Chapter 9

Multimedia

9.1 Introduction

Newspapers were perhaps the first mass communication medium to employ the multimedia. They used mostly text, graphics, and images. In 1895, Gugliemo marconi sent his first wireless radio transmission at Pontecchio, Italy. A few years later (in 1901) he detected radio waves beamed across the Atlantic. Initially invented for telegraph, radio is now a major medium for audio broad casting. Television was the new media for the 20th century. It brings the video and has since changed the world of mass communications.

Multimedia means that computer information can be represented through audio, video, and animation in addition to traditional media (i.e., text, graphics drawings, images). Generally defining, multimedia is the field concerned with the computer controlled integration of text, graphics, drawings, still and moving images (video), animation, audio and any other media where every type of information can be represented, stored, transmitted and processed digitally. Adding more media to the messages increases the likelihood of the audience understanding the message better.

Multimedia application is an application which uses a collection of multiple media sources, e.g., text, Graphics, images, sound/audio, animation and video. Hypermedia can be considered as one of the multimedia applications. Hypertext is a text which contains links to other texts. Hypermedia is not constrained to be text-based though. It can include other media e.g., graphics, images and especially the continues media- sound and video. The World Wide Web (WWW) is the best example of hypermedia applications.

A **multimedia system** is a system capable of processing multimedia data and applications. The processing, storage, generation, manipulation and interpretation of multimedia information characterize a multimedia system.

From the above definitions of multimedia system we can summarize the characteristics of a multimedia system as:

- Multimedia systems must be computer controlled
- Multimedia systems are integrated. Thus audio messages with combination of text can be sent to the users.
- The information they handle must be represented digitally.
- The interface to the final presentation of media is usually interactive.

Though multimedia has helped in better presentation and better understanding for the user, it faces few challenges.

Challenges for Multimedia Systems

Multimedia systems may have to render a variety of media at the same instant, a distinction from normal applications. There is a temporal relationship between many forms of media, e.g. video and audio. Now the problem or the challenges we face in above case is:

- Sequencing within the media, i.e., playing frames in correct order/time frame in video
- Synchronization, lip synchronization is important for humans to watch playback of video and audio.
- Another challenge is that the data is large (several Mb for audio and video) Therefore, storage, transfer and processing overhead are high. Thus data compression techniques need to be used.
- Multimedia data is required to be represented digitally which involves scanning and sampling.

Thus the key issues multimedia systems need to deal with here are:

- How to represent and store temporal information.
- How to strictly maintain the temporal relationships on play back/retrieval
- What processes are involved in the above?

Data has to represented digitally so many initial source of data needs to be digitize-translated from analog source to digital representation. The will involve scanning (graphics, still images), sampling (audio/video) although digital cameras now exist for direct scene to digital capture of images and video.

The data is large several Mb easily for audio and video — therefore storage, transfer (bandwidth) and processing overheads are high. Data compression techniques are very common for this very purpose.

9.2 Features of Multimedia System

Features we are going to mention are desirable in point of view of above challenges discussed.

- System should have very high processing power which is needed to deal with large data processing and real time delivery of media.
- Multimedia capable file system is required, to deliver real-time media. For this purpose, system must have special hardware/software.
- A multimedia system should have ease of data representation. The file format that support multimedia should be easy to handle yet it should allow for compression/ decompression of data in real time.
- Multimedia system should provide efficient and fast input and output to the file subsystem. This would support for real time recording as well as playback of data.
- A multimedia system should have a special operating system to allow access to file system and process data efficiently and quickly. It should provide the features of direct transfer of data to disk with real time scheduling. In addition, processing of various interrupts should be fast and it should facilitate streaming of input output.
- System should provide large storage units (of the order of 50-100 Gb) and large memory (50-100 Mb) and in addition, large cache memory for efficient management.
- System should provide network support to the multimedia application thus rendering the application distributed.
- Since multimedia applications are for user help and convenience, the software tools needed to handle media, design and develop applications and deliver media, should also be user friendly.

9.3 Data Compression

Compression is the process used to reduce the physical size of a block of information. In computer graphics, we're interested in reducing the size of a block of graphics data so we can fit more information in a given physical storage space. We also might use compression to fit larger images in a block of memory of a given size. Sometimes the term data encoding is used to refer to algorithms that perform compression. Data encoding is actually a broader term than data compression. Data compression is a type of data encoding, and one that is used to reduce the size of data. Other types of data encoding are involved in encryption (cryptography) and data transmission (e.g., Morse code).

The terms unencoded data and raw data describe data before it has been compressed, and the terms encoded data and compressed data describe the same information after it has been compressed.

The term compression ratio is used to refer to the ratio of uncompressed data to compressed data. Thus, a 10:1 compression ratio is considered five times more efficient than 2:1. Of course, data compressed using an algorithm yielding 10:1 compression is five times smaller than the same data compressed using an algorithm yielding 2:1 compression.

Physical and Logical Compression

Although the major use of compression is to make data use less disk space, compression does not actually physically cram the data into a smaller size package in any meaningful sense.

Instead, compression algorithms are used to re-encode data into a different, more compact representation conveying the same information. In other words, fewer words are used to convey the same meaning, without actually saying the same thing.

The distinction between physical and logical compression methods is made on the basis of how the data is compressed or, more precisely, how the data is rearranged into a more compact form. Physical compression is performed on data exclusive of the information it contains; it only translates a series of bits from one pattern to another, more compact one. While the resulting compressed data may be related to the original data in a mechanical way, that relationship will not be obvious to us.

Physical compression methods typically produce strings of gibberish, at least relative to the information content of the original data. The resulting block of compressed data is normally smaller than the original because the physical compression algorithm has removed the redundancy that existed in the data itself.

Logical compression is accomplished through the process of logical substitution—that is, replacing one alphabetic, numeric, or binary symbol with another. Changing "United States of America" to "USA" is a good example of logical substitution

Lossy and Lossless Compression

Lossless compression means when a chunk of data is compressed and then decompressed, the original information contained in the data is preserved. No data has been lost or discarded; the data has not been changed in any way. Lossy compression methods, however, throw away some of the data in an image in order to achieve compression ratios better than that of most lossless compression methods. Some methods contain elaborate heuristic algorithms that adjust themselves to give the maximum amount of compression while changing as little of the visible detail of the image as possible.

The terms lossy and lossless are sometimes erroneously used to describe the quality of a compressed image. Some people assume that if any image data is lost, this could only degrade the image. The assumption is that we would never want to lose any data at all. This is certainly true if our data consists of text or numerical data that is associated with a file, such as a spreadsheet. In graphics applications, however, under certain circumstances data loss may be acceptable, and even recommended.

In practice, a small change in the value of a pixel may well be invisible, especially in high-resolution images where a single pixel is barely visible anyway. Images containing 256 or more colors may have selective pixel values changed with no noticeable effect on the image. In black-and-white images, however, there is obviously no such thing as a small change in a pixel's value: each pixel can only be black or white. Even in black-and-white images, however, if the change simply moves the boundary between a black and a white region by one pixel, the change may be difficult to see and therefore acceptable.

There are many encoding methods available that will compress video data. The majority of these methods involve the use of a transform coding scheme, usually employing a Fourier or Discrete Cosine Transform (DCT). These transforms physically reduce the size of the video data by selectively throwing away unneeded parts of the digitized information. Transform compression schemes usually discard 10 percent to 25 percent or more of the original video data, depending largely on the content of the video data and upon what image quality is considered acceptable.

In a typical video sequence, very little data changes from frame to frame. If we encode only the pixels that change between frames, the amount of data required to store a single video frame drops significantly. This type of compression is known as interframe delta compression, or in the case of video, motion compensation. Typical motion compensation schemes that encode only frame deltas (data that has changed between frames) can, depending on the data, achieve compression ratios upwards of 200:1.

