THE ROLE OF ARTIFICIAL INTELLIGENCE IN AUTOMOTIVE DESIGN

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Abstract: This article shows the role of the automotive industry as the largest global market, with shorter development cycles putting pressure on suppliers and the supply chain. Article explores the application of artificial intelligence in the automotive industry, highlighting its potential to improve the entire automotive life cycle. AI can be applied in various stages of development, including design, production, planning, driver assistance, and collision avoidance systems. The article introduces the concept of AI and emphasizes its significant role in the automotive industry, from design to operation. The development of big data sensing, recording, and storage offers a significant opportunity to understand automotive performance, leading to a safer and better vehicle. The application of AI in the automotive industry is anticipated to significantly transform the industry. High-performance computing infrastructure and simulation methods have improved product performance, but simulation time is a bottleneck in engineers' design loop. Artificial Intelligence significantly enhances engineering companies by enabling real-time, simulation-driven design workflows. AI has significantly reduced development efforts and vehicle design campaigns by utilizing data from past vehicle development and smarter use of computer-aided engineering analysis (CAE) tools. Artificial intelligence has significantly improved our comfort, ease, and economic future by providing solutions to daily problems and challenges. Countries worldwide are investing in developing and promoting AI applications in various fields, ensuring a more efficient and economic future for all. This trend is driven by the global effort to overcome challenges and improve daily life. The data-driven analysis highlights the transformative impact of AI on automotive manufacturing and design, highlighting its role as a driving force for innovation and shaping the industry's future. The article highlights how advanced technologies can enhance the automotive industry's efficiency and customer focus, from product development to customer engagement, thereby improving overall operations and activities.
Keywords: Automotive industry, Simulation, Artificial intelligence, Application, Desing, CAE.

1. INTRODUCTION

Design in automobiles involves creating the vehicle's overall appearance and product concept development, often by design experts. Design is crucial for innovation and growth in the automotive industry, with appealing interior and exterior designs being key to introducing new ideas. Artificial Intelligence (AI) is revolutionizing the automotive industry, enhancing manufacturing efficiency and introducing innovative car designs, thereby digitalizing the sector (Pallab, D. 2016). AI is revolutionizing the automotive industry by automating quality control, increasing efficiency in e-fuel production, and improving front wheel design through aerodynamic optimization and wheel weight reduction (Sunu, P. 2017). AI algorithms can also improve performance and energy efficiency in front wheel design by optimizing aerodynamics and reducing wheel weight (Matthias,K. Asutosh, P. Andreas,T. and Dominik,W. 2018). AI is revolutionizing the automotive industry by improving design and automating manufacturing tasks.

2. CAR DESIGN: THE ART OF CREATING INNOVATIVE AND FUNCTIONAL

Algorithms used by AI are revolutionizing car design by analyzing various design options and assessing their impact on vehicle performance and efficiency, thereby reducing the traditional labor-intensive process (Oxford. 2016). AI is revolutionizing car design by enabling manufacturers to create unique shapes and features while maintaining human focus, and optimizing fuel efficiency, top speed, and aerodynamics (Pallab, D. 2016).

3D Printing in the Automotive Industry

The rise of AI in the auto industry has revolutionized manufacturing by enabling the creation of complex parts using advanced technologies like 3D printing. 3D-printed cars, created using specialized materials, offer customization and sustainability but are limited to mass production of fully functional, fully functional vehicles (John, B. 2015).

Processes like selective laser melting and direct metal laser sintering produce metals for critical components, while ceramics are used for high-temperature and wear-resistant components. (Lyudmyla, N).
3D-printing technology enhances automotive efficiency and sustainability, but not yet fully functional cars (Lyudmyla, N). However, Czinger Vehicles unveiled the 21C, the world's first 3D-printed hypercar, capable of reaching 60 miles per hour in 1.8 sec. and speeds of 253 miles (fig 1) (Czinger. 2021).

Figure 1. © Czinger Vehicle's 21C (Czinger. 2021)

The Celestiq, the latest Cadillac model (fig 2.), is the most 3D-printed vehicle by General Motors, featuring 115 structural and cosmetic components, including a massive metal 3D-printed steering wheel trim (Cadillac vehicles. 2020).

