WHITE PAPER

AI for Design and Engineering Workflows

AI is being incorporated into design and engineering solutions and workflows and new Workstations and HPC solutions are enabling engineers to effectively tap into these capabilities.

WILDFLOWER NVIDIA DELL Technologies

Algorithm-Driven Engineering

As products become more complex, design and engineering workflows must evolve to help agencies meet market demands to create innovative designs on a much faster timetable. The emergence of new types of materials, increased regulatory pressures around efficiency, sustainability, and lightweighting, and the use of new manufacturing approaches like 3D printing have also created new challenges when it comes to engineering.

Traditional design workflows make it difficult for engineers to fully explore the design space and quickly come up with solutions to emerging challenges. Organizations need to be able to rapidly iterate, to quickly test and validate those iterations, and then allow nonspecialist engineers to analyze and simulate those designs in order to keep pace.

Technologies like artificial intelligence (AI) and machine learning (ML) can help accelerate design and simulation processes by helping engineers discover novel solutions, take advantage of large amounts of existing simulation data, and improve final designs. Design and simulation software vendors are beginning to incorporate AI and ML into their solutions, taking advantage of powerful new engineering workstations equipped with modern GPUs that offer a massive upgrade in computing horsepower.

In this paper, we will explain how AI is being incorporated into design and engineering solutions and workflows, and how new workstations and high-performance computing (HPC) solutions are enabling engineers to effectively tap into these capabilities.

Engineering Use Cases for AI

Artificial intelligence is already being leveraged across the design cycle via algorithm-driven solutionslike generative design, through the use of reduced order models (ROM) for rapid validation, in making simulation processes faster and more accessible, for creating virtual environments and digital twins, and even to improve software training and support.

When it comes to AI, there are a few key terms that are sometimes used interchangeably, but that are important to understand:

Artificial intelligence: Enabling computers to solve tasks by mimicking human intelligence and cognitive functions.
Machine Learning: A subset of AI that involves training a computer to solve a specific problem. These systems attempt to minimize prediction error in pursuit of specific objectives.

Deep Learning: A subset of machine learning that uses neural networks (a concept similar to a human brain) to solve problems. Deep learning requires large amounts of data.

Generative AI: A subset of deep learning that uses neural networks to understand context from data such as text, images, computer software, etc., to create new content that mimics human generated content. ChatGPT is probably the most well-known example of generative AI.

In the engineering space, the technologies defined above are being deployed in a variety of computer aided design (CAD), engineering simulation (CAE), and manufacturing-related solutions to optimize and automate various parts of the design cycle. In most cases, these solutions leverage large amounts of existing design and simulation data to help engineers more quickly identify the best designs, analyze and validate those designs, and optimize production.
Using these AI/ML-based tools can streamline tasks throughout the design cycle, and help engineers more quickly explore the design space, create better designs faster, and take advantage

of existing data sets for rapid inference and analysis. Several specific use cases have emerged in both CAD and simulation that illustrate these benefits.

AI for Product Design
In design and CAD scenarios, AI has already made an impact through the emergence of generative design tools. This software (available from most of the major CAD solution vendors) leverages AI and ML to create a range of optimal design options based on predefined constraints. Generative design tools require engineers to create those constraints up front (which can include anything from thermal performance to stiffness to materials options and even specific manufacturing processes), enabling the software to create hundreds or even thousands of options for evaluation. Those options can then be narrowed down by fine-tuning the constraints. Generative design simultaneously broadens the scope of the design space, while making it easier for designers to arrive at a final solution more quickly.

In the electronic CAD (ECAD) space, some companies have also developed AI-enabled software tools that allow designers to accelerate printed circuit board (PCB) design. Using data from past designs, these tools help automate place-and-route design for circuit boards, which improves productivity.

Conceivably, future AI-based tools could allow engineers to use natural language prompts to create multiple iterations of a particular design. Such systems could be used for high-level design concepts or to help engineers find novel ways to, for example, reduce weight in a component or system.

AI-driven rendering and visualization tools are also emerging. NVIDIA AI, for example, leverages the open source Stable Diffusion model, allowing users to generate 2D sketches and images using text prompts. One new startup, Depix Technologies, offers a tool that allows users to create high dynamic range (HDR) panoramic images and backplates using simple text prompts.

