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A BRIEF HISTORY OF CAD AND RELATED TECHNOLOGIES

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Abstract: *Computer-Aided Design (CAD) evolved from its origins in late-1950s computer graphics to today's integrated digital-manufacturing environments. Initially used for simple 2D drafting, CAD advanced in the 1960s with the advent of 3D modeling, enabling the creation of complex surfaces and driving adoption in the automotive and aerospace industries. Subsequent breakthroughs—solid, feature-based and parametric modeling—spurred market growth but also delayed uptake of newer approaches like direct modeling, partly because established users favored familiar methods and partly because newer techniques remain under refinement. In recent years, CAD innovations have been absorbed into broader frameworks such as Computer-Integrated Manufacturing (CIM), Product Lifecycle Management (PLM) and digital manufacturing, all of which leverage emerging technologies: artificial intelligence, generative design, cloud computing, real-time simulation, augmented reality and virtual reality. Drawing on both literature and extensive practitioner experience, the paper offers a concise historical overview and outlines current CAD trends.*

Keywords: *Computer-Aided Design (CAD), 3D Modeling, Parametric Design, Direct Modeling, Product Lifecycle Management (PLM), Generative Design, Digital Manufacturing.*

1. INTRODUCTION

Computer-aided design (CAD) software has come a long way from automated drafting applications to highly integrated and versatile solutions. At the end of the 1950s, the progress of computer graphics facilitated the early use of CAD for graphical representation of geometrical figures and symbols. 2D CAD drafting programs emerged next, but the real CAD, in context of geometrical modeling, was born in the 60s with the invention of 3D modeling software. The key advance in 3D CAD was indisputably the possibility to create complex 3D surfaces.

3D modeling software was primarily developed and used in automotive and aerospace industry. Major breakthroughs that facilitated the creation of flexible CAD models and user-friendly CAD systems were the inventions of solid, feature-based and parametric 3D modeling. Those ideas had an enormous influence on the growth of CAD software market and industry applications. This, to an extent, slowed down the adoption of new concepts that emerged later, such as direct modeling. It may be argued that, aside from engineers being used to well-known ideas, the new ones have still not been perfected to a level that would allow them to take over the market.

The new inventions in CAD are finding their specific places in a broader concept of CIM, PLM, digital manufacturing etc. The mentioned paradigms are related to integration and digitalization of the whole product lifecycle, which increasingly relies on new technologies such as artificial intelligence (AI), generative design, cloud computing, real-time simulation, augmented reality (AR), virtual reality (VR) and more.

This paper aims to bring a brief history of CAD systems, based on the available literature and the extensive experience of the authors in application, customization and teaching of CAD systems.

2. BRIEF HISTORY OF CAD

Geometric modeling in CAD programs has evolved through a series of stages during which the geometric presentation of physical objects and/or design concepts have been improved. This brief history of CAD is mainly related to geometrical modeling and organized according to decades and key breakthroughs.

2.1 The beginnings of CAD

The first software with CAD-like features was in fact CAM software PRONTO, developed in 1957 by Patrick Hanratty. The expression “Computer-aided design” was coined by Douglass Ross, a computer scientist who greatly contributed to development of computer graphics and invented numerical control language APT. Nevertheless, the title “father of CAD” is usually attributed to Ivan Sutherland who in 1963, within his PhD thesis at MIT, developed Sketchpad (Figure 1). Computer graphics based on wire models was invented at MIT at the beginning of the 1960s, but Sketchpad was the first software that utilized interactive graphics for engineering design and drafting, introducing CRT monitor and light pen as peripheral devices that will later be extensively used by various software [1].

Figure 1. Sketchpad user interface [2][1]

2.2 Early CAD systems and CAD related inventions in the 1960s

1960s were the era of in-house CAD systems, as the computers capable of CAD were very expensive and voluminous. In 1963, one of the first industrial CAD systems "DAC - 1" (Design Augmented by Computers) was created (General Motors and IBM). The other notable systems were CADD by McDonnel-Douglas (1966), PDGS by Ford (1967) and CADAM by Lockheed (1967), which were all basically 2D drafting applications [3].

