Computer Graphics and virtual reality systems

Q.No.1. Solve

*Q.No.1.*a. *Explain bitmap and vector based graphics.* *(05)*

Ans: Bitmap images are pixel based .It means that location and color information about the image is stored in individual pixels within a grid .In bit map images, each pixel has an assigned color. The information stored in a bitmap image regarding pixel location and color forms the image. Additional attributes of include:

1) Bitmap images are usally created and edited in photo or paint program.

2) The size of images is based on the image resolution.

3) Bitmap images are not easily scalable.

4) Bitmap images are mapped to a grid or an array of pixels.

Vector based are mathematically based images.

1) Vector based images are usally created and edited in software like CoralDRAW.

2) These images have smooth edges and created curves or shapes.

Q.No.1.b. Explain two point perspective transformations. *(05)*

Ans: Two point perspectives is a much more useful drawing system than the simpler one point perspective. Objects drawn in a two point perspective have a more natural look.

In two point perspective, sides of an object vanish to one of two vanishing points on the horizon. Vertical lines in the object have no perspective applied to them. The two -point perspective exists when the painting plate is parallel to a Cartesian scene in one axis but not to the other two axis. If the scene being viewed consists solely of a cylinder between a one point and two point perspectives.

*Q.No.1.*c) *Describe in brief physical modeling.* *(05)*

Ans: **Physical modeling:**

The next step in virtual world modeling ,following geometry and kinamatics,is the integration of the object's physical characteristics.These include weight ,inertia ,surface roughness,compilance ,deformation mode etc.These features together with object behavior ,bring more realism to the virtual world model.The physical modeling follows the stages of this pipeline ,namely collision detection ,force calculation,force smooting,force mapping and haptic texturing.

Collision detection:

The first stage of physical modeling is collision detection ,which determines whether two or more objects are in contact with each other.This can be considered a form of haptic clipping since only objects that collide are processed by the haptics rendering pipeline.Collision detection can be classified into approximate and exact. Approximate collision detection also called bounding box collision detection ,uses bounding boxes.

“Bounding box is a prism which encloses all the vertices of a given 3D objects.”

Bounding boxes are classified into oriented and axis-aligned.

In another exact collision detection method,insted of using a polygon representation for an object shape ,they used implicit functions that algebraically define the object surface.

Q.No.1.d) *Differentiate between RGB and CMY color model* *(05)*

Ans:

	RGB		CMY
1	Additive color model	1.	Subtractive color model
2	For computer displays	2.	For printing material
3	Uses light to display color	3	Uses ink to display color
4	Colors result from transmitted light	4	Colors result from reflected light
5	red+green+blue=White	5	Cyan+magenta+yellow=Black

Q.No 2. a . Write the DDA line drawing algoritm.Calculate the pixel coordinate of line AB using DDA Algorithm. Where A=(0,0) and B=(4,6) *(10)*

Ans: DDA algorithm:

The vector generation algorithm which step along the line to determine the pixels which should be turned ON are sometimes called digital differential analyzers.

We know that the slope of a straight line is given as

m=dy/dx=y2-y1/x2-x1

This differential eqation can be used to obtain a rasterised straight line.

Steps:

1)Read the line end points (x1,y1) and (x2,y2)

2)dx=|x2-x1|

dy=|y2-y1|

3)if (dx>=dy)

length=dx

```
else
        length=dy
4)select the raste unit i.e
        dx=(x2-x1)/length
        dy=(y2-y1)/length
5)      x=x1+0.5*Sign(dx)
        y=y1+0.5*sign(dy)
6)    Now plot the points
          i=1
          while (i<=length)
        {
                plot(x,y)
                x=x+dx
                y=y+dy
                i=i+1
        }
7) Stop
```

Q.No. 2.b. Write the matrices and draw the diagrams for scaling and rotation. *(10)*

Ans: **Rotation:** *Rotating an object with θ° in anti-clockwise direction.*

To generate a rotation transformation for an object, we must designate an axis of rotation and the amount of angular rotation. Rotation can be specified around any line in space. So, here rotation has 3 steps. They are

About z-axis
About y-axis
About x-axis

- **about z-axis (xy plane):**

If θ is an angle of rotation about z-axis in anti-clockwise direction,

the transformation equations are

$x^1 = x \cos\theta - y \sin\theta$

$y^1 = x \sin\theta + y \cos\theta$

$z^1 = z$

Therefore the transformation matrix is

$$[x^1 \;\; y^1 \;\; z^1] = [x \;\; y \;\; z \;\; 1] \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Transformation equations for rotations about the other two

co-ordinate axes can be obtained with a cyclic permutation of the co-ordinate parameters x, y, and z. i.e., we have to use the replacements in above equations

$x \rightarrow y \rightarrow z \rightarrow x$.

