APPLICATION OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN CAD/CAM SYSTEMS

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Abstract: Artificial Intelligence is becoming increasingly sophisticated in learning and problem solving. As artificial intelligence grows increasingly intertwined with software and technology, it is only logical that such beneficial technology will surely make its way into CAD/CAM systems and become an integral and vital part of them. Hence, the new CAD/CAM systems will incorporate some sort of 'intelligence' (AI) or machine learning in them. AI drastically cuts down the time for operations like designing or modifying the design for a new or existing model otherwise performed by a human operator. It is also believed that in the future it will completely replace human operators outperforming them in almost every function. This paper examines the status of AI in CAD/CAM systems and presents the pros and cons of its implementation.

Keywords: artificial intelligence, machine learning, CAD/CAM systems.

Introduction

CAD/CAM or computer-aided design/computer aided manufacturing have started in its infancy as s 2-dimensional design and drawing software. Nowadays CAD/CAM software systems are used for the design and manufacture of prototypes, finished products, and production runs. Furthermore, CAD/CAM systems cover a wide range of applications from drawing blueprints of simple models to complicated 3D models and design tools.

Additional to that, inclusion of attribute software information in database assigning physical meanings to the graphical representation of components, etc. has made CAD/CAM a competitive factor in the increasingly competitive market [10]. CAD/CAM has enabled new methodology in design and manufacturing such as coincident engineering or simultaneous engineering for a reduction in lead-time [9]. Therefore, a reduction in product lead-time is a significant competitive advantage [9]

The introduction of artificial design knowledge and assistance in CAD/CAM software will allow distribution of sophisticated design and manufacturing assistance and knowledge to all its operators. This process will considerably improve the overall design performance and drastically reduce design time. The Artificial Intelligence sector has received an explosive amount of attention and resources, the reason for which lies in how effective machines can be. It can replace massive amounts of manual trial and error, as well as labor, with exact and precise actions. Not only that but AI can also point out existing mistakes, which will reduce the time, and effort specialists put in the making of a quality product. Artificial intelligence and machine learning also finds applications in wide specter of fields including military vehicles and systems [1, 8].Further implementation of AI is made in the fields of satellites and environmental monitoring [5,6]

The importance of AI in CAD/CAM

Currently some of the best CAD/CAM software on the marked provide the operator with a wide range of powerful features such as: design optimization, analysis function and design guidance. Older CAD/CAM systems require the designer to consider not only the designing aspects but also the manufacturing ones, as they also need to be optimized. Hence, the designer needs to have both design and manufacturing knowledge and experience that enables him to design effectively. Therefore, there is a need to incorporate the design and manufacturing concepts as well as the experience of a good designer in CAD/CAM. Currently AI has reached a point where it can easily outperform human engineers in many fields of expertise including the design and manufacturing processes [7]. With the above-mentioned features incorporated in CAD/CAM systems, they can assist the operator "intelligently" in decision-making and design optimization [10].

AI or sometimes referred as machine intelligence is a software technique that programs use to exhibit behavior normally identified with human intelligence [12]. A typical AI analyzes the environment and takes actions which maximize its chance of success. [11] The intended utility function (or goal) can be simple (For example if the AI wins a game of Go it is a considered a success or a "1", if it does not it is considered a failure or a "0".) or complex (Repeating and improving mathematically similar actions to the ones that succeeded in the past.) Goals can be explicitly defined, or induced. If the AI is programmed for "reinforcement learning", goals can be implicitly induced by rewarding some types of behavior or punishing others [11]. Knowledge based systems however rely on factual knowledge and heuristics rather than clever programming, although they posses both expertise and conceptional information. Expert knowledge systems contain three basic components, namely control mechanism, knowledge base and inference mechanism [12]. The main difference between this type of systems and conventional systems is that the aforementioned modularize the data, inference mechanism and controlled mechanism. This process allows for changes in the system by just modifying the knowledge base, thanks to which it grows as the experts behind it use the software, which in turn continues to add information in order to optimize performance. Therefore, incorporation of knowledge base feature into CAD/CAM systems is very important and will be a significant advantage [10].

