Notes

Augmented & Virtual Reality

**Unit-3**

1. What do you understand by representation in Virtual reality? Explore the various issues related to representation in Virtual Reality?

   Representation is the choice of what to render. The importance of representation is consistent regardless of the subject matter. For example, for both visualization and sonification (i.e., the presentation of information via sound) of scientific data, the focus is on how different representational techniques can help researchers gain insights about their work and how to communicate those insights with others.

   - Quantitative and Qualitative Representations
   - Human Perception
   - Verisimilitude
   - The Realism Axis
   - Semiotics
   - Choosing a Mapping

   Representation Issues Related to VR

   In addition to the global issues of representation, there are a few issues particular to the medium of virtual reality. For VR, the experience designer must also consider the implications of real time rendering, good interactions, user safety, and overall experiential concerns, such as directing attention, providing a narrative within an interactive space, and the added benefits and considerations of having multisensory displays. ϖ In daily life, people use all of their senses to interpret the world around them. Babies exemplify this in their exploration of a new toy. At first they see an object, but to learn more about it, they grab and find out how it feels, they shake it to see what it sounds like, and they bring it to their face to smell and taste it. e.g. experience of walking into a restaurant.

2. Explain how vision is used in a VR Experience. Justify the use of depth cues in a VR Experience.

   How Vision is used in a VR Experience::

   A major function of vision in a virtual world is to determine our position relative to various entities. This is useful both to help us find our way through a space and to deal with objects, creatures, and people in the world. A variety of depth cues help us determine the distance and orientation of objects in a scene. Sight can be classified as a distant sense in that we can perceive objects beyond our immediate reach. In addition to seeing where entities are, we can see their form, color, and other attributes that help us learn more about them.

3. Discuss the use of aural representation in Virtual Reality.

   Sound greatly enhances the participant's ability to become mentally immersed in the world. Sound is compelling.(force to do something or belive something) ϖ Sounds can be attention grasping. ϖ Loud noises or sounds the participant is trained to respond to (such as their name) can be used to call attention to an object or location within the virtual world. Sounds also help determine an object's position relative to the listener. Significantly, sound is also less expensive to produce, relative to the other display modalities used in VR, so the benefits of sound can be added to a VR experience without spending a lot of money.

Sound can be used to increase the verisimilitude of the experience, supply additional information, help set a mood or indicate a situation, or any combination of these. ¬ Realistic sounds help with mental immersion, but they also provide practical information about the environment. ¬ For example, the VR work of Caterpillar Inc. includes the use of sound to inform the driver of the machine's operating condition.
Sonification: Sonification is the presentation of information in an abstract sound form. It is the use of non-speech audio to represent information: you take data of some kind and create sound with it. The information is translated into pitch, volume, stereo position, brightness, etc. ϖ Ambient Sounds: Background noise or ambient noise is any sound other than the sound being monitored. Background noise is a form of noise pollution or interference. Ambient sounds can have the effect of making the experience more compelling, increasing mental immersion. ϖ Markers: Markers are sounds that mark the occurrence of some event. The types of events that can be marked include world events, user interface events, sonification events, or sensory substitution events.

4. Explain the features of aural representation in Virtual Reality.
   Features of Sound: ¬ long distance perception ¬ unrestricted field of regard ¬ constantly open perceptual channel ¬ The time and space features of sound differ from those of visual perception. what we see exists in both time and space, but what we hear exists primarily in time ϖ We can hear changes in very high-frequency sonic information. ϖ The fact that sounds exist in time means that they have a beginning, a middle, and an end. ϖ If the beginning of a sound is changed, leaving the middle and end the same, it will have an impact on what is heard. ϖ A visual image may be initiated arbitrarily at any time, but a sound usually must be started at its beginning and played out in its proper sequence over time.