- **about x-axis (yz plane):**

$y^1 = y \cos\theta - z \sin\theta$

$z^1 = y \sin\theta + z \cos\theta$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

- **about y-axis (xz plane):**

$x^1 = x \cos\theta - z \sin\theta$

$z^1 = x \sin\theta + z \cos\theta$

$y^1 = y$

$$[x^1 \;\; y^1 \;\; z^1 \;\; 1] = [x \;\; y \;\; z \;\; 1] \begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$-\sin\theta \quad 0 \quad \cos\theta \quad 0$$

Scaling:

Enhancing or reducing the size of the object.

A scaling transformation alters the size of an object. This operation can be carried out for polygons by multiplying the co-ordinate values (x, y) of each vertex by scaling factors Sx , Sy and sz to produce the transformed coordinates.

The 3-D scaling transformation is

$$[x^1 \quad y^1 \quad z^1 \quad 1] = [x \quad y \quad z \quad 1] \begin{bmatrix} Sx & 0 & 0 & 0 \\ 0 & Sy & 0 & 0 \\ 0 & 0 & Sz & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

where Sx, Sy and Sz are scaling factors in x, y, z directions.

Q.No. 3.a. Describe the Sutherland -Cohen line clipping algorithm used for 3D. (10)

Ans: Similar to 2D ,the Cohen -Sutherland method can be extended to 3D by using six bit codes instead four .the extended algorithm in a 3D space clipping window boundaries defines 27 regions .Bits are set according to their position in the 3D space in reference to the viewing volume bounded by the viewing planes.

The Left, Right,Bottom,Top,Near/Front,Far/Behind (LRBTNF) out code can be used to determine segments that are trivially visible, trivially invisible or indeterminate.

The following are the important observations of the Cohen Sutherland algorithm:

*If codes of the endpoint are both zero, the line is visible.

*If the logical AND or intersection of end codes is not zero the line is tollally invisible.

*If the logical AND or intersection of end codes is zero,the line may be partially or fully invisible. The exact visibility of the line can be founded by determining the intersection of the line and clipping planes of the clipping volume.

In the indeterminate case, we intersect the line segment with faces of clipping cube determined by the out code of an end point that is outside of the clipping cube.

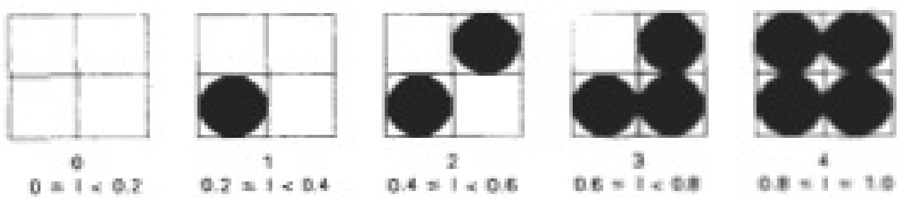
The algorithm suits well for a rectangular, parallelpiped,having parallel projections but required additional considerations for perspective clipping volumes.

Q.No. 3.b. Describe Halftoning, Thresolding,and Dithering technique. *(10)*

Ans: ***Half toning:***

In contrast to antialising where we use multiply intensity levels to increase the resolution ,halftoning is a technique for obtaining increased visual resolution with a minimum number of intensity levels .Basically ,rectangular grid of pixels are treated as single pixels. Halftone printing is a screen or cellular process. This is how photographs are usually reproduced for magazines and books.

For example ,using a 2x2 grid we can get five different intensities.



For a display of fixed resolution, several pixels are combined to yield a pattern cell .

Printed images are made up of millions of tiny dots. Before an image can be printed, it needs to be halftone ,or broken down into dots based on the different colors being used in the image .

Thresholding:

Half toning results in loss of spatial resolution which is accepteble if the image is of lower resolution than the display system. The technique for improving the visual resolution while maintaining the spatial resolution have also been developed .The simplest one is thresolding.The thresolding is to use a fixed threshold for each pixel .

