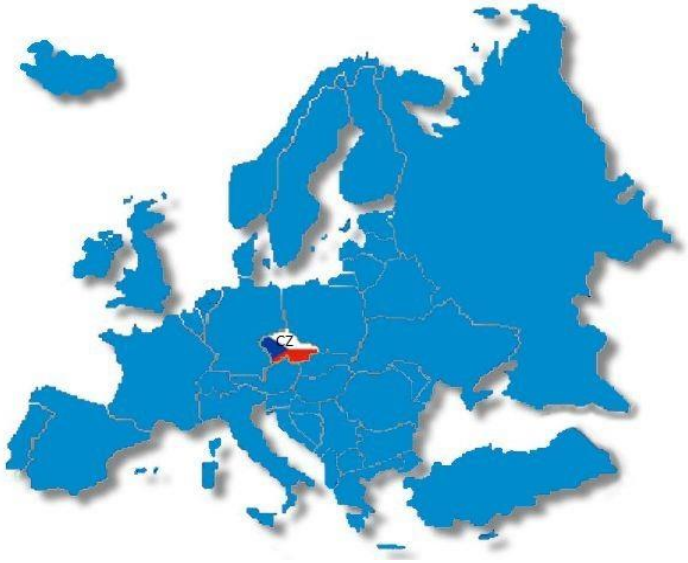


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A COMPARISON OF TWO DIFFERENT PRINCIPLES OF 3D SURFACE FABRIC RECONSTRUCTION

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Introduction

- An evaluation of changes in fabric appearance properties (such as pilling) is often carried out by objective methods.
- The objective methods are usually based on image processing techniques.
- Fabric appearance properties can be evaluated in a two-dimensional (2D) or a three-dimensional (3D) image by the methods.
- However in the case of the pilling evaluation, it has been proved that analysis of 3D images should give more accuracy results.
- A selection of a method for a 3D fabric surface reconstruction plays one of the most important parts in an acquisition of accurate results.

Goal of the study

- A comparison of complexity and acurracy of two different principles of a 3D surface reconstruction.
- Results of 3D surface reconstruction will be evaluated with regard to a fabric defects detection – pills = small balls of entangled fibers protruding from fabric surface.

The methods used for the 3D surface reconstruction:

- **Method A**: The gradient field method.
- **Method B**: Noncontact laser profilometry.

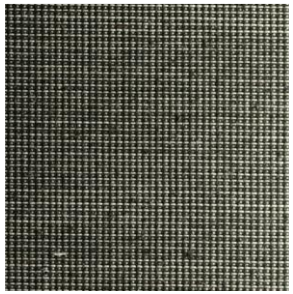
Experimental samples

- For the comparison of complexity and acurracy of results of the methods, five woven fabrics were tested.
- The samples differ in type of a weave, material, yarn density, design, color, structure, and so on.
- The samples had various number of defects (pills) on the top of surface.
- The capturing area of a sample fabric: 5x5 cm.

Sample 1 *Sample 2* *Sample 3* *Sample 4* *Sample 5*







Method A – the gradient field method

- Reguired devices: a camera, a planar light source, pc, a special algorithm in software MatLab.
- The method is based on methods called as *Shape from Shading.*
- The main point of the method represents a creation of object shadows (pill) and a shape reconstruction of the surface using the changes in pixel values of an image.

A procedure of the 3D surface reconstruction:

