Computer Animation

Introduction

Computer animation is the art of creating moving images via the use of computers.

The main goal of computer animation is to synthesize the desired motion effect that involves mixing of natural phenomena, perception, and imagination. An animator designs an object's dynamic behavior with his imagination. Computer animation methods may also help us understand physical laws by adding motion control to data in order to show their evolution over time. Visualization has become an important way of validating new models created by scientists. Many people can use computer animation and virtual reality applications in their professions, such as pilots, architects, and even surgeons.

Computer animation may be defined as a technique in which the illusion of a movement is created by displaying on a screen or recording on a device, individual states of a dynamic scene. Formally, any computer animation sequence may be defined as a set of objects characterized by state variables evolving over time. It is a time sequence of visual changes in a scene. For example, a human character is normally characterized using its joint angles as state variables.

Key frame animation

A key frame animation consists of an automatic generation of the intermediate frames based on a set of key frames, supplied by an animator. There are two fundamental approaches to a key frame:

(a) In-betweens are obtained by shape interpolation. It plays a major role in film production and has been improved continuously by using sophisticated mathematical tools. This method makes it possible to transform a geometrical form into another during an animation. There is a serious problem for an image-based key frame; the motion can be distorted due to the interpolation. The problem becomes complicated when the two drawings do not have the same number of vertices. In this case, it is initially necessary to carry out a preprocessing step to equalize the number of vertices of the two drawings.

(b) A way of producing better images is to interpolate parameters of the model instead of the object itself. This technique is called a parametric key frame animation and a key transformation animation. The parameters are normally spatial parameters, physical parameters, and visualization parameters that decide the model's behavior.

The parametric key fame animation is considered as a direct kinematics method in motion control when the interpolated parameters are defined in the joint space of an articulated figure.

In both key-fame methods, a linear interpolation produces undesirable effects such as lack of smoothness in motion, discontinuity in the speed of motion, and distortion in rotations.

Construction of an animation sequence

In general, a typical animation sequence is obtained using:

- a storyline
- object definition
- key frame specification
- twining

Most of the animations belong to a frame-by-frame animation, where each frame of a scene is individually generated and displayed in the real-time playback mode or even stored for later processing.

A ***storyline*** is a sketch out of the action defining the motion progression as a set of basic events that must take place. It comprises all the events in a story, particularly rendered towards the achievement of some particular artistic or emotional effects. Depending on the type of animation to be produced, the storyline would consist of a set of rough sketches, or it could be a list of the basic ideas for the motion.

An ***object*** is a participant in an action that can have some properties and bear relations to other objects. An object definition is given to each participant in the action defined in terms of basic shapes, such as polygons, circles, arc, and spheres, coupled with movements of each object in the story.

A ***key frame*** in an animation is a drawing that defines the starting and ending points of any smooth transition. A sequence of key frames defines which movement will be seen, whereas the position of the frames in the animation defines the timing of the movement. Because only two or three key frames over the span of a second do not create the illusion of a movement, the remaining frames are filled in with in-betweens. More key frames are specified for a complex motion than a simple one, slowly varying the motion.

Twining, a short form for “in-betweening,” is a process of generating intermediate frames between two images to give an appearance that the first image evolves smoothly into the second image. The “in-betweens” are the drawings between the key frames that help create the illusion of motion. Twining is a key process in all types of animation, including a computer animation. The sophisticated animation software enables one to identify specific objects in an image and define how they should move and change during the twining process. Software may be used to manually render or adjust transitional frames by hand or may be used to automatically render transitional frames using interpolation of graphic parameters. The number of in-between frames needed is determined by the media to be used to display the animation.

Motion control methods

The key issue of computer animation is defining motion, commonly known as Motion Control Methods (MCMs). An MCM specifies how an object or an articulated body is animated and may be characterized, according to the type of information to which it is privileged in animating the object or the character. For example, in a key frame system for an articulated body, the privileged information to be manipulated is joint angles. In fact, any motion control method will eventually have to deal with geometric information (typically joint angles), but only geometric motion control methods are explicitly privileged to this information at the level of an animation control.

