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Perspectives on advanced and basic engineering technologies

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Abstract. After presenting in the Introduction the goals of the paper, in its second section the paper is presenting and summarizing important features and details about the professional engineering software programs such as CAD, CAM, CIM, CFD, their advantages and downsides and how they have been used and have been helpful until now. In the second section of the paper, the computer games exhibiting the construction's feature are presented and how they are impacting the today's children's lives.
In the last section, the paper draws conclusions about the products of the game industry in general, its possible evolution and also about the engineering technologies in particular and brings the software programs in relationship with the nowadays' advanced technologies: Artificial Intelligence (AI), big data, block chain technology, 3D printing, Virtual Reality (VR) and Internet of Things (IoT).

Keywords: software programs, advanced engineering technologies, CAD, CAM, CIM, CFD, AI, big data, block chain technology, 3D printing, VR, IoT

1. Introduction

The paper sets out to analyse the former advanced engineering technologies together with their advantages and features but also the how these once advanced technologies have become more and more accessible and transformed themselves into basic technologies.

What was in the recent past cutting edge advanced engineering technology used only by highly skilled engineering personnel to develop highly complex products such as automobiles, ships or aircraft, is nowadays used to design and 3D print simple objects by almost anyone having some basic gaming skills. This connection between the nowadays basic technologies and gaming, together with its upsides and downsides but also possible development and evolutions based upon gaming, are extensively presented and commented in the last chapter of the paper.

2. Advanced engineering technologies from yesterday and nowadays

According to [2], the term advanced technology is defined as a new or developing IT innovation that has a few very specialized users and also has the potential to grow and create significant value in the future.

The advanced engineering technologies of the recent past are the basic engineering technologies from today and they are presented in the first part of this chapter of the paper. According to the sources [3], [4], [5], [6], [7] and [8], the definition, features and advantages of computer aided design (CAD) are presented below. CAD is the use of computers to aid the design by creation or optimization. This design can refer to the design of electronic systems in which case is known as electronic design automation (EDA) or to mechanical design, also known as mechanical design

automation (MDA). The creation of the technical drawing with the use of computers is named computer aided drafting.

The information contained in the CAD does not only include shapes, but also information such as materials, processes, dimensions and tolerances, exactly such as in the case of the manual drafting of engineering drawings. The respective design can be made in two (2D) or three dimensions (3D).

Some of the main advantages of CAD over the manual drafting are: automated generation of bills of materials, interference checking, the ability to perform engineering calculations, the possibility to rotate the drawing in three dimensions allowing viewing of an object from any angle and even from inside out, but the dynamic mathematic modeling, as well. The obvious advantage and feature of the CAD is that the designers are able to develop work which they can save for future editing, thus saving considerable amounts of time.

CAD is only one of the whole digital product developments (DPD) and can be used jointly together with other computer tools or modules such as: computer aided engineering (CAE) and finite element analysis (FEA), computer aided manufacturing (CAM). Thus, taking into account its four properties: history, features, parameterization and high level constraints, CAD has been proven very useful for the engineers. Besides, the CAD offers to designers and engineers one common environment to work within, fact which is important when the cooperation between teams is needed, for example when is to create a new product.

One other concept based on the use of computers in the manufacturing process is that of computer integrated manufacturing (CIM). In CIM the computer is used to control the entire production process and the related integration allows to individual processes to exchange information one with another. In this way, the manufacturing is faster and is less prone to errors. CIM relies upon and is based on real time input from sensors to transmit information to closed loop control processes. CIM is also known as flexible design and manufacturing.

According to [4], there are three main challenges with regard to the development of a smoothly operating computer integrated manufacturing system: integration of machines and components from different suppliers, since they are using different communication protocols and data integrity of the data used to control the machines and the process control, meaning that the computers should be human assisted in not foreseen circumstances occurring in the manufacturing. The CIM is not the same as the factory running completely independent from human intervention (“lights out factory”), but it is an important step in that direction. Nonetheless there are computer aided techniques and subsystems that are common for both, such as: CAD, CAE, CAM, CAPP (computer aided process planning), CAQ (computer aided quality assurance), PPC (production planning and control), ERP (enterprise resource planning), a common database that integrates the whole business system. The devices and equipment required are: CNC (computer numerical controlled machine tools), DNC (direct numerical control machine tools), PLCs (programmable logic controllers), Robotics, Computers and Software.

Computer aided engineering (CAE) represents the usage of the computer software in aiding engineering and solving engineering tasks. It includes finite element analysis (FEA), computational fluid dynamics (CFD), multibody dynamics (MBD) and it works together with CAD and CAM.

The advanced technologies presented so far were operated, at their time, only by highly skilled and trained engineering staff, they were very expensive and they were mostly intended to create mainly high value products, such as automobiles, ships, a.s.o. Since they have become, in time, highly accessible, these technologies are used nowadays also to design and create much cheaper and small value products. Their accessibility has also permitted the integration of many of their features in the products of the gaming industry, such as it will be shown in the paper, in the next chapters.

Although they have become, in the present days, rather obsolete, their importance is not to be denied, since they represented the starting ideas and the building blocks on which the nowadays’ advanced engineering technology has been built.