Neural networks on the other hand are very different from knowledge-based systems. Artificial neural networks (ANN) or connectionist systems are computing systems that are inspired by, but not identical to, biological neural networks that constitute animal brains. Such systems "learn" to perform tasks by considering examples, generally without being programmed with task-specific rules. This is a very important tool for future CAD/CAM systems as it can serve as a "design suggestion tool" where the designer is uncertain. Such system can recommend new and innovative design solutions to the designer.

1.1. AI features in current CAD/CAM software systems

Different manufacturers have implemented the perspective of AI in CAD/CAM in different ways. The leading CAD/CAM software developers have already implemented or are planning to implement different AI driven tools in their software products. The purpose of this section of the paper is to review innovative AI systems and solutions in leading CAD/CAM software products. In the software products, the AI is implemented in a form of a tool for the operator to use. The company Dassault Systems with their software product SOLIDWORKS is an example of a company that already implemented artificial intelligence (AI) is featured within its software by folding AI into SOLIDWORKS CAM 2018 and Xdesign 2019.

SOLIDWORKS xDesign combines CAD modeling and cloud collaboration using a web browser (Fig 1). SOLIDWORKS xDesign incorporates ease of use with innovative design methodologies and cloud collaboration. The ease of use comes with the ability to access the cloud-based software from your browser given the operator has and login credentials. This allows for near instantaneous deployment, allowing companies to quickly add to their CAD portfolio as and when the need arises [13]. An AI sys-

tem in the Design Guidance function of the software. Where the AI guides and assist the operator, it generates solutions during model design. Design guidance is capable of "suggesting solutions for your design challenges" where the AI assists the operator during the design phase. Xdesign is an AI based tool in SOLIDWORKS that utilized design guidance to help engineers to create the best suitable shape for a part that best suits the part's given tasks. The designer inputs the information concerning the constrains and loads on the model and out of this data the AI creates the part geometry automatically [15].
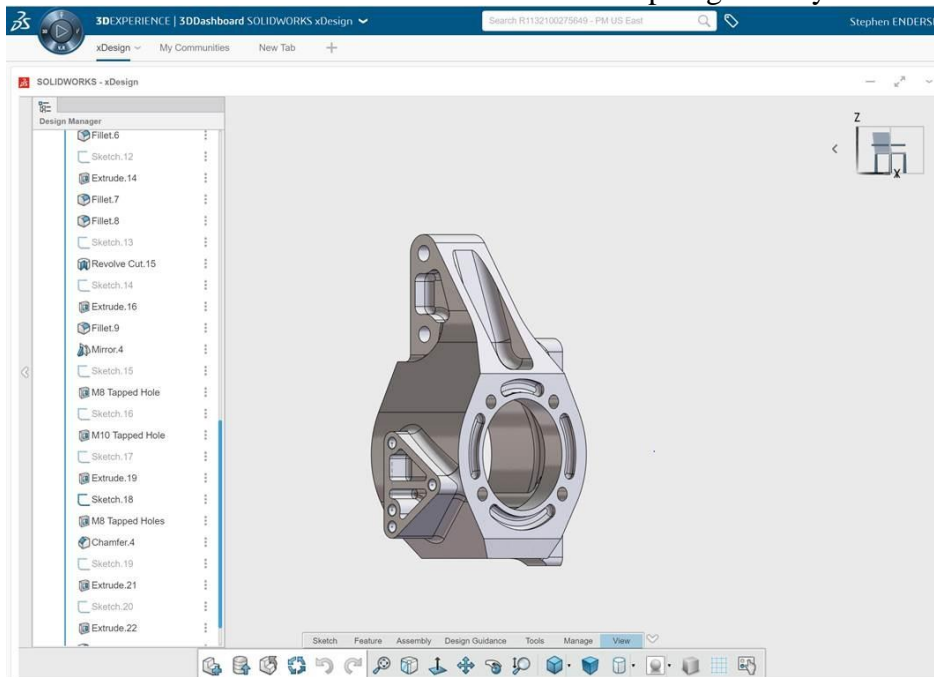

Figure 1: xDesign web based interface [15].