If I(x,y)>T then

paint pixel with white color

else

paint pixel with black color

Where I(x,y) is the intensity of the image at spatial coordinates (x,y) and T is the threshold value.

Dithering:

Full-color photographs may contain an almost infinite range of color values. Dithering is the most common means of reducing the color range of images down to the 256 (or fewer) colors seen in 8-bit GIF images.

Dithering is the process of juxtaposing pixels of two colors to create the illusion that a third color is present. A simple example is an image with only black and white in the color palette. By combining black and white pixels in complex patterns a graphics program like Adobe Photoshop can create the illusion of gray values:

$$D_2 = \begin{bmatrix} 3 & 1 \\ 0 & 2 \end{bmatrix}$$

Q.No. 4.a. Explain LeGrange interpolation curves. *(10)*

Ans: The primary objective of LeGrange interpolation is to create a smooth curve that passes through an ordered group of points.When used in this fashion ,these points are called the control points.Like all curve algorithms,this method also uses the control points to generate parametric equations .To draw the curve ,all that is then needed is to step through u at some small amount,drawing straight lines between the calculated points.The smaller the step size,the more smooth the curve will appear .The step size can be calculated based on the amount of pixels available in the output image.

To perform LeGrange interpolation ,we wish to specify a curve that will pass through any number of control points .The curves function can be constructed as a sum of terms ,one for each control point.

These functions can be formulated as

The function Bi(u) is called blending function and specifies how much the ith control point effects the position of curve.

To achive the goal of LeGrange interpolation ,getting a curve that passes through all the specified control points ,the blending funcions must be defined so that the curve will go through each control point in the proper order.This can be done by creating blending functions ,Where the first control point is passed through at u=-1 the second control point is passed through at u=0,the third at u=1.The mathematical expression that does so is:

u(u-1)(u-2).........[u-(n-1)] (1)

at u=-1 ,this expression is

-1(-2)(-3)........(1-n) (2)

so dividing eq(1)by (2) gives

Bi(u)=u(u-1)........[u-(n-1)]/(-1)(-2).....(1-n) (3)

The number of control points used is most commonly four.

Q.No. 4.b Describe the various warping techniques. *(10)*

Ans: ***Warping techniques:***

An image warping is a process of digitally manipulating an image such that any shape portrayed in an image gets significantly distorted.The warping may be used for creating an image distotion as well as for creative purposes.

a*)Mesh Warping:*

a mesh Warping is a two pass algorithm that relates features in source and destination images with meshes.The algorithm relates features with a non-uniform mesh in the source and destination images.The mesh warping maps regions in a source grid to corresponding regions in a destination grid.This causes the features contained in a region of the source grid to morph into the features contained in the corresponding region of the destination grid.

b)Feature-based image warping:

The feature-based image warping method gives an animator a high level of control over the process.The animator interactively selects the corresponding feature lines in the images to be morphed.The algorithm uses lines to relate the features in the source image to the features in the destination image.It uses the reverse mapping for warping the image.

c) Thin plate spline based image warping:

A thin-plate spline (TPS) is a conventional tool for the surface interpolation over the scattered data.It is an interpolation method that finds a minimally blended smooth surface that passes through all given points.

The name “thin-plate” comes form the fact that a TPS more or less stimulates how a thin metal plate would behave if it is forced through the same control points.

Q.No. 5.a. Describe the design of a virtual reality system.Also explain types of virtual reality systems. *(10)*

Ans: ***Types of VR Systems***

A major distinction of VR systems is the mode with which they interface to the user. This section describes some of the common modes used in VR systems.

a. Window on World Systems (WoW)

Some systems use a conventional computer monitor to display the visual world. This sometimes called Desktop VR or a Window on a World (WoW). This concept traces its lineage back through the entire history of computer graphics. In 1965, Ivan Sutherland laid out a research program for computer graphics in a paper called "The Ultimate Display" that has driven the field for the past nearly thirty years.

b. Video Mapping

A variation of the WoW approach merges a video input of the user's silhouette with a 2D computer graphic. The user watches a monitor that shows his body's interaction with the world. Myron Kruger has been a champion of this form of VR since the late 60's. He has published two books on the subject: "Artificial Reality" and "Artificial Reality II". At least one commercial system uses this approach, the Mandala system. This system is based on a Commodore Amiga with some added hardware and software. A version of the Mandala is used by the cable TV channel Nickelodeon for a game show (Nick Arcade) to put the contestants into what appears to be a large video game.

