Video Games: 3DUIs for the Masses

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▶3DUI and Video Games – Why?

- Video games
  - multi-billion dollar industry: $18.8 billion in 2007
  - 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: 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 exiting
  - will transfer 3DUI to other practical applications, e.g. education and medicine

- Video game industry $10.5 billions in US in 2005, $25.4 billions worldwide;

-Not for kids anymore: average player is 33 years old, the most frequent game buyer is 40 years old;

-Technological transfer and strong impact on other areas of technology:

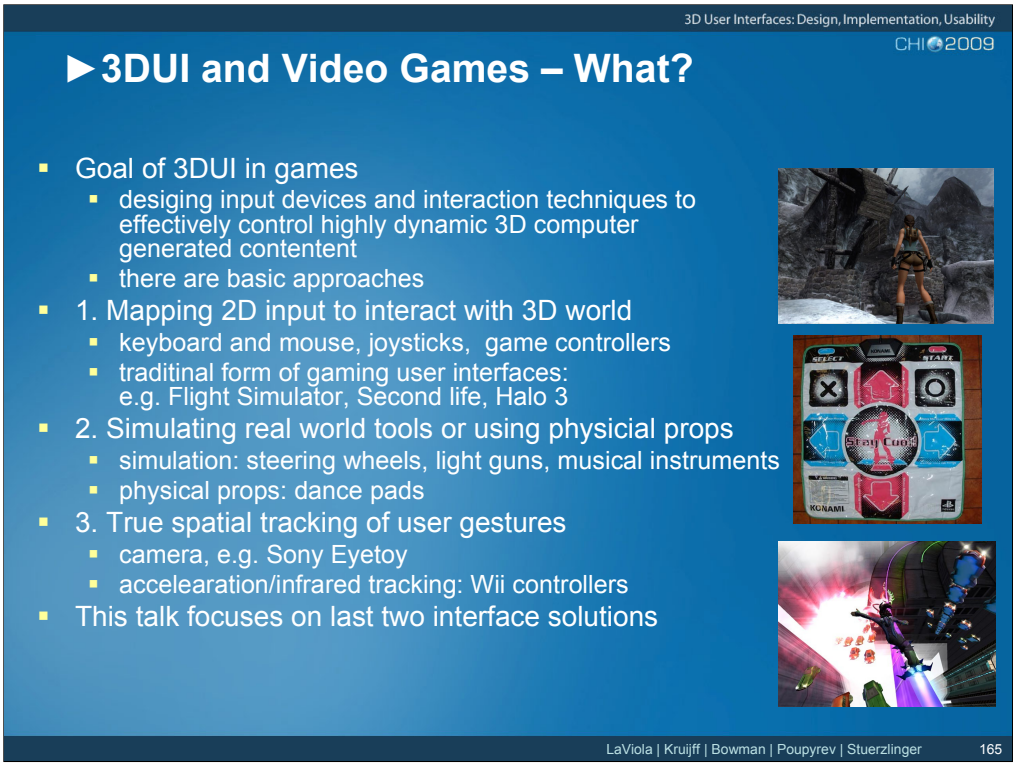
The poster on this slide (www.allposters.com) demonstrates a very common misconception.

In fact its completely opposite, the rapid innovation in games software and hardware allows for economical and practical applications of 3D computers graphics in healthcare, biomedical research, education and other critical areas.

The most recent example is Folding@Home which is a PS3 software that turns millions of PS3 into a world largest distributed computing environment to process computationally intensive simulation of protein folding and molecular dynamics for biomedical research purposes. In another example, military has been using flight simulators and FPS to train solders as a cheaper and safer alternative to virtual reality simulators and real exercise.

-Innovation not only in hardware and software, but also in interaction, 3D UI has finally came to homes, i.e. Nintendo Wii

- Investigating 3D UIs for games is an exiting and important research direction and with time we believe it will transfer to other application just as it happens with 3D hardware and software.



What do we mean by 3D UI in games?

-The goal is the same as for any 3DUI research: developing hardware and software techniques that would allow to effectively control highly dynamic 3D computer generated content in home environment;

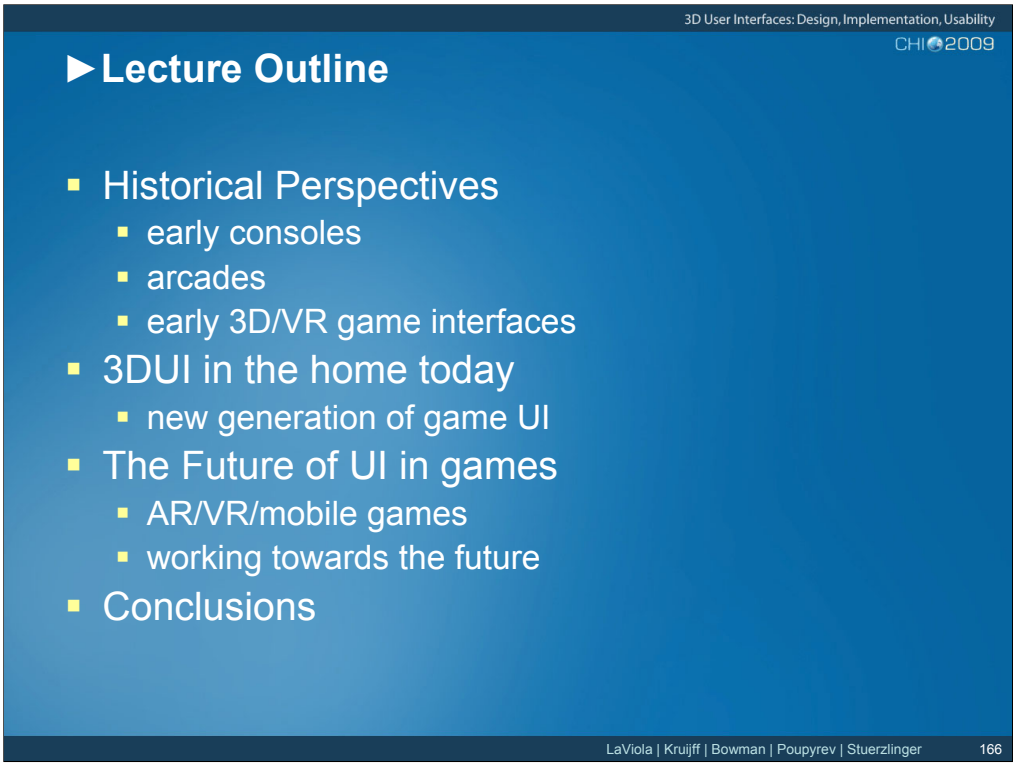
-There are 3 general approaches:

