B.Tech.

Fourth Semester Examination, May-2011

Multimedia Technologies (IT-204-F)

Note : Attempt **five** question. Questions **No.1** is **compulsory** and attempt only **one** question from each of the **four** Sections.

Q. 1. Write short notes on :

(a) Morphing

(b) Shading

(c) Vector drawing

(d) Need for compression

Ans. (a) Morphing : The word marph derives from the word metamorphosis meaning to change shape, appearance or form. According to Vaughn morphing is defined as "an animation technique that allows you to dynamically blend two still images, creating a sequence of in-between pictures that, when played in Quick Time, metamorphoses the first image into the second."

Yongyue Zhang gives a detailed explanation of the process of morphing :

Morphing is achieved by coupling image warping with color interpolation. As the morphing proceeds, the source image is gradually distorted and is faded but, while the target image is faded in. So, the early images in the sequence are much like the first image. The middle image of the sequence is the average of the first image distorted halfway towards the second one and the second image distorted halfway back towards the first one. The last image in the sequence are similar to the second one. Then the whole process consists of warping two images so that they have the same ''shape'' and then cross dissolving the resulting images.

(b) Shading : Shading is a process used in drawing for depicting levels of darkness on paper by applying media more densely or with a darker shade for darker areas, and less densely or with a lighter shade for lighter areas. There are various techniques of shading including cross hatching where perpendicular lines of varying closeness are drawn in a grid pattern to shade an area. The closer the lines are together, the darker the area appears. Likewise, the farther apart the lines are, the lighter the area appears. Shading refers to depicting depth perception in 3D models or illustrations by varying levels of darkness. Light patterns such as objects having light and shaded areas, help when creating the illusion of depth on paper. In computer graphics, Shading refers to the process of altering a color based on its angle to lights and its distance from lights to create a photorealistic effects. Shading is performed during the rendering process.

(c) Vector Drawing : Vector drawing has come into its own for computer aided design (CAD) applications, bring with it bit-reduced images as a bonus. In recent years vector drawing has been introduced into microcomputer softwares. Graphics created in the Apple Lisa machine were stored as the co-ordinates of points along outlines generated automatically when the user created drawings. "Tools" were provided for assembling and manipulating outlines. Circles, lines , rectangles, polygons, etc. could be modified to form drawings. In the macintosh similar facilities are provided for graphics. This type of software enables special graphics effects to be achieved economically and easily.

Images that were created in a bitmap format cannot be easily converted to a vector format. Vector graphics, however, can be converted to bitmaps. In vector software, if you save as a bitmap file, the software will automatically convert it for you, which is particularly useful if you want to use a vector image on a web page.

Vector software with line-tracing capabilities can approximate a bitmap image. The daffodil shown earlier has been traced, creating a vector version of the bitmap image. The colors are not quite as sharp and well defined, but the advantage of having a vector drawing makes it worth the changes.

(d) Need for Compression : Multimedia files are large and consume lots of hard disk space. The files size makes it time-consuming to move them from place to place. Compression shrinks files, making them smaller and more practical to store and share "Window Media" and "Quick Time" are popular examples of compression formats for video clips.

While smaller data storage requirements would be the main benefits of an effective data compression technique, data could be handled more conveniently in compressed form. Data acquisition now requires shipping thousands of tapes from remote locations reducing the data volume would lower these shipping cost. Much of the seismic industry's computer resources is used simply to more seismic data from tape to computer memory where they are processed. While compressing and reconstructing data increases computational costs, the cost of data transfer might offset this. Morever data compression technique fit the old storage technology as well as the new technologies and reduces the need for these costly new technologies.

Advantages of Data Compression :

(i) Less disk space

(ii) Faster writing and reading

(iii) Faster file transfer

(iv) Variable dynamic range

(v) Byte order independent.

