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Modeling, Analysis and Simulation Community

Conference Abstracts

AI, Data Driven Models & Machine Learning:

How Will Advanced Technologies Shape Future Simulation Processes?

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Presenter Name: Ankit Agrawal

Presenter Company: Northwestern University

Presentation Title: AI-Driven Learning of the Science and Engineering of Materials from Simulations

Location: Stage 1

Presentation Date & Time (EST; New York): 2/23/2022 @ 10:00

Keywords:

Abstract:

The increasing availability of data from the first three paradigms of science (experiments, theory, and simulations), along with advances in artificial intelligence and machine learning (AI/ML) techniques has offered unprecedented opportunities for data-driven science and discovery, which is the fourth paradigm of science. Within the arena of AI/ML, deep learning (DL) has emerged as a transformative technology in recent years with its ability to effectively work on raw big data, bypassing the (otherwise crucial) manual feature engineering step traditionally required for building accurate ML models, thus enabling numerous real-world applications, such as autonomous driving. In this talk, I will present some of the ongoing AI/ML/DL research in our group to learn the forward and inverse processing-structure-property-performance (PSPP) relationships in material systems using data from a variety of simulations - such as density functional theory (DFT), finite element method (FEM), discrete dislocation dynamics (DDD), and rigorous coupled wave analysis (RCWA). We will also briefly discuss how AI models trained on simulations can be adapted for experimental data.

Presenter Name: Rani Harb

Presenter Company: Hexagon | MSC Software

Presentation Title: Hybrid Approach Combining Machine Learning and Meta-Modeling to Predict Material Behavior

Location: Stage 1

Presentation Date & Time (EST; New York): 2/23/2022 @ 10:35

Keywords: machine learning, material data, meta-modeling, digital twin, virtual material engineering

Abstract:

In today's highly competitive industrial landscape, we witness a pervasive economic pressure to constantly innovate and bring forward novel solutions at a faster rate. In the field of materials and ICME, there is a strong interconnection between manufacturing processes, environmental conditions and the underlying microstructure that drives the part performance. Understanding these connections would require exhaustive testing and trial-and-error, which are set against the current pressure to rapidly innovate and shrink development times. To this point, physical testing covering a broad spectrum of environmental scenarios and material conditions (temperature, strain rates, fiber content, additives, etc.) can be dauntingly large and impractical to cover exhaustively, leaving material suppliers and other OEMs to reluctantly accept large "voids" in the design space. As such, we propose a hybrid workflow based on data analytics, machine learning and meta-modeling in order to build and predict highly reliable virtual results for a broad spectrum of temperatures, strain rates, humidity contents, material types, etc. These results can also be used to construct material models able to predict part performance under given test conditions with requisite accuracy.

Presenter Name: Zhenyuan Gao

Presenter Company: Dassault Systemes Simulia Corp

Presentation Title: Neural Network Approaches for Plastic Material Modeling

Location: Stage 2

Presentation Date & Time (EST; New York): 2/23/2022 @ 10:35

Keywords:

Abstract:

Neural network approaches have been widely applied to constitutive modeling of elastoplastic materials, due to their ability to calibrate a large number of parameters and to approximate arbitrary mathematical equations. Some neural network approaches (e.g., recurrent neural network) can also be used to approximate history-dependent behavior. Given that material model calibration usually requires engineering expertise, neural network approaches offer an intriguing alternative. In this work, different neural network and hybrid approaches are utilized to model isotropic and anisotropic plastic materials. The feasibility to implement such methods into finite element analysis is evaluated. Focus is placed on adapting the existing methods to different material behavior and structural problems. Benchmark results show that the present models and methods can adequately predict different plasticity behavior.

Presenter Name: Thomas Von Tschammer

Presenter Company: Neural Concept Ltd.

Presentation Title: Reducing CAE Costs and Lead Time Thanks to Deep-Learning in CAD/CAE

Location: Stage 1

Presentation Date & Time (EST; New York): 2/23/2022 @ 11:10

Keywords:

Abstract:

Numerical simulations have gained primary importance for the CAD/CAE industry over the last decades. Nevertheless, a simulation must be re-run each time an engineer wishes to change the shape being designed, leading to a slow and costly engineering process. A typical alternative is to test only a few designs without a fine-grained search in the space of potential variations. This is a severe limitation accompanied by many attempts to overcome it. Direct applications with faster simulation results for new designs are extremely wide, including interactive design exploration, real-time control in digital twins or large-scale shape optimization.

In this talk, we explain how a new generation of software, powered by recent algorithms based on Geometric Deep-Learning, allows shortcutting any simulation chain through a predictive model that outputs post processed results right from the CAD design. These models are being used in various industries, for instance automotive and aerospace, to simplify processes and to emulate the expertise of simulation engineers in the hands of product or design engineers early in the development process. Thus, the number of iterations between teams are reduced while accelerating the design activities.

