Games and 3D User Interfaces: Past, Present, and Future

Lecture #2: Games and 3DUI*
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3DUI and Video Games – Why?

- Video games
  - multi-billion dollar industry: $98 billion in 2018 in US
  - major driving force in home entertainment: average gamer today is 33 years old
  - advanced 3D graphics in HOME rather than universities or movie studios
- Driving force in technological innovation
  - graphics algorithms and hardware, sound, AI, etc.
  - technological transfer to healthcare, biomedical research, defense, education (example: Folding@Home)
- Recent innovations in 3D user interfaces
  - graphics is not enough anymore
  - complex spatial, 3D user interfaces are coming to home (example: Nintendo Wii)
- Why 3D user interfaces for games?
  - natural motion and gestures
  - reduce complexity
  - more immersive and engaging
- Research in 3D UI for games is exciting
  - will transfer 3DUI to other practical applications, e.g. education and medicine
3DUI and Video Games – What?

- Goal of 3DUI in games
  - designing input devices and interaction techniques to effectively control highly dynamic 3D computer generated content
  - three are basic approaches
- Mapping 2D input to interact with 3D world
  - keyboard and mouse, joysticks, game controllers
  - traditional form of gaming user interfaces: e.g. Flight Simulator, Second life, Halo 3
- Simulating real world tools or using physical props
  - simulation: steering wheels, light guns, musical instruments
  - physical props: dance pads
- True spatial tracking of user gestures
  - camera, e.g. Microsoft Kinect
  - acceleration/infrared tracking: Wii controllers, Sony Move

Lecture Outline

- Historical Perspectives
  - early consoles
  - arcades
  - early 3D/VR game interfaces
- 3DUI in the home today
  - new generation of game UI
- The Future of UI in games
  - AR/VR/mobile games
  - working towards the future
- Conclusions
Historical Notes on Game UIs

Early Video Games

- 1947: Cathode-ray tube amusement device
  - probably the earliest proposal for electronic gaming device
  - not known if it was implemented
- Proposed interface
  - knobs and buttons
Early Video Games

- **Tennis for two**: Second ever video game:
  - 1958 by William Higinbotham @ Brookhaven National Laboratory
  - display: oscilloscope, Input: dial and a button
  - first ever computer game was invented by Douglas, A. at Cambridge in 1952

- **Spacewar!** first (?) computer game:
  - 1961 by Russell, S., Graetz, M. and Wiitanen, W. at MIT used DEC PDP-1
  - interface: mostly buttons, but also joysticks and light pen
Early video games

1971: “Computer Space” is a first ever arcade game
- Spacewar! clone created by Nolan Bushnell
- interface is mostly buttons
- has not become very popular since its rules were too complex

1972: Magnavox “Odyssey” is a first ever home game console
- invented by Ralph Baer
- could play Ping-Pong game
- collaborative: two people
- first game controllers: button and dials: 1D
- battery operated

1975: Atari creates Pong for home and arcades
- game industry is born
Early Video Games

1977: Atari 2600 console
- cartridge based system, i.e. allows to change software
- 2D controllers: Joystick as well as peripherals devices, i.e. trackball
- introduce quality sound hardware: still popular today

1978: Magnavox Odyssey²
- includes full-sized keyboard
- used for educational software and programming
- first home electronics device with speech synthesis
Modern Consoles

- **1983: Nintendo Famicon**
  - modern controller layout: controls for both hands, directional buttons
  - increasingly complex controllers and interfaces: games are still 2D, but interaction is becoming more complex and rich.

- **1994: Nintendo 64**
  - first “true” 3D console
  - adds joystick to controller, game pad gets more controls

- **1996: Sony dual-shock controller**
  - adds second joystick and shoulder buttons
  - standard controller for PS, PS2, PS3

- Some observations
  - gradually increasing complexity of game interfaces to allow more expression in games;
  - difficult to master
  - focuses more and more on “hard-core” gamers;
  - casual gamers often find games difficult
  - similar situation was in early arcades games
Arcade Games

- Arcade games:
  - “Easy to learn, but difficult to master”
    - has to be learned immediately
    - can not have complex interfaces
    - specialized interfaces for particular games
    - many innovative and original interfaces
    - often based on simulation activities
      - shooting, driving, snowboarding, fishing, sliding etc.
    - many innovative and original interfaces has been developed: 3D, haptic response, realistic.

