TC304/TC309 Student Contest on Spatial Data Analysis Applied to 304dB

(September 22 2019, Hannover, Germany)

Question:

Robertson (2016) proposed the use of "Soil Behaviour Type" (SBT) index, denoted by I_c, for the purpose of cone penetration test (CPT)-based soil classification. This paper is open access and can be downloaded: http://www.nrcresearchpress.com/doi/pdf/10.1139/cgj-2016-0044

Robertson and Wride (1998) proposed the following Soil Behaviour Type (SBT) index classification:

Table 1. SBT index classification proposed by Robertson and Wride (1998)

Soil behavior type index, I_c	Classification	Soil behavior type
$I_c < 1.31$	SBT7	Gravelly sand
$1.31 \le I_c < 2.05$	SBT6	Sands – clean sand to silty sand
$2.05 \le I_c < 2.60$	SBT5	Sand mixture – silty sand to sandy silt
$2.60 \le I_c < 2.95$	SBT4	Silt mixture – clayey silt to silty clay
$2.95 \le I_c < 3.60$	SBT3	Clays
$I_c \ge 3.60$	SBT2	Organic soils – peat

The task of this Student Contest is to conduct underground stratification based on CPT profiles, such as I_c profiles (I_c versus z data, where z stands for depth). Please download the following datasets:

1. Training dataset: Figure 1 (download); I_c data in Column Q.
2. Testing datasets: Figure 2 (a), (b), and (c) (download); I_c data in Column Q.

In the datasets, the original CPT data (e.g., cone resistance q_t & sleeve friction f_s) are provided. The I_c values in the datasets are computed by Eq. (4) in Robertson (2016) by letting $Q_t = Q_{tn}$, and Q_{tn} is computed based on Eq. (5). An upper bound of 1.7 (Idriss and Boulanger 2008) is used for the stress normalization factor $(p_a/\sigma'_{vo})^n$ in Eq. (5).

Please develop an algorithm that can automatically run in your computer (e.g., a matlab code) for the purpose of underground stratification. The input to the algorithm is the CPT profile (e.g., I_c versus z data; one example is in Figure 1a). Feel free to choose the input. It can be I_c versus z data, or it can be q_t versus z + f_s versus z data. The output is the stratification result (e.g., Figure 1b). Feel free to choose the stratification classification system. You can choose the SBT system in Table 1 above, or you can invent a reasonable classification system.

There are two criteria to verify the effectiveness of the algorithm:

1. For the training dataset, the algorithm must produce a "reasonable" stratification result.
   For instance, Figure 1a shows the I_c profile of the training dataset, and Figure 1b shows one possible reasonable stratification result. The stratification result in Figure 1b is reasonable because it captures the main I_c variation, while it does not produce noisy thin layers (e.g., I_c profile from 26 to 31 m varies drastically, yet only a single layer SBT3 is identified). Some thin layers seem real (e.g., the SBT3 thin layer near the depth of 32.5 m). It is reasonable to have those thin layers identified.
   Note that the direct use of the I_c-SBT mapping in Table 1 may not produce reasonable results. Figure 1c shows the stratification result if the I_c-SBT mapping is directly used. Let us take 0 to 2.1 m as an example. From 0 to 2 m, the soil layer is classified as SBT6. The small bump in I_c near 2.1 m (see Figure

1a) slightly exceeds 2.05 (I_c = 2.05 is the threshold between SBT5 and SBT6), so a very thin SBT5 layer is identified near 2.1 m in Figure 1c. In general, Figure 1c contains noisy thin layers, and those thin layers may not be reasonable.

With the training dataset in Figure 1a, you can fine tune your algorithm so that it performs as reasonably as Figure 1b. Performance such as Figure 1c should be avoided.

2. For the testing datasets, the same algorithm must also produce reasonable stratification results. Figure 2 below shows the I_c profiles of the testing datasets. Whether or not the results are reasonable is judged based on the comparison with the results from the stratification algorithms previously developed by reputed scholars.

Students are encouraged to read the following references to understand the challenge of this Student Contests. These references are meant to provide a flavour of the question and challenge. Students are not expected to apply the techniques in the papers.

Wickremesinghe, D.S. and Campanella, R.G. (1991). Statistical methods for soil layer boundary location using the cone penetration test. Proceedings of the 6th International Conference on Applications of Statistics and Probability in Civil Engineering (ICASP 6), Mexico City, 636-643.

