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Mini Review

KYAMOS Software - Mini Review on the Computer-Aided Engineering Industry

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Abstract

This review underscores the transformative impact of Computer-Aided Engineering (CAE) on modern engineering, emphasizing its role in advancing sustainable and efficient technological solutions. The CAE industry is further analyzed, focusing on market trends and future directions. The CAE market is projected to grow significantly in the next five years in industries like automotive, aerospace, and energy, especially with the rapid advancements in High-Performance Computing (HPC), Artificial Intelligence (AI), Internet of Things (IoT), and Digital Twin technologies that enhance real-time optimization and predictive capabilities, thus fostering innovation in sustainable product design and performance. Lastly, this review presents KYAMOS Software and its state-of-the-art CAE solutions for tackling high-demand engineering problems, mainly concerning green technologies.

Introduction

Computer-aided Engineering (CAE) uses software and computational methods to simulate and test engineering products virtually, facilitating problem resolution and system optimization [1]. CAE allows for more efficient and innovative product development processes in various industries like energy, aerospace, automotive, and healthcare. CAE simulation methods focus on multiphysics analysis, including structural, thermal, fluid dynamics, and mechanics of materials. Key CAE methods, such as Finite Element (FE), Finite Volume (FV), and Lattice-Boltzmann (LB), simplify complex continuous systems into manageable discrete versions, enabling analysis at various scales, such as microscopic or mesoscopic scales [2]. CAE tools accelerate product launches and lower costs by enabling early evaluation, risk reduction, anomaly detection, and design optimization [3]. They ensure functionality, efficiency, and durability, enhancing quality and reliability, which boosts customer satisfaction and product longevity. Moreover, early design corrections and simulations reduce the need for physical testing, saving time and expenses. Digital twin technology further advances CAE by enabling fault prediction and maintenance planning across industries, reducing downtime and operational costs [4]. Moreover, CAE interacts with computer-aided auditing in engineering workflows by utilizing object-based modeling, automated tools, and software to ensure regulatory compliance during the CAE processes, as demonstrated in fire engineering design [5]. In this review, the CAE Market and its future directions and trends will be presented.

CAE market

The global Computer-Aided Engineering (CAE) market, valued at $9.8 billion in 2023, is projected to reach $22.2 billion by 2032, with a CAGR of 12.3% from 2023 to 2030 [6]. Market research reported that North America led the market with a 33% share, driven by manufacturing automation, IoT advancements, and defence spending [7]. Germany led Europe with a 28% share, driven by its automotive sector, while the U.K. and France contributed through aerospace and automotive industries, supported by government innovation initiatives. In Asia, China held over 16% market share, followed by India and Japan, reflecting increased digital engineering and precision manufacturing. The Kingdom of Saudi Arabia is also experiencing growth due to investments in infrastructure and tech-driven industrial projects. The prevalent method was the FEA segment with over 51% market share in 2023.

The CAE industry is mostly driven by automotive, aerospace, defence, electronics, and energy products. The most attractive tools focus on safety and electric mobility in automotive, structural integrity and fluid dynamics in aerospace and defence, and optimization and efficiency in the energy sector. The leading companies include ANSYS, COMSOL, Altair Engineering, ESI Group, Exa Corporation, and Dassault Systèmes, which specialize in simulation and multiphysics

analysis, providing tools for structural, fluid, thermal, and electromagnetic simulations. Moreover, companies like Siemens, Autodesk, Bentley Systems, and Dassault Systèmes focus on design and engineering software, offering CAD and PLM solutions, while Maplesoft and MathWorks excel in mathematical computing and model-based design with products like Maple and MATLAB/Simulink.

Future directions and trends

The future of the CAE industry is shaped by cloud-based solutions, making high-performance computing more accessible and reducing dependency on costly hardware. Sustainability drives the use of CAE for designing eco-friendly, energy-efficient systems. Demand for multiphysics simulations is growing, especially in renewable energy and sustainable mobility, optimizing battery performance and vehicle efficiency. Key sectors like automotive, aerospace, defence, and energy are leading CAE adoption for design optimization and safety compliance. AI and ML integration in CAE tools is increasing, enabling automated design optimization and real-time analysis [8,9]. Digital twins, using sensors, IoT, and real-world data, enhance predictive maintenance and performance [4,10]. Lastly, industry-specific customization and regulatory compliance further influence CAE advancements [5].