5. Discuss the use of haptic representation in Virtual Reality.
   Haptics in Virtual Reality (VR) offers an extra dimension by letting users feel the virtual environment not only through senses such as voice-based or vision-based interaction but also through the sense of touch. ϖ The types of information represented by haptic systems include surface properties, such as texture, temperature, shape, viscosity, friction, deformation, inertia, and weight. ϖ While haptic display usually comes from direct physical contact, changes in temperature and air movement can be felt in the air surrounding the skin.
   How Haptic Information Is Used in a VR Experience: ¬ Haptic interaction is not used very much in daily human to human communication, with a few obvious exceptions like a handshake, punch, slap, etc ¬ More often, humans use haptic information to investigate objects in the world. Haptic information helps us determine features like weight, density, elasticity, and surfac texture. ¬ Force display: is very beneficial for interacting with, controlling, or otherwise manipulating objects and is especially useful for delicate and small operations. ¬ Tactile display is beneficial when the details and surface features of an object are important as opposed to just the overall shape.

6. Explain features of haptic representation in Virtual Reality.
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Features of Haptics: ϖ the most important feature of haptic representation is that, when available, the cues it provides about the world are the ones that are most trusted by the cognitive system when confusing or conflicting information is presented to the senses - seeing is believing, but touching is knowing. ϖ Key feature of haptic display is that perception only happens local to the user whereas visual and Aural can be perceived from objects well out of reach. ϖ Haptic representations are realistic, a cube should feel like a cube, a warm object should transfer heat to the skin, and so on.

7. Explain representation of Virtual world.

8. What is rendering system? List and explain the different methods of visual rendering.

   Rendering or image synthesis is the process of generating a photorealistic or non-photorealistic image from a 2D or 3D model by means of a computer program. OR ϖ Hardware and software systems are used to transform computer representations of the virtual world into signals sent to the display devices, so they can be perceived by human senses. Because each sense (visual, aural, and haptic) has different display and rendering requirements, they are usually created by different hardware and software systems. ϖ The temporal resolution required to create an acceptable illusion of continuous existence varies to a large degree according to each sense. ¬ A common visual display rate is 24 Hz . ¬ Haptic displays require updates at approximately 1,000 Hz ¬ Aural display sound quality varies from about 8,000 Hz for telephonequality voice to 44,100 Hz for CD-quality music, to 96,000 Hz for DVDquality sound.

   The software rendering system refers not to the actual application program, but the graphical rendering routines and formats on which the software system is built. ϖ This is the component of the VR system that can parse a file containing prebuilt graphical shapes and/or the instructions to generate the shapes that compose the visual image. ϖ Types of Rendering System::: ¬ Geometrically based -polygons, NURBS, and CSG. ¬ Nongeometrically based -volumetric rendering and particle systems.

   Three common geometrically (surface) based graphical representations are ¬ Polygonal ¬ Non-Uniform Rational B-splines (NURBS), and ¬ Constructive Solid Geometry (CSG) schemes ϖ Surface-based methods work best with solid, nontransparent objects.

9. What is rendering system? Describe the geometrically based rendering methods.

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10. What is rendering system? Describe the non geometric rendering methods.
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Surface-based methods work best with solid, nontransparent objects. ϖ When surfaces are transparent, geometric rendering techniques may not be the best choice; this is particularly true when a space is occupied by varying densities of semi translucent material (e.g., patchy fog or the human body when viewed via X-rays, MRI scans, or CT scans). ϖ In such cases, nongeometric methods may offer certain advantages. ϖ Nongeometric (nonsurface) methods of representing objects in a computer- based virtual world include 1. volumetric and 2. particle systems.

11. What is rendering system? Describe different methods of aural rendering.
Methods of Aural Rendering:: ¬ Three basic methods of rendering aural signals: ⎪ (1) the playback of recorded waveform samples, ⎪ (2) synthesis (algorithmic rendering), and ⎪ (3) the postprocessing of existing sound signals. ¬ Sounds are vibrations that travel through the air (or other media) in waves. ¬ The frequency of the waves, or how many cycles of the wave occur per unit of time, determines whether the sounds are high- or low-pitched. ¬ The wave's amplitude, the other key feature of sound, determines the loudness of the sound

12. What is rendering system? Describe different methods of haptic rendering.
Haptic displays: (I) tactile devices (attached to the skin), (II) end-effector displays (mechanical force applied to a stylus, fingergrip, etc.), and (III) robotically operated shape displays (mechanism for placing physical objects in the appropriate position).
Methods

- Thermal Rendering
- Pin based Rendering
- Kinesthetic Display
- Robotically Operated Shape Display (ROSD)
- Specific Robotically Operated Shape Display
- Physical Rendering Object (3D Hardcopy)

13. How to render complex visual scenes? Explain the techniques shading and reducing polygon waste.

The complexity of visual scenes can be enhanced by using hardware or software techniques. Complex scenes can profit the viewer by providing a richer visual experience, including a more exacting realism or a more detailed presentation. There are a number of techniques involved. • Shading • Reducing Polygon Waste o Texture Mapping o Culling.