c. Immersive Systems

The ultimate VR systems completely immerse the user's personal viewpoint inside the virtual world. These "immersive" VR systems are often equipped with a Head Mounted Display (HMD). This is a helmet or a face mask that holds the visual and auditory displays. The helmet may be free ranging, tethered, or it might be attached to some sort of a boom armature.

d. Telepresence

Telepresence is a variation on visualizing complete computer generated worlds. This a technology links remote sensors in the real world with the senses of a human operator. The remote sensors might be located on a robot, or they might be on the ends of WALDO like tools. Fire fighters use remotely operated vehicles to handle some dangerous conditions. Surgeons are using very small instruments on cables to do surgery without cutting a major hole in their patients. The instruments have a small video camera at the business end. Robots equipped with telepresence systems have already changed the way deep sea and volcanic exploration is done. NASA plans to use telerobotics for space exploration. There is currently a joint US/Russian project researching telepresence for space rover exploration.

e. Mixed Reality

Merging the Telepresence and Virtual Reality systems gives the Mixed Reality or Seamless Simulation systems. Here the computer generated inputs are merged with telepresence inputs and/or the users view of the real world. A surgeon's view of a brain surgery is overlaid with images from earlier CAT scans and real-time ultrasound. A fighter pilot sees computer generated maps and data displays inside his fancy helmet visor or on cockpit displays.

Q.No. 5.b. Explain the graphical rendering pipeline. *(10)*

Ans: “The VR engine is a key component of any VR system which reads its input devices,accesses task-dependent databases,performs the required real-time computations to update the state of the virtual world ,and feeds the result to the o/p displays.”

a)The rendering pipeline:

The rendering is generally associated with graphics.its represents the process of converting the 3D geometrical models populating a virtual world into a 2D scene preseted to the user.

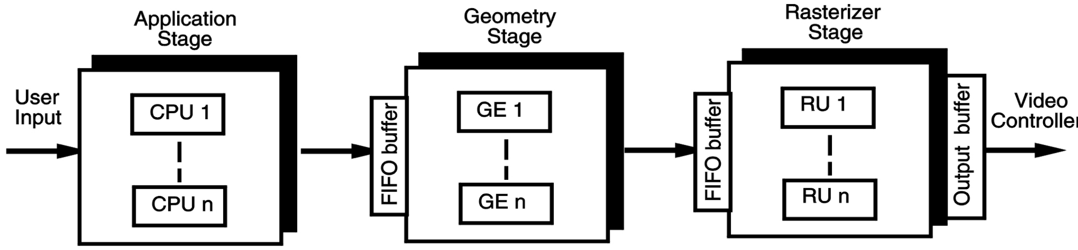
*The graphics rendering pipeline:

The process of creating a 2-D scene from a 3-D model is called “rendering.” The rendering pipeline has three functional stages. The speed of the pipeline is that of its

Slowest stage.

Old rendering pipelines were done in software (slow) Modern pipeline architecture uses parallelism and buffers. The application stage is implemented in software, while the other stages are *hardware-accelerated*.

The graphics rendering has three functional stages.



The first stage is the application stage ,which is done entirely in software by the CPU .It reads the world geometry database as well as the user's input mediated by devices such as mice ,trackballs, trackers or sensing gloves.

The application stage results are fed to the geometry stage, which can be implemented either in software or in hardware.

The last stage in the graphics pipeline is the rasterizing stage, which is done in H/W in order to gain speed.

Q.No. 6.a. Describe the input and output devices for virtual reality. *(10)*

Ans: **a)input devices:**

1)*Three dimensional position tracker:*

manny computer application domains such as navigation ,ballistic missile tracking,robotics,biomechanics,architecture,CAD,education and VR require knowledge of the real time position and orientation of moving objects within some frame of reference.these applications have varying requirements in terms of such parameters as measurement range,precision and temporal updates rates.

2)Trackball:

A class of interface that allow navigation/manipulation in relative coordinate are trackballs such as the Logitech Magollan.This is a sensorised cylinder that measures three factors and three torques applied by the users hand on a complaint element.

