# TOWARDS COGNITIVE COMPUTER AIDED ENGINEERING

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## ABSTRACT

Computer Aided Engineering (CAE) methods such as finite element based simulation and optimization techniques have become invaluable for product development in many industry sectors (e.g. automotive). Due to the continuously growing computational power and the introduction of cloud infrastructures CAE tools are becoming more powerful, faster and cheaper to deploy. However, they still require a lot of time and expert knowledge in order to be used correctly and effectively. In order to make simulation technology ubiquitous even in small and medium sized enterprises, it is necessary to develop CAE tools that are equipped with intuitive interfaces and that can be used by non-experts (CAE democratization).

In this paper we present a set of methods that pave the way for a computerbased Cognitive Simulation Assistant (CoSA). Such an assistance system can help design engineers to leverage the full power of CAE tools in the same way as a human simulation engineer. This includes in particular the construction of the whole simulation workflow by autonomously selecting the appropriate tools, solver types, boundary conditions, numerical parameters and required cloud resources.

The idea to automate simulations using knowledge based systems has already been proposed in the 1990s [1]. However, as in many other domains, these rule based expert achieved only limited success. Instead of trying to build general purpose solutions, recent work focuses on the concept of simulation templates (simulation apps) in order to simplify the CAE user interface [2]. However, advances in artificial intelligence technologies (e.g. semantic web, deep learning) have the potential to finally deliver on the original promise to make extensive expert knowledge computer readable and usable. These so called cognitive systems are highly successful in a range of

applications such as autonomous vehicles, medical computing or robotics. In contrast, these methods have seen very limited use within the CAE community.

Semantic web technologies such as the Web Ontology Language have been used by many groups to describe formal knowledge in the CAE domain. This includes data integration, collaborative engineering or geometric representations [3][4]. However, all these ontologies are not integrated into a top-level ontology. This prevents their combination and thus their re-use in a general cognitive framework for the whole simulation workflow. In order to achieve this goal we have developed the Computer Aided Engineering Modeling Language Ontology (CAEMLOnto), which is integrated into the Basic Formal Ontology (BFO). It not only relies on existing CAE standards (STEP AP 209), but also makes use of other established ontologies (e.g. Information Artefact Ontology). Furthermore, CAEMLOnto adds important simulation specific knowledge such as discretization methods, solver types, contact models etc. This knowledge about the different simulations properties is essential for a CoSA.

However, not all information that is associated with simulation scenarios can be captured in a semantic (i.e. symbolic) representation. This in particular applies to all properties that are directly associated with the geometry such as boundary conditions or defeaturing operations. It has been notoriously difficult to make such sub-symbolic knowledge computer readable. In the realm of image understanding, deep learning approaches that mimic the human understanding have recently achieved extraordinary success in this regard [5]. Inspired by these results, we present a novel convolutional neural network for shape understanding (i.e. classification and segmentation) from CAD meshes.

In addition to the previously presented methods, we also outline how they can be combined into a CoSA. We illustrate how such an approach can be used to build intuitive user interfaces for CAE tools in a very generic, data driven approach. In order to facilitate the adaptation of the technology in the CAE community, CAEMLOnto will be published under an open source license.

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