [2]. It appears that this fractal dimension from "iso-gray set" is more sensitive to change than the fractal dimension from the whole time series [3,4]. The fractal dimension describes the time series with only one number. This number is changed with the character of the time series, and can be used for the on-line control of the production process.

We can elaborate the "iso-gray set" from the time series and estimate a fractal dimension of this set. The "iso-gray set" is generated by setting suitable brightness thresholds and using the time at which the brightness of the set average crosses these thresholds (Fig.2), [4]. The set contains zeros

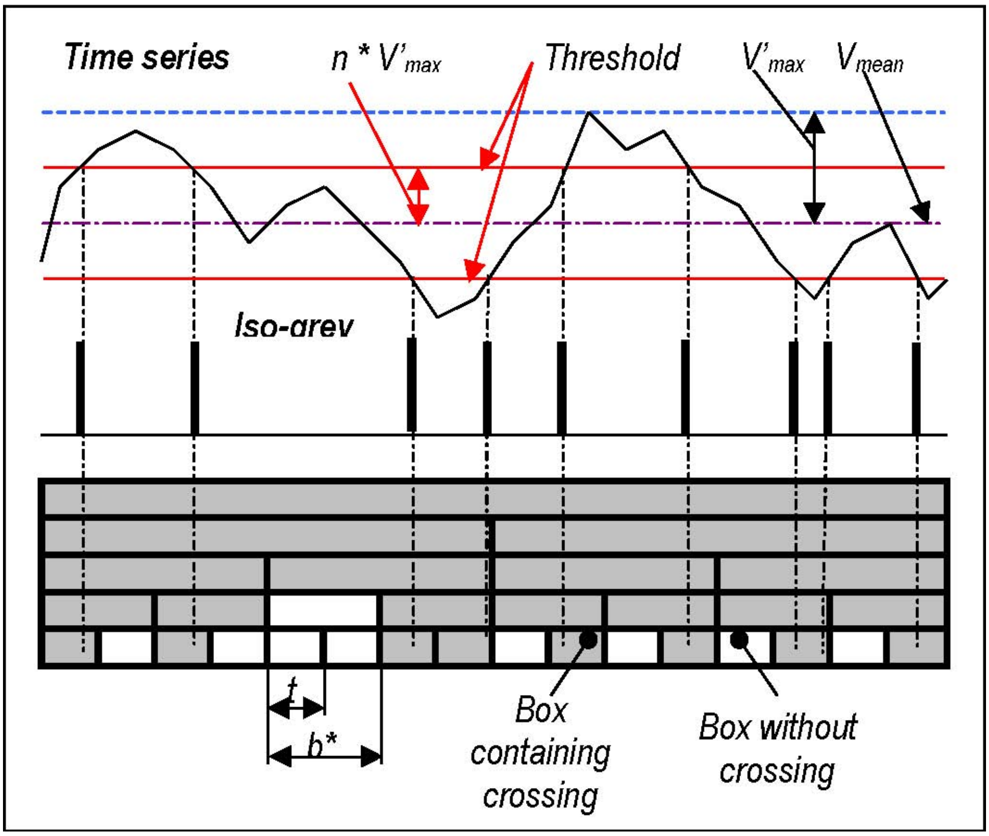

Figure 2: Construction of iso-grey set – by making each time at which trace crossed chosen threshold values and principle of Box Dimension computing.

and ones, in which the ones represent the crosses. The fractal dimension of the "iso-gray set" can be estimated by using the Box Counting Procedure or another procedure [1]. The principle of the box dimension computing is in Fig.2. Starting from box size *ts* (sampling time interval), the number of boxes that contain a crossing is recorded. The box size is then increased by factor *b* (increasing factor or box division factor) and the procedure continues until the entire time series is contained in one single box. This is illustrated for b=2.

The Box-Plot is then log2 of the number of boxes that contain a crossing against the –log2 of the normalised box size (box size divided by sampling time interval *ts*). Fig.3 shows a typical Box-Plot for a measured time series at n=0,08, ts = 0,5 and b = 1,4. The box dimension *DB* of "iso-grey set" can be determined from the slope of the regression line. The typical Box- plot from the production process (Fig.3) consists of a three-part slope. The lower slope has the estimated fractal dimension DB = 1. This dimension is equal to the Euclidean dimension of a smooth curve. The reason for this is that every box in the interval contains a non - zero value of the "iso-grey set". This part has not been used for the estimating of the "iso-grey set" fractal dimension, whereas the central and upper slopes have been used.