9.4 Multimedia Data and File Formats

Multimedia data and information must be stored in a disk file using formats similar to image file formats. However, these multimedia formats need to store wide variety of data because of which these formats are more complex as compared to other formats. Multimedia data includes text, image, audio, video, animation and other forms of binary data, such as Musical Instrument Digital Interface (MIDI), control information, and graphical fonts. Typical multimedia formats do not define new methods for storing these types of data. Instead, they offer the ability to store data in one or more existing data formats that are already in general use. For example, a multimedia format can store the data in Rich Text Format (RTF) rather than in conventional ASCII plain-text format. Still image bitmap data may be stored as BMP or TIFF files rather than as raw bitmaps.

Multimedia formats are also optimized for the types of data they store and the format of the medium on which they are stored. CD-ROM is the common medium on which multimedia data is stored. But it has the limitation on the amount of information which it can store. A multimedia format must therefore make the best use of available data storage techniques to efficiently store data on the CD-ROM medium.

9.4.1 Multimedia Data

As we have already mentioned that multimedia data includes text, image, audio, video animation and graphics.

1. Text and Static Data

Text and static data can be recorded through keyboard, floppies, disks and tapes. The data is stored character by character in case of text and storage is 1 byte per character. In case of other forms of data e.g., spreads sheet files may be stored as text format and some may be stored as binary encoded format. The format of text can be raw (e.g., notepad) or can be properly formatted (e.g., word document). Text and static data are now temporal, i.e., no synchronization is necessary, but it may have a natural implied sequence. The size of text and static data is of less significance w.r.t. other multimedia objects.

2. Graphics

Graphics are specified through graphic primitives and their attributes. Graphics primitives include lines, rectangles, circles and text strings. Attributes such as line style, line width and color affect the outcome of graphical image. Graphics primitives and their attributes represent a higher level of an image representation. This higher level of representation needs to be converted at some point of the image processing into lower level of image representation.

One of the properties of graphics is that they are editable unlike images. The source of graphics may be through a keyboard (for text and cursor control), mouse, track ball, and graphics tablet. These data do not make up a very high storage overhead.

3. Images

An image is a spatial representation of an object, a two-dimensional or a three-dimensional scene or another image. It can be real or virtual. Images are considered to be still pictures in uncompressed form and are represented as a bitmap i.e., grids of pixels. Programs that are similar to graphics or animation programs may be used to generate images. The source of images can be photographs or pictures that are converted to digital form by a digital scanner or a digital-camera. The storage requirement of image can vary from 1 bit per pixel (for black and white), 8-bits per pixel (for gray scale) to 24 bits per pixel (for true color). Thus number of colors that can be displayed increase and thus quality of image improves. The storage overhead of such data increases with the increase in size. To reduce this overhead, compression technique is applied.

4. Audio

Sound is a physical phenomenon produced by the vibration of matter, such as violin string. As the matter vibrates, pressure variations are created in the air surrounding it This alteration of high and low pressure is propagated through the air in a wavelike motion. When a wave reaches the human ear, a sound is heard. Audio techniques is thus responsible for processing these sound waves.

Audio signals are continuous analog signals that are recorded through microphones and are then digitized and stored after compression.

Multimedia systems make use of sound only within the frequency range of human hearing. This sound with the human hearing range is called audio, and the waves in this frequency range are called acoustic signals.

All multimedia file formats are capable, by definition, of storing sound information. Sound data, like graphics and video data, has its own special requirements when it is being read, written, interpreted, and compressed. All of the sounds that we hear occur in the form of analog signals. Because computers are now digital devices it is necessary to store sound information in a digitized format that computers can readily use. A digital audio recording system does not record the entire wave form as analog systems do. Instead, a digital recorder captures a wave form at specific intervals, called the sampling rate. Each captured wave-form snapshot is converted to a binary integer value and is then stored on magnetic tape or disk.

The quality of an audio sample is determined by comparing it to the original sound from which it was sampled. The more identical the sample is to the original sound, the higher the quality of the sample. This is similar to comparing an image to the original document or photograph from which it was scanned.

The quality of audio data is determined by three parameters:

- Sample resolution
- Sampling rate
- Number of audio channels sampled

The *sample resolution* is determined by the number of bits per sample. The larger the sampling size, the higher the quality of the sample. Just as the apparent quality (resolution) of an image is reduced by storing fewer bits of data per pixel, so is the quality of a digital audio recording reduced by storing fewer bits per sample. Typical sampling sizes are eight bits and 16 bits.

The *sampling rate* is the number of times per second the analog wave form was read to collect data. The higher the sampling rate, the greater the quality of the audio. A high sampling rate collects more data per second than a lower sampling rate, therefore requiring more memory and disk space to store. Common sampling rates are 44.100 kHz (higher quality), 22.254 kHz (medium quality), and 11.025 kHz (lower quality). A sound source may be sampled using one channel (monaural sampling) or two channels (stereo sampling). Two-channel sampling provides greater quality than mono sampling as it produces twice as much data by doubling the number of samples captured.

One solution to the massive storage requirements of high-quality audio data is data compression. For example, the CD-DA (Compact Disc-Digital Audio) standard performs mono or stereo sampling using a sample resolution of 16 bits and a sampling rate of 44.1 samples/second, making it a very high-quality format for both music and language applications. Storing five minutes of CD-DA information requires approximately 25 megabytes of disk space which is only half the amount of space that would be required if the audio data were uncompressed.

Audio compression algorithms, like image compression algorithms, can be categorized as lossy and lossless. Lossless compression methods do not discard any data. The decompression step produces exactly the same data as was read by the compression step. A simple form of lossless audio compression is to Huffman-encode the differences between each successive 8-bit sample. Huffman encoding is a lossless compression algorithm and, therefore the audio data is preserved in its entirety. Lossy compression schemes discard data based on the perceptions of the psychoacoustic system of the human brain. Parts of sounds that the ear cannot hear, or the brain does not care about, can be discarded as useless data.

5. Video

In conventional black-and-white TV sets, the video signal is displayed using a CRT. Audio video signal representation includes three aspects : the visual representation, transmission and digitization. Like audio, video also has an analog form and are captured by video camera and then digitized. Thus it is converted from analog to digital representation, using sampling and quantization.

Each sample captured from the video stream is typically stored as a 16-bit integer. The rate at which samples are collected is called the *sampling rate*. The sampling rate is measured in the number of samples captured per second (samples/second). For digital video, it is necessary to capture millions of samples per second.

Quantizing converts the level of a video signal sample into a discrete, binary value. This value approximates the level of the original video signal sample. The value is selected by comparing the video sample to a series of predefined threshold values. The value of the threshold closest to the amplitude of the sampled signal is used as the digital value.

The components of a composite video signal are normally decoded into three separate signals representing the three channels of a color space model, such as RGB, YUV, or YIQ. Although the RGB model is quite commonly used in still imaging, the YUV. YIQ models are more often used in motion-video imaging. A video sequence is displayed as a series of frames. Each frame is a snapshot of a moment in time of the motion-video data, and is very similar to a still image. When the frames are played back in sequence on a display device, a rendering of the original video data is created. In real-time video the playback rate is 30 frames per second. This is the minimum rate necessary for the human eye to successfully blend each video frame together into a continuous, smoothly moving image.

