

CS 59000 - Extended Reality Spring 2025

Week 1: XR system and applications overview

- XR headset
 - Immersive and stereoscopic visualization, tracking, rendering
 - The XR virtual to real continuum (virtual/mixed/augmented reality)
- Sample applications
 - Treating the fear of heights
 - Surgical telementoring
 - Distance education

Weeks 2-3: Foundations

- Vectors, points, rotations, translations, coordinate systems
- Planar pinhole camera model: construction, projection, posing, view interpolation
- Geometric modeling: triangle meshes, particle systems
- Interactive 3D computer graphics pipeline: projection, rasterization, graphic hardware support (vertex and fragment shaders)
- Computer vision: inside-looking-out tracking, features, simultaneous location and mapping (SLAM)
- Computer animation: forward and inverse kinematics, motion capture
- Immersive displays: VR only, video pass-through, optical pass-through

Weeks 4-5: VR navigation

- Teleportation, walking in place, treadmills
- Static and dynamic redirection

Week 6: Haptic feedback

- Active and passive haptics
- Encountered-type haptic devices (ETHD)

Week 7-8: Avatars

- Computer animation characters
- Live motion capture
- Digital humans: depth and color acquisition, segmentation, rendering, headset removal through inpainting

Week 9-10: Seamless integration of virtual into real

- Depth compositing, lighting, shadow casting, and reflections in mixed reality 3D scenes

Week 11: Cloud XR

- Complex virtual environments on thin XR clients: rendering load reduction (visibility, level of detail adaptation, near-far partitioning, streaming)
- Multi-user distributed XR: low-latency collaboration, scalability at server with number of clients by taking advantage of user virtual and real location coherence

Week 12-13: User experience

- Sustaining a sense of presence
- Avoiding cybersickness
- Achieving application effectiveness
- User study: design (within or between subjects, number of participants, tasks), data collection, data analysis, institutional review board approval

- *Design Principles* (considerations for UI/UX, spatial design, and designing for accessibility)
- *Ethical Considerations* (Address the ethical considerations of XR: privacy concerns, data collection in XR, potential misuse, and its implications on mental health (e.g., prolonged exposure effects))

Week 14-16: Applications

- Treating phobias
- Virtual training
- Telemedicine
- Distance education
- Entertainment
- Affordance the VR/AR technologies bring in comparison to other interactive technologies, e.g., computers, mobile/wearable devices, etc.
- VR for exposure therapy for treating some physical/mental conditions (PTSD, phobia, and pain mitigation for burn patients)