Image Design and Animation
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About this COURSE MATERIAL

Introduction to Image Processing and Animation has been produced by The National Open University of Nigeria. All Course Materials produced by The National Open University of Nigeria are structured in the same way, as outlined below.

The course overview

The course overview gives you a general introduction to the course. Information contained in the course overview will help you determine:

- If the course is suitable for you.
- What you will already need to know.
- What you can expect from the course.
- How much time you will need to invest to complete the course.

The overview also provides guidance on:

- Study skills.
- Where to get help.
- Course assignments and assessments.
- Activity icons.
- Units.

We strongly recommend that you read the overview carefully before starting your study.

The course content

The course is broken down into units. Each unit comprises:

- An introduction to the unit content.
- Unit Objectives
- Unit outcomes.
- New terminology.
- Core content of the unit with a variety of learning activities.
- A unit summary.
- Assignments and/or assessments, as applicable.
- Answers to Assignment and/or assessment, as applicable

Resources

For those interested in learning more on this subject, we provide you with a list of additional resources at the end of this course material; these may be books, articles or websites.

Your comments

After completing Image Design and Animation we would appreciate it if you would take a few moments to give us your feedback on any aspect of this course. Your feedback might include comments on:

- Course content and structure.
- Course reading materials and resources.
- Course assignments.
- Course assessments.
- Course duration.
Course support (assigned tutors, technical help, etc.)
Your constructive feedback will help us to improve and enhance this course.

Course objectives
The objectives of this course are:
• To provide the students with sound concepts, principles and theories that would aid understanding of image design and animation
• To assist readers understand the basic techniques involved in image design and animation
• To understand animation and its uses
• To assist students learn how to design images and animations

Course outcomes
Upon completion of Image Design and Animation studies, you will be able to:
• understand basic image design and animation concepts, principles and techniques.
• acquire skills necessary to create images and understand basic image design and animation concepts, principles and techniques.
• ability to use drawing tools for creating and editing of graphics(image) and animation
• apply techniques learned for life long knowledge and work places
• demonstrate ability to function as an individual in multidisciplinary and multicultural environments with the capacity of an effective team member

Need help?
This course is offered at The Open University of Tanzania, ICT department.

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Assessments

There are activities, case studies, assignments and review questions in the units of this course. All these learner’s activities are assessed in three modalities

- Peer – review
- Self – assessment
- Instructor – marked assessment

NB: Review questions are for self – assessment
Unit 1
Introduction to Image and Design

Introduction
Images are used in different areas of our societies and lives. They are applied both professionally and in our personal lives. Most people have had an image of them drawn or being taken with a camera and printed on a photo paper. In today’s society technology has made it easier. There are gadgets that can be used to produce and store images in digital form. Basic devices such as your mobile phones can be used to create and store images in digital forms. Images are created for various purposes. They can be either for personal use or professional purposes.

Professionals are concerned with design. Design is a complex art which involves different skills and tools. In designing one first of all identifies the purpose of the design. This helps to fashion out the requirements, specifications and the deliverables.

Upon completion of this unit you will be able to:

- Explain Imaging, Image development and Image processing
- Understand the concept of design
- Able to discuss various Image formats

Terminology

**Image:** An image (from Latin: imago) is an artifact that depicts visual perception, for example, a photo or a two-dimensional picture, that has a similar appearance to some subject—usually a physical object or a person, thus providing a depiction of it.

**Design:** Design is the creation of a plan or convention for the construction of an object, system or measurable human interaction (as in architectural blueprints, engineering drawings, business processes, circuit diagrams, and sewing patterns).

**photography:** Photography is the science, art, application and practice of creating durable images by recording light or other electromagnetic radiation, either electronically by means of an image sensor, or chemically by means of a light-sensitive material.
pixel: a pixel, pel,[1] dots, or picture element[2] is a physical point in a raster image, or the smallest addressable element in an all points addressable display device; so it is the smallest controllable element of a picture represented on the screen.

quantization: It is the process of constraining an input from a continuous or otherwise-large set of values (such as the real numbers) to a discrete set (such as the integers).

Image Design

An image can be said to be a two-dimensional signal. In mathematics it can be defined by the function f(x,y) where x and y are the two horizontal and vertical co-ordinates. The value of f(x,y) at any point gives the pixel value at that point of an image. Almost everyone has a picture of him/herself or a picture of something else. The image in such picture is formed through traditional photography or digital photography. Traditionally, images were created and processed manually by either drawing or cameras which were then processed unto photographic papers. With the evolution of technology, images can now be processed digitally. The can be created, manipulated, processed and stored digitally. A digital image can be said to be a numeric representation of a two-dimensional image. In digital image creation, data is converted into a digital form by method of sampling and quantization. The sampling and quantization generates a two-dimensional array or matrix of numbers which can be called a digital image.

Digital Imaging comes into use across various fields/professions. These include:

- Image sharpening and restoration
- Medical field
- Remote sensing
- Transmission and encoding
- Machine/Robot vision
- Colour processing
- Pattern recognition
- Video processing
- Microscopic Imaging

Digital imaging has improved research in various professions. For example, in medical field, digital imaging has helped improved both x-ray and Magnetic Resonance Imaging MRI scan amongst others. In the defence sector, satellite imagery has been improved greatly with clearer pictures.
Depending on whether the image resolution is fixed, it may be of vector or raster type. By itself, the term "digital image" usually refers to raster images or bitmapped images.

**Image Processing**

When image processing is mentioned it is referring to a process/method whereby an image is converted to digital format and certain actions are executed on it with the aim of enhancing the image or extracting relevant details from it. Image processing can be classified as a form of signal dispensation whereby the input is an image (video or photograph) and output may be image or features related to the input image.

Image processing basically includes the following three steps.

- Importing
- Analysing and manipulating
- Exporting

The image is imported from a source which can be a camera, scanner, etc. The image is then analysed and manipulated. This can include image enhancement. The final image is then exported (output).

Image processing is carried out for certain reasons. These reasons can be grouped into five main groups:

i. Visualization - Observe the objects that are not visible.
ii. Image sharpening and restoration - To create a better image.
iii. Image retrieval - Search for an image of interest.
iv. Measurement of pattern – calculate the sizes of various objects in an image.
v. Image Recognition – Differentiate the objects in an image

**Types of Image Processing**

Image processing methods are of two types:

i. Analog image processing
ii. Digital image processing

Analog image processing is executed on analog signals. It involves executing on two dimensional analog signals. In this type of processing, the images are manipulated by electrical means by varying the electrical signal. Analog processing can be used for the hard copies like printouts and photographs.

Digital image processing involves manipulation of digital images through a digital computer. It is a subfield of signals and systems but emphasis particularly on images. At the system input, digital
image is fed. The system processes the image using efficient algorithms, and gives an image as an output.

Digital image processing has dominated over analog image processing with the passage of time due its wider range of application

**Application of Image Processing**

**Automatic Visual Inspection System**: In the manufacturing industry, image processing can help in quality controls checks. It helps improves the quality and productivity of product. Examples are:

- Inspection of incandescent lamp filaments – This involves inspection of the bulb manufacturing method. Owing to absence of uniformity in the pitch of the wiring in the lamp, the filament of the bulb becomes fused within a short duration. In inspection process, a binary image slice of the filament is created from which the silhouette of the filament is created. Silhouettes are analysed to recognize the non-uniformity in the pitch of the wiring in the lamp.

- Automatic surface inspection systems – when manufacturing in metal industries it is important to detect the defects on the surfaces. It is important to spot any sort of abnormality on the rolled metal surface in the hot or cold rolling mills in a steel plant. Image processing techniques such as texture identification, edge detection, fractal analysis etc. are used for the detection.

- Faulty component identification – Faulty components in electronic or electromechanical systems are identified using image processing applications. High measure of thermal energy is produced by these faulty components. The Infra-red images are generated from the distribution of thermal energies in the assembly. The defective components can be recognised by analysing the Infra-red images

**Defence Surveillance** – Satellite and aerial surveillance approaches are EMPLOYED to uninterruptedly retain watch on the land and oceans. Image processing is employed to identify places and activities of interest. The important duty is to divide the various objects present in the image. Parameters such as length, breadth, area, perimeter, compactness are set up to classify each of divided objects. Recognizing the distribution of these objects in different directions is important to interpreting images. We can interpret the entire scenario from the spatial distribution of these objects.
Remote Sensing – For this application, sensors capture the pictures of the earth’s surface in remote sensing satellites or multi-spectral scanner which is mounted on an aircraft. These pictures are processed by transmitting it to the Earth station. Techniques used to interpret the objects and regions are used in flood control, city planning, resource mobilization, agricultural production monitoring, etc.

Raster and Vectors

Analysing a vector from the mathematics perspective, it is a combination of a magnitude and a direction which can be used to relate the relationships between points. A vector image is an assembly of one or more vectors. Here the entity to be controlled is the vector. Vector graphics can be transformed without data loss from one state to another. They can be described mathematically and look smooth at any size/resolution. Vector graphics are best used to represent more structured images because they are composed of true geometric primitives. Vector graphics are flexible than raster images, as such they are much more versatile, flexible and easy to use.

Raster image can also be referred to as bitmap. It is a collection of pixels (one or more). In manipulating a raster image, each pixel can be controlled individually. In order for a raster image to have a smooth appearance, it requires higher resolution and anti-aliasing. They are best suited for photographs and images with shading. Raster images are pixel-based and as such they suffer a disorder called image degradation. Raster graphics are better used for non-line art images. These typically include subtle chromatic gradations, undefined lines and shapes, and complex composition.

Conclusion

An image can be said to be a two-dimensional signal. A vector image is an assembly of one or more vectors. Raster image can also be referred to as bitmap. It is a collection of pixels (one or more). A digital image can be said to be a numeric representation of a two-dimensional image. Digital Imaging comes into use across various fields/professions. Image processing can be of two forms: analogue and digital.
Video

For lecture video on this Unit follow the URL

http://tinyurl.com/yc6hqv6

Unit summary

In this unit, we have studied image, digital image, image processing, types of image processing, application of image processing, vectors and raster.

Assessment

1. What do you understand by digital image?
2. Identify application areas of image processing.
3. Differentiate between raster image and vector image.
4. Explain image processing with a short note and its various types.
Unit 2
Elements and Principles of Design

Introduction
Design cuts across professions. Initiated with a set of specifications, engineers and architects seek a cost-effective solution that satisfies the specifications. Design is an iterative process. Designer works in an iterative manner, a possible design is generated, tested and then the results are used as the basis for exploring other solutions. Some websites captures users’ sights more easily than others. Many factors can be attributed to this but a very critical factor amongst all factors is design.

This also applies to image production. A good and captivating image is very dependent on its design. This unit discusses the principle and elements of design.

Upon completion of this unit you will be able to:
- Discuss design
- Understand the major elements of design
- Understand the major principles of design

Terminology
- **Image**: An image (from Latin: imago) is an artifact that depicts visual perception, for example, a photo or a two-dimensional picture, that has a similar appearance to some subject—usually a physical object or a person, thus providing a depiction of it.
- **Design elements**: Components/parts which have the ability to be isolated and defined in an image.
- **Color**: The characteristic of human visual perception described through color categories, with names such as red, blue, yellow, green, orange, or purple.

Image Design
Design elements can be said to be components/parts which have the ability to be isolated and defined in an image. They can be said to be the structure of the work, and have the capacity to carry an extensive diversity of messages.

A well-produced standard image depends on order, as such the main elements which delivers and enforces order: line, shape, form,
texture, pattern, and color. An image, consciously or unconsciously, comprises of one or more of these element, which are known as the elements of design. These elements play major roles in an image greatly.

**Line**

A line can be described as a form which has width and length. In Art, Artists use lines to create a shape. A shape is key in creating a form. In the absence of a form, a texture cannot exist and as such no pattern. Therefore, a line can be said to be important and influential amongst the elements. Lines are powerful and influential devices. When a line is smartly applied, it can be used to manipulate the feeling and mood of an image by guiding the viewer’s eyes towards a point of interest in the image.

Different types of lines send messages to the viewers. Thin lines can be interpreted as unstable by a few, while others see it as vulnerable. Thick lines on the other hands can be interpreted by a few as rigid and dependant, while others sees it as dominating or stern. Curved lines are most times are interpreted as soft, soothing, settling, and relaxing. Jagged lines can be interpreted as forceful, chaotic, sharp, and threatening.

The emotional effect of lines on an image cannot be ignored. They sometimes feel restful, soothing, rigid, active, guiding, or threatening. Mood can be depicted from the direction of a line:

- **Horizontal lines** are calm and quiet. When used in an image, they tend to cast a feeling of restfulness, permanency, and stability. Layers of multiple horizontal lines in an image can create drama and rhythm, and can become the main interest of the image all by themselves.
- **Vertical lines** in an image convey different moods, varying from power and strength, to growth vertical lines suggest more of a potential for movement.
- **Diagonal lines** strongly suggest movement and give more of a feeling of vitality to an image. They are good in guiding the viewers’ attention towards the main subject in an image. They can portray an image as dynamic and interesting.
Shape
A Shape can be described as an area/environment which is contained/enclosed within implied line, or is perceived and acknowledged because of color or value changes. Shapes have two dimensions (length and width). It can be geometric or free-form. It is a fundamental element of design, because shape is the primary element of identification.

In an image, the primary shapes are considered the positive shapes. The spaces around the shapes are the negative spaces.

Form
Form describes volume and mass, or the three dimensional aspects of objects that take up space. Form is basically a three-dimensional shape, and is best accentuated by side lighting since it casts soft elegant shadows, and the difference between light and shadows gives a better illustration of the depth of an object and amplifies the
sensual understanding of its meaning and message. Forms can and should be viewed from any angles.

**Pattern**

Pattern is part of our cosmic existence. We can confidently say “without patterns our lives would be utter chaos”. Life is overflowing with patterns. Very often we don't recognize or we overlook patterns due to our busy, routine-driven, daily lives. There are two major techniques applicable in working with patterns: Pattern can either be emphasised or broken.

In emphasising a pattern, a sense of size and expansion can be made more noticeable/prominent. The goal is to zoom in onto the pattern and fill the frame with it. An example of an emphasized pattern can include bricks of a wall.

To break a pattern is all basically identifying an object which disrupts the continuous flow of a pattern. The object can be in clear contrast with the rest of the objects; be it in shape, colour, or even texture.

**Color**

There are three major properties of colors: value, hue, and saturation. The primary hues are yellow, red, and blue. Secondary colors are made by mixing two primary colors. The next property of color which is value refers to the lightness or darkness of hue. Intensity refers to the purity of the hue.

![Primary Colors](image1)
![Secondary Colors](image2)
![Tertiary Colors](image3)

Fig 3.2.5a: Colors

The arrangement of colors can either establish an image or destroy it. Each color delivers different messages, and have an important visual weight and impact on an image. Giving understanding to colour and its messages and meanings and how it affects an image can aid in producing a standard captivating image.

Vibrant colors are energetic, interesting, and active. Understanding the colour wheel and its architecture would enhance your understanding.
Principles of Design

Having discussed the elements of design, we proceed to discuss the principles. These are concepts used to organize/arrange the structural elements of design.

The principles are:
- Balance
- Proportion
- Rhythm
- Emphasis
- Unity

Balance

Balance is the distribution of the visual weight of objects, colors, texture, and space. It is a psychological sense of equipoise. It positions and fixes in the parts of a visual in an aesthetically attractive arrangement.

Balance is:
- formal when both sides are symmetrical in terms of arrangement.
- informal when sides are not exactly symmetrical but the resulting image is still balanced. This is more dynamic than formal balance and captures the learner's attention focused on the visual message.

Balance are of three main types: symmetrical balance, asymmetrical balance, radial balance. In symmetrical balance, the elements employed on a side of the design are comparable to those on the other side; in asymmetrical balance, the sides are different but still look balanced. In radial balance, the elements are organized about a central point and may be similar.
Proportion
Proportion refers to the relative size and scale of the several elements in a design. This is the sensation of unity formed when all parts (sizes, amounts, or number) interact well with each other. For example, in image of a human being, proportion can refer to the size of the head compared to the rest of the body.

Rhythm
Rhythm is created when one or more elements of design are used repeatedly to create a feeling of organized movement. It is the repetition of visual movement of the elements. To keep rhythm exciting and active and to avoid monotony, variety is essential. Movement and rhythm work together to create the visual equivalent of a musical beat or dancing.

Emphasis
Emphasis is the part of the design that catches the viewer’s attention. Usually the artist will make one area stand out by emphasizing color, value, shapes, or other art elements to achieve
dominance. Emphasis is used by artists to create dominance and focus in their work.

Unity
Unity means the harmony of the complete composition. It is the sensation of harmony between all parts of the work. It creates a sense of completeness. The images work together to create meaning. The parts of a composition made to work together as a total visual theme. Unity is the relationship among the elements of a visual that helps all the elements function together.

Conclusion
Design is an iterative process. What capture a viewer’s attention to an image are the elements of design. A good standard image can be created by having a good understanding of the elements of design. The elements include: Line, Shape, Texture, Pattern, and Color. Also the principles of designs are essential in order to achieve a standard result. These principles are concepts used to organize/arrange the structural elements of design.
Video

For lecture video on this Unit follow the URL

http://tinyurl.com/y8hyfdx9

Unit summary

In this unit we learnt the elements and principles of design. The elements include: Line, Shape, Texture, Pattern, Color. These principles are concepts used to organize/arrange the structural elements of design. They include: balance, proportion, rhythm, emphasis, unity.

Assessment

1. What do you understand by design elements?
2. Which of the elements of design can you say is the “most important” and why?
3. What do you understand by design principle and list them.
Unit 3
Image Creation and Manipulation

Introduction

An integral part of image creation is the color content of the image. In this section, we will cover different types of color, the effect of color on both our mental and physical conditions, understand the communication power of colour, various color components and different messages it convey, we will also look into the component, format and editing styles that an image can be subjected into.