Section—A

Q. 2. (a) What are MM systems ? Also explain their characteristics.

Ans. Multimedia System : Multimedia systems discuss the basic characteristics of multimedia operating systems, networking and communication and multimedia middleware systems. The overall goal of the back is to provide a board understanding of multimedia systems and applications in an integrated manner : a multimedia applications and its user interface must be developed in an integrated fashion with underlying multimedia middleware, operating system, networks, security and multimedia devices.

Multimedia is usually recorded and played, displayed or accessed by information content processing devices, such as computerized and electronic devices, but can also be part of a live performance. Multimedia also describe electronic media devices used to store and experience multimedia content. The use of computers to present text, graphics, video, animation and sound in an integrated way. Long touted as the future revolution in computing, multimedia applications were uncommon due to expensive hardware required.

Characteristics of Multimedia :

(i) Multiple Types of Works Combined into a Single Work : It can be used to combined different types of work into a single category.

(ii) Adaptability : Multimedia is suitable for many different applications including professional service, education, training, sales and entertainment.

(iii) Storage and Delivery Medium : A motion picture stored on videotape for example combines two separate type—audio and visual into one work.

(iv) Digital Form : Multimedia store data and information into digital form whether it is text, video, audio or computer software.

(v) Interactivity and Involvement of Users : Interactivity refers to the ability of the users to make an immediate response to what is happening and modify the processes.

(vi) Ease of Distribution : The distribution of information through multimedia should be simple or highly automated.

Q. 2. (b) Explain ATM in detail.

Ans. ATM : An automated teller machine (ATM) is an electronic computerized telecommunication device that allows a financial institution's customers to directly use a secure method of communication to access their bank account, order or make cash withdrawls and check their account balances without the need for a human bank teller. Many ATMs also allow people to deposit cast or cheques. Transfer money between their bank accounts, top up their mobile phones pre-paid account or even buy postage stamp.

How Do ATM Work : An ATM is simply a data terminal with two input and four output devices. Most host processors can support either leased-line or dial-up machine. Leased line machine correct directly to the host processor through a four-wire, point to point, dedicated telephone line. Dial-up ATMs connect to the host processor through a normal phone line using a modem and a toll-free number, or though an Internet service provider using a local access number dialed by modem.

Leased-line ATMs are preferred for very high volume locations because of their through-put capability and dial-up ATMs are preferred for retail merchant locations where cost is a greater factor than through-put.

The host processor may be owned by a bank or financial officer or institution, or it may be owned by an independent service provider. Bank owned processors normally support only bank-owned machines. Whereas the independent processors support merchant owned machine Parts of the machine :

Input Devices :

(i) Card Reader : The card reader captures the account information stored on the magnetic stripe on the back of an ATM/Debit or Credit card. The host processor uses this information to route the transaction to the cardholder's bank..

(ii) Keypad : The keypad lets the cardholder to choose his action like cash withdrawl, balance enquiry etc. Bank requires the cardholder's PIN for verification.

Output Devices :

(i) Speaker : The speaker provides the cardholder with auditory feedback when a key is pressed.

(ii) Display Screen : The display screen shows the output of the cardholder's action.

(iii) Receipt Printer : The receipt printer provides the cardholder with a paper receipt of the transaction.

(iv) Cash Dispenser : The heart of an ATM is the safe and cash-dispensing mechanism. The entire bottom portion of most small ATMs is a safe that contains the cash.

Q. 3. (a) Explain various types of MM Authoring systems.

Ans. Authoring System : The "intelligent tutorial system" research community uses the term authoring systems to refer to a computer based system that allows a general group to create content for intelligent tutoring system. While a few intelligent tutoring system have been successfully created, they are very closely to construct

In the development of educational system, an authoring system is a program that allows a non-programmer to easily create software with programming features. The programming features are built in but hidden behind buttons and other tools, so the author does not need to know how to program. Generally authoring system provides lots of graphics, interaction and other tools educational software needs. Authoring system are related to authoring languages. An authoring language is the programming language that is behind the authoring system available for the programmer who is also developing educational software. This programmer can take advantages of tools built into the authoring system and then fine tune the product by accessing the language behind it

Authoring system vary widely :

(i) Orientation

(ii) Capabilities and

(iii) Learning curve

Use of an Authoring System :

(i) Can speed up programming possibly content development and delivery about 1/8th.

