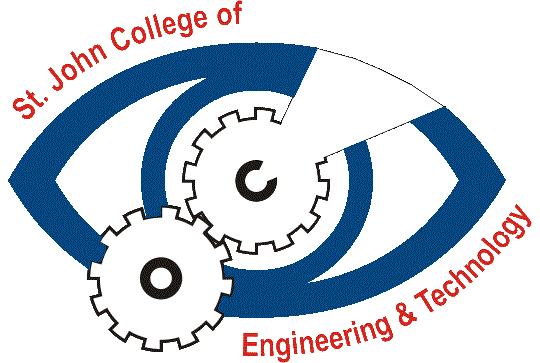
***Aldel Education Trust’s***

**ST. JOHN COLLEGE OF ENGINEERING AND TECHNOLOGY**

****

**CERTIFICATE**

### This is to certify that the presentation report on “Computer graphics” is genuine effort of following students of SE Comps A:

* Diana Varghese
* Lendl Paul
* Srihari Pillai
* Sneha Varghese
* Joel Ulahanna
* Sivanesh Nadar
* Purva Sankhe
* Ashwini Utturkar
* Neil Pereira
* Valentine Correia

Date:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ Staff-in-charge Principal

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**Thank you.**

### Abstract

This report explores in depth a very interesting and untouched topic-COMPUTER GRAPHICS.

It begins with the study of computer graphics followed by twelve principles then two dimensional and three dimensional then generations followed by pioneers then the of animation then it’s history then lastly motion graphics.

It is used in every day by all of us as it makes designing in computers more exciting Moreover it helps in representing the things as we require on the computer with all it’s effect. Three dimensional animation is responsible for this. It mainly helps in web designing. Animation now has emerged to be a whole new sector as well as it has immense scope in this field.

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**1.Introduction**

* "A picture is worth a thousand words" is a well-known saying, and highlights the advantages and benefits of the visual presentation of our data. We are able to obtain a comprehensive overall view of our data and also study features and areas of particular interest.
* The term computer graphics includes almost everything on computers that is not text or sound. Today almost every computer can do some graphics, and people have even come to expect to control their computer through icons and pictures rather than just by typing.
* Today there are very few aspects of our lives not affected by computers. Practically every cash or monetary transaction that takes place daily involves a computer. In many cases, the same is true of computer graphics. Whether you see them on television, in newspapers, in weather reports or while at the doctor's surgery, computer images are all around you.
* A well-chosen graph is able to transform a complex table of numbers into meaningful results. Such graphs are used to illustrate papers, reports, and theses, as well as providing the basis for presentation material in the form of slides and overhead transparencies.
* We think of computer graphics as drawing pictures on computers, also called rendering. The pictures can be photographs, drawings, movies, or simulations -- pictures of things which do not yet exist and maybe could never exist. Or they may be pictures from places we cannot see directly, such as medical images from inside your body.
* A range of tools and facilities are available to enable users to visualise their data, and this document provides a brief summary and overview.
* We spend much of our time improving the way computer pictures can simulate real world scenes. We want images on computers to not just look more realistic, but also to BE more realistic in their colors, the way objects and rooms are lighted, and the way different materials appear

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **2.Study Of Computer Graphics** | |  | | |
|  | | | | |
|  | |  | |
| * **Color In Computer Graphics**   Computers don't create [colour](http://www.graphics.cornell.edu/online/tutorial/color/) exactly the way we see it. As illustrated in the following picture | | | | |
| http://www.graphics.cornell.edu/online/tutorial/color/heidirgb.jpg  Computers typically display color in three components - red, green, and blue. When combined, these three colors make the full-color image seen in the upper left of this image.  http://www.graphics.cornell.edu/online/tutorial/color/heidiblnd.jpg  By controlling color display, we can simulate on the computer different kinds of color blindness. | | | | |

|  |  |
| --- | --- |
| * **Reflection and Transparency** |  |
|  | | |
| These two images illustrate the extent to which light reflection can be modeled by tracing the paths of light rays entering your eye. The images are calculated from one specific viewpoint only, and must be completely recreated if the viewer's position moves.  .http://www.graphics.cornell.edu/online/tutorial/raytrace/rcbumps.jpg  The face is applied to the cube by mapping a flat image "texture" onto the object, as if it were wallpaper on a wall. The bumpiness is simulated by a process called, appropriately enough, "bump mapping".The glass object is transparent, so the lighting model must allow a certain percentage of light to pass through. Since the square piece of glass is not perfectly transparent, we see its shadow clearly. Note that we also see a dim image that appears to be etched on the glass and projected on the surface of the table  http://www.graphics.cornell.edu/online/tutorial/raytrace/rem10.jpg | | |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | * **Object Rendering Shading Techniques** |  | | [Shading techniques](http://www.graphics.cornell.edu/online/tutorial/vase/) extend the realistic appearance of objects and introduce features such as transparency and textures. | | | | http://www.graphics.cornell.edu/online/tutorial/vase/vase1.4h.jpg  This vase has been modeled as a symmetrical pattern of vertically-oriented surfaces - tiny flat patches which approximate the round shape of the vase. In this image, each tiny surface is shaded separately with a different gray value based on its orientation to the light source.  http://www.graphics.cornell.edu/online/tutorial/vase/vase2.4h.jpg  By introducing a technique called Gouraud shading, we can smooth out the appearance of the vase and hide the individual surfaces from view. The shading is varied on each surface in proportion to values calculated at the edges and from neighboring surfaces.  http://www.graphics.cornell.edu/online/tutorial/vase/vase3.4h.jpg  Phong shading improves the apparent realism of the rendering still further by introducing highlights. The way light reflects from real surfaces depends on how shiny the surface is and on the angle you are looking from. Most surfaces are not shiny but "diffuse" appearance.The surface of this vase is just shiny enough to reflect some light directly to the viewer at certain angles, but around the sides the appearance is much duller. Light hitting the vase at flatter angles is scattered more evenly in all directions.  http://www.graphics.cornell.edu/online/tutorial/vase/vase4.4h.jpg  In this last image the shading technique has been extended to let some light pass through the vase - for transparency.These shading techniques (and more) have all been incorporated into the generalized rendering technique called **ray tracing**. | | | |

# 3. 12 Principles Of Animation

# 1. Squash and stretch:-

* Animated sequence of a race horse galloping.
* The horse's body demonstrates squash and stretch in natural musculature.
* The most important principle is "[squash and stretch](http://en.wikipedia.org/wiki/Squash_and_stretch)" the purpose of which is to give a sense of weight and flexibility to drawn objects.
* It can be applied to simple objects, like a bouncing ball, or more complex constructions, like the musculature of a human face.
* Taken to an extreme point, a figure stretched or squashed to an exaggerated degree can have a comical effect.
* In realistic animation, however, the most important aspect of this principle is the fact that an object's volume does not change when squashed or stretched.
* If the length of a ball is stretched vertically, its width (in three dimensions, also its depth) needs to contract correspondingly horizontally.