Upon completion of this unit you will be able to:

- Understand colour component of an image.
- Understand what constitute an image.
- Understand various image editing method.
- Understand various image format for print and web.

Terminology

**Light:** Light is electromagnetic radiation within a certain portion of the electromagnetic spectrum.

**Color model:** A color model is an abstract mathematical model describing the way colors can be represented as tuples of numbers, typically as three or four values or color components.

**Color:** Color is material goods of light.

Color Theory

Color is material goods of light, and is used for various purposes in image design: it can be used to portray a mood, control attention and make an indelible statement, color has a significant effect on our mental, physical and psychological view, hence various color or mixture of colors used in image design can carry a lot of messages.

**COLOR TYPES**

Color types can be primary, secondary or Tertiary. In the red–yellow–blue (RYB) or subtractive color model, the primary colors are red, yellow and blue. The three secondary colors (green, orange and purple) are created by mixing two primary colors. Another six tertiary colors are created by mixing primary and secondary colors.
MODELING COLOR SPACES.
A color model is an abstract mathematical model describing the way colors can be represented as tuples of numbers, typically as three or four values or color components e.g. RGB (Red Green Blue) and CMYK (cyan, magenta, yellow and key) are color models. However, a color model with no associated mapping function to an absolute color space is a more or less arbitrary color system with little connection to the requirements of any given application. Adding a certain mapping function between the color model and a certain reference color space results in a definite "footprint" within the reference color space. This "footprint" is known as a gamut, and, in combination with the color model, defines a new color space. For example, Adobe RGB and SRGB (Standard Red Green Blue) are two different absolute color spaces, both based on the RGB model.

In image design, several tools are available to control the theme or colour of the image object. In most software, the fill and Stroke tool is used in painting the image object. Various method and painting style with the functionalities to adjust the percentage of blurriness and opacity of the image object. These colors are group under different models as presented below:

RGB MODEL
In RGB model, colors are view as a mixture of red, green, and blue light, color are model after the three components colors. These three principal color can be combine in various proportion by varying the light component to obtain various other color like yellow.

The RGB color model is also the standard way of specifying colors on a Web page. In general, any color may be specified as a color name of the form “#RRGGBB”. Within this color name, the RR part is a hexadecimal (base 16) 6 number between 00 and FF that specifies the amount of red in the color, where 00 means no red and FF means the maximum amount of red.

Similarly, the G and B parts of this color name specify the relative amount of green and blue. For example, color #FFFF00 means full intensity of red and green, but no blue, and gives you yellow. Any numbers of intermediate values are possible. For example, #ff8000 is an orange hue: it specifies the maximum amount of red and half intensity of green, which puts it halfway between red and yellow on the color wheel.
The Hue-Saturation-Light (HSL) color model

Another way to characterize a color is in terms of the HSL model.

- The **hue** (H) of a color refers to which pure color it resembles. All tints, tones and shades of red have the same hue. Hues are described by a number that specifies the position of the corresponding pure color on the color wheel, as a fraction between 0 and 1. Value 0 refers to red; 1/6 is yellow; 1/3 is green.
- The **saturation** (S) of a color describes how white the color is. A pure red is fully saturated, with a saturation of 1; tints of red have saturations less than 1; and white has a saturation of 0.
- The **lightness** (L) of a color, describes how dark the color is. A value of 0 is black, with increasing lightness moving away from black.

The CMY model

Note on the diagram of the color wheel that each of the three colors cyan, magenta, and yellow are opposite one of the additive primary colors: red is opposite cyan, green is opposite magenta, and yellow is opposite blue. These pairs are called *complementary colors*. 
For example, if you take white light and filter out red, the result is cyan; if you take white light and filter out blue, you get yellow.

You can use the CMY model, like the HSV and RGB models, to characterize any color by specifying the amount of cyan, magenta, and yellow. The three values of a color in the CMY system are the opposite of the values in the RGB system. If each value is expressed as a value between 0 and 1, the $C$ value of a color is $(1-R)$, and also $M = (1-G)$ and $Y = (1-B)$. These colors are sometimes called the *subtractive primary colors*: if you start with white light, you can filter out various amounts of cyan, yellow, and magenta to produce any color.

**The CMYK model**

The term *gamut* refers to the range of colors that can be reproduced by a given process. When considering colors for display either on paper or on a display device, it is important to consider the gamut of that process. Computer monitors can usually produce brighter colors than ink on paper. Colored inks on paper act to filter out reflected colors. The subtractive primaries (cyan, yellow, and magenta), when combined on a printed page, act to remove colors from the light reflected from them. Yellow ink absorbs blue; magenta ink absorbs green; and cyan ink absorbs red.

In theory, if all three subtractive colors are printed on a page, the result should be black. However, in practice, the combination of these colors does not produce a completely black page. Hence, all quality printing processes use four colors: cyan, magenta, yellow, and black. The black ink is applied to the darkest areas of the page, where the sum of the other three ink colors does not produce a dark enough color.

Various combinations of the above color model result into some of the following color of the image object.

- Flat Colour
- Line Gradient
PIXELS AND IMAGES
Pixel is the picture element that constitutes an image, it is the smallest single component of an image.

The more pixels used to represent an image, the closer the result can resemble the original. The number of pixels in an image is sometimes called the resolution, The pixels, or color samples, that form a digitized image (such as a JPEG file used on a web page) may or may not be in one-to-one correspondence with screen pixels, depending on how a computer displays an image. In computing, an image composed of pixels is known as a bitmapped image or a raster image.

In image design terminology – understating pixels as smallest single component – picture element that made up an image or the dimensional structure that constitute an image, bits per pixel colour relationship is of great importance.

Bits per pixel
Color depth
The number of distinct colors that can be represented by a pixel depends on the number of bits per pixel (bpp). A 1 bpp image uses 1-bit for each pixel, so each pixel can be either on or off. Each additional bit doubles the number of colors available, so a 2 bpp image can have 4 colors, and a 3 bpp image can have 8 colors:

- 1 bpp, \(2^1 = 2\) colors (monochrome)
- 2 bpp, \(2^2 = 4\) colors
- 3 bpp, \(2^3 = 8\) colors
- 8 bpp, \(2^8 = 256\) colors
- 16 bpp, \(2^{16} = 65,536\) colors ("Highcolor")
- 24 bpp, \(2^{24} = 16,777,216\) colors ("Truecolor")

For color depths of 15 or more bits per pixel, the depth is normally the sum of the bits allocated to each of the red, green, and blue.
components. Highcolor, usually meaning 16 bpp, normally has five bits for red and blue, and six bits for green, as the human eye is more sensitive to errors in green than in the other two primary colors. For applications involving transparency, the 16 bits may be divided into five bits each of red, green, and blue, with one bit left for transparency. A 24-bit depth allows 8 bits per component. On some systems, 32-bit depth is available: this means that each 24-bit pixel has an extra 8 bits to describe its opacity (for purposes of combining with another image).

**Images Editing**

In this section, the focus we be on studying the effect of pixels alteration on an image, understanding the effect of image editing on the color and brightness of an image, various types of image enhancement like cropping, sharpness – contrasting, rotation/flipping, red eye removal, image selection and merging

Image editing encompasses the processes of altering images, whether they are digital photographs, traditional photochemical photographs, or illustrations. Traditional analog image editing is known as photo retouching, using tools such as an airbrush to modify photographs, or editing illustrations with any traditional art medium. Graphic software programs, which can be broadly grouped into vector graphics editors, raster graphics editors, and 3D modelers, are the primary tools with which a user may manipulate, enhance, and transform images.

In this section, our focus will be based on editing image paths

**Editing Paths**

Image created with pen and pencil tools is called path. A path is a sequence of straight line segments and/or Bezier curves which as any other image object may arbitrary fill and strokes properties. But unlike a shape a path can be edited by freely dragging any of its nodes (not just predefined handles) or by directly dragging a segment of path. Select this path and switch on the node tools as shown in the object fig below

You will see a number of gray squares nodes on the path. These
nodes can be selected and drag to edit the object to obtain image b. Paths are edited by dragging their nodes, node handles, or directly dragging a path segment. Various functions are available to edit the shape to satisfaction.

A node can be made cusp, which means its two handles can move independently at any angle to each other; smooth – which means its handles are always on the same straight line (collinear); symmetric – which is the same as smooth, but the handles also have same length; and auto-smooth, a special node that automatically adjusts the handles of the node and surrounding auto-smooth nodes to maintain a smooth curve.

**Sub-paths and Combining**
A path object may contain more than one sub-path. A sub-path is a sequence of nodes connected to each other. (Hence, if a path has more than one sub-path, not all of its nodes are connected.). In the fig below, three sub-paths belong to a single compound path; the same three sub-paths on the right are independent paths objects:

There are various functionality to combine paths into compound paths and break apart a compound path into separate paths.

Combining overlapping paths with fill usually the fill will disappear in the area where the paths overlap:

**Converting to path**
Any shape or text object can be converted to path. This does not change the appearance of the object but removes all capabilities specific to its type.
The stroke of any object can be converted into path as shown above.

**Boolean Operations**
There are several functionality/command that will allow you to combine two or more objects using Boolean operations:

**Inset and outset**
Scaling is a method by which an object shapes can be expanded and contracted, another method is by offsetting an object’s path, i.e. by displacing it perpendicular to the path in each point. The corresponding commands are called inset and outset. Shown below is the original path (red) and a number of paths inset or outset from that original:
Understanding Image Size and Resolutions

With the capability to observe or measure the smallest object clearly with distinct boundaries and understanding pixel size image resolution component, you can resize images in several ways using Image design software. To get the best result when you resize images, you need to understand the concepts behind and the results of each resizing method. These concepts affect how the Crop tool options operate as well. If you resize and crop images without being aware of the concepts involved, you can see unexpected results.

Image sizes onscreen and in print
The size of an image when you view it onscreen is different from its size when you print it. If you understand these differences, you can develop a better understanding of which settings to change when you resize an image.

Screen size
The screen resolution of your monitor is the number of pixels it can display. For example, a monitor with a screen resolution of 640 x 480 pixels displays 640 pixels for the width and 480 pixels for the height. There are several different screen resolutions you can use, and the physical size of the monitor screen usually determines the resolutions available. For example, large monitors typically display higher resolutions than small monitors because they have more pixels.

To find out what your screen resolution is, choose Start > Control Panel > Display > Settings and look at the screen resolution (Windows), or choose System Preferences > Displays and look in the Resolution list (Mac OS).

Image size onscreen
Images are of a fixed pixel size when they appear on your monitor. Your screen resolution determines how large the image appears onscreen. A monitor set to 640 x 480 pixels displays fewer pixels...
than a monitor displaying 1024 x 768 pixels. Therefore, each of the
pixel on the 640 x 480 pixel monitor is larger than each pixel
displayed on the 1024 x 768 pixel monitor.

A 100 x 100-pixel image uses about one-sixth of the screen at 640
x 480, but it takes up only about one-tenth of the screen at 1024 x
768. Therefore, the image looks smaller at 1024 x 768 pixels than
at 640 x 480 pixels.

**Image size in print**
The other values used in resizing image—the physical size of the
image when printed, and the resolution—aren't used until the
image is printed. Then, the physical size of the image, the
resolution, and the pixel dimensions determine the amount of data
in the image and its print quality. In general, higher resolution
images print at a higher quality. See the sections that follow for
more information on resolution and physical size.

**Image Size dialog box**
When you use the Image Size dialog box to resize your images
(choose Image > Image Size), four aspects of your image can change:

- **Pixel dimensions:** The width and height of the image.
- **Image size when it's open in Image design software:** This
  value appears at the top of the dialog box.
- **Document size:** Physical size of the image when printed,
  including a width and height.
- **Image resolution when printed:** This value appears in pixels
  per inch or pixels per centimeter.

Image design software calculates the physical size, resolution, and
pixel dimensions of an image as follows:

- **Physical size = resolution x pixel dimensions**
- **Resolution = physical size / pixel dimensions**
- **Pixel dimensions = physical size / resolution**

The Image Size dialog box allows you to resize your images in two
ways. You can increase or decrease the amount of data in the
image (resampling). Or, you can maintain the same amount of data
in the image (resizing without resampling). When you resample,
the image quality can degrade to some extent. You may have to do
some extra work, such as using the Unsharp Mask filter to sharpen
your image, to compensate for the resampling.

**Tip:** To reset the Image Size dialog box to its original state, press
Alt (Windows) or Option (Mac OS). Pressing these keys changes
the Cancel button to a Reset button.
**Resizing and resampling images**
When you resize and resample an image, you change the amount of data in that file. To resample your image, ensure that Resample is selected at the bottom of the Image Size dialog box. Resample is on by default.

Resampling changes the total number of pixels in the image, which are displayed as Width and Height in pixels in the Image Size dialog box. When you increase the number of pixels in this part of the dialog box (upsampling), the application adds data to the image. When you decrease the number of pixels (down sampling), the application removes data. Whenever data is removed from or added to the image, the image quality degrades to some extent. Removal of data from an image is typically preferable to the addition of data. That's because up sampling requires that Image design software guess which pixels to add. This procedure is more complex than guessing which pixels to remove when you down sample. You get the best results working with images you bring into Image design software in the proper resolution for the output you want. You could get the results you need by resizing your image without resampling. However, if you resample your images, do so only once.

When you turn on Resample, you can change any of the values in the Image Size dialog box: pixel dimensions, physical size, or resolution. If you change one value, you affect the others. The pixel dimensions are always affected.
- Changing the pixel dimensions affects the physical size but not the resolution.
- Changing the resolution affects the pixel dimensions but not the physical size.
- Changing the physical size affects the pixel dimensions but not the resolution.

You cannot set the file size; it changes when you change the total amount of data in the image (the pixel dimensions). Note the file size value before you change the other values in the dialog box. Then, you can use the file size information to understand how much data is removed or added to your image when you resample it. For example, if the file size changes from 250 KB to 500 KB, you add twice as much data to the image, which can degrade it. Degraded images can look blurry, jagged, or blocky.

**Resizing images without resampling**
When you resize an image and do not resample it, you change the image's size without changing the amount of data in that image. Resizing without resampling changes the image's physical size
without changing the pixel dimensions in the image. No data is added to or removed from the image. When you deselect, or turn off, Resample, the pixel dimension fields are not available. The only two values you can change are the physical size (Width and Height in Document Size) or the resolution (pixels/inch). When you resize without resampling, you can set either the physical size or the resolution of the image. To keep the total amount of pixels in the image the same, Image design software compensates for the value you set by increasing or decreasing the other value. For example, if you set the physical size, Image design software changes the resolution.

When the pixel dimensions are constant and you decrease the physical size of an image, the resolution increases correspondingly. If you decrease the physical size of an image by half, the resolution doubles. Twice as many pixels can fit into the same space. If you double the size of an image, the resolution decreases by half, because the pixels are twice as far apart to fit the physical size.

For example, a 400 x 400-pixel image, has a physical size of 4 x 4 inches and has a resolution of 100 pixels per inch (ppi). To reduce the image's physical size by half without resampling, you set the physical size to 2 x 2 inches. Image design software increases the resolution to 200 ppi. Resizing the image this way keeps the total number of pixels constant (200 ppi x 2 x 2 inches = 400 x 400 pixels). If you double the physical size (to 8 x 8 inches), the resolution decreases to 50 ppi. Adding more inches to the image size means that there can only be half as many pixels per inch. If you change the image resolution, the physical size changes as well.

**Important:** The pixel dimensions control the amount of data, and the resolution and the physical size are used only for printing.

**Note:** Pixels per inch (ppi) is the number of pixels in each inch of the image. Dots per inch (dpi) relates only to printers, and varies from printer to printer. Generally, there are 2.5 to 3 dots of ink per pixel. For example, a 600-dpi printer only requires a 150- to 300-ppi image for best quality printing.

**Using the Crop tool**
When you use the Crop tool to resize an image, the pixel dimensions and the file size change but the image isn't resampled. When you use the Crop tool, the pixel dimensions and resolution incorporate more pixels per inch based on the size of the crop region. However, Image design software isn't specifically adding or removing data from the image.
When you crop an image, you remove data from or add data to the original image size to create a different image. Because you are removing or adding data relative to the original image, the concept of resampling loses much of its meaning. That's because the number of pixels per inch can vary based on the number of pixels in the crop selection area. When the number of pixels in the crop area allows, Image design software tries to keep the same resolution of the original image. This method is considered cropping without resampling. However, when you are not exact about the number of pixels you select, the pixel dimensions and file size changes in the new image.

**Crop tool options**
The options in the Crop tool options bar change after you draw the selection area. When you first select the Crop tool, you can specify a width, height, and resolution. You can measure the width and height in inches, centimeters, millimeters, points, and picas. Type the unit or the unit abbreviation after the number in the value field. For example, 100 px, 1 in, 1 inch, 10 cm, 200 mm, 100 pt, or 100 pica. If you do not specify a unit of measure in the Width and Height fields in the Crop options bar, the default unit is inches. You can also set a value for the resolution of the cropped image in the Resolution field. Choose pixels/inch or pixels/cm from the pop-up menu.

**Changing inch size only**
When you set the physical size of the image in inches in the Crop tool options and you don't change the resolution, the pixel dimensions change. The dimensions change based on the ratio of the number of pixels you drew in the crop selection to the pixel dimensions of the original image. The resolution changes to fit the extra pixels into each inch of the image based on the image's original size.

**Note:** The original image used in the examples below is 4 x 4 inches, 100 ppi, 400 x 400 pixels at 468.8 KB.

<table>
<thead>
<tr>
<th>Inch size (you set)</th>
<th>Resolution (changed by Image design software)</th>
<th>Pixel dimensions (size of the crop selection you drew)</th>
<th>File size</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x 2 in</td>
<td>104 ppi (original res = 100 ppi)</td>
<td>208 x 208 px (original = 400 x 400 px)</td>
<td>125.8 KB  (original 468.8 KB)</td>
</tr>
</tbody>
</table>

In this example, Image design software reduces the image by half...
of the physical size (from 4 inches square to 2 inches). Image design software also reduces the pixel dimensions by 50%. The original resolution (100 ppi) is maintained, but it increases to compensate for the extra pixels (8 pixels/inch) added to the crop rectangle.