AI capabilities can also flow through to the manufacturing process. Generative design has proven valuable for helping users take advantage of additive manufacturing, for example, because they can create shapes and lattices that might not otherwise be possible in a machining or molding environment. Because AI technology is able to evaluate large data sets and identify patterns, the technology could be used to automate 3D printer settings by predicting deformation patterns for a given material and printing process, for example.

There are also companies in the computer aided manufacturing (CAM) and manufacturing space that are leveraging AI for programming CNC milling machines and robotic production systems, which can save significant time when setting up these systems.

AI for Simulation

AI solutions that leverage GPU acceleration could provide even greater benefits when it comes to improving productivity and design quality. Analysis and simulation have traditionally been a bottleneck in the design cycle, especially as models have become larger and more complex. Some of these advancements are targeted at making simulation tools easier to use. For example, simulation software companies are testing ChatGPTstyle natural language tools to improve the user interface and expand access to simulation software. Users can potentially use text prompts to run a simulation, even if they are not well-versed on a specific solver. This could help engineers accelerate the time it takes them to learn how to use new software. One company, Ansys, has already announced a ChatGPT-based tech support tool (AnsysGPT) to help manage common customer support requests. There have even been reports of individual users leveraging ChatGPT to write Java programs to execute specific simulation tasks without programming.

Where the rubber really meets with road in analysis, however, is the use of reduced order models (ROMs) to provide rapid evaluation during the design process, without the need to use the solver for a full-scale simulation.

A ROM built using data from existing detailed simulations can provide analysis in near real-time, allowing engineers to quickly evaluate and tweak a model. This approach does require access to a sufficient amount of training data that is relevant to new variations on existing products or designs. However, ROMs can also provide answers to similar cases outside the scope of the original simulation data.

Most of the major simulation software providers are investigating, if not actively testing, AI features for their software suites. There are at least three products already in use, however, that exemplify how AI can improve workflows.

In 2023, Altair released its physicsAI solution for making fast physics predictions using CAD models and meshes. The solution not only provides rapid results without the need for a simulation solver, it also benefits from GPU acceleration and can be utilized in a desktop workstation environment.

Leveraging a process called geometric deep learning, physicsAI allows engineers to evaluate designs and make predictions about performance in a few seconds. The simulation data is fed into the solution and then used to train an AI model to test for specific outcomes. Users can then test its performance against known computer aided engineering (CAE) tests to gain confidence in the AI models.

Accessing the tool within the Altair Hyperworks environment, users can check different physics (like CFD or warpage prediction) hundreds of times faster than they could by running a traditional solver.

Once a design is complete, engineers can then run a full-scale simulation to verify design integrity and performance. According to Altair, smaller physicsAI models can be created and trained directly on a laptop or desktop.

Larger and more complex models are best handled using HPC or cloud resources, according to the company. In either case, the deep learning processes at the heart of the solution benefit from the highly parallel architecture of GPUs.

According to benchmark data from Altair and NVIDIA, physicsAI experienced a 14-times speedup on an NVIDIA A100 40GB GPU compared to an 8-core laptop CPU. Using a workstation with an NVIDIA RTX™ A4000 GPU provided an 8-times speedup for training physicsAI models.

Monolith AI has developed an AI platform that helps engineers leverage existing test and simulation data to solve complex problems. The company is also a member of NVIDIA's global startup program, NVIDIA Inception, and its products take advantage of GPU acceleration.

Kautex, a Textron Inc. company, is an automotive supplier for a number of global original equipment manufacturers, and has used the Monolith AI solution to help its engineers reduce the noise of fuel sloshing in a tank, while also lowering prototyping and testing costs.

Traditionally, a company like Kautex would have had to physically test and measure the slosh noise created by a tank, or use simulation to virtually test the effects of its noise dampening structures. Both options are time and cost-intensive.

Because the company already had decades of test and simulation data on hand, they were able to use Monolith AI to evaluate new models during the early stages of design, which allowed them to avoid frequent and costly CAE analysis. Because of the wealth of existing data available, they were also able to validate the results of the AI analysis against realworld information, which built trust in the results.

