# Emerging Issues in Computer Science

## Week 10: Human-Computer interaction (HCI) AND Augmented Reality (AR)/Virtual Reality (VR)

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# Lecture Learning Out Come

- At the end week 10 lesson, you will be able to:
- Understand Human computer interaction, Augmented reality and Virtual Reality
- Understand the key aspects of Augmented Reality and Virtual Reality
- Understand Earlier human interaction models
- Understand Applications of Augmented reality and Virtual reality
- Understand the integration of AI in AU
- Understand the limitations the AU AND VR

# Understanding Augmented Reality

**Definition**

- The word "Augmented" means to add. It is created by using the technology by adding digital information to an image or something
  Augmented Reality (AR) refers to a technology that enriches a user's perception of the real world by overlaying digital elements—such as images, videos, or data—onto their physical surroundings. This blend of real and virtual content creates an enhanced, interactive view of the environment.
- **Technology:**
  AR systems integrate both hardware and software components. Cameras and sensors capture the real-world context, while processing units and display devices project digital content onto it. The software interprets the physical environment and inserts relevant virtual information accordingly.

# Augmented Reality


- How Can Augmented Reality Benefit The Manufacturing Industry?

# Virtual Reality and Human-Computer Interaction

- **Overview:** Virtual Reality (VR) marks a leap forward in Human-Computer Interaction (HCI) by offering fully immersive environments where users can engage with digital content in realistic or fantastical settings. It explores core principles, applications, and the benefits and drawbacks of VR in enhancing HCI.
- **Definition and Core Concepts:** VR is a cutting-edge technology that generates entirely artificial environments, separate from the physical world. Users are immersed through specialized hardware that stimulates the senses, creating the illusion of being present in a virtual space. These environments are crafted through advanced computing systems to replicate or invent scenarios that feel lifelike.

# Virtual Reality

- [Virtual reality - Wikipedia]

# Early Human-Computer Interaction Models

## Early Human-Computer Interaction Models

- **Command-Line Interfaces (CLI):**
  Developed in the 1960s, CLIs were the first method of user interaction with computers. Users had to type specific text commands to operate the system, requiring familiarity with command syntax. While efficient for experienced users, CLIs posed a challenge for beginners and limited accessibility. Despite their complexity, CLIs laid the groundwork for subsequent interaction models.

# Early Human-Computer Interaction Models

- **Graphical User Interfaces (GUI):**

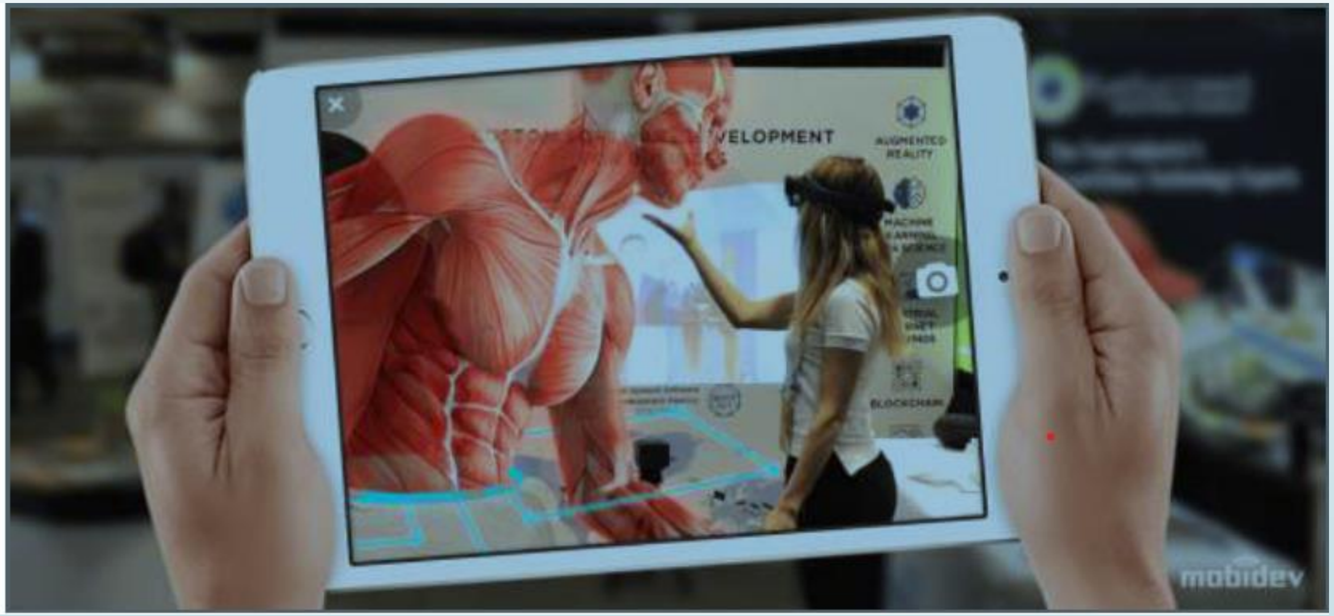
  The 1980s saw the rise of GUIs, beginning with the Xerox Alto and popularized by the Apple Macintosh. GUIs enabled interaction via visual elements like icons, windows, and buttons, reducing the need for memorized commands. This visual approach made computing more user-friendly and accessible to the general public, significantly influencing the evolution of software design.