**Changing inch size and resolution**

When you set the physical size of the image in inches in the Crop tool options, and change the number of pixels per inch, the pixel dimensions change. The resulting image has more or fewer pixels in the document as a whole. You set the inches and the number of pixels in each of those inches. Image design software removes or adds data to fit the number of pixels in each of the inches you specified.

**Note:** The original image used in the examples below is 4 x 4 inches, 100 ppi, 400 x 400 pixels at 468.8 KB.

<table>
<thead>
<tr>
<th>Inch size (you set)</th>
<th>Resolution (you set)</th>
<th>Pixel dimensions (changed)</th>
<th>File size</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x 2 in</td>
<td>200 ppi</td>
<td>400 x 400 px</td>
<td>468.8 KB</td>
</tr>
<tr>
<td>2 x 2 in</td>
<td>300 ppi</td>
<td>600 x 600 px</td>
<td>1.03 MB</td>
</tr>
<tr>
<td>2 x 2 in</td>
<td>50 ppi</td>
<td>100 x 100 px</td>
<td>29.3 KB</td>
</tr>
</tbody>
</table>

In the first example, you reduced the physical size by half but balanced that by doubling the resolution. Therefore, the pixel dimensions and file size remained the same.

In the second example, you reduced the physical size by half and increased the resolution. Therefore, the pixel dimensions increased to hold the extra number of pixels per inch. The file size also increased.

In the third example, you reduced the physical size by half and reduced the resolution (the ppi). Therefore, the pixel dimensions decreased because there are fewer pixels now in the image. The file size also decreased.

**Changing the pixel dimension only**

When you set the pixel dimensions but you do not set the resolution, the resolution stabilizes at the same resolution as the original image. The new physical size is produced to hold the number of pixels specified in the image and per inch. The file size changes because you are changing the pixel dimensions while letting Image design software stabilize the number of pixels per inch.
Note: The original image used in the examples below is 4 x 4 inches, 100 ppi, 400 x 400 pixels at 468.8 KB.

<table>
<thead>
<tr>
<th>Inch size (changed)</th>
<th>Resolution (changed)</th>
<th>Pixel dimensions (you set)</th>
<th>File size</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x 2 in</td>
<td>100 ppi</td>
<td>200 x 200 px</td>
<td>117.2 KB</td>
</tr>
<tr>
<td>3 x 3 in</td>
<td>100 ppi</td>
<td>300 x 300 px</td>
<td>263.7 KB</td>
</tr>
<tr>
<td>6 x 6 in</td>
<td>100 ppi</td>
<td>600 x 600 px</td>
<td>1.03 MB</td>
</tr>
</tbody>
</table>

In these examples, the resolution is unchanged but the pixel dimensions have changed. The physical size changes to fit the number of pixels per inch you specified (pixel dimensions).

Changing the pixel dimension and the resolution
When you set the pixel dimensions and the resolution, Image design software creates a different physical size. The image holds the number of pixels in the image and number of pixels per inch you specified. The files size changes because you are changing the total number of pixels in the image and the number of pixels in each inch.

Note: The original image used in the examples below is 4 x 4 inches, 100 ppi, 400 x 400 pixels at 468.8 KB.

<table>
<thead>
<tr>
<th>Inch size (changed)</th>
<th>Resolution (changed)</th>
<th>Pixel dimensions (you set)</th>
<th>File size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x 1 in</td>
<td>600 ppi</td>
<td>600 x 600 px</td>
<td>1.03 MB</td>
</tr>
<tr>
<td>2 x 2 in</td>
<td>300 ppi</td>
<td>600 x 600 px</td>
<td>1.03 MB</td>
</tr>
<tr>
<td>.667 x .667 in</td>
<td>300 ppi</td>
<td>200 x 200 px</td>
<td>117.2 KB</td>
</tr>
</tbody>
</table>

In these examples, both the pixel dimensions and resolution are changed. The physical size changes to fit the total number of pixels and the number of pixels in each inch (pixel dimensions and resolution).

Changing the resolution only
When you change only the resolution in the Crop tool options, the image size depends on the number of pixels in the crop area. Look at the Info panel to see how many pixels are included in your crop area.

The original image used in the examples below is 4 x 4 inches, 100 ppi, 400 x 400 pixels at 468.8 KB.
<table>
<thead>
<tr>
<th>Inch size (result)</th>
<th>Resolution (you set)</th>
<th>Pixel dimensions (result)</th>
<th>Your crop size (you drew)</th>
<th>File size</th>
</tr>
</thead>
<tbody>
<tr>
<td>.767 x .767 in</td>
<td>300 ppi</td>
<td>230 x 230 px</td>
<td>2.3 x 2.3 in</td>
<td>115 KB</td>
</tr>
<tr>
<td>1 x 1 in</td>
<td>300 ppi</td>
<td>300 x 300 px</td>
<td>3 x 3 in</td>
<td>263.7 KB</td>
</tr>
<tr>
<td>75 x .75 in</td>
<td>400 ppi</td>
<td>300 x 300 px</td>
<td>3 x 3 in</td>
<td>263.7 KB</td>
</tr>
<tr>
<td>1 x 1 in</td>
<td>200 ppi</td>
<td>200 x 200 px</td>
<td>2 x 2 in</td>
<td>117.2 KB</td>
</tr>
<tr>
<td>.5 x .5 in</td>
<td>200 ppi</td>
<td>100 x 100 px</td>
<td>1 x 1 in</td>
<td>29.3 KB</td>
</tr>
<tr>
<td>1.5 x 1.5 in</td>
<td>200 ppi</td>
<td>300 x 300 px</td>
<td>3 x 3 in</td>
<td>263.7 KB</td>
</tr>
</tbody>
</table>

In these examples, Image design software uses the size of your crop selection and the resolution you specify to resize the image. The new image's physical size and pixel dimensions fit the number of pixels in the crop selection you drew and the new resolution you set.

**Creating Images for Print and Web**

Understanding workflow, file formats and tools use in print and web development, mastering the view method, users perception, the design lifecycle, compatibility and layout.

**Creating the Correct Image Size**

Getting the proper image size is the first step. Your current screen size is the default. Using this information as reference, figure out how big you want the image to appear on screen. Once you have a general idea for the image size, look at the available tools to figure out what DPI you want to scan your image at.

This will open the Image Size window. Here you can set the image to whatever size you wish. Unchecking "Constrain Proportions" will allow for more freedom over image size, but at the risk of looking disproportioned.

**Preparing Images for Web**

When creating images for web use, keeping the file size low is very important. To achieve this, format and compression levels must be taken into consideration. The formats most commonly used for web images are GIF and JPG. These formats offer low file sizes and moderate to very high quality. GIF is commonly used for simple illustrations, while JPEG is more commonly used for photographs.
If you are working with a photo, the JPEG file format is suggested. If it is a graphic, such as a banner, logo or navigational tool, GIF format is suggested.

Preparing Images for Print
When preparing images for print, the highest quality images are desired. The ideal file format choice for print is TIFF, followed closely by PNG.

File Format & DPI Guide

Quick File Format Guide

<table>
<thead>
<tr>
<th></th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>JPEG</td>
<td>Great for putting photos on the web.</td>
<td>More padding. Compression is irreversible.</td>
</tr>
<tr>
<td>GIF</td>
<td>Low file size, lossless compression. Great for logos or simple art.</td>
<td>Only works with images that have less than 256 colors. Very bad for photos.</td>
</tr>
<tr>
<td>PNG</td>
<td>Great image quality. Can be used in web and print.</td>
<td>Not very well supported.</td>
</tr>
</tbody>
</table>

DPI Guide
The DPI equation is a helpful tool in figuring out how big your image will appear on the computer.
(Width of image in inches x DPI) x (Height of image in inches x DPI) = Image size on screen.
Example:
(6 inches x 100 dpi) x (4 inches x 100 dpi) = 600 x 400 pixels

Image Formats
Understanding the image file size, image compression algorithm, graphic file format for both print and web design comprising of raster (jpeg/jfif, exif, tiff etc), vector (CGM, SVG, VML, WMF etc).

Image file formats are standardized means of organizing and storing digital images. Image files are composed of digital data in one of these formats that can be rasterized for use on a computer display or printer. An image file format may store data in
uncompressed, compressed, or vector formats. Once rasterized, an image becomes a grid of pixels, each of which has a number of bits to designate its color equal to the color depth of the device displaying it.

**Image file compression**
There are two types of **image file compression** algorithms: lossless and lossy.

**Lossless compression** algorithms reduce file size while preserving a perfect copy of the original uncompressed image. Lossless compression generally, but not always, results in larger files than lossy compression. Lossless compression should be used to avoid accumulating stages of re-compression when editing images.

**Lossy compression** algorithms preserve a representation of the original uncompressed image that may appear to be a perfect copy, but it is not a perfect copy. Often lossy compression is able to achieve smaller file sizes than lossless compression. Most lossy compression algorithms allow for variable compression that trades image quality for file size.

**Major graphic file formats**
Including proprietary types, there are hundreds of image file types. The PNG, JPEG, and GIF formats are most often used to display images on the Internet. These graphic formats are listed and briefly described below, separated into the two main families of graphics: raster and vector.

In addition to straight image formats, **Metafile** formats are portable formats which can include both raster and vector information. Examples are application-independent formats such as WMF and EMF. The metafile format is an intermediate format. Most applications open metafiles and then save them in their own native format. **Page description language** refers to formats used to describe the layout of a printed page containing text, objects and images. Examples are PostScript, PDF and PCL.

**Raster formats**

**JPEG/JFIF**
JPEG (Joint Photographic Experts Group) is a lousy compression method; JPEG-compressed images are usually stored in the **JFIF** (JPEG File Interchange Format) file format. The JPEG/JFIF filename extension is **JPG** or **JPEG**.
JPEG 2000
JPEG 2000 is a compression standard enabling both lossless and lossy storage. The compression methods used are different from the ones in standard JFIF/JPEG; they improve quality and compression ratios, but also require more computational power to process. JPEG 2000 also adds features that are missing in JPEG. It is not nearly as common as JPEG, but it is used currently in professional movie editing.

The Exif (Exchangeable image file format) format is a file standard similar to the JFIF format with TIFF extensions; it is incorporated in the JPEG-writing software used in most cameras. Its purpose is to record and to standardize the exchange of images with image metadata between digital cameras and editing and viewing software. The metadata are recorded for individual images and include such things as camera settings, time and date, shutter speed, exposure, image size, compression, name of camera, color information. When images are viewed or edited by image editing software, all of this image information can be displayed. The actual Exif metadata as such may be carried within different host formats, e.g. TIFF, JFIF (JPEG) or PNG. IFF-META is another example.

Vector formats
As opposed to the raster image formats above (where the data describes the characteristics of each individual pixel), vector image formats contain a geometric description which can be rendered smoothly at any desired display size.

At some point, all vector graphics must be rasterized in order to be displayed on digital monitors. Vector images may also be displayed with analog CRT technology such as that used in some electronic test equipment, medical monitors, radar displays, laser shows and early video games. Plotters are printers that use vector data rather than pixel data to draw graphics.

Gerber format (RS-274X)
The Gerber format (aka Extended Gerber, RS-274X) was developed by Gerber Systems Corp., now Ucamco, and is a 2D bi-level image description format. It is the de facto standard format used by printed circuit board or PCB software. It is also widely used in other industries requiring high-precision 2D bi-level images.

Compound formats
These are formats containing both pixel and vector data, possible
other data, e.g. the interactive features of PDF.
- EPS (Encapsulated PostScript)
- PDF (Portable Document Format)
- PostScript, a page description language with strong graphics capabilities
- PICT (Classic Macintosh QuickDraw file)
- SWF (Shockwave Flash)
- XAML User interface language using vector graphics for images.

Conclusion
The value and quality of your image will be adjudged by color component, size, resolution and formats measure of your design.

Video
For lecture video on this Unit follow the URL
http://tinyurl.com/vcrawtsl

Unit summary
One of the major requirement in image and animation design is the understanding of color theory, size and resolution, and the formats require by the production/presentation platform.

Assessment
1. Give three example of raster image format
2. Give two requirements for web images
3. What is scaling in image editing?
Unit 4

Image Design Software

Introduction

Essence of computerization is to work faster and smarter, likewise in the field of image and image animation design – thousands of software both free and many you can purchase are available in the market today, that when employed in the process of your image design will add a professional taste to your final output. In this unit we will familiarize ourselves with some of this software and there capabilities.

Upon completion of this unit you will be able to:
- Understand software’s use in image design.
- Understand basic tools in image design software.
- Understand image drawing, colouring and editing.
- Understand professional image design.

Terminology

Software: It is a collection of instructions that enable the user to interact with a computer, its hardware, or perform tasks.

Image: An image (from Latin: imago) is an artifact that depicts visual perception, for example, a photo or a two-dimensional picture, that has a similar appearance to some subject—usually a physical object or a person, thus providing a depiction of it.

Drawing: The result or the act of making an image with a writing utensil

Image Design Software

Introduction to various software that can be used for vector image design, editing and visualization of image will be our focus on Image design software. Several other software with capabilities of image and animation design in these other category are vector art, Serif drawplus, Pixlr, Paint, Sumopaint etc.

Drawing, Painting, Image Manipulation and Photo Editing Software

Krita

Krita is a digital sketching and painting software for a number of systems. It has a wide variety of brushes including pixel, smudge,
duplicate, filter, hairy, hatching, texture, chalk, colormudge, curve, deform, dyna, experiment (Alchemy), grid, particle, sketch and spray. Other features include the ability to rotate or mirror your canvas; vector tools like normal text, artistic text, calligraphy, selection, path, fill and gradient; raster tools like a number of shapes and lines (e.g., ellipse, polygon, rectangle, star, etc), crop, move, perspective grid, the ability to select in different ways (e.g., freehand, polygon, outline, etc) and act on that selection (e.g. to fill it), zoom, pan, etc; layer management; filters (e.g., colour adjustment, brightness, contrast, desaturate, raindrops, oil paint, pixelize, motion blur, sharpen, Gaussian noise removal, etc — there are far too many to list here); support for different color models (RGBA, Gray, CMYKA, Law, YCbCr, XYZ) and color management; etc. It supports numerous file formats for import and export, such as PSD (ie Photoshop images), PNG, JPEG, JPEG-2000, Windows BMP, TIFF, PDF, PPM, PGM, PBM, EXR, Open Raster document, etc. Supported platforms include Windows, Linux and FreeBSD.

The program, mt Paint creates "pixel art" and manipulate digital photographs. It presents you with a pixel grid of your picture, at varying zoom levels, so that you can accurately paint or edit it. It works with pressure sensitive graphics tablets, supports multiple layers (up to 100, at the time this was written), has numerous brush patterns, user-defined gradients, undo, multiple image clipboards, gamma correction, a variety of effects (eg, invert, greyscale, isometric transformations, edge detect, sharpen, "unsharp" mask, soften, Gaussian blur, emboss, etc), crop, rescaling, screen capture, etc. The program works in Windows and Linux, and is open source, under the GNU General Public License.

Pencil — 2D Animation Software
Pencil is an open source (free) animation drawing software that runs on Windows, Mac OS X and Linux. That is, you can use it to draw pictures that you can string together to form an animation or cartoon. This cartoon can be exported as a series of PNG images, in a Flash file format (which you can exhibit on your own website) or as a QuickTime movie (the QuickTime movie export only works in the Mac OS X version at the moment). Sound can also be added to cartoon. The program supports both bitmap and vector graphics.

PhotoPos Lite
This is a photo and graphics editor that lets you work with multiple images simultaneously, edit and enhance those pictures, apply filters to your photos, use basic shapes and paint brushes to draw your pictures, use flood fill, apply simple gradients, apply special effects, print your pictures, etc. This is a Windows program.
Helios Paint
This freeware paint program may be used to create and edit images on Windows, Mac OS X, Linux and Unix. Features include a pencil for editing pixels, a variety of lines (curved, straight, freehand), a paint brush with resizable heads, a spray can with resizable nozzle and a global spray facility, shape tools (star, moon, heart, regular polygon, freehand), paint can with color bleed sensitivity, text entry, HSB/RGB/contrast/gamma adjustment, image filters (invert, grey, black and white, color, sharpen, blur, edge feathering, edge detection, oil painting effect, emboss), image color and transparency adjustment, zoom in and out, selection and moving tools (scissors, lasso, wand), undo and redo, printing with page auto-fit, etc.

RealWorld Paint
This image editor lets you create and modify JPG, PNG, BMP and other types of raster images. It supports layers with effects, has many drawing tools that can do gamma-blending and color gradient interpolation, has sub-pixel accuracy, the usual assortment of tools (magic wand, transformation, brushes, rectangles, ellipses, polygons, etc) and filters (drop shadow, blur, bevel, color corrections, etc), supports PhotoShop plugins as well as customization using JavaScript, etc.

Dia
Dia is a diagram creation program inspired by the commercial "Visio". A drawing program rather than a painting one, it has many facilities to help you draw diagrams, including special objects for drawing entity relationship diagrams, UML diagrams, flowcharts, network diagrams, etc. It saves files to a custom XML format, but can also export to other formats like EPS, SVG, XFIG, WMF and PNG. Other features include the ability to print multi-page diagrams. Dia works on Windows and Linux. Source code is also available.

IrfanView
IrfanView is primarily an image viewer that can double as a simple image editor that can perform tasks like resizing of images, converting images between formats, renaming of files, etc. It is able to perform batch conversion of images and pictures as well as batch renaming of files, which is a handy feature when you have many files you need to process.

