ABSTRACT

Researchers hitherto used Computer Vision and digital image processing for grabbing images of machined surfaces, improving their quality by pre-processing and then analysed them for evaluation of surface finish with reasonable success. In the conventional mechanical stylus method used for roughness evaluation, many of the fundamental requirements need to be taken care during measurements which include alignment of components with the stylus pick up movement, tracing length, filter cut off length, etc. Inspection of parts by machine vision requires accuracy, high speed, reliability and consistency. Also it is required that images are to be rotated, sheared and scaled while preserving image integrity. Practical use of Computer Vision for surface roughness estimation faces many challenges, as only image is used for evaluation rather than the components. Existing schemes are less suited for real-time machine vision applications due to the great computational burden involved in processing a large image. For example, an operation such as rotation and scaling involves four multiplications and four additions per pixel, which is going to be computationally complex. This problem is getting worse when the size of the input image increases, which poses a common problem for today’s machine vision system.

In this work, an attempt has been made to use a novel Evolvable Hardware based image processing algorithm for preprocessing the images and
enhance the image quality. In trend with the rapid rise of cost-performance efficiency of image acquisition systems, the major focus in this work is not only on accuracy, but also on the reduction in computational complexity for real-time machine vision applications. The improved quality images are processed to assess surface roughness of machined parts produced by the milling and grinding process. To ensure the effectiveness of this approach the roughness values quantified using these images are then compared with widely accepted standard mechanical stylus instrument values. Quantification of digital images for surface roughness is performed by extracting three parameters (major peak frequency, and principal component magnitude squared value) using Fourier transform along with the standard deviation of gray level intensity value. The quantitative measure of surface roughness is also estimated in the spatial frequency domain using wavelet transformation performed by extracting four features namely Total Energy ($E_t$), Energy horizontal ($E_h$), Energy vertical ($E_v$) and Energy diagonal ($E_d$). Two artificial neural networks (ANN), which take image features as the input, are developed to estimate the surface roughness measures. The first network trains with Fourier transform image features and the second uses wavelet transform image features. The experimental result indicates that the surface roughness could be estimated with a reasonable accuracy using Computer Vision consisting of image enhancement, feature extraction and ANN based estimation. The suitability of implementing the evolvable hardware based image enhancement scheme on a dedicated hardware is also explored in this thesis. The Xilinx family FPGA based board is used for the hardware implementation. The coding is done using the popular VHDL language with
the algorithms developed so as to exploit the implicit parallel processing capability of the chip. The processing speed i.e. the speed with which the features of the captured image are enhanced, increases significantly when implemented in such hardware units. The proposed method can reduce the computational complexity significantly. As a result, the proposed method is many times faster than conventional ones.

Thus, in this work an exhaustive analysis is done with comparison studies wherever required to make sure that the proposed method of estimating surface finish based on the computer vision processing of image is more consistent and could be implemented in real time on a hardware.