With traditional approaches, the models are trained on a specific parametric representation of the design space. Thus, any modification in the design space or in the boundary conditions will require generating a new dataset of simulations and training an independent model. In many industries, each project involves many changes in the description of the parametric space or in the external conditions. Moreover, most engineering teams work on improving or redesigning variants of the same class of devices. Either way, the necessity to generate a completely new dataset at each iteration, without being able to leverage simulations collected during previous iterations, is underwhelming for the engineer.

Furthermore, Geometric Convolutional Neural Networks can be used to build surrogate models of numerical solvers, like other learning-based methods, while also being agnostic to the shape parameters as it directly processes the mesh representation of the design. Hence, a single predictor can be trained with a large amount of data and can be used for numerous optimization tasks and the engineer does not have to choose and stick to a specific parametrization from the beginning to the end of experiments. Furthermore, it can leverage on transfer learning abilities of Deep models to blend simulations from multiple sources and with multiple fidelities.

Neural Concept Shape, as a software platform, allows engineering teams, at all levels of expertise, to implement these latest deep learning-based engineering practices into their development processes. In this talk, we will also discuss some industrial use cases where our software has been implemented successfully, leading to substantially lower CAE costs and lead times.

References [1] Lassila, Toni; Manzoni, Andrea; Quarteroni, Alfio; Rozza, Gianluigi (2014). Model Order Reduction in Fluid Dynamics: Challenges and Perspectives [2] Chinesta, Francisco; Ladeveze, Pierre; Cueto, Elías (11 October 2011). "A Short Review on Model Order Reduction Based on Proper Generalized Decomposition"

[3] Geodesic Convolutional Shape Optimization. (2018) Pierre Baqué, Edoardo Remelli, François Fleuret, Pascal Fua

[4] Geometric deep learning: going beyond Euclidean data. (2017) Michael M. Bronstein, Joan Bruna, Yann LeCun, Arthur Szlam, Pierre Vandergheynst

Presenter Name: Juan Betts

Presenter Company: Front End Analytics LLC

Presentation Title: New Developments in Physics Informed Machine Learning & Artificial Intelligence

Location: Stage 2

Presentation Date & Time (EST; New York): 2/23/2022 @ 11:10

Keywords:

Abstract:

Over the past three years the field of Physics Informed Machine Learning (PIML) and Artificial Intelligence (AI) has experienced a dramatic renaissance. New methods for integrating physics based principles into ML are being developed redefining what problems can be solved with PIML & AI. PIML & AI is revolutionizing applications such as predictive maintenance, electrification & autonomy, and even the discovery of new drugs to treat disease. This paper describes some of the emerging methods and trends shaping this exciting new field.

Presenter Name: Xun Jiao

Presenter Company: Villanova University

Presentation Title: Machine Learning-based Timing Error Simulation of Microelectronic Circuits

Location: Stage 1

Presentation Date & Time (EST; New York): 2/23/2022 @ 12:00

Keywords:

Abstract:

As the transistor size scales down to deep nanometer era, microelectronic circuits are increasingly susceptible to microelectronic variations. The most immediate manifestation of such variations is the delay uncertainty which can prevent circuits from meeting their timing specification, resulting in timing errors. Without proper protection, such timing errors can pose great threats to the reliability of digital systems. While gate-level simulation can accurately simulate circuit timing errors, it is often prohibitively slow and could require expensive licensing fee to access commercial simulation tools. In this talk, I will present our work in using machine learning methods to build predictive models that can classify the timing errors of circuits under different operating conditions, clock speeds, and input workload. Our model is able to achieve an average classification accuracy above 95% and is 50-100X faster than gate-level simulation. The promising results can potentially lead to a novel path in using machine learning to complement or replace simulation tools in electronic design automation.

Presenter Name: Nikita Jaipuria

Presenter Company: Ford Motor Company

Presentation Title: Photorealistic Synthetic Data Generation For AI-Based Feature Development

Location: Stage 1

Presentation Date & Time (EST; New York): 2/23/2022 @ 12:30

Keywords: Generative Adversarial Networks, data augmentation, style transfer, automated driving

Abstract:

AI feature development for automated driving applications is heavily reliant on large quantities of diverse data. Generative Adversarial Networks (GANs) are now widely used for photo-realistic image synthesis. However, in applications where a simulated image needs to be translated into a realistic image (sim-to-real), GANs trained on unpaired data from the two domains are susceptible to failure in semantic content retention as the image is translated from one domain to the other. This failure mode is more pronounced in cases where the real data lacks content diversity, resulting in a content mismatch between the two domains - a situation often encountered in real-world deployment. This presentation will discuss the role of the discriminator's receptive field in GANs for unsupervised image-to-image translation with mismatched data, and study its effect on semantic content retention. The presentation will also show how targeted synthetic data augmentation - combining the benefits of gaming engine simulations and sim-to-real GANs - can help fill gaps in static datasets for vision tasks such as parking slot detection, lane detection and monocular depth estimation. Prior knowledge in computer vision and deep learning will be helpful in getting the most out of this session.

