Modelling Subsurface Stratigraphy within the Taipei Basin using Markov Random Field Theory

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Abstract

It is estimated that around 80% of problems discovered on construction projects are attributable to unexpected ground conditions, which is a result of uncertainty in geological models. The use of random field modelling could help quantify uncertainty in geological models, and therefore ground investigations as well, by modelling the stratigraphic boundaries in subsurface stratigraphy. The random field modelling in this research will use Markov random field theory, which in general terms is a graphical model of a joint probability distribution. The first step for producing the model is to input site investigation data, including elevation, distance between boreholes, soil type, and strata orientation. This information is discretised and used to construct a neighbourhood system for the simulation. The spatial correlation in the local neighbourhood system is divided into two components: ψ (orientation information of geological formations) and a (ratio of the strength of tangential correlation and normal correlation). During the simulation stage, known data from the boreholes are used to predict the lithology across the whole domain. The boreholes used for modelling are divided into conditional and observational boreholes. The conditional boreholes are used during the simulation, while the observation boreholes not simulated and are used to calibrate the 'a' value by using the maximum likelihood principle. After this, the uncertainty of the predicted lithological profile is assessed by the information entropy. The preliminary results show that an 'a' value of 120 will generate the most accurate result for modelling the north-south section chosen within the Taipei basin for this study. Furthermore, the spatial parameters have a direct effect on the information entropy within the geological model.

Keywords: Geological modelling, Markov random field, Stratigraphic uncertainty, Spatial correlation