# Augmented Reality (AR)

- First appearing in the 1990s, AR enhances real-world settings by overlaying virtual content. Early tools like ARToolKit used markers and cameras for simple augmentations. Today, AR incorporates devices like smartphones and smart glasses, using sensors and displays to seamlessly add digital layers onto the physical environment. Its practical uses span education, retail, and healthcare—enabling real-time, context-aware interactions without removing the user from their real-world surroundings.

**Augmented Reality (AR**

- Augmented reality, means introducing virtual elements to the real scene that we see in front of us, enabling us to attain a new reality comprising of physical components that we can touch with our hand, and virtual components that we can perceive their presence and interact with, but we are unable to touch them.




Ale, N. K. (2024).

# Evolution of Interaction Models

- **From 2D to 3D Interfaces:**

  The move from two-dimensional (2D) to three-dimensional (3D) interfaces marked a major progression in human-computer interaction. Traditional graphical user interfaces were confined to flat screens, whereas 3D interfaces introduced depth and spatial dynamics. This shift enabled users to engage with virtual environments in ways that mimic real-world interactions, allowing for the manipulation of objects in a 3D space. Such interfaces are especially beneficial in fields that demand spatial understanding, like gaming, design, and simulation, and they laid the foundation for immersive technologies like Virtual Reality.

# Evolution of Interaction Models

- **Advancements in Interaction Methods:** Modern interaction methods have significantly improved how users interact with digital systems. Innovations like gesture-based input, voice control, and tactile (haptic) feedback offer more natural, intuitive ways to engage with technology:
- **Gesture Recognition:** Using cameras and sensors, systems can interpret physical movements, enabling users to control interfaces with gestures like swiping or waving—without touching a device.
- **Voice Control:** Speech recognition allows users to operate devices through spoken commands, supporting hands-free functionality commonly found in virtual assistants and smart devices.

# Evolution of Interaction Models

- **Haptic Feedback:** This technology simulates the sense of touch, providing physical responses during interactions. It is essential in VR applications, where it helps create a more realistic and immersive experience.
- These technologies are vital to the performance of modern AR and VR systems, enhancing realism and improving user engagement through more intuitive controls.

# Augmented Reality (AR) in Human-Computer Interaction

- **AR as a Transformative HCI Tool:**

  Augmented Reality significantly reshapes how humans interact with digital systems by blending virtual elements with the physical world. It offers enhanced interactivity, real-time data delivery, and contextually rich experiences that go beyond traditional interfaces.