Presenter Name: Uyiosa Abusomwan

Presenter Company: Rice University

Presentation Title: I4.0 Product Engineering & the Role of AI in the Future of Product Development

Location: Stage 1

Presentation Date & Time (EST; New York): 2/24/2022 @ 10:00

Keywords:

Abstract:

Presenter Name: Richard Ahlfeld

Presenter Company: Monolith AI

Presentation Title: Accelerating Manufacturability Processes Using PINNs

Location: Stage 1

Presentation Date & Time (EST; New York): 2/24/2022 @ 10:35

Keywords: AI, Engineering, Simulation, Manufacturability, Surrogate Modelling

Abstract:

Design optimization and identifying critical regions in a design fast is one of the primary objectives for the manufacturability of a new product. Each iteration using classical CAE methods can come with an enormous effort in time and cost. One major obstacle of using classic design optimization algorithms are speed and lack of important input and output information for critical applications. The traditional CAE approach often forces engineers to run multiple parametric studies for new designs which not only creates huge data lakes but also makes this process very costly and tedious especially because the simulation must be re-run each time an engineer makes a change. Surrogate models leveraged by Monolith AI can help overcome on-premise hardware restrictions and exploit raw data using them for training and getting new key insights from seemingly irrelevant old data lakes. This gives users an easy to interpret output such as the manufacturability of a component by learning from complex input data and mapping them to surface fields in an unparalleled fast manner and fewer simulations that need to be run in the long run. This patent-pending approach works on all types of meshes and has proven to be very efficient when varying the geometry and mapping tested conditions to geometries which have not be seen in training.

Presenter Name: Sergey Morozov

Presenter Company: DATADVANCE

Presentation Title: How to Develop and Deploy Hybrid (sim/ML) Models at Scale

Location: Stage 2

Presentation Date & Time (EST; New York): 2/24/2022 @ 10:35

Keywords:

Abstract:

True value of simulation or machine learning models or even hybrid simulation and ML models can only be uncovered if they are developed and deployed at the scale of the whole design office and even whole enterprise. Traditional approach would require an army of skillful simulation engineers and data scientists, - digital transformation superheroes. Low-code coupled with smart ML algorithms is an efficient approach to democratize development, deployment and management of sim/ML models at scale. In this talk we will demonstrate how it works on a set of industrial use cases.

Presenter Name: Nilesh Tralshawala

Presenter Company: Xerox PARC

Presentation Title: Critical Asset Predictive Maintenance with Data-Driven and Physics-Based Simulation Software

Location: Stage 1

Presentation Date & Time (EST; New York): 2/24/2022 @ 11:10

Keywords:

Abstract:

Unplanned downtime is one of the largest sources of lost production in chemical manufacturing processes. The average unplanned downtime for a mid-sized chemical plant costs approximately \$5 million per year and 40% of the maintenance was unnecessary. Predictive maintenance (PdM) has made significant strides in recent years with advances in computational capabilities of data science, machine learning, and physics modeling. PdM now represents the strongest solution to this persistent manufacturing issue, but many manufacturers are still struggling to successfully implement these solutions. Successful IT-OT system integration is one of the challenges. Depending on how that is handled, is largely based on thought put into and identification of experienced deployment agents. After successful integration, the next problem is amount and quality of data. To provide accurate prognostics, you often need large amounts of specific data about when faults happen or run-to-failure information. A possible solution is to move away from purely using machine learning based solutions and instead use a combination of advanced data-driven machine learning and physics-based algorithms to monitor critical assets for anomalies and prognostics of remaining useful life (RUL). Use of subject matter expertise to fill in the gaps in the data, identify good versus bad data, and to create models and algorithms that ensure that physics is correctly accounted for is very important.

In this presentation, we will talk about the science behind these models, how they can be made configurable and easy to deploy, and calibrated on the fly or with OEM information. We will also include a few examples of anomaly detection and prognostics models based on physics-based and machine learning models and how they are applied to real world situations. Some of the common assets-valves, seals, heat exchangers, and pumps-found in the chemical industry will be covered. We will also present business use cases that resulted in up to a 6-month lead time with 95% accuracy of critical failure on certain assets.

Presenter Name: NAFEMS Engineering Data Science Working Group

Presenter Company:

Presentation Title: Current and Emerging Machine Learning Techniques for Engineering Applications

Location: Stage 1

Presentation Date & Time (EST; New York): 2/24/2022 @ 12:00

Keywords:

Abstract:

A panel discussion led by the NAFEMS Engineering Data Science Working Group