

# Applications of Computer Graphics

## Simulation / visualization

Scientific / education data visualization, simulation

Games, entertainment: Cave

3D computer desktops: volume > area

E- Commerce (Web3D) – display products in 3D

military training, mission planning

MRI, other scans, planning surgery

Phobia therapy

## Telepresence

Remote conferencing w/ 3D avatars – Second Life

Augmented surgery – false image overlay during surgery

robotic control, hazardous situations / chemical spill cleanup

warfare remote control drones, missiles, tanks ...

# Concepts

## 3D Topics

Rendering	graphics pipeline, render loop,
Modeling	geometries, materials, textures, lights, modelers
Interacting	select, manipulate

## 3D graphics algorithms / programming concepts

collections	geometry, transforms
Math	matrix composition, dot and cross products
interaction	selection: pick rays, high lighting
animation	motion, collision
behaviors	AI – path finding, flocking, chase / evade, NPC
modeling	procedural

1951	UNIVAC-1	general purpose commercial computer
1957	FORTRAN	high level programming language
1962	Spacewars SketchPad	first video / computer game – CRT interactive CG system, Sutherland
1963	CG film mouse DAC-1	Bell labs Englebart (also hypertext, wysiwyg editor) CAD system
1968	head mounted display	Sutherland
1969	SIGGRAPH ARPANET	Graphics professional society internet backbone

**70's**

1972	Pong	video arcade game, Bushnell
	Wumpus	adventure game, Yob
1973	Ethernet	Metcalf
1977	Apple II	color graphics personal computer
	Zork	"dungeon" game
1979	MUD	multi-user dungeon game (Zork) ..
	CompuServe	on-line email ...

**80's**

1980	Tron	Disney movie – game / VR Pac-Man
1981	Xerox Star	OOP, bit mapped GUI, ethernet, smalltalk
1982	TCP/IP	network protocol
1984	Wavefront tech.	first 3D graphics software AliasWavefront Polhemus 3D digitizer and motion tracker
1985	NES	Nintendo home game system (US)
1989	Game boy	hand held arcade games

**90's**

1990	3D consoles	Virtua Racer, Star Fox
	3D Studio Max	3D modeler (initially DOS based )
1991	Strategy, simulation	Civilization
	World Wide Web	http, Berners-Lee – hypertext, no GUI ....
	OpenGL 1.0	Open system independent graphics API
	CAVE	walk-in VR – "holodeck"
1993	Myst	storytelling, stunning graphics
	Doom	"3D" first person shooter game, Id Co.
	Mosaic	Graphical Web browser – usage takes off
1994	VRML	web based Virtual Environments (X3D)
1995	DirectX	Microsoft game API
	Interactive Halogram	SIGGRAPH – 16 fps interactive lathe
1997	Ultima Online	MORPG, internet game explosion
1998	Mobile Phone	Nokia installs Snake
	Maya	3D modeling software

