

# **3-D Object Representation, Geometric Transformations and Viewing Part-1**



### 3-D Object Representation, Geometric Transformations and Viewing Part-1

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#### COLOUR MODELS

##### COLOUR

**Additive Colour:** It is obtained by adding together lights of different colors. The absence of all colors is black while the presence of all colors is white. It works with emitted light.

**Subtractive Colour:** It is obtained by subtracting lights of different colors. The absence of all colors is white while the presence of all colors of black. It works with reflected light.

#### COLOUR REPRESENTATION

There are basically three modes of representing color combination on a display:

- **Palette.** An indexed array usually with 256 entries, each three bytes long, representing the amount of R, G and B to be used to represent the color at the pixel in question.
- **Hi-Color.** Sometimes referred to as “thousands of colors”, uses 16 bits to represent colors, thus allowing 64K colors to be displayed.



- **True-Color.** Sometimes referred to as “million of colors”, uses 24 bits (3 bytes) to represent colors, thus allowing  $256 \times 256 \times 256$  colors to be displayed.

## COLOUR CONCEPT

Some of the key terms used in terminology are:

- **Shades.** Adding a pigment of black colour to some other colour produces a darker shade.
- **Tints.** Obtained by adding a white pigment to the original colour, making it lighter.
- **Tones.** They are produced by adding both black and white colour pigments

An artist creates a tainting by mixing colour pigments with white and black pigments to form various shades, tints, and tones, thus, giving the object a more realistic look in the graphics appearance.

## XYZ COLOUR MODEL

The three dimensional picture is represented in computer graphics by the three vectors X, Y, and Z. The XYZ model represents pictures in additive color space. Any color  $C_i$  is represented by the equation.

$$C_i = aX + bY + cZ$$

Where, a, b and c represent the amount of standard primaries required to match  $C_i$

For convenience we normalize the amount in the above equation against luminance ( $a + b + c$ ). Normalized amounts are thus given by the following equation:

$$a_n = a/(a + b + c), b_n = b/(a + b + c), c_n = c/(a + b + c)$$

With  $a_n + b_n + c_n = 1$ . Thus, any can be represented with just  $a_n$  and  $b_n$  which are called the chromaticity values as they depend on hue and purity only.

To convert from chromaticity co-ordinates ( $a_n, b_n$ ) back to a specific color in the XYZ color space. We need an additional piece of information.

$$a = a_n/b_n, b = b, c = c_n/b_n, \text{ where } C_n = 1 - a_n - b_n$$



## COLOR MODELS

A **color models** is a particular representation of color that is useful for at least one particular application. The spectrum of light we call color can be characterized in many ways. Wavelengths, photons, and obscure mathematical equations can characterize the physical of light. Several color models permit the precise specification of color. Each model is a different way of representing, characterizing, and categorizing color.

In the computer graphics word, the most common color representation is called **RGB** (Red, Green, Blue). Image are represented in terms of their red, green and blue components. In addition, display screens (the video tubes) have active areas (phosphors) that emit red, green, and blue light. Combination of red, green and blue dots can produce simulations of continuous tone color images. The red, green and blue dots are so small that the eye are brain blend these discrete dots into a continuous tone. A particular mix of the red, green and blue components of screen area corresponds directly to the perceived colour of that area.

Another colour representation often used in computer graphics is the **HSB** Hue, Saturation and Brightness model. As brightness is often called Value, the term **HSV** is also used. Colloquially speaking, hue is the kind of color. For example, red as opposed to blue or yellow. Saturation is the depth or intensity of color for example, light red as opposed to dark red. Brightness is the overall amount or lightness of a color.

**Hue.** The attributes of color perception by means of which a color is judged to be red, orange, yellow, green, blue, purple, or intermediate between adjacent pairs of these considered in a closed ring (red purple being an adjacent pair).

**Saturation.** Attribute of a visual sensation according to which an area appears to exhibit more or less chromatic color, judged in proportion to its lightness of brightness.

**Lightness.** (1) The attribute of color perception by which a non-self-luminous body is judged to reflect more or less light. (2) the attribute by which a perceived color is judged to be equivalent to one of a series of ranging from black to white.

