Chatter detection in turning process using sound signal and simple microphone

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Abstract. Chatter is a problem that frequently found in the area of a machining process, which brings down machining productivity and surface quality. Therefore, reliable and intense chatter detection methods are needed to maintain machining quality. In this study, turning chatter detection approach by using sound signals and a simple microphone is proposed to get an accurate, simple, and low-cost detection method. For that purpose, an experimental set-up which consists of an operating turning machine, simple microphone, and Personal Computer (PC) with sound card was arranged. The chatter in the turning process was stimulated by applying artificial wear to the cutting tool. The sound signal data from normal and with chatter turning process were then grabbed by a simple microphone and PC with a sound card. The sound signals were then evaluated by Fast Fourier Transform (FFT) and Wavelet Transform (WT) for normal and chatter conditions. Both conditions data were then compared to get the characteristic of the sound signal in chatter. It is found that signals in the frequency domain, time-frequency and spectrogram have a significant magnitude spike in chatter condition. The results demonstrated that the proposed method could conscientiously identify the chatter.

1. Introduction

Nowadays, condition monitoring has become an important research topic in the field of engineering. Several methods have been investigated to get an effective way of monitoring the current condition of structures [1-4] and working machine [5-7]. One of the important machines that need to be monitored in working conditions is a lathe machine for the turning process, which can be affected by chatter.

Chatter is a problem frequently experienced in the area of machining process which brings down machining productivity and surface quality. Therefore, reliable and intense chatter detection methods are needed to maintain machining quality. Several methods have been investigated to detect the chatter, like using vibration base [8-10], and sound signal base [11-13]. Delio et al compared the microphone with other sensors to detect chatter and it was concluded that sound signals were the most appropriate for chatter detection in many instances [11]. In fact, to get the sound signal, the researcher needs to spend more expenses for high quality microphone. So, It is important to get a solution of high cost sensor by using low cost (simple) microphone.

In this research, the sound signal and simple microphone are used to detect chatter in the turning process. The simple microphone which is supported by sound card is used as a sensor to get the sound signal from the turning process. The sound signals are then processed by using Fast Fourier Transform
(FFT) and Wavelet Transform (WT). From this research, it is hoped that the potency of simple microphone and soundcard to detect chatter in turning can be determined as one of solution to get a low-cost instrument for chatter detection.

2. Methods
The experimental set-up which consists of operating a turning machine, simple microphone and personal computer (PC) with a sound card was arranged to detect chatter. The microphone used in this setup is Krezt K-818 with frequency range 30Hz 18KHz and the sensitivity of -32dB 3dB, which is usually used as a part of the sound system. The chatter in the turning process is stimulated by applying artificial wear to the cutting tool. The sound signal data from normal and chatter conditions in turning process are then grabbed by the simple microphone, sound card, and PC. The sound signals are then presented in time domain data and evaluated by fast Fourier transform (FFT) and wavelet transform (WT). The sound data of normal and chatter conditions are then compared to get the characteristics of the sound signal in chatter. The experimental set-up is shown in Figure 1.

![Figure 1. Experimental setup for chatter detection.](image)

3. Results and discussion
In this work, the turning process has the operation condition of 1000 rpm spindle rotation, 0.25 mm/r feeding, and 0.5 mm depth of cut. The comparisons of data are presented in the form of time domain, frequency domain, spectrogram of wavelet transformation, and surface quality Figure 2-5, respectively.

3.1. Time domain signal analysis
Figure 2 shows the sound signal in the time domain with the condition of normal and chatter. The normal condition shows that the amplitude of sound signal seems to have the same amplitude. Even though in the early stage some amplitude raised, the sound data then tend to be stable. For the chatter condition, the amplitude of the sound signal rises suddenly. The average value of the amplitude spike to be approximately twice. The sudden change of amplitude to be higher can be analyzed as characteristic of chatter.
3.2. Frequency domain signal analysis

The frequency domain signal of the turning process in the condition of normal and chatter can be seen in Figure 3. Some number of frequencies appears to be in higher amplitude which closes to the majority of high amplitude. It can be seen that many frequencies have a tendency of higher amplitude around 1000 Hz. Besides that, in the frequency of around 2000 Hz, 5000 Hz, and 7000 Hz the same tendency is found, but the magnitude is not so high. From the tendency of the frequency domain graph, it could be analyzed that the turning system is excited in its natural frequencies. This symptom shows the existence of chatter.

3.3. Spectrogram analysis

The spectrogram of the sound signal of the turning process in normal and chatter condition are presented in Figure 4. From the figure, it can be seen that a very strong red color contour appears in certain frequencies, in this case, appears in around 1000 Hz (60 x rpm), which is predicted as one of the natural frequencies of lathe machine. It can be analyzed that the system is excited in the frequency that closes to the natural frequency of the machine system.
3.4. The product analysis

The products which are produced from the turning process in normal and chatter condition where the sound data have been analyzed by using FFT and WT are presented in Figure 5. The product that is produced from normal turning has the best quality in the surface. When the process is excited by chatter, the surface quality became very low (damage). These are the proofs that the sound signal explained the existence of chatter which physically can be seen from the product.

![Figure 5. Surface quality of the turning process (a) normal (b) chatter.](image)

4. Conclusion

From the analysis that have been conducted for chatter detection in turning process using sound signal and simple microphone, it is shown that proposed method can detect the chatter in turning process very well. The FFT and WT were applied successfully as the sound signal processor. The signatures of chatter were explored by using the time domain signal, the frequency domain signal, and spectrogram. The surface quality analysis strengthened the verification of the existence of chatter in turning process. It can be concluded that a simple microphone and soundcard can be used as an alternative sensor to detect chatter in the turning process by sound signal base method. The data grabbed by a simple microphone and sound card determined the real condition of the turning process.

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