During the 1960s, a series of inventions took place that were very important for CAD. The most prominent ones in the hardware area were the tablet, as a cheaper and more ergonomic alternative to light pen, improved graphical displays, dedicated graphics hardware, low-cost terminals and microcomputers. In the software department, the techniques for hidden line display and shading of isometric displays were very important for later CAD software development. New advances were also present in data management and application programming, which were specific to CAD [1]. During this period, it became obvious that CAD systems would be the future of engineering design, as they were already bringing great savings in design efficiency and comfort, especially concerning repetitive activities.

2.3 1970s: commercial CAD systems and the beginning of 3D modeling

The 1970s saw the creation of the first commercial CAD software. The pioneers of CAD industry, formed in 1969, were Applicon (producing AGS) and Computervision (creator of CADDS). Soon after them, Auto-trol Technology, Calma and M&S Computing (Intergraph) were formed. They all used microcomputers and storage tube displays, as opposed to existing in-house systems that worked on mainframe computers and graphics terminals, which was an important step for commercial use of CAD software. Nevertheless, the early commercial software was still 2D and the companies were predominantly proprietary hardware producers that created software to raise their hardware sales [1]. Important place in CAD history is reserved for the software called Automated Drafting and Machining (ADAM), developed by Patrick Hanratty. Designed to function on every machine, it is still a basis for a large percentage of existing CAD software [4].

The 1970s are perhaps most important for the birth of the capable 3D modeling software, and it is when the key developments in evolution of geometric modeling took place. The early CAD systems were the emulation of 2D drafting, and the transition to 3D started by representing 3D geometry via wireframe models – points connected by lines, which are very limited in representing solid geometry [5]. The development of surface modeling methods was initiated by aircraft and automotive industries, to reduce the time and cost of design and manufacturing of typically complex sheet metal parts. The surfaces used in these industries are typically defined by several cross-sections or control points.

France and USA were the major centers where the underlying mathematics for 3D curves and surfaces used in CAD was developed. The first scientist to develop a mathematical approach to defining surfaces characteristic for the automotive industry was Paul de Casteljau in 1958 [6]. He was employed at Citroën that, aiming at keeping the competitive advantage, did not allow publishing of his work until 1974. In the meantime, other scientists developed alternative, largely similar, techniques for surface definition. Probably the best known of them is Pierre Bézier who, working for Renault, developed the well-known Bézier curves and surfaces [6], which by 1972 were used in the factory within the UNISURF application for 3D modeling and milling. UNISURF later became an important part of CATIA software. If the work of de Casteljau were published earlier, some of the credits for developing the mentioned theory would officially be his. Also important is the role of Steven A. Coons, at the time working at MIT, who developed the mathematics describing generalized surface segments, called Coons patches [7]. The underlying idea of Coons patches served as the basis for some of the most important surface definitions commonly used in CAD, like B-spline surfaces, non-uniform rational B-spline (NURB) surfaces, and others [8].

2.4 The invention and adoption of solid modeling

Mechanical CAD, of course, would not be as powerful as it is now without solid modeling [5]. Solid models are the only geometric models that are "aware" of both their boundaries and their volume, thus they allow for arbitrary operations to be performed on them. Research on solid modeling started independently in the end of 1960s and in the beginning of 1970s, in a significant number of research groups. Probably the most important of these was The CAD Group in Cambridge. In 1973 those groups met for the first time at PROLAMAT conference in Prague and started the discussion on the topic. Both B-Rep and Constructive Solid Geometry (CSG) model representation technologies were presented by different researchers [1]. Nevertheless, the appearance of the first usable solid modeling software had to wait for the technology to mature and the computers to get more powerful. This started to happen at the end of the 1970s and became reality in the late 1980s. The first commercial solid modeler is often considered to be MAGI's SynthaVision, launched in 1972.