Another method used to display color in computer graphics is **dithering**. Dithering is not a color model but a particular way of using color. Dither patterns are used to increase the perceived amount of colors on a screen at one time. While a display may be



capable of displaying only 256 distinct colors, dithering can be used to raise the perceived number of colors into thousands.

Several color models have evolved for use in **printing**. Printing is color is the act of putting inks on paper. This action reverse the additive nature of color produced with light into a subtractive process. A red, green and blue light source will appears white when combined. Red, green and bluw inks on paper will create a black area.

**CMYK.** The printing industry and many color computer use the CMYK (cyan, Magenta, Yellow Black) color model to create full color printed images. This model is also known as **process color**. Four inks with a colors cyan, magenta, yellow, and black are combined using half toning techniques to create the illusion of continuous tone color images. The perceived subtle nature of colour created by the small dots of CMYK colors is a side effect of our perception. Take a look at a colour magazine photo with a magnifying glass. The color of a person's skin is not really there. The color mixing actually carried out in our brains.

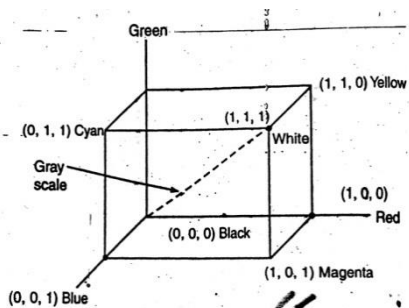
**Spot Color.** **Spot color printing** refers to the use of one, two, three, or more single distinct colors within the documents. Common uses are to color all section headings a unique color or to color arrows that point our information.

## DIFFERENT COLOR MODELS

### RGB COLOR MODEL

In this model the primary colour are red, green, and blue. It is an additive model, in which adding components produces colors, with white having all colors and black being the absence of any color. This model is used for active displays such as television and computer screens. It is usually represented by a unit cube with one corner located at the origin of a three-dimensional color coordinate system, the axes being labeled R, G, B and having a range of values [0, 1]. The origin (0, 0, 0) is considered black and the diagonally opposite corner (1, 1, 1) is called white. The line joining black to white represents a gray scale and has equal components of R, G, B.





Vertical of the cube on the axes represent the primary colours i.e. red, green, blue and remaining vertices represent the complementary colour for each of the primary colours. Primary colour intensities are added to produce other color. Each colour point within the cube bound can be represented on triple  $(R, G, B)$  where values are assigned within the range from 0 to 1. The magenta vertex is obtained by adding red and blue vertices. Similarly cyan by adding green and blue. The vertex representing magenta produces the triplet  $(1, 0, 1)$  and white at  $(1, 1, 1)$  is the sum of the red, green and blue vertices.

### CMY MODEL

Cyan, magenta and yellow are the secondary color with respect to the primary colors of red, green and blue. However, in this “subtractive model”, they are the primary colors and red, green and blue are the secondaries. This model is beneficial for describing color output to hard-copy devices. Unlike video monitors, which produce a color pattern by combining light from the screen phosphors hard-copy devices such as plotters produce a color picture by coating a paper with color pigments.

It is formed by adding blue and green light. When white light is reflected from cyan coloured ink, the reflected light must have no red component i.e., red light is absorbed by the ink.

Magenta ink subtracts green components from incident light and yellow subtracts the blue component. A unit cube representation of a CMY model.

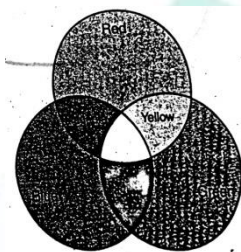
Here the point origin represents white, where point  $(1, 1, 1)$  represents black. All components of incident light are subtracted. Cube diagonal representing gray

combination of cyan and magenta producing blue light. While in similar subtractive process the other colour combinations are obtained.

Printing process with CMY model produces collection of four ink dots, whereas RGB monitor uses a collection of three phosphor dots. One dot is used for each of the primary colors (cyan, yellow and magenta) i.e. one dot is black. Since the combination of 3 primary colours produces a dark gray instead of black, so black must be included. Some plotters produce the different color combinations by spraying the ink over the each other and allow them to mix before they dry.

