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Damage detection of subway tunnel lining through statistical pattern recognition

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Abstract. Subway tunnel structure has been rapidly developed in many cities for its strong transport capacity. The model-based damage detection of subway tunnel structure is usually difficult due to the complex modeling of soil-structure interaction, the indetermination of boundary and so on. This paper proposes a new data-based method for the damage detection of subway tunnel structure. The root mean square acceleration and cross correlation function are used to derive a statistical pattern recognition algorithm for damage detection. A damage sensitive feature is proposed based on the root mean square deviations of the cross correlation functions. X-bar control charts are utilized to monitor the variation of the damage sensitive features before and after damage. The proposed algorithm is validated by the experiment of a full-scale two-rings subway tunnel lining, and damages are simulated by loosening the connection bolts of the rings. The results verify that root mean square deviation is sensitive to bolt loosening in the tunnel lining and X-bar control charts are feasible to be used in damage detection. The proposed data-based damage detection method is applicable to the online structural health monitoring system of subway tunnel lining.

Keywords: statistical pattern recognition; root mean square; cross correlation function; subway tunnel structure

1. Introduction

As ground transportation is congested in many cities, subway system has become increasingly important to urban people's daily commuting. The subway tunnel structures suffer attacks from mechanical, physical, and even chemical actions (Richards 2002). As a result, the subway tunnel structures deteriorate gradually during their service life. Structural health monitoring is concerned with the implementation of a damage detection strategy, which provides information about structure's conditions that help us to have a better understanding of the structural status (Yi *et al*. 2010, 2013, Farrar and Worden 2013, Chen and Xia 2017, Chen *et al*. 2017). Structural health

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