- Using 2D input devices to interact with 3D environment, e.g. using mouse in Second Life or joystick in Flight Simulator;

- Simulate real world tools or design simple switching props, e.g. steering wheels, light guns and dance dance revolution pads

- True spatial tracking of user gestures and body movement using camera or 3D input devices such as by Nintendo Wii controller

In this talk we are focusing on last 2 interface solutions because the first one has been very extensively developed already. We expect that true spatial tracking will serve as the main source of innovative interfaces in video games.

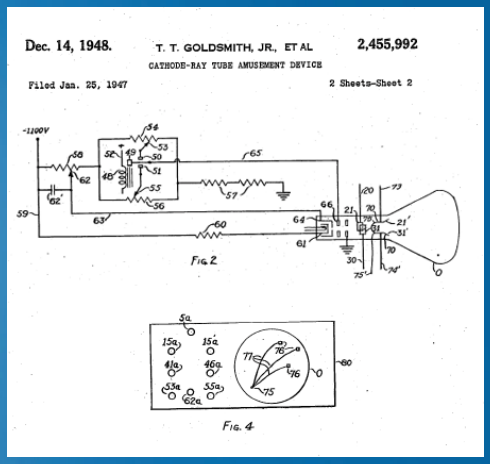


In the rest of this lecture, we will take a brief history lesson into video games looking at arcades, early console development, and attempts to bring virtual/augmented reality into the mainstream gaming market. Next, we will look at how 3D user interfaces are being used today. Finally, we will look into the future of video games by examining some gaming systems from various research institutions as well as a new game development environment for exploring how 3D user interfaces and games can come together.

Historical notes on game UIs

►Early Video Games

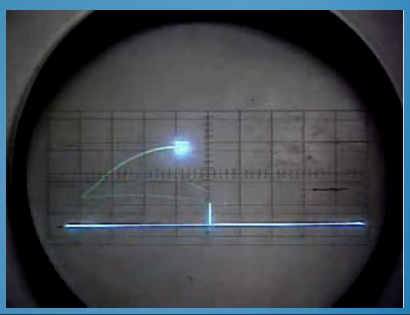
- 1947: Cathode-ray tube amusement device
  - probably the earliest proposal for electronic gaming device
  - not known if it was implemented
- Proposed interface
  - knobs and buttons



One of the first examples of an electronic gaming device can be traced back to a patent filed in January 1947. It is unknown whether the device was ever implemented but the patent proposed to have a set of knobs and buttons used to change the speed and curve of a missile fired at a target.

▶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



Considered to be perhaps the second video game ever made, Tennis for Two used an oscilloscope display and a input dial and button. It was developed by William Higinbotham in 1958. Electronic games such as checkers and tic-tac-toe were developed around this time as well.

▶Early Video Games

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

The first true computer/video game that was widely available was called Spacewar, developed at MIT in 1961. Spacewar had two ships dubbed the "Wedge" and the "Needle" for their shapes that two players controlled and moved around the screen while firing torpedoes at each other until one ship was destroyed.

Computer Space is considered to be the first arcade game. Computer Space was based on SpaceWar and was created by the eventual founding members of Atari, Inc.

▶Early Video Games

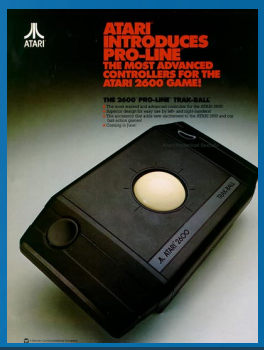
- 1972: Magnavox "Odyssey" is a first ever home game console
  - invented by Ralph Baer
  - could play Ping-Pong game
  - collaborative: two people
  - first game controllers: button and dials: 1D
  - battery operated
- 1975: Atari creates Pong for home and arcades
  - game industry is born

In 1972, the Magnavox "Odyssey" was released and is considered to be the first ever home game console. The system could not produce sound, had black-and-white graphics, and only contained enough processing power to create dots, paddles, and a few lines. The controller consisted of three dials for horizontal movement, vertical movement, and spin. A light gun shaped like a rifle was sold separately.

In 1975, Atari created Pong for both the home and arcades and an industry was 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



In 1977, the Atari 2600 console system was introduced. It used a cartridge based system so many different games could be played. The system used a simple joystick as well as an optional trackball.

►Early Video Games

- 1978: Magnavox Odyssey^2
  - includes full-sized keyboard
  - used for educational software and programming
  - first home electronics device with speech synthesis

In 1978, Magnavox released a second Odyssey system which include a full-sized keyboard. It was used for educational software and programming in addition to the traditional video games of the day. The device was also considered to be the first home electronic 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

Nintendo Famicom introduced the first version of the current game controllers by combining a number of controls on one game pad device. Games were becoming more and more complex with rich interaction; it was not Pong or Pac-Man anymore, and more complex controllers are required. Most game consoles of that time, i.e. Sega Genesis, Nintendo Super NES, followed a similar controller design. Nintendo 64 was the first true 3D console and added a joystick in addition to all other controls.

►Modern Consoles

- 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

As the power and complexity of the games increased so did the complexity of the interface. Games are becoming increasingly difficult to learn. Interestingly a similar situation faced the first arcade games, where the first arcade game was too difficult to learn and required users to read instructions. Bushnel notes that games should be “easy to learn but difficult to master”.

▶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

The first video arcades starting sprouting up in the mid 1970s. The games in these arcades, such as Pong, Breakout, and Space Invaders, were quite primitive compared to today's standards. The first video arcade game that had 3D graphics was called Battlezone. It used vector graphics and a simple interface with two joysticks. Users could more and rotate on a 2D plane and shoot at other tanks by pressing a button.