Figure 2. GM's Cadillac Celestiq (Cadillac vehicles. 2020)

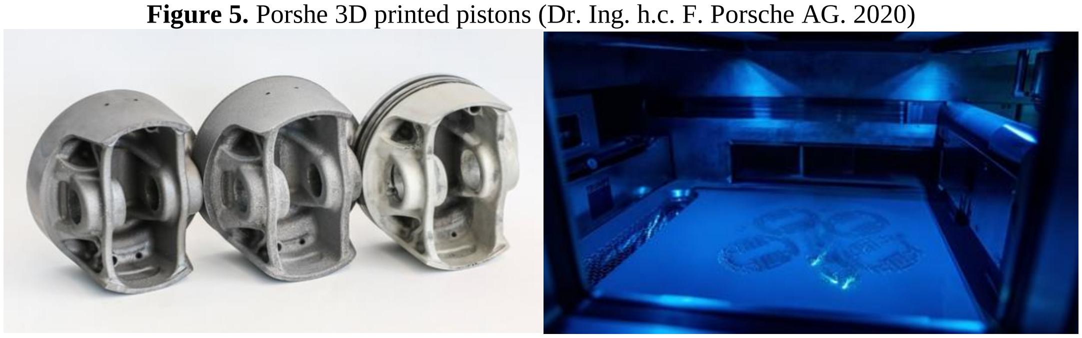
BigRep, a German company, has created the world's first fully 3D-printed electric motorcycle, NERA (fig.3). The prototype, featuring custom seating and airless tires, is not a car but a functional vehicle that surpasses vehicle engineering and production standards. The bike was developed in just 12 weeks. (Natashah, H. 2018, November 26).

Figure 3. BigRep's NERA e-motorcycle features 3D-printed custom seats and airless tires (Natashah, H. 2018, November 26).

Additive manufacturing is being used by luxury car makers like Ford and BMW to design and print parts onsite, reducing lead times and enabling easy experimentation. Volkswagen plans to produce 100,000 3D-printed components annually by 2025 using binder jetting, making it cheaper and more productive. BMW, Porsche, and Ford are leading in 3D printing, specializing in the production of tools, fixtures, prototypes, and vehicle parts. Ford produced the largest metal part in 2019, while BMW uses laser beam melting for luxury car production (BMW Group. 2016) (fig.4) and Porsche uses cooling channels.

Figure 4. BMW components are produced using selective laser beam melting (BMW Group. 2016)

Figure 5. Porshe 3D printed pistons (Dr. Ing. h.c. F. Porsche AG. 2020)



3D Printing Technology: Feedstock

Feedstock, including plastics and metals like steel, aluminum, and titanium, is used in 3D manufacturing to create 3D objects. Aluminum is cost-effective due to its lightweight, strong, and thermally efficient properties, while titanium is ideal for high loads and temperatures in engine components and suspension parts. Its weight, durability, high melting point, and improved surface finish make it ideal for automotive applications.

Figure 6. 3D printed titanium parts. (Juan, C.C.P. 2023, October 20)