The explosion in the creation and use of quality CAD software happened in the 1980s. The enabling technologies, both software and hardware, were mature enough to enable rapid expansion of CAD programs offering solid modeling. The new 32-bit minicomputers and color raster technology emerged in the beginning of the 1980s. Later in the decade engineering workstations appeared. This was a very important change for designers: the price of a CAD seat became lower and software performance more predictable, because the resources became dedicated to specific designers. From 1981 to 1983 three important software packages capable of solid modeling were released: UniSolids by Unigraphics, CATIA V1 by Dassault Systèmes (as CADAM add-on) and I-DEAS by SDRC. In 1986 Intergraph launched I/EMS, the first software that combined B-REP solids, only NURBS (Non-rational B-splines) based geometric entities and object-oriented database. Personal computers appeared in the 1980s but did not become powerful enough to support solid modeling before the next decade.

2.5 The revolution: introduction of parametric, feature-based and associative modeling

The revolution in CAD came in 1987 with the release of Pro/ENGINEER by Parametric Technology Corporation (PTC), the first commercially available parametric and associative solid modeler. It also perfected the feature-based approach to modeling (Figure 2). The brain behind the software was dr Samuel P. Geisberg, Russian emigrant born in St. Petersburg by vocation professor of mathematics. The ease of making and promoting design changes in Pro/ENGINEER very quickly fascinated potential users, and the product rapidly took off, creating large profits and managing to be launched in two updated versions each year. Other software vendors were very quickly pushed to try and embed the same technology into their software. This was not easy, as Pro/ENGINEER was built for the new functionality from the core and the other software was not. Nevertheless, as the early versions of Pro/ENGINEER were not so complete and capable in some areas like surface modeling, drafting or engineering analysis, PTC was not taking a lot of seats from main players like CATIA, UniSolids or I-DEAS. Rather, Pro/ENGINEER commonly replaced installations of CADDS from Computervision, and it often appeared as the first solid modeling software in companies working in traditional way or using 2D CAD software.

Figure 2. A parametric feature-based model of pneumatic tire created in Pro/ENGINEER [9]

In the beginning of 1990s CAD software was run on UNIX workstations and major CAD software vendors were IBM-Dassault Systèmes, EDS (Electronic data systems) - Unigraphics, Parametric Technology Corporation and SDRC [3]. Eventually, they all offered parametric, feature-based solid modeling capability in their CAD software, with various levels of success. In the beginning, the others were behind Pro/ENGINEER in parametric modeling and associativity, but over time they caught up and started to offer some new original functionality like variational modeling.

As much as parametric design is advantageous, it requires the model to be history-based, i.e. that after each change model features are rebuilt in the order in which they were built. Therefore, each model feature becomes dependent on some of the others, which it references. This is called parent/child relationships, and the ordered set of features is called history tree (Figure 3). If some of the parent features are deleted or changed, the model may fail to regenerate or unexpected changes may occur leading, in extreme cases, to the need for the whole model to be rebuilt. This is why history-based models must be carefully planned before creation. Some CAD vendors, especially SDRC, stated that using their programs helps avoid such occurrences. SDRC based its software on so-called "variational design", by which the model needn't be always fully constrained (Figure 4).

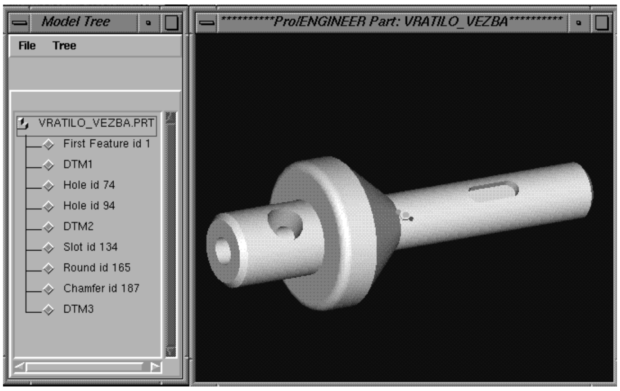

Figure 3. Solid model and history (model) tree in Pro/Engineer 20 (1999)

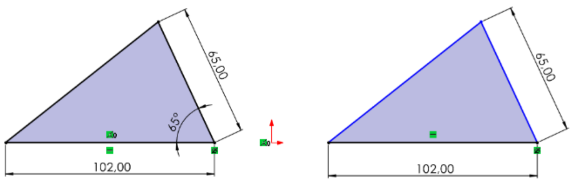

Figure 4. Fully and partially constrained sketches

2.6 Appearance of commercially available CAD kernels and mid-range CAD software

A geometry kernel provides the fundamental capabilities required to construct, modify, and evaluate both geometric entities and solid models. An important development took place at the end of the 1980s, when two solid stand-alone modeling kernels were released: ACIS by Three-Space Limited and Parasolid by Unigraphics. Together with later expansion of personal computers, this opened the door to so-called mid-range CAD solutions that appeared in the 1990s.