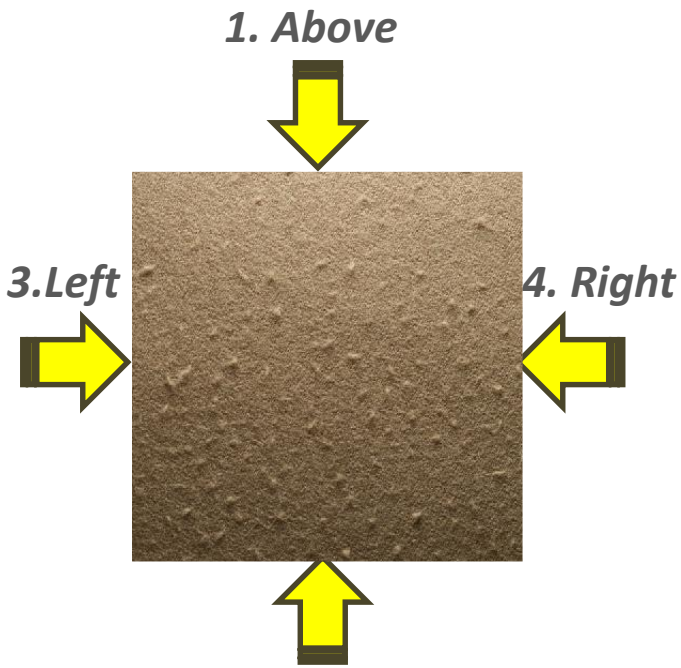
- The creation of the pills shadows by lateral illumination gradually from four sides of a sample: from above, below, right and finally from the left side.
- During individual illumination, the sample image is captured by the camera - the creation of a set of four images for each sample.
- Two gradient images are estimated from the set of sample images.
- Fabric surface is reconstructed to 3D from these two gradient images with using the special algorithm based on the gradient field method.