**2. Anticipation:-**

* Anticipation is used to prepare the audience for an action, and to make the action appear more realistic.
* The technique can also be used for less physical actions, such as a character looking off-screen to anticipate someone's arrival, or attention focusing on an object that a character is about to pick up
* For special effect, anticipation can also be omitted in cases where it is expected.

**3. Staging:-**

* This principle is akin to [staging](http://en.wikipedia.org/wiki/Staging_(theatre)) as it is known in theatre and film .Its purpose is to direct the audience's attention, and make it clear what is of greatest importance in a scene.
* what is happening, and what is about to happen. Johnston and Thomas defined it as "the presentation of any idea so that it is completely and unmistakably clear", whether that idea is an action, a personality, an expression or a mood. This can be done by various means, such as the placement of a character in the frame, the use of light and shadow, and the angle and position of the camera. The essence of this principle is keeping focus on what is relevant, and avoiding unnecessary detail.

**4. Straight ahead action and pose to pose:-**

* These are two different approaches to the actual drawing process.
* "Straight ahead action" means drawing out a scene frame by frame from beginning to end. "Straight ahead action" creates a more fluid, dynamic illusion of movement, and is better for producing realistic action sequences
* While "pose to pose" involves starting with drawing a few key frames, and then filling in the intervals later.
* On the other hand, it is hard to maintain proportions, and to create exact, convincing poses along the way. "Pose to pose" works better for dramatic or emotional scenes.
* Computer animation removes the problems of proportion related to "straight ahead action" drawing; however, "pose to pose" is still used for computer animation, because of the advantages it brings in composition.

# 5. Follow through and overlapping action:-

* "Follow through" means that separate parts of a body will continue moving after the character has stopped.
* "Overlapping action" is the tendency for parts of the body to move at different rates .
* A third technique is "drag", where a character starts to move and parts of him take a few frames to catch up. These parts can be animate objects like clothing or the antenna on a car.
* On the human body, the torso is the core, with arms, legs, head and hair appendices that normally follow the torso's movement. Body parts with much tissue, such as large stomachs and or the loose skin on a dog, are more prone to independent movement than bonier body parts. Again, exaggerated use of the technique can produce a comical effect, while more realistic animation must time the actions exactly, to produce a convincing result.
* The principle of the "moving hold". A character not in movement can be rendered absolutely still this is often done, particularly to draw attention to the main action.

# 6. Slow in and slow out:-

* The movement of the human body, and most other objects, needs time to accelerate and slow down. For this reason, animation looks more realistic if it has more drawings near the beginning and end of an action, emphasizing the extreme poses, and fewer in the middle.
* This principle goes for characters moving between two extreme poses, such as sitting down and standing up, but also for inanimate, moving objects, like the bouncing ball in the above illustration.

**7. Arcs:-**

* Most natural action tends to follow an arched [trajectory](http://en.wikipedia.org/wiki/Trajectory), and animation should adhere to this principle by following implied "arcs" for greater realism. This can apply to a limb moving by rotating a joint, or a thrown object moving along a [parabolic](http://en.wikipedia.org/wiki/Parabola) trajectory. The exception is mechanical movement, which typically moves in straight lines.
* As an object's speed and momentum increases, arcs tend to flatten out in moving ahead and broaden in turns. In baseball, a fastball would tend to move in a straighter line than other pitches; while a figure skater moving at top speed would be unable to turn as sharply as a slower skater, and would need to cover more ground to complete the turn.
* An object in motion that moves out of its natural arc for no apparent reason will appear erratic rather than fluid. Therefore when animating (for example) a pointing finger, the animator should be certain that in all drawings in between the two extreme poses, the fingertip follows a logical arc from one extreme to the next. Traditional animators tend to draw the arc in lightly on the paper for reference, to be erased later.

# 8. Secondary action:-

* Adding secondary actions to the main action gives a scene more life, and can help to support the main action. A person walking can simultaneously swing his arms or keep them in his pockets, he can speak or whistle, or he can express emotions through facial expressions.
* The important thing about secondary actions is that they emphasize, rather than take attention away from the main action. If the latter is the case, those actions are better left out.
* In the case of facial expressions, during a dramatic movement these will often go unnoticed. In these cases it is better to include them at the beginning and the end of the movement, rather than during.

# 9. Appeal:-

* Appeal in a cartoon character corresponds to what would be called [charisma](http://en.wikipedia.org/wiki/Charisma) in an actor. A character who is appealing is not necessarily sympathetic – villains or monsters can also be appealing – the important thing is that the viewer feels the character is real and interesting.

**10. Timing:-**

* Timing refers to the number of drawings or frames for a given action, which translates to the speed of the action on film.
* On a purely physical level, correct timing makes objects appear to abide to the laws of physics; for instance, an object's weight decides how it reacts to an impetus, like a push.
* Timing is critical for establishing a character's mood, emotion, and reaction. It can also be a device to communicate aspects of a character's personality.

# 11. Exaggeration:-

* Exaggeration is an effect especially useful for animation, as perfect Limitation of reality can look static and dull in cartoons.
* The level of exaggeration depends on whether one seeks realism or a particular style, like a caricature or the style of an artist. The classical definition of exaggeration, employed by Disney, was to remain true to reality, just presenting it in a wilder, more extreme form.
* Other forms of exaggeration can involve the supernatural or superreal, alterations in the physical features of a character, or elements in the storyline itself.
* It is important to employ a certain level of restraint when using exaggeration; if a scene contains several elements, there should be a balance in how those elements are exaggerated in relation to each other, to avoid confusing or overawing the viewer.

# 12. Solid drawing:-

* The principle of [solid](http://en.wikipedia.org/wiki/Solid_geometry) drawing means taking into account forms in three-dimensional space, giving them volume and weight.
* The animator needs to be a skilled [draughtsman](http://en.wikipedia.org/wiki/Draughtsman) and has to understand the basics of three-dimensional shapes, anatomy, weight, balance, light and shadow, etc. For the classical animator, this involved taking art classes and doing sketches from life. An creating "twins": characters whose left and right sides mirrored each other, and looked lifeless.