When, in the 1990s, both experienced companies and start-ups began offering mid-range solutions, these had the following characteristics: running only on MS Windows based PCs, using existing kernels and other component software technology, enabling design and leaving other functionality to be developed by third parties, and costing much less than high-end software. The trend started in the 1980s with AutoCAD by Autodesk, and at the time PCs were capable only of 2D CAD. After 32-bit Windows and Intel Pentium became available in 1994, solid modeling on PCs became feasible. Immediately after, in 1995, SolidWorks (Figure 5) became available and made a single most prominent appearance after Pro/ENGINEER. It generally offered only a part of Pro/ENGINEER's functionality, but it was created from the start as a native MS Windows application, with Windows-like user interface that in preceding years had become very popular with PC users. In the beginning, SolidWorks targeted new users of solid modeling software, transitioning from 2D CAD, and users of high-end CAD that did not need to pay for all the functionalities.

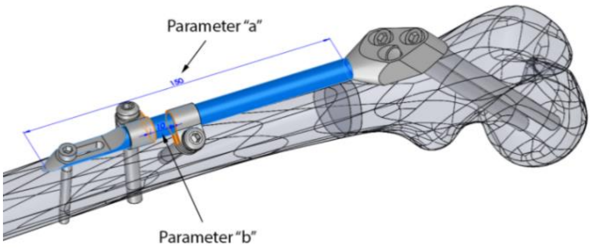

Figure 5. A model of orthopaedic fixator created in SolidWorks, with parameters used in structural optimization denoted [10]

Major software vendors, especially PTC, did not immediately see the great potential of mid-range solutions, treated them as low-end software and did not make a timely start in creating similar ones. Some have realized it earlier than others and tried to get on the train. Another mid-range software, very similar to SolidWorks, was created in 1996 by Intergraph and called Solid Edge. Autodesk entered this market with Mechanical Desktop, which shortly became the mid-range solution sold in most copies. Although this software lacked the quality of SolidWorks and SolidEdge, it was probably the popularity and wide use of AutoCAD that pushed its sales. PTC tried to sale a stripped-down version of Pro/ENGINEER, a bit unfortunately called Pro/Junior, without much success. Whole situation ended with two big acquisitions in 1997, when Dassault Systèmes acquired SolidWorks and EDS-Unigraphics bought Solid Edge. In 1998, Dassault Systèmes released CATIA v5, which was naturally supported on Windows, and in 1999 Autodesk started shipping Inventor, which was based on ACIS kernel and a much better solution than Mechanical Desktop. Eventually, Dassault Systèmes acquired ACIS in 2000, which concluded a series of acquisitions that could only mean that the big players wanted to keep control on CAD market, by putting boundaries on mid-range software development and its target customers. To end the era of “big four” (Unigraphics, I-DEAS, CATIA and Pro/ENGEINEER) and the expansion of mid-range CAD, EDS (which became UGS) acquired SDRC in 2001. In subsequent years I-DEAS technology was built in EDS-Unigraphics, and it ceased to exist as an independent software solution. Since then, a list of major CAD software providers has not changed a lot, as any subsequent technological breakthroughs mainly resulted in the acquisition of smaller companies by big software vendors.

2.7 2000s: a calmer period, PDM and direct modeling

Most of the technologies that are still predominant in current CAD systems were established by the end of 1990s. In 2000s the focus shifted to making CAD software more user-friendly and to integrate it into PLM solutions with wider functionality.

The most important novelty related to geometrical modeling in CAD software was the reinvention of direct modeling. In 1992, Solid Designer by CoCreate introduced the concept of dynamic modeling by which no history tree was needed within a solid model, but the geometrical entities could directly be created and edited [11]. This was enabled by using solid modeling kernel ACIS by Spatial, which featured so-called “local operations”. Nevertheless, direct modeling had to wait for quite a long time to become popular, i.e. until in 2007 a product called SpaceClaim was launched. The software offered direct modeling and editing of geometrical elements like surfaces and edges by moving, pulling, filling etc. (Figure 6).

