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DEPARTMENT OF CIVIL ENGINEERING

19CET308- AR/VR in Civil Engineering

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UNIT II
AUGMENTED AND MIXED REALITY

What is Augmented Reality (AR)?

- **Augmented Reality enhances the real-world environment by overlaying digital elements.**
- **AR is interactive and blends digital content with the physical surroundings.**

What is Mixed Reality (MR)?

- **Mixed Reality merges real and virtual worlds, allowing for dynamic interaction between physical and digital objects.**
- **It is more immersive than AR and relies on advanced sensors and displays.**

Augmented Reality (AR)

AR integrates digital content with the physical world, enhancing the user's perception without entirely replacing the environment.

Taxonomy:

1. **Marker-Based AR:**
   - **Uses predefined visual markers (e.g., QR codes, fiducial markers) to overlay digital content.**
   - **Example: AR applications in marketing where scanning a product logo reveals additional information or a 3D model.**
2. **Markerless AR:**
   - **Also called location-based AR, it uses GPS, accelerometers, gyroscopes, or other sensors to overlay content without markers.**
   - **Example: Mobile AR games like Pokémon GO.**

INTRODUCTION TO VR

3. Projection-Based AR:

- **Projects digital content directly onto physical surfaces, making them interactive.**
- **Example: AR interfaces on industrial machinery.**

4. **Superimposition-Based AR:**

- **Modifies or replaces parts of the real-world view with augmented elements.**
- **Example: Medical applications where AR replaces parts of a body with enhanced imagery for better visualization.**

Characteristics of AR:

- **Enhances real-world environments with digital overlays.**
- **Maintains a clear distinction between the physical and digital worlds.**
- **Interaction may be limited to specific triggers or markers.**

Mixed Reality (MR)

- MR goes beyond AR by merging real and virtual worlds to create environments where physical and digital objects coexist and interact in real-time.

Taxonomy:

1. Immersive Mixed Reality:
   - Creates highly interactive and immersive environments.
   - Example: Training simulations for pilots or surgeons using devices like Microsoft HoloLens.
2. Collaborative Mixed Reality:
   - Allows multiple users to interact with shared digital and physical spaces simultaneously.
   - Example: Remote team collaboration using MR platforms.

Characteristics of MR:

- **Seamless integration of virtual and physical objects.**
- **Supports natural interaction and manipulation of digital content.**
- **Requires advanced hardware like spatial sensors, head-mounted displays, and AI-driven interaction models.**

Differences Between AR and MR

Feature	Augmented Reality (AR)	Mixed Reality (MR)
Integration Level	Enhances the real world with overlays.	Blends real and virtual worlds seamlessly.
Interaction	Limited to predefined triggers.	Full interaction between digital and physical objects.
Hardware Requirements	Smartphones, tablets, AR glasses.	Advanced devices like HoloLens, spatial sensors.
Immersion	Low to moderate.	High, creating an immersive experience.

Applications of AR and MR

AR Applications:

- Education: Interactive learning modules and simulations.
- Retail: Virtual try-ons and product visualizations.
- Gaming: Immersive gaming experiences like Pokémon GO.
- Healthcare: Medical imaging and anatomy visualization.

MR Applications:

- Training: Simulated environments for skill development in industries like aviation and healthcare.
- Collaboration: Shared virtual workspaces for remote teams.
- Entertainment: Interactive experiences in theme parks and theaters.
- Design: Virtual prototyping for architecture and engineering.

Environmental Considerations:

- **Lighting Conditions: Ensure adequate illumination for marker detection and AR display clarity.**
- **Surface Compatibility: Textures, colors, and reflectivity of surfaces can impact AR projection.**
- **Spatial Layout: Proper spatial mapping and object recognition are vital for accurate placement of AR elements.**

Technology and Features of Augmented Reality

Core Technologies:

1. **Hardware:**
   - **AR devices (smartphones, AR glasses, headsets).**
   - **Sensors: Cameras, accelerometers, GPS, gyroscopes.**
2. **Software:**
   - **AR development frameworks (e.g., ARKit, ARCore, Vuforia).**
   - **Computer vision and image recognition algorithms.**
3. **Networking:**
   - **Cloud computing for storage and processing.**
   - **Edge computing for real-time responses.**

Features of AR:

- **Real-time interaction.**
- **Seamless integration of digital and physical elements.**
- **Location-based or context-aware functionality.**

Compatibility with the Environment

Factors to Consider:

1. **Physical Environment:**
   - **Indoor vs. Outdoor:**
     - **Indoor: Controlled lighting and stable surfaces improve performance.**
     - **Outdoor: Requires adaptability to varying light, weather, and open spaces.**
   - **Surface Types:**
     - **AR works better on matte, non-reflective surfaces.**
2. **User Context:**
   - **Mobility: Design AR experiences for both stationary and mobile users.**
   - **Accessibility: Ensure AR content is user-friendly and accessible to a broad audience.**
3. **Hardware Constraints:**
   - **Devices: Smartphones, AR glasses, or head-mounted displays may influence performance.**
   - **Sensors: High-quality sensors improve tracking accuracy.**

4. Environmental Challenges:

- **Occlusion: Managing how virtual objects appear behind or in front of real-world elements.**
- **Noise and Clutter: Minimizing background distractions that interfere with AR tracking.**

System Architecture for AR Applications

Core Components:

1. **Input Devices:**
   - **Cameras, GPS, gyroscopes, and other sensors collect environmental data.**
2. **Processing Units:**
   - **AR frameworks like ARKit (iOS), ARCore (Android), or Vuforia process input data to generate AR content.**
   - **Tasks include:**
     - **Image recognition.**
     - **Spatial mapping.**
     - **Rendering of virtual elements.**

- **Output Devices:**
  - **Displays: Smartphones, tablets, AR glasses, or projectors.**
  - **Audio: Spatial sound systems to enhance immersion.**
- **Cloud and Edge Computing:**
  - **Cloud services handle data storage, model updates, and AI-based processing.**
  - **Edge computing ensures real-time responses with minimal latency.**

Workflow:

- **Data Collection: Sensors capture real-world data (e.g., images, location).**
- **Environment Mapping: AR software analyzes spatial features and maps them.**
- **Content Rendering: The AR engine overlays virtual elements onto the mapped environment.**
- **User Interaction: Users interact with the AR elements via gestures, touch, or voice.**

Working with AR Techniques

1. **Optimize for Performance:**
   - **Use lightweight assets and efficient algorithms to reduce latency.**
   - **Prioritize battery consumption on mobile devices.**
2. **Ensure Compatibility:**
   - **Test AR applications across different devices and operating systems.**
   - **Account for varying hardware capabilities, such as camera quality and sensor precision.**
3. **Design for Scalability:**
   - **Modular architecture allows easy updates and integration of new features.**
4. **Emphasize User Experience:**
   - **Ensure intuitive interaction methods.**
   - **Focus on accessibility for users with different levels of expertise.**

AR Terminology

- **Field of View (FoV): The observable area a user can see through an AR device.**
- **Spatial Mapping: Creating a 3D map of the surrounding environment.**
- **Occlusion: Accurately placing virtual objects behind real-world elements.**
- **Persistence: Ensuring AR objects remain in place across sessions.**

Application Areas of AR

1. **Education: Interactive learning modules and simulations.**
2. **Healthcare: Medical imaging and anatomy visualization.**
3. **Retail: Virtual try-ons and product visualization.**
4. **Gaming: Location-based games and immersive experiences.**
5. **Manufacturing: Assembly guidance and quality checks**

Connectivity of Smart Devices with AR

- **Integration with IoT devices for enhanced functionality.**
- **Real-time data exchange between AR systems and smart devices.**
- **Examples:**
  - **Smart home controls via AR interfaces.**
  - **Fitness apps using AR and wearable devices.**

Difference Between AR and VR

Feature	Augmented Reality (AR)	Virtual Reality (VR)
Environment	Enhances real-world surroundings.	Replaces the real world entirely.
Interaction	Blends digital and physical elements.	Immerses users in a fully virtual space.
Hardware Requirements	Smartphones, AR glasses, tablets.	VR headsets, motion controllers.
Immersion Level	Low to moderate.	High, providing complete isolation.

Challenges with AR

- Hardware Limitations: Battery life, sensor accuracy, and display resolution.
- Environmental Constraints: Lighting, occlusion, and surface compatibility.
- User Experience: Intuitive interfaces and minimal latency are essential.
- Privacy Concerns: Data collection and security risks.
- Cost: High development and deployment expenses.

Augmented Reality Methods

1. SLAM (Simultaneous Localization and Mapping):
    - Builds a map of the environment while tracking the user's position.
    - Used in AR navigation and markerless applications.
2. Recognition-Based AR:
    - Identifies and processes objects or markers in real-time.
3. Tracking-Based AR:
    - Tracks user movements and adjusts AR content accordingly.
4. Projection-Based AR:
    - Projects visuals onto physical surfaces for interactivity.

Thankyou