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Faculty of Applied Sciences
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3D modeling software and creation

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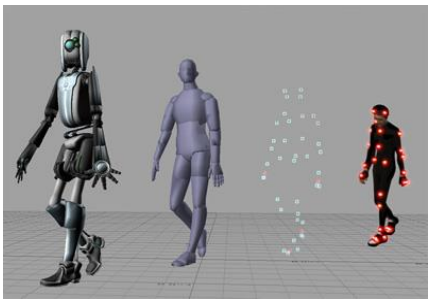


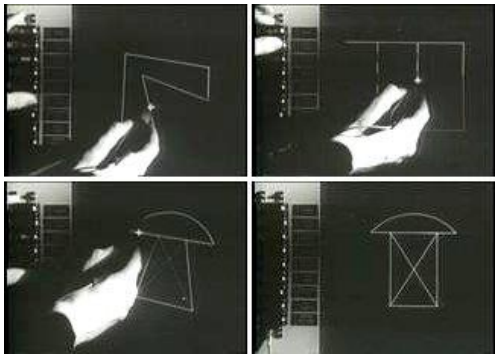
In 3D computer graphics, 3D modeling is the process of developing a mathematical coordinate-based representation of any surface of an object (inanimate or living) in three dimensions via specialized software by manipulating edges, vertices, and polygons in a simulated 3D space.

3D models can be created manually, algorithmically (procedural modeling), or by scanning. Their surfaces may be further defined with texture mapping.

1.2. History

The development of 3D mode ling technology has experienced a long history.

1.2.1. The 1960s – The Origins



We can trace the origins of 3D modeling to the 1960s. In 1963, the first graphical user interfaces---Sketchpad is written by Ivan Sutherland in the course of his PhD thesis. And then, the first 3D graphics company, Evans & Sutherland, was founded in 1968. Sketchpad has contributed greatly to the development of imaging softwares that includes CAD and modeling programs.

1.2.2. The 1970s – The Rise

The success of Sketchpad gave others impetus to work on computer graphics. Many new companies were established that worked to design better software for user needs such as Automated Drafting and Machining (ADAM) and so on.

The 1970s is also referred to as the age of rendering, and one of the most powerful images representing this age is the "Utah Teapot" rendered by Martin Newell at the University of Utah.

1.2.3. The 1990s – Modernization

Most of what we see today regarding 3D modeling software was developed in the 1990s. During this period of modernization, CAD software was at its peak, with most industries making it the standard practice for designing products.

In addition, Some free software applications like Blender gained massive acceptance. Such software popularized 3D modeling among users of all levels and boosted the reach and usage of 3D modelling technology.

1.2.4. Post-2000s

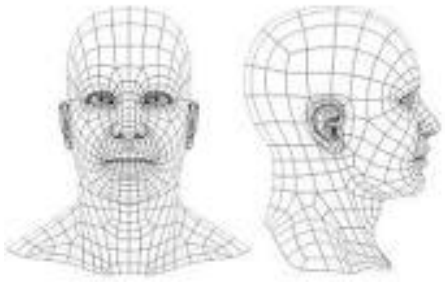
Since the year 2000, 3D modeling software has only evolved for the better. More and more software applications that cater to a wide range of applications, users are now available. 3D modeling becomes progressively advanced.

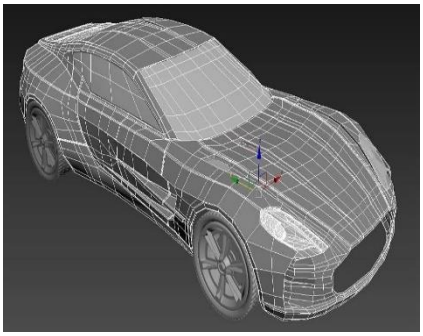
1.3. Common Types

There are three major types of 3D models types:

- Solid model
- Wireframe model
- Surface model

We can base them on the methods and techniques used to create different 3D objects.





1.4. Advantages

Compared with 2D methods, 3D modeling technology has many advantages:

- *Flexibility*, ability to change angles or animate images with quicker rendering of the changes.
- *Ease of rendering*, automatic calculation and rendering photorealistic effects rather than mentally visualizing or estimating.
- *Accurate photorealism*, less chance of human error in misplacing, overdoing, or forgetting to include a visual effect.