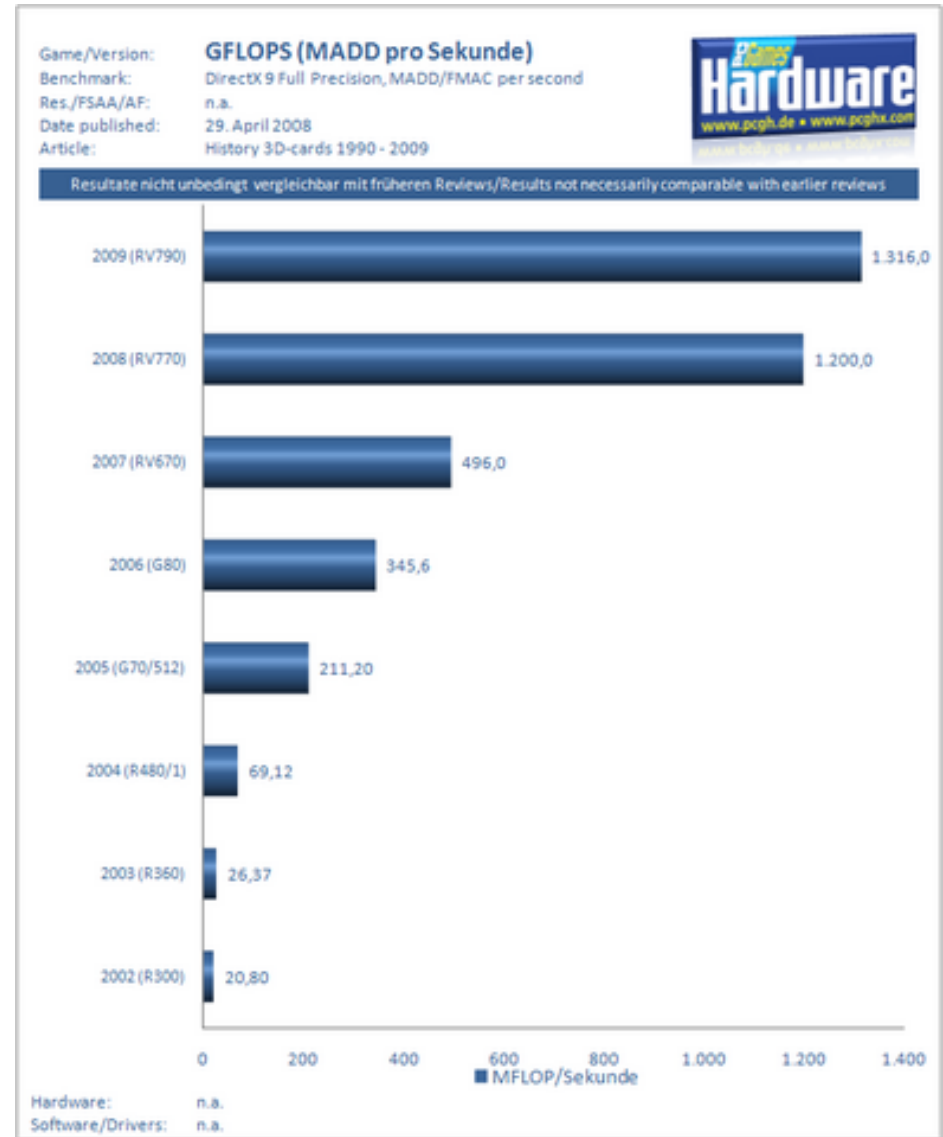
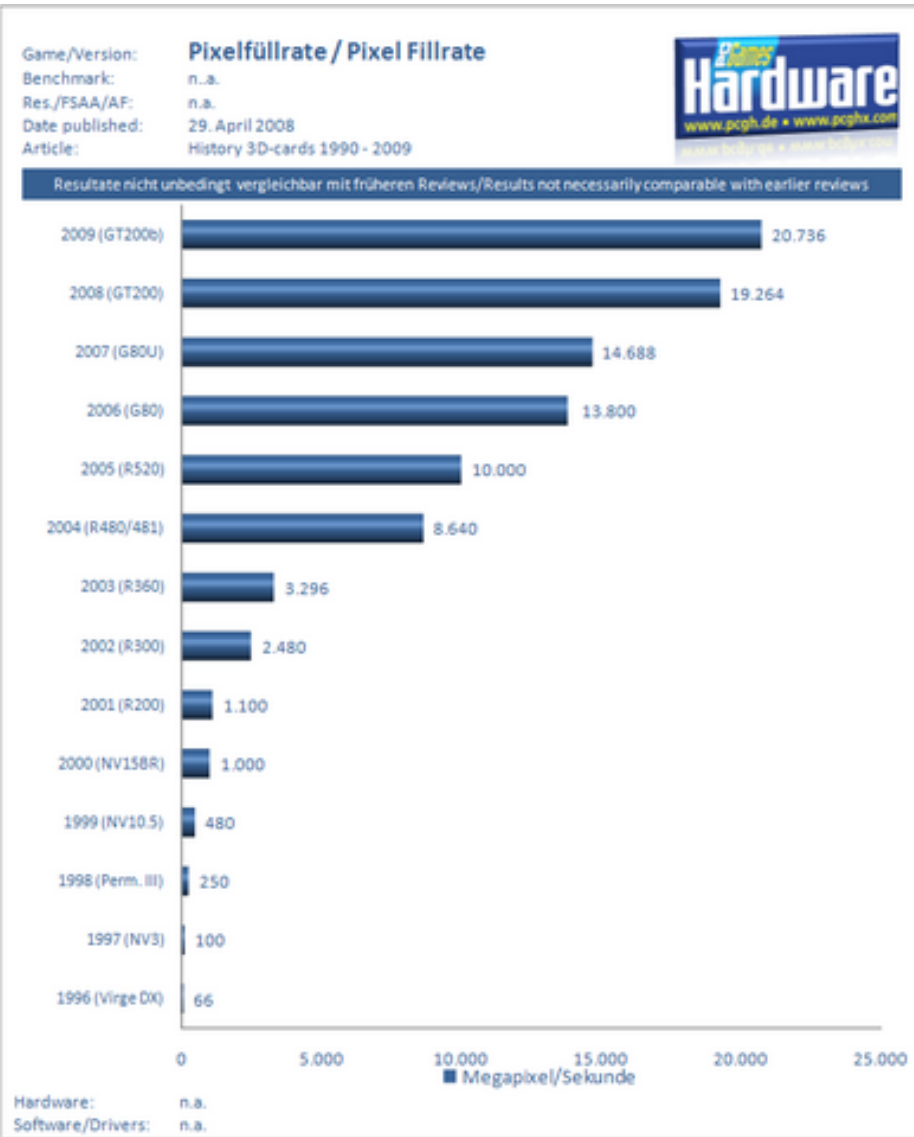
## This century