Image from http://www.lyonspinball.com/lcv_games.htm

As consoles became more and more popular with better graphics and sound, video arcade games needed to innovate at the user interface to compete. As such, there have been several interesting user interface designs in the modern video arcade game. BeachHead has the user bring a helmet like device down on his head, resulting in a 360 degree field of regard. Other games such as Football Power have players actually control the soccer ball with their feet. Aliens Extermination is an example of a game that uses realistic gun props to interact in a first person shooter style game.

Images from www.weinerd.com, www.libertygames.co.uk, www.libertygames.co.uk

►Arcade Games – UI Innovation

Manx TT

Dance Dance Revolution

Other video arcade gaming systems that made strides in user interface innovation are Manx TT where users ride a physical motorcycle to control the virtual motorcycle in the game, and Dance Dance Revolution where users interact on a dance platform.

Images from http://amusement-beheer.nl and http://www.bornrich.org/images/

▶Virtual Reality Arcade Games

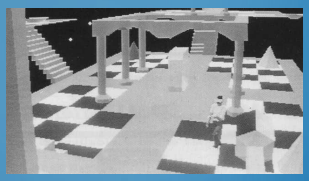
- Arcades were first to introduce Virtual Reality and 3DUI in games
  - head/body tracking
  - stereoscopic vision
  - immersive displays
  - 3D spatial interaction

Video arcades were the first places where people could play virtual reality-based games that had head and body tracking, stereoscopic vision, and 3D spatial interaction.

Images from http://electronics.howstuffworks.com/VR-gear.htm

►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

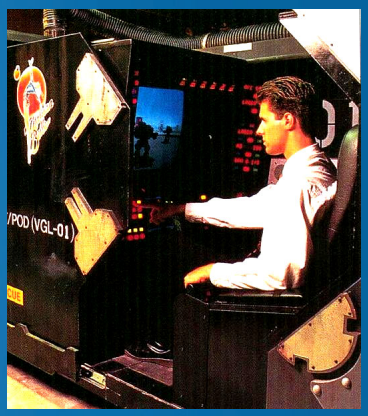


Dactyl Nightmare was one of the first VR games. It was developed as part of a suite of VR games by W Industries/Virtuality in the early 1990s. Players got into a pod like structure, put on a head mounted display, and used a tracked joystick to interact with the virtual world. The pod protected users from walking around in the physical world. The games themselves were somewhat primitive, but the immersive experience was one that had not been seen before in a video arcade game.

Images from www.cybermind.nl and http://www.amigau.com/

►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)



In several cases, VR entertainment centers started appearing around the world. One such center was called BattleTech, based on the BattleTech universe. The first one opened in Chicago in 1990. Although it provided very little in the way of 3D user interface, it was designed to provide an immersive experience where several users could play simultaneously not only at a single location, but networked across all BattleTech centers. Eventually, these VR entertainment centers failed, but BattleTech can still be played at MechCorps in Houston, Texas.

Images from www.wikipedia.com

One virtual reality center that is still in existence today is DisneyQuest, an indoor interactive theme park that opened in Orlando, Florida in 1998. DisneyQuest houses some of the most compelling virtual reality arcade games ever built.

www.gamasutra.com/features/20010706/schell_01.htm and www.wikipedia.com

▶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

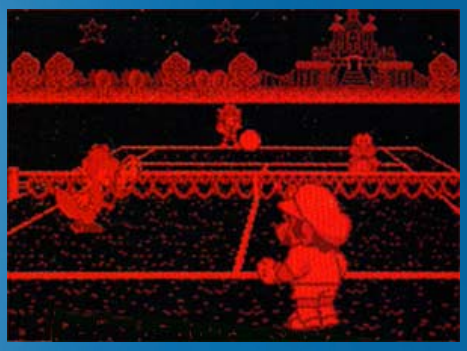
In the late 1980s and 1990s, there were several attempts to introduce 3D/VR style interfaces in the home video game market. However, these attempts were not successful for a variety of reasons including poor technology and lack of game development support for the devices.

As part of the Sega Master System, users could buy a pair of active 3D stereo shutter glasses. Unfortunately, there were only a few games supported for the 3D glasses and they were never offered on any future Sega game consoles.

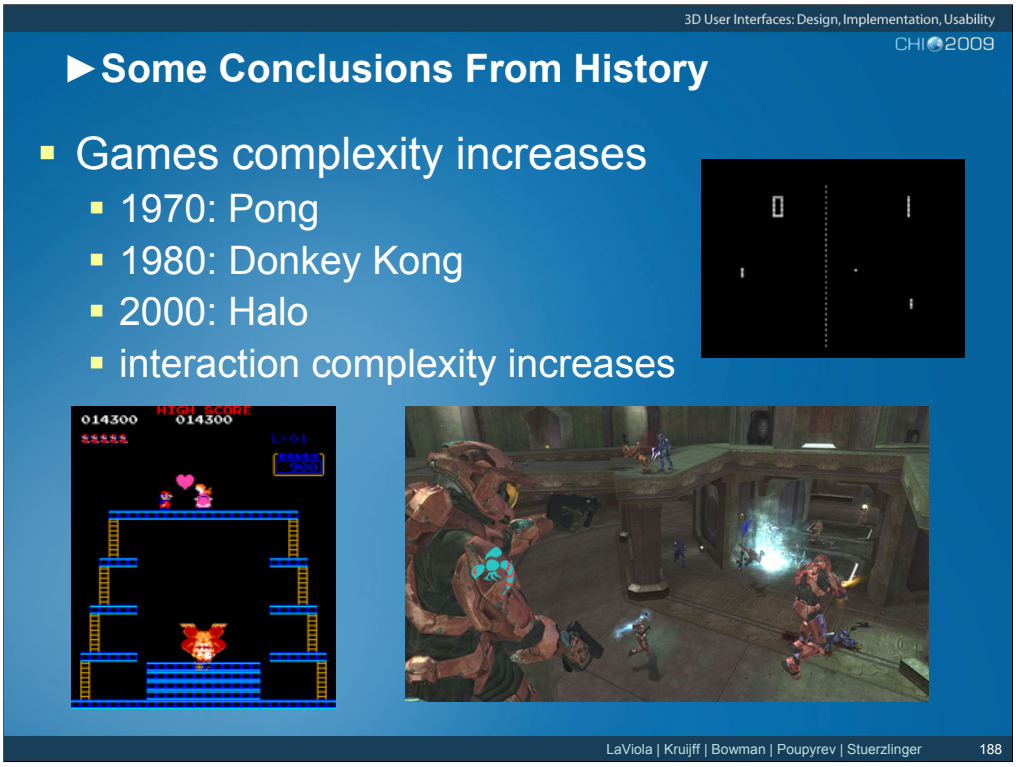
Image from
http://www.geocities.com/rabidsmily/Hardware/Sega_Master_System/SegaMasterSystem.html

▶3D and VR on Game Consoles

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



In 1995, Nintendo introduced Virtual Boy, which used virtual reality goggles.



