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System reliability analysis of slopes using least squares support vector machines with particle swarm optimization

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Abstract

This paper presents an intelligent response surface method for evaluating system failure probability of soil slopes based on least squares support vector machines (LSSVM) and particle swarm optimization. A novel machine learning technique LSSVM is adopted to establish the response surface to approximate the limit state function based on the samples generated by computer experiments. Subsequently, the proposed response surface is utilized in conjunction with Monte Carlo simulation to obtain the desired reliability estimation. The hyper-parameters which are crucial to the performance of LSSVM are selected by a swarm intelligence algorithm called particle swarm optimization. Experimental results on three examples show that the proposed system reliability analysis method is promising for soil slopes with obvious system effects.

Keywords: slope stability; system probabilistic analysis; LSSVM; particle swarm optimization; response surface

1. Introduction

The factor of safety used in conventional slope stability evaluation is not able to consider the degree of uncertainty associated with soil properties. Probabilistic methods provide effective ways to reflect the uncertainties in slope stability evaluation [1]. In the recent years, numerous studies have been conducted to develop methods for reliability evaluation of slopes [2-5]. A slope can have many different failure slip surfaces [3], and the obtained failure probability of any single slip surface will be smaller than that for the system that comprises all the potential slip surfaces [6,7]. The slope reliability problem had better be solved in the framework of system reliability [8].

Some studies have dedicated to developing slope reliability analysis methods considering system effects. At the beginning, reliability-bounds theories [2,3,6,7,9] were adopted to predict the upper and lower bound values of the system failure probability. Then some approaches are also presented to get a

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