§2. 3D modeling software

2.1. Introduction—What's 3D modeling software?

3D modeling software allows you to create a mathematical representation of a 3-dimensional object or shape on you computer. This kinds of software is useful in various areas, like film and TV, game development, product design, architecture and so on.

The ability to create designs with 3D modeling software can be a huge advantage for any graphic designer. It enables you to create photorealistic illustrations and mockups that are compelling to clients, as well as expand your skill set to craft blueprints for product and environmental designs. Also designing in 3D gives you the ability to see potential issues in your design more readily, and address them earlier in the design process. Since the parts are created as 3D objects, instead of 2D views, potential interferences and trouble spots are easier to visualize.

2.2. Several popular 3D modeling softwares

2.2.1. Blender

- **Intriduction**

  Blender is a free and open-source 3D creation suite. With Blender, you can create 3D visualizations such as still images, 3D animations and VFX shots. You can also edit videos. It is well suited to individuals and small studios who benefit from its unified pipeline and responsive development process. Being a cross-platform application, Blender runs on Linux, macOS, as well as Windows systems. It also has relatively small memory and drive requirements compared to other 3D creation suites. Its interface uses OpenGL to provide a consistent experience across all supported hardware and platforms.

- **History**

  In 1988, Ton Roosendaal co-founded the Dutch animation studio NeoGeo. NeoGeo quickly became the largest 3D animation studio in the Netherlands and one of the leading animation houses in Europe. NeoGeo created award-winning productions (European Corporate Video Awards 1993 and 1995) for large corporate clients such as the multinational electronics company Philips. In 1998, Ton decided to found a new company called Not a Number (NaN) as a spin-off of NeoGeo to further market and develop Blender. At the core of NaN was a desire to create and distribute a compact, cross-platform 3D application for free. At the time, this was a revolutionary concept as most commercial 3D applications cost thousands of dollars. NaN hoped to bring professional level 3D modeling and animation tools within the reach of the general computing public. NaN's business model involved providing commercial products and services around Blender. In 1999 NaN attended its first SIGGRAPH conference in an effort to more widely promote Blender. Blender's first SIGGRAPH convention was a huge success and gathered a tremendous amount of interest from both the press and attendees. Blender was a hit and its huge potential confirmed! Internal software architecture, unfinished features and a non-standard way of providing the GUI, the enthusiastic support from the user community and customers who had purchased Blender Publisher in the past, meant that Ton could not justify leaving Blender to fade into insignificance. Since restarting a company with a sufficiently large team of developers was not feasible, Ton Roosendaal founded the non-profit organization, Blender Foundation, in March 2002.

- **Advantage**

  Blender is a fully integrated 3D content creation suite, offering a broad range of essential tools, including Modeling, Rendering, Animation & Rigging, Video Editing, VFX, Compositing, Texturing, and many types of Simulations.

  It is cross platform, with an OpenGL GUI that is uniform on all major platforms (and customizable with Python scripts).

  It has a high-quality 3D architecture, enabling fast and efficient creation workflow.

  It boasts active community support. See blender.org/community for an extensive list of sites.

  It has a small executable, which is optionally portable.

2.2.2. Maya

- **Intriduction**

  Maya is a professional 3D animation, modeling, simulation, and rendering toolset, designed for creating realistic characters and blockbuster-worthy effects.

  From fantastic creatures to sweeping landscapes and explosive battle sequences, top artists, modelers, and animators rely on Maya's award-winning toolset to bring today's most-loved animated and live-action films, TV shows, and video games to life.

- **History**

  Maya was originally an animation product based on code from The Advanced Visualizer by Wavefront Technologies, Thomson Digital Image (TDI) Explore, PowerAnimator by Alias, and Alias Sketch!. The IRIX-based projects were combined and animation features were added; the project codename was Maya. Walt Disney Feature Animation collaborated closely with Maya's development during its production of Dinosaur. Disney requested that the user interface of the application be customizable so that a personalized workflow could be created. This was a particular influence in the open architecture of Maya, and partly responsible for it becoming popular in the animation industry.