Imaging system – Sample 2

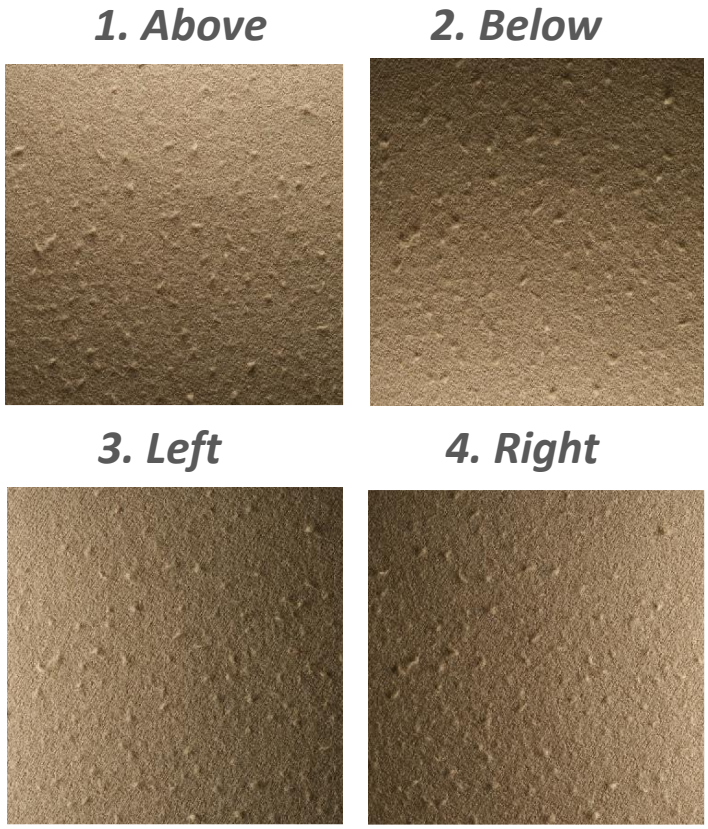
Image capruting system



Lateral illumination

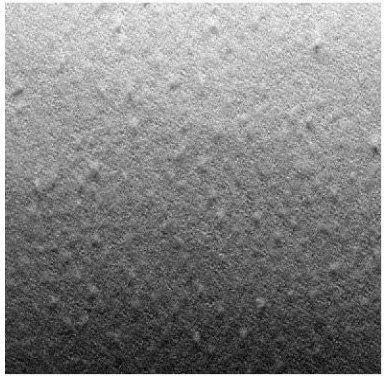


The set of 4 sample images

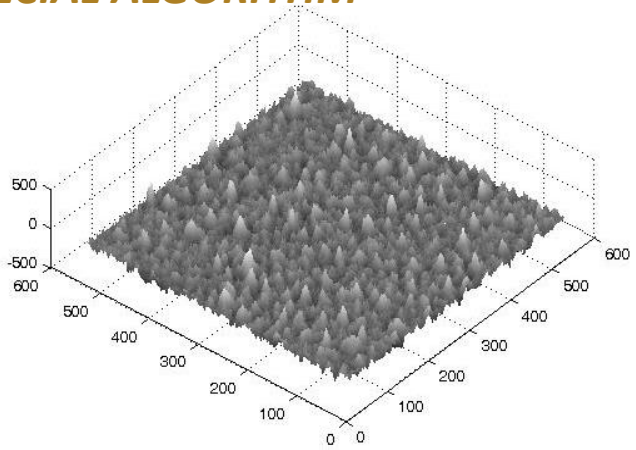


3D fabric surface reconstruction and image analysis

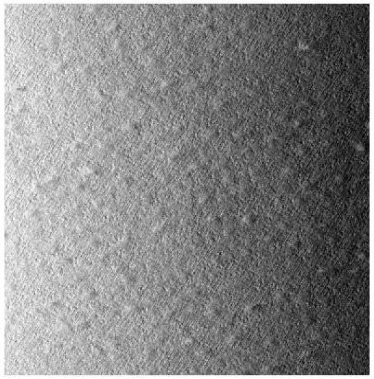
Left – Right = **GRADIENT IMAGE IN HORIZONTAL DIRECTION**



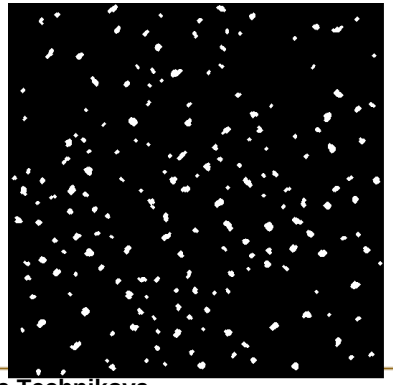
3D FABRIC SURFACE CREATED BY THE SPECIAL ALGORITHM



Below – Above = **GRADIENT IMAGE IN VERTICAL DIRECTION**



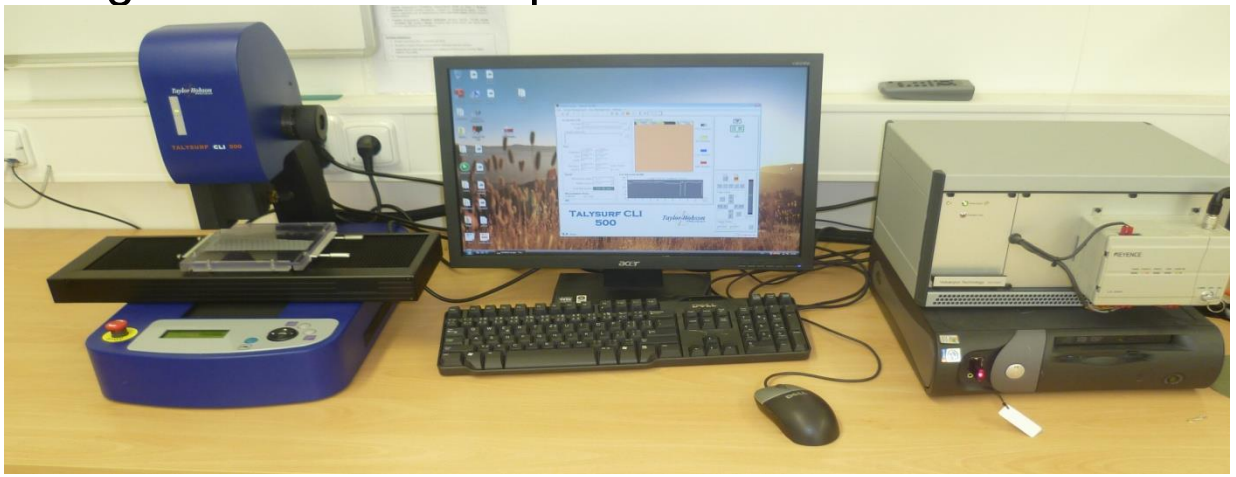
THE BINARY SAMPLE IMAGE – A LOCAL THRESHOLDING



Agrawal, A., Chellappa, R.: An Algebraic Approach to Surface Reconstruction from Gradient Fields. *8th European Conference on Computer Vision*, **1**, 174 (2005).

