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DEPARTMENT OF CIVIL ENGINEERING

19CET308- AR/VR in Civil Engineering

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UNIT - II AR/VR

AR Components

Scene Generator:

A "Scene Generator" refers to the software component responsible for creating and rendering the virtual objects and environments that are overlaid onto the real world view through an AR device, essentially defining the visual elements users see within the augmented reality experience.

Key points about the Scene Generator:

- **Function:**
- **It takes information about the user's surroundings (from tracking systems) and the desired virtual objects, and generates a 3D scene that is then displayed on the device screen, seamlessly integrating digital content with the real world.**

Rendering:

The scene generator is responsible for calculating the position, orientation, and appearance of each virtual object within the scene, ensuring they are accurately positioned relative to the real world.

Interaction with other AR components:

- **Tracking system: Provides real-time data about the user's position and device orientation, allowing the scene generator to accurately place virtual objects in the correct location.**

- **Input system: Receives user input (touch, gestures, etc.) and translates it into actions within the generated scene.**

Example applications of Scene Generators:

Product visualization:

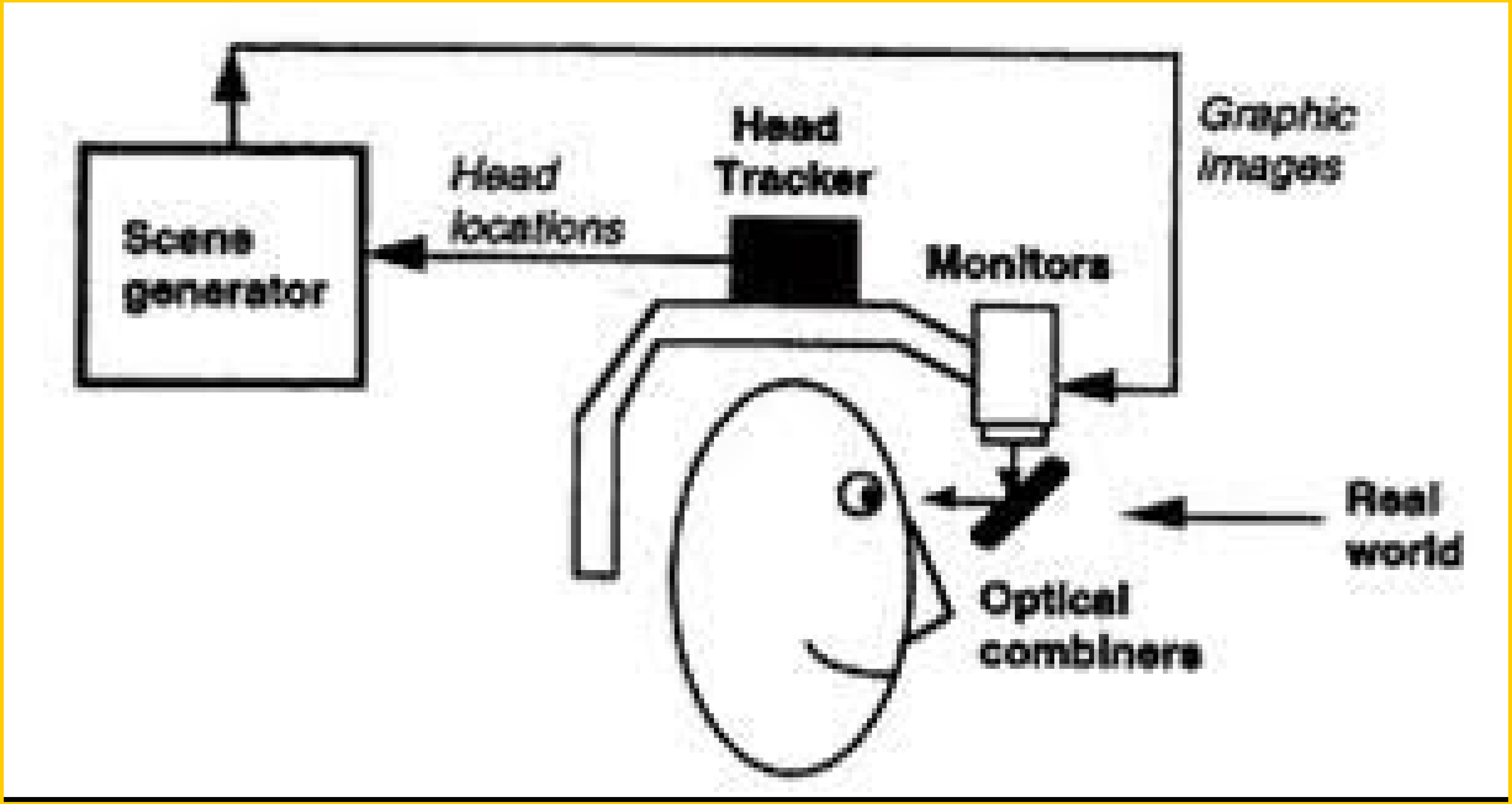
- **Overlaying 3D models of products onto a real-world environment to allow users to see how they would look in their space.**