  After Silicon Graphics Inc. acquired both Alias and Wavefront Technologies, Inc., Wavefront's technology (then under development) was merged into Maya. SGI's acquisition was a response to Microsoft Corporation acquiring Softimage 3D. The new wholly owned subsidiary was named "Alias Wavefront".

  In the early days of development Maya started with Tcl as the scripting language, in order to leverage its similarity to a Unix shell language, but after the merger with Wavefront it was replaced with Maya Embedded Language (MEL). Sophia, the scripting language in Wavefront's Dynamation, was chosen as the basis of MEL.

  Maya 1.0 was released in February 1998. Following a series of acquisitions, Maya was bought by Autodesk in 2005.Under the name of the new parent company, Maya was renamed Autodesk Maya. However, the name "Maya" continues to be the dominant name used for the product.

- **Advantage**

  It works faster and gives optimum performance to the users. Completed work can be checked at a faster speed that saves time.

  It has loads of dynamic effects, which makes you feel that you are live.

  Video Editing task is versatile that I like where we can include clips we want and filter the effects.

2.2.3. Cinema-4D

- **Introduction**

  Cinema 4D is a 3D software suite developed by the German company Maxon. Cinema 4D can be used for many applications, like animation, 3D modeling, simulation, and rendering

  Starting from 1990. C4D has developed several versions. Now it has become a powerful 3D modeling tool for artists and movie producers.

  Initially, Cinema 4D was developed for Amiga computers in the early 1990s, and the first three versions of the program were available exclusively for that platform. With v4, however, Maxon began to develop the application for Windows and Macintosh computers as well, citing the wish to reach a wider audience and the growing instability of the Amiga market following Commodore's bankruptcy.

  On Linux, Cinema 4D is available as a commandline rendering version.

- **Important models**
  - ✧ Advanced Render (global illumination/HDRI, caustics, ambient occlusion and sky simulation)
  - ✧ BodyPaint 3D (direct painting on UVW meshes; now included in the core. In essence Cinema 4D Core/Prime and the BodyPaint 3D products are identical. The only difference between the two is the splash screen that is shown at startup and the default user interface.)
  - ✧ Dynamics (for simulating soft body and rigid body dynamics)
  - ✧ Hair (simulates hair, fur, grass, etc.)
  - ✧ MOCCA (character animation and cloth simulation)
  - ✧ MoGraph (Motion Graphics procedural modelling and animation toolset)
  - ✧ NET Render (to render animations over a TCP/IP network in render farms)
  - ✧ PyroCluster (simulation of smoke and fire effects)
  - ✧ Prime (the core application)
  - ✧ Broadcast (adds MoGraph2)
  - ✧ Visualize (adds Virtual Walkthrough, Advanced Render, Sky, Sketch and Toon, data exchange, camera matching)
  - ✧ Studio (the complete package)

- **Industry uses**

  A number of films and related works have been modeled and rendered in Cinema 4D, like Spider-Man 3, Doom, Monster House, Inception, Chronicles of Narnia, Tron: Legacy, Iron Man 3, Pacific Rim, Furious 7, Avengers: Endgame, Galaxy Guards , Doctor Who, Silence in the Library , Strictly Come Dancing