Exalead OnePart – One part also developed by Dassault Systemes is an AI driven software platform. OnePart it capable of recognizing similarities in different models and checks if the part is being duplicated. The tool can be very useful in cases of company reorganizations, mergers, global projects and innovations, as it provides a set of applications to classify company assets, identify master parts for reuse, and ensure that engineering selects the preferred part without recreating a part that already exists in the design library. The tool also allows the operator to find and use existing parts, 2D and 3D designs and related product and manufacturing documentation to minimize duplication (Fig 2).
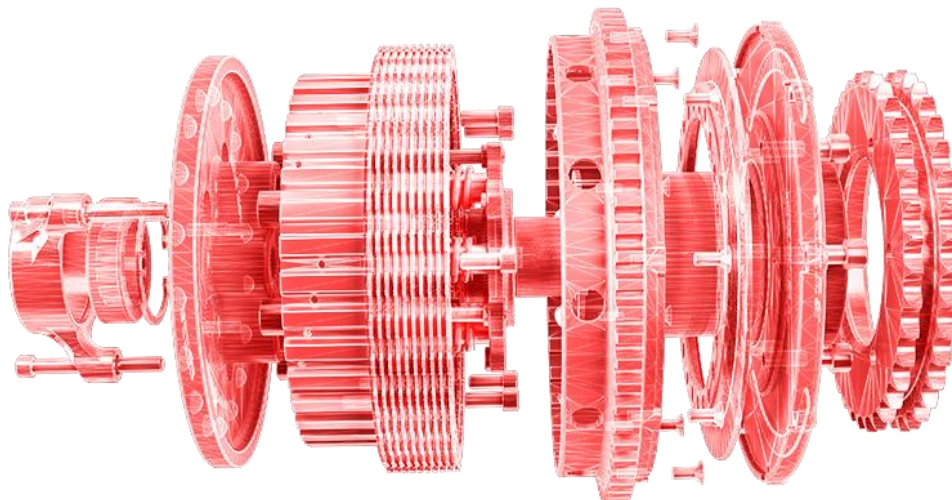

Figure 2: *OnePart* is capable of recognizing very detailed and complex parts and assemblies.

The tool is also capable of revealing all the IP assets of the user without migrating them into the 3DExperience platform. The tool only migrates the relevant data (the data that is not duplicated) lowering costs and speeding up the migration allowing for functions as reusability and standardization increasing engineering efficiency.