GIMP - GNU Image Manipulation Program
GIMP, often touted as an Adobe Photoshop replacement by its fans, allows you to create and edit images and photos. It has the
usual facilities found in many commercial paint programs such as a variety of paint tools (Brush, Airbrush, Pencil, Clone, custom brushes and patterns, etc), full alpha channel support, layers and channels, transformation tools (rotate, scale, sheer, flip), multiple undo and redo, selection tools (rectangle, ellipse, free, fuzzy, intelligent, bezier, polygonal), animation support (including MNG), numerous file formats (BMP, GIF, JPEG, MNG, PCX, PDF, PS, PSD, PNG, SVG, TIF, TGA, XPM, etc) including conversion between different file formats, and so on. Supported systems include Windows, Mac OS X, Linux, FreeBSD and Sun Solaris. This is an open source program.

Tux Paint
Tux Paint is a drawing software designed for young children. It has cute looking buttons, sound effects and a mascot that encourages children as they use the program. Supported systems include Windows, Linux, Mac OS X, FreeBSD and NetBSD.

Paint.NET
Paint.NET is an image and photo manipulation program that supports layers, unlimited undo and redo, special effects, drawing tools (tools for drawing shapes, splines, Bezier curves, etc), etc. It runs under Windows 2000, XP, 2003 and Vista. It requires the Microsoft .NET Framework (hence its name).

Image design software - open source scalable vector graphics editor
Image design software is a scalable vector graphics (SVG) editor. It is open source, and versions are available for Windows 2000, XP, 2003, and OS X.

MyPaint
MyPaint is an open source painting software that comes with a large number of brushes, including pencil, charcoal, smudge, ink, etc; support for creating your own types of brushes; unlimited canvas; layer support; support for pressure sensitive graphics tablets; and so on. Windows and Linux versions are available, as well as a plugin for GIMP (see elsewhere on this page so that you can open and save MyPaint native files with that software.

**Introduction to Basics Tools in Image Design**

**Software Interface**

*Image design software* interface consist of elements which are designed to make work simple, harmonious and contextual. It is composed principally of a single window in which drawings are created and manipulated. Within the window are particular
components which it is important to identify in order to easily navigate the software.

![Fig 3.2.1a: Image Design Software Interface](image)

We may divide it into eight major areas:
1. The **Menu** (at the top of the window)
2. The **Commands Bar**
3. The **Toolbox**
4. The **Tool Controls Bar** (also called just **Controls Bar**)
5. The **Canvas**
6. The **Rulers, Guides and Grids**
7. The **Palette**
8. The **Status Bar**

**The Menu**

As in most GTK applications, the Image design software Menu contains the essential functions of any program, those which concern the application itself: New, Open, Save, Export, Quit, etc. The functions relating to drawing are also present in the Menu.

**The Commands Bar**

The **Commands Bar** is located at the top of the workspace directly underneath the Menu. It contains icons which are shortcuts to commands which are otherwise accessible from the menus or shortcut key commands.

It also contains other controls for manipulating the document and drawing objects. For example, from the Commands Bar you can open a new or existing document, print, import an image, undo
previous commands, zoom, open the dialog to adjust document properties, etc. It is possible to see all the functions by hovering over each one and reading the tooltips.
There may be an arrow on the right side of the Commands Bar pointing down which you can click to reveal any command shortcuts that were not able to fit on the bar due to monitor size or resolution settings.

![Fig3.2.1b: The Toolbox and Tool Controls Bar](image)

The Toolbox, consisting of vertically aligned buttons located on the left of the window, is the Image design software's main editing control. It contains the basic set of drawing utilities, in particular for creating and editing shapes. There are controls for geometric shapes as well as free-form shapes and lines, text, and fills (colors and gradients).

Located directly under the Commands Bar is the Tool Controls Bar.

![Tool Controls Bar](image)

When each tool is selected in the Toolbox, the Tool Controls Bar
changes to show particular options associated with that tool. Depending on context, some of these options affect the selected object while some take effect only when drawing a new object; others can affect either existing or new objects.

Figure above has no content and title

The Canvas

The Canvas is the main workspace, and is the most central and important part of the interface, since it is here that the drawing is created and viewed. It is located in the middle of the window and is represented as a blank "page" with open space around it. By default, there is a Ruler above and a Ruler to the left of the Canvas which is set to measure in pixels (the standard SVG unit), but these defaults (ruler visibility and unit) can be adjusted in Document Properties.

While the "page" defines the boundaries of a document intended for certain media (print, export, etc.), an SVG is not limited to the page boundaries. In fact, the page border and shadow can be made invisible in the Document Properties. Some artists will prefer to use a particular page boundary and use the white space as "scratch paper"; others will prefer not to be limited by page boundaries.

Rulers

The Rulers are graduated lines placed on top and left of the canvas. The first is called "horizontal" and the second "vertical". Graduations represent distances and are expressed in units that can be set in the Units option of the Page tab of the File >Document Preferences.

When the mouse is over the canvas, two triangles appear in the rulers to show its X and Y coordinates, relative to the page's bottom left corner. Those coordinates are also displayed in the Status Bar (at the bottom of the document window) on the left, near the Zoom Control.
Note: In SVG, coordinates begin at the bottom left of the document like in Cartesian geometry.

Ctrl + R is a quick way to hide or display the Rulers. One can also do that with the View > Show/Hide > Rulers.

The Canvas

Guides
Guides are user-defined 'magnetic' lines. Using Guides makes object alignment easy even with the mouse. To use Guides, click and drag from the Rulers to the point where the Guide is to be inserted and release. Clicking and dragging from the horizontal Ruler produces a horizontal Guide. Clicking and dragging from the vertical Ruler produces a vertical Guide.

How to use Moving Guides
When the Selector Tool F1 is active, passing the mouse over a Guide will change its color to red. Then, click and drag the Guide where you want.

Deleting guides
To delete a guide, just drag it to the appropriate Ruler with the Selector Tool F1.

Guide Visibility

To make Guides invisible, without deleting them, select View > Guides from the Menu Bar.
The keyboard shortcut for toggling Guide visibility is \textbf{Shift} | (hold shift and press the pipe - | - key, which is usually paired with the backslash key.)

\textit{File} > \textit{Document properties} let you define if Guides should be displayed as default and change the color both of the Guide itself and for the highlight when the mouse passing over.

Guides are also often used with snapping that makes it much easier to place object on the canvas, especially for precise or technical drawings. In this case just check the \textit{Snap guides while dragging} checkbox.

\textbf{Grids}

Instead of using lots of Guides, it can be useful to activate Grids. Do this with the \textit{View} > \textit{Grid} menu or press # (\textbf{Shift} + 3 ).

There are of 2 types: \textbf{rectangular} and \textbf{axonometric}. They can be defined in the window from the \textit{Document} > \textit{Properties} > \textit{File} menu. The most commonly used is the rectangular Grid which is made of vertical and horizontal lines.

Axonometric Grids allow the user to define any kind of angled Grid which can be interesting for technical or architectural drawings.
Fig 3.2.1c An example of standard axonometric Grid.

Fig 3.2.1d: Guide Visibility

**How to Use**
To choose between one of those, just drop down the list in the document properties and click the new button. A new tab is created within the main one (one can define several Grids for a single document). Then define the units you would like to use and both the Origin point and the distance between two lines of the Grid. When on Axonometric Grids another option to define the angle is available.
Enabled
The user will use or not use this Grid in the document

Visible
The user will see or not the grid on the canvas. This is the default value for that grid. But if the View > Grid is uncheck, the Grid won't be visible on the Canvas even if Visible is checked here.

Grid Units
Many commonly used units are available from mm, to feet and px. Choose the one that best suits your needs. If no special needs, keep the default px.

Origin X and Y
Define the beginning point of the Grid. Usually set to '0' (zero). It is useful to change if an offset is needed especially to define margins from the Canvas side.

Spacing X and Y
Defines the space between two lines of the Grid. These spaces can be different for horizontal and vertical lines so that the Grid pattern can be set to any kind of rectangle.

Angle X and Y
Only available for axonometric Grids, defines the angle of the Grid lines.

Grid line color
Default color for the Grid is blue, but this can be changed here. There are two kinds of line. The most often used is the Grid line, but the major Grid line helps to evaluate the distance especially when the grid spacing is short and that many lines are displayed. In this case, one can define a different color for each, and set the frequency of major grid line, usually to 5 or 10.

Show dots instead of lines
Since lines can overload the screen, it can be uneasy to work with Drawing Tools. It can be done here.

Swatches

Swatches is a quick way to apply color on shapes. It is display at the bottom of the Canvas, or in a window by View > Swatches (Shift+ Ctrl + W)
How to Use
To find the color you like, just scroll the swatch line and choose. You can change the color by another preset by clicking the triangle at the right of the bar and choose one.

To apply a color in a shape as a fill color, just click on a color after selecting one or more shapes.

To apply the color on the stroke, press Shift while clicking and it's done.

Status Bar
Status Bar is the bottom-most of Image design software interface. It includes (from left to right):
- Color indicator for the object
- Quick layer selector
- Help message area
- Mouse Coordinate indicator
- And finally a zoom factor in which one can right the factor he wants to use.

Drawing, Colouring and Editing of Basics Shapes
Basics Shapes
A typical image design software consist of basic functionalities for creating and colouring most of the basics shapes: rectangles and squares, 3D boxes, circles, ellipses and arc, stars and polygons, spirals, and for creating and editing text objects.

Apart from the creation of the mentioned basic shapes, tools for drawing professional image will be mastered in this portion of this material.

In this section, freehand lines, Bezier curves and straight lines and Calligraphic and brush strokes drawing will be covered.

Draw freehand lines - Pencil Tool
With the Pencil Tool, the Image design software artist creates freehand paths by drawing directly on the canvas in the desired curves. Image design software evaluates the line or shape drawn by the user and produces nodes to form the path. After the path is drawn, the nodes of the path can be edited with the Node Tool, like other paths.

How to use
Choose the Pencil Tool and just click and drag the mouse to draw
the line. By default it has no fill, but this can be set by any means (swatch or Fill and Stroke dialog). The line can also be set with stroke properties and colors in the Fill and Stroke dialog. It is possible to close the line drawn while returning towards the initial point. When the mouse is close to this point, the point changes color to red to specify that a release of the mouse at this moment closes the shape.

Tips
These tools can create single dots on the canvas. This creates a small circle filled with the current stroke color. The radius can be set in the Preferences of the respective tools (it is specified as a multiple of the current stroke width).

Drawing Bezier curves and straight line
Bezier with Pen Tool
Bezier Curves, available in the Pen Tool, enable you to draw smooth curves with precision.

How to use Bezier
To create a Bezier curve in Image design software, click on the button in the Toolbox, Left click to create the first node.

To draw a segment, just click again further where you want the segment to end. Image design software draws immediately a straight line between these two points.

Delete a Segment
To erase the last segment/node, press del.

Draw a Curve
If you want to draw a curve, just keep the button pressed after clicking and just drag to make curve control point appear. They are symmetrically placed to make a perfect smooth curve so that you also need to move only one node. To stop drawing the actual curve you can either click the first node of the global curve (if you want it to be a closed shaper), or press Enter or double-click.
Continue a Path
To continue a path that has been previously drawn, just press b to activate the pen and click on either end and just go on.
A pen made path can be continued with the pencil F6 if needed.

Calligraphy Tool
The Calligraphy Tool uses dynamic drawing techniques that apply simple filters to the cursor place and motion. The SVG "stylus" transforms as if it were a physical stylus or brush, depending on its mass, speed, orientation and friction. (Some of these parameters are affected only by use of an input device such as a drawing tablet.) By changing these parameters, various types of "strokes" can be made. This makes the Calligraphy tool excellent for drawing more natural, smooth and consistent strokes, particularly when using a pen tablet or similar input device.

The Calligraphy Tool does not draw a single path line like the freehand tool, but a whole filled shape. This is not a live shape, like rectangles and stars, but an arbitrary shape consisting of node paths. Being comprised of multiple nodes, calligraphy strokes can be modified by other path tools, for example the Node and Tweak tools. Also, like all arbitrary SVG shapes, calligraphy paths have strokes at their edges, so they are affected by the usual Fill and Stroke settings.

How to Use
The Calligraphy Tool can be called by clicking its icon in the Toolbox.
Calligraphy shapes are drawn in the same manner as any other shape - just click on the canvas and drag.

Options
The Calligraphy Tool has many options available in the Tool Controls bar which allow the artist to create very specific types of strokes.

Width
Used to set the basic width of the line. This basic width is then automatically modified depending on the other values (such as pressure of the tablet pen) and settings (such as the toggle setting of Input Device Pressure).

**Warning:** Calligraphy stroke width is relative to the current view and zoom factor.

**Input Device Pressure**

When on, Calligraphy uses pen tablet pressure to affect such values as stroke width.

**Trace Lightness to Width**

**Trace Lightness to Width** adjusts the width of the stroke to the lightness of objects behind it. In the background objects, white translates into the minimum stroke width and black translates to the maximum (which is set by the Width parameter). This works with both bitmap and vector images and allows the artist to not only hatch over an imported bitmap image or any drawing, but to do so automatically reproducing the highlights and shades of the background with your strokes becoming lighter and heavier as needed. This can work alone or in combination with pressure sensitivity, depending on whether the "Use pressure" button is also toggled.

**Thinning**

Thinning is a way to modify the width of the calligraphy stroke dynamically according to the speed at which the stroke is made. This value enables the calligraphy tool to emulate true ink flow from a pen or brush. For instance, dragging a stroke at a uniform speed will create a mostly uniform stroke width, while increasing speed will decrease width, and decreasing speed will increase
width (to a degree). The higher the thinning value is, the more the stroke will be thinned.

Some examples are shown below. Notice that a negative thinning results in a thicking. When set to 0.0, the line keeps its width with uniformity.

```
רִסָּס
1,0 0,5 0,0 -0,5 -1,0
```

**Angle**
The **Angle** setting is used to emulate a stylus type of writing instrument. Angle will affect the direction at which the stroke creates its thinnest part, just like a calligraphy pen. Values can be set from -90° to 90°. When set to 0, the hair line is horizontal; to 90, vertical.

```
055
30° 90° 0°
```

**Tilt to angle**
When activated, Angle is modified relatively to tilt of the tablet pen.

**Fixation**
**Fixation** changes the way the Angle width follows the calligraphic
path. When set to 0.0, Angle is set always perpendicularly to the
path so that the width looks nearly the same all along the path (as if
the stylus were rotated constantly in the direction of the stroke).
When set to 1.0, Angle is set to adjust to stroke direction most
strictly (as if the stylus were kept exactly in the same direction at
all times as a machine might be able to do). A setting of a little less
than 1.0 (such as 0.9) will most closely follow natural hand
movement, like using a real stylus.

Caps
Caps determines how the line ends. At 0, the end caps will be
drawn flat. Increasing the value will create elliptical end caps, and
the higher the value the longer the ellipses will be. The max value
is 5.00.

Tremor
Tremor affects jitteriness of the stroke. It can be set from 0.0 to
1.0. When set to 0, the line is the most regular.

Wiggle
Wiggle is a kind of randomization on drawn curves, making a sort
of "bumpy" stroke. It generates these curves or "bumps" regularly,
and can help to draw some nice typographic shapes, though the
result is hardly predictable.
Mass
Mass affects how quickly the stroke follows the cursor. A heavier mass makes the stroke slower and increases smoothness or regularity of the stroke. Values can be set from 0.0 to 1.0. When set to 0.0 the path just follows the mouse as normal. When set to 1.0, the drawing of the stroke is very slow.

Default
Default resets all Calligraphy Tool Controls settings to defaults as defined in Preferences.

Drawing
Adding a New Stroke to a Calligraphy Object
Press Shift to add a new calligraphic line to those that are selected, keeping all strokes together as a single object.

Tracking a Shape
One of the most common operations in line engraving is hatching (or sometimes cross-hatching when several hatching grids cross): filling a space with many parallel straight or variously curved lines (usually of varying width to represent a gradual shading). You could try to achieve a similar effect with e.g. path interpolation (blending), but it is rather cumbersome and limited. Manual drawing of hatch lines, on the other hand, is tedious and nearly impossible to do uniformly. Now Image design software provides "assisted hatching" by tracking a guide path, allowing you to hatch quickly and uniformly and at the same time giving you sufficient manual control over the process.

First, select the guide path that you will track. It may be another calligraphic stroke, any path or shape, or even a letter of a text object. Then switch to Calligraphic pen, select the desired
parameters (line width, angle, fixation etc.) and, before starting to draw, press Ctrl. You will see a gray track circle centered at your mouse pointer and touching the closest point on the selected guide path. (If you have no guide path selected, a status bar message will tell you to select it.)

Now move your mouse close to the guide path, so that the track circle radius is equal to the desired spacing of your hatch pattern and start drawing along the guide path. At that moment, the radius of the circle gets locked; now the circle slides along the guide path – and the actual stroke is drawn by the center of the tracking circle, not by your mouse point. As a result, you are getting a smooth stroke going parallel to the guide path and always at the same distance from it.

When the stroke is ready, release your mouse button (or lift your tablet pen) but do not let go of Ctrl because, as long as you have it pressed, the tool remembers the hatch spacing you set when you started drawing. Now, you have just created a new stroke and, as usual with Image design software tools, it gets selected instead of what was selected before. In our case, this means that the newly drawn stroke itself becomes the new guide path. Next, you can draw a second stroke along the first one, then a third one along the second, etc. Eventually you can fill any desired space with uniform hatching.

Alternatively, if you uncheck "Select new path" in the Calligraphy tool preferences, newly created strokes will not be selected, so your original guide path will be kept selected. In this mode, Image
design software will increase the tracking distance after each created stroke so that you can create uniformly spaced hatching by tracking a single guide path.

The attachment to the guide path is not absolute. If you stray your mouse pointer far enough from the guide path, you will be able to tear it off (the track circle turns from green to red) and move freely. This is intentional; this feature allows you, for example, to continue drawing a stroke past the end of a guide stroke, thus making your hatching cover a wider area than the initial guide path. Special care is taken to make such tearing off as smooth as possible and to suppress violent jerks, but this is not always possible; the general advice is to not try to hatch too fast. If jerking and unintended tear-offs still bother you, try increasing the Mass parameter.