# 4. History of Computer Animation

# 4.1. Initial 1960s developments:-

* + Further advances in computing led to greater advancements in interactive computer graphics. In 1959, the TX-2 computer was developed at MIT's Lincoln Laboratory. The TX-2 integrated a number of new man-machine interfaces. A light pen could be used to draw sketches on the computer using Ivan Sutherland's revolutionary Sketchpad software.
  + Using a light pen, Sketchpad allowed one to draw simple shapes on the computer screen, save them and even recall them later. The light pen itself had a small photoelectric cell in its tip. This cell emitted an electronic pulse whenever it was placed in front of a computer screen and the screen electron gun fired directly at it. By simply timing the electronic pulse with the current location of the electron gun, it was easy to pinpoint exactly where the pen was on the screen at any given moment. Once that was determined, the computer could then draw a cursor at that location.
  + Sutherland seemed to find the perfect solution for many of the graphics problems he faced. Even today, many standards of computer graphics interfaces got their start with this early Sketchpad program. One example of this is in drawing constraints. If one wants to draw a square for example, they do not have to worry about drawing four lines perfectly to form the edges of the box. One can simply specify that they want to draw a box, and then specify the location and size of the box. The software will then construct a perfect box, with the right dimensions and at the right location. Another example is that Sutherland's software modeled objects - not just a picture of objects. In other words, with a model of a car, one could change the size of the tires without affecting the rest of the car. It could stretch the body of the car without deforming the tires.

# 4.2. Further 19761s development:-

* Also in 1961 another student at MIT, Steve Russell, created the first video game ,Space war .The engineers at DEC used it as a diagnostic program on every new PDP-1 before shipping it. The sales force picked up on this quickly enough and when installing new units, would run the world's first video game for their new customers.
* E. E. Zajac, a scientist at Bell Telephone Laboratory (BTL), created a film called "Simulation of a two-giro gravity attitude control system" in 1963.In this computer generated film, Zajac showed how the attitude of a satellite could be altered as it orbits the Earth. He created the animation on an IBM 7090 mainframe computer. Also at BTL, Ken Knowlton, Frank Sindonand Michael Noll started working in the computer graphics field. Sindon created a film called Force, Mass and Motion illustrating Newton's laws of motion in operation.
* It was not long before major corporations started taking an interest in computer graphics. TRW, Lockheed-Georgia, General Electric and Sperry Rand are among the many companies that were getting started in computer graphics by the mid-1960s. IBM was quick to respond to this interest by releasing the IBM 2250 graphics terminal, the first commercially available graphics computer.
* David C. Evans was director of engineering at Bendix Corporation's computer division from 1953 to 1962.There he continued his interest in computers and how they interfaced with people. In 1966, the University of Utah recruited Evans to form a computer science program, and computer graphics quickly became his primary interest. This new department would become the world's primary research center for computer graphics.
* In 1969, the ACM initiated A Special Interest Group in Graphics (SIGGRAPH) which organizes conferences, graphics standards, and publications within the field of computer graphics. In 1973, the first annual SIGGRAPH conference was held, which has become one of the focuses of the organization. SIGGRAPH has grown in size and importance as the field of computer graphics has expanded over time.

# 4.3.1970s:-

* Many of the most important early breakthroughs in computer graphics research occurred at the University of Utah in the 1970s. A student by the name of Edwin Catmull started at the University of Utah in 1970 and signed up for Sutherland's computer graphics class. Catmull had just come from The Boeing Company and had been working on his degree in physics. Growing up on Disney is the first animation that Catmull saw was his own. He created an animation of his hand opening and closing. It became one of his goals to produce a feature length motion picture using computer graphics.
* As the UU computer graphics laboratory was attracting people from all over, John Warnock was one of those early pioneers; he would later found Adobe Systems and create a revolution in the publishing world with his PostScript page description language. Tom Stockham led the image processing group at UU which worked closely with the computer graphics lab. Jim Clark was also there; he would later found Silicon Graphics, Include.
* The first major advance in 3D computer graphics was created at UU by these early pioneers, the hidden-surface algorithm. In order to draw a representation of a 3D object on the screen, the computer must determine which surfaces are "behind" the object from the viewer's perspective, and thus should be "hidden" when the computer creates (or renders) the image.

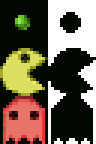
# 4.4.1980s:-

* In the early 1980s, the availability of bit-slice and 16-bit microprocessors started to revolution high resolution computer graphics terminals which now increasingly became intelligent, semi-standalone and standalone workstations. Graphics and application processing were increasingly migrated to the intelligence in the workstation, rather than continuing to rely on central mainframe and mini-computers.
* Typical of the early move to high resolution computer graphics intelligent workstations for the computer-aided engineering market were the Orca 1000, 2000 and 3000 workstations. The Orca 3000 was based on Motorola 68000 and AMD bit-slice processors and had Unix as its operating system. It was targeted squarely at the sophisticated end of the design engineering sector. Artists and graphic designers began to see the personal computer , one that could save time and draw more accurately than other methods. In the late 1980s, SGI computers were used to create some of the first fully computer-generated short films at Pixar.
* The Macintosh remains a highly popular tool for computer graphics among graphic design studios and businesses. Modern computers, dating from the 1980s often use graphical user interfaces(GUI) to present data and information with symbols, icons and pictures, rather than text. Graphics are one of the five key elements of multimedia technology.

**4.5.1990s:-**

* 3D graphics became more popular in the 1990s in gaming, multimedia and animation. At the end of the 80s and beginning of the nineties were created, in France, the very first computer graphics TV series: "La Vie des bêtes" by studio Mac Guff Ligne (1988), Les Fables Géométriques J.-Y. Grall, Georges Lacroix and Renato (studio Fantome, 1990–1993) and Quarxs, the first HD TV computer graphics series by Maurice Benayoun and François Schuiten (studio Z-A production, 1991–1993).In 1995, Toy Story, the first full-length computer-generated animation film, was released in cinemas worldwide. In 1996, Quake, one of the first fully 3D games, was released.
* Since then, computer graphics have only become more detailed and realistic, due to more powerful graphics hardware and 3D modeling software.

**5. Two-dimensional**

[](http://en.wikipedia.org/wiki/File:Blit_dot.gif)

[2D computer graphics](http://en.wikipedia.org/wiki/2D_computer_graphics) are the computer-based generation of [digital images](http://en.wikipedia.org/wiki/Digital_image)—mostly from two-dimensional models, such as [2D geometric models](http://en.wikipedia.org/wiki/2D_geometric_model), text, and digital images, and by techniques specific to them.

2D computer graphics are mainly used in applications that were originally developed upon traditional [printing](http://en.wikipedia.org/wiki/Printing) and [drawing](http://en.wikipedia.org/wiki/Drawing) technologies, such as [typography](http://en.wikipedia.org/wiki/Typography), [cartography](http://en.wikipedia.org/wiki/Cartography), [technical drawing](http://en.wikipedia.org/wiki/Technical_drawing), [advertising](http://en.wikipedia.org/wiki/Advertising), etc.. In those applications, the two-dimensional [image](http://en.wikipedia.org/wiki/Image) is not just a representation of a real-world object, but an independent artifact with added semantic value; two-dimensional models are therefore preferred, because they give more direct control of the image than [3D computer graphics](http://en.wikipedia.org/wiki/3D_computer_graphics), whose approach is more akin to [photography](http://en.wikipedia.org/wiki/Photography) than to [typography](http://en.wikipedia.org/wiki/Typography).

