VIRTUAL REALITY & ANIMATION [3HR]

5.1 Introduction to virtual reality and animation

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Virtual Environment (VE): Computer generated world with which user can interact and interaction can vary from looking around to interactively modifying world.

Virtual Reality: VR typically refers to computer technologies that uses software-generated realistic images, sounds and other sensations to replicate a real environment or an imaginary setting, and simulate a user's physical presence in this environment, by enabling the user to interact with this space and any objects depicted therein. VR has been defined as a realistic and immersive simulation of a three-dimensional environment, created using interactive software and hardware, and experienced or controlled by movement of the body. or as an immersive, interactive experience generated by a computer.

Virtual Reality Systems: A typical VR system consists of six main components grouped into two:

a) **Internal Components**
   a. **Virtual World**
   b. **Graphics Engine**
   c. **Simulation Engine**
   d. **User interface**

b) **External Components**
   a. **User inputs**
   b. **User outputs**

Virtual world: A scene database containing the geometric representations and attributes for all objects within the environment.

Graphics Engine:

- Responsible for actually generating the image or scene, which a viewer will see
- Usually the scene database and the viewer's current position and orientation is taken into account
- It also includes other information form the scene data base e.g. sounds, special effects textures etc

Simulation Engine:

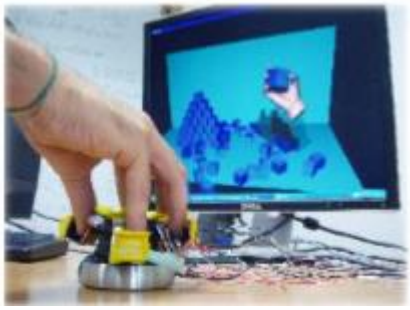
- Does most of the wok required to maintain virtual environment
- Concerned purely with the dynamics of the environment
  - how it changes over time
  - how it responds to the user's actions
- This includes handling interactions, physical simulations (gravity, inertia)

User Interface: Controls how the user navigates and interacts with this virtual environment.

Interaction styles (referring to the way the simulated/virtual environment is represented)

i] Desktop VR

- Based on the concept that the potential user interacts with the computer screen without being fully immersed and surrounded by the computer generated environment
- Applications domains involve architecture, industrial design, data visualization
- Less cost and involves less use of interacting technology



ii] Projected VR

- Based on overlapping of the image of the real user on the computer generated world
- A special movement tracking device can capture the movements of the user and enter them so that they can cause actions and reactions in the virtual world.
- Often used in VR art shows

iii] Immersive VR

- The user appears to be fully inserted in the computer generated environment
- Illusion rendered by providing HMD (Head Mounted Device) with 3D viewing and a system of head tracking that gives the exact correspondence and coordination of the user's movements with the feed-back of the environment
- The goal is to completely immerse the user within a synthetic environment or make them feel a part of that environment

iv] CAVE or Fish Tank VR

- Cave is a small room where computer generated world is projected on the front and side wallsusing projectors
- Suitable for collective VR experience (allows different people to share the same experience at the same time)
- For e.g. cockpit simulations

v] Telepresence

- Here, users can influence and operate in a world that is real but in a different location
- Telepresence is used for remote surgical operations and for exploration and manipulation of hazardous environments (space, underwater)
- Remote robots used in bomb disposal operations.

vi] Augmentation

- Mixed reality provides a half way point between an non immersive and fully immersive VR system
- A user's view of the world is supplemented with virtual objects and items whose meaning is aimed at enriching the information content of the real environment
- For e.g. Head Up Displays (HUD)
    - Used in modern military aircraft
    - These superimpose flight data such as altitude, air speed upon the pilots field of view
    - This can be on a cockpit mounted display or upon the pilot's helmet visor

Virtual Reality Software:

- Software packages exist that allows users to either experience virtual worlds or even create and edit them
- 3D graphics engines and immersive environments has occurred in the gaming industry
- Most VR Packages are costly and require high specification workstations to run properly

