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# Variational Autoencoder-boosted physics-based ROM for the treatment of parametric dependencies in nonlinear problems

**Konstantinos Vlachas[1], Thomas Simpson [1], Anthony Garland [2], Carianne Martinez [2] and Eleni Chatzi [1]**

[1] ETH Zurich, Stefano-Franscini-Platz-5, 8093, Zurich, Switzerland,
chatzi@ibk.baug.ethz.ch, https://chatzi.ibk.ethz.ch/
[2] Sandia National Laboratories, Albuquerque, New Mexico, agarlan@sandia.gov

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Physics-based Reduced Order Models (ROMs) can be used as surrogates of dynamical systems via use of projection-based reduction that relies on the Proper Orthogonal Decomposition (POD) or similar approaches. However, deriving physics-based ROMs for nonlinear problems with parametric dependencies requires additional treatment, mainly due to the linear nature of the respective operators [1]. This is typically addressed via the use of local reduction bases, and thus local ROMs [2]. Such approaches assemble a pool of projection bases to inject parametric traits or address localized phenomena, and, when needed, they select the suitable subspace via clustering or interpolation strategies.

Our work explores the potential of employing Variational Autoencoders (VAEs) to perform a more accurate mapping of the parametrized subspaces, in place of the utilized clustering or interpolation. The derived ROM still relies on projection bases from response data, thus retaining the imprinted physical connotation. However, it additionally formulates a matrix of coefficients that relates the local sample dynamics to the global phenomena and applies a VAE scheme to approximate those coefficients for any input state. This attempts to define a more appropriate, nonlinear approach to approximating the respective subspaces, leading to more accurate and generalized approximations. The proposed pROM is evaluated in a published benchmark example featuring a shear frame with hysteretic links under stochastic ground motion [3].

## REFERENCES

[1] S. Fresca, and A. Manzoni, POD-DL-ROM: enhancing deep learning-based reduced order models for nonlinear parametrized PDEs by proper orthogonal decomposition. *arXiv:2101.11845*, 2021.

[2] K. Agathos, K. Tatsis, K. Vlachas and E. Chatzi, Parametric reduced order models for output-only vibration-based crack detection in shell structures. *Mechanical Systems and Signal Processing*, Vol. **162**, pp. 108051, 2022.

[3] K. Vlachas, K. Tatsis, K. Agathos, A.R. Brink and E Chatzi, Two-story frame with Bouc-Wen hysteretic links as a multi-degree of freedom nonlinear response simulator, $5^{th}$ *edition of Workshop on Nonlinear System Identification Benchmarks*, 2021