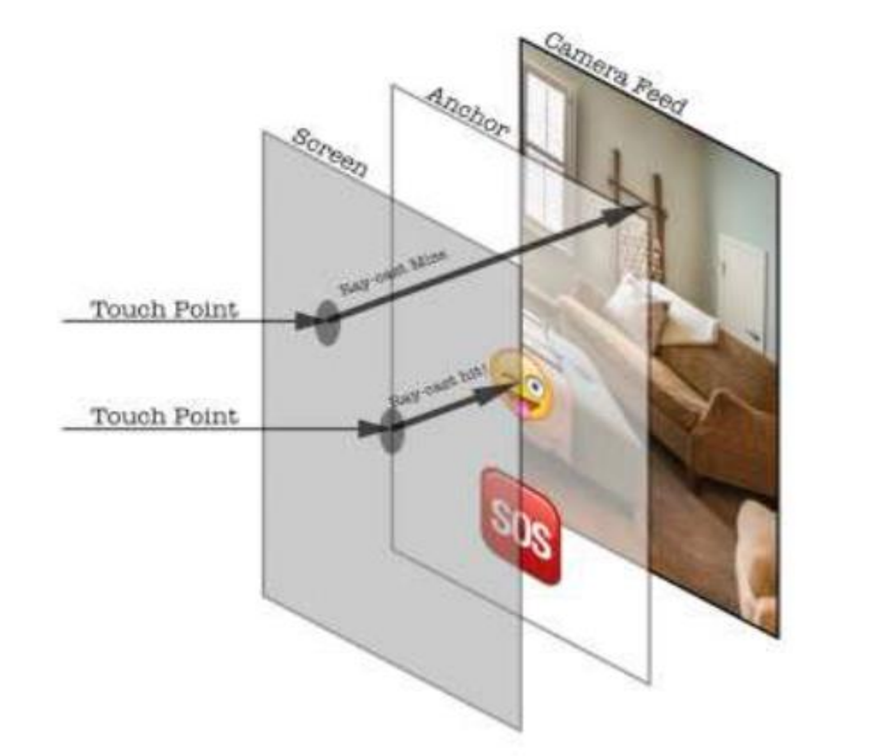
## Core Features of AR:

- **Live Interaction:** AR integrates digital content with the physical world in real-time, adjusting as users move and interact with their surroundings.
- **Context-Aware Information:** It delivers relevant data based on a user's current location or activity, enhancing decision-making and user understanding.
- **Versatile Interfaces:** AR experiences can range from simple overlays on phone screens to complex visuals projected through smart glasses or headsets, with interaction modes including touch, gestures, and voice commands.

# AR Technologies and Platforms

- **Hardware:** Devices like AR-enabled smartphones, tablets, AR glasses (e.g., Microsoft HoloLens), and head-mounted displays make AR experiences possible by combining cameras, sensors, and displays.
- **Software:** Development platforms like Apple's ARKit and Google's ARCore provide tools for building AR applications, offering APIs and frameworks tailored to real-time environment mapping and object recognition.

## ARKit




Ale, N. K. (2024).

# Applications of AR in HCI

**Education and Training:**

- *Interactive Learning:* AR brings learning materials to life by overlaying visuals and models onto real-world objects or books, improving engagement and comprehension.
- *Skill Practice:* Simulated scenarios help trainees practice in controlled environments, proving useful in industries like healthcare, engineering, and aviation.

**Navigation and Way finding:**

- *Augmented Directions:* Real-time overlays guide users with arrows and labels, simplifying navigation in both outdoor and indoor settings, such as malls or airports.

## Education and Training

- Role of AR/VR in the education system: How technology is shaping India's learning space - India Today

# Augmented reality in education

Augmented Reality (AR) In Education - eLearning Industry

# Applications of AR in HCI

**Retail and Marketing:**

- *Virtual Try-Ons:* Shoppers can see how clothes, accessories, or makeup look on them virtually, enhancing convenience and confidence in purchasing.
- *Engaging Ads:* AR campaigns offer interactive experiences—like scanning a product to reveal 3D animations or extra details.

**Healthcare:**

- *Surgical Support:* Surgeons use AR to project vital data or anatomical models during operations, aiding precision.
- *Patient Interaction:* AR apps help patients better understand their conditions or carry out guided rehabilitation exercises.

## Augmented reality in Healthcare

Augmented Reality in Healthcare: The Future of Medical Technology - ArborXR

# Benefits and Challenges of AR

**Advantages:**

- Boosts user engagement through interactive and visually rich experiences.
- Provides real-time, context-specific data that enhances decision-making.
- Supports experiential learning and effective training through simulations.