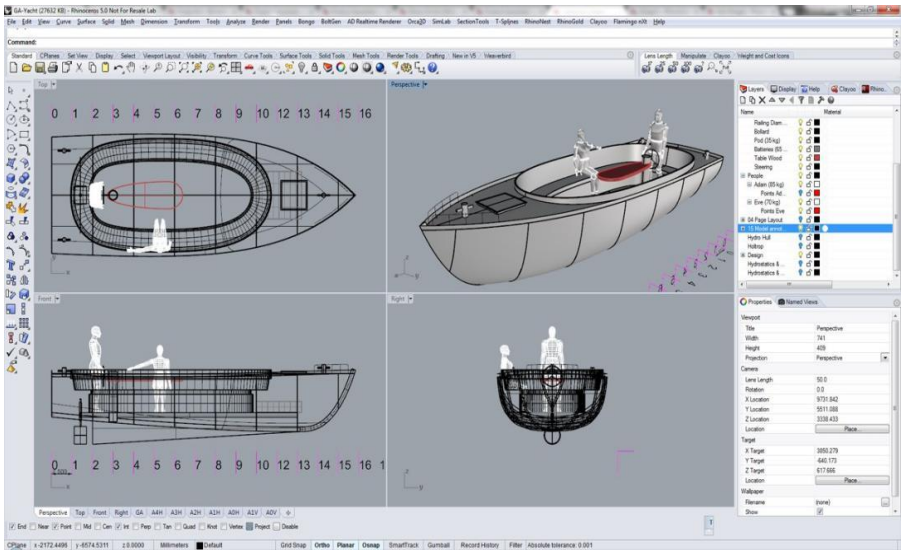
2.2.4. Rhino

- **Introduction**

  Rhinoceros (typically abbreviated Rhino or Rhino3D) is a commercial 3D computer graphics and computer-aided design (CAD) application software that was developed by Robert McNeil & Friends, an American, privately held, and employee-owned company that was founded in 1969. Rhinoceros geometry is based on the NURBS mathematical model, which focuses on producing mathematically precise representation of curves and freeform surfaces in computer graphics (as opposed to polygon mesh-based applications).

  Rhinoceros is used for computer-aided design (CAD), computer-aided manufacturing (CAM), rapid prototyping, 3D printing and reverse engineering in industries including architecture, industrial design (e.g. automotive design, watercraft design), product design (e.g. jewelry design) as well as for multimedia and graphic design

  Rhinoceros is developed for the Microsoft Windows operating system and macOS. A visual scripting language add-on for Rhino, Grasshopper, is developed by Robert McNeil & Friends.



- **History**:

  Rhino has been used in industrial design majors in the early years, and is good at product appearance modeling. However, with the development of program-related plug-ins, the application scope has become wider and wider. In recent years, it has been widely used in the field of architectural design. Rhino cooperates with The grasshopper parametric modeling plug-in can quickly create architectural shapes with various beautiful surfaces. Its simple operation method and visual operation interface are very popular among designers. In addition, it is also widely used in jewelry, furniture, shoe mold design and other industries.

§3. 3D modeling creation

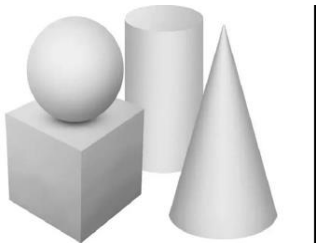
3D model creation is one of the most popular CG services used in architecture, interior and product design, as well as the automotive and gaming industries.

There are five Basic Stages of the 3D modeling creation process:

3.1. Setting Up the Precise Task

This step displays the keys poses and placements of the objects or characters that will be created.

3.2. Building up Basic Geometry



In this stage, the artist adds details to the initial 3D model blocks. Models look smoother and more detailed; they are close to their final shape. Some artists also set the lighting and the camera placements in this step in order to prepare the scene for texturing.

3.3. Adjusting Polygons and Topology

This stage that artists can make all the difference to make a scene realistic. So how to proceed? 3D artists usually rely on pictures or material photos. In addition, it is also important to add details because a too perfect scene loses its credibility. Thus we don't skimp on shadows, table corners, seals, etc.

3.4. Choosing Materials and Textures

There are tons of various material libraries for 3D software, where you can find any materials and textures starting from stone, wood, metals, fabrics, etc.

3.5. Mapping and Applying the Textures

Mapping is the process of creating a texture map and overlaying it on a 3D model. While a 3D object is a 3D volume, maps are always made in 2D. It means that they are no more than just a color flat picture without surface relief. Therefore, even having various maps in hand, 3D artists have to put effort to make the texture look realistic.

Some finished 3D modeling

§4. Applications of 3D modeling

Today, 3D modeling is widely used in many fields like game, movie, design(including industrial design and art design), calculation and even medical care.

4.1. Movie

Actually, most of the 3D modeling software in the market are using to help make movies. Some amazing scenes fulling of magic elements are made by softwares like 3Dmax and Maya. Those software provide a platform for artists to create castles, buildings in future, Aliens with sophisticated and wonderful surface material rendering.