MCMs may be classified according to the nature of the information that is directly manipulated:

1. Geometric
2. Physical
3. Behavioral

1. **Methods based on geometric and kinematics information**

These methods are heavily dependent upon an animator. A motion is locally controlled and defined in terms of coordinates, angles, velocities, or accelerations.

Different approaches include:

- Performance animation
- Key frame animation
- Image morphing techniques

The ***performance animation*** is the simplest approach and it consists of recording of direct actions of a real person. The recording is for an immediate or a delayed playback. This technique is used today especially in production environments for a 3D character animation.

The ***key frame animation*** is another popular technique in which the animator explicitly specifies the kinematics (measurement of position, velocity and acceleration of an object) by supplying key frame values whose in-between frames are interpolated by the computer.

Inverse kinematics is a technique coming from robotics, where the motion of links of a chain is computed from the end-link trajectory.

Image morphing is a warping-based technique that interpolates the features between two images to obtain a natural in-between image.

2. Methods based on physical information

In these methods, an animator provides physical data. The motion is obtained by solving the dynamics equations based on physics laws. Motion is globally controlled. We may distinguish methods based on parameter adjustment and constraint-based methods. In constraint based methods the animator states in terms of constraints and the properties the model is supposed to have without needing to adjust parameters. For example, a ball rolls down in inclined plane. If gravity were the only force acting on the ball, the ball would fall straight down. But the plane is also pushing up and sideways, the ball rolls down the plane .We can model such motion by constraints. The ball is constrained to lie on one side of the plane. If it is dropped from a height, it strikes the plane and bounces off. In the physics-based animation, the collision detection and the response are obviously important.

3. Methods based on behavioral information

Behavioral animation has been used to animate flocks of birds, schools of fish, herds, and crowds. All of these require interaction between a large number of "characters" with relatively simple, rule-based motion. Fabric can also be simulated using behavioral techniques.

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

Procedural animation

A procedural animation is a type of computer animation, used to automatically generate animation in real time to allow for a diverse series of actions.

With traditional animation method, every principal animation poses are specified by an animator. In other words these animations are predefined. In order to maximize artistic impact of their craft, animators employ traditional animation techniques to set pose manually at a specific point in time. When the objects to be animated become significantly more complex, traditional animation techniques may not be feasible. In such cases procedural animation technique can be used.

Procedural animation is a rule-base approach to creating animations. These rules are typically some form of mathematical or statistical functions which tell the animation software how an object is to be animated. In order for the geometry to be animated, these functions typically require some form of time-based variable as its input. Therefore, one can apply a chain of logical rules and algorithms to create animations without manually specify any key poses.

The procedural animation is used to simulate particle systems (smoke, fire, water, etc.), cloth and clothing, rigid-body dynamics, hair and fur dynamics, and character animation. In computer and video games, it is often used for simple things like turning a character's head when a player looks around.

Technically, the procedural animation corresponds to the creation of a motion by a procedure, specifically describing the motion. Rules are established for a system, and an initial state is defined for objects in the system. Object locations or parameters for subsequent frames are computed by applying the forces or behaviors defined for the system to the conditions established in the previous frame.

The procedural animation can be very useful for generating much life-like motion from relatively little input. Such an animation should be used when the motion can be described by an algorithm or a formula.

The number of all possible algorithms is unlimited. But, since the look of future frames is entirely dependent on conditions from previous frames, procedural approaches can suffer from a lack of explicit control over the look of individual frames.

Advantages and disadvantages - When the objects to be animated become more complex, it is difficult to implement traditional animation techniques. Therefore, procedural animation technique is used to generate real time animation automatically. Using procedural animation method infinite variation of models and animations can be created. But the disadvantage is specific key pose is often left as random chance. Therefore, computer graphics animator must decide between the combinations of both techniques in order to achieve the desired outcome.

Application of Procedural animation - Procedural animation is used extensively in visual effects for movie and gaming industry where animation data and geometry must be generated with certain random probability in order to simulate physical world.

