Application of Bayesian model class selection on differential problems in geotechnical engineering

by

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Abstract

APPLICATION OF BAYESIAN MODEL CLASS SELECTION ON DIFFERENTIAL PROBLEMS IN GEOTECHNICAL ENGINEERING

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Researches on nonlinear behavior of soil are significant since many studies in civil engineering rest on it. Derivative calculation on nonlinear behavior is frequently encountered in soil mechanics such as the evaluation of dilatancy and shear modulus from the strain-stress behavior of geomaterials. Experimental data are acquired in discrete form and contaminated by noise so direct finite difference calculation is well known to be unreliable. In this thesis, a Bayesian nonparametric methodology is proposed for derivative computation. The raw data will first be transformed to satisfy some periodicity conditions in order to avoid the error induced by the Gibbs phenomenon. Model class candidates are then constructed based on partial Fourier series. Bayesian inference provides the quantitative criterion to choose the most suitable model for curving fitting. The derivative can be computed directly by differentiating the chosen model. Especially to poor quality measurements with large noises and non-uniform intervals, the proposed approach can provide satisfying data-fitting results and derivative computation.

The proposed method is applied on three examples in this thesis. Two illustrative examples are discussed to verify the efficiency and robustness of the methodology. One set of data coming from pressuremeter tests are processed in order to obtain the shear stress-strain relationship and secant shear modulus reduction curves which are the main aims herein. Only the first order derivatives are involved in this thesis.

Key words:

Bayesian inference; Fourier series; model class selection; numerical differentiation; shear stress-cavity strain relationship; normalized modulus reduction curves

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$\sigma_i (i = 1, 2, 3)$ principal stresses

T torque

θ twist angle

G secant shear modulus

l length of the sample

r radius of the sample

τ_o shear stress of the outer radius of the hollow sample

τ_i shear stress of the inner radius of the hollow sample

r_o outer radius of the hollow sample

r_i inner radius of the hollow sample

p applied pressure

ε_c measured cavity strain

τ shear stress

D dilatancy

ε_v volumetric strain

γ shear strain

ε_v^p plastic volumetric strain

ε_q^p plastic deviatoric strain

H system function

ω frequency

ω_c cut-off frequency

ε strain

σ stress

E Young's modulus

ODE ordinary differential equation

PDE partial differential equation

RMSE root-mean-squares error

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