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

Lecture #2: Games and 3DUI*

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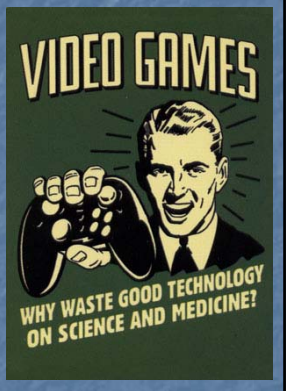
*Special thanks to Ivan Poupyrev



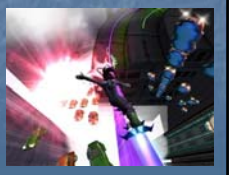
## 3DUI and Video Games – Why?

- 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 then universities or movies studios
- Driving force in technological innovation
  - graphics algorithms and hardware, sound, AI, etc.
  - technological transfer to healthcare, biomedical research defence, 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: Quest 2 controllers)
- 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
  - desiging input devices and interaction techniques to effectively control highly dynamic 3D computer generated contentent
  - 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 physicial 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: Sony Move, Quest 2





# Lecture Outline

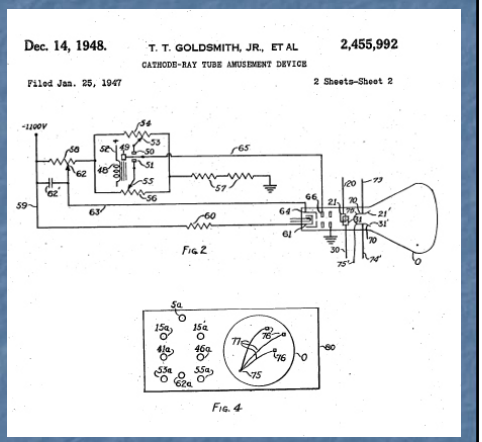
- Historical Perspectives
  - early consoles
  - arcades
  - early 3D/VR game interfaces
- Recent Trends in 3DUI in the home
  - new generation of game UI
- The Future of UI in games
  - AR/VR/mobile games
  - working towards the future
- Conclusions

# Historical Notes on Game UIs



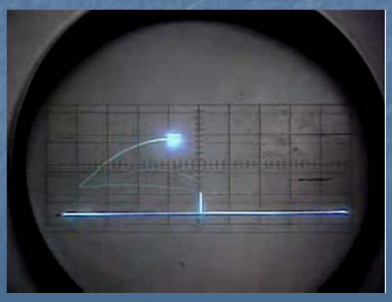
# Early Video Games

- 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





# Early Video Games

- **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

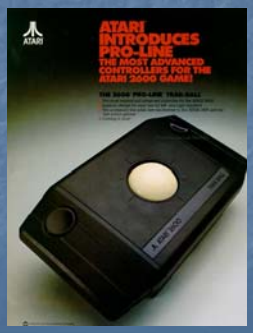



# Early Video Games

- 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




# Early Video Games

- 1978: Magnavox Odyssey$^2$
  - 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




# Modern Consoles

- 1996: Sony dual-shock controller
  - adds second joystick and shoulder buttons
  - standard controller for PS, PS2, PS3, PS4
- 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.