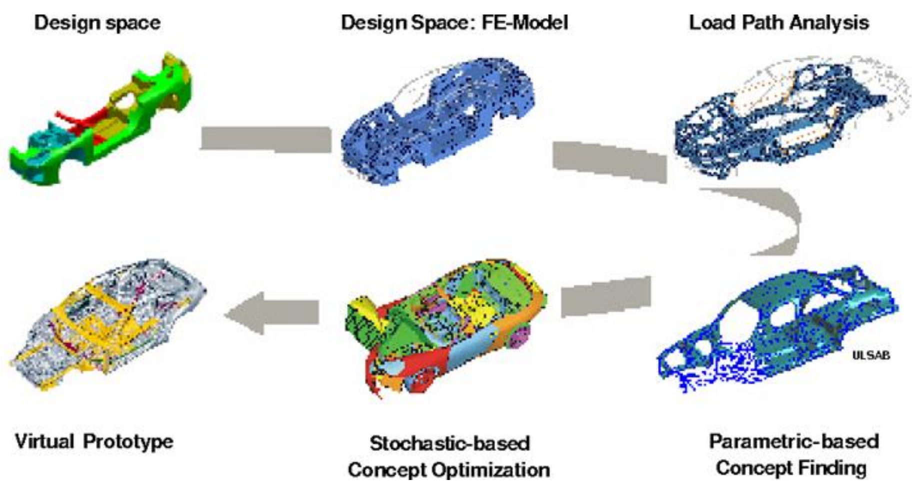
3. COMPUTER-AIDED ENGINEERING (CAE) IN AUTOMOTIVE INDUSTRY

Computer-aided engineering (CAE) tools are used in advanced research and development services for physical modeling. CAE provides analytical predictions to support automotive product designs, showing which method achieves the best performance. CAE can replace laboratory tests on the product by producing numbers or images, enhancing CAD design and predicting results. CAE simulation deals with 3D objects but has a more than graphical function. It should be reliable in predicting engineering variables, making it more than just visualization (Mario, H. Wilhelm, D. Anton & G. Lang, J. 2013).. CAE allows engineers to develop vehicle components on CAD before building prototypes, saving the budget previously dedicated to prototype building and laboratory work. This virtualization process enhances the security, safety, repeatability, and robustness of virtual experiments, ultimately saving automotive companies time and money. AI can revolutionize the 3D simulation of components, engines, wheels, and chassis in real-time, moving from automotive CAE (engineering simulation) to AI-driven simulation, marking the next step in design.

Computer-Aided Engineering (CAE) in Concept Design

Engineering simulation has significantly accelerated the decision-making process for product releases, allowing for product behavior visualization even before production. The concept design can be represented using CAD, allowing automotive engineers to assess products during early design stages for factors like external aerodynamics, thermal and mechanical fatigue, driver security, and comfort.

Figure 7. CAE tools (Herbert, E. 2001)



Computer-Aided Engineering (CAE) in Product Design

Computer-aided engineering analysis (CAE) can aid in the optimization of automotive products during later stages of design, reducing manufacturing costs. It includes applications related to solid mechanical objects (FEA) and fluid effects (CFD), focusing on fluids and thermal exchange.

Finite Element Analysis (FEA) Software

FEA Sofware, or Computer-Aided Engineering simulation of solid bodies, is a widely recognized CAE tool used by automotive corporations to assess the impact of materials, thickness, and shape on performance indicators like crashworthiness and durability, enabling a wide range of engineering use cases. Mechanical applications of FEA are crucial in predicting vibrations, fatigue-resistant parts, and passenger safety during crashes. NVH and Crashworthiness simulations are now integral to automotive design processes, enabling validation and optimization of product performance. The impact of mechanical simulation on industries includes predicting lighter, safer vehicles, noise-inducing engine types, and component cracking due to thermal fatigue. This helps in ensuring the safety and durability of vehicles.

Figure 8. NVH HyperWorks and OptiStruct simulation workflow. Image courtesy of Altair (Jess, L. (2016, June 1)