Also, special code is in place to prevent flip-overs - accidental jumps to the other side of the guide path. Brief flip-overs are suppressed, but if you intentionally go over to the other side and stay there, eventually Image design software will obey and your tracking stroke will also flip over to follow you.

Tracking a guide also allows some slight feedback by gradually changing the tracking distance in response to your drawing behavior. Thus, if you're consistently trying to draw closer or farther from the guide than the current tracking distance, the distance will correspondingly decrease or increase, so you will get a hatching that is slightly spacing in or out. (The effect is very slight, however, so as not to become a nuisance.) Also, note that since tracking follows the edge of the stroke, strokes of varying width (such as those tracing background) will result in gradual bending of the hatching pattern as you proceed.

**Introduction to Creation of Professional Image Design**

Having covered the basics and fundamental techniques in image design, this section will be based on the application of the knowledge acquired from the drawing and design of various professional image object.
We will apply an image design software, specifically a vector design method to design image to the level required in various industries like creation of logos, illustrations and art which require high scalability, also image use in marketing/branding, engineering/CAD, web graphics, cartooning etc will be covered in the following lab exercise.

**Conclusion**

Starting with numerous image design software that are available in the market today with different level of capability, we have been exposed to a common image design interface, application of the available and common tools with various method of editing and coloring of images.

**Video**

For lecture video on this Unit follow the URL

http://tinyurl.com/ybnr65z5

**Unit summary**

There are other several, good image design software apart from the few mention above, you are free to audit as many as possible as time permit. The basic tools for shapes and coloring method as describe is applicable to all the software irrespective of minimal variation that could be observed across various platform.
Assessment

1. Mention and explain 4 tools that can be used during image design
2. Explain thinning in relation to calligraphy stroke
3. Differentiate between guides and grids
Unit 5
Image Animation
Introduction

To 'animate' literally means 'to give life to'. Hence, animation refers to simulated motion pictures showing movement of drawn objects. In other words, it is the rapid display of a sequence of images of 2-D or 3-D artwork or model positions in order to create an illusion of movement. Animation adds to graphics the dimension of time which vastly increases the amount of information which can be transmitted. The most common method of presenting animation is as a motion picture or video.

Taking a critical look at the past and the present, animation has evolved over time. It started with pieces of paper and rope in 1828 and is today 3D animation videos.

Outcomes
Upon completion of this unit you will be able to:

- Understand animation and its uses.
- Understand Animation Techniques; cel, stop animations.
- Understand the processes involved in traditional animation.
- Understand the principles of animation.
- Differentiate between 2D and 3D animations.

Terminology

Animation: Animation is the process of making the illusion of motion and the illusion of change by means of the rapid succession of sequential images that minimally differ from each other.

Simulation: Simulation is the imitation of the operation of a real-world process or system over time.

Visualization: Visualization is any technique for creating images, diagrams, or animations to communicate a message.

The Uses of Animation

Cartoons
The most common use of animation, and perhaps the origin of it, is cartoons. Cartoons appear all the time on television and the cinema and can be used for entertainment, advertising, presentations and many more applications that are only limited by the imagination of the designer. The most important factor about making cartoons on a computer is reusability and flexibility. The system that will actually do the animation needs to be such that all the actions that are going to be performed can be repeated easily, without much fuss from the
side of the animator. Speed here is not of real importance, once the sequence is complete; it can be recorded on film or video, frame by frame and played back at an acceptable speed.

**Simulations**
Many times, it is much cheaper to train people to use certain machines on a virtual environment (i.e. on a computer simulation), than to actually train them on the machines themselves. Simulations of all types that use animation are supposed to respond to real-time stimuli, and hence the events that will take place are non-deterministic. The response to real-time stimuli requires a fast response and the non-determinism, requires a fast system to deal with it. This means that speed is the most important factor in simulation systems.

**Scientific Visualization**
Graphical visualization is very common in all areas of science. The usual form that it takes is x-y plots and when things get more complicated three dimensional graphs are used. However there are many cases that something is more complex to be visualized in a three dimensional plot, even if that has been enhanced with some other effect (e.g. color). This is where animation comes in. Data is represented in multiple images (frames) which differ a little from each other, and displayed one after the other to give the illusion of motion. The uses of scientific visualization can be classified into two main categories: Analysis and Teaching. Both of these are described below

**Analysis and Understanding**
Very frequently, scientists have large sets of data (often in the form of lists of numbers) that need to be understood and often a theory needs to be formulated that explains their relationship. It would be very difficult to go through these lists manually or otherwise and make any sense out of them, unless some graphical technique is used for the initial approach. If the data set is massive, a short (or long) animation of the data can give the scientists a first idea of how to approach the analysis.

**Teaching and Communicating**
One of the most difficult aspects of teaching is communicating ideas effectively. When this becomes too difficult using the classical teaching tools (speech, blackboard etc.) animation can be used to convey information. From its nature, an animation sequence contains much more information than a single image or page of text. This, and the fact that an animation can be very "pleasing to the eye", makes animation the perfect tool for
Principles of Animation

As outlined by Ollie and Frank (1981), the 13 principles of animation are listed below:

**Squash and Stretch** – This technique is used to depict exaggerated animated motion. The point of Squash and Stretch is to make the motions larger than life, rather than more swift, realistic, and sometimes unnoticed in passing observation.

**Anticipation** – Concept used to prepare the audience for an action, and to make the action appear more realistic. The anticipation is the precursor to the main action. A visual hint that is given to the viewer is to let them know what’s about to happen.

**Staging** – The positioning of characters in a scene for maximum emotional content and clear readability of actions. This can be done in 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.

**Straight Ahead & Pose to Pose** – The technique of animating in order, from beginning to the end of a scene, to achieve a natural Glow from one drawing to the next.

**Follow Through** - Follow through is the termination part of an action that shows how one part leads organically to the next until the action is resolved.

**Overlapping** – The method of animating by establishing key poses First, and then going back in to complete the breakdowns and in-betweens. Size, volumes, and proportions are controlled better this way, as is the action.

**Slow In & Slow Out** – Slow-in means slowing down the speed of an action when reaching a main pose. Slow-out means accelerating again upon leaving a main pose.

**Arches** – All actions, with few exceptions (such as the animation of a mechanical device), follow an arc or slightly circular path. This is especially true of the human Figure and the action of animals. Arches give animation a more natural action and better Glow.

**Secondary Action** – Action animated in addition to a major action, used to show nuance within the main idea. For example, a secondary action could be a character tapping his foot impatiently.
to a faster rhythm.

**Timing** – The process of determining how long each drawing or position should be on screen, based on the knowledge that 24 frames equal one second of screen time. Correct timing makes objects appear to abide to the laws of physics. This is represented by how many frames an animator assigns to a given action.

**Exaggeration** – An effect especially useful for animation, as perfect imitation 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.

**Solid Drawing** – Solid drawing is using drawing techniques to make a flat, two dimensional object, appear to be a solid three dimensional mass. This includes the use of shading and shadow to make objects appear to have depth, and the illusion that the character is in space and not on a sheet.

**Appeal** – Appeal is the visual quality that makes characters (objects) attractive, interesting and stimulating. A character who is appealing is not necessarily sympathetic – villains or monsters can also be appealing. The important idea is that the viewer feels the character is real and interesting.

"I try to build a full personality for each of our cartoon characters - to make them personalities.” - **Walt Disney**

**Traditional animation**

Traditional animation is an animation technique where each frame is drawn by hand. Hand-drawn animation, with each frame individually crafted by an artist, requires a lot of skill, a lot of patience and very little equipment. The drawing is usually done on a cell which allows multiple frames to be drawn by the same cells. Each frame can be recorded on film or video, and the amount of work going into an animation is staggering.

**Types of Traditional Animation**

**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.

**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, limited animation can be used as a method of stylized artistic expression.

**Rotoscopy** is a technique, patented by Max Fleischer in 1917, where animators trace live-action movement, frame by frame. The source film can be directly copied from actors' outlines into animated drawings.

**Live-action animation** is a technique, when combining hand-drawn characters into live action shots. One of the earlier uses of it was Koko the Clown when Koko was drawn over live action footage.

**Processes of Traditional Animations**

**Storyboards**
Here, scripts are written of images as well as words, similar to a giant comic strip. The images allow the animation team to plan the flow of the plot and the composition of the imagery. The storyboard artists will have regular meetings with the director, and may have to redraw or "re-board" a sequence many times before it meets final approval.

**Voice recording**
Before true animation begins, a preliminary soundtrack or "scratch track" is recorded, so that the animation may be more precisely synchronized to the soundtrack. Given the slow, methodical manner in which traditional animation is produced, it is almost always easier to synchronize animation to a pre-existing soundtrack than it is to synchronize a soundtrack to pre-existing animation. A completed cartoon soundtrack will feature music, sound effects, and dialogue performed by voice actors. However, the scratch track used during animation typically contains only the voices; any vocal songs the characters must sing along to, and 87 temporary musical score tracks; the final score and sound effects are added in post-production.

**Animatic**
Often, an animatic is made after the soundtrack is created, but before full animation begins. An animatic typically consists of pictures of the storyboard synchronized with the soundtrack. This allows the animators and directors to work out any script and timing issues that may exist with the current storyboard. The storyboard and soundtrack are amended if necessary, and a new animatic may be created and reviewed with the director until the
storyboard is perfected. Editing the film at the animatic stage prevents the animation of scenes that would be edited out of the film since traditional animation is a very expensive and time-consuming process, creating scenes that will eventually be edited out of the completed cartoon is strictly avoided.

Design and timing
Once the animatic has been approved, the animatic and the storyboards are sent to the design departments. Character designers prepare model sheets for all important characters and props in the film. These model sheets will show how a character or object looks from a variety of angles with a variety of poses and expressions, so that all artists working on the project can deliver consistent work. Sometimes, small statues known as maquettes may be produced, so that an animator can see what a character looks like in three dimensions. At the same time, the background stylists will do similar work for the settings and locations in the project, and the art directors and colour stylists will determine the art style and colour schemes to be used.

While design is going on, the timing director (who in many cases will be the main director) takes the animatic and analyses exactly what poses, drawings, and lip movements will be needed on what frames.

Layout
Layout begins after the designs are completed and approved by the director. The layout process is the same as the blocking out of shots by a cinematographer on a live-action film. It is here that the background layout artists determine the camera angles, camera paths, lighting, and shading of the scene. Character layout artists will determine the major poses for the characters in the scene, and will make drawings to indicate each pose. For short films, character layouts are often the responsibility of the director. The layout drawings and storyboards are then spliced, along with the audio and an animatic is formed. The term "animatic" was originally coined by Disney animation studios.

Animation
Once the animatic is finally approved by the director, animation begins. In the traditional animation process, animators will begin by drawing sequences of animation on sheets of transparent paper perforated to fit the peg bars in their desks, often using coloured pencils, one picture or "frame" at a time. A key animator or lead animator will draw the key drawings in a scene, using the character layouts as a guide.
Timing is important for the animators drawing these frames; each frame must match exactly what is going on in the soundtrack at the moment the frame will appear, or else the discrepancy between sound and visual will be distracting to the audience. For example, in high-budget productions, extensive effort is given in making sure a speaking character's mouth matches in shape the sound that character's actor is producing as he or she speaks. While working on a scene, a key animator will usually prepare a pencil test of the scene. A pencil test is a preliminary version of the final animated scene; the pencil drawings are quickly photographed or scanned and synchronized with the necessary soundtracks. This allows the animation to be reviewed and improved upon before passing the work on to his assistant animators, who will add details and some of the missing frames in the scene. The work of the assistant animators is reviewed, pencil-tested, and corrected until the lead animator is ready to meet with the director and have his scene reviewed by the director, producer, and other key creative team members. Similar to the storyboarding stage, an animator may be required to re-do a scene many times before the director will approve it.

**Pencil test**
After all the drawings are cleaned-up, they are then photographed on an animation camera, usually on black and white film stock. Nowadays, pencil tests can be made using a video camera, and computer software.

**Backgrounds**
While the animation is being done, the background artists will paint the sets over which the action of each animated sequence will take place. These backgrounds are generally done in gouache or acrylic paint, although some animated productions have used backgrounds done in water colour, oil paint, or even crayon. Background artists follow very closely the work of the background layout artists and colour stylists (which is usually compiled into a workbook for their use), so that the resulting backgrounds are harmonious in tone with the character designs.

**Traditional ink-and-paint and camera**
Once the clean-ups and in between drawings for a sequence are completed, they are prepared for photography, a process known as ink-and-paint. Each drawing is then transferred from paper to a thin, clear sheet of plastic called a cel, The outline of the drawing is inked or photocopied onto the cel, and gouache or a similar type of paint is used on the reverse sides of the cels to add colours in the appropriate shades.
When an entire sequence has been transferred to cels, the photography process begins. Each cel involved in a frame of a sequence is laid on top of each other, with the background at the bottom of the stack. A piece of glass is lowered onto the artwork in order to flatten any irregularities, and the composite image is then photographed by a special animation camera, also called rostrum camera. The cels are removed, and the process repeats for the next frame until each frame in the sequence has been photographed. Each cel has small registration holes along the top or bottom edge of the cel, which allow the cel to be placed on corresponding peg bars before the camera to ensure that each cel aligns with the one before it; if the cels are not aligned in such a manner, the animation, when played at full speed, will appear "jittery." Sometimes, frames may need to be photographed more than once, in order to implement superimpositions and other camera effects.

**Digital ink and paint**
The current process, termed "digital ink and paint," is the same as traditional ink and paint until after the animation drawings are completed; instead of being transferred to cels, the animators' drawings are scanned into a computer, where they are coloured and processed using one or more of a variety of software packages. The resulting drawings are composited in the computer over their respective backgrounds, which have also been scanned into the computer (if not digitally painted), and the computer outputs the final film by either exporting a digital video file, using a video cassette recorder, or printing to film using a high-resolution output device. Use of computers allows for easier exchange of artwork between departments, studios, and even countries and continents.

**Computers and digital video cameras**
Computers and digital video cameras can also be used as tools in traditional cel animation without affecting the film directly, assisting the animators in their work and making the whole process faster and easier. Doing the layouts on a computer is much more effective than doing it by traditional methods. Additionally, video cameras give the opportunity to see a "preview" of the scenes and how they will look when finished, enabling the animators to correct and improve upon them without having to complete them first. This can be considered a digital form of pencil testing.

**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. Computer software is widely available to create this type of
animation. There are many different types of stop-motion animation, usually named after the type of media used to create the animation. Examples are:

1. **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 inside of them to keep them still and steady as well as constraining them to move at particular joints.

2. **Puppetoon**, created using techniques developed by 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.

3. **Clay animation**, or 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 or wire frame inside of them, similar to the related puppet animation (below), that can be manipulated in order to pose the figures. Alternatively, the figures may be made entirely of clay, such as in the films of Bruce Bickford, where clay creatures morph into a variety of different shapes.

4. **Cut-out animation** is a type of stop-motion animation produced by moving 2-dimensional

5. **Silhouette animation** is a variant of cut-out animation in which the characters are backlit and only visible as silhouettes

6. **Model animation** refers to stop-motion animation created to interact with and exist as a part of a live-action world. Intercutting, matte effects, and split screens are often employed to blend stop-motion characters or objects with live actors and settings.

7. **Go motion** is a variant of model animation which uses various techniques to create motion blur between frames of film, which is not present in traditional stop-motion.

8. **Object animation** refers to the use of regular inanimate objects in stop-motion animation, as opposed to specially created items.

9. **Graphic animation** uses non-drawn flat visual graphic material (photographs, newspaper clippings, magazines, etc.) which are sometimes manipulated frame-by-frame to create movement. At other times, the graphics remain stationary, while the stop-motion camera is moved to create on-screen action.

10. **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.
Fig 3.4 Stop Motion animation

**Computer Animation**

Computer animation is the process used for generating animated images by using computer graphics. Modern computer animation usually uses three-dimensional (3D) computer graphics, although two-dimensional (2D) computer graphics are still used for stylistic, low bandwidth, and faster real-time renderings. Sometimes the target of the animation is the computer itself, but sometimes the target is another medium, such as film.

Computer animation is essentially a digital successor to the stop motion techniques used in traditional animation with 3D models and frame-by-frame animation of 2D illustrations. Computer generated animations are more controllable than other more physically based processes, such as constructing miniatures for effects shots or hiring extras for crowd scenes, and because it
allows the creation of images that would not be feasible using any other technology. It can also allow a single graphic artist to produce such content without the use of actors, expensive set pieces, or props.

To create the illusion of movement, an image is displayed on the computer screen and repeatedly replaced by a new image that is similar to it, but advanced slightly in the time domain (usually at a rate of 24 or 30 frames/second). This technique is identical to how the illusion of movement is achieved with television and motion pictures.

**2D animation**
2D animation is when scenes and characters are animated in a 2D space instead of a 3D environment.

Today, artists use computer software to create everything in a 2D animation, including environments, characters, visual effects, and more.

Although drawing skills are still required to be a 2D animator today, most of the work is done with the use of computer software. These programs often have a huge toolbox of features that help the artists manipulate the animation in a number of ways, including making it look smoother by fine-tuning important elements such as timing.

Other advantages of 2D animation over the traditional way include being able to save and load work. Being able to do so proves very handy if something didn’t work and you need to revert back to an earlier version of the animation.

Being skilled in a particular 2D animation program also allows you to make good use of a vast library of visual effects.

Of course, every 2D animation software comes with its own learning curves, which only get steeper the better the program is.

Knowing what each tool does and how to use it effectively is essential if you want to be a good 2D animator that isn’t limited to a few techniques.

**Notable 2D Animation Programs**
- Toon Boom Studio
- Autodesk’s Sketch Book Pro
- Anime Studio Debut
- Draw Plus
2D animation is widely used in a number of creative industries and is still widely used despite the rise of 3D animation.