www.afterpicture.com



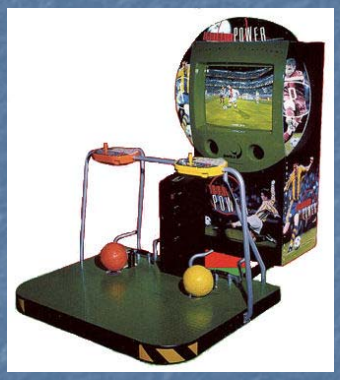
# Arcade Games

- 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




# Arcade Games – UI Innovation

Manx TT


Dance Dance Revolution

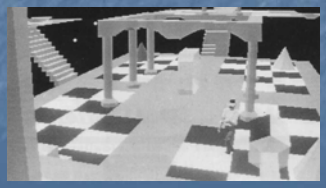
# Virtual Reality Arcade Games

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



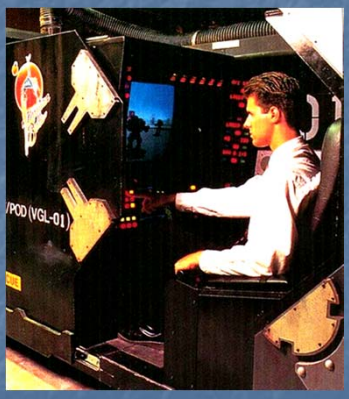
# Virtual Reality Arcade Games

- 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

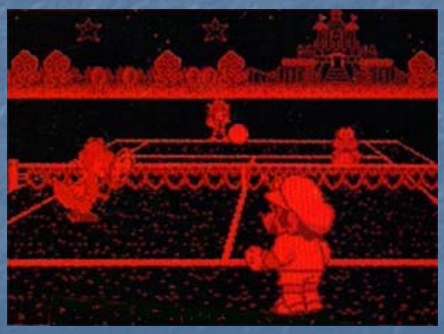



# 3D and VR on Game Consoles

- 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




# Recent Trends in 3DUI in the Home

# 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

- 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

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




# 3DUI in the Home

- 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

Nunchuk

Steering Wheel


Zapper

Wii Helm

Boxing Gloves

Sports Pack

Fishing Reel



# 3DUI in the Home

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

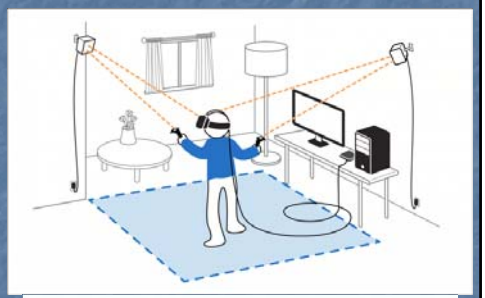
# 3DUI in the Home

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



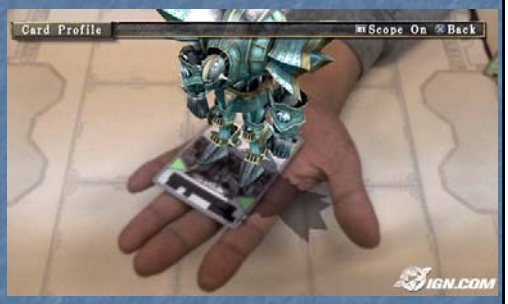

# 3DUI in the Home

- HTC Vive
  - room based tracking
    - head and hands
  - 6 DOF controllers



# 3DUI in the Home

- 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






# 3DUI in the Home

- 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, 8K resolution

# 3D UI in the Home



# 3DUI in the Home

- 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?
  1. Transfer the body of VR research into games
  2. Development of complex Augmented Reality games
  3. Outdoor games with complex 3DUI
  4. Mobile 3D games
- Some examples follow

Toshiba Bubble Helmet (360 degree view)

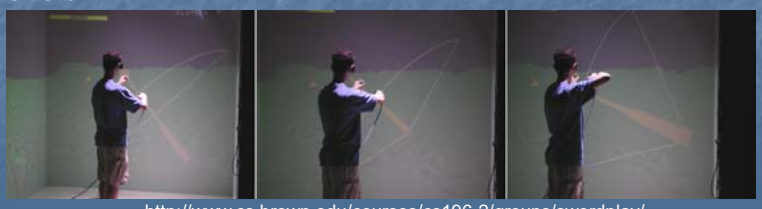
# Future of Gaming: VR

- 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 developement" (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



http://www.cs.brown.edu/courses/cs196-2/groups/swordplay/

# Future of Gaming: VR

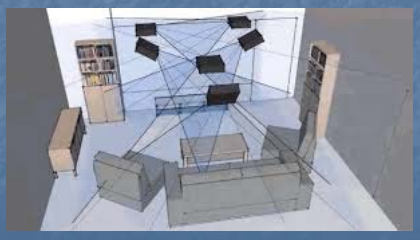
- IllumiRoom
  - combines projector and Kinect
  - augments TV's surrounding area
  - number of different styles
- Strong potential for gaming

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: VR

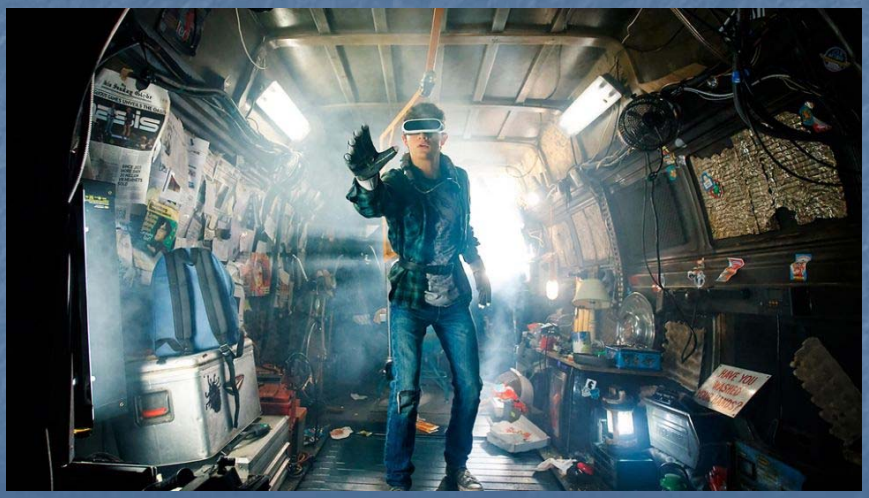


Image credit: Jaap Buitendijk/Warner Bros

# 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

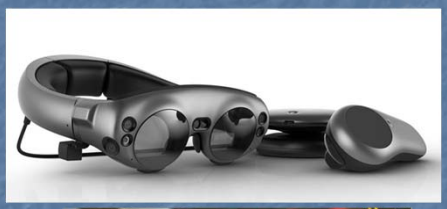


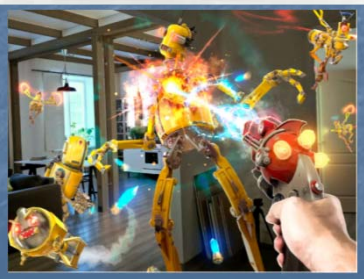
# Future of Gaming: AR

- 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://www.magicleap.com/



# Future of Gaming: AR

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

# 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


# Future of Gaming: Mobile AR

Image courtesy of Freddy Wong
https://www.youtube.com/watch?v=Z-FRb8CZ__I&w=600&h=335



# 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
- Its 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.)