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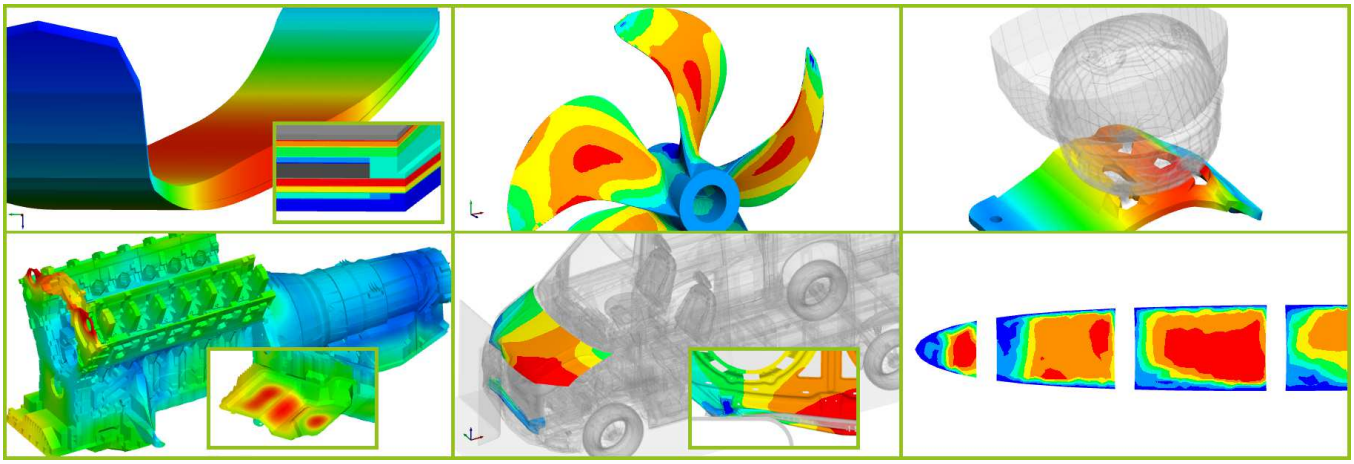

HdT Journal

The Engineering Revolution: How AI Is Shaping the Future – Interview with Erich Payer

Increasing global competition is putting more & more pressure on companies from 'industrialized' countries. The reasons are manifold, with one of the main ones being the changing role of 'emerging' nations. In many cases, these countries no longer are 'just producing low-cost products' but are increasingly achieving top performances in 'high-tech' fields too. In addition, digitalization is pushing new competitors into areas that previously were 'in the hands' of German engineering.

In order to not fall behind, significantly more innovation, faster time-to-market and better cost efficiency will be required in the coming years.

With this respect, the 'dawn' of artificial intelligence (AI) and neural networks (nN) may prove to be a stroke of luck. AI related technological possibilities already are triggering change in engineering processes. How exactly – and with what advantages – we asked Erich Payer. He is a widely acknowledged expert in development and application of simulation methods and AI solutions for product development, working successfully for OEMs and suppliers from different industrial areas.

HDT-Journal: *Mr. Payer, the use of AI & neural networks in product development enables massive time savings and cost reductions. Can this be generalized or are there areas that benefit either less or not yet at all?*

Erich Payer: In the field of product development, this absolutely can be generalized. In all industrial areas – from automotive & aerospace over mechanical engineering to household and sporting goods industries - AI solutions and neural networks can be used to develop better products faster and with reduced costs.

But, also when looking at product life cycles, you can see that AI and neural networks can successfully be used in all phases – from design to disposal... ...from the analysis and optimization of relevant product properties, over the commitment to manufacturing processes, on to the choice of materials for a best possible recyclability of products. In other words, wherever simulation techniques are used today.

HDT-Journal: *What are concrete advantages in comparison to conventional methods and especially in terms of sub-aspects when differentiating between concept phase, actual product development, prototyping, testing and validation, as well as production?*

Erich Payer: The AI solutions and neural networks of my engineering consultancy basically focus on the areas of design and engineering. Accordingly, they are primarily used in the concept and detailed design phases, but of course they can also be used for predictions in the field of testing or in other phases of product life cycle if related nN training data are available. For example, we recently also developed neural networks for WLTP tests which are able to predict coolant temperatures and other parameters resulting from specific vehicle configurations.