**Limitations:**

- Device constraints, such as limited processing power and battery life, can hinder performance.
- Designing intuitive AR interfaces is complex, with risks of user confusion or distraction.
- Privacy concerns arise from constant use of sensors and cameras, requiring secure data practices.
- Creating AR content is resource-intensive and demands accurate environmental tracking.

# Virtual Reality in Human-Computer Interaction

***Fundamental Concepts***

- **Immersion:** VR achieves immersion by creating the illusion that users are physically present in a digital world. This is accomplished through a combination of high-resolution visuals, surround sound (3D spatial audio), and often tactile (haptic) feedback. The aim is to move beyond passive viewing, making users feel embedded in the virtual experience.
- **Presence:** Presence refers to the psychological feeling of truly "being there" within a virtual environment. This sensation is strengthened by realistic graphics, consistent sensory feedback, and responsive environments that align with users' movements and expectations.

## *Fundamental Concepts*

- **Interactivity:** VR environments are built for user interaction, allowing people to move through, manipulate, and engage with virtual objects and scenarios in a way that mimics real-world actions, contributing to a more natural and engaging experience.

## VR Hardware

- **VR Headsets:** These are the primary devices that deliver immersive visuals. With wide fields of view and stereoscopic 3D imagery, headsets provide the depth and perspective needed to replicate real-world visual experiences.

**Examples:** *Oculus Rift:* Known for advanced optics and accurate tracking.


Oculus Rift S PC-Powered VR Gaming Headset : Amazon.co.uk: PC & Video Games

## VR Headsets:

- *HTC Vive:* Offers room-scale tracking and intuitive motion controls.

- HTC reveals Vive VR – a new power-packed virtual reality headset | Virtual reality | The Guardian

- *PlayStation VR:* Provides a console-based VR experience for gamers.

- PlayStation VR: What It Is and How It Works

## VR Hardware

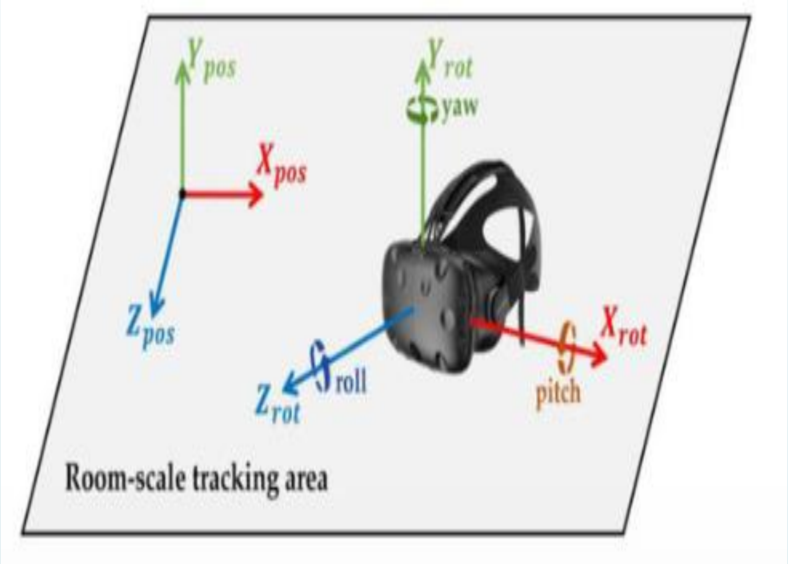
- **Motion Controllers:** These devices translate hand movements into the virtual world, allowing users to interact naturally with objects and environments.

**Examples:**

  - *Oculus Touch:* Designed for precision and comfort.
  - *HTC Vive Controllers:* Feature versatile inputs for detailed control.
  - *PlayStation Move:* Integrates with PlayStation VR for motion input.

## VR Hardware

- **Tracking Systems:**
  - *Room-Scale Tracking:* Uses external sensors to monitor user movement across a physical space.
- *Inside-Out Tracking:* Utilizes built-in sensors in the headset to track movements without external equipment.