The nowadays advanced technologies, such as artificial intelligence (AI), virtual reality (VR), internet of things (IoT), block chain technology, big data, 3D printing, a.s.o. are the basic technologies

of tomorrow. Some of the concepts, introduced in the past, when the computers were not so good performing as today, such as the concepts of “lights out factory”, “autonomous car” “autonomous vessel”, “intelligent house”, a.s.o. have been taken over and become real only recently when the integration of machines, devices and robots is possible due to sensors (IoT) and 5G communication technology. As it will be shown in the third chapter of the paper, state of the art technologies of yesterday have been taken over and integrated also by the gaming industry and in the same chapter of the paper it will be presented how this move can freely help the software industry but also what the influences, dangers and downsides for the game users are.

3. Basic engineering technologies and gaming

In contrast with the advanced engineering technologies presented in the previous chapter, the basic engineering technologies are defined as mature past innovations that are used by many individuals already and which have reached somehow a saturation limit, being very likely to be replaced by new advanced engineering technologies and furthermore there are accessible in use for many.

In order to better understand the difference between advanced and basic engineering technologies, expressed from general point of view and also the relationship between gaming and basic engineering technologies, one can consider the case of one of the most successful, bestselling and awarded construction videogame of all times, Minecraft, [9], [10].

Minecraft is a game based on creativity and construction, enabling to the players to build with a large variety of cubes in a three dimensional world. The other activities in the game are exploration, resources’ gathering, craftsmanship, the construction of tools, but also the fight. The game has few different modes, such as: Survival, Creative, Adventure and Spectator. In the Survival mode the players have to obtain the resources by themselves and progressively advance, while in the Creative mode the players have the opportunity to use their creativity by means of unlimited resources. The mode Adventure has a high difficulty and makes accessible worlds created by other players. The players have also the possibility to modify the game in order to create new gameplay mechanics, items and assets. The game is continuously developing and it receives periodical updates. Minecraft has been bought by Microsoft from the company Mojang and the value of the transaction was in 2014, of 2.5 Mlrd. USD.

Minecraft has no specific goals to achieve, allowing players a lot of freedom in choosing how to play the game. These features are enabling and fostering imagination and creativity, fact which, as will be seen in the next chapter of the paper, is crucial in obtaining and exploiting the best creativity ideas from its players.

The game has, however, an achievement system, based on “advancements” or “trophies”, depending on the environment of the game. The game world is composed of 3D rough objects, mainly cubes or fluids, which are called “blocks” and are representing materials such as: dirt, stone, ores, tree trunks, water and lava. The core gameplay bases on the picking and using these objects in a 3D grid, while the players have the possibility to move in the surrounding game world. The game also contains a resource known as “redstone”, which can be used to produce in the game mechanical devices, electrical circuits and logic gates allowing the construction of complex systems.

There exists an Education edition of the game, designated to be used in schools and the Raspberry PI edition allows player to open the game code and to use the software Python in order to modify the game world. The game has also a virtual reality (VR) version, which is included in the PlayStation4 version.

The applications of the game in CAD and education are obvious and they will be approached in the next chapter.

4. Perspectives and relationships between basic and advanced engineering technologies

Based on the facts already presented and other ideas with regard to the engineering technologies presented, this section shows how the results of the players in the game could be used freely by the owner of the game to gain new ideas, how the game could evolve by adding new features and how

could be used in conjunction with other technologies such as VR, FEA (strength of materials), 3D printing or databases with material resources for construction. The chapter is also asking some important questions with regard to the videogames and is drawing some conclusions regarding the technologies presented.

Such as evolving from the previous chapter of the paper, the basic technologies are nowadays to be found also included in videogames. Some of these games, like Minecraft, are including, in an accessible way, computer aided design engineering technology but are also helping young players to develop designing skills and abilities which in the past were only owned by highly skilled engineering staff.

One of the most important assets when designing an object: car, building, aircraft, ship a.s.o. is the creativity and imagination. The features of Minecraft, among which: no specific goals to achieve, virtual structure of a game of Lego (one of the most creative games), virtually infinity of the game and its procedurally generation, are making it one of the most intellectually stimulating games ever created.

An important advantage of the game for users is hence, the development of the imagination and creativity of the young players and the enhancing of their 3D visual abilities. However, the subtle manipulation by means of the game has as outcome not only the development of the CAD skills of the users, but also some other unwanted side effects such as addiction in relationship with the game. Besides the addiction caused by the virtual reward and related release of dopamine in the brain of the players, there are also some other additional long term negative effects with regard to the health of the players. According to [11], this negative effect are anxiety conditions. An important question which needs to be asked in relationship with this game and the videogames, in general, is: Are competition, greed or even aggression, caused by playing of the videogames, rather useful or harmful for the young users of the games?

One other aspect is that the creativity stimulated by the game can be also used free of charge by the owners of the game in many ways. On one side, some players can access the world of other players, on the other side, the worlds created by the players can be used as free ideas received within the game, that can be used for real world objects (building, devices, a.s.o.). One can also use the objects designed by players in Minecraft and equip and merge them with other CAD features, such as engineering calculations and databases regarding possible suitable materials and their related strengths and costs, to be used to optimally construct objects in the real world. The advanced 3D printing and VR technologies could also further help to better construct real objects based on the ones created by players in the virtual world.

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