Method B – noncontact laser profilometry

- Reguired devices: instrument Talysurf CLI 500 and pc.
- Instrument Talysurf uses noncontact laser profilometry for the 3D surface reconstruction.
- The 3D surface reconstruction is based on a measurement of individual profiles in length of the surface by a laser (the laser is moving and a sample is stationary).
- 3D surface is created by connection of all the individual profiles together.
- The capturing time of one sample: 4 h a 30 min

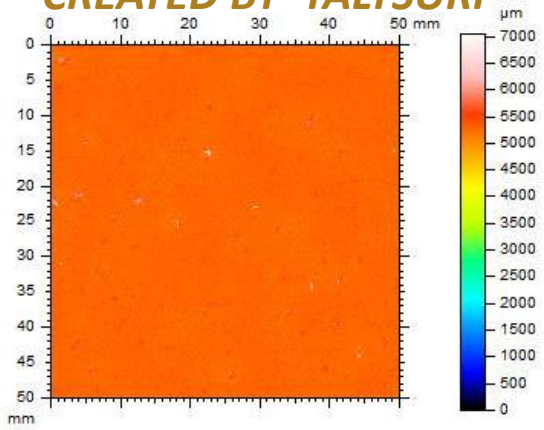


3D fabric surface reconstruction and image analysis

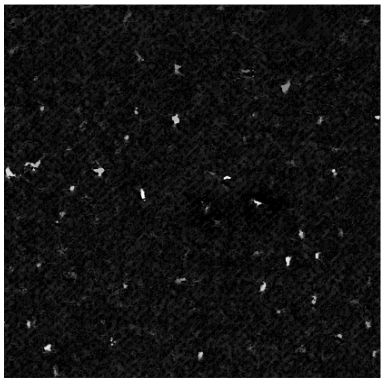
RGB SAMPLE IMAGE



2D FABRIC SURFACE CREATED BY TALYSURF



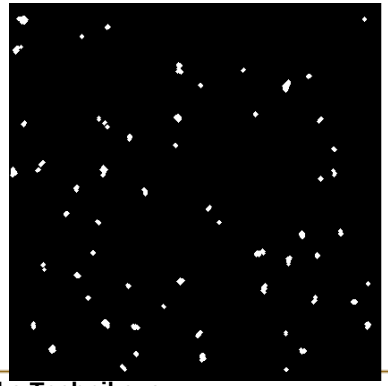
GRAY SCALE IMAGE



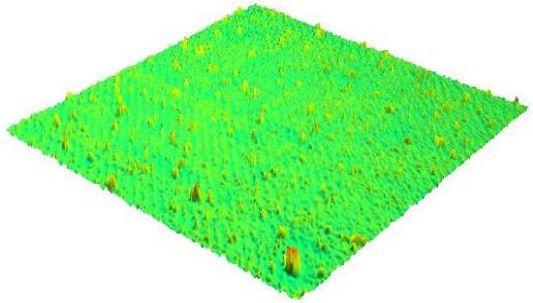
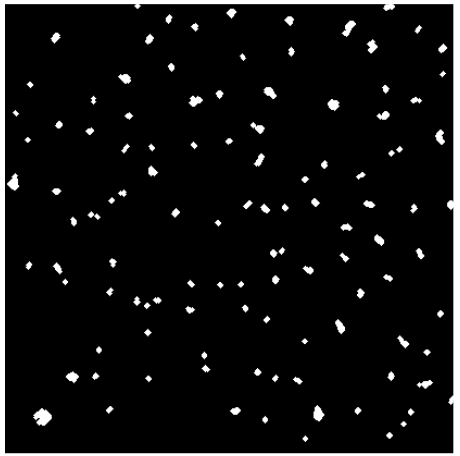
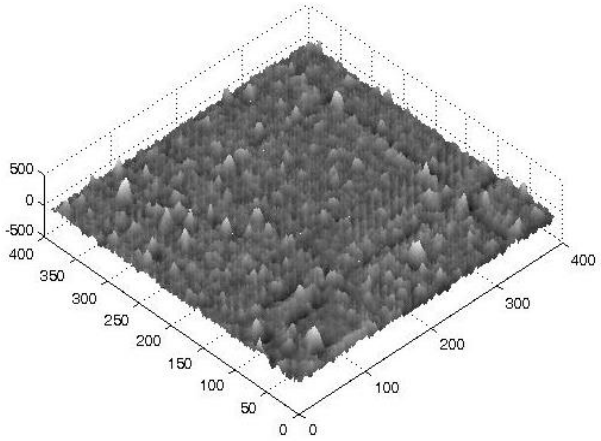
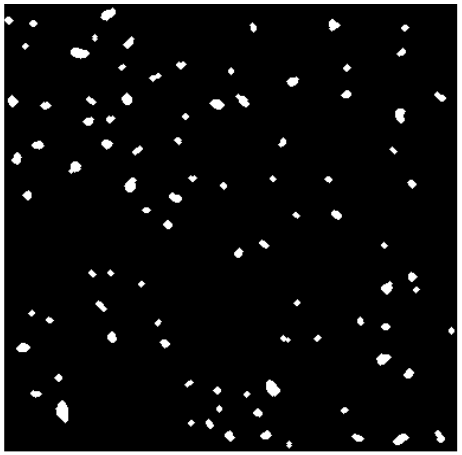
3D FABRIC SURFACE CREATED BY TALYSURF