Video Arcades began in the mid 1970s
(2D games only)
- Pong
- Breakout
- Space Invaders
First game with 3D graphics – Battlezone (1980)
- vector graphics
- very simple interaction
  - move and rotate on 2D plane
  - used two joysticks
Arcade Games - UI Innovation

BeachHead

Football Power

Aliens Extermination

Manx TT

Dance Dance Revolution
Virtual Reality Arcade Games

- Arcades were first to introduce Virtual Reality and 3DUI in games
  - head/body tracking
  - stereoscopic vision
  - immersive displays
  - 3D spatial interaction

Virtual Reality Arcade Games

- Dactyl Nightmare: one of the first VR games
  - part of several other VR games: Legend Quest, Hero, Grid Busters
  - 1-4 players
  - basic shoot-em-up game
- Developed by W Industries/Virtuality in early 1990s
  - system sold as the 1000CS
  - used Amiga 3000 computer
  - HMD with tracked 3D joystick
Virtual Reality Arcade Games

- VR entertainment centers
  - multi-user combat simulation in BattleTech universe
  - fighting robots
  - first opened in 1990
  - provided an immersive experience
  - very little in the way of 3D user interface
- Can still play in Houston, Texas
  - MechCorps (www.mechcorps.com)

Virtual Reality Arcade Games

- DisneyQuest: Indoor interactive theme park (opened in 1998)
- Several VR games
  - Pirates of the Caribbean: Battle for Buccaneer’s Gold
    - uses motion platform, shoot cannons, navigate with steering wheel
    - surround screen display, users wear stereo glasses
  - Virtual Jungle Cruise
    - users sit in raft, steer and paddle
  - Aladdin’s Magic Carpet Ride
    - users wear HMD, sit on motorcycle-like device to steer
3D and VR on Game Consoles

- Several attempts to introduce 3D/VR for game consoles
  - Nintendo U Force
  - Mattel Power glove
  - Sega 3D glasses
  - Nintendo Virtual Boy
  - Not successful
    - low quality, did not work well
    - not really necessary since games were simple enough
    - considered to be a gimmick

1986: Sega Master System
- 3D glasses
- used active LCD shutters
- few games were supported
3D and VR on Game Consoles

- 1995: Nintendo Virtual Boy
  - Virtual reality goggles, monochrome, stereo

Some Conclusions From History

- Games complexity increases
  - 1970: Pong
  - 1980: Donkey Kong
  - 2000: Halo
  - Interaction complexity increases
Some Conclusions From History

- The complexity of controllers increased
  - use same interface components as in 60s
    - Buttons
    - Joysticks
    - Keyboard / mouse
  - combined together / increased number
  - more difficult to learn and master
  - less accessible to casual user
- 3D spatial controllers / 3DUI
  - very successful in arcades
  - failed in home devices
  - inaccurate/low quality

3DUI in the Home Today
3DUI in the Home Today

- Revival and rapid growth of 3D spatial interfaces for games today
  - cheaper and higher quality of sensors
  - fast game hardware can perform complex tracking/recognition
  - need for simpler and more intuitive interaction with games
  - games has become mainstream culture, more casual not only hard-core gamers
- The first 3D UIs in people hands
  - often based on previous research results and ideas
  - simplified for price

3DUI in the Home Today

- 2003: Sony PS2 Eye Toy
  - video camera interface for PS2
  - casual/party games
  - significant success in Europe/US
  - based on several decades of research on visual tracking in robotics and computer vision
  - developed by Richard Marks
3DUI in the Home Today

- **Nintendo Wii**
- **Key innovation – Wiimote controller**
  - provides 3D UI in the home
  - Makes games accessible to casual users

Wiimote features
- uses Bluetooth for communication
- senses acceleration along 3 axes
- optical sensor for pointing (uses sensor bar)
- provides audio and rumble feedback
- standard buttons and trigger
- uses 2 AA batteries

- **Supports two handed interaction**
  - can use 2 Wiimotes simultaneously
- **Easily expandable**
3DUI in the Home Today

- Nunchuk
- Steering Wheel
- Zapper
- Wii Helm
- Boxing Gloves
- Sports Pack
- Fishing Reel

Playstation Move features
- 3 axis accelerometer
- 3 axis gyroscope
- magnetometer
- coupled with Eye
  - color changing sphere
- standard buttons
- rumble
- bluetooth

Two-handed interaction
3DUI in the Home Today

- Microsoft Kinect features
  - RGB camera
  - depth sensing camera
    - uses infrared structured light
  - multi-array microphone
- No buttons
- Full body interaction

3DUI in the Home Today

- HTC Vive
  - room based tracking
    - head and hands
  - 6 DOF controllers
3DUI in the Home Today