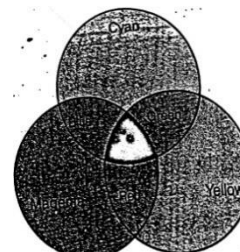
#### RGB Colour Mode

Additive colour model  
For computer displays  
Uses light to display color  
Color result from transmitted light  
 $\text{Red} + \text{Green} + \text{Blue} = \text{White}$



#### CMY Color Model

Subtractive color model  
For printed material  
Uses ink to display color  
Colors result from reflected light  
 $\text{Cyan} + \text{Magenta} + \text{Yellow} = \text{Black}$



### YIQ COLOUR MODEL

The YIQ color model is used in U.S commercial color television Broadcasting and it therefore closely related to the colour raster graphics. YIQ is a recording of RGB for transmission efficiency and for downward compatibility with black and white television. The recorded signal is transmitted using the National Television System Committee (NTSC) system.

### HLS COLOR MODEL

This color model includes color parameters Hue (H), Lightness (L), and Saturation (S), and is defined in the double-hexacone subset of a cylindrical space. Hue is the angle around the vertical axis of the double hexcone, with red or blue 0°. The color around

the perimeters occur in the same order is in the CIE diagram when its boundary is traversed counter-clockwise: red, yellow, green, cyan, blue and magenta.

## HIS COLOR MODEL

In this model, as in YIQ model, luminance or intensity (I) is decoupled from the color information, which is described by a Hue channel and a saturation channel. Hue and saturation of colors respond closely to the way humans perceive color and thus this model is suited for interactive manipulation of color images where changes occur for each variable shift that correspond to what the operator expects.

## CONVERSIONS BETWEEN COLOR MODELS

### a. Conversion from RGB to CMY Model

Subtract each RGB primary value from white, where white is represented in the RGB system as unit column vector.

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

### b. Conversion from CMY to RGB

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} C \\ M \\ Y \end{bmatrix}$$

Where, black is represented in the CMY System as unit column vector.

### c. Conversion from RGB to YIQ

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.275 & -0.321 \\ 0.212 & -0.523 & 0.311 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Based on NTSC standard RGB.

### d. Conversion from YIQ to RGB

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.956 & 0.620 \\ 1.000 & -0.272 & -0.647 \\ 1.000 & -1.108 & 1.705 \end{bmatrix} \begin{bmatrix} Y \\ I \\ Q \end{bmatrix}$$



#### e. conversion between HIS and RGB Models

Conversion between RGB and HIS is somewhat more complicated. Colors in HIS are defined with respect to normalized RGB values as.

$$1 = \frac{1}{3}(R + G + B)$$

$$H = \cos^{-1} \left[ \frac{\frac{1}{2}[(R - G) + (R - B)]}{[(R - G)^2 + (R - B)(G - B)^{1/2}]} \right]$$
$$S = 1 - \frac{3}{(R + G + B)} [\min(R, G, B)]$$

### HALFTONING

It is the process of printing continuous tone image (with multiple level of gray or color) in newspaper, magazines and books using a bi-level printer. In case of black & white printing one cannot directly print lots of shades of gray using only pure black ink on a printing press. Actually, it creates a dot pattern by exposing a negative through a fine screen (a halftone screen) onto a photosensitive printing plate. The size of the dots varies depending on the fineness of the screen and the length of exposure. Where image is light the dots are small and where the image is dark the dots are large.

The dots fuse together both on the paper and in our eye to give a convincing illusion of continuous tones. Such printed images made up of a series of varying size and varying density dots in a specific pattern to simulate the look of continuous tones are commonly known as halftones.