Factors in VR system:

Factors that can attribute to a realistic and believable virtual environment:

i] Visual Realism:

- The level of realism in a scene helps considerably in making a believable environment
- With best applications, the viewer does not notice any transition between real footage and computer generated effects
- But it requires a lot of rendering time

ii] Image Resolution

- Image resolution is closely linked with visual realism
- Computer generated images contain pixels , the size and number of these are dependent on the display size and resolution
- The color and intensity at each pixel must be generated individually, putting a heavier load on the graphics system

iii] Frame Rate

- To give the impression of a dynamic picture, the system updates the display very frequently with a new image
- Images stop flickering at frequencies above CFF which can be as low as 20 Hz
- Normal TV broadcasts update at a frequency of 50 Hz in the UK, 60 in the US Achieving this refresh rate puts a heavy load on the graphics system

Types of virtual reality:

1. **Immersive VR:** A type of VR in which user becomes immersed in the virtual world. It is also form of VR which uses computer related components.
2. **Augmented VR:** An idea of taking what is real and adding to it in some ways so that the user obtains more information from environment.
3. **Text-based VR:** When the reader of certain text form mental model of this virtual world in their head from description of people, places and things.

Application of Virtual Reality:

1. **Virtual Reality in the Military:**

   Virtual reality has been adopted by the military – this includes all three services (army, navy and air force) – where it is used for training purposes. This is particularly useful for training soldiers for combat situations or other dangerous settings where they have to learn how to react in an appropriate manner.

   A virtual reality simulation enables them to do so but without the risk of death or a serious injury. They can re-enact a particular scenario, for example engagement with an enemy in an environment in which they experience this but without the real world risks. This has proven to be safer and less costly than traditional training methods.

2. **Virtual Reality in education:**

   Education is another area which has adopted virtual reality for teaching and learning situations. The advantage of this is that it enables large groups of students to interact with each other as well as within a three dimensional environment.

   It is able to present complex data in an accessible way to students which is both fun and easy to learn. Plus these students can interact with the objects in that environment in order to discover more about them.

3. **Virtual Reality in Healthcare**

   Healthcare is one of the biggest adopters of virtual reality which encompasses surgery simulation, phobia treatment, robotic surgery and skills training.

   One of the advantages of this technology is that it allows healthcare professionals to learn new skills as well as refreshing existing ones in a safe environment. Plus it allows this without causing any danger to the patients.

4. **Virtual Reality in Entertainment**

The entertainment industry is one of the most enthusiastic advocates of virtual reality, most noticeably in games and virtual worlds. But other equally popular areas include:

- Virtual Museums, e.g. interactive exhibitions
- Galleries
- Theatre, e.g. interactive performances
- Virtual theme parks
- Discovery centres

Many of these areas fall into the category 'edutainment' in which the aim is to educate as well as entertain.

5. **Virtual Reality in Fashion**

Fashion is not something that immediately springs to mind when thinking aboutvirtual reality but nevertheless, it is used by the fashion industry in a variety of ways.

These include:

- VR software for building virtual fashion stores
- 3D avatars (virtual humans) to help with clothes design
- Fashion show in Second Life
- 3D fashion portfolio

6. **Virtual Reality and Heritage**

   This refers to the use of virtual reality in museum and historical settings, e.g. visitor centres. These settings employ interaction as a means of communicating information to the general public in new and exciting ways.

   There has been a move away from the traditional type of experience associated with museums, galleries and visitor centres. The old model was that of passive engagement in which people viewed the exhibit/s but did not get involved to an experience in which interaction is the main feature.

   Interactive displays form a large part of many exhibitions and particularly appeal to children. Children are often difficult to attract to a museum or gallery as they tend to see this as a boring experience. But the use of interactive technologies such as virtual reality has changed that perception and opened up these spaces to a new audience.