Key frame animation vs. procedural animation

Key Frame Animation	Procedural Animation
The animator creates the behavior of a model manually	Animator provides initial conditions and software generates subsequent behavior of the object
The animator has full and direct control over the positions, shapes, and motions of models during the animation	The animator has to run a simulation to see the result
The outcome can be predicted.	The outcome of varying the parameter values is often unpredictable

Introduction to Morphing

Morphing is a phenomenon by which a picture smoothly transmutes into another picture. Intermediate images, that bridge the transition, are calculated from the source and destination images using a mathematical formula. The two major techniques for calculating these intermediate images include mesh and field-morphing. An illustration of a simple morphing is given in the following figure.

The morphing is a combination of two processes:

- cross-dissolving
- warping

Cross-dissolving changes the image's colors, pixel by pixel. The cross dissolving is a process that produces the bridging images by averaging the pixel colors row by-row and column-by-column. In other words, in any intermediate image of a cross-dissolve, the pixel at row x and column y is the average of the pixel color at (x, y) in the source and the pixel color at (x, y) in the destination image. A simple morph between the two similar images with the same dimensions and resolution can be created with cross-dissolving alone. For example, the cross-dissolving can change a green circle into a blue square flawlessly. However, to change a green circle into a blue square, one would need to change the shape of the circle to fit the shape of a square before or while cross-dissolving.

Warping is used to change shapes of objects. Warping changes the shape of features in an image by shifting its pixels around. It uses one of the many algorithms to change the row and column values of an image's pixels, thus changing the actual shape of features in an image. By itself, the warping acts like a funhouse mirror, distorting the feature in a single image. Generally, the process of morphing warping deforms the two images so that their features are in the same shape followed by the cross-dissolving between them, resulting in a smooth transformation.

The process of Morphing involves three steps:

1. In the first step, one initial image and other final image are added to morphing application as shown in fig: 1st & 4th object consider as key frames.
2. The second step involves the selection of key points on both the images for a smooth transition between two images as shown in 2nd object.
3. In the third step, the key point of the first image transforms to a corresponding key point of the second image as shown in 3rd object of the figure.

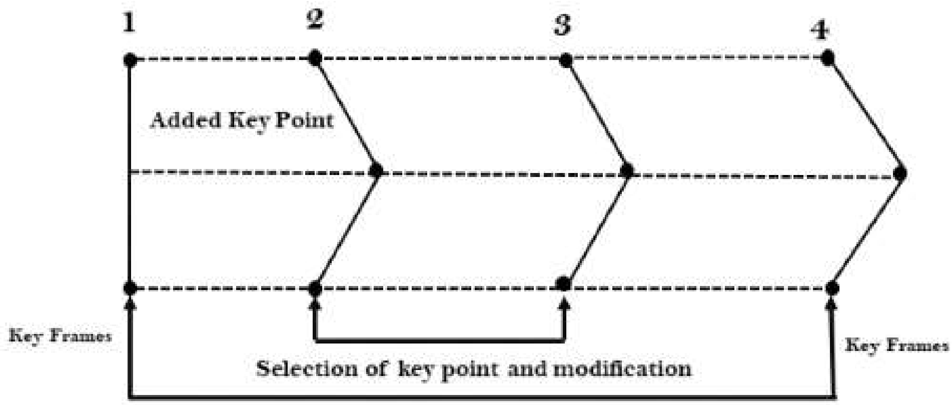


Fig: Process of Morphing

Intermediate images

To make a transition smooth, each intermediate frame is seen as a combination of beginning and ending pictures. An image's position in the sequence determines the influence that the beginning and ending frames will have upon it. It is noteworthy that early images in a sequence are much like the first source image. The middle image of the sequence is the average of the first source image distorted halfway toward the second one and the second source image distorted halfway back toward the first one. The last image in the sequence is similar to the second source image—the destination image.

For example, consider a sequence of ten total frames. The first frame is 100 percent of the start image blended with 0 percent of the end image. The second frame is 90 percent of the start image blended with 10 percent of the end image. The third frame is 80 percent and 20 percent, and so forth. In a general case, the i^{th} frame in the sequence is given by

$(Frame)_I$ = (i/ Numframes)% Destination

blended with

((Numframes-i) / Numframes) % Source

This blending of source and destination images produces the much desired gradual smooth transition from source to destination image. This technique of calculating is popular one among its counter ones.