For storing purposes, digital video needs to be compressed. There are many encoding methods available that will compress video data. The majority of these methods involve the use of a transform coding scheme, usually employing a Fourier or Discrete Cosine Transform (DCT). These transforms physically reduce the size of the video data by selectively throwing away unneeded parts of the digitized information. Transform compression schemes usually discard 10 percent to 25 percent or more of the original video data, depending largely on the content of the video data and upon what image quality are considered acceptable. The transform itself does not produce compressed data. It discards only data not used by the human eye. In a typical video sequence, very little data changes from frame to frame. If we encode only the pixels that change between frames, the amount of data required to store a single video frame drops significantly. This type of compression is known as interframe delta compression, or in the case of video, motion compensation.

6. Animation

Animation lies between the motionless world of static images and real-time world of moving video images. Animation can be seen in educational programs, motion CAD renderings, and computer games. Traditional cartoon animation consists of positional variation of the animated subjects. When large number of these animated subjects is displayed in sequence and at a fast rate, the animated figures appear to the human eye to move.

A computer-animated sequence works in exactly the same manner. A series of images is created of a subject; each image contains a slightly different perspective on the animated subject. When these images are displayed (played back) in the proper sequence and at the proper speed (frame rate), the subject appears to move.

Computerized animation is actually a combination of both still and motion imaging. Each frame, or cell, of an animation is a still image that requires compression and storage. An animation file, however, must store the data for hundreds or thousands of animation frames and must also provide the information necessary to play back the frames using the proper display mode and frame rate.

Animation file formats are only capable of storing still images and not actual video information. It is possible, however, for most multimedia formats to contain animation information, because animation is actually a much easier type of data than video to store. The image-compression schemes used in animation files are also usually much simpler than most of those used in video compression. Most animation files use a delta compression scheme, which is a form of Run-Length Encoding that stores and compresses only the information that is different between two images (rather than compressing each image frame entirely). Storing animations using a multimedia format also produces the benefit of adding sound to the animation (what's a cartoon without sound?). Most animation formats cannot store sound directly in their files and must rely on storing the sound in a separate disk file which is read by the application that is playing back the animation.

Animated sequences are used by CAD programmers to rotate 3D objects so they can be observed from different perspectives; mathematical data collected by an aircraft or satellite may be rendered into an animated fly-by sequence. Movie special effects benefit greatly by computer animation.

9.4.2 File Formats (or Data Formats)

RTF (Rich Text Format): It is a file format that allows rich text (text with special formatting like italics, bold, colored text, pictures, and the like) to be stored using plain text characters. Since RTF is represented with plain text (no special characters), documents created with RTF can be easily ported across different operating systems. Thus, RTF is some what similar to HTML in this way, HTML is a language behind web pages.

There are several methods for creating an RTF file. First, MS word is based on RTF, so any document created in word can be saved in RTF with little loss of detail. The word pad utility program that comes with windows, Text Edit utility program that comes with Mac OS both allow you to create or view RTF files.

Its a standard formalized by Microsoft corporation for specifying formatting of documents. RTF files are actually ASCII files with special commands to indicate formatting information, such as fonts and margins

TIFF (Tag Image File Format): TIFF is a flexible container format for digital still images, commonly used in desktop publishing. TIFF images can incorporate various forms of compression (like JPEG), and can be uncompressed too. Some digital cameras offer a special TIFF mode for capturing uncompressed photos. However, these files require many times more storage space than JPEGs, and can quickly fill up your camera's available memory.**TIFF** structure is defined as follows: In TIFF individual field are identified with a unique tag which are known as **tag fields**. Each tag field contains some data about the bitmap. TIFF format allow particular fields to be present or absent from the file as required by the application. When a program reads the TIFF file, it looks for the various tag codes it wants and ignores the rest. TIFF file can include name of the artist, model of the computer used to create the image, precise data on the gamma color correction to be used for the image.

TIFF file begins with an 8-byte image file header followed by the image file directory. The image file directory contains a counter of how many tag fields there are and the location of the first tag field. The image file directory is followed by tag fields. Let us now discuss the structures of these image file header and image file directory.

Structure of Image File Header: A TIFF file begins with a 8-byte image file header which contains the following information.

- Bytes 0-1: (Byte Ordering Format) the first word of the file specifies the byte order used within the file. Legal values are: _II_ (hex 4949) denotes Intel format and _MM_ (hex 4D4D) denotes Macintosh or Motorola format.
- Bytes 2-3: (Version number) the second word of the image header is supposed to be the TIFF_version number. Version number is always 42 (002AH), no matter what version of TIFF it actually is.
- Bytes 4-7: (IFD offset) this long word contains the offset of the first image file directory. The directory may be at any location in the file after the header but must begin on a word boundary.

Structure of Image File Directory: An IFD consists of a 2-byte count of the number of entries of tag fields, followed by the tag field themselves, followed by a 4-byte offset of the next Image File Directory. IFD is limited to a total of 256 tag fields, reason being the 2-bytes for the count field.

Structure of Tag Field: Each tag field is 12 bytes in length containing the following format.

- Bytes 0-1: contain the tag code for the field.
- Bytes 2-3: tells what type of data the field points to. There are five different data types:
  - 1-byte ASCII character codes.

- 1-byte unsigned integer (BYTE).
- 2-byte unsigned integer (SHORT).
- 4-byte unsigned integer (LONG).
- 8-byte fractions (4-bytes for numerator, 4-bytes for denominator) (RATIONAL).

➢ Bytes 4-7: contains the length of the field. They tell how many different data elements the tag field points to. It is specified in terms of the data type and not the total number of bytes.

➢ Bytes 8-11: if total data elements use 4 bytes or less, then bytes 8-11 contain the actual data elements, otherwise bytes 8-11 contain the pointer to the data.

TIFF file format has advantages of:

- It is independent on any computer architecture and operating system.
- It is versatile and flexible because hundreds of different types of tagged fields are available.
- It uses pointers and hence can be easily read from random access devices.
- File is quite compact.
- Supports many compression techniques.
- Supports monochromatic to true color images.
- Stores additional information about images in the file which can be used to display image accurately.

At the same time TIFF file format has disadvantages too:

- It's a complex file format as compared to others.
- Its an open ended format, so changes made by programmer may not be compatible with its newer versions.
- It does not support multiple images in one file.

MIDI (Musical Instrument Digital Interface):

It is a format for audio data. A MIDI file though, doesn't contain actual audio data, but rather contains commands that let MIDI- capable synthesizers recreate a specific musical passage. The MIDI Protocol has been used for years as a way for electronic musical instruments (like digital keyboards and sequences) to communicate with each other.

Computer sound cards typically feature the ability to interpret MIDI files into music. Since they do not actually contain the music itself, but rather the commands used to recreate music, MIDI files are a lot smaller than audio files like MP3s, WMAs, or WAVs MIDI files are small and manageable enough that it is not uncommon to find them embedded in web pages, adding a sonic element to the surfing experience. They usually appear with the '.MID' file name extension.

Sound in MIDI data is stored as a series of control messages. Each message describes a sound event using terms such as pitch, duration, and volume. When these control messages are sent to a MIDI-compatible device (the MIDI standard also defines the interconnecting hardware used by MIDI devices and the communications protocol used to interchange the control information) the information in the message is interpreted and reproduced by the device.

MIDI data may be compressed, just like any other binary data, and does not require special compression algorithms in the way that audio data does.

JPEG (Joint Photographic Experts Group): JPEG is a lossy codec for storing and transferring full-color digital images that is often used to post photography and artwork on the web. JPEG compression takes advantage of the human eye's inability to see minute color changes, removing portions of data from the original picture file. When creating a JPEG file, varying amounts of compression can be selected, depending on the desired file size and image quality. JPEG applies to color and gray-scaled still images. A fast coding and decoding of still images is also used for video sequences known as motion JPEG. Motion JPEG is used by some digital cameras and cam corders for storing video clips of relatively small file size. With motion JPEG, each frame of video is captured separately and reduced in size using JPEG compression.

