Chapter 5
Utilization of Classification Techniques for the Determination of Liquefaction Susceptibility of Soils

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ABSTRACT

The determination of liquefaction susceptibility of soil is a paramount project in geotechnical earthquake engineering. This chapter adopts Support Vector Machine (SVM), Relevance Vector Machine (RVM) and Least Square Support Vector Machine (LSSVM) for determination of liquefaction susceptibility based on Cone Penetration Test (CPT) from Chi-Chi earthquake. Input variables of SVM, RVM and LSSVM are Cone Resistance (qc) and Peak Ground Acceleration (amax/g). SVM, RVM and LSSVM have been used as classification tools. The developed SVM, RVM and LSSVM give equations for determination of liquefaction susceptibility of soil. The comparison between the developed models has been carried out. The results show that SVM, RVM and LSSVM are the robust models for determination of liquefaction susceptibility of soil.

INTRODUCTION

Liquefaction and its upshots are the major crisis dealing by the geotechnical engineers. Liquefaction is the observable fact in which the stiffness and the strength of the soil gets reduced rapidly most commonly on ground shaking during earthquake. The shear wave produced by earthquake makes the loose sand

to contract which tends in increasing the pore pressure, which in turn triggers the soil liquefaction. In the liquefied soil the effective confining stress becomes zero, automatically the strength of the soil will be zero. This clears that the liquefied soil cannot support the weight of the structure above it. Precisely, we can say the prime factors which influences the liquefaction initiation is excess pore pressure, shear strength and strain of the soil. Flow liquefaction and cyclic mobility are its varieties. Moreover, flow liquefaction occurs when the static shear stress becomes greater than shear strength of the liquefied soil, whereas for cyclic mobility static shear stress becomes lesser than shear strength. Hence, in the event of providing a quick fix for the issue on determining the liquefaction susceptibility of soil, this study has been engaged.

The Static Cone Penetration Test (SCPT) is one of the most fair and familiar in-situ tests for exploring the geotechnical properties of the soil. Furthermore, the efficiency of the SCPT is very impressive in site characterization too. The (SCPT) had been performed as per IS: 4968 Part III. The test comprises of driving a cone assembly basically consisting of a steel cone with 60 degrees apex angle and a base diameter of 35.7mm giving a cross sectional area of about $10cm^2$ and an independent cylindrical friction jacket of a slightly larger diameter than that of the cone and length 10cm giving a surface area of about $115cm^2$. The test is conducted at depth intervals of 10cm. At each depth first the cone alone and subsequently the cone and friction jacket combined are pushed into the ground via sounding rods and the corresponding loads required for penetration are recorded. In this process the cone assembly gets extended out fully. Thereafter, for conducting the test at the next depth, the cone assembly has to close up to the initial state which is achieved by pushing the mantle tube till the cone reaches the next intended depth of test. The above procedure is then repeated at the next depth and so on. In this manner, a continuous penetration of the cone assembly into the ground is achieved. The obtained cone resistance from the performed SCPT will be entertained as input for developing the models. The SCPT test has been carried out and the soil properties are driven out. Those properties of the soil will be segregated according to the requirement and it will sail as the input along with the techniques which will be described in the further section.

SVM is one of the pioneer method developed by Vapnik (1995) based on statistical learning theory. The function can be either classification or regression function. SVM uses the nonlinear mapping to transform the original training data into a higher dimension. It seeks out for the best separating hyperplane which is called as the optimal hyperplane that separates the tuples from one class to the other optimally. The support vectors are those which lie on the hyperplane. SVM has its own ability to model complex nonlinear decision boundaries with high accuracy, however it can be slow. It is much less prone to overfitting than other methods. The target values of SVM are -1 and +1.The distance from the hyperplane to the closest data points is margin. In order to maximize the margin for good generalization, kernel function and Lagrange mulitpliers were used. The radial basis function acts as the kernel function. In SVM, the target function tries to acquire minimal error on the training set and also attempt to maximize the margin simultaneously, which leads to avoid overfitting. This mechanism tends to the good generalization of support vectors.

The RVM was developed by Tipping (2000) based on the Bayesian theorem in a simple manner. RVM has its unique advantages; however it is the functional form of SVM. The Bayesian framework along with some basis functions of SVM offers the additional merits. It has the package of profits like probabilistic predictions, noise estimation, and utilization of arbitrary functions and so on. The RVM adopts the Gauissian prior with a distinct parameter. For generalization the logistic sigmoid function adopts the Bernoulli distribution. The optimal parameters are then derived. In RVM the target values assigned are 0 and +1. The important note is that there is no noise variance in RVM.

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