Some famous movies just like Spider-man, The Avengers are made with them.

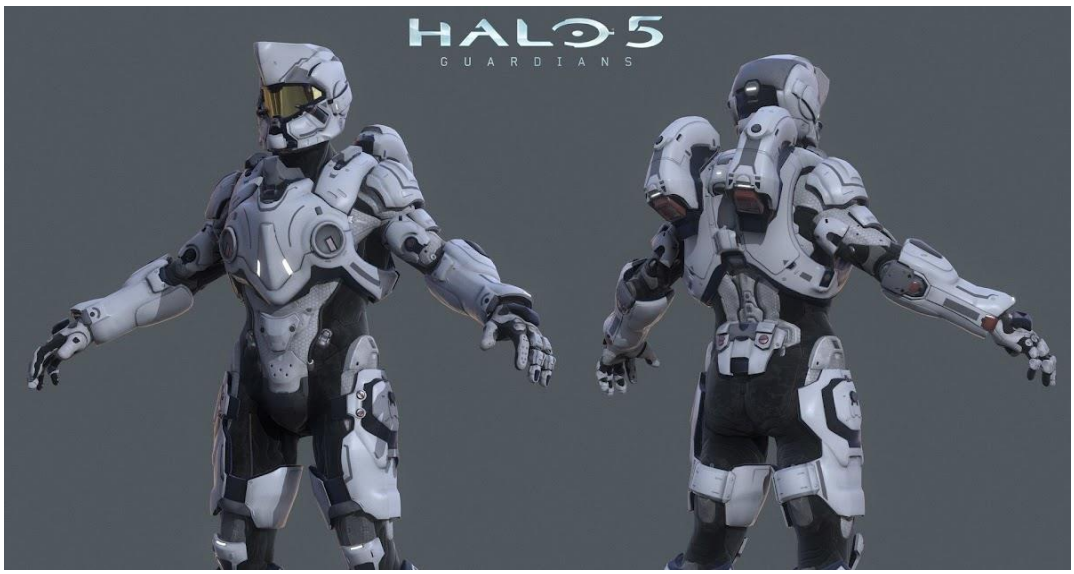
3D Scanning also is a very common technology in cinema industry. It makes this possible by taking an exact scan of an object or person and then manipulated with computer 3D design software to produce assets for film that can either be animated or rendered to produce stunning CGI effects.

4.2. Game

4.2.1. What Is 3D Modeling For Games?

Modeling or 3D modeling for games is the act of creating the geometry that the game engine renders to the screen. This can be characters, environments, props, or any other thing that's rendered in a 3D game. These objects on their own are plain, with no surface detail on them to begin with, this is then added at the texturing phase.

Depending on the company, the work of 3D modeling could be handled by a specific 3D Modeler, as is common in bigger companies. Most often in small to medium-sized companies, it will be handled by an Artist who will take care of the modeling, sculpting, texturing, and material set up. Sometimes they will also take care of rigging and skinning as well as animation although usually these positions will be held by dedicated Technical Animators and Animators respectively.



4.2.2. Methods/Tools

- **Digital Sculpting**

This is a relatively new technique. However, it is the first to consider when it comes to creating photorealistic assets. The method basically emulates the process of creating a physical sculpture but with a list of digital tools. Various software products (Blender, Zbrush) help to impact the objects in a very realistic way as they were made of clay, allowing to create the assets in a mesh-based geometry that contain millions of polygons.

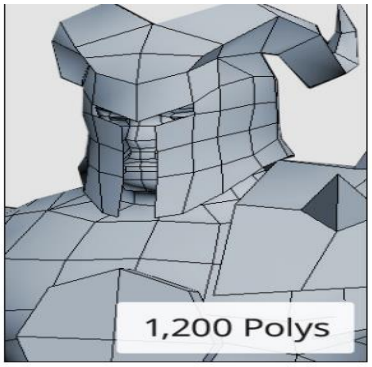
- **Procedural Modeling**

This method relies mostly on the software capacity that the artist can operate. This type of modeling can allow making a whole game location just by selecting certain types of landscape and environment, drastically reducing the capabilities and time consumption required by the artist. Such environment modeling packages as Vue, Bryce, and Terragen give access to an almost infinite preset of different objects inside the mesh, such as grass, buildings, trees, and animals. Moreover, it also enables selecting the parameters of elevation range, fallout density, and terrain distance.

