3D User Interfaces for Games and Virtual Reality

Lecture #1: Introduction

Spring 2025

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Instructor

Professor – **Joseph J. LaViola Jr.**

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Office Hours – Mon. 12pm – 1:00pm

Tues. 4:00pm – 6:00pm

Office is Harris 321

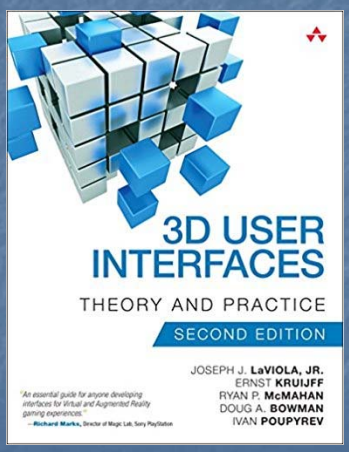
Website will have all required info

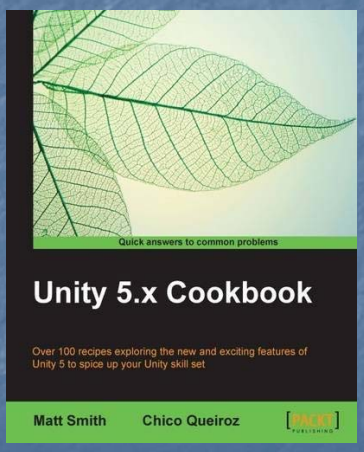
www.cs.ucf.edu/courses/cap6121/spr2025

Class Goals

- Provide in-depth introduction to spatial 3D user interfaces
- Focus on 3D games and other apps
- Speaking and presentation skills
- Start of master's projects and PhD dissertations
- Possible publications
  - Virtual Reality 2026
  - VRST 2025
  - SUI 2025
  - CHI 2026
  - SIGGRAPH Asia 2025

Required Books





Grading

Assignment 1 (group)	15%
Assignment 2 (group)	15%
Survey Paper (individual)	15%
Paper presentation (individual)	5%
Final Project (group)	50%

Final Projects

- 2-3 person teams
- Must have research component
  - Does not have to be related to games
  - innovative 3D UI
- Everyone must write and get approved a project proposal
- DEMO DAY!!!! – April 23, 2025

Class Structure (see syllabus for details)

- Lectures
  - Fundamentals of 3D user interfaces
    - hardware
    - common interaction tasks
    - user evaluation
- Student paper presentation
  - 20 minute presentation
- Final project update sessions
- Work done
  - VR Lab – Barbara Ying Center, Room 119
  - ISUE Lab – Harris 208 (laptops also)
  - Home
  - code access required

Course Topics

- Unity 3D
- 3D Hardware
  - perception
  - input and output devices
- Common 3D Interaction Tasks
  - travel (e.g., navigation and wayfinding)
  - selection and manipulation
  - system control
- 3D UI Design
- 3D UI Evaluation
- 3D UI and Augmented/Mixed Reality

Collaboration and Late Policy

- Collaboration encouraged
  - do your own work on assignments
  - cheating = BAD!!!
- All assignments must be handed in on time
  - Assignments – by 11:59pm on due date

Tools – Hardware

Tools – More Hardware

NVIDIA 3D Vision Kit

Wii Balance Board

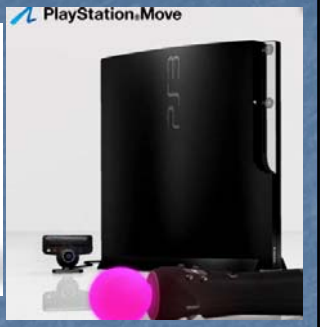
Novint Falcon

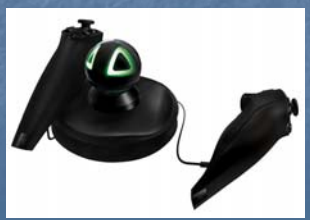
Tobii Eye X

IZ3D Monitor

Thalmic Labs Myo

Tools – Even More Hardware





Tools – Even More Hardware

Tools – Even More Hardware

Interactive Visualization Wall

Tools – Software

- Unity 3D
  - game engine
  - audio support, graphics support
  - physics engine
  - development UI
  - Scripting in C#, Javascript
  - Supports 3D stereo
  - HTC Vive support
  - Meta Quest 2/3 support
- Microsoft Research Kinect 2 SDK
- Sony Move.Me
- Leap Motion API
- Custom Client/Server code
- Google SketchUp Pro
  - nice model database