(ii) Time gain-accelerated prototyping.

(iii) However, the content creation not affected by choice of AS.

Different types of authoring system are used to create learning programs. Some of the most powerful were not developed specifically for language learning, but have been successfully used for this field. Software packages such as Authorware, toolbox and director have been on the market for many years. The problem with them is that, although they do simplify programming and are extremely powerful, they still involve quite a high learning curve if one is to get beyond the more basic presentation and in some cases are expensive. Authoring system have also been on the market for many years. These tend to concentrate on specific task like question, MC Cls, text manipulation etc.

Q. 3. (b) What is aliasing ? Write the techniques used to remove aliasing.

Ans. Aliasing : In signal processing and related disciplines, aliasing refers to an effect that causes different signal to become in distinguishable when sampled. It also refers to the distortion or artifact that results when the signal reconstructed from samples is different from the original continuous signal. When a signal digital image is viewed, a reconstruction also known as interpolation—is performed by a display and by the eyes and the brain. If the resolution is too low, the reconstruction image will differ from the original image and an alias is seen. An example of spatial aliasing is the moire pattern one can observe in a poorly pixelized image of a brick wall. Technique that avoid such poor pixelization are called **anti-aliasing**. Aliasing can be caused either by the sampling stage or reconstruction stage : these

may be distinguished by calling sampling aliasing **pre aliasing** are reconstruction aliasing postalising. Antialiasing methods were developed to combat the effects of aliasing.

There are three main classes of anti aliasing algorithms :

(i) As aliasing problem is due to low resolution, one easy solution is to increase the resolution.

(ii) The image is created at high resolution and then digitaliy filtered.

(iii) The image can be calculated by considering the intensity over a region.

Pre-filtering : Pre-filtering methods treats a pixel as an area, and compute pixel color based on the overlap of the scene's objects with a pixel's area. These techniques compute the shades of gray based on how much of pixel's area is covered by object.

Post-filtering : Post-filtering is the process by which aliasing effect in graphics are reduced by increasing the frequency of the sampling grid and then averaging the result s down. This process means calculating a virtual image at a higher spatial resolution than the frame store resolution and averaging down to final resolution.

Section—B

Q. 4. Explain the process of JPEG in detail.

Ans. JPEG : JPEG (Joint Photographic Experts Group) applies to color and gray-scaled still images. A fast coding and decoding of still images is also used for video sequence known as Motion JPEG. Today, parts of JPEG are already available as software only packages or together with specific hardware support.

JPEG fulfills the following requirements to further applications :

(i) The JPEG implementation should be independent of image size.

(ii) The JPEG implementation should be applicable to any image and pixel aspect ratio.

(iii) Color representation itself should be independent of the special implementation.

(iv) Image content may be of any complexity.

(v) The JPEG standard specification should be state of the art regarding the compression factor and achieved image quickly.

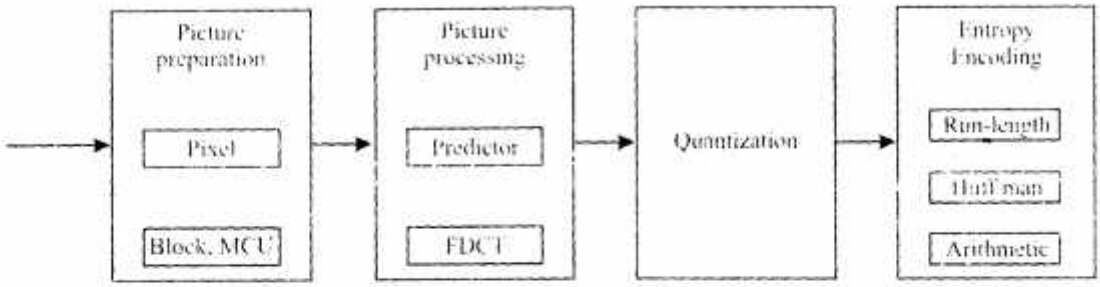
(vi) Processing complexity must permit a software solution to run on as many available standard processors as possible. Additionally the use of specialized hardware should substantially enhance image quality.