Zhang, Z. and Tumay, M.T. (1999). Statistical to fuzzy approach toward CPT soil classification. ASCE Journal of Geotechnical and Geoenvironmental Engineering, 125(3), 179-186.

Hegazy, Y.A. and Mayne, P.W. (2002). Objective site characterization using clustering of piezocone data. ASCE Journal of Geotechnical and Geoenvironmental Engineering, 128(12), 986-996.

Facciorusso, J. and Uzielli, M. (2004). Stratigraphic profiling by cluster analysis and fuzzy soil classification. Proceedings of the 2nd International Conference on Geotechnical Site Characterization ISC-2, Porto.

Liao, T. and P.W. Mayne (2007). Stratigraphic delineation by three-dimensional clustering of piezocone data. Georisk: Assessment and Management of Risk for Engineered Systems and Geohazards, 1(2), 102-119.

Jung, B.-C., Gardoni, P., and Biscontin, G. (2008). Probabilistic soil identification based on cone penetration tests. Géotechnique, 58(7), 591-603.

Wang, Y., Huang, K., and Cao, Z. (2013). Probabilistic identification of underground soil stratification using cone penetration tests. Canadian Geotechnical Journal, 50, 766-776.

Ching, J., Wang, J.S., Juang, C.H., and Ku, C.S. (2015). CPT-based stratigraphic profiling using the wavelet transform modulus maxima, Canadian Geotechnical Journal, 52(12), 1993-2007.

Wang, X., Wang, H, Liang, R.Y., and Liu, Y. (2019). A semi-supervised clustering-based approach for stratification identification using borehole and cone penetration test data. Engineering Geology, 248, 102-116.

Cao, Z.J., Zheng, S., Li, D.Q., and Phoon, K.K. (2019). Bayesian identification of soil stratigraphy based on soil behaviour type index. Canadian Geotechnical journal, in press. https://doi.org/10.1139/cgj-2017-0714

Other information

The participants in the TC304 Student Contest session are required to: (1) Submit a full length paper (it will not be formally published) in English. Academic staffs (e.g., professors) cannot be listed as co-authors, although they can be mentioned in acknowledgements; and (2) present the research findings during the session (10 minutes presentation plus 5 minutes Q&A).

TC304 Engineering Practice of Risk Assessment & Management, ISSMGE
TC309 Machine Learning & Big Data, ISSMGE

A TC304 award committee will review the papers/presentations and select the winner of the ISSMGE TC304 Student Contest Award. An award certificate will be given to the winner during the conference. Depending on the number of participants, several encouragement awards may be given as well.

Important dates

August 15 2019: Submission of full length paper
September 22 2019: TC304 Student Contest

Acknowledgements

We would like to thank Prof. CS Ku in I-Shou University, Taiwan, for providing the CPT data.

References

Idriss, I. M. and Boulanger, R. W. (2008). Soil liquefaction during earthquakes. Monograph MNO-12, Earthquake Engineering Research Institute, Oakland, CA.

Robertson, P.K. and Wride, C.E. (1998). Evaluating cyclic liquefaction potential using the cone penetration test. Canadian Geotechnical Journal, 35, 442-459.

Robertson, P.K. (2016). Cone penetration test (CPT)-based soil behaviour type (SBT) classification system — an update. Canadian Geotechnical Journal, 53, 1910-1927.