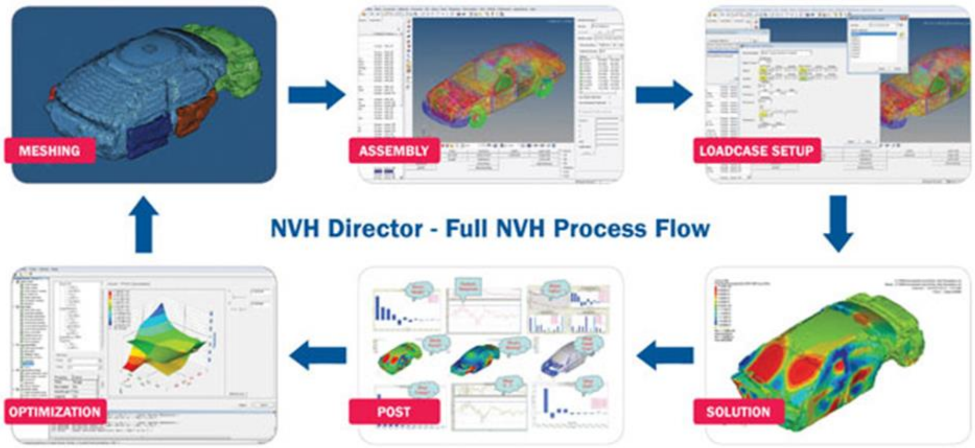
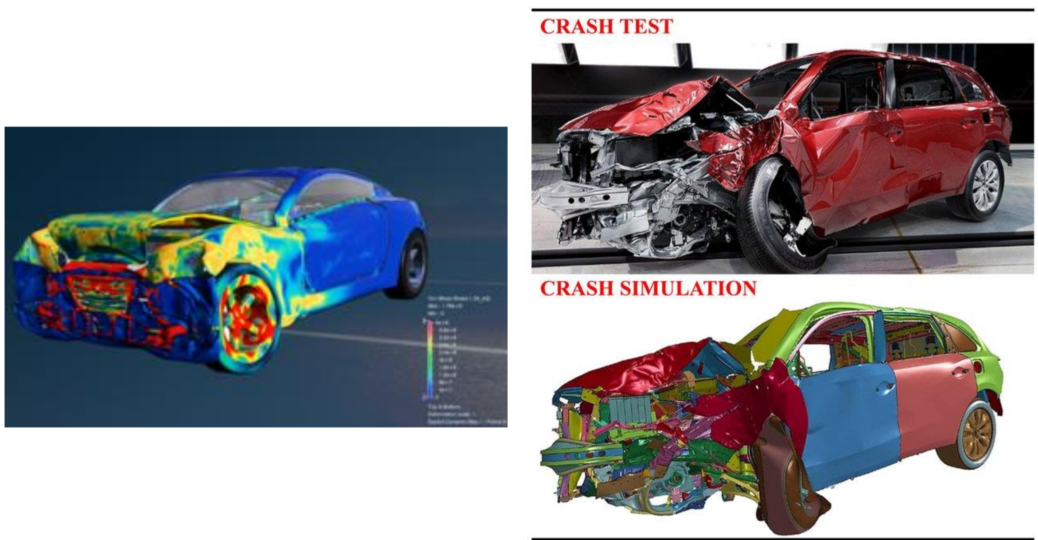


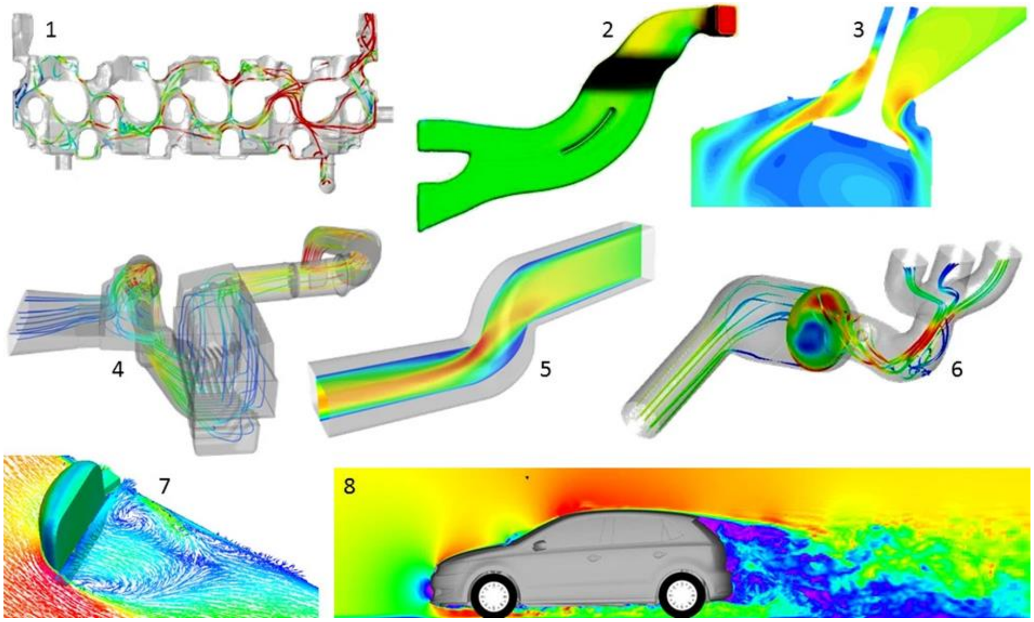
Figure 9. Crashworthiness simulation (Anindya, D. 2019)