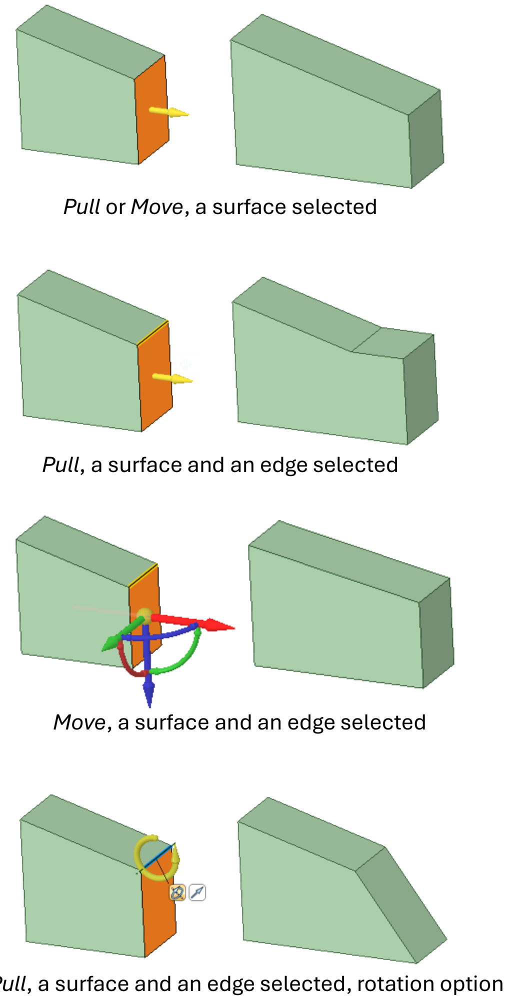

Figure 6. Results of application of pull and move operations in SpaceClaim, depending on geometry selection

SpaceClaim had practically the same functionality as Solid Designer, but the software was Windows-like, built from scratch and well marketed. It was also clearly stated that direct modeling was most useful in preparation of FEA models and CAM models. Moderate edits on existing models, especially if they do not contain model history records and/or were built by someone else, were much easier using this technology. Bearing this in mind, it is no wonder that SpaceClaim was later acquired by FEA software vendor ANSYS and became its default solid modeler.

In the late 2000s, developers of feature-based CAD software were in a hurry to enable direct modeling in their products. In 2008, NX (ex-Unigraphics) and SolidEdge, both UGS products, started to offer a new tool named Synchronous Technology, while SolidWorks used Instant 3D technology. In the same year, direct modeling was included in CATIA V6, while in 2009 Autodesk started to offer Inventor Fusion Technology. Soon direct modeling became available in Pro/ENGINEER, who acquired CoCreate and built its direct modeling technology in its rebranded product Creo, namely in a specific version called Creo/Direct. As a result of direct modeling integration, some of the CAD solutions offered a new possibility, hybrid modeling, where direct editing operations are available in parallel to history-based modeling and often present in model tree as separate entries. Description and comparison of related technologies may, for example, be found in [12] or [13].

2.8 2010 – 2025: integration of the latest IT technologies into CAD systems, improved ease of use and teamwork

Arguably, there have not been any revolutionary discoveries in geometric modeling since 2010. Variational modeling is being further developed to better support history free CAD models, i.e. to try and establish efficient and robust geometry constraining methods in 3D, similar to the ones used in 2D sketching modules of CAD programs [13]. Considerable effort has been made to integrate the latest IT technologies into CAD systems, to make them more efficient, intuitive and user-friendly.