**5.1.Pixel art**

[Pixel art](http://en.wikipedia.org/wiki/Pixel_art) is a form of [digital art](http://en.wikipedia.org/wiki/Digital_art), created through the use of [raster graphics](http://en.wikipedia.org/wiki/Raster_graphics) [software](http://en.wikipedia.org/wiki/Software), where images are edited on the [pixel](http://en.wikipedia.org/wiki/Pixel) level. Graphics in most old (or relatively limited) computer and video games, [graphing calculator](http://en.wikipedia.org/wiki/Graphing_calculator) games, and many [mobile phone](http://en.wikipedia.org/wiki/Mobile_phone) games are mostly pixel art.

#### Vector graphics

[](http://en.wikipedia.org/wiki/File:VectorBitmapExample.png)

Example showing effect of vector graphics versus raster (bitmap) graphics.

[Vector graphics](http://en.wikipedia.org/wiki/Vector_graphics) formats are complementary to [raster graphics](http://en.wikipedia.org/wiki/Raster_graphics). Raster graphics is the representation of images as an array of [pixels](http://en.wikipedia.org/wiki/Pixel) and is typically used for the representation of photographic images.  Vector graphics consists in encoding information about shapes and colors that comprise the image, which can allow for more flexibility in rendering. There are instances when working with vector tools and formats is best practice, and instances when working with raster tools and formats is best practice. There are times when both formats come together. An understanding of the advantages and limitations of each technology and the relationship between them is most likely to result in efficient and effective use of tools.

**5.2. 2D graphics techniques**

2D graphics models may combine [geometric models](http://en.wikipedia.org/wiki/2D_geometric_model) (also called [vector graphics](http://en.wikipedia.org/wiki/Vector_graphics)), [digital images](http://en.wikipedia.org/wiki/Digital_image) (also called [raster graphics](http://en.wikipedia.org/wiki/Raster_graphics)), imensional [geometric transformations](http://en.wikipedia.org/wiki/Transformation_(geometry)) such as [translation](http://en.wikipedia.org/wiki/Translation_(geometry)), [rotation](http://en.wikipedia.org/wiki/Rotation), [scaling](http://en.wikipedia.org/wiki/Scaling_(geometry)). In [object-oriented graphicts](http://en.wikipedia.org/wiki/Object-oriented_graphics)ext to be [typeset](http://en.wikipedia.org/wiki/Typesetting) (defined by content, [font](http://en.wikipedia.org/wiki/Typeface) style and size, color, position, and orientation), mathematical [functions](http://en.wikipedia.org/wiki/Function_(mathematics)) and [equations](http://en.wikipedia.org/wiki/Equation), and more. These components can be modified and manipulated by two-d, the image is described indirectly by an [object](http://en.wikipedia.org/wiki/Object_(computer_science)) endowed with a self-[rendering](http://en.wikipedia.org/wiki/Rendering_(computer_graphics)) [method](http://en.wikipedia.org/wiki/Method_(computer_science))—a procedure which assigns colors to the image [pixels](http://en.wikipedia.org/wiki/Pixel) by an arbitrary algorithm. Complex models can be built by combining simpler objects, in the paradigms of [object-oriented programming](http://en.wikipedia.org/wiki/Object-oriented_programming).

[Euclidean geometry](http://en.wikipedia.org/wiki/Euclidean_geometry), a **translation** moves every point a constant distance in a specified direction. A tran In slation can be described as a [rigid motion](http://en.wikipedia.org/wiki/Euclidean_group): other rigid motions include rotations and reflections. A translation can also be interpreted as the addition of a constant[vector](http://en.wikipedia.org/wiki/Vector_space) to every point, or as shifting the [origin](http://en.wikipedia.org/wiki/Origin_(mathematics)) of the [coordinate system](http://en.wikipedia.org/wiki/Coordinate_system). A **translation operator** is an [operator](http://en.wikipedia.org/wiki/Operator_(mathematics)) T_\mathbf{\delta} such that T_\mathbf{\delta} f(\mathbf{v}) = f(\mathbf{v}+\mathbf{\delta}).

If **v** is a fixed vector, then the translation *T***v** will work as *T***v**(**p**) = **p** + **v**.

If *T* is a translation, then the [image](http://en.wikipedia.org/wiki/Image_(mathematics)) of a subset *A* under the [function](http://en.wikipedia.org/wiki/Function_(mathematics)) *T* is the **translate** of *A*by *T*. The translate of *A* by *T***v** is often written *A* + **v**.

In a [Euclidean space](http://en.wikipedia.org/wiki/Euclidean_space), any translation is an [isometry](http://en.wikipedia.org/wiki/Isometry). The set of all translations forms the translation group *T*, which is isomorphic to the space itself, and a [normal subgroup](http://en.wikipedia.org/wiki/Normal_subgroup) of[Euclidean group](http://en.wikipedia.org/wiki/Euclidean_group) *E*(*n* ). The [quotient group](http://en.wikipedia.org/wiki/Quotient_group) of *E*(*n* ) by *T* is isomorphic to the [orthogonal group](http://en.wikipedia.org/wiki/Orthogonal_group)*O*(*n* ):

*E*(*n* ) */ T* ≅ *O*(*n* ).

**5.3. TRANSLATION**

Since a translation is an [affine transformation](http://en.wikipedia.org/wiki/Affine_transformation) but not a [linear transformation](http://en.wikipedia.org/wiki/Linear_transformation), [homogeneous coordinates](http://en.wikipedia.org/wiki/Homogeneous_coordinates) are normally used to represent the translation operator by a [matrix](http://en.wikipedia.org/wiki/Matrix_(math)) and thus to make it linear. Thus we write the 3-dimensional vector **w** = (*wx*, *wy*, *wz*) using 4 homogeneous coordinates as **w** = (*wx*, *wy*, *wz*, 1).

