HDM
HRVATSKO DRUŠTVO ZA MEHANIKU
ZAGREB - OSIJEK - RIJEKA - SL. BROD - SPLIT

**Predavanje u HDMu:**

# Computational Structural Mechanics: Natural Intelligence Vs. Artificial Intelligence

**Professor Adnan IBRAHIMBEGOVIĆ**

(University of Technology Compiègne - Alliance Sorbonne University, Institut Universitaire de France, The Academy of Europe)

## ABSTRACT

In this work we show that the structural engineering models are very helpful in constructing an accessible basis to experts in different domains of engineering science in order to build best microscale representation (as replacement of atomistic models) in multi-scale models for various multi-physics phenomena. That was the first motivation for this work. The second motivation comes from the intent to preserve the knowledge accumulated by long-term efforts of experts in structural mechanics (with many of them retired, or gone), and provide a priori selection of reduced model by means of corresponding kinematic hypotheses and constraints that reduce the cost compared to solid or continuum mechanics approach (e.g. see [1, 2]). Such an approach is opposite of the currently active research on constructing such reduced model in a posteriori fashion, by using the statistical approach of data processing to provide the reduced model in terms of Proper Orthogonal Decomposition (POD) or Proper Generalized Decomposition (PGD), which seems to reduce the model construction skills to the application of artificial intelligence algorithms. I firmly believe that the knowledge of alternative methods with natural intelligence of engineers should also be brought to bear upon any completely successful solution to complex engineering problems, and that either approach should be tried in seeking such optimal results. In fact, I would like to illustrate with this work perhaps the best possible manner to combine the expertise in structural engineering with artificial intelligence skills. Namely, for models construction in terms of the best choice of hypotheses for given goal, one should have the expertise in structural engineering, and for models selection in terms of validation and verification, one should also include the adequate stochastic tools with statistical methods and probability.

The illustrations of these ideas come from current applications in multiscale modeling and probability computations. We provide only a brief presentation of the useful synergy between the nonlinear mechanics and stochastic that can be used not only to build the model of interest for dealing with real-life heterogeneous structures, but also to develop solution procedures that reach way beyond traditional engineering tools. More details can be found in our recent works [3,4,5,6] and forth-coming book [7].

**References**

[1] A. Ibrahimbegovic, Nonlinear solid mechanics: theoretical formulations and finite element solution methods, Springer, 2009.

[2] A. Ibrahimbegovic, Computational Methods for Solids and Fluids: Multiscale Analysis, Probability Aspects and Model Reduction, Springer 2016.

[3] A. Ibrahimbegovic, Matthies, H.G., Karavelic, E., Reduced model of macro-scale stochastic plasticity identification by Bayesian inference in application to quasi-brittle failure of concrete, Computer Methods in Applied Mechanics and Engineering, 372, 113428, 2020.

[4] A. Ibrahimbegovic, Mejia-Nava R.-A., Heterogeneities and material-scales providing physically-based damping to replace Rayleigh damping for any structure size, Coupled Systems Mechanics, 10, 201-216, 2021.

[5] A. Ibrahimbegovic, Mejia-Nava, R.A., Hajdo, E., Limnios N., Instability of (heterogeneous) Euler beam: Deterministic vs. stochastic reduced model approach, Coupled Systems Mechanics, 11, 167-198, 2022.

[6] A. Ibrahimbegovic, Matthies, H.G., Dobrilla, S., Karavelic, E., Mejia Nava, R.A., Nguyen, C.U., Sarfaraz, M.S., Stanic, A., Vondrejc, J., Synergy of stochastics and inelasticity at multiple scales: Novel Bayesian applicationsin stochastic upscaling and fracture size and scale effects, SNAS Springer Nature Applied Science, 3, 1-35, 2022.

[7] A. Ibrahimbegovic, Mejia-Nava, R.A., Structural Engineering: Models and Methods for Statics, Instability and Inelasticity, Springer, 2023.