(vii) Sequential decoding and progressive decoding should be possible.

Applications do not have to include both an encoder and a decoder. In many applications only one of them is needed. The encoded data stream has a fixed interchange format that includes encoded image data, as well as the chosen parameters and tables of the coding process. If the compression and decompression process agree on a common set of coding tables to be used, for example, their data of the respective table need not be included in the data stream. These exists a common context between coding and decoding.

The interchange format can have an abbreviated format which does not guarantee inclusion of the necessary tables; however some may be provided.

Figure below outlines the steps of JPEG comptession in accordance with the overall scheme shown. Four different variants of image compression can be determined that lead to four modes.



Steps of the JPEG compression process

Each model itself includes further combinations :

(i) The lossy sequential DCT based mode must be supporting by every JPEG implementation.

(ii) The expanded lossy DCT based mode provides a set of further enhancements to the baseline process.

(iii) The loseless mode has a low compression ratio that allow perfect reconstruction of the original image.

(iv) The hierarchical mode accommodates image of different resolutions and selects its algorithms from the three modes defined above.

The baseline process takes the following techniques : Black, MCU, FDCT, Run-length and Huffman which are explained with the other modes in more detail in this section. In the next section, image preparation for all modes is presented, the remaining steps of image processing, quantization and entropy encoding are described.

Q. 5. (a) What are bitmap images ? What are the advantages and disadvantages of bitmaps over vector drawn images ?

Ans. In computer graphics, a bitmap or pixmap is a type of memory organizations or image file format used to store digital image. The term bitmap comes from the computer programming terminology meaning just a map of bits, a spatially mapped array of bits. Now along with bitmap, it commonly refers to the similar concepts of a spatially mapped array of pixels.

Bitmap is one of many types of file formats for images stored in computerized form. It carries the extension. BMP Computer uses bits of 1 and 0 to store data. A bitmap is literally a map of bits that form a particular picture when rendered to a display like a computer monitor. To understand how a bitmap image displays, it's important to understand the computer display screen. The display is made up of rows & columns of tiny blocks or pixels. In a bitmap image, each pixel is assigned at least one bit to indicate whether the pixel should reflect the background color, the foreground color or some other color.

In the case of a page of black and white text, let's consider a single letter. The many pixels that make up that letter only requires one bit of each. Either the pixel will be black or white i.e., 1 or 0.

Advantages of Bitmap over Vector Drawn Image :

(i) Bitmap image formats give a realistic result for representation of the real world, vector based image can only come as close as cartoon—style drawing of object.

(ii) Bitmap are better in presentation, adding nice shadows and affects.

(iii) The arrangement of tiny coloured square in bitmap produce the effect of an image. This is a good method of reproducing continuous tone image such as photograph.

Disadvantages of Bitmap over Vector Drawn Images :

(i) Vector based images are resolution independent. You can easily resize vector image to a thumbnail sketch or a billboard-sized graphics which is difficult in bitmap image.

(ii) Increase the size of bitmap image has the effect of increasing individual pixels, making lines and shapes appear rough and chunky.

(iii) Reduce the size of bitmap also distorts the original image.

Q. 5. (b) What is color palette ? What are the problems in color palette ?

Ans. The following are some of the widely used meanings for color palette in computing :

(i) Full Palette : For example, high color displays are said to have a 16-bit RGB palette. The limited selection of colors that can be displayed simultaneously.

(ii) Fixed Palette Selection : A given display adaptor can offer a fixed color selection when its hardware registers are appropriately set. For example, the color graphics adaptor in one of the standard graphic method.

(iii) Selected Colors or Picked Colors : In this case, the color selection generally from a wider explicitly available full palette, is always chosen by software, both by the users or by a program. For example, the standard VGA display adaptor is said to provide a palette of 256 simultaneous colors from a total of 262, 144 different colors.