Mapping orders

Image data structures allow storage and access of image in a matrix form wherein row major or column major form could be used. A morphing algorithm traverses an image row-by-row, column-by-column (or vice versa) using a formula to calculate the pixels for a new image.

The traverse order can be referred to as

- a forward mapping
- an inverse mapping

The ***forward mapping*** iterates over a source image. A source image is one of the images specified by a user. Therefore, its pixels already have color values. Any new image starts out blank, with all of its pixels colored white. The forward mapping visits each pixel in the source image and uses the morphing formula to calculate new coordinates for the pixel. It then paints the source pixel's color in the new image at the calculated set of pixel coordinates.

An ***inverse mapping*** goes the opposite way, iterates over the new image. It visits each blank (white) pixel and uses the formula to calculate the coordinates of the pixel in the source image whose color it should copy.

Introduction to Virtual reality (VR)

Virtual Reality is a technology that allows a user to interact with a computer-simulated environment, be it a real or imaginary one.

It is the key to experiencing, feeling and touching the past, present and the future. It is the medium of creating our own world, our own customized reality. It could range from creating a video game to having a virtual stroll around the universe, from walking through our own dream house to experiencing a walk on an alien planet. With virtual reality, we can experience the most intimidating situations by playing safe and with a learning perspective.

Most current VR environments are primarily visual experiences, displayed either on a computer screen or through special or stereoscopic displays. But some simulations include additional sensory information such as sound through speakers or headphones. Some advanced systems now include tactile information, generally known as force feedback in medical and gaming applications. Users can interact with a virtual environment or a virtual artifact either through the use of standard input devices (such as a keyboard and mouse) or through multi modal devices (such as a wired glove, boom arm, and omni-directional treadmill).

The simulated environment can be similar to the real world, for example, simulations for pilot or combat training, or it can differ significantly from reality, as in VR games. In practice, it is currently very difficult to create a high-fidelity VR experience, largely due to technical limitations on processing power, image resolution, and communication bandwidth. However, those limitations expected to eventually overcome as processor, imaging, and data communication technologies become more powerful and cost effective over time.

Virtual reality is essentially:

- **Believable**: You really need to feel like you are in your virtual world (on Mars, or wherever) and to keep believing that, or the *illusion* of virtual reality will disappear.
- **Interactive**: As you move around, the VR world needs to move with you. You can watch a 3D movie and be transported up to the Moon or down to the seabed—but it's not interactive in any sense.
- **Computer-generated**: Only powerful machines, with realistic 3D computer graphics, are fast enough to make believable, interactive, alternative worlds that change in real-time as we move around them.
- **Explorable**: A VR world needs to be big and detailed enough for you to explore. However realistic a painting is, it shows only one scene, from one perspective. A book

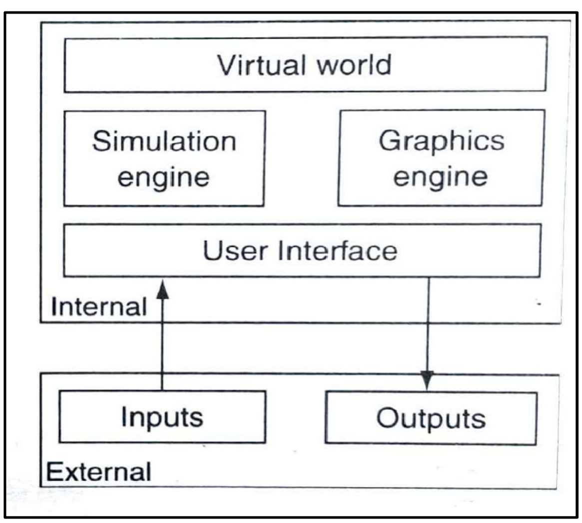
can describe a vast and complex "virtual world," but you can only really explore it in a linear way, exactly as the author describes it.

- **Immersive**: To be both believable and interactive, VR needs to engage both your body and your mind. Paintings by war artists can give us glimpses of conflict, but they can never fully convey the sight, sound, smell, taste, and feel of battle. You can play a flight simulator game on your home PC and be lost in a very realistic, interactive experience for hours (the landscape will constantly change as your plane flies through it), but it's not like using a real flight simulator (where you sit in a hydraulically operated mockup of a real cockpit and feel actual forces as it tips and tilts), and even less like flying a plane.