THE BINARY SAMPLE IMAGE – A LOCAL THRESHOLDING

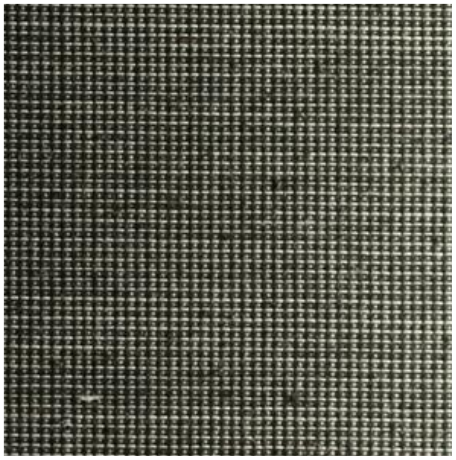


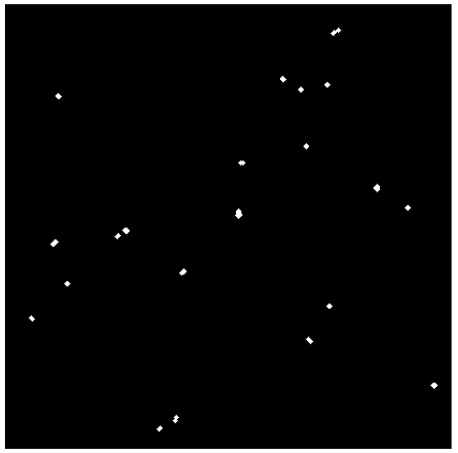
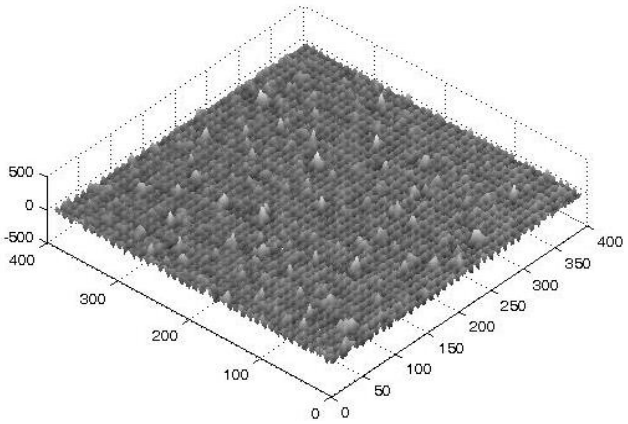
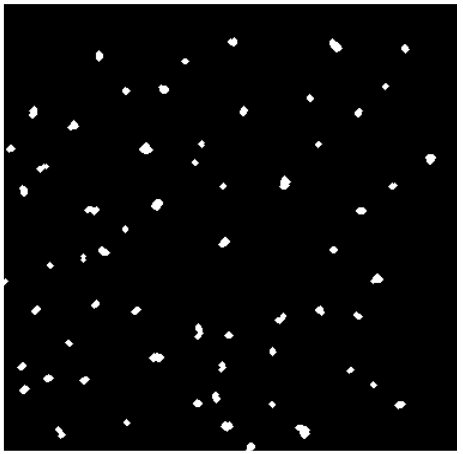
Comparison of 3D surfaces and defect detection – sample 4