2001	XBox World of Warcraft	Microsoft's game console MMORPG
2002	Sims	"most popular game?"
2004	OpenGL 2.0 – GLSL	programable shading languages
2005	Alternate controllers	Guitar Hero, Wii (2006)
2006	XNA game studio	
2007	GPGPUs OpenGL ES	general purpose programmable GPUs 3D graphics API for mobile devices
2008	Multi-genre games Nvidia Tegra	Spore DirectX mobile, OpenGL ES support graphics acceleration for mobile devices

What did I leave out??

Whats next ??

# Accelerated graphics cards



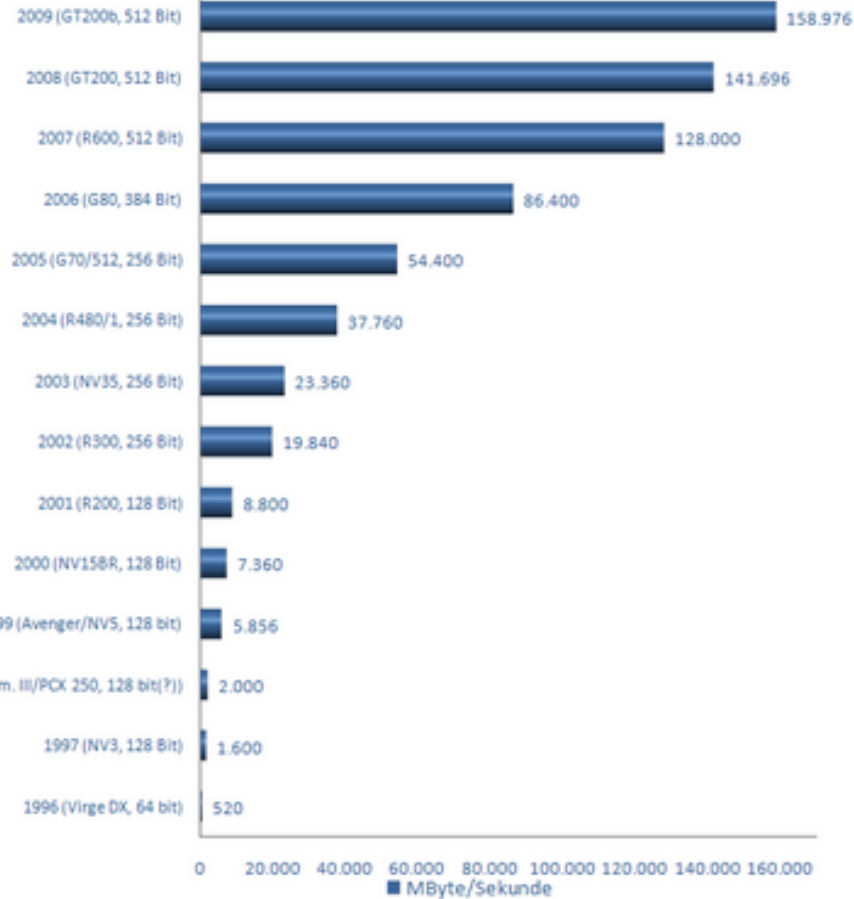
<http://www.pcgameshardware.com/aid,682883/Technical-milestones-in-the-history-of-3D-graphics-cards/Knowledge/>