To translate an object by a [vector](http://en.wikipedia.org/wiki/Vector_(geometry)) **v**, each homogeneous vector **p** (written in homogeneous coordinates) would need to be multiplied by this **translation matrix**:

 T_{\mathbf{v}} = 
\begin{bmatrix}
1 & 0 & 0 & v_x \\
0 & 1 & 0 & v_y \\
0 & 0 & 1 & v_z \\
0 & 0 & 0 & 1 
\end{bmatrix}


As shown below, the multiplication will give the expected result:

 T_{\mathbf{v}} \mathbf{p} =
\begin{bmatrix}
1 & 0 & 0 & v_x \\
0 & 1 & 0 & v_y\\
0 & 0 & 1 & v_z\\
0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
p_x \\ p_y \\ p_z \\ 1
\end{bmatrix}
=
\begin{bmatrix}
p_x + v_x \\ p_y + v_y \\ p_z + v_z \\ 1
\end{bmatrix}
= \mathbf{p} + \mathbf{v} 

The inverse of a translation matrix can be obtained by reversing the direction of the vector:

 T^{-1}_{\mathbf{v}} = T_{-\mathbf{v}} . \! 

Similarly, the product of translation matrices is given by adding the vectors:

 T_{\mathbf{u}}T_{\mathbf{v}} = T_{\mathbf{u}+\mathbf{v}} . \! 

**Because addition of vectors is commutative, multiplication of trans**

**6. 3D computer graphics**

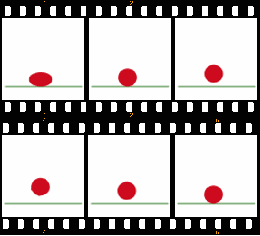
[](http://en.wikipedia.org/wiki/File:Glasses_800_edit.png)

**3D computer graphics** (in contrast to [2D computer graphics](http://en.wikipedia.org/wiki/2D_computer_graphics)) are graphics that use a three-dimensional representation of geometric data (often [Cartesian](http://en.wikipedia.org/wiki/Cartesian_coordinate_system#Cartesian_coordinates_in_three_dimensions)) that is stored in the computer for the purposes of performing calculations and rendering 2D images. Such images may be stored for viewing later or displayed in real-time.

3D computer graphics rely on many of the same [algorithms](http://en.wikipedia.org/wiki/Algorithm) as 2D computer [vector graphics](http://en.wikipedia.org/wiki/Vector_graphics) in the [wire-frame model](http://en.wikipedia.org/wiki/Wire-frame_model) and 2D computer [raster graphics](http://en.wikipedia.org/wiki/Raster_graphics) in the final rendered display. In computer graphics software, the distinction between 2D and 3D is occasionally blurred; 2D applications may use 3D techniques to achieve effects such as [lighting](http://en.wikipedia.org/wiki/Lighting), and 3D may use 2D rendering techniques.

3D computer graphics are often referred to as [3D models](http://en.wikipedia.org/wiki/3D_modeling). Apart from the rendered graphic, the model is contained within the graphical data file. However, there are differences. A 3D model is the [mathematical](http://en.wikipedia.org/wiki/Mathematics) representation of any [three-dimensional](http://en.wikipedia.org/wiki/Three-dimensional_space) object. A model is not technically a graphic until it is displayed. Due to [3D printing](http://en.wikipedia.org/wiki/3D_printing), 3D models are not confined to virtual space. A model can be displayed visually as a two-dimensional image through a process called [*3D rendering*](http://en.wikipedia.org/wiki/3D_rendering)*,* or used in non-graphical [computer simulations](http://en.wikipedia.org/wiki/Computer_simulation) and calculations.

**7. Animation**

[](http://en.wikipedia.org/wiki/File:Animexample3edit.png)

The bouncing ball animation (below) consists of these six frames.

[](http://en.wikipedia.org/wiki/File:Animexample.gif)

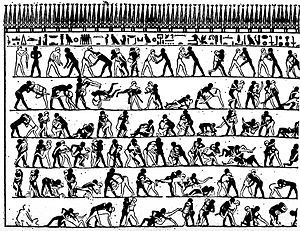
This animation moves at 10 frames per second.

**Animation** is the rapid display of a sequence of images to create an [illusion](http://en.wikipedia.org/wiki/Illusion) of movement. The most common method of presenting animation is as a motion picture or video program, although there are other methods. This type of presentation is usually accomplished with a [camera](http://en.wikipedia.org/wiki/Camera) and a [projector](http://en.wikipedia.org/wiki/Projector) or a [computer](http://en.wikipedia.org/wiki/Computer) viewing screen which can rapidly cycle through images in a sequence. Animation can be made with either hand rendered art, [computer generated imagery](http://en.wikipedia.org/wiki/Computer_generated_imagery), or three-dimensional objects, e.g. puppets or clay figures, or a combination of techniques.

**7.1.Etymology**

From Latin *animātiō*, "the act of bringing to life"; from *animō* ("to animate" or "give life to") + *-ātiō* ("the act of").

**7.2. History of animation**

[](http://en.wikipedia.org/wiki/File:Egyptmotionseries.jpg)

[*History of animation*](http://en.wikipedia.org/wiki/History_of_animation)

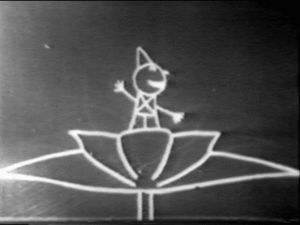
An [Egyptian](http://en.wikipedia.org/wiki/Egypt) [burial chamber](http://en.wikipedia.org/wiki/Burial_chamber) [mural](http://en.wikipedia.org/wiki/Mural), approximately 4000 years old, showing [wrestlers](http://en.wikipedia.org/wiki/Wrestler) in action. Even though this may appear similar to a series of animation drawings, there was no way of viewing the images in motion. It does, however, indicate the artist's intention of depicting motion.

Early examples of attempts to capture the phenomenon of motion drawing can be found in [paleolithic](http://en.wikipedia.org/wiki/Paleolithic) [cave paintings](http://en.wikipedia.org/wiki/Cave_painting), where animals are depicted with multiple legs in superimposed positions, clearly attempting to convey the perception of motion.

A 5,000 year old earthen bowl found in Iran in [Shahr-i Sokhta](http://en.wikipedia.org/wiki/Shahr-e_Sukhteh) has five images of a goat painted along the sides. This has been claimed to be an example of early animation. However, since no equipment existed to show the images in motion, such a series of images cannot be called animation in a true sense of the word.

Chinese zoetrope-typedevice had been invented in 180 AD. The[phenakistoscope](http://en.wikipedia.org/wiki/Phenakistoscope), [praxinoscope](http://en.wikipedia.org/wiki/Praxinoscope), and the common [flip book](http://en.wikipedia.org/wiki/Flip_book) were early popular animation devices invented during the 19th century.

These devices produced the appearance of movement from sequential drawings using technological means, but animation did not really develop much further until the advent of [cinematography](http://en.wikipedia.org/wiki/Cinematography).