Navigation apps:

- **Displaying digital arrows and directions on a live camera view to guide users through a location.**

Educational AR experiences:

- **Placing virtual objects like anatomical models or historical landmarks on top of a physical space.**


Head Tracker
Graphic images
Head locations
Scene generator
Monitors
Real world
Optical combiners

TRACKING SYSTEM

The "tracking system" is a critical component that uses sensors like cameras to continuously monitor the user's position and orientation in the real world, allowing the AR application to accurately overlay digital content onto the correct location in the user's view, essentially maintaining the virtual content's alignment with the physical environment as the user moves around.

Key points about AR tracking systems:

Function:

- **To accurately determine the position and orientation of the user's device (like a smartphone or headset) in real-time, enabling the AR system to place digital content precisely on top of the real world.**

Types of tracking technologies:

  - **Marker-based tracking: Uses visual markers (like QR codes) that the camera detects to place digital content on specific locations.**

- **Marker less tracking: Relies on features within the environment (like corners, edges, textures) to track the user's position without the need for explicit markers.**
- **Inertial tracking: Utilizes sensors like gyroscopes and accelerometers within the device to track movement, but can experience drift over time.**
- **Object tracking: Tracks the position of specific physical objects in the real world.**
- **GPS tracking: Used for outdoor AR experiences to determine the user's location with the help of satellite signals.**

Components of an AR tracking system:

Camera: Captures the live video feed from the user's environment.

Image processing algorithms: Analyze the camera input to identify and track features (markers or environment details).

Feature detection: Identifies key points in the image that can be used for tracking.
Feature matching: Compares identified features in the current frame to previous frames to calculate movement.
Pose estimation: Determines the 3D position and orientation of the device in the real world.

Applications of AR tracking:

- **Instructional guides: Overlay digital instructions on real-world objects during assembly or maintenance.**
- **Product visualization: Allow users to see how a product would look in their space before purchasing.**
- **Gaming: Integrate virtual characters and objects into the real environment.**
- **Navigation: Provide augmented directions with arrows overlaid on the real-world view.**

MONITORING SYSTEM:

An AR (Augmented Reality) monitoring system typically consists of three key components: sensors to capture real-world data, a processing unit to analyze that data and generate the augmented overlay, and a display to present the virtual information on top of the real-world view, often through a wearable device like smart glasses or a mobile phone screen.

Key components of an AR monitoring system:

Sensors:

- **Cameras: Capture the live video feed of the environment, allowing the system to identify and track objects.**
- **Depth sensors: Provide information about the distance between objects and the camera, crucial for accurate placement of virtual overlays.**
- **IMU (Inertial Measurement Unit): Includes gyroscopes and accelerometers to track the user's head movement and orientation.**
- **GPS (Global Positioning System): For outdoor applications to determine the user's location.**

Processing Unit:

- Computer vision algorithms: Analyze the camera input to detect and track objects, markers, or features in the real world.
- Object recognition: Identify specific objects within the scene.
- 3D modeling: Generate 3D virtual objects to be overlaid on the real environment.
- Registration: Accurately align the virtual objects with the real world.

Display:

- Head-mounted display (HMD): A dedicated wearable device like smart glasses that projects the augmented information directly into the user's field of view.
- Mobile device screen: Smartphones or tablets can be used for AR experiences, displaying the overlay on the screen.
- Projection systems: Projecting virtual content onto physical surfaces.

