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Analysis of surface roughness parameters digital image identification

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ABSTRACT

The article analyses some surface roughness parameters of metal parts determining the ability of the surface of digital image identification, covariance functions and Wavelet's wave theory. Expressions of covariance functions are formed using random functions, made by spreading digital image pixel arrays by columns in the form of individual vectors. The digital images used for research may vary in scale, because the frequencies of colour waves with individual pixels remain constant in the images, therefore, the image change does not influence the scale in computing covariance functions. The colour spectrum of RGB format was applied to identify the surface images of the parts. There was analysed the influence of individual RGB colour tensor components on the estimates of digital image covariance functions. The identity of digital images was evaluated by the change of correlation coefficient values in the range of RGB colours. The software was applied to compute the above process.

1. Introduction

The quality of surfaces in technological treatment of machinery, appliances and different devices is usually quantified visually and/or by a profilometer. The article deals with the application of digital imaging to quantify the roughness of surfaces in applying the numerical photogrammetric methods and the theory of covariance functions. The scales of digital images in perspective projections are different from the ones of individual pixels, but the pixel colour wave frequency remains the same regardless of the scale, and the scale change does not influence the covariance functions in the computing procedure.

Discrete Fourier transformation is usually applied in digital image processing [6,3], Wavelet function theory [4,5,1,2]. The theoretical model is based the concept of static (in the broad sense), random function, assuming that the digital image pixel parameter errors are random and of equal accuracy, i.e. the error average is $\Delta M = \text{const} = 0$, dispersion $\Delta D = \text{const}$, and the covariance function of digital images depends only on the difference of arguments, i.e. from pixel quantization interval. Thus, the surface of the parts can be analysed as a cartographic surface, applying the theory of cartographic projections.

2. Surface roughness parameters and methods of measurement

Quantifying scheme of surface profile roughness parameters is presented in Fig. 1.

The entire micro-geometric roughness of the surface is called surface roughness, when the micro-roughness on the surface profile (relief) is spaced repeatedly at a relatively small trace. Surface roughness is measured in

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0263-2241/

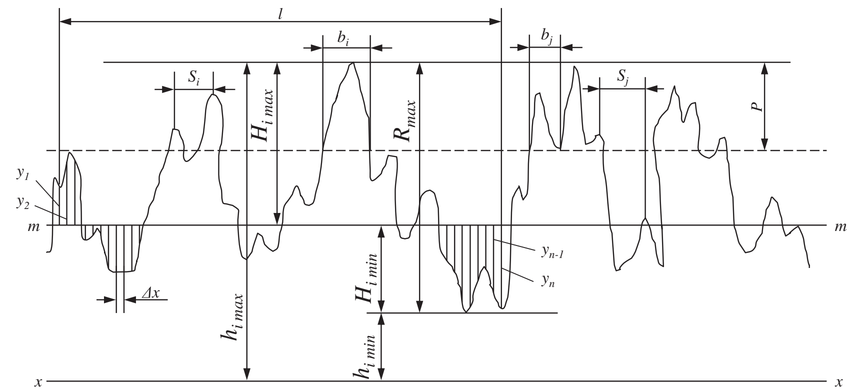

Fig. 1. Quantifying scheme of surface profile roughness parameters.

accordance with ISO 4287 and DIN 4768 standards in one or more of the following parameters: R_a – arithmetic average deviation in the profile. This is a deviation from the midline of the absolute values of the arithmetic average value over the entire sampling length:

$$R_a = \frac{1}{l}\int_0^l |y(x)|\,dx \quad (1)$$

R_z – ten point average roughness of the profile. This is the average profile micro-roughness over the entire sampling length:

$$R_z = \frac{1}{5}\left(\sum_{i=1}^{5}|H_{i\ max}| - \sum_{i=1}^{5}|H_{i\ min}|\right) \quad (2)$$

R_{max} – maximum roughness depth; S_m – average surface roughness trace;

S – average spacing between peaks; t_p – profile relative basic trace. The ratio between the basic length of the profile and the entire length l:

$$t_p = \frac{1}{l}\sum_{i=1}^{n} b_i \quad (3)$$

l – entire length, which can be measured using the indicators listed above, $H_{i\ max}$ – deviation of five highest roughness maximum in the profile, $H_{i\ min}$ – deviation of five highest roughness minimum in the profile.

The main surface roughness values of parameters R_a and R_z are measured by the entire length l, as well as other numerical values are specified in the standards. There is a number of measuring instruments operating in non-contact, contact and subjective methods for measuring surface roughness. Non-contact method in operating the instrument has the advantage that it does not contact the measured surface, therefore, the surface can neither be broken, nor scratched. These are optical and interferometric devices.

When we use the device operating by the contact method, the surface is contacted by stylus tip. The movements of the device are recorded onto the indicating panel in optomechanical, electromechanical, or other manner.

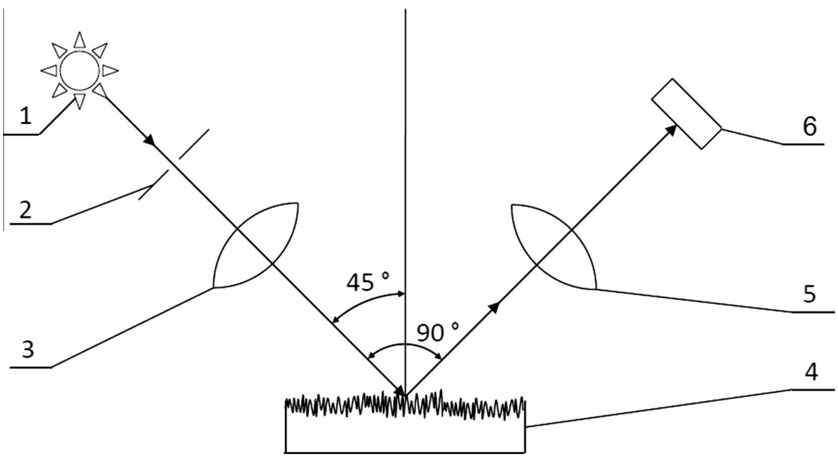

Fig. 2. The scheme of non-contact optical method for measuring surface roughness: the light source 1; diaphragm – 2, the first lens – 3; measured object – 4, the second lens – 5; CCD camera – 6. The surface profile image captured in different ways provides with the possibility to measure the roughness of surfaces by non-contact methods provides with the possibility to measure the roughness of surfaces by non-contact methods in applying the theory of cartographic projections.