[](http://en.wikipedia.org/wiki/File:Fantasmagorie_(Cohl).GIF)

[*Fantasmagorie*](http://en.wikipedia.org/wiki/Fantasmagorie_(1908_film)) by Emile Cohl, 1908

Another French artist, [ÉmileCohl](http://en.wikipedia.org/wiki/%C3%89mile_Cohl), began drawing cartoon strips and created a film in 1908 called [*Fantasmagorie*](http://en.wikipedia.org/wiki/Fantasmagorie_(1908_film)). The film largely consisted of a [stick figure](http://en.wikipedia.org/wiki/Stick_figure) moving about and encountering all manner of morphing objects, such as a wine bottle that transforms into a flower. There were also sections of live action where the animator’s hands would enter the scene. The film was created by drawing each frame on paper and then shooting each frame onto[negative film](http://en.wikipedia.org/wiki/Negative_film), which gave the picture a blackboard look. This makes*Fantasmagorie* the first animated film created using what came to be known as [traditional (hand-drawn) animation](http://en.wikipedia.org/wiki/Traditional_animation).

The production of animated short films, typically referred to as "cartoons", became an industry of its own during the 1910s, and cartoon shorts were produced to be shown in [movie theaters](http://en.wikipedia.org/wiki/Movie_theaters). The most successful early animation producer was [John Randolph Bray](http://en.wikipedia.org/wiki/John_Randolph_Bray), who, along with [animator](http://en.wikipedia.org/wiki/Animator) [Earl Hurd](http://en.wikipedia.org/wiki/Earl_Hurd), patented the [cel animation](http://en.wikipedia.org/wiki/Traditional_animation#Cels) process which dominated the animation industry for the rest of the decade.

**7.3.Traditional animation**

Traditional animation (also called cel animation or hand-drawn animation) was the process used for most animated films of the 20th century. The individual frames of a traditionally animated film are photographs of drawings, which are first drawn on paper. To create the illusion of movement, each drawing differs slightly from the one before it. The animators' drawings are traced or photocopied onto transparent acetate sheets called [cels](http://en.wikipedia.org/wiki/Cel), which are filled in with paints in assigned colors or tones on the side opposite the line drawings. The completed character cels are photographed one-by-one onto motion picture film against a painted background by a [rostrum camera](http://en.wikipedia.org/wiki/Rostrum_camera).

* **Full animation** refers to the process of producing high-quality traditionally animated films, which regularly use detailed drawings and plausible movement. Fully animated films can be done in a variety of styles, from more realistically animated works such as those produced by the [Walt Disney studio](http://en.wikipedia.org/wiki/Walt_Disney_Animation_Studios) ([*Beauty and the Beast*](http://en.wikipedia.org/wiki/Beauty_and_the_Beast_(1991_film)), [*Aladdin*](http://en.wikipedia.org/wiki/Aladdin_(1992_Disney_film)), [*Lion King*](http://en.wikipedia.org/wiki/The_Lion_King)) to the more 'cartoony' styles of those produced by the [Warner Bros. animation studio](http://en.wikipedia.org/wiki/Warner_Bros._Cartoons). Many of the [Disney animated features](http://en.wikipedia.org/wiki/Disney_animated_features) are examples of full animation, as are non-Disney works such as [*The Secret of NIMH*](http://en.wikipedia.org/wiki/The_Secret_of_NIMH) (US, 1982), [*The Iron Giant*](http://en.wikipedia.org/wiki/The_Iron_Giant) (US, 1999), and [*Nocturna*](http://en.wikipedia.org/wiki/Nocturna_(Film)) (Spain, 2007).
* [**Limited animation**](http://en.wikipedia.org/wiki/Limited_animation) involves the use of less detailed and/or more stylized drawings and methods of movement. Pioneered by the artists at the American studio [United Productions of America](http://en.wikipedia.org/wiki/United_Productions_of_America), limited animation can be used as a method of stylized artistic expression, as in [*Gerald McBoing Boing*](http://en.wikipedia.org/wiki/Gerald_McBoing_Boing) (US, 1951),
* [**Rotoscoping**](http://en.wikipedia.org/wiki/Rotoscoping) is a technique, patented by [Max Fleischer](http://en.wikipedia.org/wiki/Max_Fleischer) in 1917, where animators trace live-action movement, [frame](http://en.wikipedia.org/wiki/Frame_(film)) by frame. The source film can be directly copied from actors' outlines into animated drawings, as in [*The Lord of the Rings*](http://en.wikipedia.org/wiki/The_Lord_of_the_Rings_(1978_film)) (US, 1978
* [**Live-action/animation**](http://en.wikipedia.org/wiki/Films_with_live_action_and_animation) is a technique, when combining hand-drawn characters into live action shots. One of the earlier uses of it was [Koko the Clown](http://en.wikipedia.org/wiki/Koko_the_Clown) when Koko was drawn over live action footage
* **Stop motion**

Stop-motion animation is used to describe animation created by physically manipulating real-world objects and photographing them one frame of film at a time to create the illusion of movement. There are many different types of stop-motion animation, usually named after the medium used to create the animation. Computer software is widely available to create this type of animation.

* [**Puppet animation**](http://en.wikipedia.org/wiki/Puppet_animation) typically involves stop-motion puppet figures interacting with each other in a constructed environment, in contrast to the real-world interaction in model animation. The puppets generally have an [armature](http://en.wikipedia.org/wiki/Armature_(sculpture)) inside of them to keep them still and steady as well as constraining them to move at particular joints
  + [**Puppetoon**](http://en.wikipedia.org/wiki/Puppetoon), created using techniques developed by [George Pal](http://en.wikipedia.org/wiki/George_Pal), are puppet-animated films which typically use a different version of a puppet for different frames, rather than simply manipulating one existing puppet.

* [**Clay animation**](http://en.wikipedia.org/wiki/Clay_animation), or [Plasticine](http://en.wikipedia.org/wiki/Plasticine) animation often abbreviated as *claymation*, uses figures made of clay or a similar malleable material to create stop-motion animation. The figures may have an [armature](http://en.wikipedia.org/wiki/Armature_(sculpture)) or wire frame inside of them, similar to the related puppet animation (below), that can be manipulated to pose the figures

[](http://en.wikipedia.org/wiki/File:Animacion-con-plastilina-y-clay-animation-pelicula-Kuzmich-153.jpg)

Clay animation

* [**Cutout animation**](http://en.wikipedia.org/wiki/Cutout_animation) is a type of stop-motion animation produced by moving 2-dimensional [](http://en.wikipedia.org/wiki/File:Claychick.jpg)

material such as paper or cloth1997

* + [**Silhouette animation**](http://en.wikipedia.org/wiki/Silhouette_animation) is a variant of cutout animation in which the characters are backlit and only visible as silhouettes
* [**Model animation**](http://en.wikipedia.org/wiki/Model_animation) refers to stop-motion animation created to interact with and exist as a part of a live-action world
* [**Pixilation**](http://en.wikipedia.org/wiki/Pixilation) involves the use of live humans as stop motion characters. This allows for a number of surreal effects, including disappearances and reappearances, allowing people to appear to slide across the ground, and other such effects.