Design of a Virtual Reality System

There is always a trade-off between realism and interactivity. The more realistic a scene must appear, the longer it takes to render and the slower the virtual environment will update. This again produces two different opinions on what a VR system's goals should be. Some people believe that a VR system must look real, requiring the most detailed images possible. Other people believe that it is the fluidity and responsiveness of a 3D environment that provides a key to the VR system. Both these approaches are valid, but in terms of computer graphics, they are mutually exclusive. Incredibly detailed images make a virtual environment appear more realistic, but movement through the environment is slow and cumbersome, detracting from the experience. On the other hand, lesser-detailed scenes will appear false and artificial, but movement through the environment is smooth and responsive giving a heightened sense of immersion.

Classical components of VR system



A typical VR system consists of six main components:

- Virtual world
- Graphics engine
- Simulation engine
- User interface
- User inputs
- User outputs

The virtual world, simulation engine, graphics engine, and user interface are all internal components to a VR software package, input and outputs are external ones.

V**irtual world** - A virtual world is a scene database that contains geometric representations and attributes for all objects within the environment. The format of this representation is dependent on the graphics and simulation engines used.

Graphics engine -The graphics engine is responsible for actually generating the image that a viewer sees. This is done by taking into account the scene database and the viewer's current position and orientation. It also includes combining information from the scene database with textures, sounds, special effects, etc., to produce an impression that you are looking at the scene from a particular point.

Simulation engine- The simulation engine actually does most of the work required to maintain a virtual environment. It is concerned purely with the dynamics of the environment—how it changes over time and how it responds to user's actions. This includes handling any interactions, programmed object actions, physical simulation (for example, gravity or inertia) or user actions. Finally, the user interface controls how the user navigates and interacts with this virtual environment. It acts as a buffer between the virtual world software and the myriad of input and output devices that may be used.

Inputs and outputs- Inputs and outputs are mostly independent of the VR software except in specialized applications.

Input Devices:-The input devices are the means by which the user interacts with the virtual world. They send signals to the system about the action of the user, so as to provide appropriate reactions back to the user through the output devices in real time. They can be classified into tracking device, point input device, bio-controllers and voice device.

Tracking devices sometimes referred to as position sensors, are used in tracking the position of the user. Examples are - electromagnetic, ultrasonic, optical, mechanical and gyroscopic sensors, data gloves, neural and bio or muscular controllers.

Examples of point-input devices include 6DOF mouse and force or space ball. Their technology is an adaptation of the normal mouse with extended functions and capability for 3D.

Voice communication is a common way of interaction among humans. So it feels natural to incorporate it into a VR system. Voice recognition or processing software can be used in accomplishing this.

Output Devices:-The output devices get feedback from the VR engine and pass it on to the users through the corresponding output devices to stimulate the senses.

The possible classifications of output devices based on the senses are:

- graphics (visual)
- audio (aural),
- haptic (contact or force).

Two possible common options for the graphics are the stereo display monitor, and the HMD which provides a higher level of immersion.

Audio or sound is an important channel in VR.3D sound can be used in producing different sounds from different location to make the VR application more realistic.

Haptic is used to allow the user feel virtual objects. This can be achieved through electronic signals or mechanical devices.

Important factors in a virtual reality system

There are many factors that can attribute to a realistic and believable virtual environment.

1. Visual realism

The level of realism in a scene aids considerably in making a believable environment. Ray tracer and professional animation systems produce incredibly realistic images such as those used in special effects for movie production. Some of the best applications of this technology result in the viewer not noticing any transition or discrepancies between real footage and computer generated effects. Providing this level of detail and sophistication is extremely complex and requires a great deal of rendering time. More and more advanced features are slowly appearing in virtual environments, though it is still a long time before we reach the same quality that the current computer animation can provide.

2. Image resolution

Image resolution is another factor that is closely linked with visual realism. Computer generated images consist of discrete picture elements or pixels, the size and number of these being dependent on the display size and resolution. At higher resolutions, the discrete nature of the display becomes less apparent. However, the number of pixels in the image becomes vastly greater. As the color and intensity of each pixel must be generated individually, this puts a heavy load on the graphics system.