KYAMOS

KYAMOS LTD is a scientific software company based in Cyprus that provides state-of-the-art multiphysics solutions for complex engineering problems, focusing on green technologies. The company's goal is to develop stable and efficient energy systems, ensuring time efficiency for complex calculations using InfiniBand parallel GPU computing. Additionally, by integrating AI into traditional CAE tools, KYAMOS LTD enables engineers to perform accurate, real-time optimizations, reducing both the time and cost associated with product development. KYAMOS operates under a unique cluster/SaaS model which encompasses the best of cluster and cloud computing. Based on the current trends, KYAMOS is set to establish its position in the CAE industry under the aegis of a funded research programme, by developing six innovative modules in the fields of Radiofrequency Filters, Electromagnetics, Semiconductors, Wind Turbines, Batteries, and Thermal. These are incorporated into a user-friendly Graphical User Interface, operating under a server-client environment. This user-friendliness enhances accessibility, ensuring that even non-expert users can interact with complex multiphysics models and leverage their powerful capabilities effectively.

KYAMOS offers real-time predictive fluid behaviours, predictive maintenance, and enhanced performance optimization for energy systems. The company thrives in developing in-house scientific parallel-computing simulation solvers, including Finite Element, Lattice Boltzmann-Multiple Relaxation Time-Large Eddy Simulations finite difference time domain, Conjugate Gradient, and partitioning algorithms. KYAMOS Software stands out due to its innovative capabilities, including the development and incorporation of different geometries, such as Wind Turbines of different sizes and other two- or three-dimensional shapes, the coupling of different solvers to analyze a complex system, like the Electromagnetic module, and the integration of special boundary conditions on the complex three-dimensional porous structures. However, the models of the developed technologies are not sufficiently generalized yet, restricting their adaptability to broader scenarios. The software is primarily tailored to specific types of problems with fixed geometries and boundary conditions, which may not extend to all multidisciplinary challenges and most models are unable to analyze highly complex geometries, limiting applications in some advanced use cases.

One of KYAMOS's most noticeable breakthroughs is the time-aware, UNET model, which is a Convolutional Neural Network that predicts computation outcomes instantly, with high precision of less than 1%. Since the accuracy of the AI model depends on the availability of high-quality training data, insufficient data may pose a limitation in various industries, where data acquisition remains a challenge. However, the multiphysics solvers developed are able to simulate a range of physical phenomena, such as aerosol propagation, heat transfer, electromagnetic field propagation, oil spill dispersion, lithium-ion concentration evolution in batteries, and current, voltage, and power flow.

Most importantly, KYAMOS Software combines Computer-Aided Design (CAD) with complex computer simulations and predictive analysis for real-time analysis, significantly reducing computational time for iterative tasks through cutting-edge GPU-based parallel computing via InfiniBand. These enable researchers to model highly complex systems, such as wind turbines or semiconductors, with enhanced accuracy and efficiency. Moreover, the GUI allows users to seamlessly add electrical components, like resistors, inductors, capacitors, and input/output ports, using a drag-and-drop feature, enhancing the user's experience and efficiency. Notably, apart from the project's developments, KYAMOS has recently adopted Digital Twin methods for the industrial energy sector, driving innovation in a highly promising market.

Conclusion

As the demand for digital transformation in engineering continues to rise, the CAE industry shifts to data-driven solutions that enhance engineering capabilities across various sectors of engineering. The incorporation of AI, Digital Twins, and innovative Multiphysics algorithms into CAE tools is increasingly in demand in the CAE market. Specifically, these advancements serve as the key drivers of the market's growth, promoting efficiency, accuracy, and innovation, and solidifying CAE's role in modern product development and industrial progress. KYAMOS LTD is actively contributing

to the CAE industry through the ongoing development of innovative solutions that support the global transition to sustainable energy.

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Conflicts of interest

Author Sofia Nikolaidou was employed by the company KYAMOS Ltd. Frederick University and KYAMOS Ltd. are collaborating under the funded project CODEVELOP-GT/0322/0081 REALISATION-GREEN-CLOUD of the Cyprus Research and Innovation Foundation. Dr. Papadakis, an associate professor at Frederick University, is also affiliated with KYAMOS Ltd. (CEO of the company). The fees of this publication are covered by the funded project and the funder was not involved in the writing of this article; or the decision to submit it for publication.

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