Computational Fluid Dynamics (CFD) in Fluid Flow Analysis

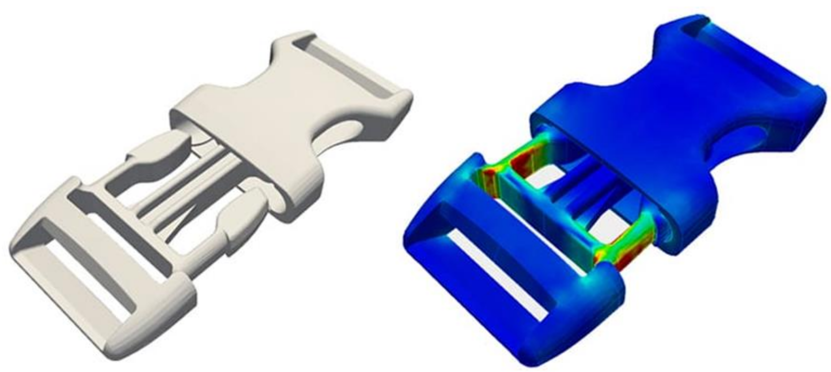
CFD (Computational Fluid Dynamics) is a 3D simulation technique used in engineering to accurately simulate various fluids, including air, gas, liquid, and combination, for both external and internal applications. Computer-Aided Engineering is crucial for automotive aerodynamics teams to assess aerodynamic forces, and drivability during races, and develop new designs. Simulations can predict the wake behind cars, allowing for optimization of drivability. AI will revolutionize this process by predicting the wake behind cars, which can be exploited by subsequent vehicles to overcome air resistance, ultimately improving the overall performance of vehicles.

Figure 10. CFD simulation is a crucial tool in automotive development, used in external aerodynamics (7,8), ducted flow, engine intake ports, water jackets (1), cabin ventilation airducts (2,5), engine intake ports (3), raw air intakes (4), and exhaust systems (6). (Carsten, O. 2014)



CAD and CAE Tools in the Automotive Industries
CAE tools can analyze products' shapes and materials stored in Computer-Aided Design (CAD), with the response time between CAD shape modifications and CAE software feedback being a critical link. A shorter response time leads to more engineering modifications, impacting product innovation and competitiveness. Computed Aided Engineering (CAE) is an analysis software that predicts product functional requirements like durability and energy efficiency, providing feedback on necessary shape modifications. To optimize product development, CAE should be deployed early, eliminating the bottleneck of product engineers with CAD skills not being specialists in engineering analysis. Recently, a solution has been to embed CAE inside CAD platforms.

Figure 11. CAD design of a snap-fit mechanism is depicted on the left, while the simulation post-processing results are shown on the right. (Vincent, Z. 2023, June 2).



4. CONCLUSION
AI is revolutionizing the automotive industry by allowing manufacturers to create unique shapes and features, pushing design boundaries and resulting in more innovative cars. As AI evolves, it will continue to push design boundaries further. Also artificial intelligence (AI) is expected to significantly impact the automotive industry, revolutionizing real-time tools and making CAE simulation more accessible to all Engineering departments (Mario,

H. Wilhelm, D. Anton & G. Lang, J. 2013). AI tools are transforming the simulation industry, enabling companies to transition from open-loop analysis to closed-loop optimization of product performance. This integration of simulations with Engineering and Manufacturing will empower automotive engineers with decision-making tools throughout the product development process, from concept design to final release.

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