Everything from cartoon series and Japanese anime to video games and full feature films are done in 2D. The fact that 2D animation is flexible enough to be done on a wide range of platforms is what makes it such a popular form for anything from entertainment and multimedia to broadcast video.

Television is where 2D animation is still used the most. The number of shows that have been made with 2D animation is near-endless, with some of the more well-known ones being The Simpsons, SpongeBob, Square pants, South Park and Avatar: The Last Air bender.

Anime, a style of Japanese animation inspired by their manga comics, also makes use of 2D animation. Some of the biggest anime hits are:
- Dragon ball Z
- Naruto
- One Piece
- Attack On Titan

3D animation

3D animation is the manipulation of three dimensional objects and virtual environments with the use of a computer program. 3D animation is digitally modelled and manipulated by an animator. In order to manipulate a mesh, it is given a digital skeletal structure that can be used to control the mesh. This process is called rigging. Various other techniques can be applied, such as mathematical functions (ex. gravity, particle simulations), simulated fur or hair, effects such as fire and water and the use of motion capture to name but a few. These techniques fall under the category of 3D dynamics. Well-made 3D animations can be difficult to distinguish from live action and are commonly used as visual effects for recent movies.

The reason 3D animation has become popular is because it can be
used to create realistic objects and scenes.

Live-action films like Transformers, Avatar, and The Avengers would not be as impressive if you removed all the 3D elements, which often include entire characters and settings. 3D has also become the standard visual style for video games because it allows players do much more than a 2D game.

But like other forms of animation, 3D has its own learning curve that involves gaining a firm understanding of 3D software programs.

These programs also tend to be pretty expensive, which means they can be hard to learn for a student who doesn’t have a few hundred dollar to spend on one.

**Notable 3D Animation Programs**
- Autodesk Maya
- Autodesk 3ds Max
- Unity
- CINEMA 4D
- Houdini
- Autodesk Softimage
- Light Wave
- Modo
- Turbo CAD Deluxe
- Sketch Up Pro

Today, 3D animation is used in more industries than ever before.

**Common examples include:**
- games
- movies
- television shows
- interior designing
- business
- architecture
- medicine
- many other multimedia fields

Without 3D animation, beloved movies like Toy Story, Frozen, How to Train Your Dragon, and Big Hero 6 would not have been possible.

When it comes to games, 3D animation is everywhere. Some of today’s most successful titles are in 3D, including Super Mario 3D World, Blood borne, Halo, Call of Duty, and many more.
Conclusion

One open challenge in computer animation is a photorealistic animation of humans. Currently, most computer-animated movies show animal characters, fantasy characters machines or cartoon-like humans. This movie is often cited as the first computer-generated movies to attempt to show realistic-looking humans.

Video

For lecture video on this Unit follow the URL
http://tinyurl.com/ya2y6wxc

Unit summary

In this unit, we have surveyed computer animation and its application areas. Animation is the rapid display of a sequence of images of 2-D or 3-D artwork or model positions in order to create an illusion of movement. Traditional animation was the process used for most animated films of the 20th century. 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.

Assessment

1. What do you understand by Computer Animation?
2. Identify traditional animation processes.
3. Explain in details animation techniques.
Keyframing is the simplest form of animating an object. Based on the notion that an object has a beginning state or condition, and will be changing over time in position, form, color, luminosity, or any other property, to some different final form. Keyframing takes the stance that we only need to show the "key" frames, or conditions, that describe the transformation of this object, and that all other intermediate positions can be figured out from these.

Upon completion of this unit you will be able to:
- Understand the key concepts of keyframing and motion picture
- Understand the applications of motion picture and their advantages over other animation techniques.
- Understand model-based animation
- Understand the idea of animation production

**Terminology**

**Animation:** Animation is the process of making the illusion of motion and the illusion of change by means of the rapid succession of sequential images that minimally differ from each other.

**Interpolation:** Interpolation is inbetweening, or filling in frames between the key frames.

**Keyframe:** Keyframe is a drawing that defines the starting and ending points of any smooth transition.

**Keyframing**

Keyframing is an animation technique where motion curves are interpolated through states at times, (~t1...~tT), called keyframes, specified by a user. A key frame is a drawing that defines the starting and ending points of any smooth transition. They are called "frames" because their position in time is measured in frames on a strip of film. A sequence of keyframes defines which movement the viewer will see, whereas the position of the keyframes on the film, video or animation defines the timing of the movement, only two or three keyframes over the span of a second do not create the illusion of movement, the remaining frames are filled with in-betweens.
Figure 3.1: Horse in motion (Muybridge, 1978)

Advantages of Keyframing
- Very expressive
- Animator has complete control over all motion parameters

Disadvantages of Keyframing
- Very labour intensive
- Difficult to create convincing physical realism. Potentially everything except complex physical phenomena such as smoke, water, or fire.

Motion Capture
Motion capture, motion tracking are terms used to describe the process of recording movement and translating that movement onto a digital model. It is used in military, entertainment, sports, medical applications, validation of computer vision and robotics. In filmmaking, it refers to recording actions of human actors and using that information to animate digital character models in 2D or 3D computer animation. When it includes face and fingers or captures subtle expressions, it is often referred to as performance capture.

Figure 3.2: Motion capture of the animated movie “The Polar Express”
Motion capture records only the movements of the actor, not his or her visual appearance. This animation data is mapped to a 3D model so that the model performs the same actions as the actor.

Camera movements can also be motion captured so that a virtual camera in the scene will pan, tilt, or dolly around the stage driven by a camera operator while the actor is performing, and the motion capture system can capture the camera and props as well as the actor's performance. This allows the computer-generated characters, images and sets to have the same perspective as the video images from the camera. A computer processes the data and displays the movements of the actor, providing the desired camera positions in terms of objects in the set.

**Advantages of Motion Capture**

Motion capture offers several advantages over traditional computer animation of a 3D model:

1. More rapid, even real time results can be obtained. In entertainment applications this can reduce the costs of keyframe-based animation. For example: Hand Over.
2. The amount of work does not vary with the complexity or length of the performance to the same degree as when using traditional techniques. This allows many tests to be done with different styles or deliveries.
3. Complex movement and realistic physical interactions such as secondary motions, weight and exchange of forces can be easily recreated in a physically accurate manner.
4. The amount of animation data that can be produced within a given time is extremely large when compared to traditional animation techniques. This contributes to both cost effectiveness and meeting production deadlines.
5. Potential for free software and third party solutions reducing its costs.

**Disadvantages of Motion Capture**

1. Specific hardware and special programs are required to obtain and process the data.
2. The cost of the software, equipment and personnel required can potentially be prohibitive for small productions.
3. The capture system may have specific requirements for the space it is operated in, depending on camera field of view or magnetic distortion.
4. When problems occur, it is easier to reshoot the scene rather than trying to manipulate the data. Only a few systems allow real time viewing of the data to decide if the take needs to be redone.
5. The initial results are limited to what can be performed within
the capture volume without extra editing of the data.
6. Movement that does not follow the laws of physics generally cannot be captured.

**Applications of Motion Capture**
1. Video games often use motion capture to animate athletes, martial artists, and other in-game characters.
2. Movies use motion capture for CG effects, in some cases replacing traditional cel animation, and for completely computer-generated creatures, such as King Kong and Avatar. Motion capture has begun to be used extensively to produce films which attempt to simulate or approximate the look of live-action cinema, with nearly photorealistic digital character models.
3. Virtual Reality and Augmented Reality allows users to interact with digital content in real-time. This can be useful for training simulations, visual perception tests and performing virtual walk-throughs in a 3D environment. Motion capture technology is frequently used in digital puppetry systems to drive computer generated characters in real-time.
4. Gait analysis is the major application of motion capture in clinical medicine. Techniques allow clinicians to evaluate human motion across several biometric factors, often while streaming this information live into analytical software.

**Techniques to Aid Motion Specification**
This section refers to the various techniques used by the animator for specifying most of the information. The animator works at a fairly low level of abstraction and these techniques differ from model based techniques in that there is a more direct relationship between the information provided by the animator and the resulting motion.

**Interpolation**
At the foundation of almost all animation is the interpolation of values. The simplest case is interpolating the position of a point in space. Even this is nontrivial to do correctly and requires some discussion of several issues: the appropriate parameterization of position, the appropriate interpolating function and maintaining the desired control of the interpolation over time.

Often, an animator has a list of values associated with a given parameter at specific frames (called keyframes or keys) of the animation. The question to be answered is how best to generate the values of the parameter for the frames between the key frames. The parameter to be interpolated may be a coordinate of the position of an object, or a joint angle of an appendage of a robot, or the
transparency attribute of an object, or any other parameter used in the display and manipulation of computer graphic elements.

How to choose the most appropriate interpolation technique and apply it in the production of an animated sequence. One of the first decisions to make is whether the given values represent actual values that the parameter should have at the key frames (interpolation), or whether they are meant merely to control the interpolating function and do not represent actual values the parameter will assume (approximation). Other issues that influence which interpolation technique to use include how smooth the resulting function needs to be (i.e. continuity), how much computation you can afford to do (order of interpolating polynomial), and whether local or global control of the interpolating function is required.

**EaseIn / EaseOut**

Note the difference between interpolating position along a curve and the speed along which the interpolation proceeds (consider the interpolating parameter to be 'time'). For example you can do linear interpolation in space but cubic interpolation of the distance with respect to the time parameter. If t is a parameter that goes between 0 and 1 then ease in/ ease out can be implemented by a function \( t' = \text{ease}(t) \) so that if t varies uniformly between 0 and 1, t’ will start at 0 slowly increasing, gaining speed until the middle values and then decelerating at it approaches 1. t’ is then used as the interpolation parameter in whatever function produces spatial values.

**Orientation Representation and Interpolation**

A common problem to address in computer animation is how to represent the position and orientation of an object in space, and how to change this representation over time to produce animation. A typical scenario is one in which the user specifies two such representations and the computer is used to interpolate intermediate positions thus producing animated motion. We will assume that there is no scaling involved, non-uniform or otherwise, so we are referring to rigid body transformations.

**Camera Path Following**

One of the simplest types of animation is that in which everything remains static except the camera. These are commonly referred to as walk-throughs or flybys. Essentially the camera can be considered just as any other object as far as orientation and positioning is concerned. The user needs to construct a path through space for the observer to follow along with orientation information. The path is usually specified by key frame positioning
followed by interpolation of the in-between frames.

The specific method used to control view direction depends a lot on what the animation is trying to show. It can be handled in variety of ways.

Full orientation control is a bit more involved; controlling the observer position and view direction leaves one degree of freedom still to be determined: the observer tilt. One option is to just interpolate the view direction and then calculate the head up orientation and apply any tilt to that. The other is to specify another spline that controls the head-up position, but this can be hard to control.

**Simple Key Frame System**
The earliest computer animation systems were derivative of conventional hand-drawn animation systems in which positions of objects and the observer were specified at certain key frames. The positions and orientations were then interpolated to produce the frames between these keys. For now, we will only consider interpolation of positions.

**Model Based Animation**
In this animation, some type of model is used to control motion. The animator is responsible for setting up the rules of the model and animation is done by developing motion that corresponds to the rules of the model. Complex motion can be attained, but detailed control of the motion is removed from the hands of the animator.

Much model-based animation is based on physical principles since these are what give rise to what people recognized as 'realistic' motion. However, other models can be used. Physically based modeling is a special case of the more general constraint modeling.

**Hierarchical Modeling and (Forward) Kinematics**
One of the simplest models to use in animation is that of linked appendages. Linked appendages naturally fall into a hierarchy that is conveniently represented by a tree structure. In such a representation, the nodes of the tree can be used to define body parts, such as torso, upper arm, lower arm, and hand. In the two-dimensional case, the data at a node is defined so that its point of rotation coincides with the origin.

Branching in the tree occurs whenever multiple appendages emanate from the same part. For example, in a simplified figure, the torso might branch into a neck, two upper arms and two upper
Links in the tree representation hold transformations that take the body part as defined at the origin to its place relative on the body part one level up in the tree. Besides the static relative transformation at the link, there is also a changeable rotation parameter that controls the rotation at the specified joint.

**Inverse Kinematics: The Analytic Case**

In inverse kinematics the problem is reversed in the sense that the desired position of the end effector (borrowing terminology from robotics) is given, and the joint angles required to attain that end effector position are calculated. For simple mechanisms, the joint angles can be analytically determined.

In determining the Jacobian, the main thing to watch out for is to make sure that all of the variables are in the same coordinate system. It is often the case that joint specific information is specified in the coordinate system local to that joint. In compiling the Jacobian matrix, this information must be converted into some common coordinate system such as the global inertial coordinate system or the end effector coordinate system. Various methods have been developed for computing the Jacobian based on attaining maximum computational efficiency given the required information in specific coordinate systems.

**Animation Production**

The topic animal production gives the readers some familiarity with how a piece of animation is broken into parts and how animators go about producing a finished piece of animation. Much of this is directly applicable to computer animation.

The terms used to discuss the subparts of the animation production comes from film production in general.

The overall animation goes by various names. Here, we will refer to it as the presentation. This refers to the entire piece under production. The major parts of the presentation are the acts. An act is a major episode within the animation and is usually identified by an associated staging area. A presentation usually consists of one to a dozen acts. An act is broken down into several scenes: a scene identifies one venue of continuous action. A scene is broken down in one or more shots. A shot is a continuous camera recording. A shot is broken down into the individual frames of film. So we have...
the following hierarchy:

Presentation>Act>Scene>Shot>Frame

The production of animation typically follows the following pattern. First, a preliminary story is decided on and a story board is developed which lays out the action scenes by sketching representative frames and writing down an explanation of what is taking place. This is used to review and critique the action. Then the detailed story is worked out which identifies the actions involved in more detail. Key frames are then identified and produced by master animators to aid in confirmation of character development and image quality. A test shot is a short sequence rendered in full color to further test the rendering and motion techniques. To completely check the motion, a pencil test may be shot which is a shot of full motion but low quality images such as pencil sketches. Associate and assistant animators are responsible for producing the frames between the key, this is called inbetweening.

Inking refers to the process of transferring the pencilled frames to cels. And then coloring is finally applied to these cels.

Computer animation production has borrowed most of the ideas from conventional animation production including the use of a story board, test shots, and pencil testing. The use of key frames and inbetweening have also been adopted in certain computer animation systems.

Story boards have pretty much translated directly over to computer animation production although they may be kept on a computer. They still hold the same functional place in the animation process.

In computer animation there is usually a strict distinction between the creation of the models, the specification of their motion and the rendering process which is applied to those models. In conventional animation, the model building, motion specification, and rendering are really all the same thing. In computer animation, speed quality tradeoffs can be made in each of the three stages during the trial and error process that characterizes much of animation.

A test shot in computer animation is usually a high quality rendering of a highly detailed model to see a single frame of the final product. Pencil testing can be performed either by simplifying the sophistication of the models used, or by using low quality and/or low resolution renderings, or by using simple motion control
algorithms. Placeholder cubes can be rendered in wire frame to present the gross motion of rigid bodies in space and to see spatial and temporal relationships among objects. This may also provide real time calculation and playback of the animation. Similarly, high quality rendering of low complexity models or low quality renderings of highly detailed models, or some intermediate levels of both the model and the renderer can be used to give the animator clues to the finished product's quality without committing to the final computation. For example, a hardware buffer display can provide good turnaround time with decent quality images before going to a ray traced image. Solids of revolution objects lend themselves quite well to allowing for three, four or five levels of detail for a given model. Also, smooth shading, texture mapping, specular reflection and solid texturing can all be options presented to the animator for a given run. To simplify motion control, for example, simple interpolation between poses may be used instead of inverse dynamics.

**Conclusion**

A keyframe is a drawing that defines the starting and ending points of any smooth transition. They are called "frames" because their position in time is measured in frames on a strip of film. A sequence of keyframes defines which movement the viewer will see, whereas the position of the keyframes on the film, video or animation defines the timing of the movement.

**Video**

For lecture video on this Unit follow the URL

http://tinyurl.com/yatgrhq2

**Unit Summary**

Keyframing is the simplest form of animating an object. Based on the notion that an object has a beginning state or condition, and will be changing over time, in position, form, color, luminosity, or any other property, to some different final form. Its use is found in video editing, video compression as a means to change parameters. Motion capture is used to describe the process of recording movement and translating that movement on to a digital model.
Assessment

1. What do you understand by keyframing?
2. Identify the advantages and disadvantages of the animation technique.
3. What is motion capture?
4. Describe any five techniques that can be used to aid motion specification.
Unit 7
Animation Technology and Hardware

Introduction
Rendering is the process of generating an image from a 2D or 3D model (or models in what collectively could be called a scene file) by means of computer programs. Also, the results of such a model can be called a rendering. A scene file contains objects in a strictly defined language or data structure; it would contain geometry, viewpoint, texture, lighting, and shading information as a description of the virtual scene. Animation Technology and Hardware facilitates the Graphics Ydesigner’s skills in animation rendering and output techniques.

Upon completion of this unit you will be able to:

Outcomes
 understand Animation Technology
 comprehend the concept of Film Technology
 understand the concept of Video Technology
You should understand the concept of Animation Hardware
 Animation rendering and output techniques.

Terminology

Animation: Animation is the process of making the illusion of motion and the illusion of change by means of the rapid succession of sequential images that minimally differ from each other.

Interpolation: Interpolation is inbetweening, or filling in frames between the key frames.

Keyframe: Keyframe is a drawing that defines the starting and ending points of any smooth transition.