(iv) Default Palette or System Palette : The given selected colors have been officially standardized by some body or corporation. For example, the well known web-safe colors for use with Internet browsers, or the Microsoft windows default palette.

(v) Color Map or Color Table : The limited color selection is stored inside the given indexed color image file.

(vi) Image Palette or Image Colors : The limited color selection is assumed to be the full list of the colors the given digital image has, even when the image file does not employ indexed color pixel encoding.

The underlying hardware that may be used to hold colors :

(vii) Hardware Palette : In order to show them, the selected colors values must be loaded in the color hardware registers of the display subsystem.

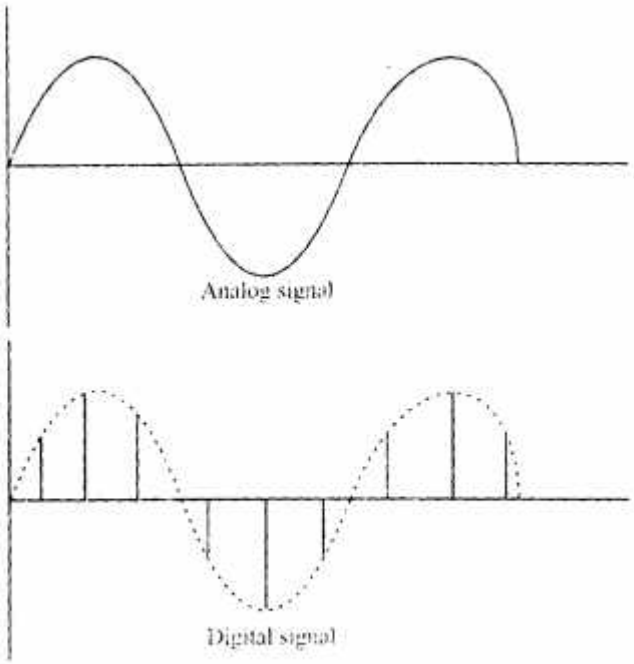
Section—C

Q. 6. (a) Explain the various methods of encoding the analog signal.

Ans. Sound in the analog world is said to be continuous in both time and amplitude. The sound's analog amplitude can be measured to an arbitrary degree of accuracy, and measurement can be taker at any point in time. A digital signal is different. Various methods of encoding the analog signal.

(i) Time-Domain Sampled Representation :

There are hardware devices called (ADCs) analog-to digital converters for moving analog to digital domain. The hardware in and around an ADC follows the input analog system signal ; takes a snapshot of its value at the sample time ; hold onto analog signal ; takes a snapshot of its value at the sample time ; hold onto that value until conversion is finished and output a number.



(ii) Other Methods of Encoding the Analog Signal : For speech signals, a widely used system works with a quantization step size that increases logarithmetically with the level of the signal. This means that the quantization levels are closest together when the signal is quiet and spaced under further apart when the signal is louder. For A-low transmission the signal is encoded according to

$$y = \begin{cases} \dfrac{A\alpha}{1+I_n A} & \left(0 \le x \le \dfrac{1}{A}\right) \\ \dfrac{1+I_n(An)}{1+I_n A} & \left(\dfrac{1}{A} \le x \le 1\right) \end{cases}$$

For μ-law encoding, the formula is

$$y = \frac{I_n(1+\mu x)}{I_n(1+\mu)} \qquad (0 \le x \le 1)$$

In standard telephone work, μ is set to 255 and A is set to 87.6 . The result in either case is an 8-bit signal that produce the dynamic range approximately associated with 12-bit PCM. In most cases, fewer bits per sample need to be transmitted, but delta modulation has problems. A more practical variant is called adaptive delta pulse code modulation or ADPCM. In order to handle both signal that change quickly as well as signals that changes slowly adjacent sample varies.