DIB (Device-independent bitmap): It is the bit mapped graphics format used by Windows. Graphics stored in DIB format generally end with a .bmp extension. It is called device independent because colors are represented in a format independent of the final output device. When a DIB image is output to a monitor or printer, the device driver translates the DIB colors into actual colors that the output device can display.

MPEG (Moving Picture Experts Group): Its a committee that sets international standards for the digital encoding of movies and sound. There are several audio/video formats which bear this group's name. In addition to their popularity on the Internet, several MPEG formats are used with different kinds of Audio/Video gear:

MPEG 1. This format is often used in digital cameras and camcorders to capture small, easily transferable video clips. It is also the compression format used to create video CDS, and commonly used for posting clips on the internet. The well-Known MP3 audio format is part of the MPEG1 Codec.

MPEG 2. Commercially produced DVD movies, home recorded DVD discs, and most digital satellite TV broadcasts employ MPEG 2 video compression to deliver their high quality picture. MPEG2 is also the form of lossy compression used by TiV0- Based hard disk video recorders. It can rival the DV format when it comes to picture quality.

400 pixels. In graphics mode, the resolution is either 640 by 480 (with 16 colors) or 320 by 200 (with 256 colors). Unlike earlier graphics standards for PCs (CGA, EGA) VGA uses analog signals rather than digital signals. Consequently, a monitor designed for one of the older standards will not be able to use VGA.

Super VGA is a set of graphics standards designed to offer greater resolution than VGA. SVGA supports 800 × 600 resolution SVGA standard supports a pallete of 16 million colors with only 256 colors that can be displayed simultaneously, this is because of limited video memory installed in a system.

9.6 User Interfaces

computer Image processing performs the analysis of scenes or reconstruction of models from pictures of 2D or 3D objects. Thus it includes image synthesis (or generation) and image analysis (or recognition).

Image synthesis is an integral part of all computer user interfaces. It is indispensable for visualizing 2D, 3D and higher-dimensional objects.

Applications running on personal computers and workstations have user interfaces that rely on desktop window systems to manage multiple simultaneous activities and on point- and- click facilities to allow users to select menu items, icons and object on the screen.

SCSI short for small computer system interface, a parallel interface standard used by Apple macintosh computers, PCs and many UNIX systems for attaching peripheral devices to computers. Nearly all apple macintosh computers, excluding only the earliest MACs and the recent iMAc, come with a SCSI port for attaching devices such as disk drives and printers.

SCSI interfaces provide for faster data transmission rates (upto 80 megabytes per second) than standard serial and parallel ports. In addition, many devices can be attached to a single SCSI port, so that SCSI is really an I/O bus rather than simply an interface. Although SCSI is an ANSI standard, these are many variations of it, so two SCSI interfaces may be incompatible. For example, SCSI supports several types of connectors.

While SCSI has been the standard interface for Macintoshes, the iMac comes with IDE, a less expensive interface, in which the controller is integrated into the disk or CD-ROM drive. **IDE** is an abbreviation for **Integrated Drive Electronics**. Other Interfaces supported by PCS include enhanced IDE for mass storage device and centronics for printers. SCSI devices can be attached to a PC by inserting a SCSI board in one of the expansion slots. Many high end new PCs come with SCSI built in

However, lack of single SCSI standard means that some devices may not work with some SCSI boards.

MCI abbreviation for **Media Control Interface**, a high-level API developed by microsoft and IBM for controlling multimedia devices, such as CD-ROM players and audio controllers. Both OS/2 and windows support MCI. MCI comprises an extensible string-based and message-based interface for communication with MCI device drivers. MCI device drivers are designed to support the playing and recording of waveform audio, the playing of MIDI files, the playing of compact disk audio from a CD-ROM disk drive and the control of some video disk players.

MCI is a device-independent programming interface that offers commands similar to an entertainment system. Few typical MCI-commands are : 'Open', 'close' and 'status of device' for all devices. For playback and recording device dependent, 'play', 'record', 'resume', 'stop', 'are' and 'seek' commands exist- 'Set cue point' command allows for synchronization, 'Get table of contents of a CD-ROM' is an example of a device-specific command.

9.7 Multimedia Tools

The tool set for building multimedia projects contains one or more authoring systems, the tools for creating and editing multimedia elements, presentation tools, tools for capturing images from the screen, translating file formats and moving files among computers.

The tools for creating and editing, i.e., painting and drawing tools are available, where painting software like Fractal Design Painter is dedicated to producing crafted bitmap images. Drawing software like Corel draw and canvas is dedicated to producing vector based linear art that can be easily printed using postscript or another mark up system such as quick draw on the MAC.

Image Editing Applications are specialized and powerful tools for enhancing the existing bitmapped images. These applications also provide tools for painting and drawing that can be used to create images from scratch as well as images digitized from scanners, digital cameras or original artwork files created with a drawing or a painting package. Gallery effects, a stand alone image editing application from Adobe offers 16 excellent effect that can directly work within Photoshop, Color Studio and Fractal Design Painter among others.

Sound editing tools for both digitized and MIDI sound allow operations like cut, paste and edit on segments of it with great precision in real time. Using sound editing software, we can make our own sound effects and install them in the system. Both MAC and windows systems provide system sounds, which are available as soon as we install the operating system. For digital waveform sounds, Windows ships with the sound recorder program that provides some rudimentary features for sound editing.

Presentation Tools

Multimedia Presentation plays a role in the design of multimedia user interfaces. To design a presentation, issues like content selection, media and presentation technique selection and presentation coordination must be considered. Content of the presentation can be influenced by constraints imposed by the size and complexity, limitations of the display hardware and need for presentation completeness.

Selecting presentation techniques needs to work out on some rules. Example, a user may specify a preference for graphical techniques, also the media must be adequate. For example, presentation on how to play tennis, for this purpose graphics and video are more suitable than more of text or only text.

Coordination can be viewed as a process of composition. Coordination of multimedia employs a set of composition operators for merging, aligning, and synthesizing different objects to construct displays that convey multiple attributes of one or more data sets. Attributes include color, position, size and medium specification (text, graphics, image).

The presentation, i.e., the optical image at the user interface can have full texts, abbreviated text, icons, i.e., graphics or micons, i.e., motion video. Any of these possibilities can have advantage for one user or disadvantage for the other. For example, an abbreviation can be understood by a frequent user but not familiar for a sporadic user Icons must have a uniform semantics inside of the window system, like a trash container is associated with a delete functions.

Authoring Tools

Multimedia authoring tools provide the important framework needed for organizing and editing the elements that includes graphics, sounds, animations and video clips. Authoring tools are used for designing interactively and provide the user interface for assembling multimedia elements into a cohesive project that can be presented on the screen Authoring software provides an integrated environment for binding together the content and the functions in the multimedia project. Authoring systems should have the ability to create, edit, and import specific types of data, assemble raw data into playback sequence, and should provide a structured method for responding to user input. With multimedia authoring software, we can generate video productions, animations, games, demo disks and interactive guided tours, presentations, simulations and technical visualizations.

We have four types of authoring tools :

- Card or page-based authoring tools. Multimedia elements are organized as pages of a book or a stack of cards. These can be best used when the bulk of content consists of elements that can be viewed individually like the pages of a book.
- Icon-based authoring tools. Multimedia elements and events are organized as a structure or flow chart. The structure or flow chart is built from events, tasks and decisions by dragging appropriate icons from a library. These icons include menu choices, graphic images, sounds and computations.
- Time-based authoring tools. Elements and events are organized along a time line with resolutions up to 1/30 second. Sequentially organized graphic frames are played back at a set time and audio events are triggered at a given time or location in the sequence of events.
- Object-oriented tools. Multimedia elements and events are organized as objects in a hierarchical order with parent and child relationships. The object are ordered according to the properties or modifiers assigned to them and messages are passed among these objects. for example, a dog object is defined by barking and jumping modifiers.