Shading: ¬ The software system can enhance the visual scene by addressing features not handled by hardware, such as shadows. ¬ Shadows are just one of many examples of shading. ¬ Shading includes all aspects of how light is reflected off objects and into our eyes. ¬ The shade of an object changes depending on its angle to a given light source; the shadow of an object may affect the shading of some other object. ¬ Hardware graphics renderers allow for some forms of shading, but rarely handle shadows.

Reducing Ploygon Waste: These techniques include ¬ texture mapping – ¬ view culling ¬ level of detail(LOD) culling ¬ Atmospheric effects

**Unit-4**

1. Explain different methods of manipulating a virtual world.

   Manipulation Methods

   Mark Mine [1995a] lists three ways in which most forms of manipulation can be performed within a VR experience:

   1. Direct user control: interface gestures that mimic real world interaction
   2. Physical control: devices the user can physically touch
   3. Virtual control: devices the user can virtually touch
   4. Agent control: commands to an entity in the virtual world

2. List out and explain the different properties of manipulation in a virtual world. (any 4)
   1. Feedback
   2. Ratcheting
   3. Constraints
   4. Distance
   5. Pointer beam scope
   6. Hysteresis
   7. Frame of reference
   8. Bimanual interface
   9. Control location
   10. Control visibility
   11. Movement formula (control order and gain)

3. Explain physical and mental immersion in detail

   Physical/Sensory Immersion:

- Physical immersion is undeniably an important aspect of a virtual reality experience (and system). Indeed, physical immersion is part of our definition of virtual reality and is the element that distinguishes VR from other media.
- Physical immersion is accomplished by presenting a virtual world to users based on their location and orientation and providing synthetic stimuli to one or more of their senses in response to their position and actions.
- The VR system presents perspective-dependent images to each eye, synchronized audio to the ears, and haptic information to the body. The computer "knows" where the user is by tracking them.

Mental Immersion:

- The degree to which mental immersion is desirable for a particular experience varies based on the goals of the experience. If the experience is designed for entertainment purposes and its success is based on how engrossed the participant becomes thereby wanting to play it more and tell friends about it-mental immersion plays a key role in the experience's fulfillment. Other virtual worlds, such as those described in novels, also depend heavily on mental immersion.
- Mental immersion in virtual reality experiences is often desirable and sometimes critical, its absence does not mean the experience is not VR.

4. Explain different types of virtual world physics.
   Types of Virtual World Physics
   There are several common motifs of virtual reality world physics. These include
   1. The static world
   2. Cartoon physics
   3. Newtonian physics
   4. Aristotelian physics
   5. Choreographed physics
   6. Other world physics

5. State and explain different forms of manipulating a virtual world.

6. What are the four categories of substance in the virtual world? Explain
   We can divide the substance of the world into four primary categories
   1. World geography
   2. Objects
   3. Agents
   4. User interface elements

7. What is Direction Selection? Enlist seven ways of selecting direction.
   Direction Selection
   Direction selection is useful as a method of item selection (objects or places) and as a directional indicator for travel control (which we discuss in the next major section, Navigation). Items can be selected whether they are within reach or not.
   Seven ways of selecting direction are.
   1. Pointer-directed
   2. Gaze-directed
   3. Crosshair-directed
   4. Torso-directed
   5. Device-directed
   6. Coordinate-directed
   7. Landmark-directed

8. Define the following terms:
   i) The static world
   ii) Cartoon physics
   iii) Newtonian physics
   iv) Aristotelian physics
   v) Choreographed physics

   The static world *A static world* is one in which there are no world physics programmed into the environment. The world consists of fixed objects that the participant has to maneuver around.
   Cartoon physics *Cartoon physics* are those that follow or resemble the way things tend to work in

many animated films. For instance: "Any body suspended in space will remain in space until made aware of its situation" or "Certain bodies can pass through solid walls painted to resemble tunnel entrances; others cannot"

Newtonian physics *Newtonian physics* are a good approximation for replicating most circumstances in our physical world. On Earth or in virtual worlds using Newtonian physics, objects fall at 9.8 m/s/s (meters per second per second are the metric units for acceleration).