Q. 6. (b) Describe the process of transmission of digital sound and what problems may occur during transmission ?

Ans. Digital Audio Transmission : The digital information transmitted to the A/v receiver is in the form of packet or frames. Unlike PCM which transmits a stream of digital numbers representing the

amplitude of the analog waveform system like Dolby digital actually transmit a compressed version of the Fast Fourier Transform of the analog signal.

The digital data transmitted to the A/v receiver in frames, which consists of two parts : control information and the compressed fast fourier transform itself. The receiver synchronizes on a unique sync word at the start of each frame, if the transmission is so bad that it cannot find the sync word, the receiver will display UNLOCK on its front panel while it tries to get into sync. If synchronization is successful, the serial bit stream is stored in a memory buffer as a series of words.

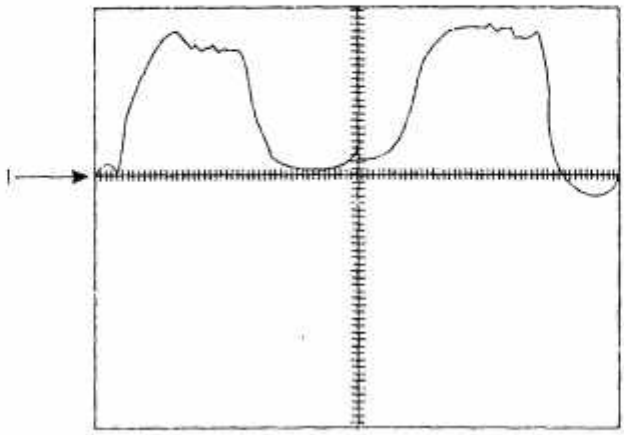


Fig. A reasonably good digital waveform.

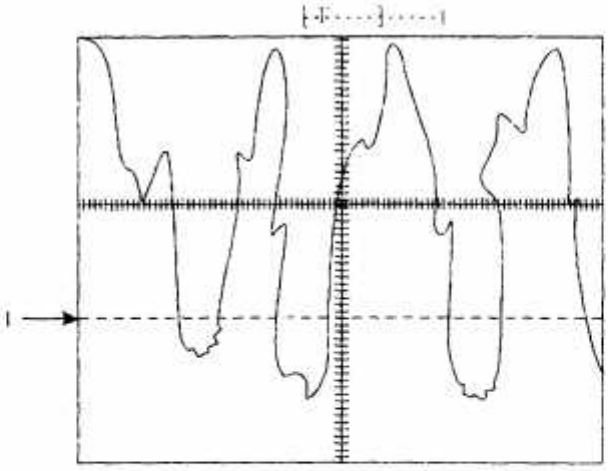


Fig. Glitches due to reflection from impedance mismatch

With the increasing use of computers the usage of and need for digital signal processing has increased. In order to use an analog signal on a computer it must be digitized with an analog to digital converter. Sampling is usually carried out in two stages, discretization and quantization. In the discretization stage, the space of signals is partitioned into equivalence classes and quantization is carried out by replacing the signal with representative signal of the corresponding equivalence class. In the quantization stage the representative signal values are approximated by values from a finite set. In

practice, the sampling frequency is often significantly more than twice required by signal's bandwidth. A digital to analog converter convert the digital signal back to analog.

Q. 7. Explain in detail the process of speech recognition and generation.

Ans. Speech recognition fundamentally functions as a pipeline that convert PCM (Pulse Code Modulation) digital audio from a sound card into recognized speech.

The elements of the pipeline are :

(i) Transform the PCM digital audio into a better acoustic presentation.

(ii) Apply a "grammar" so the speech recognition knows what phonemes to expect.

(iii) Figure out which phonemes are spoken.

(iv) Convert the phonemes into words.

Transforms the PCM Digital Audio : The first element of the pipeline converts digital audio coming from the sound card into a format that's more representative of what a person hears. The digital audio is stream of amplitudes, sampled at about 16,000 times per second. If you visualize the incoming data, it looks just like the output of an oscilloscope. It's a wavy line periodically repeats while the user is speaking. While in this form, the data isn't useful to speech recognition because it's too difficult to identify and patterns that correlate to what was actually said.