**8. Motion graphic design**

**Motion Design** is a subset of [graphic design](http://en.wikipedia.org/wiki/Graphic_design) in that it uses graphic design principles in a [filmmaking](http://en.wikipedia.org/wiki/Filmmaking) or [video production](http://en.wikipedia.org/wiki/Video_production) context (or other temporally evolving visual medium) through the use of [animation](http://en.wikipedia.org/wiki/Animation) or [filmic techniques](http://en.wikipedia.org/wiki/Film_techniques). Examples include the [kinetic typography](http://en.wikipedia.org/wiki/Kinetic_typography)and graphics you see as the titles for a film, or opening sequences for television or the spinning, web-based animations, three-dimensional [station identification](http://en.wikipedia.org/wiki/Station_identification) logo for a [television channel](http://en.wikipedia.org/wiki/Television_channel). About 12 minutes in every hour of broadcast television (≅20%) is the work of the [motion graphics](http://en.wikipedia.org/wiki/Motion_graphics) [broadcast designer](http://en.wikipedia.org/wiki/Broadcast_designer), yet it is known as the invisible art, as many viewers are unaware of this component of [television programming](http://en.wikipedia.org/wiki/Television_program).[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia:Citation_needed)] Although this art form has been around for decades, it has taken quantum leaps forward in recent years, in terms of technical sophistication. If you watch much TV or see many films, you will have noticed that the graphics, the typography, and the visual effects within this medium have become much more elaborate and sophisticated.

Technology

The elevation of this art form is largely due to technology improvements. Computer programs for the film and video industry have become vastly more powerful and more available. Probably the leading program used by motion graphic designers is [Adobe After Effects](http://en.wikipedia.org/wiki/Adobe_After_Effects), which allows them to create and modify graphics over time. Adobe After Effects is sometimes referred to as "[Photoshop](http://en.wikipedia.org/wiki/Photoshop) for film." A relatively recent product in the market is [Apple Inc.](http://en.wikipedia.org/wiki/Apple_Inc.) [Motion](http://en.wikipedia.org/wiki/Motion_(software)), now a part of [Final Cut Studio](http://en.wikipedia.org/wiki/Final_Cut_Studio). Adobe Flash is widely used to create motion design for the web.

A typical motion designer is a person trained in traditional graphic design who has learned to integrate the elements of time, sound and space into his/her existing skill-set of design knowledge. Motion designers can also come from filmmaking or animation backgrounds.

**8.1. Notable Motion Designers**

* [Saul Bass](http://en.wikipedia.org/wiki/Saul_Bass)
* Maurice Binder
* [Pablo Ferro](http://en.wikipedia.org/wiki/Pablo_Ferro)

**8.2. Motion design & digital compositing software packages**

Since motion design is created using images and video sequences, a necessary tool is a software package. Such packages can generate images or video sequences with an [alpha channel](http://en.wikipedia.org/wiki/Alpha_channel), which stores all the transparency information.

Motion Design applications include:

* [Adobe After Effects](http://en.wikipedia.org/wiki/Adobe_After_Effects)
* [CineFX](http://en.wikipedia.org/wiki/CineFX)
* [Autodesk Combustion](http://en.wikipedia.org/wiki/Autodesk_Combustion)
* [Apple Motion](http://en.wikipedia.org/wiki/Apple_Motion)/[Shake](http://en.wikipedia.org/wiki/Apple_Shake)
* [Max/MSP](http://en.wikipedia.org/wiki/Max/MSP)
* Apple [Quartz Composer](http://en.wikipedia.org/wiki/Quartz_Composer)
* Various [VJ](http://en.wikipedia.org/wiki/VJ_(video_performance_artist)) Programs
* Smith Micro Software [Anime Studio](http://en.wikipedia.org/wiki/Anime_Studio)
* [Adobe Flash](http://en.wikipedia.org/wiki/Adobe_Flash)

3D Programs used in motion graphics include:

* Modo 3D [Luxology](http://en.wikipedia.org/wiki/Luxology)
* Maxon [Cinema 4D](http://en.wikipedia.org/wiki/Cinema_4D)
* Softimage [XSI](http://en.wikipedia.org/wiki/Softimage_XSI)
* Autodesk [3d studio max](http://en.wikipedia.org/wiki/3d_studio_max)
* Autodesk [Maya](http://en.wikipedia.org/wiki/Maya_(software))
* NewTek [Lightwave](http://en.wikipedia.org/wiki/Lightwave)
* e-on [Vue Infinite](http://en.wikipedia.org/wiki/Vue_Infinite)
* The Blender Foundation [Blender](http://en.wikipedia.org/wiki/Blender_(software))
* EI Technology Group [Electric Image Animation System](http://en.wikipedia.org/wiki/Electric_Image_Animation_System)

Motion graphics plugins include:

* [Magic bullet](http://en.wikipedia.org/wiki/Magic_bullet_(software))
* [Trapcode](http://en.wikipedia.org/w/index.php?title=Trapcode_Particular_(software)&action=edit&redlink=1)

**8.3. History**

[William Fetter](http://en.wikipedia.org/wiki/William_Fetter) was credited with coining the term *computer graphics* in 1961[[1]](http://en.wikipedia.org/wiki/3D_computer_graphics#cite_note-0)[[2]](http://en.wikipedia.org/wiki/3D_computer_graphics#cite_note-1) to describe his work at [Boeing](http://en.wikipedia.org/wiki/Boeing). One of the first displays of computer animation was [*Futureworld*](http://en.wikipedia.org/wiki/Futureworld) (1976), which included an [animation](http://en.wikipedia.org/wiki/Animation) of a human face and a hand—produced by [Ed Catmull](http://en.wikipedia.org/wiki/Edwin_Catmull) and [Fred Parke](http://en.wikipedia.org/wiki/Fred_Parke) at the [University of California](http://en.wikipedia.org/wiki/University_of_California).

**8.4. Modeling**

The model describes the process of forming the shape of an object. The two most common sources of [3D models](http://en.wikipedia.org/wiki/3D_model) are those that an artist or engineer originates on the computer with some kind of 3D modeling tool, and models [scanned](http://en.wikipedia.org/wiki/3d_scanning) into a computer from real-world objects. Models can also be produced [procedurally](http://en.wikipedia.org/wiki/Procedural_modeling) or via [physical simulation](http://en.wikipedia.org/wiki/Physical_simulation). Basically, a 3D model is formed from points called *vertices* (or *vertexes*) that define the shape and form *polygons*. A polygon is an area formed from at least three vertexes (a triangle). A four-point polygon is a *quad*, and a polygon of more than four points is an *n-gon*The overall integrity of the model and its suitability to use in animation depend on the structure of the polygons.