Aristotelian physics Aristotle also described a set of "rules of nature" based on his observations. His system is less accurate than Newton's, but is often the way people think things work. Consequently, simulations that reflect *Aristotelian physics* may look more natural to many people.

Choreographed physics Choreographed physics are laws of nature that consist of preprogrammed (animated) actions chosen by the experience designer. The system is provided with a list of instructions of what to do in each circumstance

9. What is Wayfinding? Enlist real and virtual-world aids to improve wayfinding in navigation.

   Wayfinding

   Wayfinding refers to methods of determining (and maintaining) awareness of where one is located (in space or time) and ascertaining a path through an environment to the desired destination.

   1. Divide and conquer
   2. Global network
   3. Progressive expansion
   4. Narrative elaboration

10. Enlist different properties of manipulation of the world.
    1. Feedback
    2. Ratcheting
    3. Constraints
    4. Distance
    5. Pointer beam scope
    6. Hysteresis
    7. Frame of reference
    8. Bimanual interface
    9. Control location
    10. Control visibility
    11. Movement formula (control order and gain)

11. What are the different ways to navigate in virtual world?

    Common forms of manipulation include:

    a) Positioning and sizing objects
    b) Exerting force on a virtual object

c) Modifying object attributes
d) Modifying global attributes
e) Altering state of virtual controls
f) Controlling travel

12. What is navigation? What are the two components of navigation?
Navigation involves two separate components, travel and wayfinding
Wayfinding
*Wayfinding* refers to methods of determining (and maintaining) awareness of where one is located (in space or time) and ascertaining a path through an environment to the desired destination. common real- and virtual-world aids to improve wayfinding:
1. Path following
2. Maps
3. Landmarks
4. Memorable placenames
5. Bread crumbs (leaving a trail)
6. Compass
7. Instrument guidance
8. Exocentric view
9. Coordinate display and orthogonal grid structure
10. Constrained travel

❖ Properties of Travel Interfaces: Some of the properties of manipulation techniques can also be applied to the various methods of travel (in the same manner as discussed for manipulation):
- Feedback
- Ratcheting
- Bimanual interface
Other manipulation properties have travel-specific components:
- Manipulation method (direct, physical, virtual, agent)
- Constraints
- Frame of reference
- Movement formula (control order and gain)

13. Explain the substance of the virtual world.
We can divide the substance of the world into four primary categories:
1. World geography
2. Objects
3. Agents
4. User interface elements

14. What is Immersion? Explain the two types of immersion.

Physical/Sensory Immersion:

- Physical immersion is undeniably an important aspect of a virtual reality experience (and system). Indeed, physical immersion is part of our definition of virtual reality and is the element that distinguishes VR from other media.
- Physical immersion is accomplished by presenting a virtual world to users based on their location and orientation and providing synthetic stimuli to one or more of their senses in response to their position and actions.
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- Mental immersion in virtual reality experiences is often desirable and sometimes critical, its absence does not mean the experience is not VR.

**Unit-5**

1. Explain different categories of sensors used in Augmented Reality.

   Augmented reality application consists of at least the following ingredients:

   1. Augmented reality application
   2. Content
   3. Interaction
   4. Technology
   5. The physical world
   6. Participant(s)

2. Write short note on:

   i. Visual Depth Cues in AR
   ii. Auditory Depth Cues in AR
   iii. Spatial Multiplexing
   iv. Temporal Multiplexing

3. List and explain in detail the different ingredients of Augmented Reality applications.
4. How does augmented reality work? Explain in detail

   The Two-Step Process of Augmented Reality Applications

   In general, two primary things need to happen for every time step of an augmented reality application. The two steps are:

   1. The application needs to determine the current state of the physical world and determine the current state of the virtual world.

   2. The application needs to display the virtual world in registration with the real world in a manner that will cause the participant(s) to sense the virtual world elements as part of his or her physical world and then return to step 1 to move on to the next time step.

5. What are major hardware components for augmented reality systems?

   Sensor(s)

   In order to be able to respond correctly to the physical world, an augmented reality application must have information about the real world in real time.