Film Technology
The first computer animation used film to record the single frames. Single frame film technology has been around for a long time. It had been used in the late 1800s to produce some of the first film animation. The requirements are a film recorder that is capable of precise positioning of a single frame of film over the shutter in a static situation. If the positioning is not precise enough, then the image will jitter or float when played back. For each frame, the image is displayed and the shutter is opened and then closed during which time the film is exposed to the image. The film can then be advanced to the next frame and the next image displayed in preparation of the next frame exposure. The opening and closing of
the shutter can be done manually, although this is a very human labour intensive operation. It is facilitated greatly if there is a computer interface to such a camera. This technology had been developed for traditional single frame animation (stop motion animation). One advantage of film technology is the resolution of the medium itself. The emulsion that coats the film celluloid can capture very high frequency image components. The early film medium was 16mm film. The problem with this technology was the standard use of 16 frames per second (fps) playback rate which often is not fast enough to avoid flicker. The 35mm standard that employs 24 frames per second playback rate results in a much more stable image and has been used for most of the computer animation captured on film. For very high quality animation, a 70mm standard is used with a playback rate of 24 fps. 70mm usually requires that images be calculated at least at 2000 by 2000 resolution which drives up the cost of computer generated animation. An easy way to transfer an image onto film is to position a camera in front of the screen, plot an image on the computer screen, open the camera shutter, close the camera shutter, advance the film to the next frame and repeat the process. Drawbacks of this approach include difficulties in eliminating extraneous light, the curvature of the screen, color shifting, and mechanical difficulties in maintaining a stable device. Another thing to keep in mind is that the image on the computer screen is not a static image, but one that is continuously being drawn, decaying and being redrawn (refreshed) on the screen, even if it is a static image. Therefore, it is important that the camera shutter be open for several refreshes of the computer screen so that a solid image is recorded on the film or that it be precisely coordinated with the screen refresh so that an entire single refresh is captured on film. Usually, the former approach is taken due to its relative simplicity.

Some of the early computer animation used random vector displays to render the frames. A color filter was placed on the camera and that component of the image was scanned out while the camera lens was open. The process was repeated for the various color components (usually red, green and blue). Currently there are many film products made specifically for computer animation. Film recorders have a special high-resolution, flat screen onto which the image is drawn so as to minimize distortion of the image. On some, mounting brackets allow either Single Lens Reflex (SLR) cameras or single frame motion cameras to be mounted on the unit.

Film plotters use special electronics that ‘draw’ an image directly onto the film without the intermediate screen involved. Typically,
these special purpose recorders and plotters are designed as very high-resolution devices (e.g., 4000 by 4000).

Some of the main drawbacks to using film technology are:
1) The medium (film) can’t be reused.
2) There is a delay between the time the recording is done and the time it can be viewed (developing).

**Video Technology**

The advent of video technology and the fact that it is driven by a mass consumer market has brought it into the price range of just about everybody. This has resulted in affordable video single frame recorders and controllers. Video technology is based on a raster scan display refreshing format. Raster scan refers to the pattern used to scan out the image: top-to-bottom, a line at a time, left-to-right along a line.

A line is called a *scanline*. The image is drawn by an electron beam which strikes a phosphor coated screen which emits photons in the form of light. The intensity of the electron beam is controlled by the image being scanned out whether that image is stored in the digital memory of a computer, or generated by the similar raster scanning of a video camera. After a scan of an individual scanline, the electron beam is turned off and is positioned at the beginning of the next scanline line. The time it takes to do this is called the *vertical retrace interval* and the signal which notifies the electronics of this is called *vertical blanking* or *vertical sync*. When the beam gets to the bottom of the image, it is turned off and is returned to the top left of the screen. The time it takes to do this is called the *horizontal retrace interval* and the signal which notifies the electronics of this is called *horizontal blanking* or *horizontal sync*. A complete scan of all the scanlines of an image is called a *frame*. In some video formats, all the scanlines are done at once (*progressive scan*). In another video formats, every odd numbered scanline is done on one pass and every even numbered scanline is done on the next pass (*interlaced scan*). In interlaced scan, each pass is called a *field* (two fields per frame).

**Animation Hardware**

Special purpose graphics hardware can produce real-time or near real time computer animation. It comes in the form of anything from flight simulators to graphics workstations to personal computers with built-in graphics processors. While the term real-time is loosely defined in manufacturer's claims, true real-time performance would produce on the order of thirty frames of animation a second. Notice the difference between refresh rate,
which is the number of times the image on the display gets refreshed (typically thirty or sixty frames a second on most displays), and animation rate which refers to the number of different images that can be produced and displayed. Saturday morning cartoons have degenerated into the range of six to eight frames of animation per second (while the TVs they are showed on still operate at the refresh rate of thirty frames a second).

Simulators are special purpose computer graphics systems that are designed to only produce displays of shaded imagery in response to human manipulated controls in mock-up cockpits. Usually most of the database is static containing few moving objects such as planes, boats, tanks, cars, etc. A human operator manipulates controls which the simulator samples, processes and updates the status of the vehicle being simulated. This results in a new viewpoint which must be used to produce new images on the screens of the cockpit.

Graphics workstations have built-in display processors which can typically handle tens of thousands of polygons in real-time. However, the definition of a 'display polygon' varies from spec to spec and can drastically impact performances statistics. Silicon Graphics, HP, DEC and SUN are among the manufacturers that support special graphics facilities in otherwise general purpose workstations to enhance display performance.

Applications programs, if they are fast enough, can then produce polygon definitions at real-time rates and pass the polygons on to the rendering engines inside these workstations.

Some personal computers, most notably the Amiga, also have some special purpose graphics hardware built in to operate in the same way. However, at this level the support is almost exclusively for two-dimensional graphics.

Check out the following list of hardware (under construction):

- digital storage and editing system for video: Newteck Incorporated
- digital video editing system Miro
- motion tracking system: Polhemus
- motion tracking system: Ascension
- Digital Film and Video Services: CineBYTE
- Imaging Inc.
- workstation: HP
- workstation: SGI
- workstation: DEC
Animation Rendering, and Output Techniques

Rendering

Rendering is the process of generating an image from a 2D or 3D model (or models in what collectively could be called a scene file) by means of computer programs. Also, the results of such a model can be called a rendering. A scene file contains objects in a strictly defined language or data structure; it would contain geometry, viewpoint, texture, lighting, and shading information as a description of the virtual scene. The data contained in the scene file is then passed to a rendering program to be processed and output to a digital image or raster graphics image file. The term "rendering" may be by analogy with an "artist's rendering" of a scene. Though the technical details of rendering methods vary, the general challenges to overcome in producing a 2D image from a 3D representation stored in a scene file are outlined as the graphics pipeline along a rendering device, such as a Graphics Processing Unit (GPU).

A GPU is a purpose-built device able to assist a CPU in performing complex rendering calculations. If a scene is to look relatively realistic and predictable under virtual lighting, the rendering software should solve the rendering equation. The rendering equation doesn't account for all lighting phenomena, but is a general lighting model for computer-generated imagery. 'Rendering' is also used to describe the process of calculating effects in a video editing program to produce final video output.

Rendering is one of the major sub-topics of 3D computer graphics, and in practice is always connected to the others. In the graphics pipeline, it is the last major step, giving the final appearance to the models and animation. With the increasing sophistication of computer graphics since the 1970s, it has become a more distinct subject.

Rendering has uses in architecture, video games, simulators, movie or TV visual effects, and design visualization, each employing a different balance of features and techniques. As a product, a wide variety of renderers are available. Some are integrated into larger modeling and animation packages, some are stand-alone, some are free open-source projects. On the inside, a renderer is a carefully engineered program, based on a selective mixture of disciplines.
related to: light physics, visual perception, mathematics, and software development.

In the case of 3D graphics, rendering may be done slowly, as in pre-rendering, or in real-time. Pre-rendering is a computationally intensive process that is typically used for movie creation, while real-time rendering is often done for 3D video games which rely on the use of graphics cards with 3D hardware accelerators.

Many rendering algorithms have been researched, and software used for rendering may employ a number of different techniques to obtain a final image.

Tracing every particle of light in a scene is nearly always completely impractical and would take a stupendous amount of time. Even tracing a portion large enough to produce an image takes an inordinate amount of time if the sampling is not intelligently restricted.

Therefore, a few loose families of more-efficient light transport modelling techniques have emerged:
- rasterization, including scanline rendering, geometrically projects objects in the scene to an image plane, without advanced optical effects;
- ray casting considers the scene as observed from a specific point of view, calculating the observed image based only on geometry and very basic optical laws of reflection intensity, and perhaps using Monte Carlo techniques to reduce artifacts;
- ray tracing is similar to ray casting, but employs more advanced optical simulation, and usually uses Monte Carlo techniques to obtain more realistic results at a speed that is often orders of magnitude slower.
- The fourth type of light transport technique, radiosity is not usually implemented as a rendering technique, but instead calculates the passage of light as it leaves the light source and illuminates surfaces. These surfaces are usually rendered to the display using one of the other three techniques.

Most advanced software combines two or more of the techniques to obtain good-enough results at reasonable cost.

Another distinction is between image order algorithms, which iterate over pixels of the image plane, and object order algorithms, which iterate over objects in the scene. Generally object order is
more efficient, as there are usually fewer objects in a scene than pixels.

A high-level representation of an image necessarily contains elements in a different domain from pixels. These elements are referred to as primitives. In a schematic drawing, for instance, line segments and curves might be primitives. In a graphical user interface, windows and buttons might be the primitives. In rendering of 3D models, triangles and polygons in space might be primitives.

If a pixel-by-pixel (image order) approach to rendering is impractical or too slow for some task, then a primitive-by-primitive (object order) approach to rendering may prove useful. Here, one loops through each of the primitives, determines which pixels in the image it affects, and modifies those pixels accordingly. This is called rasterization, and is the rendering method used by all current graphics cards.

Rasterization is frequently faster than pixel-by-pixel rendering. First, large areas of the image may be empty of primitives; rasterization will ignore these areas, but pixel-by-pixel rendering must pass through them. Secondly, rasterization can improve cache coherency and reduce redundant work by taking advantage of the fact that the pixels occupied by a single primitive tend to be contiguous in the image. For these reasons, rasterization is usually the approach of choice when interactive rendering is required; however, the pixel-by-pixel approach can often produce higher-quality images and is more versatile because it does not depend on as many assumptions about the image as rasterization.

The older form of rasterization is characterized by rendering an entire face (primitive) as a single color. Alternatively, rasterization can be done in a more complicated manner by first rendering the...
vertices of a face and then rendering the pixels of that face as a blending of the vertex colors. This version of rasterization has overtaken the old method as it allows the graphics to flow without complicated textures (a rasterized image when used face by face tends to have a very block-like effect if not covered in complex textures; the faces are not smooth because there is no gradual color change from one primitive to the next). This newer method of rasterization utilizes the graphics card's more taxing shading functions and still achieves better performance because the simpler textures stored in memory use less space. Sometimes designers will use one rasterization method on some faces and the other method on others based on the angle at which that face meets other joined faces, thus increasing speed and not hurting the overall effect.

Ray casting

In ray casting the geometry which has been modeled is parsed pixel by pixel, line by line, from the point of view outward, as if casting rays out from the point of view. Where an object is intersected, the color value at the point may be evaluated using several methods. In the simplest, the color value of the object at the point of intersection becomes the value of that pixel. The color may be determined from a texture-map. A more sophisticated method is to modify the color value by an illumination factor, but without calculating the relationship to a simulated light source. To reduce artifacts, a number of rays in slightly different directions may be averaged.

Rough simulations of optical properties may be additionally employed: a simple calculation of the ray from the object to the point of view is made. Another calculation is made of the angle of incidence of light rays from the light source(s), and from these as well as the specified intensities of the light sources, the value of the pixel is calculated. Another simulation uses illumination plotted from a radiosity algorithm, or a combination of these two.

Raycasting is primarily used for real-time simulations, such as those used in 3D computer games and cartoon animations, where detail is not important, or where it is more efficient to manually fake the details in order to obtain better performance in the computational stage. This is usually the case when a large number of frames need to be animated. The resulting surfaces have a characteristic 'flat' appearance when no additional tricks are used, as if objects in the scene were all painted with matte finish.
Ray tracing aims to simulate the natural flow of light, interpreted as particles. Often, ray tracing methods are utilized to approximate the solution to the rendering equation by applying Monte Carlo methods to it. Some of the most used methods are path tracing, bidirectional path tracing, or Metropolis light transport, but also semi realistic methods are in use, like Whitted Style Ray Tracing, or hybrids. While most implementations let light propagate on straight lines, applications exist to simulate relativistic space-time effects.

In a final production quality rendering of a ray traced work, multiple rays are generally shot for each pixel, and traced not just to the first object of intersection, but rather, through a number of sequential 'bounces', using the known laws of optics such as "angle of incidence equals angle of reflection" and more advanced laws that deal with refraction and surface roughness.

Once the ray either encounters a light source, or more probably once a set limiting number of bounces has been evaluated, then the surface illumination at that final point is evaluated using techniques described above, and the changes along the way through the various bounces evaluated to estimate a value observed at the point of view. This is all repeated for each sample, for each pixel.

In distribution ray tracing, at each point of intersection, multiple rays may be spawned. In path tracing, however, only a single ray or none is fired at each intersection, utilizing the statistical nature of
Monte Carlo experiments.

As a brute-force method, ray tracing has been too slow to consider for real-time, and until recently too slow even to consider for short films of any degree of quality, although it has been used for special effects sequences, and in advertising, where a short portion of high quality (perhaps even photorealistic) footage is required.

However, efforts at optimizing to reduce the number of calculations needed in portions of a work where detail is not high or does not depend on ray tracing features have led to a realistic possibility of wider use of ray tracing. There is now some hardware accelerated ray tracing equipment, at least in prototype phase, and some game demos which show use of real-time software or hardware ray tracing.

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### Video

For lecture video on this Unit follow the URL

https://tinyurl.com/ybom3yu4

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### Unit Summary

In this unit you learned learned the concepts of film technology, video technology and Animation Hardware also you have learnt that Rendering is the process of generating an image from a 2D or 3D model (or models in what collectively could be called a scene file) by means of computer programs. Also, the results of such a model can be called a rendering. A scene file contains objects in a strictly defined language or data structure; it would contain geometry, viewpoint, texture, lighting, and shading information as a description of the virtual scene. Rendering has uses in architecture, video games, simulators, movie or TV visual effects, and design visualization, each employing a different balance of features and techniques. In the case of 3D graphics, rendering may be done slowly, as in pre-rendering, or in real-time. Pre-rendering is a computationallly intensive process that is typically used for movie creation, while real-time rendering is often done for 3D video games which rely on the use of graphics cards with 3D hardware accelerators Many rendering algorithms have been researched, and software used for rendering may employ a number of different techniques to obtain a final image.
Assessment

- Differentiate between Film technology and video technology.
- In your own word explain with illustration the concept of animation rendering
Unit 8

Animation Software

Introduction

Animation software are computer image designing applications used to animate objects in game development, TVs and cartoon videos or films. Two animation software are discussed here. They are Maya and Inkscape. Maya is an application used to generate 3D assets for use in film, television, game development and architecture. Inkscape is a free and open-source vector graphics editor; it can be used to create or edit vector graphics such as illustrations, diagrams, line arts, charts, logos and complex paintings.

Upon completion of this unit you will be able to:

Outcomes

- Understand the key concepts of Animation Software or Application
- Be able to use Maya.
- Be able to operate basic features of Inkscape to animate objects
- Understand better the concept of animation production

Terminology

- **Rendering**: Rendering or image synthesis is the automatic process of generating a photorealistic or non-photorealistic image from a 2D or 3D model (or models in what collectively could be called a scene file) by means of computer programs.

- **Vector graphics**: Vector graphics is the use of polygons to represent images in computer graphics. Named after Claude-Louis Navier and George Gabriel Stokes, describe the motion of viscous fluid substances.

- **Navier–Stokes equations**: Named after Claude-Loius Navier and George Gabriel Strokes, describes the motion of viscous fluid substances.

Maya

Maya is an application used to generate 3D assets for use in film, television, game development and architecture. The software was initially released for the IRIX operating system. However, this support was discontinued in August 2006 after the release of
version 6.5. Maya was available in both "Complete" and "Unlimited" editions until August 2008, when it was turned into a single suite.

Users define a virtual workspace (scene) to implement and edit media of a particular project. Scenes can be saved in a variety of formats, the default being .mb (Maya D). Maya exposes a node graph architecture. Scene elements are node-based, each node having its own attributes and customization. Thus, the visual representation of a scene is based entirely on a network of interconnecting nodes, depending on each other's information. For the convenience of viewing these networks, there is a dependency and a directed acyclic graph.

Users who are students, teachers (or veterans or unemployed in USA markets) can download a full educational version from the Autodesk Education community. The versions available at the community are only licensed for non-commercial use (once activated with the product license) and some products create watermarks on output renders. The software comes with a full 36-month license. Once it expires, users can log in to the community to request a new 36-months license and download the latest Autodesk product.

Components
Since its consolidation from two distinct packages, Maya and later contain all the features of the now defunct unlimited suites.

Fluid Effects
A realistic fluid simulator based on simplified, incompressible Navier–Stokes equations\(^{[16]}\) for simulating non-elastic fluids was added in Maya 4.5. It is effective for smoke, fire, clouds and explosions, as well as many thick fluid effects such as water, magma or mud.

Bifröst
Bifröst is a computational fluid dynamics framework\(^{[17]}\) based on fluid-implicit particle simulation. It is available in Maya 2015 and later, following the acquisition of Naiad fluid simulation technology from Exotic Matter. Bifröst allows liquids to be modelled realistically, including details such as foam, waves and droplets.

Classic Cloth
A dynamic cloth simulation tool set utilizing a planar pattern based workflow inspired by the process used to design real world garment patterns. In modern productions,
the Maya Cloth module has been largely replaced by the faster, more flexible nCloth system introduced in version 8.5. Prior to this, third party plugins, most notably Syflex, were generally preferred for their superior performance, simulation stability and their polygon modeling based workflow already familiar to 3D artists.