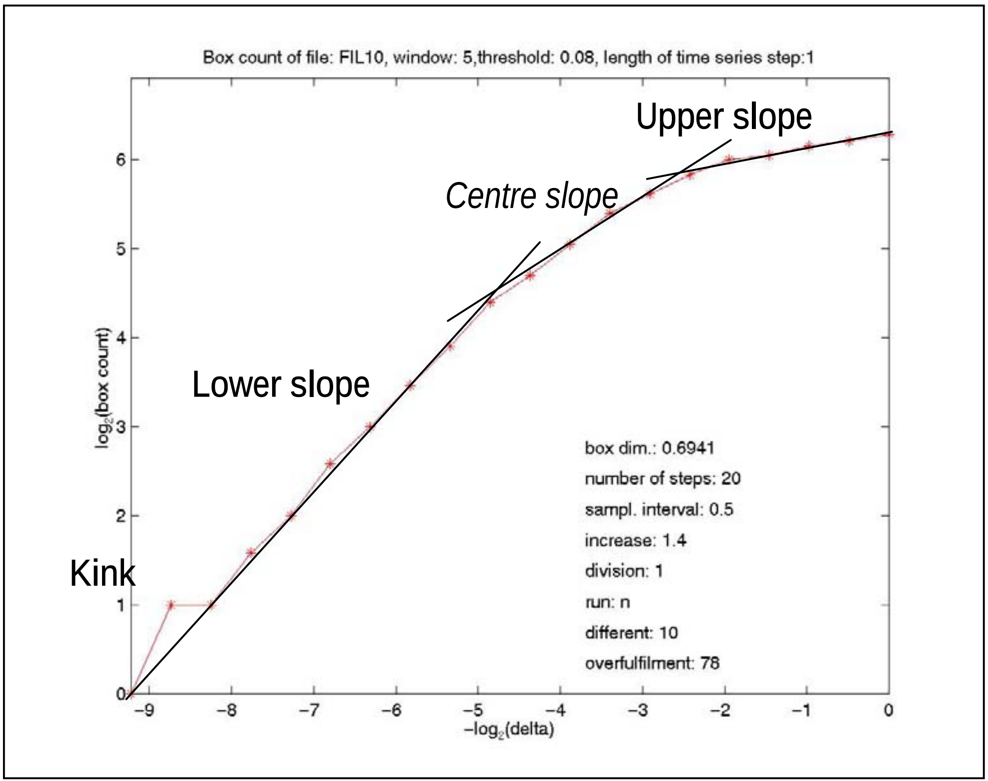

Figure 3: Example of typical Box-Plot

3 COMPARING OF TWO QUALITIES

Two data records form the wet-laying process of a fibrous layer is shown in this chapter. This process is used in the production of nonwoven fabrics, and in fact, is derived from paper making techniques. Data record FIL09 and FIL10 are from the same position, but from two different fibre suspension levels (No.9 = 50 cm, No.10 = 35 cm). The suspension levels designate the quality of the final product. On the data record it is possible to observe local faults that were also generated. For this analysis 10 windows of size 15x15 pixels were used. The first images with windows, time series from first window of data record FIL09, FIL10 and outer windows 1,10 from data record are in Fig.4. The window 1 is without fatal faults and represents quality, while the window 10 shows fatal faults. At first sight we can see on the first images differences in degree of grey. However, the degree of grey does not represent quality or low-quality, nor contain information about changes in time series. In this case, the degree of grey instead defines quality of illumination.