Through time, video game complexity increased in terms of both graphics, sound, and interaction.

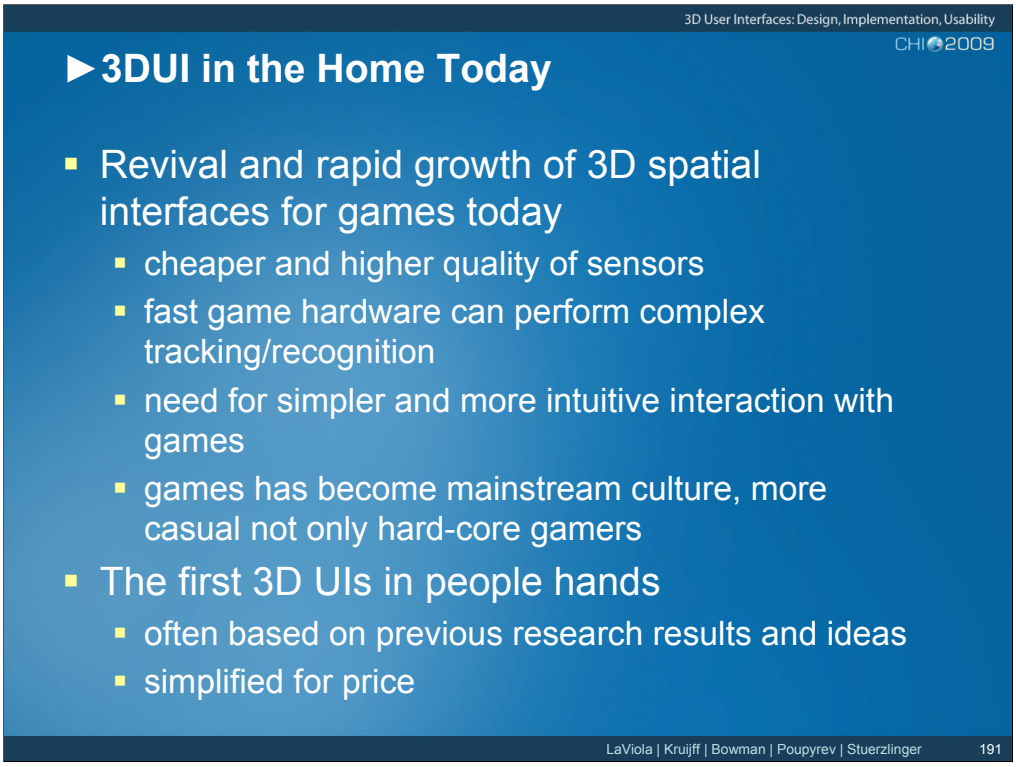
►Some Conclusions From History

- 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

With the increasing complexity of video games, came increasing complexity of the controllers used to play them. These controllers still used the same interface components (e.g., buttons, joystick) that had been utilized since the early days of video games. However, modern video game controllers employed many more of these components making the devices more difficult to learn and master. This complexity made them inaccessible to the casual gamer. As these devices became more complex, 3D spatial controllers and other innovate interfaces were developed in the arcades and were quite successful.

History has shown that the high quality video arcade games of the past became the high quality home console video games of the present. Thus, it was only a matter of time for 3DUI technology to catch up and for 3D spatial interfaces, that were successful in arcades, to make their way into the home.

3DUI in the Home Today



There has been a revival and rapid growth of 3D spatial interfaces in games today. The reasons for this revolution include faster and cheaper sensors, faster processors that can perform complex tracking and recognition, and the need for simpler and more intuitive interfaces.

▶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

One example of a device that sparked the growth of 3D user interfaces in the home is the Sony Eye Toy.

The latest gaming console from Nintendo, the Wii, has made one of the most important technological innovations in gaming technology with respect to 3D user interfaces. The key innovation of the Wii is its controller, the Wiimote. This input device not only acts as a gamepad, but makes games accessible to the casual gamer because it can sense 3D motion.

Images from Nintendo

▶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

One of the latest advances in 3D user interfaces for console video games in the Playstation 3's Eye of Judgment. This game represents the first 3D augmented reality game on the market.

▶3DUI in the Home Today

- DLP – digital light projection
  - developed by Texas Instruments
- 3D DLP HDTV
  - high resolution 1920x1080
  - high definition 1080p
  - no special graphics card needed
  - runs at 120Hz (60 Hz each eye)
  - requires shutter glasses
  - 3D stereoscopic content sent to TV via DVI or HDMI port
  - available on Samsung and Mitsubishi TVs
- Play games in 3D
  - DVDs as well
- Plasma and LCD 3D on the way!!

3D stereoscopic vision has been a common component of virtual reality systems in research labs around the world for almost two decades. The ability to see in 3D stereo helps to make a game more interesting and more immersive. Advances in 3D stereo technology has reached a point now where it is very easy to have 3D stereo in the home. An example of this is 3D DLP technology developed by Texas Instruments. With 3D DLP, projection TVs (currently from Samsung or Mitsubishi) are providing a 3D option where, when users wear a pair of active shutter glasses, they can view movies and play games in 3D. In addition, since these TV have high definition, they have excellent resolution up to 1920 x 1080. The other benefit of 3D DLP technology is that no special graphics cards are needed. Thus, anyone with a reasonable graphics card and the appropriate 3D content can view and play games in 3D stereo.

Image from http://www.dlp.com/hdtv/3-d_dlp_hdtv.aspx

►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!