9.8 Multimedia Communication Systems Architecture & Model

9.8.1 Introduction

Future multimedia systems will rely on broadband networks, e.g., the B-ISDN and sub-networks which will be able to provide the required type of communication services and meet the stringent quality of service (QOS) demands. However, many sub-networks that are existing or under design will not be sophisticated enough to provide the services with the right characteristics. This will require the use of sophisticated multimedia end systems which are able to compensate for the deficiencies of the networks. In particular, the structuring and functionality of the higher layer protocols will be affected. This shall impact the introduction strategy of multimedia applications. It is likely that, initially, use will be made of a simple transport layer service, which in turn will be implemented on top of various network services. Here we focus on the upper layers of the OSI Reference Model. It examines the structuring, services, and major protocol functions that are required in the upper layers in order to support end-to-end multimedia communication, assuming a simple transport service. It is also assumed that variable bit rate (VBR) coding techniques will be used in future multimedia systems. Mutual stream synchronization, integral management, and multiparty connections appear to be crucial issues in multimedia communication. Let us consider multimedia end systems consisting of an application process and an open-ended multimedia communication system, which supports the simultaneous use, manipulation, and transfer of diverse types of information within a single communication instance with other such systems. Strongly different types of information are referred to as media, and instances of information exchange of a particular type are called streams. Examples of streams are compressed video, voice, interactive data, and graphics. An implementation of an end system will be called a terminal. Narrow band networks such as the ones based on X.25 and the ISDN are only to a limited extent usable for multimedia communication because some media require a high throughput. Broadband communication networks, on the other hand, which will be able to provide through-puts of tens of Mb/s per connection are fully enabling multimedia **Communication.**

According to the bit rate of the service, two classes of transfer (bearer) services can be distinguished: VBR transfer services and constant bit rate (CBR) transfer services. Characteristics of a VBR transfer service are the variable data transfer delay and irregular servicing of the queues of packets waiting for transmission. The service rate may possibly be guaranteed but the inter-service time is variable. This type of service typically supports VBR traffic which is generated by applications such as interactive data, file transfer, electronic mail, document exchange and graphical image transfer, and also by applications which require a constant end user-to-end user delay like (VBR coded) video, voice, and HDTV. A constant bit rate (CBR) transfer service is characterized by a constant data transfer delay and a periodic availability of service quanta at the packet queues. It typically supports CBR traffic like voice, video, and HDTV when they appear as CBR sources. CBR transfer services are generally related to circuit-switched implementations which make use of fixed bandwidth reservation. VBR sub-network or lower layer transfer services are related to implementations which are based on packet switching, which enables statistical resource sharing. This classification of transfer services is included in the ATM AAL classification of services. Broadband communication sub-networks can be classified according to the classes of the OSI Sub-network Specific 3A or the Data Link Layer (DLL) services into two categories: those providing a VBR transfer service and those providing both CBR and VBR transfer services. Examples of the former are frame relaying networks, CFR , Orwell, and Metrobridge. Examples of the latter are FDDI-II, IEEE 802.6, and B-ISDN.

9.8.2 Protocol Functions, Structuring and Services

Let us now present our views on the issues related to the protocol functions, structuring, and services in the upper OSI layers for multimedia communication. This section is organized into subsections dealing with the application layer, presentation layer, session layer, multiplexing and concatenation, and management

(A) Application Layer

Application layer multimedia communication is inherently connection-oriented. Multimedia communication can best be realized by a single application layer connection. This simplifies multimedia call establishment, release and control, authentication and authorization, and management. An illustration of the proposed architectural concept is shown in Fig.9.1. Usually in multimedia multiparty applications, a master station is designated. The application process at the master station is the one who give turns in multiparty communication. In addition, it is possible that each station sends information to the master station where the application process selects information, maybe processes or merges it, and then sends identical data to each participant. An alternative is that the participant who has the turn in a multimedia application sends data to all participants directly. In any case, a multimedia multiparty connection at the application layer can be considered a centralized multi-endpoint connection. Furthermore, a central communications control and management system can be efficiently realized at the master station, e.g., the addition of a new participant or the recovery of a failed one in a multiparty connection asks for refined resynchronization functions which can more easily be handled centrally by a master station than in a distributed way. In the lower OSI layers, use can be made of multipoint and multicast communication services, e.g., in B-ISDN and HSLAN's. The streams require diverse lower application layer services. Already in the lower part of the application layer, connections are to be implemented using protocol functions between the peer entities as has been done in the standardized application blocks. This implies that, in the lower part of the application layer, separate connections have to be used for the streams. Thus, a splitting function is to be used within the application layer. An Association Control Service Element (ACSE) is used within the application layer to provide for connection establishment and release of each data stream. Reliable Transfer Service Elements (RTSE), Remote Operations Service Elements (ROSE), or similar elements (which, as a rule, use ACSE service) are used for VBR data transfer. For CBR end users, e.g., audiovisual users before coding is implemented, a similar element should be specified. Let us name it CBR Transfer Service Element (CTSE). It uses ACSE services and provides itself the corresponding services, controls the stream, transparently transfers information between its service user and the presentation layer entity, and provides other functions which are to be investigated further e.g., functions related to data presentation under windows. Therefore, the application layer should provide the following major functions:

- A single (unique) connection for a multimedia call which can be a multipoint connection.
- A splitting function, splitting a single multimedia call into a number of stream connections.
- Connections for each data stream in the lower part of the application layer, and
- Multimedia connection integrity control, i.e., control of service elements and their function in a multimedia connection.

(B) Presentation Layer

The presentation layer service is to be provided separately to each stream. A single association is mapped onto a single presentation layer connection. Negotiation of the communication contexts is possible and significantly different data presentation techniques, e.g., coding techniques, can be available for diverse streams. The presentation layer, thus, provides specific presentation functions for each data stream separately. The VBR codec functionality should be part of the presentation entity.