### Game/Version: Video-RAM Bandbreite / Bandwidth

Benchmark: n.a.  
 Res./FSAA/AF: n.a.  
 Date published: 29. April 2008  
 Article: History 3D-cards 1990 - 2009



Resultate nicht unbedingt vergleichbar mit früheren Reviews/Results not necessarily comparable with earlier reviews



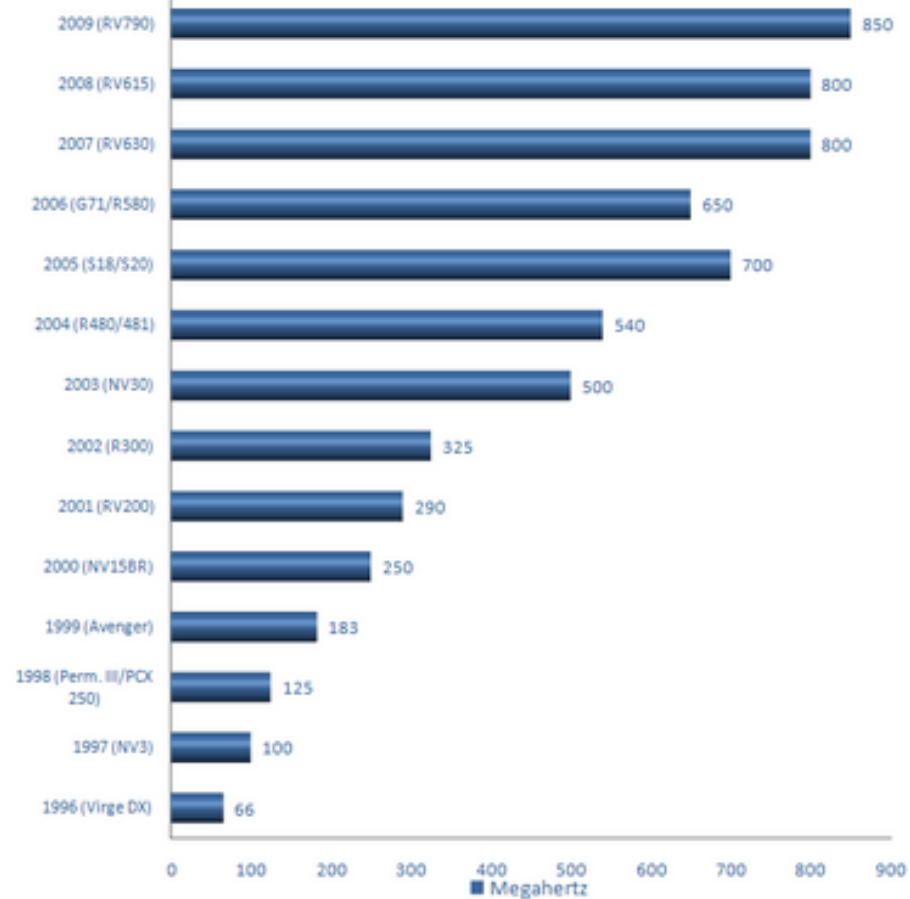
Hardware: n.a.  
 Software/Drivers: n.a.