One of the current trends in CAD is the use of cloud-based systems, where computing resources — servers, storage, databases, networking, and software — are available on-demand over the Internet. For CAD, this brings advantages such as working anywhere from any device with internet connection; quick deployment – no installation and steep learning curve; fast access to new software features; easy tracking of changes; real-time collaborative editing; reuse of shared content; or data security and projects scalability [14]. The product that probably meets the previous criteria best and can be characterized as cloud native CAD is OnShape (Figure 7). It was launched in 2015 by the company of the same name, including two former SolidWorks CEOs, and then acquired in 2019 by PTC. One of the early promoters of cloud technology is also Autodesk's Fusion. According to our experience, it still functions better as a stand-alone application than as an in-browser CAD solution, but it strongly relies on could technology for wider functionality, such as data storage, collaboration or generative design. Autodesk Fusion is currently a common choice of smaller companies or individuals who require a solid set of design and manufacturing features for a moderate price.

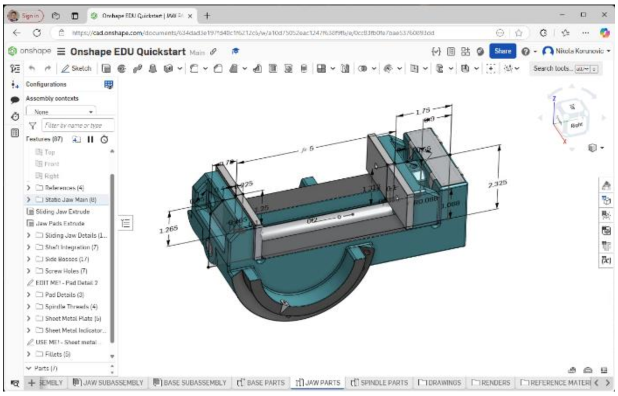

Figure 7. OnShape user interface, functional in arbitrary Web browser

Generative design is a process focused on exploring design possibilities. Generative design tools require the input of design objectives along with specifications such as performance or spatial needs, materials, manufacturing methods, and budget constraints. The software quickly produces design options by examining many variations of a solution. With each iteration, it assesses new concepts to identify successful and unsuccessful outcomes [15]. Based on continuous evaluation and design comparison, iterative optimization is carried out until the recommended solutions are identified. In addition to topology optimization techniques, generative design uses optimization algorithms and AI. Enabling generative design in CAD software is currently an important priority for software vendors. Successful examples of generative design tools are Autodesk Fusion (Figure 8), PTC Creo, Siemens NX, Solid Edge or Dassault Systèmes CATIA.

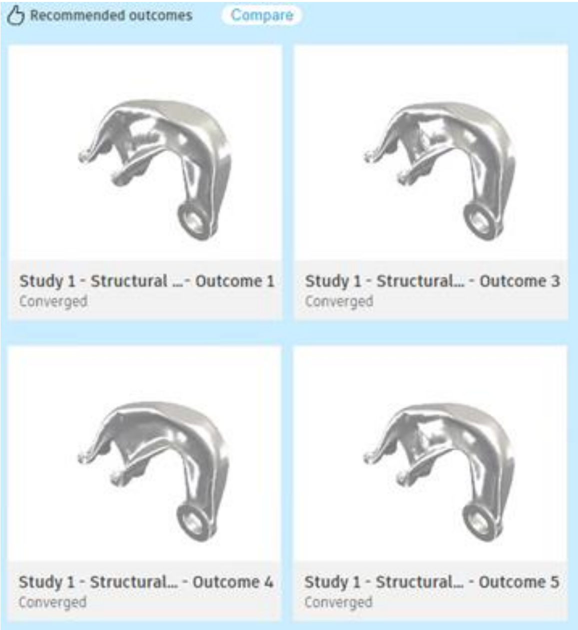

Figure 8. Outcomes of generative design study in Autodesk Fusion

Utilization of AI is currently a largest trend in software development, and it naturally finds its place in CAD. The application of AI in CAD is not a new idea. The potential of applying AI in intelligent design was recognized all the way back in 1965 by Mann [16] and later explored by many researchers and software vendors. The latest developments in AI have only accelerated its use and made it more common. One of the important applications of AI in CAD is within generative design. Current applications also include automated design generation, error detection and correction, personalized workflows, generation of CAD models from text prompts [17] or Building Information Modeling (BIM) [18].

