The Future of CAD/CAM:

The Future Development of CAD Tools

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Abstract

This report gives a short overview of the current state of CAD/CAM technologies and introduces the latest innovations in the design and manufacturing industry. It analyses which impact these innovations may have on the future of CAD tools. The main goal of this written work is to propose what may be the driving forces in the design and manufacturing industry in the closest future - few years time, and also in long term.

It is predicted that the development towards more intelligent CAD software is likely to have a major impact on the way CAD tools are used in the future. There is likely to be a greater harmony between the designer and system, and the software would be able to detect the issues in the early stages of process. Additionally, there are several researches being carried out to make software easier to use, with the intention that the user base would be wider than merely qualified CAD designers – for instance, the clients could be involved in all stages of product design.

The shift towards "cloud computing" is predicted to transform the whole industry. Few CAD companies have already begun the trial programs that are being run on the "cloud" – this move would enable the businesses to benefit from the lower costs and time-savings from simplified operational aspects.

Therefore, even though majority of the CAD users state that software meets their needs, the closer analysis demonstrates there is still room for more advanced systems to emerge, which would be highly beneficial for both, the users of CAD tools and their clients.

1. Introduction: Current State of CAD/CAM technologies

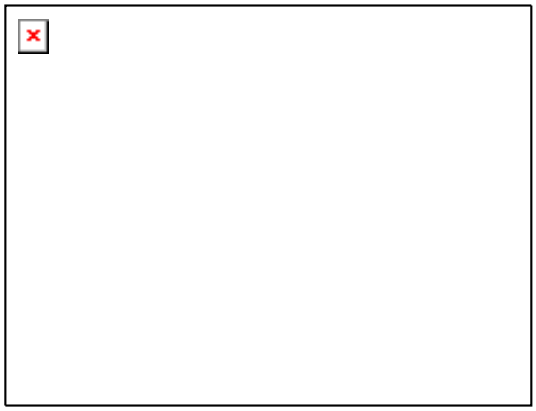
CAD/CAM technologies started to develop since 1950s in the form of complex numerically controlled machines. Because of their complexity, they were used by highly specialised professionals and cost benefits could only be obtained for high value items (*Llewelyn, 1989*).

Since 1950s the development of these tools has been remarkable - CAD/CAM applications are now widely available, can be run on almost any operating system and do not need any special hardware or software. They are essential elements in several industries – automotive, aerospace, construction - which is due to their advanced capabilities, relative ease of use and cost/time savings related to the technology. Additionally, CAD is used in computer animation and increasingly in designing health care facilities, where it has proved to be the ideal tool (*Ratib et al, 2000*).

CAD (Computer Aided Design) provides a means to determine the behaviours of a completed or partially completed design (*Gero, 1996*). These designs can be 2D, 3D or even 4D (3D + time dimension). 4D is mainly used in construction industry – it simulates the process of transforming space over time (*McKinney et al, 1996*), therefore it aids towards more efficient planning and scheduling. However, the development of 4D tools has not been as rapid as users were expecting and there are several shortcomings to the applications. Hence, the majority of CAD applications are still 2D or 3D. In effect, one quarter of the world's designers design in 3D and three quarters in 2D, which is due to the fact that manufacturers still work from 2D drawings (*McEleney, 2009*).

The major force behind the development of CAD has been the desire to improve the productivity of designers – more repetitive aspects of the design have been automated (*Xu, 2009*). However, the limitation of CAD is its inability to help designer in a more creative and intuitive way. Additionally, with the practices of concurrent engineering, there is need for CAD systems to be increasingly integrated with manufacturing and marketing activities.

CAM (Computer Aided Manufacturing) involves the use of software application to directly convert the design into the code that enables the machine to manufacture the product.



Graph 1. Growth of 3D Printers sales from 1996-2007
Source: Wohlers Report 2008

Rapid prototyping (RP) technology has a significant impact on manufacturing industry and on the way products are modelled, prototyped and tooled (*Strategic Direction, 2004: 27-29*). Wohlers Report (2008) reveals that RP industry is growing impressively and considerable amount of the growth is due to the development of 3D printers – unit sales grew by 21% in 2007 (*Graph 1*). At the present time, 3D printers are relatively inexpensive and widely used in CAD companies. Estimations see the huge potential in Rapid Prototyping technology – it is even predicted it will drive the future manufacturing industry.