Applications of AR monitoring systems:

- Industrial maintenance: Visual overlays providing instructions and highlighting areas needing repair on machinery.
- Medical procedures: Visual guidance during surgery by overlaying anatomical information.
- Warehouse logistics: Picking and packing assistance with item identification and location overlays.
- Retail shopping: Product information and virtual try-on experiences.
- Navigation: Real-time directions overlaid on the user's view.

Optical See-Through HMD:
An "Optical See-Through HMD" (OST-HMD) is a key component in Augmented Reality (AR) systems, allowing users to see the real world while simultaneously overlaying digital information on top of it, essentially "augmenting" their view by projecting virtual images directly onto their line of sight through a transparent optical system.

Key points about OST-HMDs:
Functionality:

- **It combines the user's real-world view with computer-generated graphics by utilizing a special optical element called a "beam combiner" to merge the two images seamlessly.**

Advantages:

  - **Natural Perception: Provides a more natural experience as users can see their surroundings without significant visual disruption compared to video see-through HMDs.**
  - **Depth Perception: Can potentially offer better depth perception due to the direct view of the real world.**

Components:

  - **Microdisplay: A small high-resolution display that generates the virtual images.**
  - **Optical Combiner: A semi-transparent mirror or waveguide that directs the virtual images towards the user's eyes while allowing the real world view to pass through.**
  - **Tracking System: Sensors to track the user's head movements, ensuring the virtual images align with the real world.**

Challenges of OST-HMDs:

Field of View (FOV):

- **Achieving a wide field of view with good image quality can be challenging, as the combiner needs to be designed to effectively merge the virtual and real images across a large viewing area.**
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Image Registration:

- **Precise alignment of the virtual images with the real world is crucial, and any misalignment can cause discomfort or disrupt the user experience.**

Brightness and Contrast:

- **Ensuring the virtual images are bright enough to be seen in various lighting conditions while maintaining transparency in the combiner can be difficult.**

Virtual Retinal Display

In an augmented reality (AR) system, a "virtual retinal display" functions as a specialized display technology that projects images directly onto the retina of the user's eye, essentially overlaying digital information onto the real world view, considered a potential future advancement in AR display technology; key components include a light source, a scanning mechanism to direct the light onto the retina, and often, an eye-tracking system to precisely position the projected image based on the user's gaze.

Key points about virtual retinal systems in AR:

Direct projection onto the retina:

- **Unlike traditional AR displays that project images onto a lens or waveguide, a virtual retinal display projects light directly onto the retina, allowing for a highly immersive experience with a large perceived field of view.**

Scanning mechanism:

- **A critical component is a high-precision scanning mechanism that rapidly directs the light beam across the retina, creating the image pixel by pixel.**

Eye tracking:

- **To ensure accurate image placement, most virtual retinal systems incorporate eye tracking technology to monitor the user's gaze and adjust the projected image accordingly.**

Potential advantages:

- **High visual fidelity and immersion due to direct retinal projection**
- **Wide field of view**
- **Potential for compact and lightweight AR devices**

Challenges:

- **Technical complexity in developing a safe and effective scanning mechanism**
- **Power consumption requirements**
- **Potential for eye strain or discomfort due to direct light stimulation**

Components of a virtual retinal display system:

- **Light source: A high-quality light source like a laser diode to generate the projected image**
- **Scanning mechanism: A system of mirrors or other optical elements to precisely direct the light beam across the retina**
- **Control electronics: Circuits to manage the scanning pattern and intensity of the light source**
- **Eye-tracking system: Cameras or sensors to monitor eye movement for image alignment**
- **Optics: Lenses or other optical elements to guide the light beam into the eye**

Monitor-Based System:

In a monitor-based augmented reality (AR) system, the "display" component refers to a standard computer monitor that acts as the visual interface, where the real-world video captured by a camera is overlaid with digital information, creating the augmented reality experience on the screen, essentially showing the user a combined view of the physical environment with added digital elements.