- **PS3 AR Game / Eye of Judgement**
  - first 3D AR games on the market
  - 3D interaction and manipulation of 3D graphics images possible
  - based on Cybercode: technology for tracking 2D square markers
  - invented in 1990s at Sony CSL

- **3D HDTV**
  - high resolution 1920x1080
  - high definition 1080p
  - no special graphics card needed
  - runs at 240Hz (120Hz each eye)
    - as high as 480Hz
  - requires shutter glasses
  - 3D stereoscopic content sent to TV via DVI or HDMI port

- **Play games in 3D**
  - DVDs as well, TV channels
  - DLP, LCD, LED, Plasma

- Latest – 4K resolution
3DUI in the Home Today

- Some observations/conclusions
  - renaissance of 3D / spatial user interfaces in gaming
  - for the first time very successful with public
  - attracts casual gamers
  - allows for easier introduction of new 3D user interfaces in the future
  - still very simplistic when compared with 3DUI developed in research labs
  - great possibilities for the future growth!

Future of Game UI
Future of 3DUI in Gaming

- What are the technologies that will influence future game 3DUIs?
  - Transfer the body of VR research into games
  - Development of complex Augmented Reality games
  - Outdoor games with complex 3DUI
  - Mobile 3D games

- Some examples follow

Toshiba Bubble Helmet (360 degree view)

Future of Gaming: VR

- Port of Quake II to the CAVE
  - developed by Paul Rajlich (NCSA)
  - fully immersive experience
  - uses 6DOF wand as gun proxy
  - head tracking allows for peering around walls
  - players can physically jump and duck
- Quake III Area ported to CAVE as well
Future of Gaming: VR

- **SwordPlay**: explore what 3D UIs are appropriate in gaming
  - developed as part of course in “Innovating Game Development” (Brown U. 2006)
  - user has sword and shield/bow and arrow
  - uses Mine’s Over-the-Shoulder deletion technique to invoke bow and arrow
  - user can draw spells in 3D with sword

- **IllumiRoom**
  - combines projector and Kinect
  - augments TV’s surrounding area
  - number of different styles
  - Strong potential for gaming

Jones et al. 2013
Future of Gaming: VR

- **RoomAlive**
  - combines projectors and Kinects
  - augments entire room
  - dynamic mapping to room content

  Jones et al. 2014

Future of Gaming: VR

- **Omni**
  - virtual navigation system
  - uses special shoes
  - combine with HMD and trackers

http://www.virtuix.com/
Future of Gaming: AR

- **AquaGuantlet**
  - developed at Mixed Reality Systems Laboratory, Japan (Tamura et al. 2001)
  - collaborative AR environment
  - players wear see-through HMDs
  - shoot creatures superimposed into real scene
  - guns have vibration feedback

www.jello.net

Future of Gaming: AR

- **Markerless AR technology**
  - tracking natural features (SLAM techniques)
  - no visual markers: works in any unprepared environment
  - future of AR gaming
Future of Gaming: AR

- Head worn display
- Contains environment acquisition camera
- Scans entire room
- Make use of real world in AR

http://sulontechnologies.com/

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Future of Gaming: AR

- Retro reflective surfaces
- Projection-head worn displays
- Technical Illusions
  - Cast AR

http://technicalillusions.com/

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Future of Gaming: Outdoor Games

- AR Quake where monsters are superimposed into real world (i.e., Quake in the physical world)
  - developed by Thomas, Piekarski et al. in 2000 (South Australia)
  - can walk around in both indoor and outdoor environments
  - equipment is somewhat cumbersome
    - getting smaller and cheaper

Future of Gaming: Mobile Games

- Today mobile gaming platforms
  - PSP and Nintendo 3DS
  - interaction is still mostly 2D
- Future mobile platform
  - true 3D spatial interaction
    - does make use of inertial sensors
  - location-based interaction
  - AR tracking and interaction
Moving Towards the Future of 3DUI and Games

- Body of knowledge on 3D user interfaces
  - interaction technique
  - interaction metaphors and styles
  - input devices
  - usability studies
- Want to transfer to the video game domain
  - reduce interaction complexity
  - provide more realistic experiences
  - exercise!!!

Conclusions

- 3D UI for games is important and interesting research area
- It’s real and possible to create new user interface culture
- Transfer to other areas of everyday human activity
- You can start developing 3D game user interfaces yourself
Next Class

- Unity 3D Bootcamp begins
- The Video Game Motion controllers and you
- Readings
  - LaViola and Marks’ SIGGRAPH 2010 course notes
  - Unity 5.x Cookbook (Smith, M., Queiroz, C.)