Time-frequency analysis of vibration signals for monitoring the process status in Ultra-Precision machining of complex components

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Abstract

The ever-advancing digital manufacturing is fueling a rethink of the current machining process. The conventional way of controlling cutting parameters is not reconfigurable to meet the soaring demand. Complex process dynamics like regenerative chatter, tool wear, etc.., seriously affect the production. This ensembles the requirement of the high precision monitoring and the in-process production optimization, assuring minimal maintenance and interruptions. The use of vibrational signals for automated and/or autonomous monitoring in ultra-precision machining (UPM) is still in its infancy. Capturing these complex spatiotemporal patterns through signal processing and advanced algorithms to detect the changes in trends of surface generation mechanism is quite tricky, which is essentially important in tedious ultraprecision machining of complex components. The earlier tried to study relayed on improving the frequency assessment and refining the termporal resolution. Due to the inherent transient, noise-contamination, nonlinear dynamics, traditional signal processing methods are ineffective in portraying the complex UPM process.

Keeping in mind the circumstances mentioned earlier, in this paper, an attempt has been made to use the time-frequency analysis of vibrational signals to monitor the machining status in UPM using the B&J 4533-B accelerometer. In this study, a single-axis vibration sensor (feed direction) has been used to detect unexpected anomalies during machining. The results obtained from Continuous Wavelet Transform (CWT) analysis show excellent results for the assessment of machining conditions. In the analysis of the non-linear and non-stationary dynamics, CWT can be helpful in discriminating the frequencies that remain constant. This differentiation of continuous and varying frequencies helps to relate the linear and non-linear behaviour. CWT allows better visualization of data extracted from the machining process. Spectrograms are frequency spectrum representations of the signal as a function of time. The main objective of this work is to overcome the shortfalls in monitoring by using time-

frequency-based log-spectrogram analysis. This log-spectrogram analysis provides a robust and accurate machining status assessment like a surface scratch, sudden workpiece drop, rubbing and ploughing mechanisms.

Keywords: Ultra-Precision machining, log-spectrum analysis, Vibrational signal, Continous Wavelet Transform, complex components

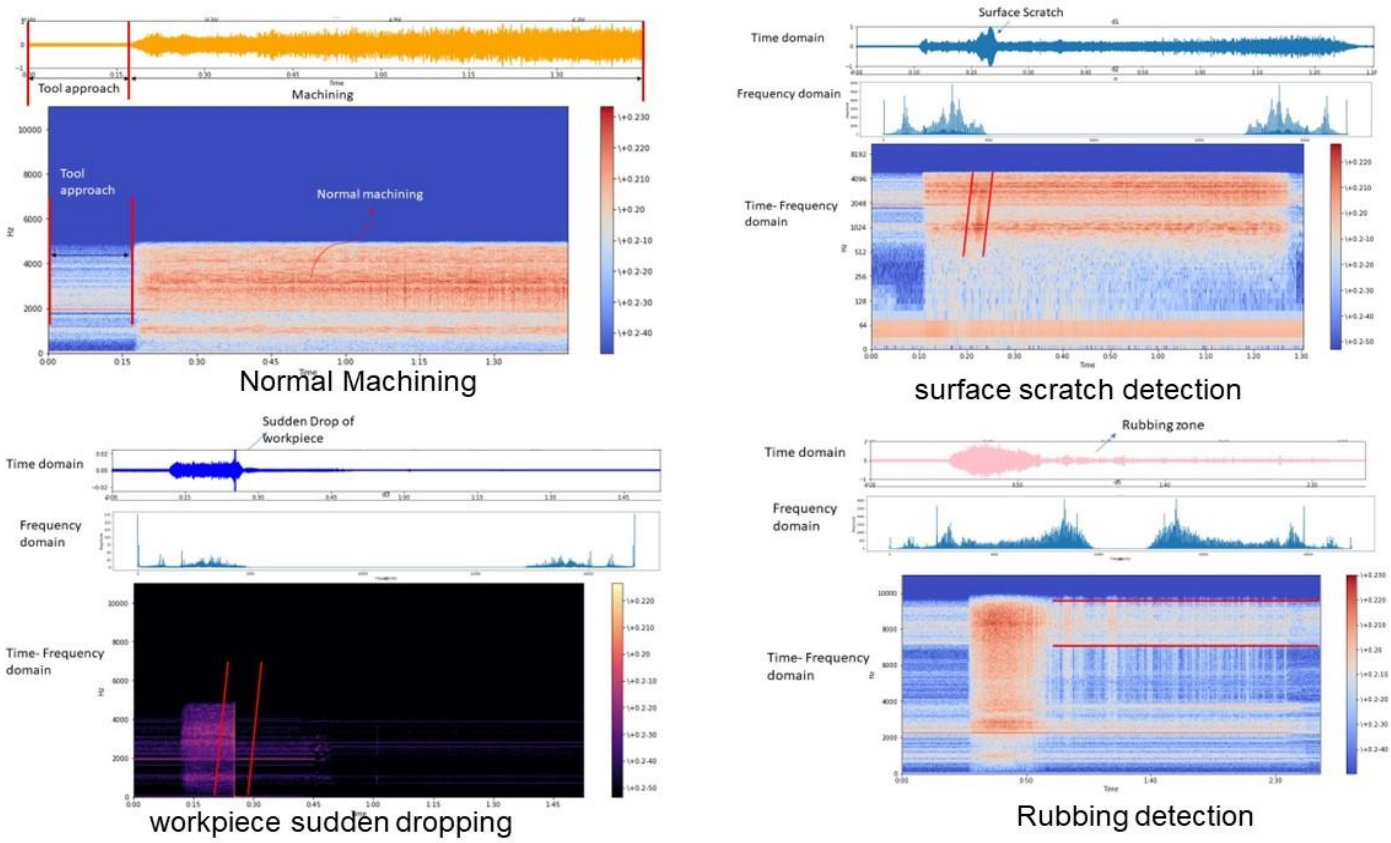

Figure 1: Time-frequency domain log- spectrogram analysis for monitoring of mahcining status

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