ABSTRACT

Surface characterization belongs to a large family known as texture Analysis and is still remains a challenging task. During measuring the roughness of a surface, the result can be understood as an image where the grey levels correspond to the surface finish. When the surface is deeper a valley, the corresponding pixel of the image will be darker subsequently, the higher a peak, the brighter the corresponding area in the image. Analysis of these images in order to characterize them is still an open field as there is no single technique that can be used to entirely characterize the roughness parameters. Conventional ways of measuring the surface roughness are Optical (Non-contact) and Stylus technique (Invasive or contact). The main drawback in stylus technique is that it is a contact method and hence can damage the surface, whereas in optical technique, it is common for the surface components to have roughness less than a nanometer.

Image acquired through modern cameras are normally contaminated by variety of noise sources (e.g. Photon or On-Chip electronic noise) and also by distortion such as shading or improper Illumination. Therefore a preprocessing unit (Image filter) has to be incorporated to improve the image quality. Industry requires automatic design of such filters since the system should adapt to the changing environment autonomously (e.g the change of illumination or after replacement of a damaged camera)
A new approach to automatic design of image filters for a given type of noise is introduced. This approach employs evolvable hardware filter (EHW) at functional level and produces circuits that outperforms conventional design in terms of the resulting image quality. Features are extracted from the preprocessed machine vision image by suitable algorithms and are used for surface roughness estimation.

Over the last two decades, ideas from the theory of evolution in natural systems have inspired the development of a powerful group yet extraordinarily flexible optimization methods known collectively as evolutionary computation (EC). The advantage of EC is its flexibility: such that if a fitness measure for a problem can be derived, then the problem might be solved using EC. A crucial issue when using EC is how to represent candidate solutions so that they can be manipulated by EC effectively and in this context, there is a need to evolve individuals that represent possible image processing algorithms. In this work, the basis set of primitive image operators are identified and presented as a chromosomal representation of a complete algorithm. The advantage of this work is that the threshold and logical operations have been used to allow the system to match Boolean ground truth without any requirement, thus the system apply operators in any predefined order. With this arbitrariness, the image noise filter is evolved such that additional operators can be added quickly and easily to the current set of basic operators. Indeed, one of the main aims is to permit evolution of useful combinations of operators that can be promoted to new, indivisible building blocks.
Subsequent to the evolved filter based machined image noise filtering, wavelet based feature extraction is presented. The multi-spectral analysis platforms (wavelet) is used to effectively search for spectral, spatial, and possibly hybrid spatial-spectral signatures, towards the extraction of features from machined images with specific focus to milling and grinding process.

Using the wavelet extracted image features, an artificial neural network (ANN) is trained and tested to arrive at the surface roughness values. Further the surface finish values ($R_t$) are estimated in two cases (milling and grinding) using ANN approach and the estimated values are compared with that obtained using conventional stylus method. The experimental results indicates that the surface roughness could be estimated with a reasonable accuracy using the combined technique of Machine Vision, evolved filtering, wavelet and ANN respectively.