The Research on System Reliability in Complex External Conditions Based on SVM

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Abstract. Analysis method based on support vector machine and finite element combined with Monte Carlo is applied for the parts in complex external conditions or surroundings, it is difficult to built reliability model of the parts in complex the external conditions or surroundings and it is difficult to establish stress and intention distribution and joint probability density because they work in an uncertain environment, the support vector machine has a good generalization ability prediction ability, integration algorithm based on support vector machine, finite element and Monte Carlo can solve the questions and can excellently use for reliability simulation and calculation for complex and certain system. It is used for reliability analysis of catenary parts in the high-speed electrified railway, integration algorithm mathematic model of reliability analysis for location hook is built, and the outside parameter influence on wrist-arm of location hook is analyzed by the model.

Keywords: Integration algorithm, support vector machine, location hook, complex the external conditions or surroundings, Reliability analysis, catenary.

1 Introduction

Catenary system works in complex external conditions or surroundings, and the fault in the high-speed electrified railway mainly results from catenary system, and the fault mainly caused by its low reliability. The reliability analysis of critical force-bearing parts of catenary system is an important task in catenary design [1].

Analysis method based on support vector machine and finite element combined with Monte Carlo is applied for force-bearing parts of catenary system in complex external conditions or surroundings, it is difficult to built reliability model of the parts in complex the external conditions or surroundings and it is difficult to establish stress and intention distribution and joint probability density because they work in an uncertain environment, the support vector machine has a good generalization ability prediction ability, integration algorithm based on support vector machine, finite element and Monte Carlo can solve the questions and can excellently use for reliability simulation and calculation for complex and certain system. An example are given for reliability analysis of location hook in this paper, integration algorithm mathematic model of reliability analysis is built, and the outside parameter influence on wrist-arm of location hook is analyzed by the model.
2 Integration Algorithm Mathemation Model of Reliability Analysis

2.1 Stress-Intention Interference Model

Every component of mechanism part may be invalid because of all kinds of complex static loads and dynamic loads lead to internal stress exceeding material intensity limit, the failure probability can be obtained by (1) according to stress-intention interference theory [2-4].

\[ P_f = P(\delta - S \leq 0) = \iint_D f_\delta(\delta, s) d\delta ds. \] (1)

Where \( \delta = X_{\alpha}, X_{\beta}, X_{\gamma}, \ldots, X_{\delta} \), \( S = X_{\mu}, X_{\nu}, X_{\xi}, \ldots, X_{\eta} \). \( f_\delta(\delta, s) \) is stress and intention joint probability density of every component, \( X_{\alpha} \) is structural intention, \( X_{\eta} \) is stress.

If \( X = (X_1, X_2, \ldots, X_n)^T \) is random parameters vector, then state function is expressed as:

\[ g(X) = \delta(X) - S(X). \] (2)

The components will invalidate if \( g(X) \leq 0 \) according to (2) and probability and statistics theory, failure probability and reliability can be calculated in a certain amount of random numbers \( \delta \) and \( S \).

2.2 Reliability Simulation Step of Integration Algorithm

Reliability simulation step of Integration algorithm is as follows [3-4]. At first, Critical factors that influence the reliability of the parts are established.

Then \( N \) groups of random data are generated according to statistical distribution for the selected parameters, maximum stress in the dangerous section for each group of parameters are calculated by the finite element [5]. After selecting the fragment structure unit, characteristic analysis of typical unit is necessary, the relationship of any point displacement is derived by nodal displacements.

\[ \{w\} = [N]\{u\}^{(e)} \] (3)

Where \( \{w\} \) is column vector of any point displacement in the unit, \( \{u\}^{(e)} \) is column vector of nodal displacement, \([N]\) is shape function matrix. The relationship of unit strain and unit stress and unit balance equation are obtained by equation (3).

\[ \{\varepsilon\} = [B]\{u\}^{(e)}. \] (4)

\[ \{\sigma\} = [D][B]\{u\}^{(e)}. \] (5)

\[ \{P\}^{(E)} = [k]^{(e)}\{u\}^{(e)}. \] (6)