To make pattern recognition easier, the PCM digital audio is transformed into the "frequency domain". Transformation are done using a windowed fast fourier transform. The output is similar to what a spectrograph produces. In frequency domain, you can identify the frequency components of a sound. From the frequency components, it's possible to approx. how the human ear perceives the sound.

The fast fourier transform analyzes every $1/100^{th}$ of a sound and convert the audio data into the frequency domain. Each $1/100^{th}$ of a second result is a graph of the amplitudes of frequency components, describing the sound heard for that $1/100^{th}$ of a second. The speech recognizer has a database of several thousand such code book that identify different types of sound the human voice can make. The sound is "identified" by matching it to its closest entry in code book, producing a number that describes the sound. This number is called the "feature no."

The input to the speech recognition began as a stream of 16,000 PCM values per second. By using fast fourier transforms and the code book, it is boiled down into essential information, producing 100 feature no. per second.

Speech Generation : Speech generation is the process which allows the transformation of a string of phonetic and prosodic symbols into a synthetic speech signal. The quality of the result is a function of the quality of the string, as well as of the quality of the generation process itself. For a review of speech generation in English.

Lest us examine first what is requested today from a text to speech system. Usually two quality criteria are proposed. The first one is intelligibility, which can be measured by taking into account several kinds of unit (phonemes, syllables, words, phrases). The second one more difficult to define, is often labelled as pleasantness or naturalness. Actually the concept of naturalness may be related to the concept of realism in the field of image synthesis : the goal is not to restitute the reality but to suggest it. Thus, listening to a synthetic voice must allow the listener to attribute this voice to some pseudo-speaker and to perceive some kind of expressivity as well as some indices characterizing the speaking style and particular situation of elocution. For this purpose the extra-linguistic information must be supplied to the system.

Section—D

Q. 8. (a) Explain application of VR in various fields.

Ans. Applications of VR in Various Field : In the early 1090's the public's exposure to virtual reality rarely went beyond a relatively primitive demonstration of a few blocky figures being chased around a chessboard by a crude pterodactyl. While the entertainment industry is still interested in virtual reality applications in Games and theatre experiences, the really interesting uses for VR system are in various other field.

(i) Some architects create virtual models of their building plans so that people can walk through the structure before the foundation is even laid. Clients can move around exteriors and interiors and ask questions, or even suggest alterations to the design. Virtual models can give you a much more accurate idea of how moving through a building will feel than a miniature model.

(ii) Car companies have used VR technology to build virtual prototypes of new vehicles, testing them thoroughly before producing a single physical part. Designers can make alterations without having to scrap the entire model, as they often would with physical ones.

(iii) Virtual environments are used in training programs for military, the space program and even medical students. The military have long been supporters of VR technology and development. Training programs can include everything from vehicle simulations to squad combat. On the whole, VR systems are much safer and, in the long run, less expensive as those who trained under traditional conditions.

(iv) In medicine, staff can use virtual environments to train in everything from surgical procedures to diagnosing a patient surgeons have used virtual reality technology to not only train and educate, but also to perform surgery remotely by using robotic devices.

(v) Another use of VR technology is psychological therapy. Dr. Barbara Rothbaum of Emory University and Dr. Larry Hodges of the Georgia Institute of technology pioneered the use of virtual environment in treating people with phobias and other psychological conditions.

(vi) In order to study molecular and cellular structure in a more efficient and productive manner, virtual reality uses a method of computerized modeling.

Q. 8. (b) What is Desktop virtual reality ?

Ans. Desktop Virtual Reality : Desktop virtual reality refers to computer programs that simulate a real or imaginary world in 3D format that is displayed on screen (as apposed to immersive virtual reality).