7. **Virtual Reality in Business**

Virtual reality is being used in a number of ways by the business community which include:

- Virtual tours of a business environment
- Training of new employees
- A 360 view of a product

Many businesses have embraced virtual reality as a cost effective way of developing a product or service. For example it enables them to test a prototype without having to develop several versions of this which can be time consuming and expensive.

8. **Virtual Reality in Engineering**

Virtual reality engineering includes the use of 3D modelling tools and visualisation techniques as part of the design process. This technology enables engineers to view their project in 3D and gain a greater understanding of how it works. Plus they can spot any flaws or potential risks before implementation.

This also allows the design team to observe their project within a safe environment and make changes as and where necessary. This saves both time and money.

What is important is the ability of virtual reality to depict fine grained details of an engineering product to maintain the illusion. This means high end graphics, video with a fast refresh rate and realistic sound and movement.

9. **Virtual Reality in Sport**
   Virtual reality is used as a training aid in many sports such as golf, athletics, skiing, cycling etc. It is used as an aid to measuring athletic performance as well as analysing technique and is designed to help with both of these. It also used in clothing/equipment design and as part of the drive to improve the audience's experience.
10. **Virtual Reality in Media**

Virtual reality has featured in several film and television programmes. It is often used to illustrate the concept of being trapped within the machine (or in this case, cyberspace), or as a form of advanced technology.

Examples of VR inspired films include:

- The Lawnmower Man
- The Matrix
- Tron (1982 version)
- The Thirteenth Floor
- eXistenZ
- Vanilla Sky

Computer Animation:

Animation is a rapid display of the sequence of images of 2D or 3D artwork or model positions in order to create the illusion of movement. It is the optical illusion of motion due to phenomenon of persistence of vision & can be created & demonstrated in no of ways. Most common method of presenting animation is as motion picture or video programs, even although several other forms of presenting animation also exist. Computer animation generally refers to any time sequence of the visual changes in scene. Early example of attempts to capture a phenomenon of motion drawing can be found in the cave paintings, where an animal are depicted with multiple legs in the superimposed positions, clearly attempting to convey perception of motion. The Computer animation encompasses variety of techniques, unifying factor being that an animation is created digitally on the computer.

2D Animation

2D animation figures are created & edited on computer using two-dimension bitmap graphics or created & edited using 2D vector graphics. This includes the automated computerized versions of the traditional animation techniques such as morphing & interpolated rot scoping.

Examples: *Foster's Home for the Imaginary Friends, Danny Phantom*

- Analog computer animation
- Flash animation
- PowerPoint animation

3D Animation:
They are digitally modeled & manipulated by animator. In order to manipulate mesh, it is given digital skeletal structure which can be used to control a mesh. This process is known as rigging. Various other techniques can be applied, such as mathematical function, simulated fur or hair, effects such as fire & water & use of Motion capture to name but few, these techniques fall under a category of 3D dynamics. Many 3-D animations are very believable and are commonly used as visual effects for the recent movies.

Design of Animation sequences:

In general, the animation sequence is designed with following steps:

1. **Storyboard Layout:**

It is outline of action. It defines motion sequence as the set of basic events which are to take place. Depending on type of animation to be produced, it could consist of the set of rough sketches or it could be list of basic ideas for the motion.

2. **Object definitions:**

It is given for participant to action. An object can define in terms of the basic shapes, such as polygons or splines. In addition, associated movements for each object are specified along with shape. In simple manual systems, objects can be simply artist drawings.

- In computer generated animations, models are used.
- Examples of the models:
  –"flying logo" in TV advert
  –walking stick man
  –dinosaur attacking its prey in the Jurassic Park
  – Static camera, moving object

3. Key frame specifications:

It is the detailed drawing of a scene at certain time in an animation sequence. Within each key frame each object is positioned according to time for that frame. Some key frames are chosen at extreme positions in action; others are spaced so that time interval between key frames is not too great.

