Surface Roughness Estimation of Turned Parts from Optical Image Measurements and Wavelet Decomposition

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ABSTRACT

The surface roughness is very significant information required for product quality on the field of mechanical engineering and manufacturing, especially in aeronautic. Its measurement must therefore be conducted with care. In this work, a measuring method of the surface roughness based on machine vision was studied. The authors’ use algorithms to evaluate new discriminatory features thereby than the statistical characteristics using the coefficients of the wavelet transform and used to estimate the roughness parameters. This vision system allows measuring simultaneously several parameters of the roughness at the same time, order to meet for the desired surface function used. The results were validated on three different families of materials: aluminum, cast iron and brass. The impact of material on the quality of the results was analyzed, leading to the development of multi-materials. The study had shown that several roughness parameters can be estimated using only features extracted from the image and a neural network without a priori knowledge of the machining parameters.

Keywords: 2D Wavelet Transform, Aluminum, Brass, Cast Iron, Neural Network, Surface Roughness, Vision System

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INTRODUCTION

Faced with the increasing demand of automation in manufacturing, vision system plays an important role in the quality inspection and process monitoring. The surface metrology is still considered as a demanding and vital in manufacturing and particularly in real time information processing systems. The surface quality of workpiece produced by manufacturing processes must be evaluated in order to meet the functional performance of components. The surface roughness also affects several functional attributes of parts, such as friction, wear, light reflection, heat transmission, resistance to fatigue and corrosion, distribution capacity and holding a lubricant (Smriti H. Bhandari, 2007). The choice of the roughness parameter must be essential to allow the parts to play the role for which it was designed. The study of the roughness should not be limited to a single roughness parameter, but more in relation to the function of the surface (Kamguem, Songmene, Kenne, & Tahan, 2011). Thus, the surface roughness has been the subject of experimental and theoretical studies for many recent years.

The three main techniques for measuring surface topography are based on profiling, area and microscopy (Badashah & Subbaiah, 2011). Profiling techniques are more accurate compared to the technical area. The two simple ways used to measure the surface roughness are optical techniques and the use of a stylus. The traditional method (using the stylus) is the most widely used in manufacturing industry. The stylus measuring method has a problem because it requires direct physical contact with the surface to be measured and the measurement is made at the sampling line and cannot symbolize the actual characteristics of the surface. It has limited flexibility in the evaluation of complex parts geometric (Livens, 1998). Alternatively, optical measurement methods are applied to overcome the limitations of the stylus method, but cannot be used on surfaces with roughness values of the order of nanometers. In addition, the optical technique is sensitive to lighting conditions and noise (Al-Kindi & Shirinzadeh, 2009). Surface analysis assumes that the irregularities of the surface geometry can be used as a fingerprint of the process and the machine tool. A small change in the process parameters, on the tool state or in the state of the machine tool leads to changes in the surface geometry, size, texture, form, or a combination (Whitehouse, 1997). Thus it is better not to be limited to machining parameters for the evaluation of roughness by vision system (R. Kamguem, Tahan, & Songmene, 2013).

For the machine vision approach, the scanned part image is processed using a computer and is represented by a rectangular matrix with elements corresponding to the brightness at each appropriate location. Texture analysis of these images (with intent to characterize them) is still an open field, because there is no single technique which can be used to fully characterize a texture. With the advance of the computer and with adequate systems for image processing, the image processing technique is as a better alternative for measuring the surface roughness of machined parts. But the size and the high cost of existing systems limit their general use in the inspection.

In recent years, the problem of assessing surface roughness has been solved using different techniques. Some authors (Buj-Corral, Vivancos-Calvet, & Dominguez-Fernandez, 2012; Yujun, Lizhen, & Panxin, 2010) have used an approach based on pure modeling. In addition, methods of artificial intelligence have been used for predicting the surface quality through the development of models of artificial neural networks (ANN), genetic algorithms, fuzzy logic, and expert systems. Among the authors who have used fuzzy logic for assessing surface roughness, one can mention (Natarajan, Palani, & Anandampilai, 2012; D. Shome, 2009; S. Kumanan, 2008). Moreover, neural networks are also a technique increasingly used by researchers(Natarajan, et al., 2012; Palani & Natarajan, 2011; Wang & Petriu, 2011; Z. S. Zhang, Chen, Shi, Ma, & Jia, 2009). Traditionally, analysis of the image is done in the spatial domain. Nevertheless, many authors today are working in the frequency domain for each point.
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