3. Frame rate

A frame rate is another factor of a discrete nature used in computer graphics and animation. To give the impression of a dynamic picture, the system simply updates the display very frequently with a new image. This system relies on the human phenomenon of persistence of vision, our ability to integrate a rapid succession of discrete images into a visual continuum. This occurs at frequencies above the critical fusion frequency (CFF) that can be as low as 20 Hz. Normal television broadcasts update at a frequency of 50 Hz or 60 Hz. This means that in order for a virtual environment to appear flicker free, the system must update the image greater than 20 times each second—again a heavy load on the graphics system.

4. Latency

Latency (or lag) has been one of the most important aspects of a VR system that must be addressed to make the environment not only more realistic but also tolerable. Latency is the delay induced by various components of a VR system between a user's inputs and the corresponding response from the system in the form of a change in the display. As latency increases, a user's senses become increasingly confused as their actions become more and more delayed. Chronic cases can even result in a simulator sickness, a recognized medical problem associated with virtual environments. Latency must be kept to a minimum in order to create a usable VR system.

Types of virtual reality systems

The term Virtual Reality has limitless interpretations. There are a number of different classifications of VR system that are based mainly on the interface methods used.

1. Window-on-world or desktop VR

One of the most common and accessible forms of VR is desktop VR, or window on world (WoW) systems. Desktop VR involves displaying a 3D virtual world on a regular desktop display without using a specialized movement-tracking equipment. These systems do not rely on any specialized input or output devices in order to use them; typically, a normal computer mouse or a monitor is sufficient. In a desktop VR, a computer user views a virtual environment through one or more computer screens. Many modern computer games can be used as an example, using various triggers, responsive characters, and other such interactive devices to make the user feel as though they are in a virtual world. A user can then interact with that environment, but is not immersed in it. A common criticism of this form of immersion is that there is no sense of peripheral vision, limiting the user's ability to know what is happening around them.

2. Video mapping VR

A video mapping VR uses cameras to project an image of a user into a computer program, thus creating a 2D computer character. Although fully immersed in the environment, it is difficult to interact with the user's surroundings. Monitoring the user with a video camera provides another form of interactive environment. The computer identifies the user's body and overlays it upon a computer generated scene. The user can watch a monitor that shows the combined image. By gesturing and moving around in front of the camera the user can interact with the virtual environment.

3. Immersive VR

The goal of VR is to completely immerse a user within a synthetic environment, make them feel a part of that environment. This means the user is effectively cut off from the real world and instead has his presence and viewpoint within the virtual world. This usually involves a head mounted display (HMD) that provides visual and auditory feedback. An immersive VR uses an HMD to project a video directly in front of the user's eyes, plays audio directly into the user's ears, and tracks the whereabouts of the user's head. Then a data glove (or data suit) is used to track movements of the user's body, and then duplicates them in the virtual environment. When the user cannot distinguish between what is real and what is not, then immersive VR has succeeded. Another such an immersive system uses a "cave" environment. This is a room that uses multiple, large projectors to display the appropriate viewpoints on each wall of the room.

One important difference between using an HMD and using a cave system is - the CAVE system can be a directly shared experience, whereas in HMD, each user would only be aware of other users via a graphical representation of them.

4. Telepresence

Telepresence is a technology that links remote sensors in the real world with the senses of a human operator. It links remote sensors and cameras in the real world with an interface to a human operator.

For example, the remote robots used in bomb disposal operations are a form of telepresence. The operator can see the environment that the robot is in and can control its position and actions from a safe distance.

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. Such systems are widely used in applications that must be performed in hostile or dangerous environments.

5. Augmented Reality (AR)

AR is a technology that lets people superimpose digital content (images, sounds, text) over a real-world environment. An augmented (or mixed) reality provides a half way point between a non-immersive and fully immersive VR system. Augmented reality (AR) systems overlay computer-generated information over the user's view of the real world, without completely occluding it. In other words, the computer-generated inputs are merged with telepresence inputs and the users view of the real world.