Special tools like SpeedTree also give the option of generating a multitude of unique objects and details of trees and bushes with the help of recursive assets generation, which allows each of them to look unique throughout the entire location.

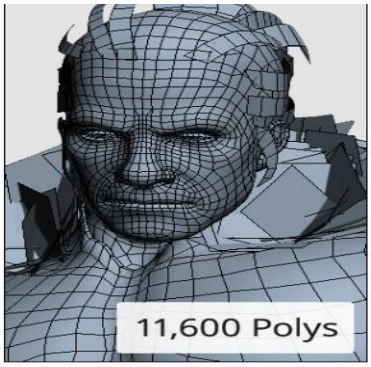
4.2.3. Polys

Poly is an important element in 3D modeling especially in games. Typically, the more polys a model has, the more exact it is , below is a comparison between PS and PS3.



Example PlayStation Model

The original PlayStation required a lower poly count than is popular with current gaming systems. The above image is an example of the low poly count that could be found with these earlier generation game models.



Example PlayStation 3 Model

As you can tell, just a few extra polys can add a ton of details that previous generation consoles couldn't handle. With new technology like the PlayStation 4 and Xbox One being released, that means the average gamer's system will be able to handle more polys.

4.2.4. The differences of the Modeling for games and modeling for movies

One of the biggest and most obvious differences between the two is the ever-present polygon budget that's found in any game development process. When it comes to modeling for movies, whether it's an animated feature like Toy Story 3 or a live action film with CG integrated in like Pacific Rim there's not really a limit on the amount of polygons that can be in any given model.

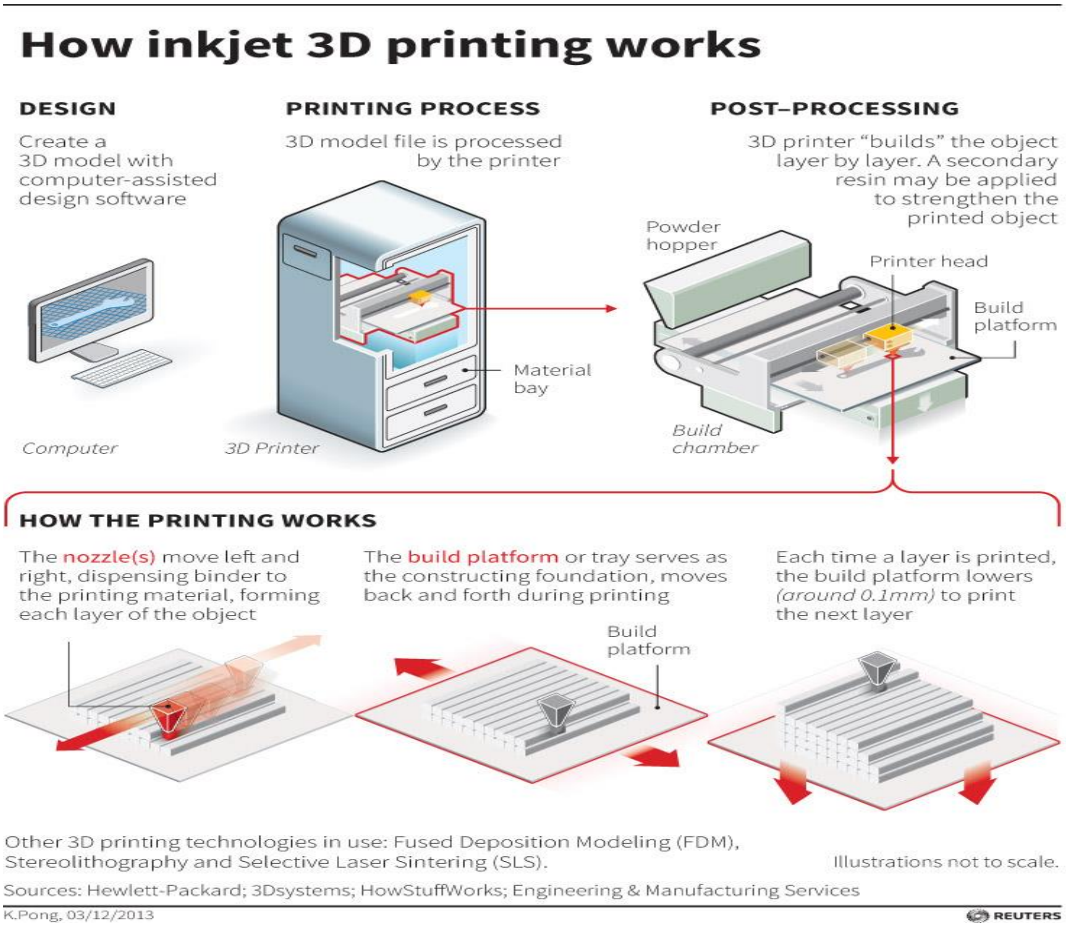
For movies, often times the only constraint you have is time. Like any other production, movies have deadlines which must be met. This means you'll need to be able to produce great looking models on time and on budget. In movies you've got free range to use however many polygons it takes to get the model to look good on screen because, in the end, that's what matters the most. For games it's different because you're limited by the power of the game engine and the hardware it's being played on. Of course, hardware is constantly advancing, and with consoles like Xbox One and PlayStation 4 the graphical capabilities have increased. But even with next-gen consoles today there's still a strict polygon budget that must be met in order for the game to be able to play smoothly. Games are rendered in real-time right in front of the player, so in order for the game to run at a constant frame rate and maintain it throughout the gameplay, the 3D models must be created at a level that's not taxing on the game engine.

