

Extension of the Generalized Unknown Input Kalman Filter for Online Reconstruction of External Structural Loads

Y. NIU, M. KLINKOV and C.-P. FRITZEN

ABSTRACT

External load information is of great interest in structural health monitoring (SHM), since it can help to evaluate possible damage of a structure due to fatigue loading or after extreme events. However, some loads might not be measured directly and have to be reconstructed from structural response measurements. This is a type of ill-posed inverse problem where small perturbation of the measurements may cause unstable solutions. Therefore, a robust load reconstruction strategy is needed.

In this paper, an extension of the generalized Kalman filter with unknown inputs method (G-KF-UKI) (Generalized Kalman Filter with Unknown and Known Inputs) is proposed. This method can realize online input force estimation and is robust to modeling errors and measurement noise. Besides this, the presented G-KF-UKI strategy also includes known inputs (e.g. control inputs or known force inputs), which makes it applicable to a larger class of systems. An experiment on a laboratory two-storey structure and a simulation study on wind load reconstruction are given as examples to show the effectiveness of this method.

INTRODUCTION

In structural health monitoring (SHM), the knowledge of external loads is very useful for the safety evaluation of structures under fatigue loading but also for extreme events (e.g. boat crash on a bridge or a typhoon). Due to physical or economical restrictions, a direct measurement of such loads might be not possible. A widely used strategy is to reconstruct the unknown loads from structural response measurements. This is usually a type of ill-posed inverse problem, in the sense that the inevitable measurement noise may lead to big estimation errors [1]. To overcome this difficulty, a variety of methods has been proposed. Some recent progress are mentioned in [2].

Among the available studies, methods with online force reconstruction ability are very promising. The recently proposed generalized Kalman filter with unknown inputs (G-KF-UKI) method [3] is a new member in this family. It can estimate the unknown input forces in real-time and is robust to measurement noise. Furthermore, it is also suitable for the case that the process noise and measurement noise are correlated.

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In this paper, an extension of the generalized Kalman filter with unknown inputs method, G-KF-UKI (Generalized Kalman Filter with Unknown and Known Inputs), is proposed. This method can realize on-line input force estimation and is robust to modeling errors and measurement noise. Besides this, the presented G-KF-UKI strategy also includes known inputs (e.g. control inputs or known force inputs), which makes it applicable to a larger class of systems. An experiment on a laboratory two-storey structure and a simulation study on wind load reconstruction are given as examples to show the effectiveness of this method.

Ключевые слова:

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