   Three primary categories of sensors are used in AR systems:

   1. Sensors used for tracking
   2. Sensors for gathering environmental information
   3. Sensors for gathering user input

   Processor

   At the heart of any augmented reality system is a processor that coordinates and analyzes sensor inputs, stores and retrieves data, carries out the tasks of the AR application program, and generates the appropriate signals to display.

   Display

   A display is the component that causes an appropriate signal to impinge on a participant's senses. For example, a visual display shows visual imagery to the participant. One example of a visual display is a computer monitor.

6. What is augmented reality? Enlist different ingredients of an augmented reality experience.

Ingredients of an augmented reality experience.

1. Augmented reality application
2. Content
3. Interaction
4. Technology
5. The physical world
6. Participant(s)

7. What are different categories of sensors that are used in AR systems?

   Three primary categories of sensors are used in AR systems:

   1. Sensors used for tracking
   2. Sensors for gathering environmental information
   3. Sensors for gathering user input

8. What is Depth Cues? Explain Monoscopic and Stereoscopic image depth in detail.

   Depth cues are information used to determine how far away things are from us and how we understand the three-dimensional world we live in.

   Monoscopic Image Depth

   Human beings typically have two eyes. The fact that each eye sees the world from a different perspective gives information about the three dimensionality of the world. Many depth cues, however, don't rely on having two eyes available
   and work as depth cues with even one eye. We refer to these kinds of depth cues as monoscopic depth cues.

   Stereoscopic Image Depth (Stereopsis)

   *Stereopsis* is the depth cue we get from seeing the same scene from two slightly different physical perspectives. Each eye sees a slightly different image than the other.

9. Describe Registration and Latency related to AR systems.

   Registration and Latency

   Registration and latency both refer to proper alignment of the virtual world with the physical world. Although registration can refer to temporal registration, it is used primarily in reference to the geographic (spatial) registration of the system. Latency is directly related to temporal registration.

10. Explain all hardware used in Augmented reality

    Sensor

    1. Sensors used for tracking
    2. Sensors for gathering environmental information
    3. Sensors for gathering user input

    Processor

    Display

    1. Visual Display
    2. Aural Display
    3. Haptic Display

11. What is dimensionality?

**Unit-6**

1. List and explain the functional components of the software that is involved directly in Augmented Reality applications.

   Software Involved Directly in the Augmented Reality Application

   The software that is involved directly in the AR application includes the following functional components:

   - Environmental acquisition (sensors)
   - Sensor integration
   - Application engine
   - Rendering software (visual, audio, etc.)

2. Categorize the software involved in creating and using an augmented reality application.

   The software involved with creating and using an augmented reality application can be divided roughly into four categories:

   - Software involved directly in the AR application
   - Software used to create the AR application
   - Software used to create the content for the AR application
   - Other software related to AR

   Another way to conceptualize the software components for augmented reality systems is:

   - Low-level programming libraries (e.g., tracking software)
   - Rendering and application building libraries
   - Plug-in software for existing applications
   - Standalone applications (e.g., content building, complete AR authoring)
   - Software to create the content for the AR application

3. What is Mobile Augmented Reality? Write down different advantages and disadvantages of Mobile Augmented Reality.

   Mobile augmented reality is AR that you can take with you wherever you go. Most specifically, this means that the hardware required to implement an AR application is something that you take with you wherever you go. There is an important distinction between mobile augmented reality and portable augmented reality. Mobile

   Advantages of Mobile Augmented Applications

   Augmented reality is especially well suited to ideas such as “ubiquitous learning” in which the plan is that every person learns all the time, wherever they are, when they need to.

   They are often very low cost compared to more permanent or special-purpose technologies.

   The *key* advantage of mobile AR is that in addition to being inexpensive, many people *already own* the necessary hardware. Current smartphones and tablets already contain the sensors, processing, and displays necessary for mobile AR applications.