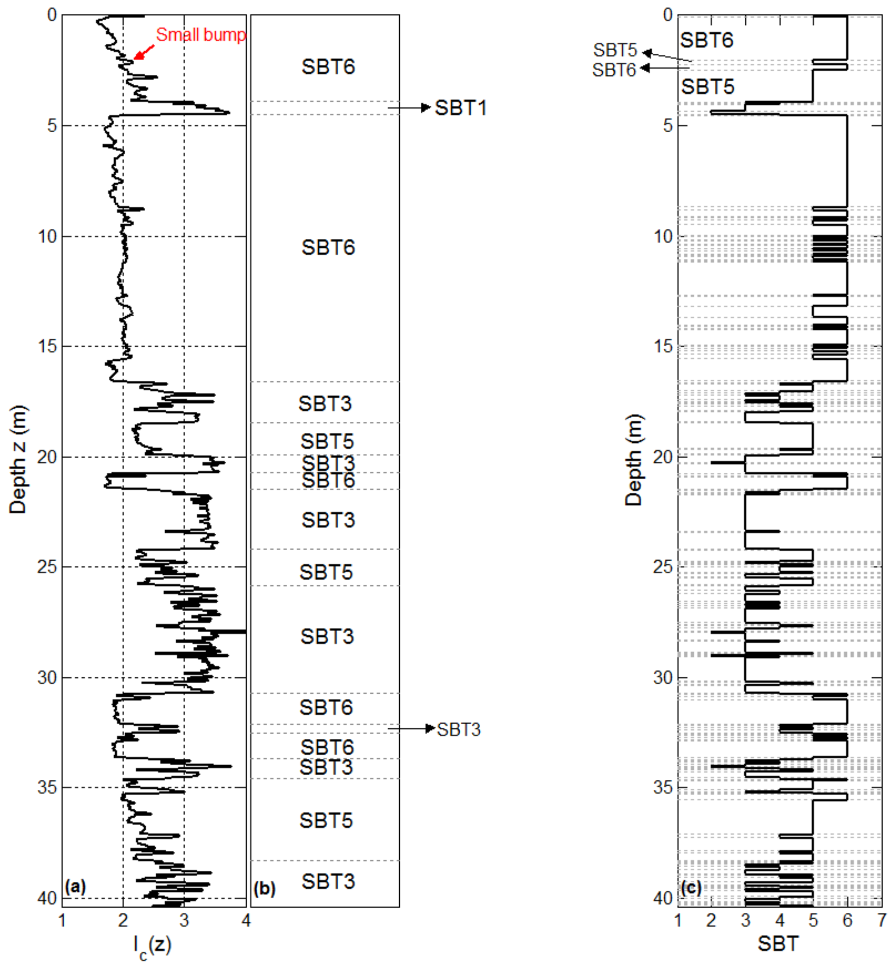

Figure 1 (a) Training dataset; (b) one possible reasonable stratification result; (c) stratification result by directly using the mapping in Table 1.

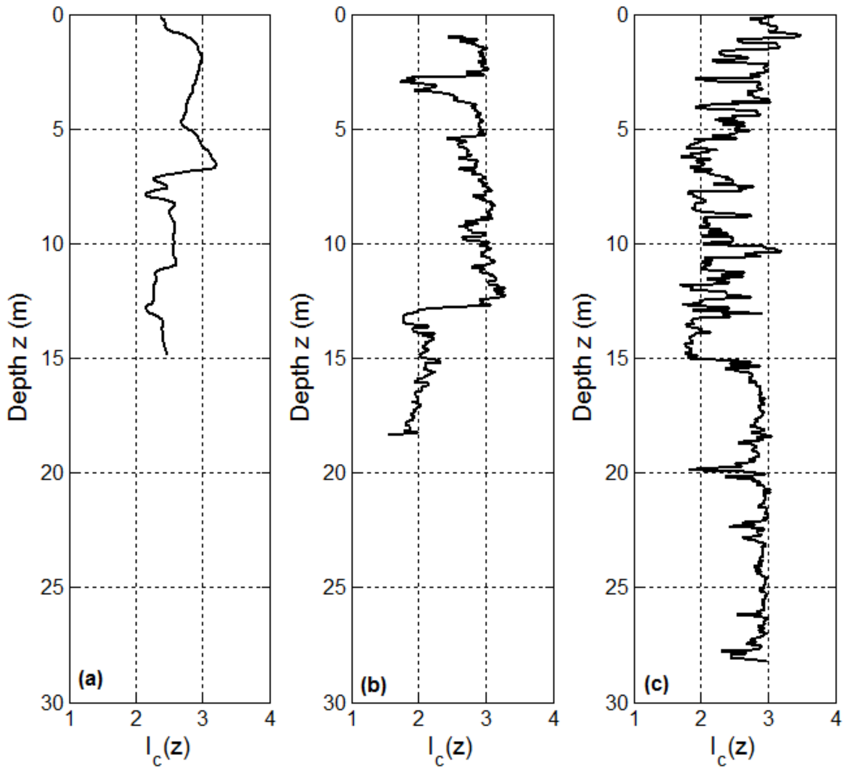

Figure 2 (a) Testing dataset #1; (b) testing dataset #2; (c) testing dataset #3.