From the current technologies found in console games in the home today, we can see a renaissance of 3D/spatial user interfaces in gaming with devices such as the Sony Eye Toy and the Nintendo Wii. For the first time, this type of interface has become successful with the public because it attracts casual gamers and makes video games easier to play. Although these interfaces are relatively simplistic compared to the 3D user interfaces that are being developed in research labs around the world, there are excellent opportunities for future growth.

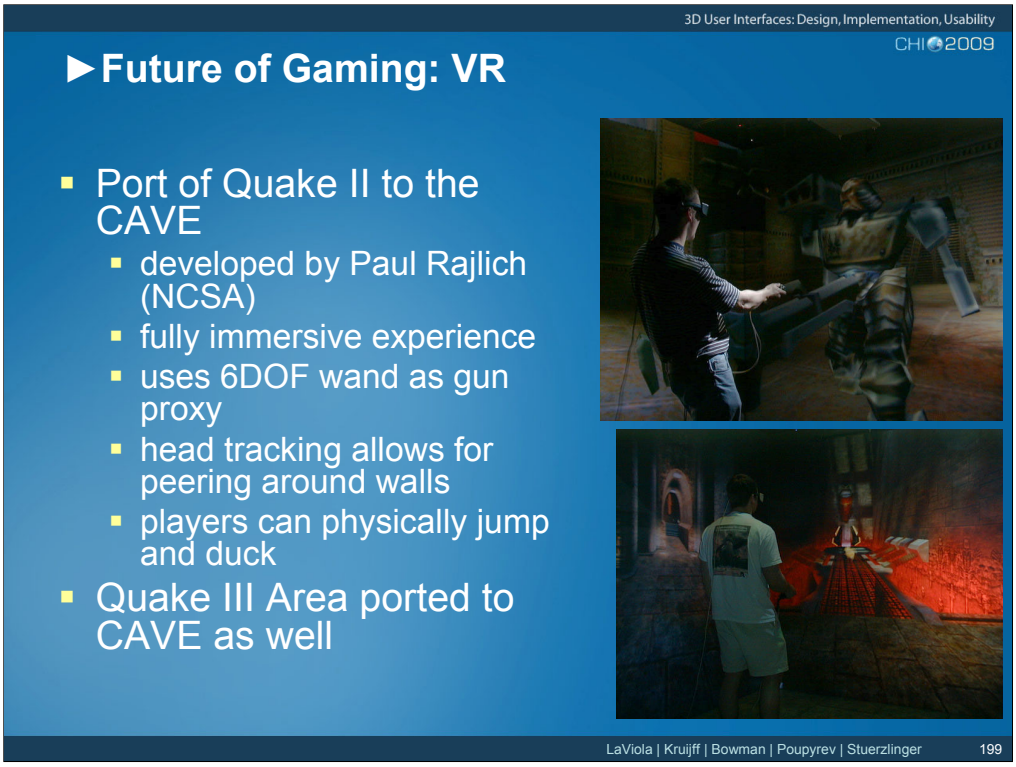
Future of Game UI

►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

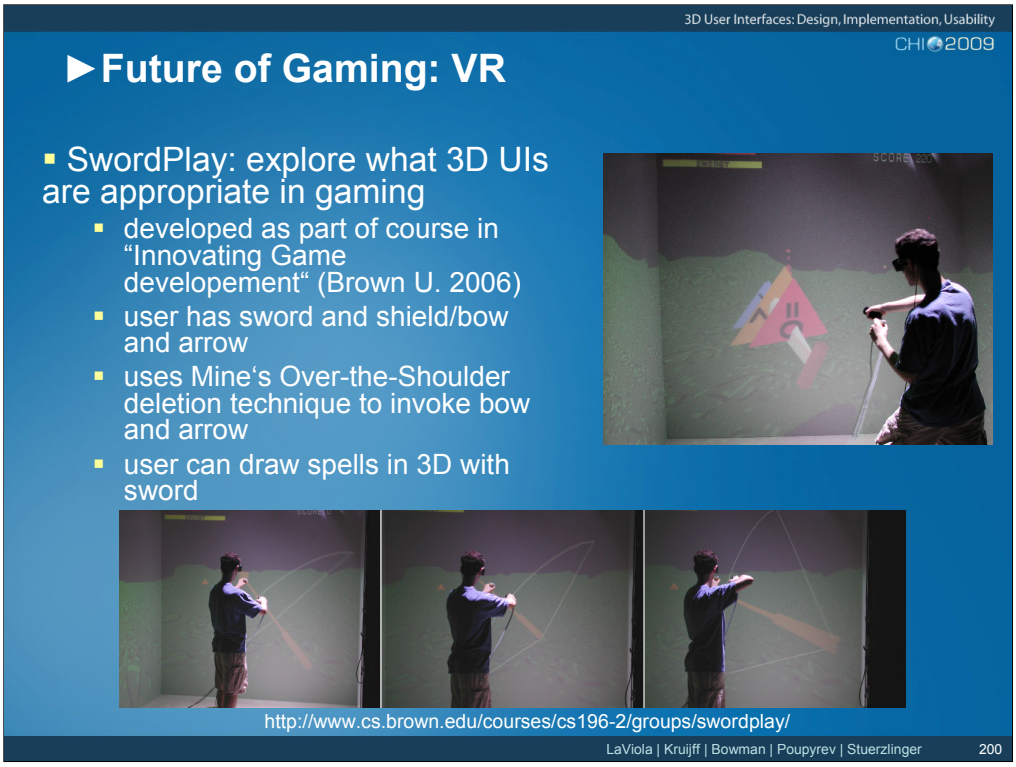
Toshiba Bubble Helmet (360 degree view)

There are several technologies that will influence the future of 3DUIs in games. These technologies include 3DUIs found in traditional virtual and augmented reality systems as well as mobile and outdoor peripherals such as cell phones and PDAs.



CAVE Quake was developed by Paul Rajlich at NCSA in the late 1990s. He took Quake II, a popular video game at the time, and ported it to a surround screen virtual environment with 3 walls and a floor. A six degree of freedom tracking device was used as a gun proxy and for navigation. Since users where head tracked, peering around walls was possible in addition to jumping and ducking. CAVE quake is an example of the type of 3D user interface that could be mass produced in the future. However, a good amount of research is needed before this vision becomes a reality.

