Computational Inverse Technique in Nondestructive Detection of Flaws in Railway Tracks Using Genetic Algorithm

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Abstract

Computational inverse techniques in conjunction with nondestructive methods have been proposed as potentially valuable tools for evaluating the substructure performance, determining locations along the track that require maintenance, and identifying appropriate solutions. In this paper, development of a Finite Element Analysis based on GA computing model is proposed for detecting uneven local settlement of ballast from simulated FWD data without the need for destructive field tests. For this purpose, the inverse problem is expressed as a minimization problem with the objective function being the mean square root of the differences between the measured quantities and the corresponding computed quantities from the assumed structural configuration. This objective function is used by the Genetic Algorithm (GA) to measure the fitness of individuals in a population of candidate solutions. The unknown parameter set to be identified is the reference loose sleeper number to indicate the location of settlement (in other words, reference number of springs with zero stiffness). The results indicate that the GA computational inverse technique has the potential to solve the inverse structural identification problems in a systematic and robust way.

Keywords: Computational inverse technique, Nondestructive tests, Genetic algorithm, Flaw, Railway track

1. INTRODUCTION

This paper is based on genetic algorithms for the solution of inverse problems pertaining to the identification of flaw location in railway tracks. This method has also been used for asphalt pavement crack classification, crack detection, delamination in composite laminates and detection of flaws in structures [1-4].

Computational techniques for the solution of inverse problems usually consist of two parts, i.e. the numerical discretization methods for the ill-posed structures or objects with assumed geometric and/or boundary conditions and the iterative procedures that are used to search for the actual structural and geometrical configuration. The most difficult part in the formulation and numerical solution methods for realistic inverse problems, however, lies in finding a robust iterative procedure for a large variety of complex problems that will proceed towards the final configuration [4].

In this research, the inverse problem is expressed as a minimization problem with the objective function being the mean square root of the differences between the measured quantities and the corresponding computed quantities from the assumed structural configuration. This objective function is used by the GA to measure the fitness of individuals in a population of candidate solutions. Possible approximate solutions are found by the GA gradually leading to an increase in the average fitness of the population.

The GA computational technique offers several advantages over the traditional methods. First, unlike various traditional gradient based formulations, the present method does not require the calculation of the Jacobian and/or the Hessian matrices or the various sensitivity parameters of the system. Second, unlike the traditional methods in which various penalty functions or Lagrangian multiplier procedures are used to impose the required constraints such as the internal structure flaws' sizes, location ranges etc., treatments for these constraints are much simpler in the GA. Finally, because the GA performs the solution search globally, the problem of local minimum in traditional gradient based analytical search methods is mitigated [5].

In this research, in order to find the solution to the problem of inverse detection of flaw in the railway track (loose of sleeper support due to uneven settlement), the following procedure have been implemented: 1) Identification of the response of structure (e.g. deflection) with true damage parameters at the sampling