SOLIDWORKS CAM – SolidWorks Cam powered by CAM Works from HCL Technologies. The AI CAM tool automatically generates the manufacturing toolpath after the design. This CAM software used the CAD models as it generates the toolpath for the computer assisted manufacturing machine (Fig 3). Engineers and designers who use CAM can evaluate designs earlier in the design process to ensure that they can be manufactured, thus avoiding product costs and delays [15]. Essentially SOLID-WORKSCAM is capable of capturing the design strategies while also recognizing the features and types of materials. These capabilities allow the tool to create a CAM solution that is completely automated.
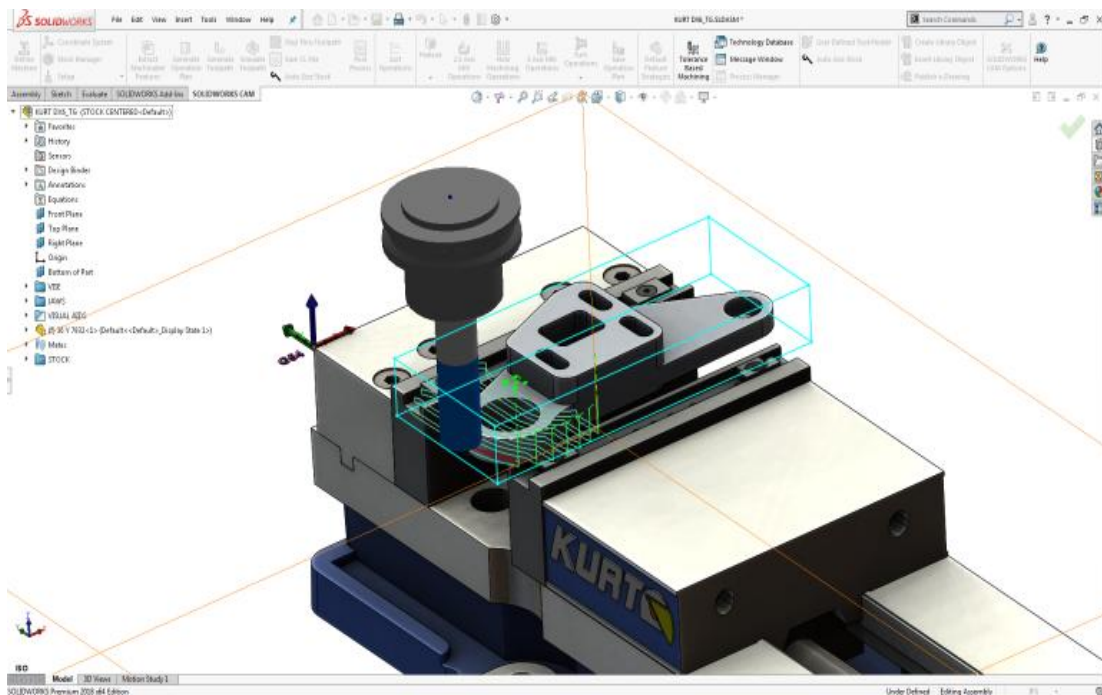

Figure 3: SOLIDWORKS CAM automatically generating the manufacturing toolpath[16].

SOLIDWORKS CAM is also capable of understanding the tolerances within a given part file and change machining strategies accordingly. This helps maintain consistency when programming and saves time by using information that is already created in a 3D model. The process also reduces the chance for error and the possibility of missing a dimension on a traditional drawing [16]. Another capability of SOLIDWORKS CAM is the VoloMill technology provided by CAMWorks [16]. This science-based toolpath allows users to increase output while extending tool life and reducing machine wear with the ability to be used on conventional machines with standard tooling. Because CAD and CAM act as one system within SOLIDWORKS CAM, it makes CAM easier and more straightforward to the software's users. The vendor's tool opens the way toward making CAM ubiquitous on engineers' desktops, much in the way that 3D CAD is now more or less used across an industry that once relied on 2D drawings.

Artificial intelligence Denoiser - Another AI tool implemented by Dassault Systems is an Artificial intelligence Denoiser. Created by INVIDIA the AI Denoiser utilizes machine learning and artificial intelligence, studying thousands of images and sample project files (Fig.4) [14]. The AI Denoiser allows Visualize to anticipate and magically eliminate noise in images increasing quality results 10x faster [12]. Completing any Visualize render job 10x faster is truly game changing. This could be a still image, animation, camera fly, exploded view, new 360-VR content, etc – all 10 times faster than how it is cur-

rently rendered today. Visualize is already known for fast rendering, but this AI Denoiser takes render speeds to another level. This truly makes Visualize the fastest and easiest to use visualization tool available on the market so far. The AI Denoiser is also capable of working both in Fast and Accurate render modes with different render settings. AI and machine learning also finds a large application in geographical transformation of images and image analysis [2, 3].

Figure 4: The effect on the Denoiser tool on an image. On the left, the tool is on removing the noise from the image [4].