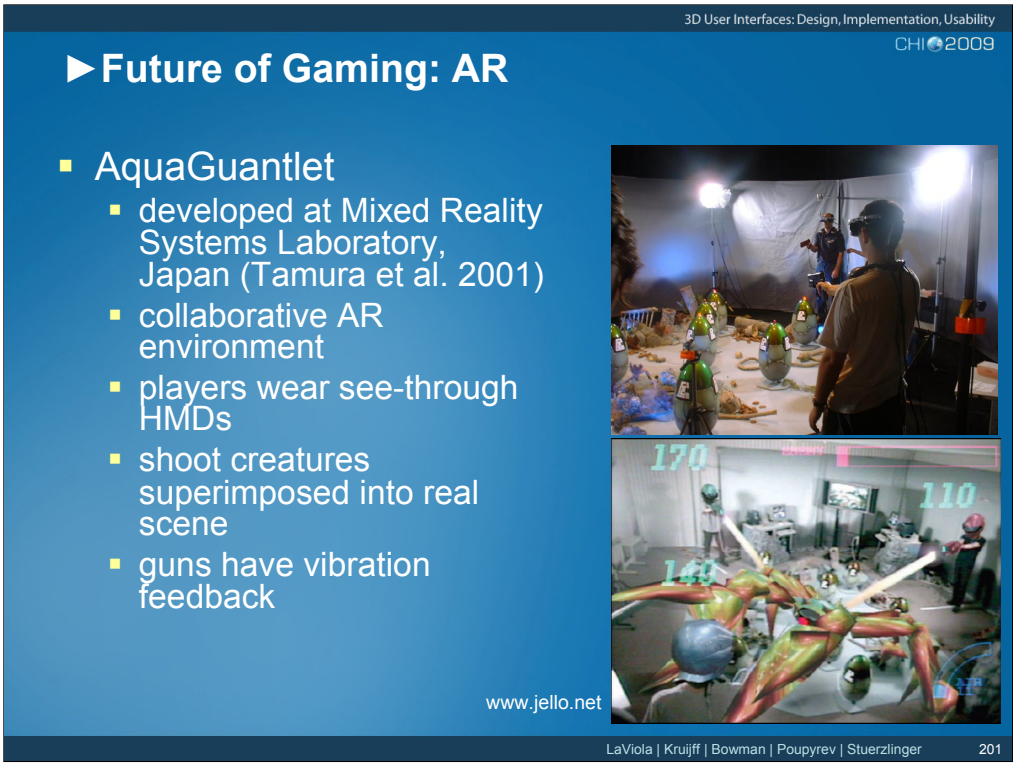
Images from http://brighton.ncsa.uiuc.edu/~prajlich/caveQuake/ and http://www.visbox.com/cq3a/



Another system that explored gaming in a CAVE was called SwordPlay. Specifically, SwordPlay was a game designed to explore what 3D user interfaces might be appropriate in a 3D, immersive gaming environment. The game was developed as a final project in a course called, "Innovating Game Development", taught at Brown University in 2006. In the game, two tracked wands are used to invoke a sword and shield and a bow and arrow to fight enemies. Players could also cast spells in 3D by drawing with the sword.

References:

Katzourin, M., Ignatoff, D., Quirk, L., LaViola, J., and Jenkins, O. "SwordPlay: Innovating Game Development through VR", *IEEE Computer Graphics and Applications*, 26(6):15-19, November/December 2006.



AquaGauntlet is a mixed/augmented reality game developed at the Mixed Reality Systems Lab in Japan by Tamura et al. in 2001. In this game, a group of players must shoot creatures that spawn out of egg-like objects on the ground. They wear see-through head mounted displays so virtual objects can be superimposed into the real world. Players used a gun prop, with vibration feedback, to shoot the creatures.

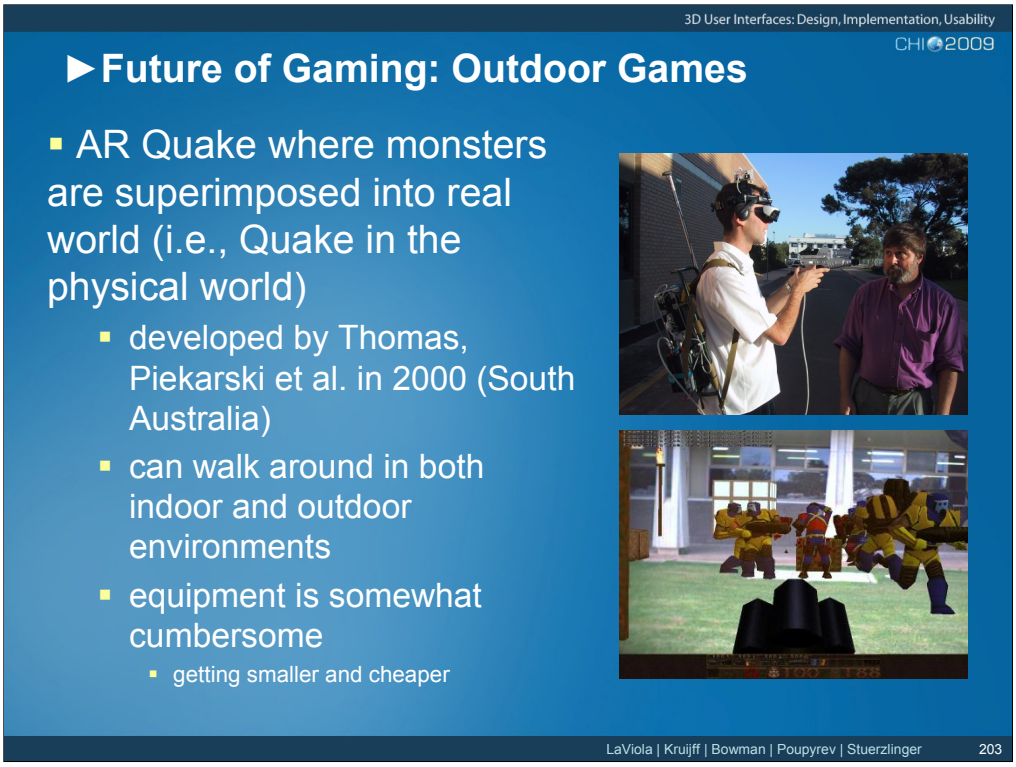
References:

Tamura, H., Yamamoto, H., and Katayama, A. Mixed Reality: Future Dreams Seen at the Border between Real and Virtual Worlds. *IEEE Computer Graphics and Applications, 21* (6), 64-70, 2001.

