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Optical surface analysis with Support Vector Machines based on two different measurement techniques

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The surface topography as well as the optical perception are important features for evaluating the quality of fine grinded knives. Parameters as the surface roughness, gloss or coloring are used for the quantification of these features. The measuring is implemented by the use of traditional methods, which are manual, time-consuming and cost-intensive. On top of that, the application of these methods for the condition monitoring of the ongoing process is rather limited. Therefore, a new, faster and more cost-effective approach is needed to improve the classical measurement methods. A conceivable approach could be based on image analysis.
Over the past years, different contactless image analysis based approaches have been developed to simplify the traditional roughness measurement methods. Some studies propose picture pre-processing and feature extraction in combination with machine learning algorithms.
The overall goal of the presented research activities is the development of a condition monitoring tool which can be implemented in the ongoing grinding process of the knives. It should be used to ensure the knives quality and to reduce rejects by an immediate detection of deviations of the target values and the possibility to adapt the production process accordingly. For this reason, a data set based on cutlery samples has been generated and analyzed. The extraction of features of the data set is presented for a better understanding of the training process. The features are used to train various machine learning algorithms with and without a combination of logged process parameters to evaluate the surface roughness.
Within this study the image of each grinded surface is analyzed regarding its measured arithmetic average roughness value (Ra) by the use of Support Vector Machine (SVM) and Support Vector Regressor (SVR) algorithms.

Keywords: Machine Learning, SVM & SVR, supervised learning, surface topography, condition monitoring.

1. General Appearance

The optical perception of high precision, fine grinded surfaces is an important quality feature for these products. Its manufacturing process is rather complex and depends on a variety of process parameters (e.g. feed rate, cutting speed) which have a direct impact on the surface topography. Therefore, the durable quality of a product can be improved by an optimized configuration of the process parameters.

To improve the conventional methods of condition monitoring, a new image processing analysis approach is needed to get a faster and more cost-efficient analysis of produced surfaces. For this reason, different optical techniques based on image analysis have been developed over the past years.

In this study, fine grinded surface images have been generated under constant boundary conditions in a test rig built up in a lab. The gathered image material in combination with the classical measured surface topography values is

used as the training data for machine learning analyses.

In real-world applications, data often exists in unbalanced class distributions, which can result in biased trained machine learning models. Since the manufacturer of these surfaces would produce economically prohibitive rejects, the used data also consist of an imbalanced distribution. Since the data basis plays an essential role for the training of machine learning models, the challenge in the application is often to find cost-efficient, fast and at the same time process-adaptable measurement methods that also have sufficient accuracy. Basically, the measured arithmetic average roughness value (Ra) out of two different measurement methods was used as the target variable in this study. The measurement methods used are distinguished between tactile and optical convocal measurement, which ensure different precisions and different scattering. This results in two data sets with unequal imbalanced distributions and different statistical variance.

The present target values are available both as a class and as a continuous value, so that a classification as well as regression analysis with Support Vector Machines can be performed. SVMs are a type of machine learning algorithms which can be particularly applied for any kind of analysis based on extracted features. In order to find suitable parameters for the SVMs, a comprehensive parameter study for the different data sets was performed. Finally, the influence of the different measurement methods with the same input database is analysed and discussed in detail.

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