A Walking-in-Place Method for Virtual Reality Using Position and Orientation Tracking

# VR Software and Development Platforms

- **Development Platforms:** Software like Unity and Unreal Engine allows creators to build VR applications, incorporating 3D models, interactive components, and immersive environments.

**Examples:**

  - *Unity:* Offers a flexible development environment for VR apps.
  - *Unreal Engine:* Renowned for producing highly realistic visuals and responsive environments.

- **Applications:** VR is used across diverse areas, including games, training, education, and virtual collaboration. Tools like 3D modeling software and interaction design frameworks help developers craft realistic and responsive experiences optimized for VR hardware.

# Applications of VR in HCI

***Gaming and Entertainment***

- **Immersive Game Worlds**: VR creates detailed, computer-generated environments that can replicate real places or invent fantastical landscapes. These worlds often feature first-person perspectives, enhancing the player's sense of immersion.
- **3D Audio and Natural Interaction:** VR uses spatial audio to simulate realistic sound positioning and motion controllers or hand tracking to allow for direct interaction with game elements, such as picking up or manipulating virtual objects.

# Applications of VR in HCI

- **Dynamic Experiences:** Unlike traditional games, VR engages multiple senses and offers more interactive gameplay, contributing to deeper emotional investment and heightened presence.
- **Narrative and Engagement:** VR supports interactive storytelling, allowing players to shape the storyline and experience consequences based on their actions, making the narrative more immersive.
- **Virtual Entertainment Beyond Gaming:** *Virtual Concerts:* Let users attend live or recorded performances with interactive features like multiple camera angles and virtual meet-and-greets.

# Applications of VR in HCI

- **Virtual Entertainment Beyond Gaming:**
  - *360-Degree Cinema:* Provides immersive film experiences where viewers can choose their vantage point.
  - *Virtual Theme Parks:* Simulate rides, exhibits, and adventures that mirror real-world attractions.
  - *Virtual Museums:* Offer interactive tours of art collections or historical artifacts from anywhere in the world.
  - *Sports & Fitness:* Deliver immersive sports viewing or virtual workout classes with real-time interactivity.

# Virtual Entertainment

[Is Virtual Reality the Future of Entertainment? | Bernard Marr]

# Applications of VR in HCI

- **Content Accessibility:** VR expands access to entertainment globally, allowing users to overcome physical or geographical barriers and experience events or cultural content remotely.

***Training and Simulation***

- **Professional Training:** VR is used in high-stakes fields like aviation, military, and healthcare to simulate real-world procedures in a safe, risk-free environment.
- **Emergency Preparedness:** Simulated drills help train individuals for disaster response or emergency situations by mimicking high-pressure scenarios with realistic dynamics

# Applications of VR in HCI

***Virtual Collaboration and Remote Work***

- **Virtual Meetings:** VR enabled Applications of VR in HCI enable remote participants to gather in lifelike virtual meeting spaces, enhancing communication and collaboration through immersive shared environments.
- **Simulated Workspaces:** Users can perform tasks, interact with tools, and collaborate with teammates in a virtual office environment, allowing for flexible and engaging remote work experiences.

## Applications of VR in HCI

- ***Education and Learning***
- Interactive Learning: VR makes learning more engaging by allowing students to explore virtual worlds, historical events, or complex scientific concepts in an experiential manner.
- **Skill Development:** Hands-on VR simulations offer learners the opportunity to practice and refine real-world skills in a controlled environment, improving learning outcomes and retention.

- Interactive School Concept Kids in VR Headsets Sitting at Desks and Having Virtual Reality Learning, Education Stock Footage ft. school & learning - Envato

# Applications of VR in HCI

- **Natural Interaction:**

  Users can interact with virtual elements in realistic ways, enhancing satisfaction and improving application effectiveness across domains.

- **Effective Simulations:**

  Ideal for training and education, VR creates realistic scenarios that allow users to learn and practice without real-world risks.

## Limitations

- **User Experience Challenges:** Designing intuitive, comfortable, and accessible VR interfaces can be complex, and some users may experience discomfort or motion sickness.
- **Development Complexity:** Creating immersive, responsive content for VR demands significant resources, including skilled developers and detailed 3D assets.
- **Hardware Requirements:** VR experiences require specialized hardware, including high-performance headsets and motion controllers. This hardware can be expensive and may require significant setup and calibration.
- High costs and setup requirements can be barriers to widespread adoption and accessibility.