►Future of Gaming: AR

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

A technology that has the potential to revolutionize video game interfaces is using natural features to track users and objects. This type of tracking would allow systems to track in unprepared environments.



The idea of playing a video game such as Quake in an indoor or outdoor environment without any restriction of movement and where the interaction is based on real world physical metaphors is one that many a gamer has envisioned. There are, of course, many technical challenges to make this type of game play a reality. AR Quake is an example prototype of such as system and was developed by Thomas, Piekarski et al, in 2000. Players wear a backpack that houses a computer and a tracking device along with a see-through head mounted display. Virtual creatures are super imposed in the indoor or outdoor environment.

Images from http://wearables.unisa.edu.au/projects/ARQuake/www/index.html

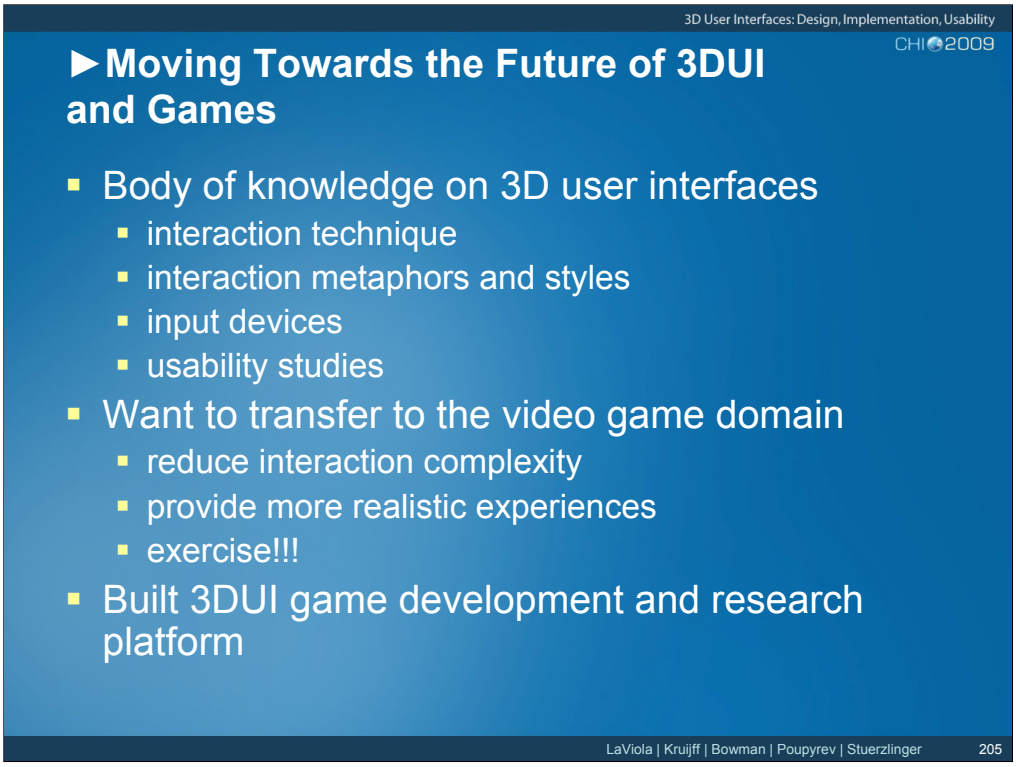
References:

Thomas, B., Close, B., Donoghue, J., Squires, J., De Bondi, P., Morris, M., and Piekarski, W. ARQuake: An Outdoor/Indoor Augmented Reality First Person Application. In 4th Int'l Symposium on Wearable Computers, 139-146, Atlanta, USA, Oct 2000.

The potential exists for 3D user interfaces to find their way into mobile technologies such as cell phones, the Sony PSP, and the Nintendo DS.

Top image http://www.icg.tu-graz.ac.at/pub/pubobjects/experienceswithhandheldar

Bottom image http://images.macnn.com/macnn/news/0803/flicksportsmoto-lg.jpg

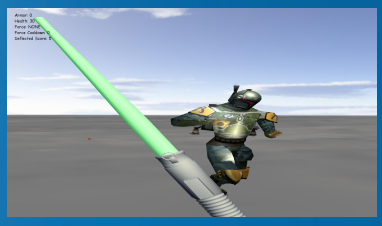


We have seen several examples of 3D user interfaces and interaction devices used both in research labs and in the home. However, there is still a significant amount of research that needs to be done to improve 3D user interfaces in games. There exists a body of knowledge on 3D user interfaces that stems from applications in scientific visualization, virtual prototyping, architectural design, etc… Thus, an interesting research question is how this knowledge can be effectively transferred into the video game domain and what new 3D user interfaces can we develop to reach the next level of gaming innovation. To explore these issues, a new 3DUI game development and research platform has been developed.