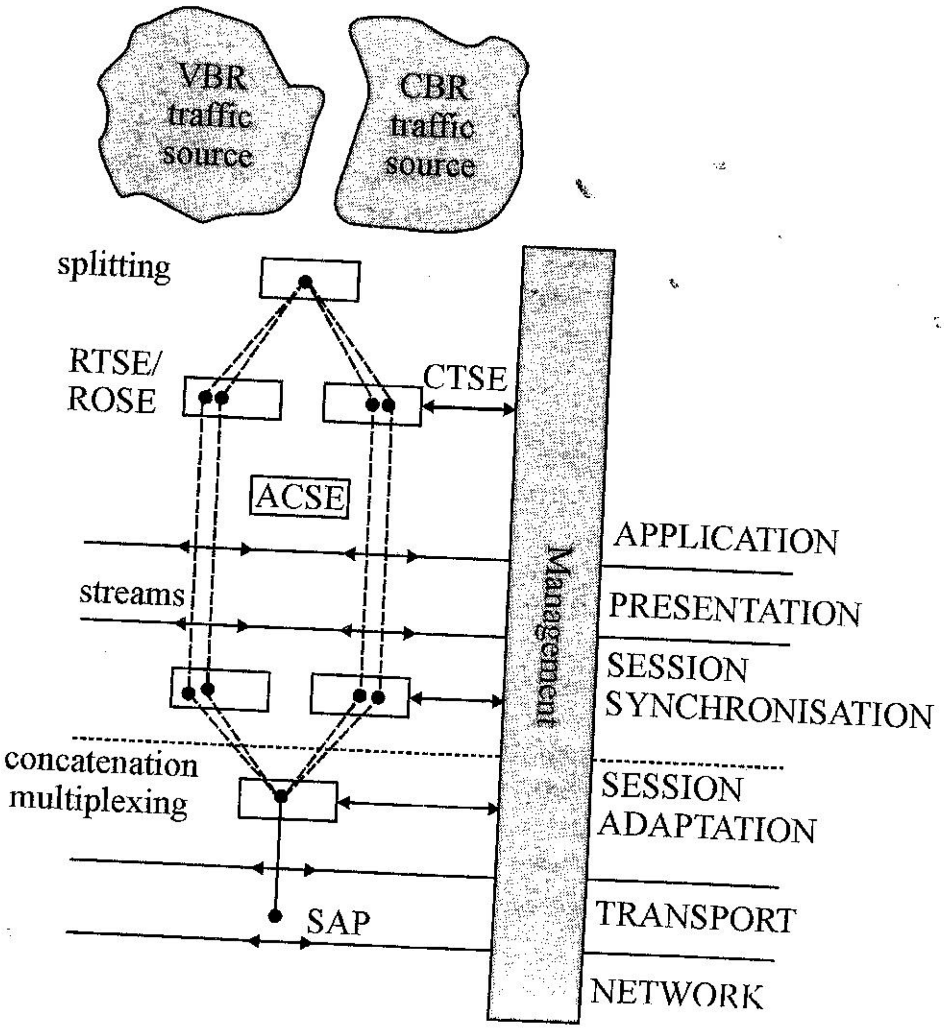

Figure 9.1 Illustration of the upper OSI layer structyure with major element functions, and interfaces.

(C) Session Layer

The session service is to be provided to each stream separately. For example, session connection synchronization is available for each stream separately, e.g., activity dialog, major and minor token features, or activity token service which enables half-duplex communication. A presentation connection is mapped on a session connection. On the other hand, it is required that mutual synchronization of the streams is performed in the session layer since the underlying transport service is assumed to be simple and not to offer any such service. The session layer is organized into the following two subsessions: an upper one (synchronization) and a lower one (adaptation). Both sublayers provide for a connection- oriented service. The synchronization sublayer performs functions which are common for the session layer according to the OSI Reference Model. For example, the synchronization sublayer performs connection establishment and release, dialog management, and synchronization and resynchronization of each stream in a multimedia conversation. The adaptation sublayer performs multiplexing of data streams into a small number of connections, e.g., two transport multimedia connections; furthermore,

It handles concatenation providing constant data transfer delay, treatment of special PDU's, and management of particular data streams. The concatenation function is used for connections for which the multiplexing function is used as well. Concatenation is a function in the session layer. An option in the OSI Reference Model which was left for possible future use allows multiplexing within the session layer. This option is to be used in multimedia communication. The session layer should provide the following major functions and service characteristics:

- connection synchronization for each stream like dialog management
- flow control by means of back pressure to the streams separately and to the multiplexed components of the integral multimedia communication
- mutual synchronization of the streams
- stream multiplexing
- concatenation
- constant data transfer service duration, and
- management of each data stream and the multimedia communication

(D) The Multiplexing and Concatenation Issue

In general, the traffic streams do not need to be multiplexed. However, if multiplexing and concatenation are not used as a session layer function, large fluctuations are possible in the transfer delay of the information which belongs to different connections and, therefore, to different streams.

On the other hand, sub-network bandwidth allocation and congestion control do not necessarily require that a distinction be made between different VBR information types (including VBR video) and between the corresponding streams within a single sub-network such as the B-ISDN or a HSLAN. The bandwidth allocation can be handled as follows. Since different streams are handled by different application layer, presentation layer and synchronization sublayer entities, large fluctuations in the traffic load, e.g., the start of a file transfer, can be signaled during the multimedia conversation to the adaptation sublayer or transport layer connection(s) which, in turn, can signal it to the lower layer connections(s). The sub-network congestion control can signal the congestion state or impending congestion, and end-to-end flow control can be used to resolve the congestion. End-to-end flow control is performed by the transport protocol and possibly by the lower layer protocols. Thus, the control is done over the multiplexed components of the integral multimedia connection. Flow control can also be exerted by means of back pressure in the multiplexed components of the integral multimedia connection and in each data stream in the session layer. Such flow control can help the network congestion control function. It also enables the use of different stream intensity control techniques used by adaptive coding techniques. The effectiveness of such a congestion control scheme depends on network monitoring and response time. It is expected that, due to the technological progress, this will not be a problem. The purpose of concatenation is to ensure a constant packet delay, i.e., a constant adaptation sublayer service duration. The adaptation sublayer protocol also supports particular PDU's which have their own PDU format and possibly their own connection endpoint identifier. These PDU's can be of use in exception handling and other procedures.

(E) Management

Multimedia end user connection establishment, release, and control relies on management functions. Essentially, it is important that the management entity of the application and other concerned layers have full information on the requirements and status of the multimedia connection. The application layer management entity and systems management need full coordination. The application layer management entity has a natural role to trigger functions of the other layers. It also provides an interface to the application process and its management. In particular, multimedia application management should perform, among others, the following functions:

- integrity and commitment control
- check-pointing and recovery.

9.8.3 Implementation Elements And Complexity

VBR coding and decoding in a multimedia terminal is considered to be part of the presentation layer functionality. Therefore, the interface between the presentation layer and the application layer which also provides for the interaction with the application

12

Animation

12.1 INTRODUCTION

The word *animation* derives from **'animate'** meaning *'to give life to'*. Animations are created from a sequence of images. Each image is slightly changed from the previous one with respect to one or more objects in the image.

Animation is the process of creating movement on the screen with a series of still pictures with the help of 'persistence of vision'. Animation is possible because of biological phenomenon known as persistence of vision. An object seen by human eye remains on retina for a brief time (about 0.1 second) after the viewing. Therefore, a series of images having a small change in position of objects in each time if projected rapidly on the eye, creates a virtual illusion of the movement. A complete screen full image of animation sequence is called **frame.**

Figure 12.1 shows sequence of images of a filled circle with different values of radius when displayed rapidly over one after another gives the illustration of circle moving inside.

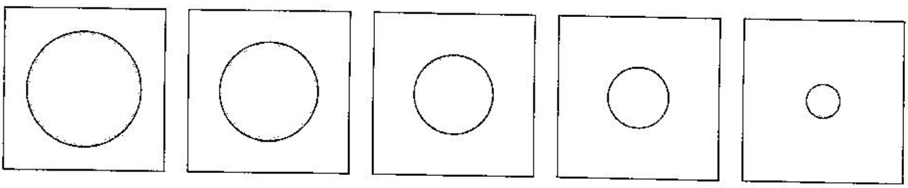

FIGURE 12.1

Animation is based on the way our eye and brain work. If slow sequence of images are presented in front of our eyes, then brain interprets as separate; and if fast sequence of images are presented, then brain starts motion with flickers, then as continuous motion, and, finally, as a distort. The rate of animation should be fast enough to create the perception of continuous motion but slow enough so as not to waste resources. In practice playback rates of 24 to 30 frames per second are normally used.

12.1.1 Why do We See these Images as Moving?

The reason our eyes are tricked into seeing movement can be explained by the 'Persistence of Vision' theory.

The Persistence of Vision Theory

Our brain holds onto an image for a fraction of a second after the image has passed. If the eye sees a series of still images very quickly one picture after another, then the images will appear to move because our eyes cannot deal with fast-moving images -our eyes have been tricked into thinking they have seen movement. We see these many pictures per second!

