THE DEEP LEARNING REVOLUTION AND ITS IMPACT ON COMPUTER AIDED ENGINEERING

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SUMMARY

In the last couple of years, machine learning methods based on deep artificial neural networks (deep learning) have achieved tremendous success in many applications. Often branded as Artificial Intelligence (AI), these methods are able to provide accurate, data-driven process automation. In the context of Computer Aided Engineering, deep learning has the potential to automate a variety of manual tasks that require an intuitive understanding of geometric patterns. In this way, the technology enables the democratization of complex engineering tools and opens up new business models.

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1: Introduction

Computer Aided Engineering (CAE) methods have been a remarkable success story over the last decades and have become an invaluable tool for product development in many industry sectors. However, the adoption rate and growth of CAE has significantly slowed down during recent years. In many applications, especially in the realm of small and medium sized enterprises (SME), significant obstacles exist that impede the efficient use of CAE tools: Huge time investments for manual tasks, significant license costs and the deep numerical expertise that is required in order to set-up CAE workflows.

In the last couple of years, machine learning methods based on deep artificial neural networks (deep learning) have achieved tremendous success in many applications. These systems that are often referred to as a form of artificial intelligence (AI) in the media and have already gained superhuman performance in a variety of tasks such as image recognition, lip reading or playing Go [1][2][3]. With the ability to automate processes purely based on large amounts of sub-symbolic data, deep learning is currently revolutionizing many industries. Although deep neural networks for geometry understanding are still a topic of rapidly progressing research, the available methods can already be used to automate many routine tasks within CAE workflows [4].

2: CAE Automation through deep learning

By reducing the amount of manual routine work in steps such as geometry preparation, meshing, simulation monitoring and post-processing, simulation results can be obtained faster and cheaper. This can speed up developing cycles and strengthen simulation-driven design workflows. Moreover, by fully automating CAE processes, they can be packaged into easy-to-use simulation apps. In this way, CAE becomes accessible to design engineers and small development teams in SMEs. Also, automation is key to establish simulation methods in areas outside of product development and enable physics based digital twins that can be used to optimize machine parameters or maintenance cycles.

Deep Learning offers superior automation for many applications in the engineering process. In the context of CAE typical applications include manual tasks in the context of pre-processing, simulation monitoring

and post-processing. In order for the machine learning based automation to be effective, a task should have the following properties:

1. The task requires an intuitive understanding of geometric patterns which cannot reliably expressed in a rule-based framework.
2. The task is performed on a set of geometries that share common traits.
3. Enough data in terms of successfully performed tasks is either available or can be generated with reasonable effort.

3: Technology and software platforms

While deep learning technology for image, text and speech understanding are already well established, deep neural networks for geometry understanding are a much younger research field. Different algorithms such as multi-view or volumetric methods exist to encode geometric information into convolutional neural networks. Each of these approaches has their own advantages and limitation in terms of speed, memory requirements, data loss and resolution. That is why the appropriate methods have to be engineered for different applications.

There are many open source deep learning software frameworks available. However, these frameworks typically cater to general-purpose AI researchers. They are not well equipped for industrial-grade data management, they offer only limited deployment capabilities of deep learning solutions and they do not provide easy-to-use connectors to engineering data formats. That is why new platforms have to be established for deep learning based automation of engineering processes.

4: The deep learning revolution in CAE

It is likely that deep learning will not only enable a new wave of process automation for CAE. It will also speed up the development of tools that allow non-experts to use sophisticated simulation capabilities (CAE democratization). This in turn will open up new business models.

4.1: Role of the numerical analyst in the age of AI-powered simulation apps

In addition to setting up and performing simulations by themselves, numerical analysts will soon assume additional responsibilities: They will create, manage and supervise highly automated, AI-powered workflows. In this context, numerical analysts have to acquire the necessary skillset for these kinds of tasks. This in particular includes a working knowledge of machine learning and deep neural networks.

4.2: From service to product – the business side

AI-powered process automation is inherently customer and application specific. That means that deep learning will accelerate the movement from powerful, monolithic, one-size-fits-all simulation packages towards small, application-specific, easy-to-use software tools. Ideally, these tools are built by the experts that are familiar with the associated simulation workflows. Buy building and training such tools, simulation consultants can turn process knowledge into marketable software products.

5: Conclusions

In the last couple of years, machine learning methods based on deep artificial neural networks (deep learning) have achieved tremendous success in many applications. Often branded as Artificial Intelligence (AI), these methods are able to provide accurate, data-driven process automation. In the context of Computer Aided Engineering, deep learning has the potential to automate a variety of manual tasks that require an intuitive understanding of geometric patterns. In this way, the technology enables the democratization of complex engineering tools and opens up new business models.

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