   Disadvantages of Mobile Augmented Reality Applications

   User Understanding

   Technological Constraints

   Environmental Constraints

4. Explain the following terms related to interaction in virtual world.

i) Manipulation

ii) Communication
iii) Navigation

5. What is marker based and marker-less tracking system in augmented reality?
   Marker-based augmented reality experiences require a static image also referred to as a trigger photo that a person can scan using their mobile device via an augmented reality app. The mobile scan will trigger the additional content (video, animation, 3D or other) prepared in advance to appear on top of the marker. Marker recognition can be local or cloud-based, it means that marker databases can be stored on device and recognition also happens on device.
   Markerless augmented reality works by scanning the surrounding environment and there is no trigger photo necessary to retrieve the augmented reality content.

6. What are the advantages and disadvantages of markerless AR

   Pros and Cons of Markerless AR

| Benefits | Challenges |
|---|---|
| Increase range of motion with AR | Depends of flat, textured surfaces |
| Use a headset to initialize an AR app | Apps running mobile consume a lot of power |
| Share the experience | Slow adoption |
| Wider field of view for AR content | |

7. What is content? Explain in short how visual content is created.
   Visual content for AR applications can be categorized as three basic types:
   - Three-dimensional (3D) objects

     3D computer graphics objects can be obtained in one of four ways, or any combination of these ways:
     - Created from scratch using a computer graphics modeling program
     - Created dynamically from an algorithm that generates the objects
     - Created from a real-world object by scanning an object with a 3D scanner
     - Obtained by purchasing or otherwise obtaining an extant 3D model
   - Two-dimensional (2D) images (including text)

     Two-dimensional images are one of two basic formats:
     - Vector images
     - Raster images
   - Visual elements that vary with time (animation, video clips, etc.)

8. What is interaction? Between who is interaction established in augmented reality.
   Interaction can be defined roughly as a mutual influence of one thing on another. That is, one entity does something, and the other entity responds in some way.
   Interactions can be between:
   - participant and AR application
   - participant and another participant(s) via the AR application
   - virtual world and real world
   - participant and virtual world
   - participant and real world

9. What is interaction? Compare how interaction is established in the Virtual World and in an Augmented Reality experience.
   Interaction can be defined roughly as a mutual influence of one thing on another. That is, one entity does something, and the other entity responds in some way.
   Interactions in the virtual world can be boiled down to three primary categories:
   1. Manipulation
   2. Navigation
   3. Communication

10. Explain applications of augmented reality in mobile?
    Application Areas. Explain few applications in detail
    Education
    Science
    Business and manufacturing
    Medicine
    Public safety and military
    Art
    Advertising
    Entertainment

11. Write short notes on

a) Software involved directly in an AR application
b) Software used to create AR application
c) Software used to create the content for AR application

Software involved directly in an AR application
The software that is involved directly in the AR application includes the following functional components:
- Environmental acquisition (sensors)
- Sensor integration
- Application engine
  - Rendering software (visual, audio, etc.)

Software used to create AR application

Beyond the AR libraries, or the same functionality from other sources, creating an AR application is not significantly different than any other interactive, media-intensive application. Of course, efficiency is of the utmost concern to

minimize lag and latency, but the same types of tools and resources used for other types of applications are also used for developing AR applications.

Software used to create the content for AR application

Software for creating and editing three-dimensional graphics

- Software for creating and editing two-dimensional graphics
    - Software for creating and editing sound

12. Discuss the following terms related to Software Involved Directly in the Augmented Reality Application.

a) Environmental acquisition (sensors)
b) Sensor integration
c) Application engine
d) Rendering software (visual, audio, etc.)

Environmental acquisition (sensors) The software that supports environmental acquisition is the software that interfaces between the AR system and the sensors used to gather information about the state of the real world.

Sensor integration - Sensor integration is the step in which signals from the sensors are processed and integrated to make them suitable for the AR application. That is, the lowlevel sensor signals are converted into a piece of information that is required for the AR application.

Application engine - The application engine is the core structure and framework for the AR application that the participants will interact with. The application engine gathers the inputs from the sensor integration component(s) and the participant(s) and generates the information that will be given to the renderer(s) to generate the signals for the display device(s).

Rendering software (visual, audio, etc.) - rendering software is the component that converts the information from the AR application into signals to drive the AR display(s). There is rendering software for graphics (visual output), for sound (audio output), for (potentially) haptics (tactile and force output), and, although rare, for smell output, taste output, and any other sensory output.

13. What is marker based and marker-less tracking system in augmented reality? Design and explain one application of each.