4.3. 3D printing

3D printing is a new field which become popular in recent 10 years. It can be used in many areas just like industry material, manufacturing of precision mechanical parts, and even medical area(use special ‘print ink’ to make some parts of body).

4.3.1. Printing process

Think of your desktop printer adding a single layer of ink to a page to print a pattern designed on a computer. Now, imagine that the same printer was able to add multiple layers until that pattern was three-dimensional. That, in essence, is 3D printing, and it's a technology with almost limitless applications that is opening up endless possibilities in a variety of sectors and industries.



4.3.2. Why are 3D printers so important?

3D printers offer designers and manufacturers remarkable flexibility and almost unlimited innovation possibilities at little to no extra cost compared with traditional manufacturing. They allow companies and individuals to create value-add, customized or high-performance parts and products accurately, quickly, and economically. They can be used at every stage of the product life-cycle, from rapid prototyping for design to final production and even for spare parts post-sales - and can be used to create individual bespoke parts or to print at large, industrial level volumes.

§5. Conclusion

With the rapid development of Internet technology, 3D modeling is increasingly applied to many aspect of our life such as automotive, animation, 3D printing and so on. Throughout its long history, 3D modeling technology has always been optimized and advanced with the development of the times. Although it's impossible to predict exactly how technology and new applications will affect its future, for 3D modeling the future has always been bright.

§6. References

overview	https://www.selfcad.com/blog/when-did-3d-modeling-start-a-brief-history
	https://en.wikipedia.org/wiki/3D_modeling
	https://www.cadcrowd.com/blog/do-you-know-the-three-major-types-of-3d-models/
3D modeling software	https://www.autodesk.com/solutions/3d-modeling-software
	https://en.wikipedia.org/wiki/Blender_(software)
	https://en.wikipedia.org/wiki/Autodesk_Maya
	https://en.wikipedia.org/wiki/Cinema_4D
	https://en.wikipedia.org/wiki/Rhinoceros_3D
3D modeling creation	https://cgifurniture.com/3d-model-creation-5-stages/
Applications of 3D modeling	3D Modeling in Games vs Movies: A battle of the budget? | 3D-Ace Studio
	How 3D has made an impact on the film industry - Europac3D
	3D Modeling - Game Dev Insider
	3D Modeling Techniques in Games | 3D-Ace Studio
	How does 3D printing work? | HP® Official Site