**8.5. Layout and animation**

Be placed (laid out) in a [scene](http://en.wikipedia.org/wiki/Scene_(fiction)). This defines spatial relationships between objects, including [location](http://en.wikipedia.org/wiki/Location_(geography)) and [size](http://en.wikipedia.org/wiki/Dimension). Animation refers to the *temporal* description of an object, i.e., how it moves and deforms over time. Popular methods include [keyframing](http://en.wikipedia.org/wiki/Keyframing), [inverse kinematics](http://en.wikipedia.org/wiki/Inverse_kinematics), and [motion capture](http://en.wikipedia.org/wiki/Motion_capture).

These techniques are often used in combination. As with modeling, [physical simulation](http://en.wikipedia.org/wiki/Physical_simulation) also specifies motion.

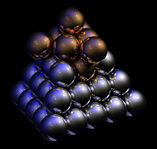
**8.6. Rendering**

*Rendering* converts a model into an image either by simulating [light transport](http://en.wikipedia.org/wiki/Light_transport_theory) to get photo-realistic images, or by applying some kind of style as in [non-photorealistic rendering](http://en.wikipedia.org/wiki/Non-photorealistic_rendering). The two basic operations in realistic rendering are transport (how much light gets from one place to another) and scattering (how surfaces interact with light). This step is usually performed using [3D computer graphics software](http://en.wikipedia.org/wiki/3D_computer_graphics_software) or a [3D graphics API](http://en.wikipedia.org/wiki/List_of_3D_graphics_APIs). Altering the scene into a suitable form for rendering also involves [3D projection](http://en.wikipedia.org/wiki/3D_projection), which displays a three-dimensional image in two dimensions.

**Examples of**[**3D rendering**](http://en.wikipedia.org/wiki/3D_rendering)

[](http://en.wikipedia.org/wiki/File:Engine_movingparts.jpg)

[](http://en.wikipedia.org/wiki/File:Dunkerque_3d.jpeg)

[](http://en.wikipedia.org/wiki/File:Cannonball_stack_with_FCC_unit_cell.jpg)

***Left:*** A [3D rendering](http://en.wikipedia.org/wiki/3D_rendering) with [ray tracing](http://en.wikipedia.org/wiki/Ray_tracing_(graphics)) and [ambient occlusion](http://en.wikipedia.org/wiki/Ambient_occlusion) using [Blender](http://en.wikipedia.org/wiki/Blender_(software)) and [YafaRay](http://en.wikipedia.org/wiki/YafaRay).

***Center:*** A 3d model of a [Dunkerque class battleship](http://en.wikipedia.org/wiki/Dunkerque_class_battleship) rendered with [flat shading](http://en.wikipedia.org/wiki/Flat_shading).

***Right:*** During the [3D rendering](http://en.wikipedia.org/wiki/3D_rendering) step, the number of reflections “light rays” can take, as well as various other attributes, can be tailored to achieve a desired visual effect. Rendered with [Cobalt](http://en.wikipedia.org/wiki/Cobalt_(CAD_program)).

**9. Pioneers in computer graphics**

These are some of the people how have given birth to computer graphic. The following list of people are the pioneers..

**1.Charles Csuri**

[Charles Csuri](http://en.wikipedia.org/wiki/Charles_Csuri) is a pioneer in computer animation and digital fine art and created the first computer art in 1964. Csuri was recognized by [Smithsonian](http://en.wikipedia.org/wiki/Smithsonian_(magazine)) as the father of digital art and computer animation, and as a pioneer of computer animation by the [Museum of Modern Art](http://en.wikipedia.org/wiki/Museum_of_Modern_Art) (MoMA) and [Association for Computing Machinery](http://en.wikipedia.org/wiki/Association_for_Computing_Machinery) ([SIGGRAPH](http://en.wikipedia.org/wiki/SIGGRAPH)).

**2.Donald P. Greenberg**

[Donald P. Greenberg](http://en.wikipedia.org/wiki/Donald_P._Greenberg) is a leading innovator in computer graphics. Greenberg has authored hundreds of articles and served as a teacher and mentor to many prominent computer graphic artists, animators, and researchers such as [Robert L. Cook](http://en.wikipedia.org/wiki/Robert_L._Cook), [Marc Levoy](http://en.wikipedia.org/wiki/Marc_Levoy), and [Wayne Lytle](http://en.wikipedia.org/wiki/Wayne_Lytle). Many of his former students have won Academy Awards for technical achievements and several have won the [SIGGRAPH](http://en.wikipedia.org/wiki/SIGGRAPH) Achievement Award. Greenberg was the founding director of the NSF Center for Computer Graphics and Scientific Visualization.

**3. Aaron Marcus**

[Aaron Marcus](http://en.wikipedia.org/wiki/Aaron_Marcus) is one of the first graphic designer in the world to work with computer graphics. He has written over 250 articles and written/co-written six books. He has published, lectured, tutored, and consulted internationally for more than 40 years and has been an invited keynote/plenary speaker at conferences of ACM/SIGCHI, ACM/SIGGRAPH, Usability Professionals Association (UPA). He was was named an AIGA Fellow in 2007 and was elected in 2008 to the [CHI Academy](http://en.wikipedia.org/wiki/CHI_Academy). He is the founder of [Aaron Marcus and Associates, Inc.](http://en.wikipedia.org/wiki/Aaron_Marcus_and_Associates,_Inc.), a pioneering, world-renowned design firm specializing in user-interface/user-experience development applications.

**4. A. Michael Noll**

[Noll](http://en.wikipedia.org/wiki/A._Michael_Noll) was one of the first researchers to use a [digital](http://en.wikipedia.org/wiki/Digital) [computer](http://en.wikipedia.org/wiki/Computer) to create artistic patterns and to formalize the use of random processes in the creation of [visual arts](http://en.wikipedia.org/wiki/Visual_arts). He began creating digital computer art in 1962, making him one of the earliest digital computer artists. In 1965, Noll along with Frieder Nake and Georg Nees were the first to publicly exhibit their computer art. During April 1965, the Howard Wise Gallery exhibited Noll's computer art along with random-dot patterns by [Bela Julesz](http://en.wikipedia.org/wiki/Bela_Julesz).

**10. Conclusion**

Conclusion to this topic is that computer graphics is important topic. It’s application like animation has wide scope in this generation. It helps in web designing and many more stuff. It is a very vast subject and almost every year there is new addition to it.

It is a very promising field as it is applicable almost everywhere. In this world where everything is computerized graphics will go a long way in developing the current systems . And all the inventions in this sector will be a help in all the sectors.

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