# Limitations

**Motion Sickness:**

- Some users experience motion sickness or discomfort while using VR, particularly if there is a mismatch between visual motion and physical movement.
- Limits the usability of VR for extended periods and may require additional measures to mitigate discomfort.
- **Content Development:** Creating high-quality VR content requires substantial resources, including 3D modeling, animation, and programming. This can be time-consuming and costly, especially for complex applications.
- High development costs and resource requirements can limit the availability of high-quality VR content.

## Limitations

**Physical Space:**

- VR systems often require a dedicated physical space for movement, which can be a limitation for users with limited room or those in small environments.
- Restricts the use of VR to environments where sufficient space is available, potentially limiting accessibility for some users.

# Integration of AR and VR in Modern HCI
# Augmented Reality v/s Virtual Reality


Virtual Reality vs. Augmented Reality: Differences and Applications | مدونة أدونيس

# Integration of AR and VR in Modern HCI
# Augmented Reality v/s Virtual Reality

[Augmented Reality (AR) vs Virtual Reality (VR)]

| **Augmented Reality** | **Virtual Reality** |
|---|---|
| In AR user is partially immersed with the real world, i.e. user is immersed with mix of real-world and virtual world. | In VR, the user is completely immersed in a virtual world. |
| In augmented reality, it is easy to distinguish between both real-world and virtual world. | In Virtual reality, it is hard to distinguish between the virtual world and real world. |
| In AR, there is a use of tablet, smartphones, or another mobile device. | In VR, there is a use of head-mounted display or glasses. |
| Augmented reality is 75% real and 25% virtual. | Virtual reality is 75% virtual and 25% real. |
| Augmented reality requires upwards of 100Mbps bandwidth. | A virtual reality video with 720p requires a connection of atleast 50Mbps. |
| In Augmented reality, a user always has a sense of presence in the real world. | Whereas, in virtual reality, the visual senses are under control of the system. |

Augmented Reality v/s Virtual Reality: https://www.tpointtech.com

# Artificial Intelligence and Augmented Reality

- Enhanced Human-Computer Interaction through AI and AR
- **Natural Interaction:** AI and AR enable users to interact with virtual environments and characters in intuitive ways using natural language processing (NLP) and speech recognition.
- **Personalized Experiences:** Machine learning algorithms analyze user behavior to adjust the virtual environment dynamically for more personalized interactions.
- **Guided Navigation with AR:** AR overlays visual information (e.g., maps, object highlights) to help users navigate virtual spaces more efficiently.

# Artificial Intelligence and Augmented Reality


Role of Artificial Intelligence and Virtual Reality in Modern Education

## Current Applications

- **Gaming:** AI is used to create intelligent, responsive NPCs; AR adds interactive virtual elements to the physical world for enhanced gameplay.
- **Remote Work & Collaboration:** AI virtual assistants help navigate virtual meetings; AR overlays shared documents and tools in users’ physical spaces.
- **Virtual Tourism:** AI guides offer interactive tours; AR provides location-based information to enhance user immersion.

# Future Potential

- **Sectors for Expansion:** Retail, education, healthcare, and entertainment are expected to benefit significantly from AI and AR integration in the metaverse.
- **Responsive Virtual Worlds:** Environments that adapt in real time to user preferences and actions could become standard, offering hyper-personalized experiences.

## Challenges and Limitations

- **Technological Complexity:** Progress is needed in NLP, machine learning, and realistic virtual environment design to improve user experience.
- **Infrastructure Requirements:** AI and AR demand **high-performance computing** and **low-latency networks** to support real-time, high-quality interactions.
- **Privacy and Security:** Large-scale data collection raises concerns about protecting personal information.

# Challenges and Limitations

- **Cost Barrier:** Advanced AR/VR hardware remains expensive and less accessible for average consumers.
- **Sensory Limitations:** Current tech cannot fully replicate the human sensory experience, limiting realism and immersion.

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# Next Lecture

## Green Computing and Sustainable Technologies