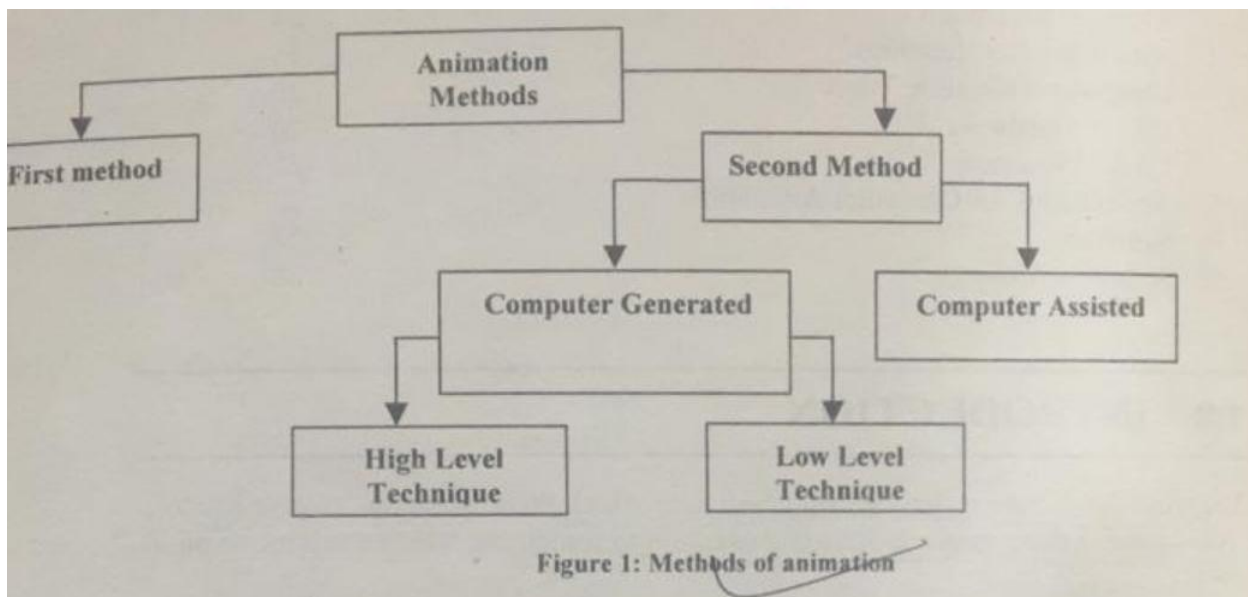
Similarly color halftones are actually made up of series of dots in cyan, magenta, yellow and black (CMYK) that fools the eye into seeing the millions of colors that make up the original image.

In computer graphics, **Digital halftoning** is adopted to simulate the traditional halftoning process. In this process an image is decomposed into a grid of halftone cells. Each such cell treated as a megapixel is a small two-dimensional array of actual pixels. The number and pattern of pixels turned on or off in them determine the gray value of the resulting picture element. The more number of off pixels in a halftone cell, the darker the cell appears.



### Traditional and historical methods for production of animation

We have studied transformation involved in computer graphics but you might not have noticed that all transformations are related to space and not to time, lies the basic difference between animation and graphics. The difference is animation puts to graphics, the dimension of time, which vastly increases the amount of information to be transmitted, so some methods are used to handle this huge information and these process are known as animation methods.



**First method:** Artist builds a succession of cartoon frames, which are then combined into a film.

**Second method:** The physical models are positioned to the image to be recorded. On completion model shifts to the next image for recording and this process is continued. The historical approach of animation has classified computer animation into two main categories:

- a) **Computer-** accommodate animation refers to 2D systems that computerize traditional animation process. The technique used is interpolation between key shapes which is only algorithm use of the computer in the production of this type of animation equation, curve morphing, image morphing.

- b) Computer generated animation is animation presented via film or video, Which is based on the concept of persistence of vision because the eye-brain assembles a sequence of images and interprets them as a continuous movement and if the rate of change of pictures is quite fast then it induce the sensation of continuous motion.

This motion features for computer- generated animation is further divided into 2 categories:

**Low level technique:** Techniques used to fully control the motion of any graphic object in any animation scene, such techniques are also referred as motion techniques because we can specify the motion of any graphic object in scene, techniques like interpolation, approximation etc., are used in motion specification of any graphic object. They are used when animator usually has a fairly specific idea of the exact motion then he or she wants.

**High level techniques:** Techniques used to describe general motion behavior of any graphic object, these techniques are algorithm or models used to generate a motion using a set of rules or constraints. The animator builds the rules of the model, or chooses an appropriate algorithm, and selects initial values or boundary values. The system is set into motion and the motion of the objects is handled by the algorithm or model, this approaches often rely on fairly sophisticated computation such as vector algebra and numerical technique and others.

Isn't it shocking that the computer animation has been around as long as computer graphics which is used to create realistic elements which are intermixed with the live action to produce animation. The developed way of animation is building basis of computer general animation system and are widely used now a days by different companies like, Disney, MGM, warner bros, etc., to produce realistic 3D animation using various animation tools.