### Game/Version: GPU-Taktrate / GPU clockspeed

Benchmark: n.a.  
 Res./FSAA/AF: n.a.  
 Date published: 29. April 2008  
 Article: History 3D-cards 1990 - 2009



Resultate nicht unbedingt vergleichbar mit früheren Reviews/Results not necessarily comparable with earlier reviews



Hardware: n.a.  
 Software/Drivers: n.a.

# Fuzzy Computer Graphics Taxonomy

Window Interface  $\leq$  Computer Graphics(CG)  $\leq$  Computer game  
 $\leq$  Special Effects  $\leq$  Virtual Reality  
 $\leq$  Animation

2D, 1 view

3D, n fixed views  
 film, tv

CG, any view,  
**interactive,**  
**multi-user**

2D clip  
 // projection  
 ! Penetration

3D clip  
**perspective projection**  
 penetration

3D clip  
**immersion**  
**collision**

event driven  
 (user events)

event, timer driven  
 static viewpoint

user, timed,  
 program driven

render “on change”

**render pipeline**

**render loop**

# From model to view

World object db (world coordinates)



Object transforms (wc)



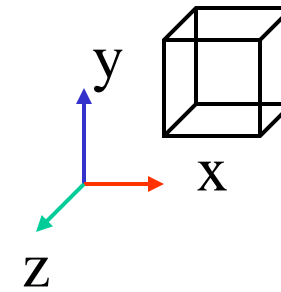
Cull / clip non-viewable objects (vc)



Viewing transform (view coordinates)



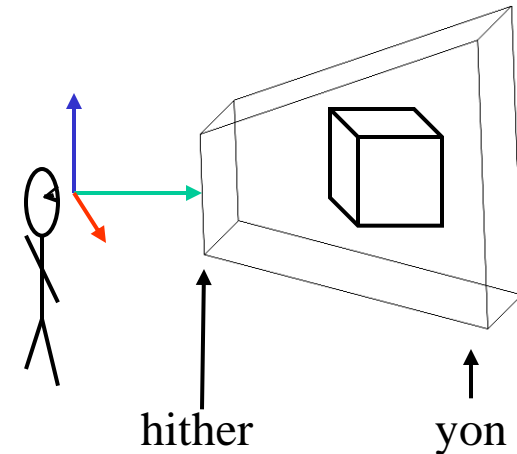
Render (lights, surface properties) (vc)