- Compute first small no of key frames
- Interpolate remaining frames in between these key frames
- Key frames can be computed
  – At equal time interval
  – According to some other rules
  – For example when direction of path changes rapidly

5.1.2 Overview, importance and Key Terms of virtual reality and animation.

Morphing:

Transformation of object shapes from one form to another is called morphing, which is shortened form of metamorphosis. Morphing method can be applied to any motion or transition involving charge in shape. Given the key frames for an object transformation, we first adjust the object specification in one of the frames so that the number of polygon edges (vertices) is the same for two frames.

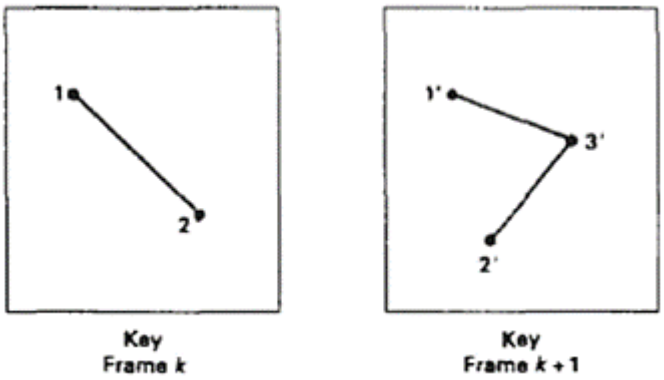


Fig: An edge with vertex position 1 and 2 in key frame k evolves into two connected edges in key frame k+1

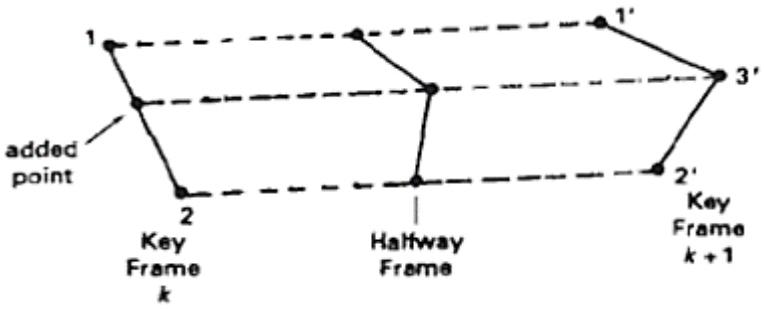


Fig: Linear interpolation for transforming a line segment in key frame k into two connected line segment in key frame k+1

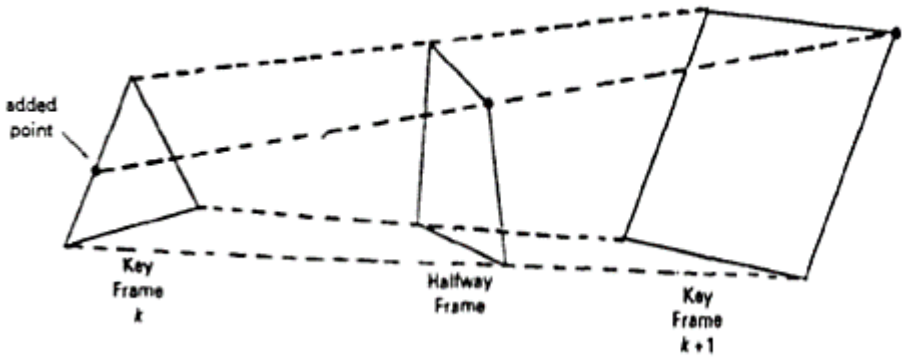


Fig: Linear interpolation frame for transforming a triangle into quadrilateral

We can state general preprocessing rule for equalizing key frames in terms of either the number of edges or the number of vertices to be added to a key frame.