After having some briefings about the overall topic of animation, now let us go to its detail. Firstly we define computer animation which is a time-based phenomenon that



covers any change of appearance or any visual effect with respect to the time domain, which includes motion i.e. positional change time-varying changes in shape, color, transparency and even changes of the rendering technique.

### **Definition**

A phenomenon for imparting visual changes in any scene according to any time sequence, the visual changes could be incorporated through translation of object, scaling of object, surface texture etc.

**Note:** It is noted that computer animation can be generated by changing camera parameters such as its position, orientation, focal length etc. plus changes in the light effects and other parameters associated with illumination and rendering can produce computer animation too.

### **Traditional Animation Techniques**

Before the arrival of computer animation, all animation was done by hand, which includes an enormous amount of work. You can have an idea of work by considering that each second of animation film contains 24 frames then, one can imagine the amount of work in creating even the shortest of animated films. Before, creating any animation the first step is to design the concerned storyboard which the first sight of what a cartoon or a piece of animation is going to look like. It appears as a series of strip comics, with individual drawings of story lines, scenes, characters, their emotions and other major part of movie.

### **Key frames**

After a storyboard has been laid out, the senior artists go and draw the major frames of the animation. These major frames are frames in which a lot of change take place. They are the key points of the animation. Later, a bunch of junior artist draw in the frames in between. This way, the work load is distributed and controlled by the key frames. By doing work this way, the time in which an animation can be produced is



cut dramatically, depending on the number of people working on the object. Work can be done continuously by some people, thus cutting down the time needed to get a final product out.

### **Cell Animation**

Creating an animation using this process, every character is drawn on a separate piece of transparent paper. A background is exhausted on a separate piece of opaque paper. When it comes to shooting animation, the different characters are overlaid on top of the background in each frame. This method also saves time in that the artist does not have to draw in entire frames, but rather just the parts that need to change such as individual characters, even separate parts of a character's body are placed on separate pieces of transparent paper.

These traditional techniques were extended to the era of computer animation techniques and hence different animation systems have evolved. We cannot say which technique is better because different techniques are used in different situations. In fact, all these animation techniques are great, but they are most useful when all of them are used together. It would not help out much if it wasn't for key frames and being able to distribute the workload across many people.

Frame animation non-interactive animation rectangular shape (cartoon movies)

It is an "internal" animation process i.e., it is animation inside a rectangular frame. It is close to cartoon movies: a sequence of frames that follow each other at a fast rate, fast enough to convey fluent motion. It is typically pre-compiled and non-interactive. The frame is typically rectangular and non-transparent.

Sprite animation interactive, may be non-rectangular (computer games)

In easy form it is a 2D graphic object that shifts across display. It often can have transparent areas. They are not restricted to rectangular shapes. It lends itself well to be interactive. The position of every sprite is handled by the user or by an application program. It is called "external" animation. We refer to animated objects as "animobs".



## Types of Animation Systems

We have studied that sequencing of animation is useful in developing any animation. This sequencing is high or low “same in all animation systems”. Before taking measures to the types of animation in the next section, let us study the types of animation systems.

### Key Frame Systems

This technique is for low-level motion control. These systems comprise languages which are designed simply to generate the in-betweens from the user- specified key frames.

**Note:** From above discussion it is notify that in this system in-between frames can be generated from the specification of two or more key frames, and among them we can place the motion path of the object under consideration by describing its kinematics description as a set of spline curves. For complex scenes we can distribute frames into separate components is called cells. In these complex scenes, we can interpolate the position of individual objects between any two times. And in this interval the complex objects in the scene may suffer from various transformations like the shape or size of object may change overtime, etc., or the entire object change to some other object. These transformations in a key frame system lead to morphing, zooming, partial motion, planning(i.e., shifting of background to give the illusion that the camera seems to follow the moving object, so that the background seems to be in motion), etc.

### Morphing

Modification of object shapes from one form to another is called morphing. The method can be applied to any motion or transition involving a change in shape.