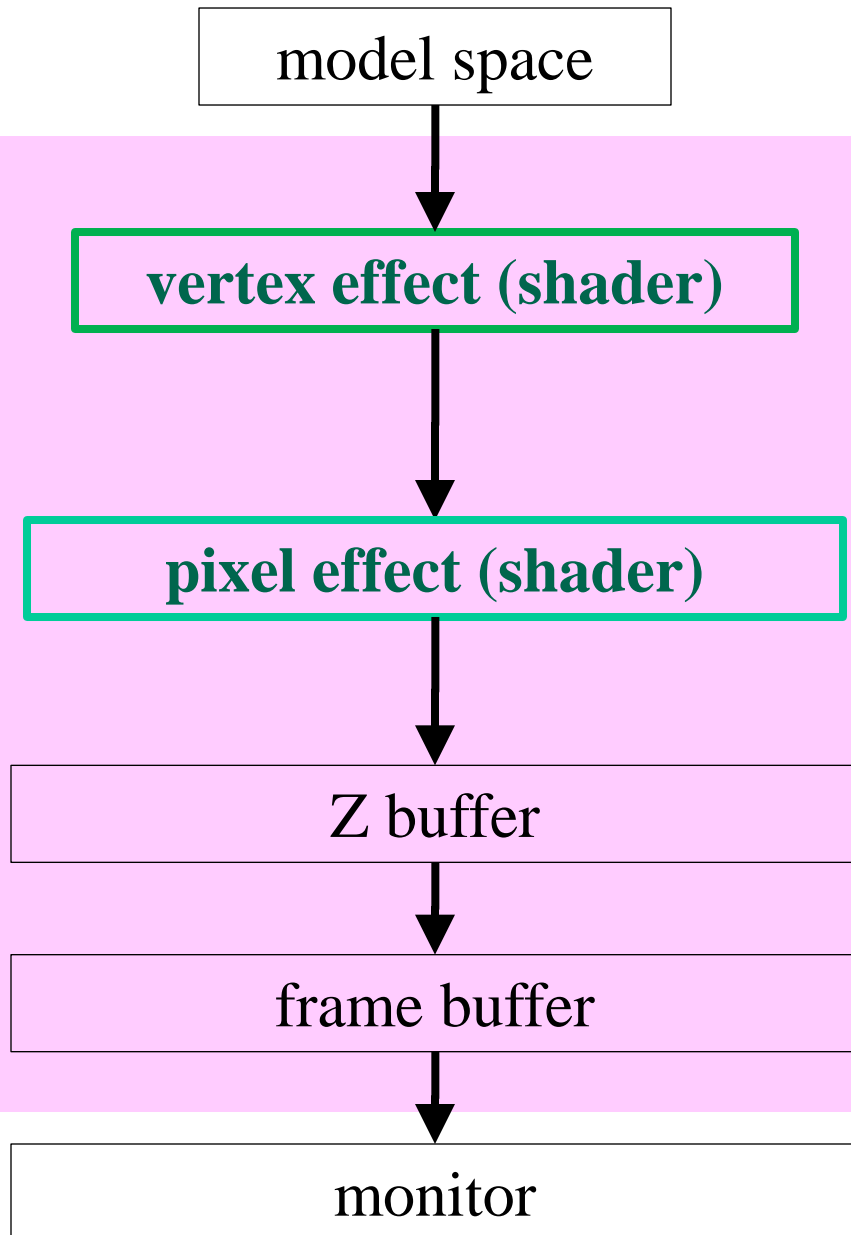
Model



View



# Graphics Pipeline Draw a frame



Application space

world & view transformations,  