Terminology

Human-computer interaction (HCI)

- Field of study that examines all aspects of the interplay between humans and interactive technologies
- Communication between users and systems

Terminology

User interface (UI)

- Medium for human-system communication
- Translates human actions/state to a system representation and vice-versa

Terminology

Input device
- Physical device allowing users to communicate with a system

Degrees of freedom (DOF)
- The number of independent dimensions of the motion of a body

Output device
- Physical device allowing system to communicate with users through any of the senses (*display*)

Terminology

Interaction technique
- Method by which a user accomplishes a task via the UI
- Has hardware components (input/output devices)
- Has software components (mappings)

Terminology

Usability
- Characteristics of an artifact that affect the user's use of the artifact
- Includes ease of use, task performance, user comfort

User experience (UX)
- Characterization of a user's entire relationship with an artifact
- Includes usability, but also usefulness and emotional impact

UX evaluation
- Process of assessing or measuring some aspects of the user experience of an artifact

Terminology

3D interaction
- Human-computer interaction in which the user's tasks are performed *directly* in a *real* or *virtual* 3D *spatial context*
  - 2D device input translated directly to 3D virtual action (e.g., mouse dragging virtual sphere for 3D object rotation)
  - 3D device input to interact in a 2D virtual space (e.g., tracked laser pointer to define 2D cursor location on a large display)
  - Focus of the book: 3D device input to interact in a 3D virtual space (e.g., tracked controller to grab/move objects in VR)

3D user interface (3D UI)
- A UI that involves 3D interaction

Terminology

Virtual environment (VE)

- Synthetic, spatial world seen from a first-person POV
- View is under real-time user control

Virtual reality (VR)

- An approach using technologies to immerse the user in a VE
- VE and VR sometimes used interchangeably

Terminology

Augmented reality (AR)

- An approach using technologies to enhance the user's view of a real-world environment with synthetic objects or information

Mixed reality (MR)

- A set of approaches in which real and virtual information is mixed in different combinations
- Includes VR and AR
- MR continuum (Milgram & Kishino 1994)

Terminology

Ubiquitous computing (UbiComp)

- Computing devices and infrastructure may be scattered and mobile so that users have anytime, anywhere access to computing

Telerobotics

- Remote control of one or more robots

Both UbiComp and telerobotics may involve 3D UIs

Why 3D Interfaces?

- 3D applications should be useful
  - immersion
  - natural skills
  - immediacy of visualization
- But, applications in common use have low complexity of interaction
- More complex applications have serious usability problems
- Technology alone is not the solution!

What makes 3D interaction difficult?

- Spatial input
- Lack of constraints
- Lack of standards
- Lack of tools
- Lack of precision
- Fatigue
- Layout more complex
- Perception

Interaction Goals

- Performance
  - efficiency
  - accuracy
  - productivity
- Usability
  - ease of use
  - ease of learning
  - user comfort
- Usefulness
  - interaction helps meet system goals
  - interface relatively transparent so users can focus on tasks

Universal 3D Interaction Tasks

- Navigation
  - travel: motor component
  - wayfinding: cognitive component
- Selection/Picking
- Manipulation
  - specification of object position & orientation
  - specification of scale, shape, other attributes
- System Control
  - changing the system state or interaction mode
  - may be composed of other tasks
- Symbolic Input