Generative Design – is an innovative approach using AI developed by AUTODESK. Generative design is a form-finding process that can mimic nature's evolutionary approach to design. Computer scientists have found ways to aid the building design process. It usually starts with clearly specifying the design goals and then explore innumerable possible permutations of a solution to find the best option. It becomes clearer with an example (Fig.5). An Autodesk team in Toronto has moved into a new building, which was designed using a new design process. Researchers used generative design to assist them in finding the ideal design for the building that met all their needs. The process began with understanding all the parameters that would be important to the residents of the office building — adjacency preference, work style preference, buzz, productivity, daylight, and views to outside [4]. The gathered data is then fed into a computer system that understood these design parameters along with the requirements of the physical location. The algorithm then produced several designs, which fit all these needs that the architect can pick from to match the style and other needs. Since this process was very quick, it was easy to make the design experience iterative and work and reform the final design based on several conversations [4]. Generative design could also raise the efficiency and economy of the overall development process by producing designs that improve scheduling and coordination between multiple stakeholders.
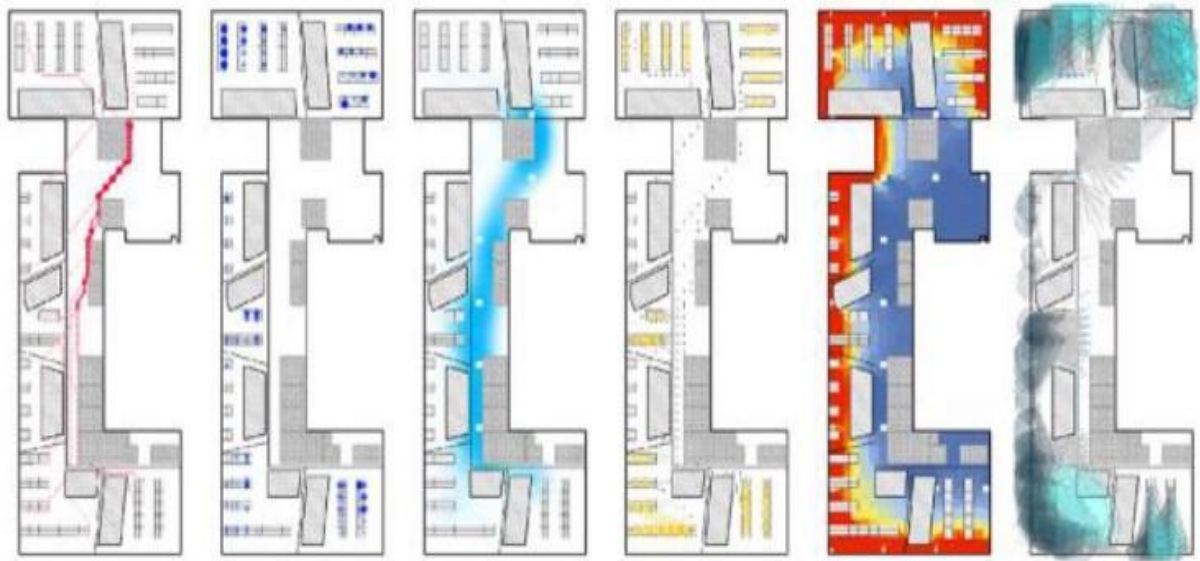
Figure 5: From left to right, each plan is overlaid with a simulation of the following parameters: adjacency preference, work style preference, buzz, productivity, daylight, and views to outside [4].

Conclusion

Artificial intelligence and machine learning technology is growing even more sophisticated every year. Different companies are implementing even more AI and machine learning driven tools in their software products. These tools greatly help engineers in decision-making and problem solving while also increasing their performance and ease of work. In the coming years more and more companies will create their own AI tools, for example ones whose purpose is quality control or ones that enhance and expand model based definition. Full AI driven automation is also an area where AI will play the leading role in future advancements. Judging from the increasingly fast development of AI and machine learning, in a few years' time we might see AI performing all the engineering and modeling work while the creative thinking will be left for the engineer. AI and machine learning are definitely here to stay and they will continue to improve and impress with their features in CAD/CAM systems. Considering the amount of investment and change, which the AI sector has, underwent, it is safe to assume that it is indeed worthwhile. Creating and developing new technologies has always been the key way to stay ahead.

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