lighting, projection transformations

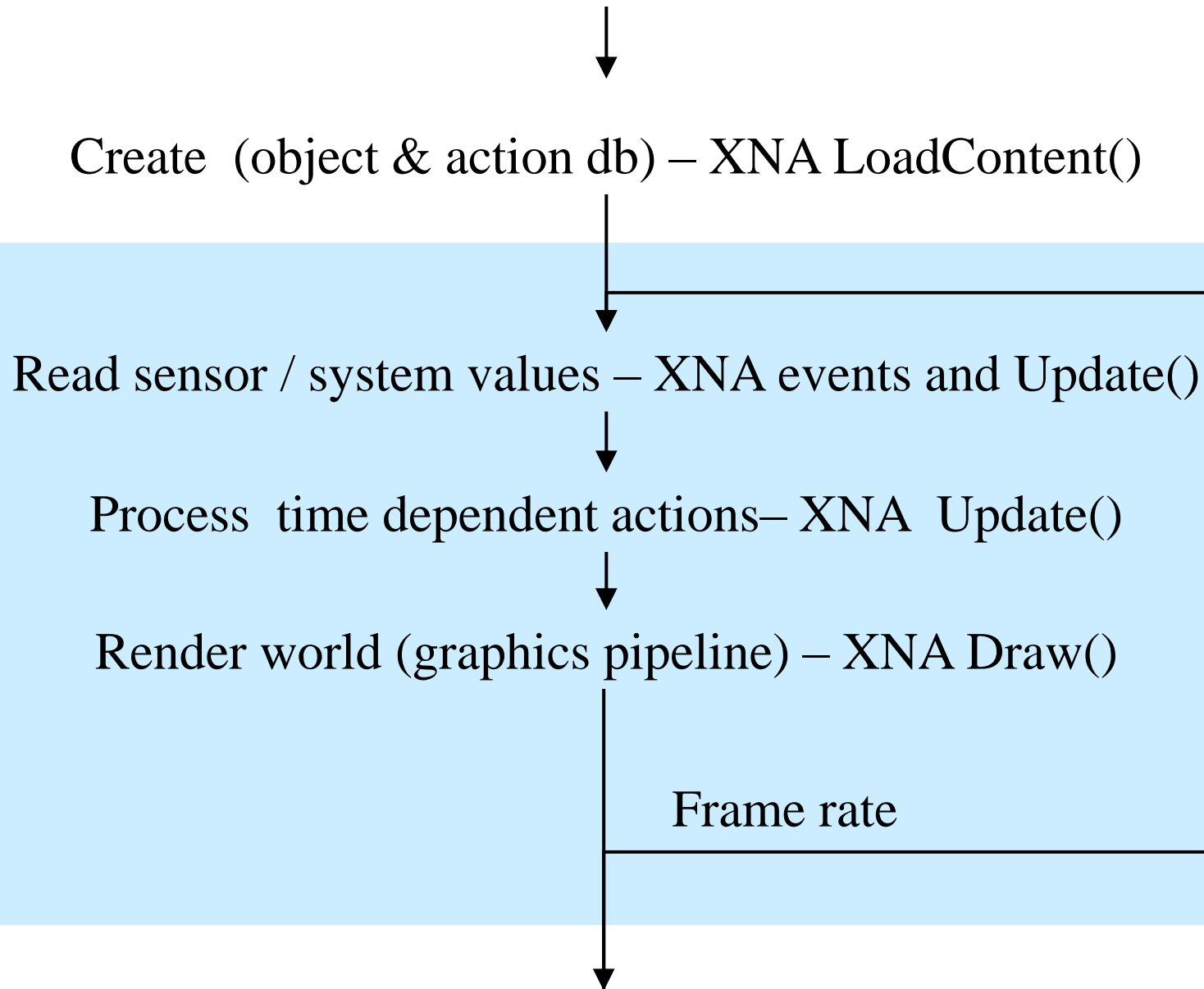
transformed points: screen position,  
color (lighting), normals.

