3D User Interfaces for Games and Virtual Reality

Lecture #1: Introduction
Spring 2023
Joseph J. LaViola Jr.

Instructor

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Office Hours – Mon. 12pm – 1:00pm
Tues. 4:00pm – 5:30pm
Office is Harris 321

Website will have all required info
www.cs.ucf.edu/courses/cap6121/spr2023
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 2024
  - VRST 2023
  - SUI 2023
  - CHI 2024
  - SIGGRAPH Asia 2023

Required Books

- 3D User Interfaces: Theory and Practice, Second Edition
- Unity 5.x Cookbook
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!!!! – May 1, 2023
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

- PlayStation Move
- Wii U
- Xbox
- VR Headset

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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 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

**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)

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**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

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**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

**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

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**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

Areas influencing 3D UIs
- Theoretical background
  - 3D user interface design
  - Human spatial perception, cognition, and action
  - Visualization design
- Technological background
  - Interactive 3D graphics
  - 3D display devices
  - Input devices
  - Interaction design
  - Visualization systems
  - Augmented reality systems
- Popular media background

3D UIs
- 3D interaction techniques and interface components
  - Interaction techniques for visualization
  - Interaction techniques for composite and application-specific tasks
  - 3D UI widgets and tools
  - 3D interaction techniques using 3D devices
- 3D UI design approaches
  - Hybrid interaction techniques
  - Two-handed interaction
  - Multimodal interaction
  - General 3D UI design strategies
- 3D UI software tools
  - Development tools for 3D applications
  - Specialized development tools for 3D interfaces
  - 3D modeling tools

Areas impacted by 3D UIs
- Application areas
  - Visualization and training
  - Education
  - Entertainment
  - Art
  - Virtual data analysis
  - Architecture and construction
  - Medicine and psychiatry
  - Collaboration
- Standards
  - For interactive 3D graphics
  - For UI description
- Reciprocal impacts
  - On graphics
  - On HCI
  - On art and animation

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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

**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