2. Future of CAD: The Continuing Improvement of CAD Tools

The rapid development of CAD tools has been due to the great demand from users and the willingness of developers to enhance the technology. Majority of the users now say CAD technology meets their needs. However, they admit there is room for development in the simpler usability of the applications and the costs related to CAD technologies (implementation of software and training for users) could be decreased even further. These developments are likely to be achieved in the nearest future, predictably through the improvements in the related technologies - rapid prototyping and cloud computing. Additionally, as there is strong rivalry on the current marketplace, companies need to find methods to improve their efficiency in order to stay competitive. The implementation of concurrent engineering practices is proved to be a successful way to enhance overall productivity and product quality.

2.1 Intelligent Software and Hardware

There have been numerous discussions about the need for more intelligent software for CAD designers to support the people involved. The main issue at the current state is that although CAD tools are suitable to check how the parts fit from geometrical point of view, they do not monitor the projects from the functional perspective (*Colombo et al, 2006*). Therefore, the success of the design is entirely dependant on the experience and knowledge of the designer.

Additionally, there have been suggestions that CAD tools should be made easier to use. In this way the software could be used not only by qualified CAD designers, but also by managers of the company for instance - they may have outstanding ideas, but not the skills to develop these ideas into a proper design. Also, by improving the usability of CAD, the consumers of the product would be able to be involved in the customising and designing process.

Jon Hirschtick (2009) from SolidWorks gives a presentation where he talks about the development of voice recognition for the CAD software and simple interaction between the engineer and system. However, these ideas have already been taken further – researches from The Open University and the University of Leeds are developing an intuitive CAD system that would examine the movements of eye (using eye tracking capability) to recognise which parts of the design sketches the designer is particularly interested in. The research suggests that when we are interested in something, our eyes are naturally drawn back to the object of interest – eye tracking device would detect these movements and additionally, the software would make gentle suggestions to improve the design (*CAD User, 2009:10*). The result of this development would be the complete creative harmony between the designer and software, without the designer having to physically interact with the software.

The other research, carried out by Professor Randall Davis and his students in Massachusetts Institute of Technology, was dedicated to develop sketch interpretation software. The outcome of their project was a tool that allows an engineer to sketch a

mechanical system and then interact with that design, also to see the simulations of this drawing (*Davis, 2003*). Microsoft was interested in the concept at the time and was considering adapting the software. However, the problems occurred that although the simulation was eye-catching, the difficulty lied in writing a program that would understand the sketches without resorting to a preset method of drawing objects (*Mass High Tech, 2003*).

Figure 1. PHANTOM Freefrom modelling system
Source: http://www.sensable.com

Last few years have seen rapid development in freeform features modelling technique. It can be seen as an extension of feature modelling, and the purpose is to provide engineers with faster and more intuitive modelling (*Berg et al, 2002*) – they can work freely and do not spend time on details. As the result of integrating freeform modelling with haptics technology, researchers have created the device that allows users to interact directly with their model in the computer via touch. One of the first this kind of devices (PHANToM haptic device by SensAble Technologies) is shown in Figure 1. It enables users to sculpt and form “virtual clay” employing similar tools than used in physical world. The major disadvantage of the freeform method is the relative imprecision – it is desirable in the first stages of design as it aids creativity, however, at the later stage of product development the higher accuracy is required.

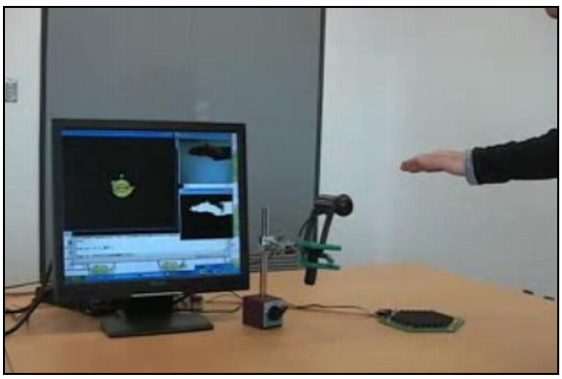


Figure 2. Haptics technology
Source: Develop3D

The latest prototype in haptics technology has been unveiled by researchers in University of Tokyo. This device allows users to "touch" and actually feel the object they see on the screen, using ultrasonic technology (Figure 2). Array of ultrasonic transducers that emit sound are being set up – "solid" object is created where waves interfere with each other *(Develop3D, 2008)*. However, there is a drawback of this technology – the investigation shows that the ultrasound used could scatter and cause damage to the eardrums. Fortunately, the further research is already in progress to combat the possible deafness.

The commercial release of this enhanced haptics technology would bring new opportunities to CAD industry – it is already established the method aids designers to focus more on the creative side on the design and more complicated designs can be achieved.

Hence, the developers are still trying to find the appropriate solutions for the problem how to make software easier to use and how to improve the designing experience. There are numerous researches undertaken, which are ought to make human and computer interaction perfectly harmonised.