Simulating Acceleration:

Curve fitting techniques are often used to specify the animation paths between key frames. Given the vertex positions at the key frames, we can hit the positions with linear or non-linear paths. To simulate

accelerations, we can adjust time spacing for the in-betweens. For constant speed (zero acceleration), we use equal interval time spacing for the in-between for key frames at time t1 and t2. The time interval between key frames is then divided into (n+1) subintervals, yielding an in-between spacing of

$$\Delta t = (t2-t1)/(n+1)$$

We can calculate the time for any in-between as:

$$tBj = t1+j\Delta t,\ j=1,2,\ldots\ldots\ldots\ldots,n$$

And determine the values for the coordinate positions color, and other physical parameters. None zero accelerations are used to produce realistic displays of speed charges, particularly at the beginning and end of the motion sequence. We can model the starting and slow down portion of an animation path with spline or trigonometric functions. Parabolic and cubic time functions have been applied to acceleration modeling, but trigonometric functions are mare commonly used in animation packages.

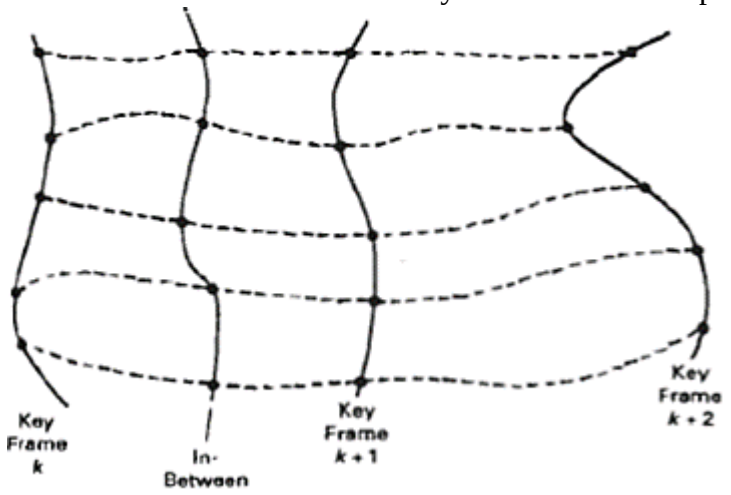


Fig: Fitting key frame vertex positions with non-linear splines

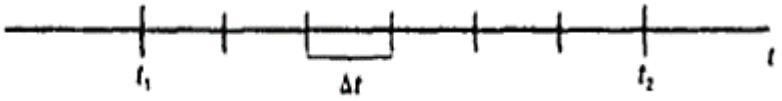


Fig: In-between for motion at constant speed

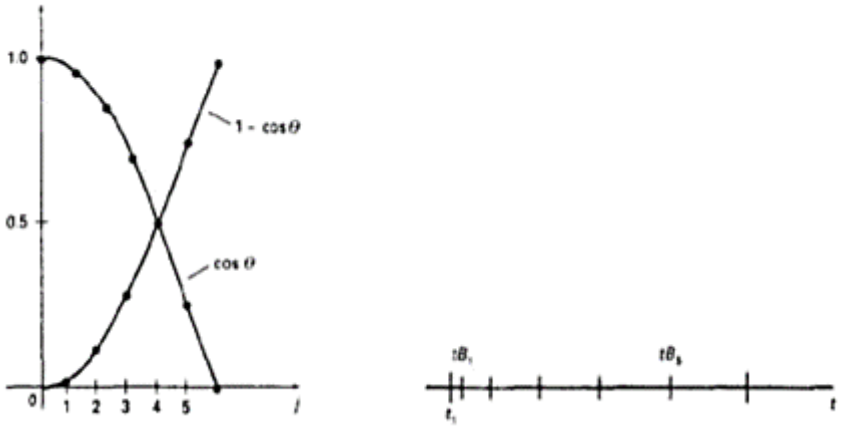


Fig: In-between for motion of variable speed

Exercise

1. Explain the virtual reality and its applications in the computer graphics.
2. Explain the basic steps for computer animation.
3. What do you mean by virtual reality and animation? Explain.