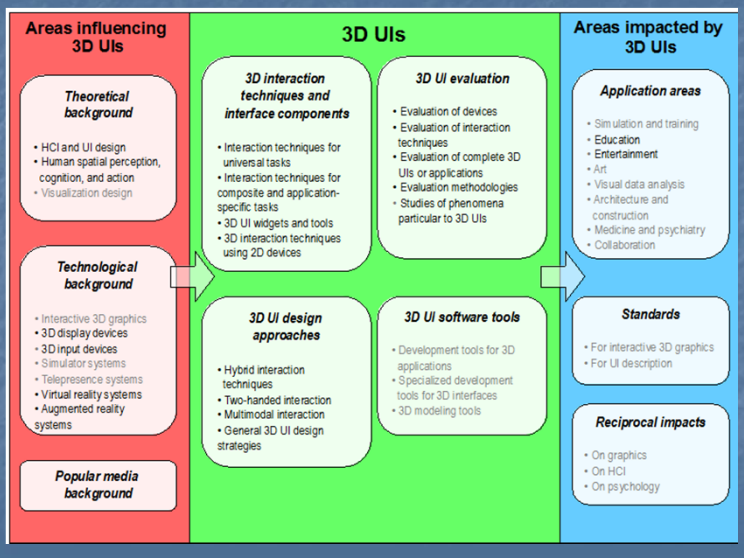
3D UI Design Philosophies

- Artistic approach: Base design decisions on
  - intuition about users, tasks, and environments
  - heuristics, metaphors, common Sense
  - aesthetics
  - adaptation/inversion of existing interfaces
- Scientific approach: Base design decisions on
  - formal characterization of users, tasks, and environments
  - quantitative evaluation results
  - performance requirements
  - examples: taxonomies, formal experimentation

Applications

- Architecture / CAD
- Education
- Manufacturing
- Medicine
- Simulation / Training
- Entertainment – *Games!!!*
- Design / Prototyping
- Information / Scientific Visualization
- Collaboration / Communication
- Robotics

3D UI RoadMap



Introduction to Case Studies

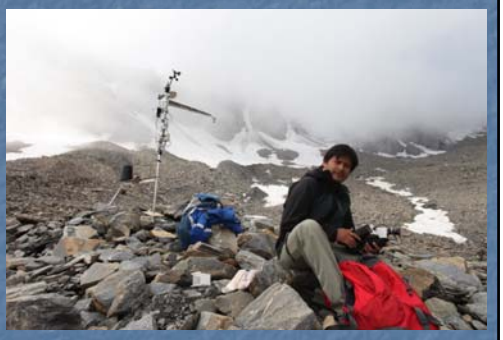
VR Gaming Case Study

- Speculative, but based on reasoning from research and experience
- Action-adventure genre (puzzles + physical skill)
- Large indoor environment (spooky hotel)
- Goal: escape via the roof while avoiding monsters
- Challenges: natural navigation, unobtrusive system control, avoid cybersickness

Introduction to Case Studies

Mobile AR Case Study

- HYDROSYS: *in situ* environmental analysis with mobile AR, sensor stations, and remote cameras
- Users: environmental scientists but also general public
- User tasks: data observations and deeper analysis
- Challenges: robust handheld AR platform, navigation among multiple camera viewpoints



Next Class

- Games and 3DUIs
- Readings
  - LaViola – Chapters 1 and 2
  - Bowman, D., Chen, J., Wingrave, C., Lucas, J., Ray, A., Polys, N., Li, Q., Haciahmetoglu, Y., Kim, J., Kim, S., Boehringer, R., and Ni, T. "New Directions in 3D User Interfaces", *International Journal of Virtual Reality*, vol. 5, no. 2, 2006, pp. 3-14.
  - LaViola, J. "Bringing VR and Spatial 3D Interaction to the Masses through Video Games", *IEEE Computer Graphics and Applications*, 28(5):10-15, September/October 2008.
  - Doug A. Bowman, Sabine Coquillart, Bernd Froehlich, Michitaka Hirose, Yoshifumi Kitamura, Kiyoshi Kiyokawa, Wolfgang Stuerzlinger, "3D User Interfaces: New Directions and Perspectives," *IEEE Computer Graphics and Applications*, vol. 28, no. 6, pp. 20-36, Nov/Dec, 2008