Translational AI Center (TrAC) Seminar
Fall 2023

Yuri Bazilevs

August 25 at 12:00 noon (US Central Time)
Iowa State University, Ames, IA
2004 Black Engineering

DDDAS for Systems Analytics in the Mechanics of Solids, Structures and FSI

Abstract

We will begin the presentation by providing an overview of the Dynamic Data-Driven Application Systems (DDDAS) concept, with a particular emphasis on the analytics of systems coming from the field of Applied Mechanics and focusing on the applications in Aerospace Structures. The main goal of DDDAS in this context is to provide a framework where the dynamic measurement data for a given system forms a symbiotic relationship with the advanced, geometrically complex, multi-physics model of that system to reliably predict its future behavior, shield it from undesired loading scenarios that accelerate failure, and estimate its remaining useful life. It is well known that aerospace composite materials and structures exhibit a strong multiscale behavior, which necessitates the development of a multiscale DDDAS framework where measurements and models interact at all the relevant spatial and temporal scales of the system of interest to maximize the resulting predictive power. We will present a set of examples, both academic and practical, that clearly illustrate that it is precisely the combination of dynamic data and advanced models, and not exclusively one or the other, that is needed to be truly predictive.

We will shift gears and critically examine the modern data-driven approaches for systems analytics in applied mechanics. This topic, which has great relevance with DDDAS, has received significant attention in recent years. The applied mechanics community is trying to bring data science methods, such as Neural Networks (NNs), to bear on some of the key challenges, including the design of better materials and architected structures. NN-based approaches were also deployed as part of the so-called Physics Informed Neural Networks (PINNs) framework recently developed to bring more physics into predictions. PINNs accomplish this by defining an objective function that simultaneously minimizes the errors in the observed data, boundary conditions, and some form of the energy or PDE residual governing the problem at hand. A distinguishing feature of PINNs is that the discretization of a PDE does not make use of traditional methods like FEM, but rather NNs themselves. As a result, by construction, and in spirit, PINNs are yet another instantiation of the DDDAS concept that effectively blends data and physics-based models to achieve superior predictability. We will focus on the ability of approaches, incorporating NNs (as a tool) into DDDAS, to model large-deformation elastoplastic behavior of solids and structures and provide guidance for making such approaches more competitive than traditional modeling methods, so that they can be seamlessly integrated into structural systems analytics and beyond.

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Short Bio

Yuri Bazilevs is the E. Paul Sorensen Professor in the School of Engineering at Brown University, where he was the Lead and Executive Committee representative of the Mechanics of Solids and Structures group. Yuri's research interests lie in the broad field of computational science and engineering, with emphasis on the modeling and simulation in solids and structures, fluids, and their coupling in HPC environments. For his research contributions Yuri received many awards and honors, including the 2018 Walter E. Huber Research Prize from the ASCE, the 2020 Gustus L. Larson Award from the ASME, the inaugural 2021 Centennial Mid-Career Award from the Materials Division of the ASME, and the Computational Mechanics Award from the International Association for Computational Mechanics (IACM). He is included in the lists of Highly Cited Researchers, both in the Engineering (2015-2018) and Computer Science (2014-2019) categories. Yuri recently completed his service as the President of the US Association for Computational Mechanics (USACM) and as the Chairman of the Applied Mechanics Division of the ASME. He currently serves on the US National Committee for Theoretical and Applied Mechanics (USNCTAM).