Fur
Fur simulation designed for large area coverage of short hairs and hair-like materials. It can be used to simulate short fur-like objects, such as grass, carpet, etc. In contrast to Maya Hair, the Fur module makes no attempt to prevent hair-to-hair collisions. Hairs are also incapable of reacting dynamically to physical forces on a per hair basis. Physics-like effects are achieved through nearby fur effectors that approximate the effect of physical forces averaged over nearby follicles.

nHair
Hair simulator capable of simulating dynamic forces acting on long hair and per-hair collisions. Often used to simulate computationally complex human hair styles including pony tails, perms and braids. The simulation utilizes Non-UniformRationalB-Spline (NURBS) curves as a base which are then used as strokes for Paint Effects brushes thereby giving the curves a render time surface-like representation that can interact with light and shadow. A simulation on the curves alone for other, non-hair purposes (such as flexible tubing, cables, ropes, etc.) is often known simply as Dynamic Curves.

Maya Live
A set of motion tracking tools for Computer Graphics (CG) matching to clean plate footage. It has been largely obsoleted by MatchMover.

nCloth
Added in version 8.5, nCloth is the first implementation of Maya Nucleus, Autodesk’s simulation framework. nCloth provides artist with detailed control of cloth and material simulations. Compared to its predecessor Maya Cloth, nCloth is a faster, more flexible and more robust simulation framework.

nParticle
Added in version 2009, nParticle is addendum to Maya
Nucleus toolset. nParticle is for simulating a wide range of complex 3D effects, including liquids, clouds, smoke, spray, and dust. nParticles are more flexible than Maya's previous particle system in that nParticles may be used to simulate viscous fluids as well as supporting true particle-to-particle collisions. nParticles also interact with the rest of the Nucleus simulation framework without the need for costly work-arounds and custom scripting.

**MatchMover**
Added to Maya 2010, this enables compositing of CGI elements with motion data from video and film sequences, a process known as Match moving or camera tracking. This is an external program but is shipped with Maya.

**Composite**
Added to Maya 2010, this was earlier sold as Autodesk Toxik. This is an external program but is shipped with Maya.

**Camera Sequencer**
Added in Autodesk Maya 2011, Camera Sequencer is used to layout multiple camera shots and manage them in one animation sequence.

**Maya Embedded Language**
Alongside its more recognized visual workflow, Maya is equipped with a cross-platform scripting language, called Maya Embedded Language. MEL is provided for scripting and a means to customize the core functionality of the software, since many of the tools and commands used are written in it. Code can be used to engineer modifications, plug-ins or be injected into runtime. Outside these superficial uses of the language, user interaction is recorded in MEL, allowing even inexperienced users to implement subroutines. Scene information can thus be dumped, extension .ma, editable outside Maya in any text editor.

**Supported Operating Systems**
Autodesk Maya 2016 is supported on 64-bit Windows (Windows 7 (SP1) or later), Mac (OS X 10.9.5 or later), and Linux (RedHat Enterprise Linux 6.5 WS or CentOS 6.5) platforms. Support for Silicon Graphics IRIX was dropped after version 6.5 and openSUSE Linux support was dropped in Maya 2009.

**Inkscape**
Inkscape is a free and open-source vector graphics editor; it can be used to create or edit vector graphics such as illustrations,
diagrams, line arts, charts, logos and complex paintings. Inkscape's primary vector graphics format is Scalable Vector Graphics (SVG), however many other formats can be imported and exported.

Inkscape can render primitive vector shapes (e.g. rectangles, ellipses, polygons, arcs, spirals, stars and 3D boxes) and text. These objects may be filled with solid colors, patterns, radial or linear color gradients and their borders may be stroked, both with adjustable transparency. Embedding and optional tracing of raster graphics is also supported, enabling the editor to create vector graphics from photos and other raster sources. Created shapes can be further manipulated with transformations, such as moving, rotating, scaling and skewing.

Inkscape began in 2003 as a code fork of the Sodipodi project. Sodipodi, developed since 1999, was itself based on RaphLevien's Gill (GNOME Illustration Application).

The Inkscape Frequently asked questions FAQ interprets the word *Inkscape* as a compound of *ink* and *scape*.

Four former Sodipodi developers (Ted Gould, Bryce Harrington, Nathan Hurst, and MenTaLguY) led the fork; they identified differences over project objectives, openness to third-party contributions, and technical disagreements as their reasons for forking. With Inkscape, they said they would focus development on implementing the complete SVG standard, whereas Sodipodi development emphasized developing a general-purpose vector graphics editor, possibly at the expense of SVG.

Following the fork, Inkscape's developers changed it greatly: they changed the programming language from C to C++; adopted the GTK+ (formerly GIMP Toolkit) toolkit C++ bindings (gtkmm); redesigned its user interface, and added a number of new features. Notably, Inkscape's implementation of the SVG standard, although incomplete, has shown gradual improvement.

Since 2005 Inkscape has participated in the Google Summer of Code program.

Up until the end of November 2007, Inkscape's bug tracking system was hosted on Source Forge. Thereafter it moved to Launch pad.
Features
Object creation

Fig 3.6.1: Inkscape 0.48.2, showing a rectangle (selected with the select tool), an ellipse, a star and two text objects

The basic objects in Inkscape are:

- **Rectangles & Squares tool**: creates rectangles and squares, corners of squares and rectangles can be rounded.
- **3D Boxes tool**: creates 3D boxes that have adjustable XYZ perspectives and configurable values for vanishing points. 3D boxes are in fact groups of paths and after ungrouping can be further modified.
- **Circles/Ellipses/Arcs tool**: circles and ellipses can be transformed into arcs (e.g. open half-circle) and segments (e.g. closed half-circle).
- **Stars & Polygons tool**: Multi-pointed (3 to 1,024 points) stars with two (base and tip) radius control handles can be used to emulate spirographs. Polygons with one control (base) handle can be used to create items based on the number of sides hexagons, pentagons, etc.
- **Spirals tool**: creates spirals that have a configurable number of turns (revolutions), divergence (density/sparseness of outer turns), inner radius (roll out from center)
- **Pencil tool** (Paths): which allows freehand drawing of lines.
- **Pen (Bézier) tool** (Paths): creates a Bézier node-by-node curve and or line segments in the same path.
- **Calligraphy tool** (Paths): creates freehand calligraphic or brush-like strokes, optionally the tool can use pressure and tilt readings from a graphics tablet.
- **Text tool**: creates texts that can use any of the Operating Systems (OS) outline and Unicode fonts including right-to-left scripts. Text conversion to paths, Normal, Bold, Italic, Condensed and Heavy, Alignments (left, right, center, full), Superscript, Subscript, Vertical and Horizontal text are
implemented. All text objects can be transformed via Line Spacing, Letter Spacing, Word Spacing, Horizontal Kerning, Vertical Shift and Character Rotation either manually or via menu settings. Text can be put along a path (both text and path remain editable), flowed into a shape or spell checked. Bullet lists, numbered lists, indentations, and underlined text are not available as of version 0.91.

- **Spray tool**: creates copies or clones of one or several items, select the item(s), then to Spray click on the canvas, move the mouse or scroll the mouse wheel.

- **Paint Bucket tool**: fills bounded areas of a given object (vector). The Paint Bucket tool works optically rather than geometrically and can assist with image tracing.

- **Connector tool**: creates object based connected paths, often used in flow charts, diagrams or schematics.

Additionally, there are more specialized objects:

- **Raster graphics**: Inkscape supports the export of bitmap images (as PNG images) of the whole drawing (all objects), the current selection, objects within the page outline and custom coordinates. Imports bitmap images, >File >Import allows the user to select either 'embed' or 'link' the image into the file. Pasting (v0.48) images into Inkscape automatically embeds images into the file. Inkscape supports importing and pasting of PNG, JPEG and BMP. Inkscape supports image tracing, the process of extracting vector graphics from raster sources.

- **Clones**: clones are child objects of an original parent object(s) which can have different transformations applied from those of the parent object. Clones can be created via Copies, the Spray tool or a Menu interface. Transformations include; size, position, rotation, blur, opacity, color and symmetry (layout). Clones are updated live whenever the parent object changes.

- **Render >Extensions >Render (menu) feature will render objects onto the canvas**, rendering examples include barcodes, calendars, grids, gears, spirographs, spheres and more.

- **Symbols >Objects >Symbols (menu) allows copying and pasting symbols from both the document being edited and from symbol libraries**, a v0.91 feature.
Object manipulation

Fig 3.6.2: Screenshot of Inkscape 0.45 on Ubuntu, showing outline view

Every object in the drawing can be subjected to arbitrary affine transformations: moving, rotating, scaling, skewing and a configurable matrix. Transformation parameters can be also specified numerically in the Transform dialog. Transformations can snap to angles, grids, guidelines and nodes of other objects. Grids, guides and snapping properties are defined on a per-document basis. As an alternative to snapping, an Align and Distribute dialog is provided, which can perform common alignment tasks on selected objects: e.g. line them up in a specified direction, space them equally, scatter them at random and remove overlaps between objects.

Objects can be arbitrarily grouped together. Groups of objects behave in many respects like "atomic" objects: for instance, they can be cloned or assigned a paint. Objects making up a group can be edited without having to ungroup it first, via an Enter Group command: the group can then be edited like a temporary layer.

The Z-order determines the order in which objects are drawn on the canvas. Objects with a high Z-order are drawn last and therefore drawn on top of objects lower in the Z-order. Order of objects can be managed either using layers, or by manually moving the object up and down in the Z-order. Layers can be locked or hidden, preventing modifying and accidental selection.
A special tool, Create Tiled Clones, is provided to create symmetrical or grid-like drawings using various plane symmetries. Objects can be cut, copied and pasted using a clipboard. However, as of version 0.46, Inkscape uses an internal variable rather than the Operating System clipboard, which limits copy and paste operations to one application instance. Objects can be copied between documents by opening them from the File menu in an already opened window, rather than by opening a second file from the operating system's shell.

**Styling objects**

Each object in Inkscape has several designs which determine its style. All of the designs can generally be set for any object:

- **Fill**: can be a solid color, a pattern, a linear or radial gradient, custom swatch, inherited from a parent object. The color selector has RGBA, HSL, CMYK, Color Wheel, Color Management System (CMS) color options available, but all selected colors are currently converted to RGBA. Gradients can have multiple stops, radial supports optional direct or reflected gradients. All colors can have an alpha value specified. Patterns can be constructed from any collection of objects, or one of the several supplied stock patterns can be used.

- **Stroke fill**: can have the same values as fill, but is applied to the object's stroke.

- **Stroke style**: width can be set by 9 different measurement (pixels, inches, meters, etc.) settings; join (corners) styles featured are miter, rounded or bevel joints; cap styles available are butt, round or square; dash strokes of 35 (and custom) styles with configurable offsets are available; markers for start, mid and end of various (over 65) types (arrows, dots, diamonds, etc...) are supported.

- **Opacity**: specifies alpha value for all fill colors. Each object has a distinct opacity value, which e.g. can be used to make groups transparent.

- **Filters**: the fill & stroke menu has an easy-to-use slider for Gaussian blur of each object; there are hundreds of categorized filter options under the SVG filters can be constructed using the >Filters menu.

Appearance of objects can be further changed by using masks and clipping paths, which can be created from arbitrary objects, including groups.

The style attributes are 'attached' to the source object, so after cutting/copying an object onto the clipboard, the style's attributes
can be pasted to another object.

Operations on paths
Inkscape has a comprehensive tool set to edit paths, as they are the basic element of a vector file.

- **Edit Path by Node tool**: allows for the editing of single or multiple paths and or their associated node(s). There are four types of path nodes; Cusp (corner), Smooth, Symmetric and Auto-Smooth. Editing is available for the positioning of nodes and their associated handles (angle and length) for Linear and Bézier paths or Spiro curves. A path segment can also be adjusted by dragging (left click + hold). When multiple nodes are selected, they can be moved, scaled and rotated using keyboard shortcut or mouse controls. Additional nodes can be inserted into paths at arbitrary or even placements, and an effect can be used to insert nodes at predefined intervals. When nodes are deleted, the handles on remaining ones are adjusted to preserve the original shape as closely as possible.

- **Tweak tool (sculpting/painting)**: provides whole object(s) or node editing regions (parts) of an object. It can push, repel/attract, randomize positioning, shrink/enlarge, rotate, and copy/delete selected whole objects. With parts of a path you can push, shrink/enlarge, repel/attract, roughen edges, blur and color. Nodes are dynamically created and deleted when needed while using this tool, so it can also be used on simple paths without pre-processing.

- **Path-Offsets; Outset, Inset, Linked or Dynamic**: can create a Linked or Dynamic (unlinked) Inset and or an Outset of an existing path which can then be fine-tuned using the given Shape or Node tool. Creating a Linked Offset of a path will update whenever the original is modified. Making symmetrical (i.e., picture frame) graphics easier to edit.

- **Path-Conversion; Object to Path**: conversions of Objects; Shapes (square, circle, etc.) or Text into paths.

- **Path-Conversion; Stroke to Path**: conversions of the Stroke of a shape to a path.

- **Path-Simplify**: a given path's node count will reduce while preserving the shape.

- **Path-Operations** (Boolean operations): use of multiple objects to Union, Difference, Intersection, Exclusion, Division and Cut Path.

Inkscape includes a feature called *Live Path Effects* (LPE), which can apply various modifiers to a path. Envelope Deformation is available via the Path Effects and provides a perspective effect. There are more than a dozen of these live path effects. LPE can be
stacked onto a single object and have interactive live on canvas and menu-based editing of the effects.

**Text support**
Inkscape supports text editing for both regular multi-line text (SVG's `<text>` element) and flowed text (the non-standard `<flowRoot>` element, formerly proposed for SVG 1.2). As of version 0.47, flowed text is not rendered by other applications, due to a lack of an appropriate parallel `<switch>` structure in the SVG document. The SVG 1.2 Tiny `<textArea>` element is not supported. All text is directly editable on canvas. Text rendering is based on the Pango library, which allows Inkscape to support several complex scripts including Hebrew, Arabic, Thai, Tibetan, etc. Kerning and letter-spacing can be adjusted on a per-glyph basis using keyboard shortcuts. Putting text on path is also supported, and both the text and the path remain editable. Inkscape supports italicized and bold, as well as super and subscript character attributes, but underlining is not yet implemented.

**Rendering**
For a long time, unlike many other GTK+ applications, Inkscape used its own rendering library to create graphics, called libnr. From version 0.91 on, Inkscape uses Cairo to render graphics, which brought a significant increase in rendering speed of the application.

**File formats**
Inkscape's primary format is Scalable Vector Graphics (SVG) version 1.1, meaning that it can create and edit with the abilities and within the constraints of this format. Any other format must either be imported (converted to SVG) or exported (converted from SVG). The SVG format is using the Cascading Style Sheet (CSS) standard internally. Inkscape's implementation of SVG and CSS standards is incomplete. Most notably, it does not support animation. Inkscape has multilingual support, particularly for complex scripts.
Inkscape can natively import the following formats:
- Adobe Illustrator Artwork (AI)
- CorelDRAW (CDR)
- Microsoft Visio Drawing (VSD)
- Portable Document Format (PDF)
- SVG Zip (SVGZ)
- Raster formats:
  - Joint Photographic Experts Group (JPEG)
  - Portable Network Graphics (PNG)
  - Graphics Interchange Format (GIF)
  - Bitmap image file (BMP)
It can import the following formats with the aid from extensions:
- Computer Graphics Metafile (CGM) (using UniConvertor)
- Dia Software (DIA)
- Encapsulated PostScript (EPS) using Ghostscript
- Postscript (PS) using Ghostscript
- sK1 (SK1) (using UniConvertor)
- Sketch
- Xfig Software (FIG)

Inkscape can *natively export* the following formats:
- Encapsulated PostScript (EPS)
- Flash XML Graphics (FXG)
- Hewlett-Packard Graphics Language (HPGL)
- HTML5 Canvas
- LaTeX (TEX)
- Portable Document Format (PDF)
- PostScript (PS)
- POV-Ray (POV)
- Synfig Animation Studio (SIF)
- Extensible Application Markup Language (XAML)

**Other features**
- *XML Editor* for direct manipulation of the SVG XML structure
- Editing of Resource Description Framework (RDF) a World Wide Web Consortium (W3C) metadata information model
- Command-line interface, exposes format conversion functions and full-featured GUI scripting
- More than sixty interface languages
- Extensible to new file formats, effects and other features
- Mathematical diagramming, with various uses of LaTeX
- Experimental support for scripting

**Interface and usability**
One of the main priorities of the Inkscape project is interface consistency and usability. This includes efforts to follow the GNOME human interface guidelines, universal keyboard accessibility, and convenient on-canvas editing. Inkscape has achieved significant progress in usability since the project started. The number of floating dialog boxes has been reduced, with their functions available using keyboard shortcuts or in the docked toolbars in the editing window. The tool bar controls at the top of the window always display the controls relevant to the current tool. All vector transformations, scale, rotation and positioning (minus skewing) have keyboard shortcuts with consistent modifiers (Alt transforms by 1 screen pixel at the current zoom, Shift multiplies the transformation by 10, etc.). These keys work on nodes in Node
tool as well as on objects in the Selector Tool. The most common operations (such as transformations, zooming, z-order) have convenient one-key shortcuts.

Inkscape provides *mouse over* tooltips and *status bar* hints for all buttons, controls, commands, keys, and on-canvas handles. The status bar hint messages are dynamic: A given object can display up to four hints while editing it with just one tool. The hints update based on two items—the tool being used, and the type of object/node/handle being edited—text, shapes, paths, node types, etc. It comes with a complete keyboard and mouse reference (in HTML and SVG) and several interactive tutorials in SVG.

The interface of Sodipodi (Inkscape's predecessor) was based on those of CorelDRAW and GIMP. The Inkscape interface has been influenced by Xara Xtreme.

**Video**

For lecture video on this Unit follow the URL

http://tinyurl.com/yc6hqry6

**Unit summary**

In this unit you learned about Animation software. These are computer image designing applications used to animate objects in game development, TVs and cartoon videos or films. Two animation software were studied that is; Maya and Inkscape.

**Assessment**

- Differentiate between Maya and Inkscape.
- Use Maya to animate a 3D object
- Use Inkscape to create various Dimensional shapes of a Pentagon