GUIMARÃES 2019 IABSE SYMPOSIUM
IABSE Symposium 2019 Guimarães
Towards a Resilient Built Environment - Risk and Asset Management
March 27-29, 2019, Guimarães, Portugal

Application of a Model-free ANN Approach for SHM of the Old Lidingö Bridge

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Abstract

This paper explores the decision making problem in SHM regarding the maintenance of civil engineering structures. The aim is to assess the present condition of a bridge based exclusively on measurements using the suggested method in this paper, such that action is taken coherently with the information made available by the monitoring system.

Artificial Neural Networks are trained and their ability to predict structural behaviour is evaluated in the light of a case study where acceleration measurements are acquired from a bridge located in Stockholm, Sweden. This relatively old bridge is presently still in operation despite experiencing obvious problems already reported in previous inspections. The prediction errors provide a measure of the accuracy of the algorithm and are subjected to further investigation, which comprises concepts like clustering analysis and statistical hypothesis testing. These enable to interpret the obtained prediction errors, draw conclusions about the state of the structure and thus support decision making regarding its maintenance.

Keywords: Artificial Neural Networks, Clustering analysis, Model free damage detection, Statistical Hypothesis Testing, Structural Health Monitoring.

1. Introduction

Civil engineering structures serve our societies in many ways, contributing for their sustainability and rapid development. However, a significant part of these structures is presently being used past the timeframe they were originally designed for. Additionally, this extended use may take place under environmental and operational conditions different from the initial ones, for e.g. if a bridge experiences an increase in traffic it will be thus exposed to higher loads. In this sense the natural deterioration process can even be accelerated and it is not uncommon that when damage is exposed it has already grown far and required reparations are extensive and expensive. In a more severe case the structure may even be found beyond repair and required to be demolished and, in the utmost extreme case, if action is taken too late, the safety of the users can be compromised with consequent great costs.

2. Structural Health Monitoring and Damage Detection

Systematic monitoring and inspection are needed to assess the present state of a structure and predict its future condition. If irregularity is noticed, repair actions may take place and the adequate intervention will most probably reduce the future costs with maintenance, minimize downtime and increase safety by avoiding the

https://doi.org/10.2749/guimaraes.2019.0200