2.2 Cloud Computing

"Cloud computing" is the latest idea of computer industry, which is based on the concept that computing will be increasingly delivered as a service over the Internet. Documents, e-mail and software will be stored online, making them accessible from any PC (*The Economist, 2009:13*).

Few CAD software companies have already followed the lead – for instance Autodesk with its trial system Project Twitch (*Develop3D, 2009:9*). While the trial system

is still heavily restricted (users need to be within 1000 mile radius, service only runs on Windows platform and there can be no more than 50 users logged on simultaneously), then the development of this technology could have a significant impact on the CAD users in the future.

The main benefits in cloud computing for CAD companies lie in cost savings and access to the latest versions of software. At the present, many problems for design companies occur from updating the current system, or implementing totally new system, which are often time-consuming and costly processes and interrupt the daily work of the business. Cloud computing promises to ease these transformations, as software and data, both would be stored in the central server.

2.3 Concurrent Engineering and CAD

Concurrent engineering is the method where product and process designs are generated simultaneously in the early stages of product development process (*Tan and Vonderembse, 2005*). The intent is to involve all the functional areas of firm in product design activity, often even suppliers and customers are included. As a result, product development performance – time, quality and productivity, improves. This design management method is still relatively new; however, it has quickly become widely used in several industries, particularly in aerospace engineering.

The implementation of concurrent engineering starts from the organisational level and involves more than just design teams. However, as discussed previously, with the development of more intelligent and simpler CAD software, these organisational changes would be easier to execute, as more employees could be involved with the design process.

Therefore, when the usage of CAD tools is successfully combined together with concurrent engineering, the overall performance of the company may increase significantly. Among the users of concurrent engineering are for instance Rolls-Royce, NA-

SA and Boeing – Boeing 777 was designed and developed in record time, development cycle was reduced from 60 to 48 months (*Encyclopedia of Management, 2009*).

The competition on the market is toughening even further and time pressure has become the main force in project-based product development environment. The ownership of the latest CAD tools will not provide a company with enough competitive advantage - the implementation of the concurrent engineering method with these tools, on the other hand, may be highly beneficial. Cloud computing offers the environment where collaboration and communication are supported, therefore – integration of cloud computing and concurrent engineering would create a desirable situation where design data is integrated and controlled.

2.4 Advanced Rendering

Rendering is the method of creating an image from three dimensional data. At the present time, it is mainly used in architecture, videogame and movie industries. However, lately there has been a shift towards the greater use of rendering methods (i.e. ambient occlusion) in the other industries, like automotive (Figure 3) and aerospace, primarily for demonstrating the design for the client (*Jon Hirschtick, 2009*). The wider usage of rendering methods has created the demand for advanced software, which would make the designs to look more realistic. Additionally there is need for the more efficient rendering methods, as the current methods may take a very long time. This would be highly beneficial for the design companies, which could then use the rendered images for wider purposes.

Figure 3. Rendered Aston Martin

Currently, automotive agencies use physical prototypes to market their new designs (*Experience Manufacturing, 2009:8*). By using advanced rendering methods, their creative potential would be unlocked and they would benefit from the enhanced possibilities which would be very costly to achieve with traditional photography. Therefore, new designs could star in the adverts, before they are even built.

3. Conclusions

CAD/CAM tools have developed significantly over the past 50 years. The main forces in this progress have been the more demanding users and also the developers who have been willing to broaden the possibilities of software. Currently, majority of the industries use CAD/CAM tools in one or several ways and the release of more advanced software packages has increased the amount of different means these systems are used for.

There is number of researches in progress to enhance the CAD tools. Although majority of users are rather satisfied with the attributes of CAD software, there is a need for more advanced tools. The latest innovations have been haptics technology which enables the user to actually "touch" and feel the designed object, and system with eye tracking capability which allows harmonic interaction between designer and computer. Some of these innovations are not fully developed and in commercial use yet, however, they incorporate in themselves a huge potential.

Another feature users would benefit from is easier usability. CAD has always been used merely by qualified engineers. Due to more demanding market conditions companies need to ensure their products are designed according to their clients' requirements. Therefore, by making software simpler to understand, the user base of tools could be wider and consumers could be involved from the first stages of product design.

Additionally, when analysing the future of CAD tools, the development of related technologies has to be taken into the consideration. The latest initiative of computer industry - cloud computing – is likely to have a great impact on CAD tools. The idea is to store everything in central server (cloud platform) and nothing in users PCs. In this situation the keywords include communication and collaboration - this creates the suitable environment for concurrent engineering which is the increasingly used product development method to improve the overall performance.

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