Figure 9. Parametric CAD model created based on text prompt in Zoo Design Studio

For parametric CAD models, it is often advantageous for their sketches to be fully constrained—both dimensionally and geometrically. Such fully defined sketches make the resulting model more flexible and robust, permitting dimensional edits and error-free rebuilds. Zhou and Camba. [17] review multiple LLM (Large Language Models)-based systems that automate the generation of parametric sketches or complete partially drawn ones. All these systems accept text or vector sketch input, and some also process raster sketch images, substantially reducing the time required for sketch creation. Beyond 2D sketches, 3D CAD models can be produced from user text prompts (see Figure 9), hand-drawn sketches, point clouds, or a combination of these inputs.

According to Zhou and Camba, research in 2021–2022 was evenly divided between 2D sketching and 3D modeling, but publications on 3D model generation have risen in 2023 and 2024, signaling a shift toward more intuitive parametric 3D modeling workflows.

Implicit modelling is an innovative technique for creating parametric 3D models (see Figure 10) in which a solid is described by a single mathematical function rather than by explicit topological elements (surfaces, curves, edges, etc.). In this method, the geometry of a body is captured as a signed distance field: points outside the boundary carry positive values, points inside carry negative values, and the surface itself is zero. This approach is particularly well suited to the complex shapes often required in additive manufacturing.

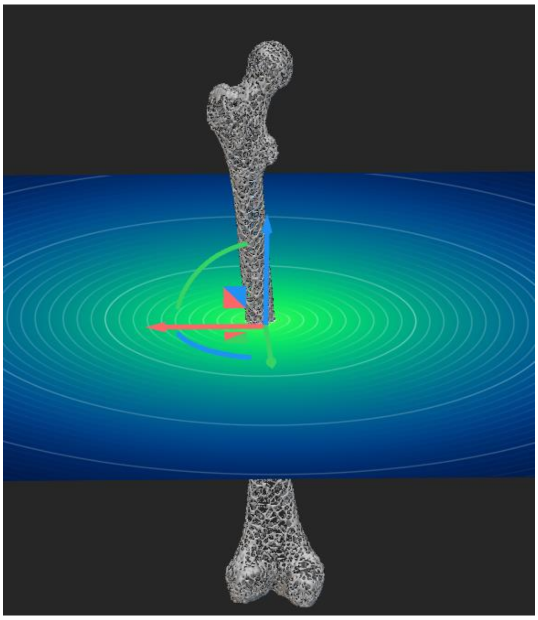

Figure 10. Implicit CAD model of bone made up of lattice structures with a field view in nTop

Real-time simulation is another useful tool that enables CAD modeling to be driven by mechanical behavior of a design. As the shape of the CAD model is changed by the designer, an optimized real-time FEA running in the background is updating the results on its deformation, stresses, strain or similar, helping get the right design early in the process. This is facilitated by the development of real-time simulation algorithms [19] as well as by increased performance of a typical CAD workstation.

Augmented reality (AR) and virtual reality (VR) devices enable a more realistic experience in CAD modeling, design exploration and presentation. That is why many vendors feature some of these technologies in their CAD software [20].

There are also a number of free and open-source CAD solutions available that have found their use among designers, usually for not so demanding modeling tasks. Examples include FreeCAD, based on a geometry kernel OpenCasCade, or Blender that is often used in modeling for rendering and animation.

3. ON INTEROPERABILITY AND UNIVERSAL FILE FORMATS

Each CAD program has its own native (natural, own) format, which precisely describes all geometric and non-geometric elements of the model. If the two programs do not use the same native format (which is often the case), data conversion must be performed.

Interoperability between different CAD software started in 1980 with the release of IGES (Initial Graphics Exchange Specification), vendor-neutral file format by U.S. National Bureau of Standards. It was initiated by United States Air Force (USAF) and based on Boeing data translation software. Other universal exchange programs that emerged over time, with the most prominent place belonging to STEP (STandard for the Exchange of Product model data).

There are currently two approaches to Product Data Exchange (PDX): geometric data exchange (GDE) and feature data exchange (FDE). In GDE the B-rep model is translated, from the native format of one to the native format of another CAD system. Feature data are lost, and the result is B-rep without features (dumb geometry). It is most often applied in practice. FDE - based on the model tree in one system, a model tree is created in another system, based on which the same geometry is created. It is not always possible and depends on the program version. Independent programs that are used for such translation tend to be expensive. One example of FDE translator is Proficiency by IT, which currently supports mutual FDE between NX, SolidEdge, CATIA V5, SolidWorks, Creo and Inventor.

