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Tool wear monitoring by machine learning techniques and singular spectrum analysis

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ABSTRACT

This paper explores the use of data mining techniques for tool condition monitoring in metal cutting. Pseudo-local singular spectrum analysis (SSA) is performed on vibration signals measured on the toolholder. This is coupled to a band-pass filter to allow definition and extraction of features which are sensitive to tool wear. These features are defined, in some frequency bands, from sums of Fourier coefficients of reconstructed and residual signals obtained by SSA. This study highlights two important aspects: strong relevance of information in high frequency vibration components and benefits of the combination of SSA and band-pass filtering to get rid of useless components (noise).
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1. Introduction

Cost optimization of metal cutting processes reveals to be of prime importance, particularly within stringent constraints brought about within the high requirements of competitiveness defined by global economy. Tool condition and life span are critical components of cost optimization. There is a real need to devise means of detecting tool wear as well as to predict remaining life for effective management of manufacturing lead time. Dimensional tolerances as well as the quality of the finished workpieces are dependent on this. Given high stresses, friction and temperature that tools must withstand, wear is inherent to any cutting process. A method for early detection and monitoring of wear evolution is a necessity within a "just in time" policy for tool change [1–3].

Tool wear monitoring methods can be classified into two groups:

- direct methods in which wear is directly measured using optical, radioactive or electrical resistance sensors;
- indirect methods which perform wear evaluation on the basis of parameters measured during the cutting operation: cutting forces, acoustic emission or vibrations.

One can distinguish, in this, on-line methods, i.e. used during the cutting process and off-line methods where the process is interrupted to carry out the control. Indirect methods, which are concerned in this paper, are usually on-line methods. Fig. 1 summarizes how indirect methods can be implemented.

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