Our AI/nN solutions typically are based on simulation results and/or models of reference products. Thus, they initially leverage the values of simulation and, at the same

time, are able to replace simulation in many areas. Accordingly, I would now also like to compare these two approaches.

Simulation techniques enable 'virtual' analyses and optimizations of the mechanical properties of products and, in comparison to manufacturing and testing of 'physical' prototypes, they help to avoid excessively high product development times and costs. At the same time, however, their application can be pretty complex, require a high amount of 'expertise' and, thus, make it very difficult for 'casual' users to deploy simulation techniques for product development.

Neural networks, on the other hand, are able to 'learn'. They represent systems similar to human brains and are able to recognize relationships, for example, between the geometry and the mechanical properties of products. They can be trained and subsequently be used for rapid and high-quality predictions. And, as these trainings (i.e. the training data) incorporate the 'expertise' mentioned above, neural networks eventually also open up great new possibilities for occasional users to easily analyze and optimize their designs.

HDT-Journal: *Could you give our readers a concrete example for a successful deployment of AI in the field of product development?*

Erich Payer: Gladly. Let me go straight into two examples that are completely contrary in terms of the boundary conditions, but both of which impressively demonstrate the advantages that – regardless of the product - result from the use of neural networks.

Crash Behavior of Vans

Firstly I'd like to cover a use case which we executed for Volkswagen. It was about developing a neural network for crash predictions of vans.

As a related reference model Volkswagen provided us with existing crash simulation data of a VW Crafter, i.e. finite element results for 400 different design & impact variations. The amount of data was rather high, altogether more than 4 TB of data. And, the number of output values for the neural network was more than 9.6 million. That's because the neural network got trained to predict the displacement components for all nodes of the FE model. And the number of these nodes was more than 3.2 million.

VW defined six parameters which they wanted us to be considered on the input side of the neural network. Those parameters were the thicknesses of the upper and the lower deformation elements, the thickness of the bumper cross carrier, the impact angle, the friction coefficient, and the time history of the crash event.

Based on these data sets & definitions we executed the training of the neural network on a standard PC. And, utilizing its GPU together with Nvidia's CUDA features, it just took us a couple of hours to train the network and to generate the related crash prediction template for Volkswagen, see Fig. 1.

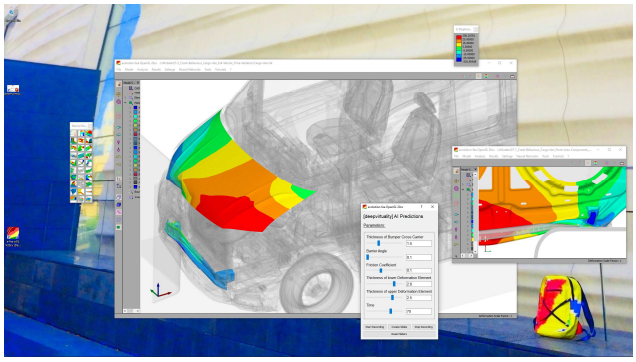

Fig. 1 nN Template for Crash Predictions

A core component of our neural network templates always is a set of sliders for the parameters which we consider on the input side of the network. In this case we have 6 sliders for 6 design & impact parameters. These sliders can now be used by the Volkswagen designers & engineers to instantly modify the related parameters, and to get live predictions of how these modifications influence the mechanical properties of the structure.

Just let me invite you and our readers to take a look at a related video on our website.

To validate the quality of the neural network, Volkswagen used statistical methods and 50 additional test data sets. The correlation between predictions & simulation results was excellent.

But, it's not only that the quality is excellent on the technical side, By deploying our neural network solutions as core component of their Van development processes Volkswagen from now on is able to derive massive benefits from the economic point-of-view too.

That's because for each vehicle and for each crash event they are able to reduce required HPC simulation times by at least 600 hours, which means that they are able to reduce the related development costs by at least € 60,000.

And, once again, that's true for each of their vehicles, and for each crash scenario!

Stiffness of Alpine Racing Skis

My second example is a use case which we executed for Fischer Sports, an Austrian Alpine and Nordic ski manufacturer. It was about generating a neural network for stiffness predictions of alpine racing skis.

