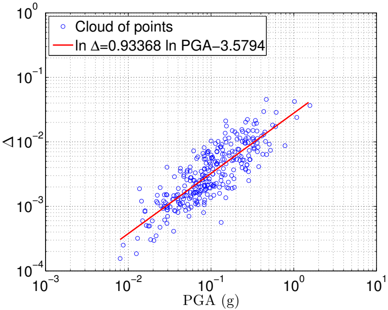
Stochastic ground motion

Parameters of the excitation

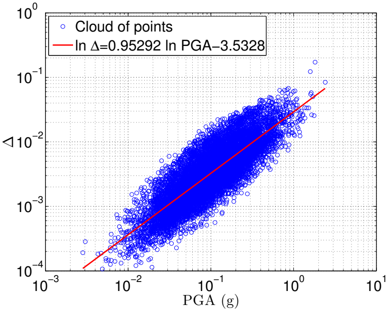
Parameter	Distribution	Support	Mean	Standard deviation
I_a (s.g)	Lognormal	$(0, +\infty)$	0.0468	0.164
D_{5-95} (s)	Beta	[5, 45]	17.3	9.31
t_{mid} (s)	Beta	[0.5, 40]	12.4	7.44
$\omega_{mid}/2\pi$ (Hz)	Gamma	$(0, +\infty)$	5.87	3.11
$\omega'/2\pi$ (Hz)	Two-sided exponential	[-2, 0.5]	-0.089	0.185
ζ_f (.)	Beta	[0.02, 1]	0.213	0.143

Training and validation data

- Reference solution: Monte Carlo sampling of 10,000 non linear transient analyses
- PC-NARX: 300 samples



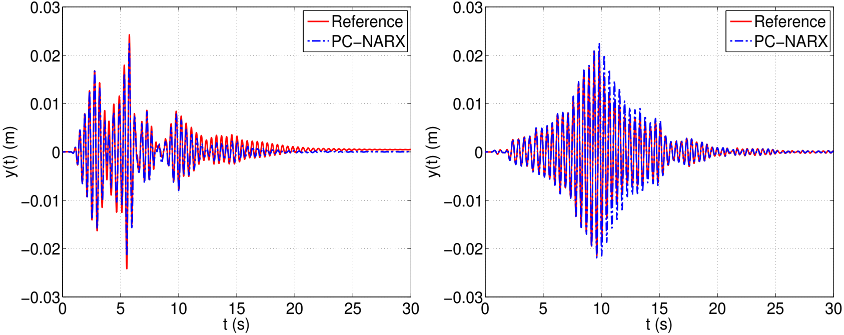
300 simulations (training PC-NARX)



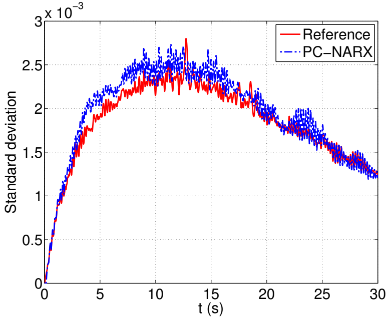
10,000 simulations

Two trajectories (first floor displacement)

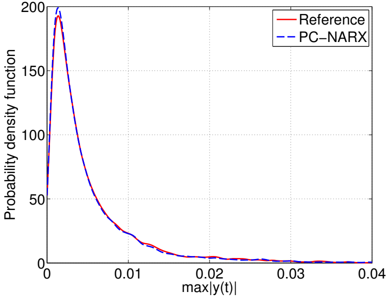
- Reference solution: Monte Carlo sampling of 10,000 non linear transient analyses
- PC-NARX: 300 samples



Statistics of the first floor drift



Standard deviation

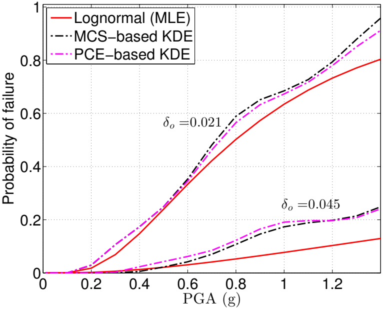


PDF of max. drift

Fragility curve – maximal drift

- Reference solution: Monte Carlo sampling of 10,000 non linear transient analyses
- PC-NARX: 300 samples

Fragility curves

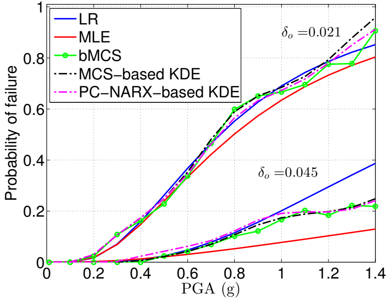


Kernel density estimation

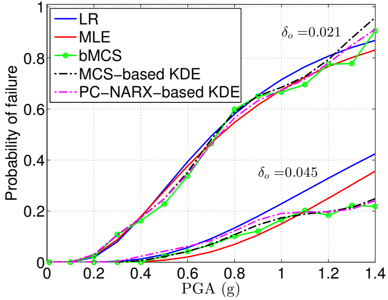
Fragility curve – maximal drift

- Reference solution: Monte Carlo sampling of 10,000 non linear transient analyses
- PC-NARX: 300 samples

Fragility curves



Using 300 points



Using 10,000 points

Conclusions

- Polynomial chaos expansions are facing challenging issues when modelling time-dependent systems such as arising in structural dynamics
- A non-intrusive approach based on NARX models (from structural identification) and sparse PCE is proposed
- The accuracy is remarkable on the statistical moments (mean/std. deviation), PDF of the maximum output, but also on particular trajectories
- The method was successfully used for computing fragility curves in earthquake engineering applications

Questions ?

Chair of Risk, Safety & Uncertainty Quantification

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Thank you very much for your attention !

References

M Shinozuka, M Feng, J Lee, and T Naganuma.
Statistical analysis of fragility curves.
J. Eng. Mech., 126(12):1224–1231, 2000.

B. Ellingwood.
Earthquake risk assessment of building structures.
Reliab. Eng. Sys. Safety, 74(3):251–262, 2001.

S. Rezaeian and A. Der Kiureghian.
Simulation of synthetic ground motions for specified earthquake and site characteristics.
Earthq. Eng. Struct. Dyn., 39(10):1155–1180, 2010.

C. V. Mai.
Polynomial chaos expansions for uncertain dynamical systems – Applications in earthquake engineering.
PhD thesis, ETH Zürich, Switzerland, 2016.

C.-V. Mai, M. D. Spiridonakos, E.N. Chatzi, and B. Sudret.
Surrogate modeling for stochastic dynamical systems by combining nonlinear autoregressive with exogeneous input models and polynomial chaos expansions.
Int. J. Uncer. Quant., 6(4):313–339, 2016.

C.-V. Mai, K. Konakli, and B. Sudret.
Seismic fragility curves for structures using non-parametric representations.
Frontiers Struct. Civ. Eng., 11(2):169–186, 2017.