It may be argued that, during historical development of CAD software, vendors have most often chosen to disable FDE between their software and other software, excluding other programs of the same vendor. This was the way to bind customers to their solutions. Even now, this tends to be the case.

4. ON MODEL-BASED DEFINITION (MBD)

It was already mentioned that the possibility of automatic generation of 2D technical documentation or its complete avoidance was recognized very early, with the beginning of 3D modeling.

Today, there are two approaches to creating technical documentation based on 3D models: automated generation of technical documentation based on 3D models (technical drawings, components, expansion drawings...) and model-based definition (MBD) or digital product definition (DPD) (Figure 11) – use of 3D models and associated non-geometric data to define (specify) individual components or assemblies (without the need for technical drawings).

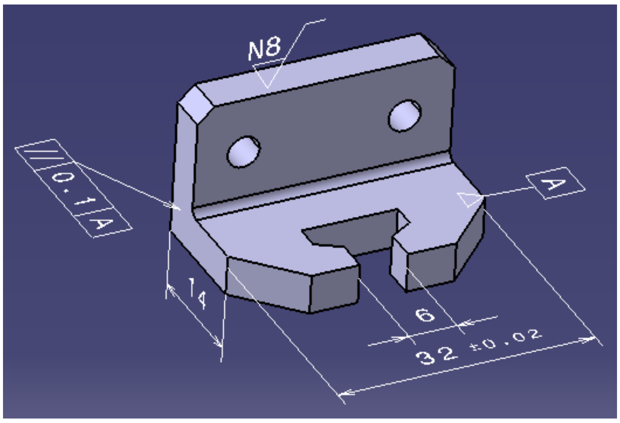

Figure 11. MBD in CATIA v5

5. CONCLUSION

A brief review of CAD development, from its beginnings to current state of the art, was given in previous chapters. It is too short to capture all the important events in history of CAD, but the effort of the authors was to capture the most important ones and name the key underlying technologies, giving at the same time their own views and sharing their own experience.

In our opinion, the key events in CAD development were:

1. Creation of sketchpad, the first software that utilized interactive graphics CRT monitor and light pen (1963)
2. Inventions of tablet improved graphical displays, dedicated graphics hardware, low-cost terminals and microcomputers (1960s)
3. Creation of techniques for hidden line display and shading (1960s)
4. Development of underlying mathematics for modeling curves and surfaces (late 1950s to late 1960s)
5. Appearance of commercial CAD software (1970s)
6. Birth of first 3D CAD software
7. Development of solid modeling (end of 1960s, 1970s)
8. Introduction of parametric, feature-based and associative modeling (1980s)
9. Appearance of geometric kernels as separate products (1980s)
10. Development of mid-range CAD solutions (1990s)
11. Introduction of direct modeling (1980s – 2000s)
12. Introduction of AI into CAD

In previous chapters it was also commented on how the developments in computer hardware influenced CAD software development. Today, new and fast evolving IT technologies like AI or cloud computing are having a great influence on CAD systems, leading to completely cloud-based CAD solutions, generative design enabled software, modeling in VR and others.

The competition between CAD software vendors has had both positive and negative influences on the development of CAD technology. On the one hand, the appearance of CAD-related inventions was very much accelerated by the appearance of smaller companies offering a lot of big system functionality for modest prices. On the other hand, numerous acquisitions of smaller companies by big players were obviously achieved to take control of its fast-developing technology, slowing the overall improvement of CAD technology. David Weisberg wrote: “There is a phenomenon that takes place in the computer industry that is the reverse of the biological food chain. Except in this case, rather than the larger animals eating successively smaller animals the lower levels of the technology food chain absorb the capabilities of the higher levels. This phenomenon explains both the vast improvements we see in performance coupled with steadily reduced costs, particularly in regards to hardware” [1].

Following the fast and extensive evolution of CAD, we can only watch and hope for the next revolution.

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