Examples of such applications are head-up displays (HUD) used widely in modern military aircraft. These superimpose flight data such as altitude, air speed, artificial horizons, and targeting information upon the pilot's field of view. This can be on a cockpit-mounted display, or even upon the pilot's helmet visor. There are many, possibly very useful, applications of AR systems that will probably be more acceptable and desirable than fully immersive or desktop VR systems.

6. Fish tank VR

The phrase, fish tank VR, was used to describe a hybrid system that incorporated a standard desktop VR system with a stereoscopic viewing and head-tracking mechanism. The system uses LCD shutter glasses to provide the stereoscopic images and a head tracker that monitored the user's point of view on the screen. As the user moves his head, the screen display is updated to show the new perspective. This provides a far superior viewing experience than normal desktop VR systems by providing motion parallax as the user moves his head.

Advantages of Virtual Reality

VR has a lot of benefits. It gives disabled people the opportunity to join the activities not usually available to them.

Helps with Impressive Visualization – It helps in exploring various facts and can even alternate the level of experience. If you wear a VR headset, you can experience the best quality visualizations.

Allows Students to Get Engaged – These days it has become difficult for the teachers to conduct classroom interaction sessions. With the introduction of the Virtual Reality technicality, interaction with the student can be made so easy. The students can take help of virtual reality to speak about their personal experiences.

Creating Interest – Virtual Reality has made watching more enjoyable than reading. VR technicality is extremely interesting and engaging. VR technology creates enjoyable experience. This technology motivates the students to learn and know better in life.

Improves Educational Value – VR technology also works best in fields of editing and content writing. It helps in locating mistakes in contents. There are preferred software arrangements to make fault detections. VR technology also helps with perfect editing options.

Helps to Overcome Language Barriers – Language barrier is a significant problem in the field of education. In case, if you are not studying in your hometown you need to adopt the dialect of the place where you are considering. With the implementation of Virtual Reality the possible language can be aptly implemented by making use of the suitable software.

Training- In some sectors, VR is used to train employees, especially in dangerous environments. For example, pilots use simulators in case they make a mistake, and aspiring doctors take advantage of virtual reality to avoid medical accidents. Pilots landing a plane, firefighters prepping before their first fire – this is immersive learning at its most powerful. Immersive learning will lessen the difference between beginners and veterans in many professions.

Conferencing- VR has the potential to bring digital workers together in digital meetings and conferences. There will be real-time event coverage. Rather than merely seeing the other person on a screen, you will be able to feel as if you are in the same room with them, despite being miles away. With the rise of the freelancer economy, virtual meetings may become the norm rather than the exception.

Convenience- VR can save organizations time and money and make work more convenient. Workers won't have to travel in order to make decisions and complete projects. For example, architects from across the globe can use virtual reality to evaluate designs. VR also opens the door for a virtual marketplace, where shoppers can try on garments, and you can see what that Arabian rug will look like in your den.

Disadvantages

Lacks Flexibility – In the classroom you can act with flexibility. You are open to give suggestions and ask questions. This is not possible with virtual reality. With the virtual reality headset, you can make use of the same program in all the sessions. There is no scope for positive interaction.

Ineffective Human Connections – Virtual Reality comes with the set of disadvantages. The conventional education system is mainly based on interpersonal connections and the level of individual human communication. The concept of Virtual Reality is different. It is only about you and the software.

Getting Addicted – Addiction to Virtual Reality is extremely common. The students can get addicted to the virtual world. The section of the population is getting addicted to video games and the rest. In the world of Virtual Reality, one can even get addicted to harmful drugs.

Review Questions

1. What is computer animation? Briefly describe the elements of designing an animation sequence.
2. Compare and contrast different types of motion control methods.
3. What is a procedural animation? Explain how it generates motion? Compare it with the key frame animation technique.
4. Write a note on Morphing.
5. Write a detailed note on: (a) Cross-dissolving (b) Twining (c) Behavioral animation
6. What is mapping order? Explain how it affects morphing.
7. What are virtual reality systems? Describe the basic components of a typical virtual reality system.
8. List and explain the factors affecting the design of a virtual reality system.
9. List and explain different types of virtual reality systems.
10. Discuss the advantages and disadvantages of VR systems.