3)Three dimentional probes:

It consists of a small ,sensorised mechanical arm that sits on a support base,with a small 6 in x6 in footprint.the probe has six joints.

Each rotory joint represents one degree of freedom and thus probe has six degree of freedom.

4)Gesture interfaces:

"Gesture interfaces are devices that measure the real –time position ofthe users fingers in order to allow natural ,gesture-recognition–based interaction with the virtual environment."

Most gesture interfaces today are sensing gloves that have embeded sensors which measure the position of each finger versus the palm.

a)The pinch Glove

b)The 5DT Data Glove

c)The Dijiglove

d)The cyberGlove

b)output devices:

1)Head mount displays:

these project on image floating some 1-5 m in front of the user .

They used special optics placed between the HMD small image panels and the users eyes in order to allow the eyes to focus at such short distances without tiring easily.

Consumer grade HMD's use LCD displays,while more expensive professional -grade devices incorporate CRT based displays,which tend to have higher resolution.

The HMD weight ,comfort and cost are additional criteria to be considered in comparing the various models on the market.

2)Hand Supported displays(HSD):

These are personal graphics that the user holds in one or both hands in order to periodically view a synthetic scene.

3)Floor supported displays

4)Desk supported displays

5)Large volume displays:

“graphics displays that allow several users located in close proximity to simultaneously view a sterio or monoscopic image of the virtual world are called large volume displays.”

a)Monitor-based large volume Displays

b)projector based Displays

6)Sound Displays:

“Sound displays are computer interfaces that provide synthetic sound feedback to users interacting with the virtual world.The sound can be monoaural

or binaural”

7)Haptic feedback:

“Touch feedback conveys real time infomation on contact surface geometry ,visual object surface roughness,slippage and temp.It does not actively resist the user

s contact motion and cannot stop the user from moving through virtual surfaces.”

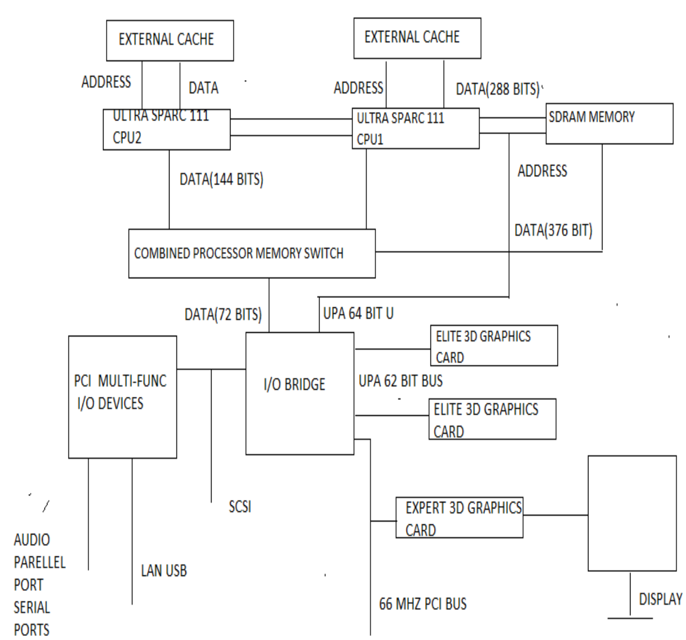
Q.No. 6.b. Explain in detail the sun Blade 1000 Architecture. *(10)*

Ans: ***a)The Sun blade 1000 architecture:***

In Sun Microsystems introduced a virtual holographic workstation .This system has evolved to the current sun blade 1000 workstation with Expert 3D graphics rendering 6 million triangles/sec.

The Blade 1000 has two 900Mhz Ultraspark III 64-bit processors each of which is twice as fast as the previous generation Ultraspark II CPUs.Their performance and low latency are helped by the presence of primary and secondary caches,which reduce the need to access the slower main memory.The data bus is wide and fully independent of the control/address bus.This is realised with the aid of a novel six processor combined processor memory switch through the data are routed.This design allows multiple memory calls to be serviced simultaneously and out of order ,such that one operation need not wait for another to be completed

SYSTEM ARCHITECTURE OF SUNBLADE 1000 WORKSTATION



Q.No. 7.a. Explain the winding number method. *(05)*

Ans: This is alternative method for even odd method for finding points interior to a polygon Winding number method also uses line running from outside of a polygon to the point in question and remembers the polygon edges it crosses .The winding number method gives each edge of a polygon a number called winding number in addition to counting the number of intersections as in case of the even odd method.