Neural Concept, a Swiss start-up and NVIDIA Inception member, also offers a cloud-based machine learning software that benefits from NVIDIA GPU acceleration. The company was able to train a convolutional neural network to calculate the aerodynamic properties of different forms, for example, to calculate polygon meshes and optimal shapes for a design without human bias. Customers have used the platform to create an AI-based app to predict if a given design configuration would produce battery contact during a crash simulation in a vehicle; to improve the performance of a vehicle crash box design by 10% while shortening the development cycle; and to rapidly predict the performance of new check valve designs across a wide design space.

AI has the potential to not only allow for rapid analysis during the early phases of design, but to make it easier for engineers to apply traditional simulation solvers to those designs without extensive knowledge or training.

In addition, AI is required for generating synthetic data, which has emerged as a key enabler for training autonomous vehicle systems. Because training a self-driving car, for example, would require millions of hours of operational data across an infinite number of vehicle scenarios, synthetic data that mirrors real-life scenarios can be used to accelerate the process virtually. NVIDIA, for example, offers the NVIDIA DRIVE Sim™ platform (based on NVIDIA Omniverse™) for running largescale, physically accurate multi-sensor simulations in an immersive 3D environment. The NVIDIA Omniverse Replicator platform generates synthetic data for these simulations. This type of data also eliminates the need for time-consuming data scrubbing and labeling that otherwise be required to use existing data sets.

In each of these use cases, artificial intelligence augments engineering activities by accelerating or automating tasks and improving data analysis, giving designers and engineers more time to evaluate and fine-tune their work. The technology acts as another tool that engineers can use to eliminate friction points in the design process and provide insights that might be difficult to discover using traditional methods. Specific engineering expertise is still required to evaluate design options and make final decisions.

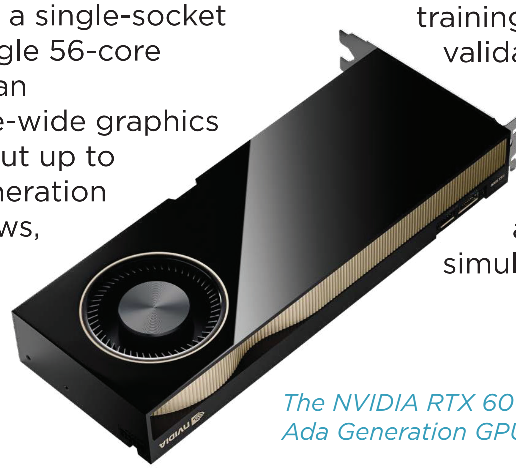
AI-Ready Engineering Workstations

Advanced, AI-based design and simulation tools operate more effectively and efficiently on engineering workstations equipped with the latest NVIDIA RTX™ GPUs.

Dell Technologies offers configurations of its workstation line specifically targeted at AI and data science applications that provide the compute resources necessary for engineers to work with these tools. The Dell Precision 7960 tower workstation can be configured with single or multiple NVIDIA RTX GPUs to enable AI-based engineering workflows.

The recently redesigned 7960 is a single-socket computer that offers up to a single 56-core CPU with a larger chassis that can accommodate up to four double-wide graphics cards. That means users could put up to four NVIDIA RTX 6000 Ada Generation GPUs for AI-based CAE workflows, as well as rendering and visualization. The NVIDIA RTX 6000 includes 48GB of graphics memory, allowing users to work with massive data sets as well as perform simulation and rendering tasks on large, complex models.

This type of workstation, equipped with one or multiple NVIDIA RTX GPUs, allow engineers to work with the large models and data sets typical of AI-based workflows right on their desktop. By enabling them to perform AI model training locally, and then leverage rapid validation via educed order models (ROMs) during the early stages of design, advanced engineering workstations play a key role in the evolution of more accessible and automated design and simulation scenarios.



The NVIDIA RTX 6000 Ada Generation GPU.

Conclusion

Artificial intelligence and machine learning tools can improve and optimize design and simulation processes, and help organizations improve the efficiency and capacity of their engineering teams.

While not applicable in every scenario, teams with access to sufficient amounts of legacy design, simulation and test data can leverage AI to expand the potential design space, discover novel engineering insights, and accelerate the validation and simulation process to arrive at better designs at a faster pace.

In addition to the need for data to train these solutions, companies also need powerful workstation and high-performance computing resources to support advanced AI-based workflows. Dell Technologies professional workstations and NVIDIA RTX GPUs offer the processing power to enable engineers to adopt these emerging AI-based tools and support evolving design workflows in the future.

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