### Types of Animations

**Procedural animation:** This animation is used to generate real time animation, which allows a more diverse series of actions to happen. These actions can generated using some predefined animation procedures are used to define movement over time. There



might be procedures that uses the laws of physics or animator-generated methods. Some example of this is collision which is an activity that is the result of some other action, for example throwing a ball which hits another object and causes the second object to move: simulating particle systems (smokes water etc.) hair and for dynamics. In computer video games it is often used for simple things like players head rotation to look around, etc.

**Representational Animation:** This uses stochastic processes(a stochastic process can be considered as a random function). This randomness could be in time or space variable of function, the randomness in time leads to stochastic animation to control groups of objects, such as in particle systems. Examples are fireworks, fire, waterfalls, etc., or speech audio signal, medical data ECG,BP, etc., or random walk.

**Behavioral animation:** Used to control the motion of many objects automatically .Objects or “actors” are given rules about how they react to their environment . The primary difference is in the objects being animated , instead of simply procedurally controlling the position of tiny objects. This type of animation as generally used to animate flocks, school, herds and crowds.

### **Applications for computer animation**

Some applications in different domains are:

**Entertainment:** Games, advertising, film , television, video, multimedia are some of the entertainment fields in which computer animation has wide-contribution, the topic is self-explanatory as you all are exposed to the usage of animation in these fields from yor day to day life programs on television, computers etc.

**Film:** computer animation has become regular and popular in special effects. Movies such as “Jurassic park” and “ The Abyss” have brought computer animation to a new level in their films. Scale models are fast and cost effective method of creating large alien scenes. But animation has done just as well in animating fire, smoke, humans, explosions and heads made out of water.



A major part in integrating live film and the computer animation is to make absolutely sure that the scale and perspective of the animations are right. The scale is important to making the animation believable. The animators go through a great deal of work to make sure this is right. Usually computer animation is only used when the scene needed would be impossible or very difficult to create without it.

**Television:** Computer animation plays a great role in television . most of the titles on the television programs, news casts, and commercials, are done with computer animation. In the past, when computers were not a part of the process, animations were done with live-video, cell animation, scale models and character generators. Now, with the advent of computers, special programs could be used.

Computer animation has simplified the making of television program titles, because of the versatility of computer generated animations, almost anything is possible. An animator can have a totally computer generated animation or have an animation with live video integrates, or even live video with animation integrated. Computer animation has advantaged the media also desires. With computer animation, professional animators can use pre-made templates to create animation for broadcasting with in minutes of receiving the news.

**Video:** Everyone heard of animated cartoons. There is new era of cartoons emerging on television. Computer animated cartoons can be generated faster than cell animated ones. This is because, the animator does not have to draw every single frame, but only has to create a key frame using, which the computer generates the in-between frames.

Sometimes computer animation looks more realistic. Sometimes, it is even possible to create computer animations that looks realistic so that a person might not be able to tell, if it is real or not by simple looking at it, but this requires, enormous team effort.

Low level techniques	High level technique
It provide aid to the animator in precisely specifying the motion. It includes techniques such as shape interpolation, algorithms which help the animator fill in the details of the motion. The animator has fairly specific idea of the exact motion that he or she wants.	It is used to describe general motion behavior. This technique are algorithms or models used to generate a motion using a set of rules or constraints. The animator set up the rules of the model or chooses an appropriate algorithm, and selects initial values or boundary values. The system is then set into motion of the objects is controlled by the algorithm or model. This approach often relies on fairly sophisticated computation such as vector algebra and numerical techniques and other.
Cel animation	Key frames
When creating an animation using this method, each character is drawn a separate piece of transparent paper. A background is also drawn on a separate piece of opaque paper. Then, when it comes to shooting the animation, the different characters are overlaid on top of the background in each frame. This method also saves time in that the artists do not have to draw in entire frames, but rather just the parts that need to change such as individual characters. Even separate parts of a characters body are placed on separate pieces of transparent paper.	After a storyboard has been laid out, the senior artist go and draw the major frames of the animation. These major frames are frames in which a lot of change take place. They are the key points of the animation. Later, a bunch of junior artists draw in the frames in between and controlled by the key frames. By doing work this way, the time in which an animation can be produced is cut dramatically, depending on the number of people working on the project. Work can be done continuously by many people, thus cutting down on the time needed to get the final product out.





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