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# Data-driven approach to modelling bearing behaviors of OWT foundations

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# Background

- Uncertainties of soil parameters have great effects on the behaviors of OWT foundations
- Sources of uncertainties: Lack of uniformity between in-situ test and laboratory experiment; spatial variability of soil profile, rationality of the constitutive model...
- Traditional statistical analysis is based on Monte Carlo, which is time-consuming and laborious.

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# Background-Uncertainties

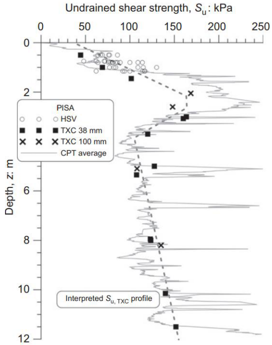


Figure 1: Untrained strength profile at Cowden[1]

In this soil profile, we can see that:

- Fluctuating curve indicates the spatial variability
- Non-uniformity between in-situ test and laboratory experiment

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# Background-Probability

- Back-analysis based on Monte Carlo is time consuming (controlling soil parameters can vary from 2 to 14)
- Bayesian inference is the basic mathematical tool for quantifying this uncertainty

$$P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)} \tag{1}$$

$P(A|B)$: posterior;$P(B|A)$:likelihood; $P(A)$: prior

- Challenge: How to get the best possible soil parameters, based on the given priors, while avoiding extreme FE Monte Carlo calculations.

# Methods-Markov Chain

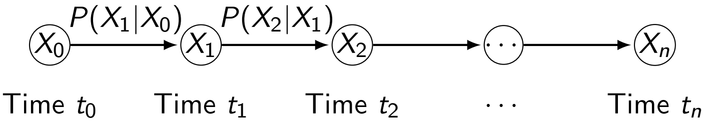



Figure 2: Markov Chain process

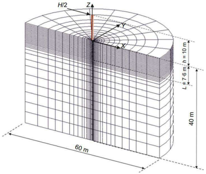
Why Markov chain?

- The state transition of Markov chains depends only on the current state, not on the past state
- Bayesian inference based on Markov chain can fully utilize the FE results and greatly reduce the number of Monte Carlo FE analysis time

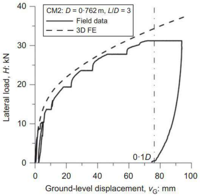
# Example on Markov Chain-FE simulation

| Parameters |
|---|
| $X = 0{\cdot}548,\ Y = 0{\cdot}698,\ Z = 0{\cdot}100$ |
| $\alpha = 0{\cdot}25,\ n = 0{\cdot}40$ |
| $\beta = 0{\cdot}20,\ m = 1{\cdot}00$ |
| $v_1 = 2{\cdot}20,\ \lambda = 0{\cdot}115$<br>$\kappa = 0{\cdot}021$<br>$G_0^* = 110\,\mathrm{MPa},\ p'_{\mathrm{ref}} = 100{\cdot}0\,\mathrm{kPa}$ |
| $a = 9{\cdot}78 \times 10^{-5},\ b = 0{\cdot}987,\ R_{\mathrm{G,min}} = 0{\cdot}05$ |

a Soil parameters




b FE simulation




c Field results

# Aims:Calibration + assimilation + prediction

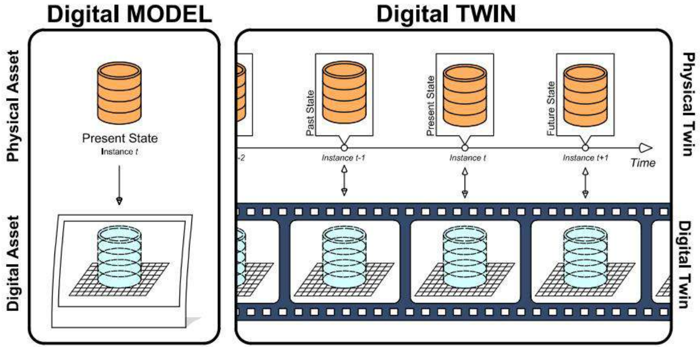



Figure 3: Digital Twin [2]

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# Reference


[1] Lidija Zdravković et al. “Ground characterisation for PISA pile testing and analysis”. In: *Géotechnique* 70.11 (2020), pp. 945–960.

[2] Mattia Francesco Bado et al. “Digital twin for civil engineering systems: an exploratory review for distributed sensing updating”. In: *Sensors* 22.9 (2022), p. 3168.