
# Complex Signal Analysis for Planetary Gearbox Fault Diagnosis via Shift Invariant Dictionary Learning

Zhipeng Feng, Ming Liang

PII: S0263-2241(16)30158-0
DOI: http://dx.doi.org/10.1016/j.measurement.2016.04.078
Reference: MEASUR 4028

To appear in: *Measurement*

Received Date: 5 March 2015
Revised Date: 16 March 2016
Accepted Date: 27 April 2016

Please cite this article as: Z. Feng, M. Liang, Complex Signal Analysis for Planetary Gearbox Fault Diagnosis via Shift Invariant Dictionary Learning, *Measurement* (2016), doi: http://dx.doi.org/10.1016/j.measurement.2016.04.078

# Complex Signal Analysis for Planetary Gearbox Fault Diagnosis via Shift Invariant Dictionary Learning

Zhipeng Feng[1*] and Ming Liang[2]

[1] School of Mechanical Engineering, University of Science and Technology Beijing, Beijing 100083, China

[2] Department of Mechanical Engineering, University of Ottawa, Ottawa, ON K1N 6N5, Canada

**Abstract:** Planetary gearbox vibration signals are intricate due to the unique structure, complex kinetics and background noise interference. Moreover, they have time shift invariant feature because of the periodical rotation of the mechanical components. Reliable feature extraction from such signals is the key to success in planetary gearbox fault diagnosis. The recently proposed shift invariant K-means singular value decomposition (SI-K-SVD) dictionary learning method offers a good approach to analyze such signals. This method requires neither a priori knowledge on signals to construct any analytic dictionary, nor a large number of sample signals to form a training dictionary. It is therefore data-driven in nature, and highly flexible and adaptive to represent signals. In this paper, such properties of the SI-K-SVD are exploited to extract the latent constituent components of complex signals and use them to represent signals sparsely, thus suppressing background noise and revealing the true vibration patterns. To apply the SI-K-SVD method to planetary gearbox signals, the criteria for determining the key parameters used in the SI-K-SVD, i.e., the length of pattern and number of decompositions, are suggested. The method has been illustrated by analyzing numerically simulated signals. It has been favorably compared with the frequently used matching pursuit (MP) and K-means singular value decomposition (K-SVD) methods. Its effectiveness in real planetary gearbox fault diagnosis has been validated by analysis of lab experimental signals of a planetary gearbox. The results show that both localized and distributed gear faults can be diagnosed successfully.

**Keywords:** Fault Diagnosis, Planetary Gearbox, Sparse Representation, Dictionary Learning, K-SVD, Shift Invariant

## 1 Introduction

Planetary gearboxes are widely used in many kinds of machinery, such as wind turbines, helicopters and heavy trucks, thanks to its large power transmission capacity in a compact structure. For such key equipment, once fault occurs, it could lead to reduction in transmission efficiency, shut-down of the entire drivetrain, or even catastrophic losses. Therefore, planetary gearbox fault diagnosis has been an important topic in the field of machinery diagnostics.

* Corresponding Author. Tel:+86 10 62332865; Fax: +86 10 62329145. Email Address: fengzp@ustb.edu.cn (Z. Feng)