Desktop virtual reality uses a computer monitor for virtual reality applications. Virtual reality is the technology that provides almost real and/or believable experience in synthetic or virtual way. Desktop VR uses a computer monitor as display to provide graphical interface for users. It is cost effective when compared to immersive VR as it does not require any expensive hardware and software and is also relatively easy to develop. Although they lack the immersion quality, they consist of computer generated environments which exist in three dimensions. It is possible to enhance the user experience by using stereoscopic 3D view, on a regular monitor, through the use of special software and 3D goggles. Because the world exist in three-dimensions, users can freely navigate in three dimensions around in the world. It is generally believed that the graduate deployment of desktop 3D monitors will increase the applicability of desktop VR in the near future.

The Personal Space Station (PSS) brings virtual reality to the desktop of the medical and scientific professional. Its purpose is to make VR more useful and accessible for the effective analysis of 3D and 4D data in medical and biological research. To this end, PS-Tech in the Netherlands and CWI in

developing and improving new technologies and techniques and methods for the application of VR in 3D and 4D Data analysis.

Desktop VR began in the industry (entertainment) making its first appearance in video arcade games. Made possible by the development of sophisticated computer graphics and animation technology, screen-based environment that were realistic, flexible, interactive and easily controlled by users opened major new possibilities for what has been termed unwired or unencumbered VR. Early in their development, advanced computer graphics were predicted, quite accurately, to make VR a reality for everyone at very low cost and with relative technical ease. Today the wide spread availability of sophisticated computer graphics software and reasonably priced consumer computer with high end graphics hardware components have placed the world of virtual reality on everyone's desktop.

Q. 9. (a) Explain Virtual Reality operating system.

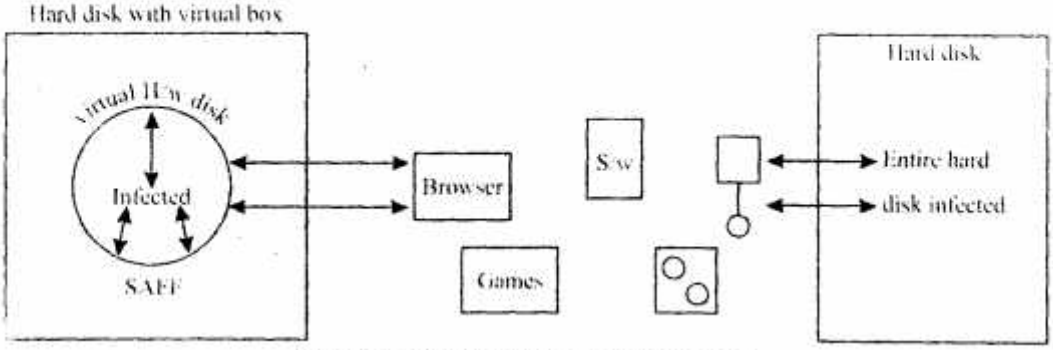
Ans. Virtual Reality Operating System : As technology matures, the demands on the performance of key components increases. In the case of computer technology, we have passed through massive mainframe to personal computer to powerful personal workstations. A growth in complexity of software tasks has accompanied the growth of hardware capabilities.

The virtual environment operating system or virtual reality operating system is currently under development at the human resource interface technology lab at the university of Washington. The VEOS project is the responsibility of Dr. William Bricken and a team of several graduate students lead by Geoffrey coco. VEOS is designed to integrate the diverse components of a virtual environment.

VEOS consists of several software subsystems. The kernel manages processes, memory and communication. The entity interface permits modeling objects in the environment, and the environment itself, in a consistent, object oriented manner. The interaction tools empower a participant within the virtual environment.

The design of VEOS reflects multiple objectives, many practical constraints, and some components. Most importantly, VEOS is a research prototype, intended to show the way rather than to be sold for profit. VEOS is supported by a consortium of industrial partners and is developed in the high turnover environment of a university research lab. Thus, it is constantly undergoing revision and iterative refinement.

The operating system capabilities required for virtual environment include : Support of very large number of light weight process communicating via shared memory, support of automatic and transparent distribution of task of multiple computing system, support of time-critical computation and rendering, and very high resolution time slicing and guaranteed execution for high priority processes.



Isolated OS on a virtual Environment