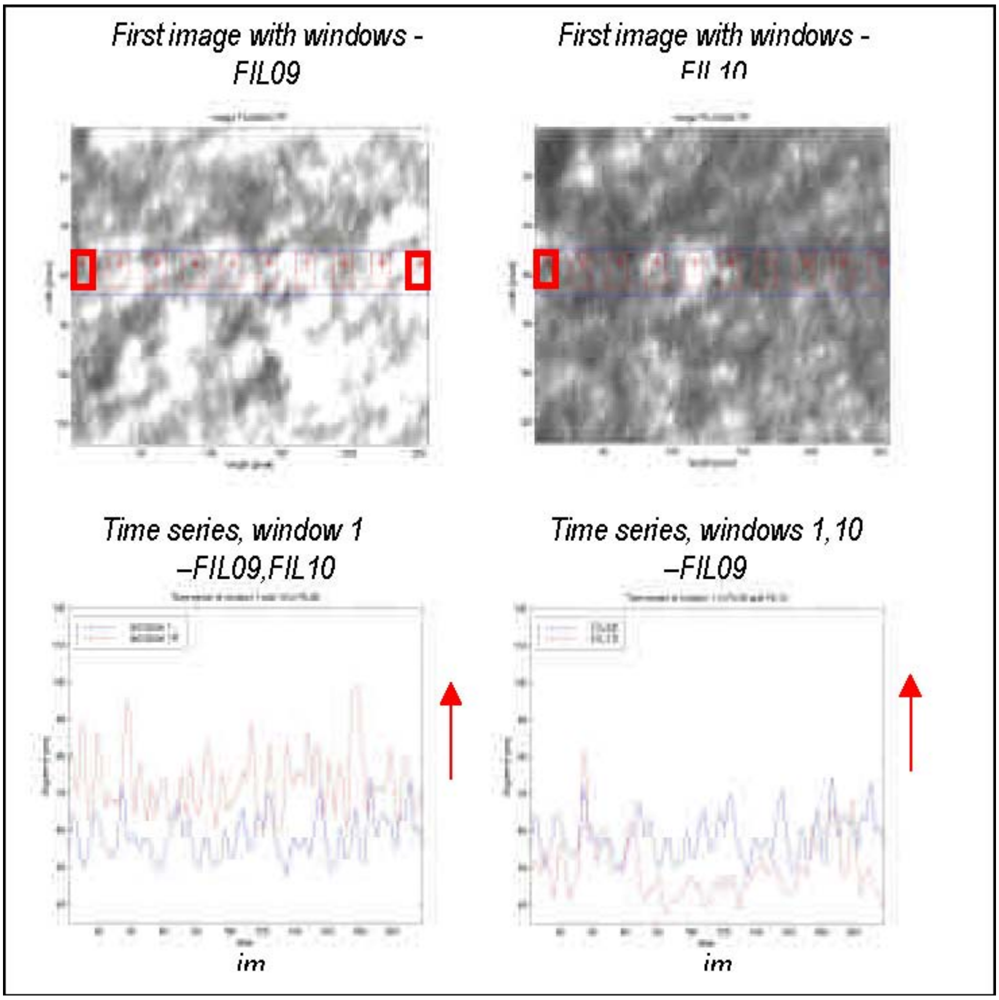

Figure 4: First images of production process FIL09, FIL10 with windows and time series from two production processes

Result of the analysis is shown in Fig.5. The upper graphs are an estimated fractal dimension (R/S and Box dimension) of time series versus windows (for example: time series of window 2 data record FIL10 has R/S dimension 1.52 and data record FIL09 has R/S dimension 1.77). The lower graphs are the results of standard deviation and the mean value of the time series versus windows. R/S dimension, Box dimension, and standard deviation of the time series from windows are radically changed in the windows. The reasons for this effect are in the fatal faults of the