	3D surface	*Final binary image*
Talysurf		
Gradient fields		



Comparison of 3D surfaces and defect detection – sample 5



	3D surface	*Final binary image*
Talysurf		
Gradient fields		

Results

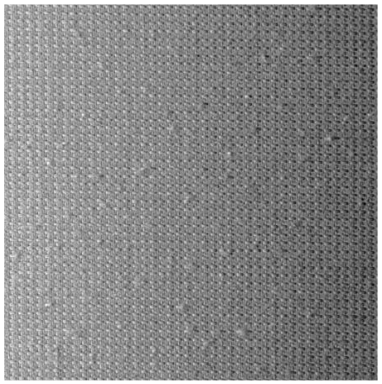
Pill characteristics	Sample 1		Sample 2		Sample 3		Sample 4		Sample 5	
	A	B	A	B	A	B	A	B	A	B
Pills number [-]	61	115	60	112	312	244	111	91	21	63
Average area of pills [mm^2]	0,45	0,80	0,54	0,93	0,75	0,92	0,56	0,73	0,33	0,67
Standard deviation [mm^2]	0,18	0,31	0,26	0,46	0,42	0,42	0,33	0,40	0,09	0,27
Pills density [1/mm^2]	0,024	0,046	0,024	0,045	0,12	0,098	0,044	0,037	0,008	0,025
Pilling grade	4	3	4	3	1	1	3	3	4-5	4

*** A – the gradient field method**
B – instrument Talysurf

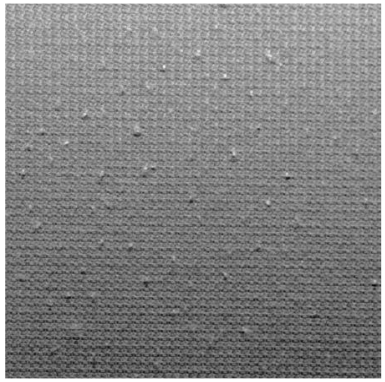
Descision

Dysplay of two gradient images and their comparison with final binary images acquired from method A and B:

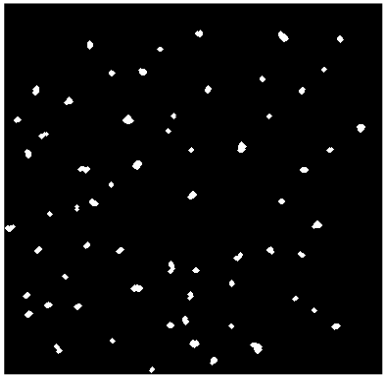
Gradient image in horizontal direction



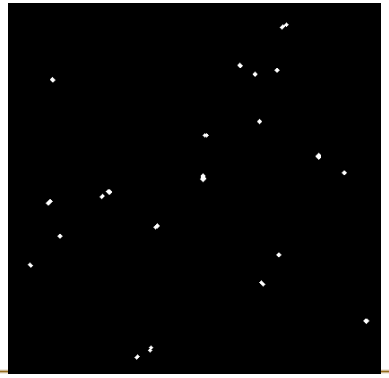
Gradient image in vertical direction



The binary image from method A



The binary image from method B



Conclusion

- **Method A:** short time of a 3D surface reconstruction and data processing, using cheap devices for capturing and processing the 3D surface.
- **Method B:** necessity of more expensive device (Talysurf) and longer time for a 3D surface reconstruction.

Method A – the gradient field method – proved as more reliable, accurate and faster tool for the 3D surface reconstruction of a fabric with defects on the surface top.

In a textile industry, the gradient field method could be useful for the objective quality control of the garments – especially for the evaluation of fabric surface defects.

THANK YOU FOR YOUR ATTENTION