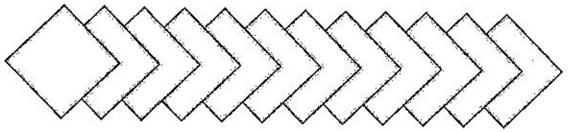

FIGURE 12.2

The Moving Hand Theory

You can do this by waving your hand in front of your eyes very fast. You will seem to see several hands at once. Try doing this in front of a television screen when it is switched on. You will see even more images of your hand because the television is actually flickering. By waving your hand in front of it you make your eyes very confused about what they are actually seeing.

In fact computer graphics has three stages:

First stage: to display a single image consisting of smooth, curved, realistic looking, surfaces.

Second stage: to create and display an entire animation made of many frames, where each frame is an image.

Third stage: It is related to virtual reality, where the user can interact with animation.

12.2 WHAT IS ANIMATION?

Definition I

Webster define animate as

" *to give life to; to make alive*"

Definition II

Animation is the illusion of motion that is created by displaying a series of images or frames, each one slightly different from the last, over a brief period of time.

Definition III

Animation is the process by which we see still pictures MOVE. Each picture is shot on film one at a time and is shown at the rate of 24 pictures per second making the pictures appear to move.

Definition IV

Animation refers to change in object position with translation or rotation. It could also be involving size or color or transparency variation.

Definition V

Animation is the process (computer algorithms) resulting time-varying visual effects of motion, shape, color, texture, and so on.

12.3 EFFECTS ON PICTURE DURING ANIMATION

In animation, you get moving images when the pictures change in some way. Here are some ways in which pictures can change:

- **Change in size:** Things can get bigger (grow) or get smaller (shrink). Try drawing a balloon. Now draw it again but a little bit bigger. Now draw it getting even bigger. Draw it so that it is so big that it bursts!
- **Change in position:** Imagine the spokes on a bike-wheel moving around as the wheel runs full circle. Draw the wheel five times—each time showing how the spokes on the wheel have moved.
- **Change in angle:** Draw the hands of a clock as time is passing. Each time the hands should show a different angle.
- **Change in speed:** Draw a car parked. Now draw the same car speeding down a road. How could you show the element of speed?
- **Change in colour:** Draw six circles and colour them in, each time showing how the colours are getting darker.
- **Change of shape:** Draw a face that is sad. Now draw three other faces changing the eyes and mouth to make, in four stages, a happy face.

Computer animation can also be generated by changing camera parameter such as position, orientation, and focal length. Computer animation can also be produced by changing lighting effects or other parameters and procedures associated with rendering and illumination.

12.4 CATEGORIES OF ANIMATION

Animation deals with graphics drawn by hand or by animation software. Depending upon the techniques used to create and manage the frame. There are two broad categories of animation.

12.4.1 Cel Animation

Traditional animation sequence is created by two types of artists:

- The lead artists or experts who draw those frames where major changes take place within the sequence, called **key-frames.**
- Assistants draw a number of frames in between the frames, process is called **tweening.**
- Traditional animation is based on key-frames. Traditional animation films are created by hand. Artists draw image on films and each frame is called cel (drawn from celluloid). Hence, named cel animation. As 25 frames need to be displayed to achieve the effect of smooth motion of objects. Even a small sequence of animation requires thousands of cells.

12.4.2 Computer Animation

There are two main categories of computer animation

- **Computer assisted (two-dimensional) animation**
  It is also based on key-frame concepts. The advantage of computer assistant animation is that in-between frames are created by the animation software, instead of junior assistant animator who requires more time to create frames.
  Computer animation software simulates the process of traditional cel based animation by placing the animated object. Computer animation programs usually have grid and alignment commands to help animation to correctly register drawing.
  It uses the computer to interpolate between two-dimensional shapes. 2D animations are more popular, most cartoons that you watch on television are based on 2D animation technique.
- **Computer-generated (three-dimensional) animation**
  It uses the computer to build three-dimensional objects, to move both camera and objects along their paths, and to stop and take a snapshot at each frame. In this case mathematical model of a 3D object is created to portray its width and height as well as depth. 3D animation is mostly used in computer-aided design (CAD).
  A complete piece of animation is sometimes called **presentation.** It consists of a number of acts, where each act is broken down into several scenes. A scene is made of several slots of sequence of animation, each a succession of animation frames, where there is small change in scene and camera position between consecutive frames.

Thus, the order is: [See Figure 12.3]

12.5 PROBLEMS IN COMPUTER ANIMATION

- How to display on the screen, only parts of the scene that would be seen by an actual camera located at a certain point?

- How to move camera along any desired path and rotate it during the movement so it always points to the centre of intersect?
- How to move the scene along another path and move parts of the scene in different ways?

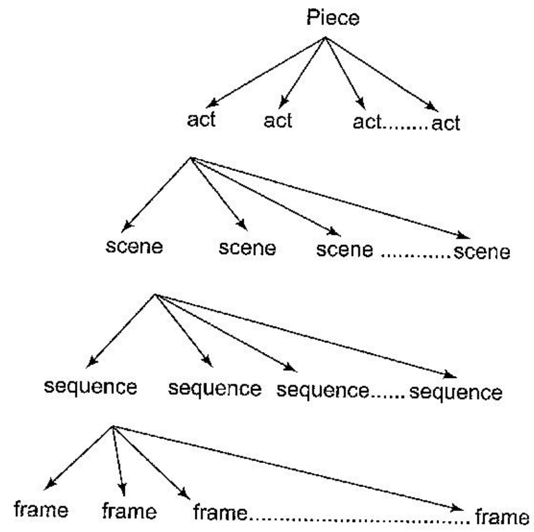

FIGURE 12.3 Piece of Animation

12.6 ANIMATION FUNCTIONS

12.6.1 Zooming

If we fix the window on an object but reduce or increase its size, the object would appear bigger(**zoom in**) or smaller(**zoom out**), respectively.

Reducing the size of window is much like **zooming in** on the object with a camera.

The contents in the window must be stretched to fit into the fixed viewport, so when the window is made smaller, the portion inside becomes more enlarged.

Similarly, increasing the size of window is much like **zooming out** from the object with a camera.

The example in Figure 12.4 points out how changing can produce useful effects. The window is made smaller (about a fixed center).

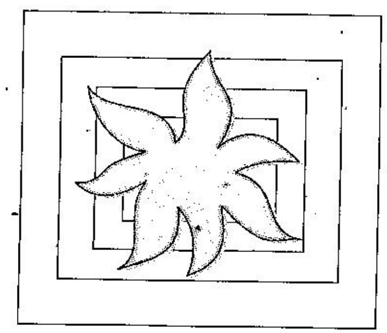

FIGURE 12.4 Zooming in on the Plant

12.6.2 Panning

Panning effects are produced by moving a fixed-size window across the various objects in a scene. In other words, if backward/forward is moved, then object appears to move in opposite direction than backward/forward. Sometimes it is also called **roaming.**

The example in Figure 12.5 illustrates how moon is moving down when backward(sky) is moving upward.

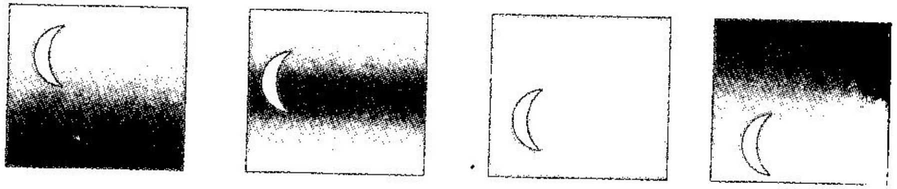

FIGURE 12.5 Effect of Panning, Background is Moved Upward

On an object both zooming and panning functions can be performed simultaneously.

12.6.3 Tweening

Tweening is an interesting animation function. It facilitates us how one figure "tweened" onto other.