Fischer did not provide us with any simulation models or data of reference skis. Instead, they specified more than 100 different design parameters to be consider for the neural network. Those design parameters were for example the side cut, the camber & the core shape versus length, the number and thicknesses of the different layers, the material properties & more.

So, in that case, the number of design parameters was rather high. However, thanks to the advanced features of our design variation tools we were able to generate all of the related training data rapidly.

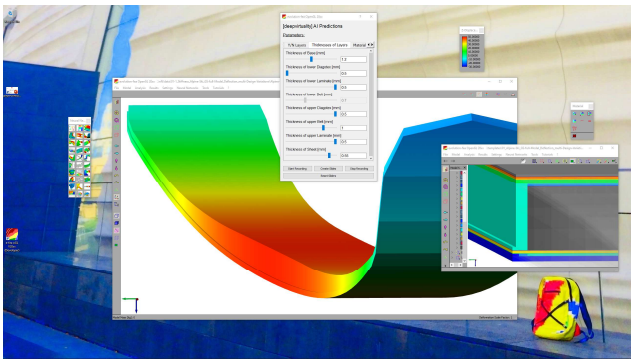

Fig. 2 nN Template for Stiffness Predictions

Based on this neural network, the Fischer designers & engineers from now on do not have to perform any simulation works. They just use our neural network to create alpine ski designs which meet their specific stiffness requirements. They just work with the sliders of the template, see Fig. 2, they modify the design parameters by just moving the related sliders, and they get live predictions about how their design variations influence the bending line and the stiffness properties of their designs.

And, using a tailored model generation tool, the designers & engineers even can instantly generate solid models for 3D printing, or splines for mold building etc. Thus, they also can speed up their overall prototyping and production processes.

From the technical point-of-view, the correlation between neural network predictions and related testing results again was excellent.

And on the economic side, by deploying neural network solutions for Alpine ski development, Fischer was able to reduce the related development times & costs by 80%.

HDT-Journal: *Would you say that AI also helps to improve customer value and supports product sales processes?*

Erich Payer: Yes, that's absolutely the case! As you can see from the examples covered earlier, AI & neural network solutions are able to revolutionize design and engineering processes in multiple industrial sectors, both economically and technologically.

In comparison to simulation methods, neural networks enable massive time and cost savings. And, by enabling designers & engineers to instantly determine how specific designs and design variations influence key product attributes such as stiffness, strength, vibration, acoustics, crash behavior, fluid dynamics and so on, neural networks contribute to significant quality improvements too.

Accordingly, AI solutions and neural networks are predestined to develop better products – i.e. products with higher customer benefits - faster, to develop them more cost-effectively, and to eventually sell them more easily and with higher margins.

HDT-Journal: *Maybe it's still too early to say, but to what extent will the technological change induced by AI, influence future job profiles, education and training needs in the fields of product design and development?*

Erich Payer: From the technological point of view, AI solutions and neural networks for product development are rather an 'evolution' than a 'change'. And, to use one of today's buzzwords, AI/nN solutions are 'democratizing' virtual product development.

That's because, by means of appropriately trained neural networks, technologies such as advanced simulation techniques, which previously might rather have been reserved for 'experts', now can be successfully deployed by 'occasional' users too.

At the same time the boundary conditions, requirements & needs associated with AI solutions and neural networks – such as processing of large amounts of data, machine learning algorithms, GPU programming etc. – also open up fascinating new challenges and tasks for 'experts'.

With this respect, 'life long learning' strategies with online and/or onsite educational seminars enable designers and engineers not only to stay up-to-date with related technologies, but especially also to empower them and create excellent new job & business opportunities.

And, more and more colleges are including the development of AI and neural network solutions and their deployment for engineering tasks in their curricula. Among other things, this increasingly enables students to write AI related bachelor's or master's theses, both on the theoretical and on the industrial application side.

That's a very good way!

HDT-Journal: *Mr. Payer, we thank you for the deep insights and the concluding remarks, which make me feel truly optimistic.*

This interview was conducted by Michael Graef, Editor in Chief of HDT-Journal. The original, German, Version is available at https://www.hdt.de/hdt-journal/die-product-engineering-revolution-wie-ki-die-zukunft-gestaltet-interview-mit-erich-payer

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- Acoustics of a V12 Engine
- Crash Behavior of a Cargo Van
- Fluid Dynamics in a HVAC Channel

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