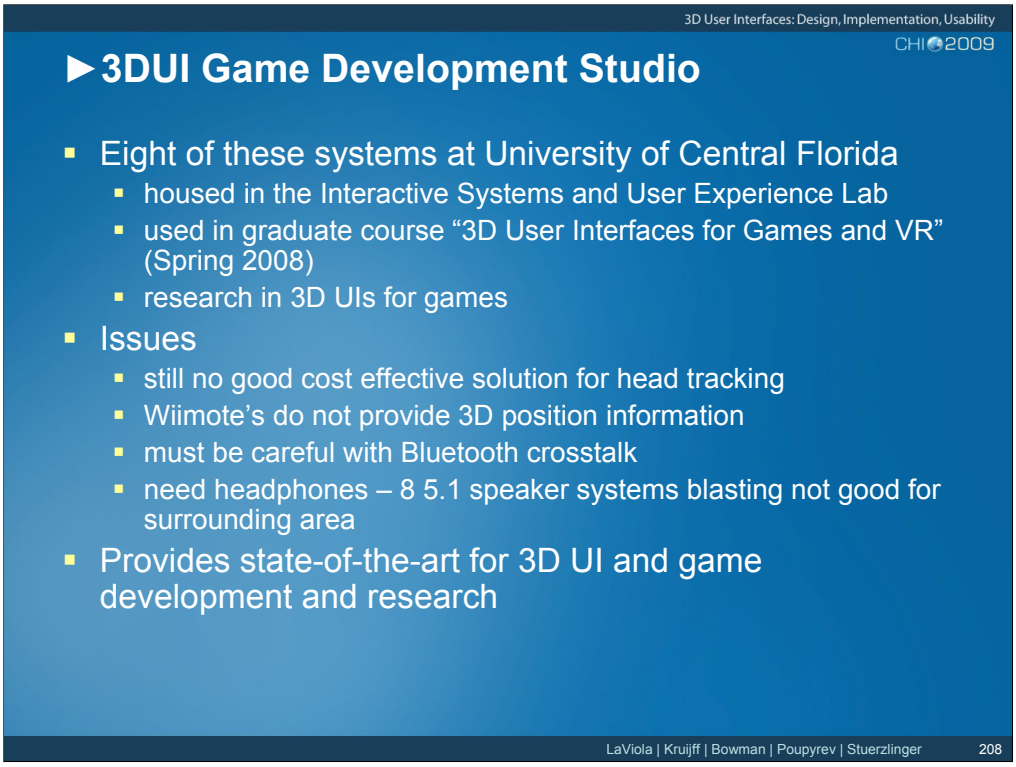
The 3DUI game development studio is designed to allow game developers and 3DUI researchers to advance the state of the art in game user interfaces. The studio has both a hardware and software component. The hardware component uses off-the-shelf technologies and makes used of 3D DLP high definition TV as the display medium along with Nintendo Wii controllers and active stereo 3D shutter glasses. The total price for the hardware configuration shown in the slide is only $3000.

▶3DUI Game Development Studio – Software

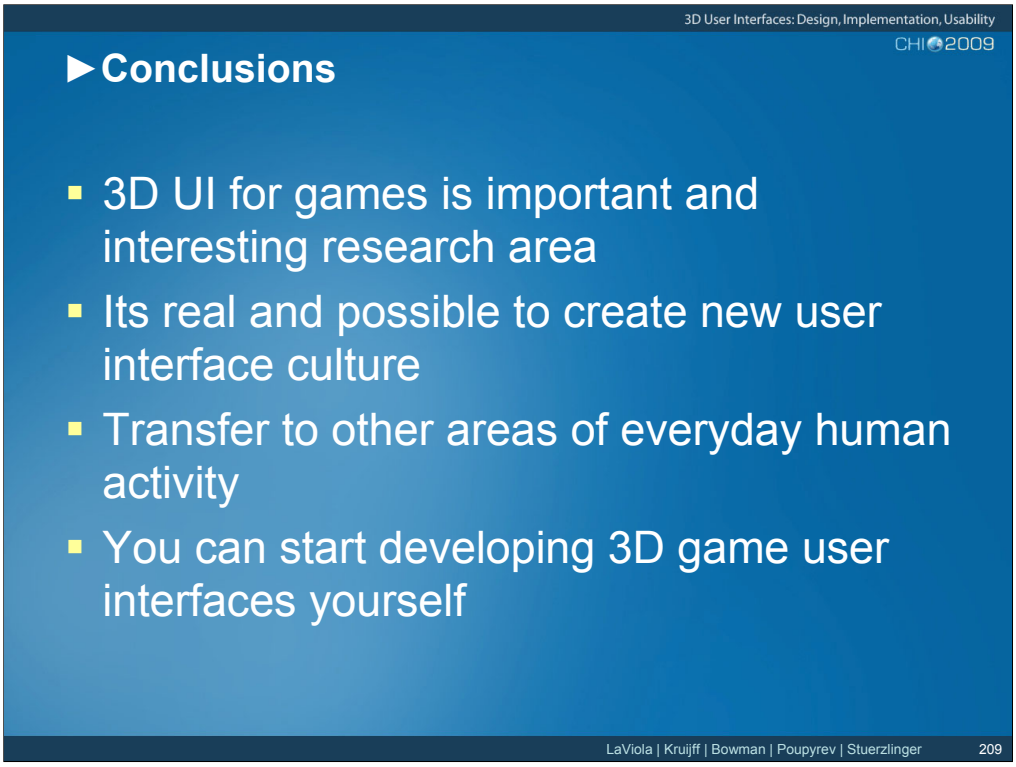
- Microsoft XNA 2.0
  - basis of development environment
  - audio support, vector/matrix tools
  - physics engine (external component)
    - Bullet (3D)
    - PhysX (3D)
    - Farseer (2D)
  - our version: modified to handle 3D DLP stereo
- Custom built XNA components
  - Scenegraph
  - Wii controller API
  - head tracking (TrackIR from Natural Point)
  - many others
- Everything downloadable for free!



The 3DUI game development studio's software component uses Microsoft's XNA game development environment as basis. It has several useful features such as a vector/matrix library and audio support. Since stereo is done differently with 3D DLP TVs (allowing any reasonably powerful graphics card to be used), the 3DUI game development studio's version of XNA has a modified rendering algorithm to support this form of stereo (see http://www.dlp.com/hdtv/3-d_dlp_hdtv.aspx for more details on the 3D DLP stereo format). Using XNA as a base, several custom XNA components are needed as part of the studio environment including a scenegraph, a Wii controller API, and head tracking support. The primary developer of the custom XNA components is Paul Varcholik, a PhD student at UCF and the API is freely downloadable and can be found at http://www.eecs.ucf.edu/isuelab/downloads.php?theme=4. Note that XNA is freely downloadable on Microsoft's webpage.



There are currently eight 3DUI game studios housed at the University of Central Florida and are part of the Interactive Systems and User Experience Lab at UCF. They are currently being used in a graduate level course called “3D User Interfaces for Games and Virtual Reality” and for research in 3DUIs for games.



3D user interfaces for video games is an important and interesting research area and we have started to see a revolution in the way games are played in the home. As technology improves, new and innovative techniques will be developed making 3D spatial interfaces a staple in the video game industry.