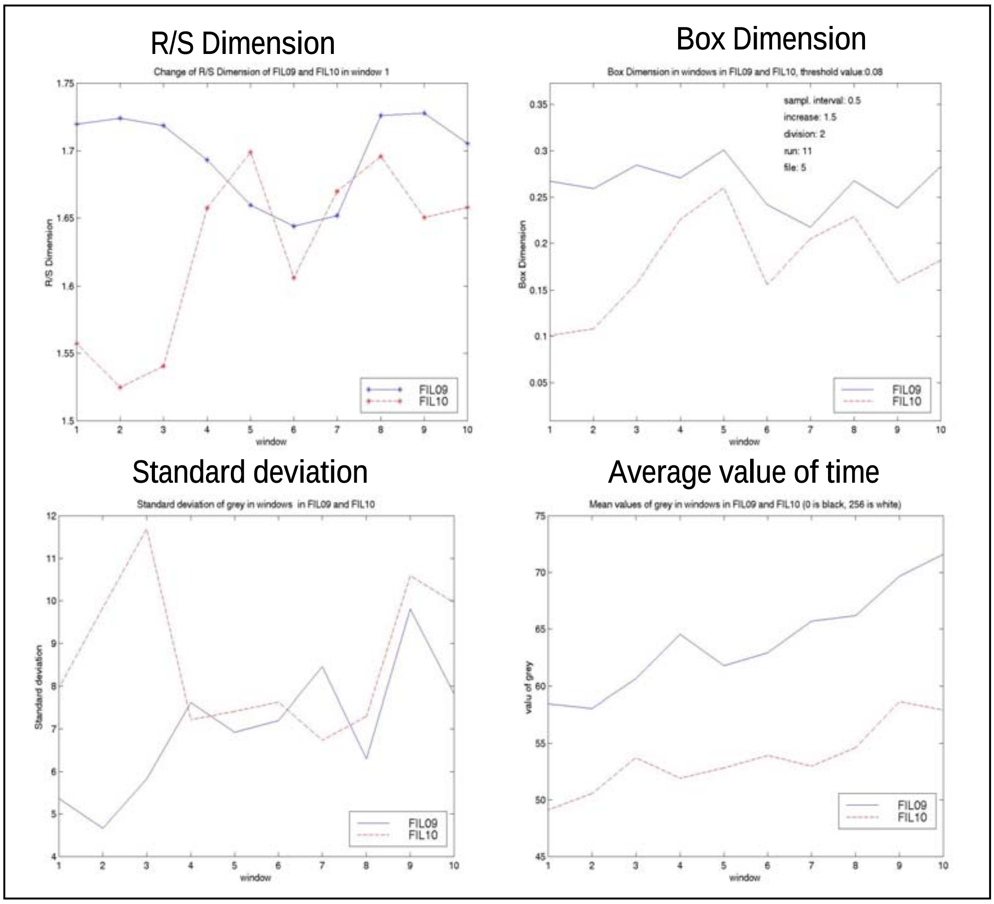

Figure 5: Results of analysis

production process, and consequently, we can't compare quality and low-quality. However, we can notice the sensitivity of the fractal dimension on the character of the time series. The Box dimension of two processes do not cross each other, and on the Fig.5 the R/S dimension of time series window 2 and window 5 of FIL10 are compared.

The mean value of the time series represents illumination but does not represent quality or low-quality. The statistical methods (standard deviation, power spectral analysis) are used for describing the time series. The methods are powerful and the comparison of the statistical method with fractal analysis is now impossible. The results are narrow and data records have faults that represent only low-quality. The algorithm of analysis must be specified on new data records. However, the sensitivity of the fractal dimension with the change of character time series is evident, and the application of the "Noviscam Technique" is also possible to be used in the textile industry.

4 APPLICATION OF NOVISCAM TECHNIQUE IN TEXTILE INDUSTRY

The application of the "Noviscam Technique" may be used in the entire textile production processes involve typical irregularities – irregularities of the fibre, filaments, yarns, webs, woven fabrics, nonwoven fabrics, etc. Improved process and product quality contributes to the increased profitability and to customer satisfaction. In textile production exists a significant demand for objective, reliable, time and cost effective evaluation of production processes and their outcomes. The first experience with Noviscam Technique in textile production was obtained in wet-laying web production. We also tried to use this technique in the web forming processes on the carding machine and on the printed woven fabrics. For the scanning we used a CCD camera or camcoder. The analysis of structures and the surface of the textile material is provided by fractal analysis, statistic analysis and by the imaging photometry. The segmentation of the scanned surface into pixels and its description with a map of microphotometrical values creates appropriate conditions for the application of means and procedures of more complex and sophisticated evaluation methods such as image analysis, frequency analysis of signals, multidimensional statistical analysis etc. This investigation confirmed that many production processes can use the same principles of analysis in its processes. The research shows the possibilities of application of fractal dimension in various processes.

5 CONCLUSION

The method of visualisation is currently performed by the maximizing of accuracy, hence a greater accuracy than human inspectors may have. The fractal analysis allows “On-line” evaluation with immediate feedback to the process. The fractal dimension is changed according to changes in a scanned production process. Changes are observed between a process conducive to a quality product and a process conducive to a low-quality product. The fractal dimension is suitable for investigation and is used for a process production control. We confirm that the “Noviscam Technique” can be used in the textile industry. The possibilities of this technique in the textile industry are still being tested and compared with other methods. We can state that the fractal dimension is a powerful tool and can be especially used in chaotic and fast production processes.

Acknowledgement
Our activity was supported by the EU project Noviscam and MSMT project No.282.

References

[1] Chrpova, E.: Surface Quality Control Based on Image processing methods. Fibres and Textiles. Vol.10 No.2, p.70-75, 2003.

[2] Sirok, B, Nancovska, I., Trdic,F.: Fractional Analysis of the Motion of Solid Particles in a Turbulent Air Flow, 6th ISFV, Yokohama 1992.

[3] Trdic,F, Sirok, B, Bullen, P., Philpott, D., Angwafo, A.: Monitoring the production of mineral wool by computer aided visualizatin, Poceedings Comadem’94 ,1994.

[4] Tsuji, Y., Honda, K., Tsunotda,I., Nakamura,I.: Fractal aspects of iso-velocity set in turbulent boundary layer, JSME International Journal, series B Vol.36, No.1,1993.

[5] Kraft, R., Kauer, J.: Estimating the Fractal Dimension from Digitised Images, http://www.edv.agrar.tu-muenchen.de/algorithms/algorithms.html, 1996.