Key components of a monitor-based AR system:

Camera:

- **Captures the live video feed of the real-world environment, which is then used as the background for the augmented information.**
- **Processing Unit (Computer):**
- **Processes the camera input, generates the digital overlays based on the AR application logic, and renders the combined image on the monitor in real-time.**

AR Software:

- **The software application that manages the tracking of objects in the real world, calculates the position of digital overlays, and renders them accurately on the screen.**

User Input Device (Optional):

- **Can include a mouse, keyboard, or other input devices to interact with the digital elements displayed on the monitor.**

Advantages of Monitor-Based AR Systems:

Accessibility:

- **Since most people already have access to a computer and monitor, it is a readily available and cost-effective option for basic AR applications.**

Ease of Development:

- **Developing AR applications on a monitor-based system can be simpler compared to building complex head-mounted displays.**

Limitations of Monitor-Based AR Systems:

Limited Immersion:

- **The user needs to look at the monitor to see the augmented content, which can be less immersive than a head-mounted display.**

Restricted Field of View:

- **The viewing angle is limited to the monitor screen, which can affect the natural interaction with the real world.**

Projection Display:

In Augmented Reality (AR), a "projection display" refers to a type of display technology where digital information is projected onto real-world surfaces, allowing users to see augmented content overlaid directly onto their environment without needing to wear special glasses, typically using a dedicated projector as the primary display component; this is considered one of the main display types within AR systems alongside near-eye displays like waveguides and optical combiners.

Key points about projection displays in AR:

How it works:

- **A projector generates the digital image which is then cast onto a surface like a wall, table, or even a specific object, creating the augmented visual effect.**

Advantages:

  - **Large viewing area: Can project onto large surfaces, making it suitable for collaborative experiences or public displays.**
  - **No need for dedicated AR glasses: Users can see the augmented content without wearing any special equipment.**
  - **Flexibility in placement: Can be positioned to project onto different surfaces depending on the application.**

Disadvantages:

- **Environmental limitations: Can be affected by ambient light, making it challenging to use in bright environments.**
- **Limited interaction: May require specific gestures or markers to interact with the projected content, depending on the system.**
- **Alignment challenges: Precise alignment of the projected content with the real world can be difficult.**

Video See-Through System

A "video see-through system" in the context of AR displays refers to a technology where a camera captures a live video feed of the real world, which is then digitally combined with computer-generated virtual content in real-time, allowing the user to see both the real environment and the superimposed virtual objects simultaneously on a display, like a screen on a headset or a smartphone screen; essentially, the user "sees through" the video image to view the augmented reality.

Key components of a video see-through AR system:

Camera- Captures the live video feed of the user's surroundings.

Image processing unit- Processes the camera input, performs object recognition and tracking, and aligns the virtual content with the real world.

Graphics processing unit (GPU)- Renders the virtual content in real-time, combining it with the live camera feed.

Display- A screen where the combined real-world and virtual content is displayed to the user.

How it works:

1. Capture- The camera captures a live video stream of the environment.

2. Processing- The captured video is processed by the computer to identify relevant features and track object movement.

3. Overlay- The virtual content is generated and aligned with the real world based on the processing data.

4. Display- The combined real-world and virtual content is displayed on the screen, allowing the user to see the augmented reality.

Advantages of video see-through AR:

Accurate alignment- Virtual objects can be precisely positioned in the real world due to real-time camera tracking.

Flexibility- Can be implemented on various devices like smartphones, headsets, or dedicated AR glasses.

Disadvantages of video see-through AR:

- **Potential lag: Processing the video stream can introduce latency, impacting the smoothness of the AR experience.**
- **Limited field of view: Depending on the camera lens and display size, the visible area of augmented reality may be limited.**
- **Power consumption: Real-time video processing can require significant power.**

Augmented Reality (AR) and Virtual Reality (VR) technologies have many advantages and disadvantages, including cost, health concerns, and privacy.

Advantages

- Immersive learning: AR and VR can create more engaging and immersive learning experiences.
- Risk-free practice: VR can allow users to practice in a risk-free environment.
- Cost savings: AR and VR can reduce costs associated with hiring instructors, facilities, and physical equipment.

Disadvantages

- Cost: AR and VR technologies can be expensive to implement and maintain.
- Health concerns: Extended use of AR and VR can cause headaches, eye strain, and motion sickness.
- Privacy and security: AR and VR technologies can raise privacy and security concerns.
- Misuse and distraction: AR technologies can be misused and distracting.
- Accessibility: Not everyone may have access to AR and VR technologies.
- Technical limitations: AR and VR technologies may have technical limitations.
- Ethical and privacy concerns: VR technologies can raise complex ethical and privacy concerns.

Other considerations

- AR and VR technologies can be used to enhance customer experience and drive engagement.
- AR and VR technologies can be used for immersive training.

Thankyou