It plays important role in film industry. In earlier days an artist has to draw 24 pictures for each second film, because movies display 24 frames per second. With the assistance of computer, however, an artist need draw only the first and final pictures, called key-frames and others are generated automatically.

Traditional animation sequence is created by two types of artists:

- The lead artists or experts who draw those frames where major changes take place within the sequence, called **key-frames.**
- Assistants draw a number of frames in between the frames, process is called **tweening.** It means insert in between other things (in be)tweening.

Figure 12.6 illustrates the motion of filled circle.

12.6.4 Morphing

Transformation of object shapes from one form to another is called **morphing.** Morphing is a shortened form of metamorphosis. It is special type of tween which deals with two different objects. For example, tween between face of one person to another person, cat and tiger, engine oil to tiger, vehicle to tiger.

Morphing is used in TV advertisements, movies, commercials, cartoons, and entertainment, etc.

There are two parts to the morphing algorithm:

Wrap

Wraping is the process of distorting the source image so that it matches with the target image.

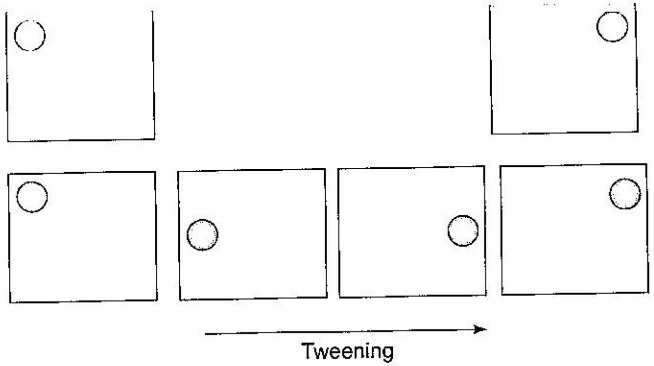

FIGURE 12.6 Effect of Tweening

Dissolve

It creates the sensation of melting the source image into subsequent image frames finally target image.

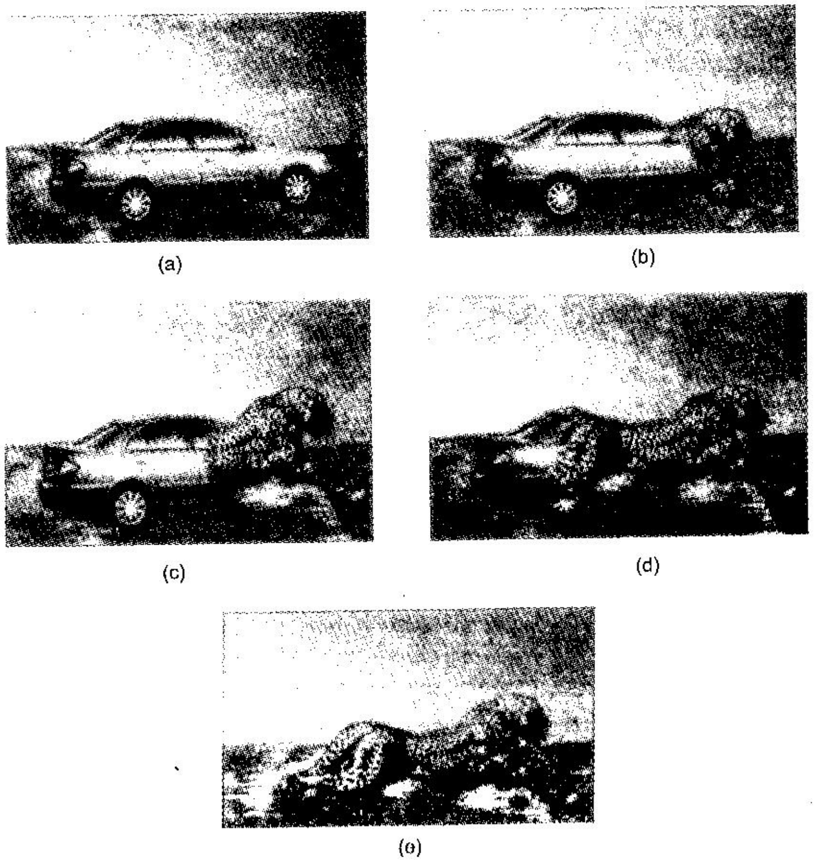

FIGURE 12.7 Morphing

12.6.5 Partial Motion

The term partial motion refers to the movement of parts of an object. Figure 12.8 illustrates the partial motion.

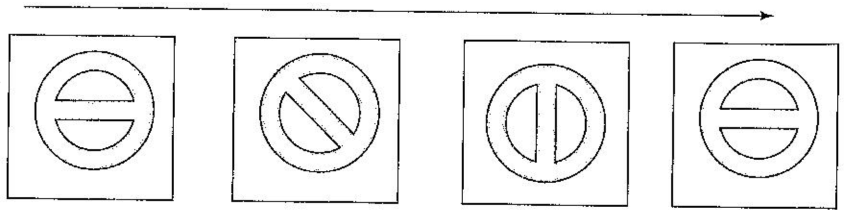

FIGURE 12.8 Effect of No Motion

12.7 ANIMATION TECHNIQUES

There are four basic techniques used in animation. These are:

- Drawn animation
- Cut-out animation
- Model animation or stop motion animation
- Computer animation or computer generated imagery (CGI)

12.7.1 Drawn Animation

This covers any form where one drawing is replaced by another in a sequence. Each drawing is slightly different from the one before. It works the way a flip book does.

These animated films are made up of thousands of drawings which are shown on screen very quickly one after the other.

Advantage

It looks great.

Disadvantage

It takes a very long time to film from start to finish and is expensive needing many animators to complete the work.

12.7.2 Cut-out Animation

This covers any form of animation where cut-out shapes are moved around or replaced by other cut-outs. Flat objects like buttons, matchsticks and string can also be used in this form of animation. Cut-outs can also be laid on top of drawings.

Advantage

It is very quick and easy to do.

Disadvantage

It is difficult to have more than one or two cut-outs moving at the same time. Cut-out animation appears to move in a very stiff and awkward way.

12.7.3 Model Animation or Stop Motion Animation

This involves the filming of puppets or any form of three-dimensional models. The materials used could include plasticine, clay or wire, in fact anything that can be bent or formed into another shape. The puppets are positioned and filmed before being moved ever so slightly and filmed again. These shots are put together as a piece of film and will give the impression of the models moving.

Advantage

Models can be used over and over again and copies made of them to shoot different scenes at the same time so that the filming takes less time.

Disadvantage

This type of animation needs a lot of time and hard work. The makers of 'James and the Giant Peach' were only able to complete 45 seconds of stop-motion animation a week, 10 seconds a day. This was because each puppet had so many joints that needed moving for each frame—the centipede alone had 72.

12.7.4 Computer Animation or Computer Generated Imagery (CGI)

This refers to the drawing of three-dimensional models and sets on the computer. Images can be scanned into the computer using digital photography or made within the computer itself. Human characters can be built from clay whilst sets and furnishings are modeled using design systems similar to architect's drawings. These models are scanned into the computer as wire frame models which are gradually built up into a coloured and textured form which will finally be recorded onto film.

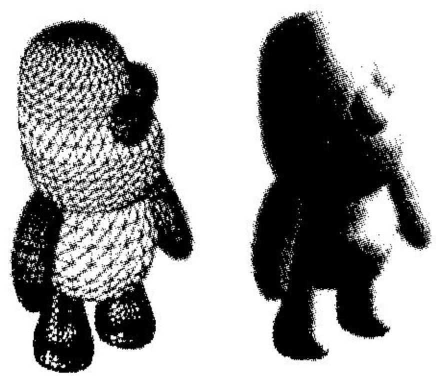

FIGURE 12.9