The winding number method is quiet simple and works well in most cases.

The method now associates a direction number called winding number with each edge .The sum of winding number of all sides called net winding number, determines if the point under consideration is inside or outside the polygon .The rule for the same is stated as if the winding number is non zero then the point is inside the polygon otherwise outside the polygon.

Q.No. 7.b. Explain virtual reality programming with reference to JAVA 3D. *(05)*

Ans: **JAVA 3D:**

Java 3D is one of the Java API's ,which was designed for object oriented programming of interactive 3D graphics applications.Similar to WTK,Java 3D uses OpenGL and Direct3D low level graphics library functions as well as the graphics accelerators that impliment them.

a)Model geometry and appearance:

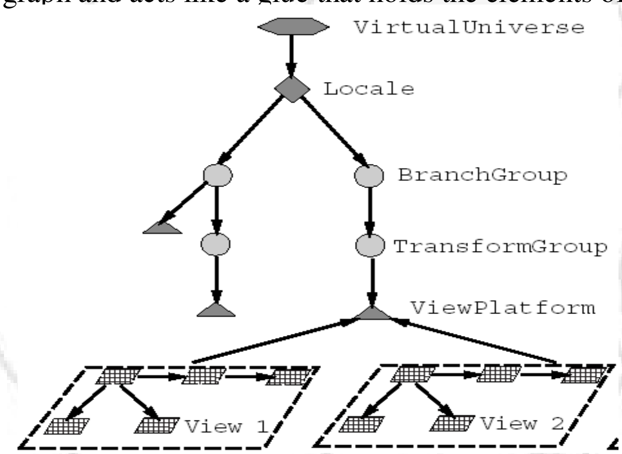
An object's 3D shape and appearance are specified by the Java3D class Shape3D(),which is an extension of the scene -graph leaf nodes.The specific values within the Shape3D( ) class are set by functions called methods,namely SetGeometry( ) and SetAppearance( ).

b)Java 3D scene graph:

following fig illustrates the major components of the java 3D scene graph.

The virtual world ,or universe has a collection of scene graphs.it has a Locale node,which anchors the multiple branch graphs in the world.

Each branch graph has a group node called BranchGroup,which defines a compilable subgraph and acts like a glue that holds the elements of the branch together.



Q.No. 7.c) Describe the motion control methods. *(05)*

Ans: ***Motion control methods:***

An Motion control methods specifies how an object or an articulated body is animated and be characterised according to type of information to which it is priviledged in animating the object or the character.

a)Methods based on geometric and kinamatic information:

These methods are based on animator.a motion is locally controlled and defined in terms of coordinates,angles,velocities or accelerations.Different approaches include performance animation,keyframe animation and image morphing techniques.

b)Methods based on physical information:

In these methods,an animator provides physical data, and motion is obtained by solving the dynamic equations.Motion is globally controlled.

c)Methods based on behavioral information:

A behavioral animation takes into account the relationship among different objects.The control of an animation may be performed at a task level. In fact ,a behavioral method is a method that derives the behavior of objects by performing high level directives,indicating a specific behavior without any other stimulus

Q.No. 7.d) Explain the applications of virtual reality in military and medicine. *(05)*

Ans: ***1)MILITARY VR APPLICATIONS***

The military has long understood the importance of simulation and training under the doctrine"we train as we fight and fight as we train". The current trend toward increased technological complexity and shorter military hardware lifespan requires simulators that are flexible, upgradeable, and less expensive. After all, if a simulator is designed only for a given tank model or aircraft model. Another trend in modern military training is networking. This allows remote simulation without having to transport trainees to the simulator site. Networking is also needed in team simulations, which are more realistic than single user ones. VR is networkable, flexible, and easily upgradeable.

2)Medical Application Of VR :

In recent years increased computer and Internet usage in medicine has started to change the way health care is delivered .the power of computing allows online medical education, patient databases, presurgery simulation, use of robotics ,remote consulating, digital radiography, expert systems and so on .the resulting increase in the quality of medical procedure marks up for increased equipment costs. Additionally, Internet computing facilitates patients , access to medical care, either locally or in remote locations where specialists are usually not available.

References:1)Computer graphics with virtual reality by R.K.Maurya

2)Computer graphics by D.Hearn M.baker