pixel color and depth

**GPU**

Display device

# Render Loop



# Virtual Reality

6 Degrees of Freedom: freely navigate, manipulate, and view 3D objects

- 3 degrees for translation in each dimension: X, Y, and Z
- 3 degrees for rotations on each dimension: pitch, yaw, roll

Immersive VR places the user inside the world.

- wear a tracking stereoscopic head mounted display (hmd)
- have the ability to navigate with a joystick, mouse, 3D wand
- manipulate / grab objects with a glove or other device

Non-Immersive / “Through the looking glass” VR.

- Participant is outside looking into the world and manipulating objects via pointer devices.
- Machine / device independent, easy to distribute.
- Efficient medium resolution solution to 3D graphics.

# Trends

games drive computer upgrade cycle

games metaphor for software interfaces / applications  
**serious games** – languages, training,

3D active desktops – Sun, Microsoft ...

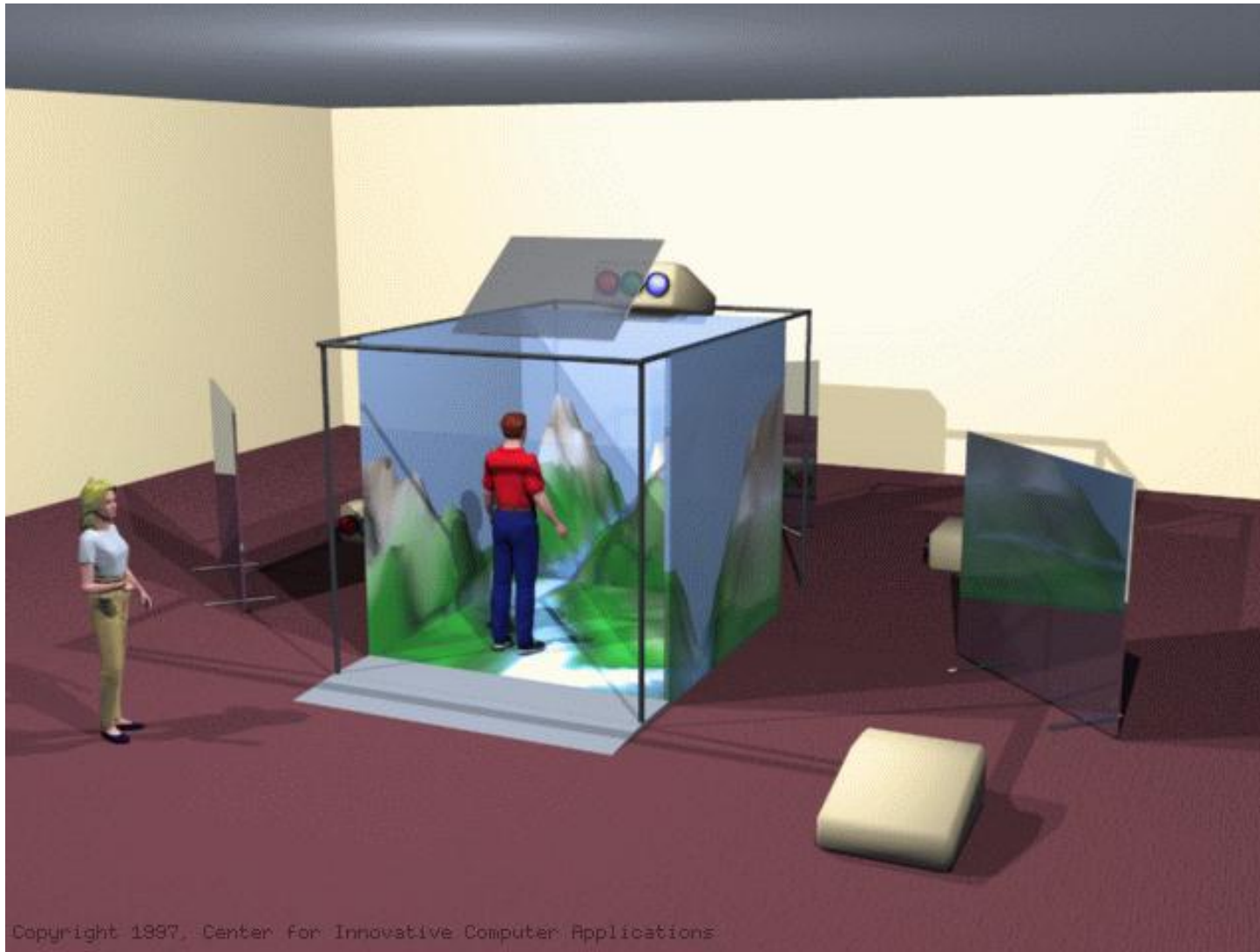
games → scientific & business

games → less immersive – peripheral dependen

AR – **augmented reality**, wearable virtual overlay in “real world”.

Ubiquitous computing where everything is smart and part of a distributed computing environment. You can inspect ("right click") objects in your world – via pda, cell phone, clothes, ...

Immerisive VR (Caves) → home entertainment systems



Reference link for caves

<http://www.evl.uic.edu/pape/CAVE/oldCAVE/CAVE.html>

# Quake in a cave



## Hardware

- 2 Quad core 2.6 ghz, 4 gb, Nvidia GeForce 8800gtx 768 mb, DX 10, CUDA
- 2Quad core 2.6 ghz 4 gb, dual SLI Nvidia GeFore 8800 gt 512 mb , DX 10, CUDA
- 1 XBOX 360 w/ some games ...
- 4 XBOX controllers for PCs
- 2 5DT data gloves
- 1 io-display stereo hmd
- 6 LCD shutter glasses
- 2 3DConnexion 3D mice
- 3 Natural Point TrackIR head trackers

## Software

- ParallelGraphics Cortona VRML,
- Blender Publisher (open source 3D modeler)
- AC3D (3D modeler)
- Visual Studio .NET 2010, DirectX 10.0 for C#, C++
- XNA Game Studio 4.0 (Windows & Xbox 360 SDK)
- Java JDK
- Open source software: OpenGL, SDL, file format converters...

# Objectives

## Concepts

Model / View: objects, cameras, projections

Math: Transformations of objects, cameras, *Mathematica*, *Freemat*

Lighting, materials, normals, colors, textures

Interaction: selection, manipulation

Animation: navigation in scene, proximity detection

Modeling: vertex -- mesh geometries

**Graphics APIs:** XNA Game Studio 4.0

**Experience:** graphics APIs, visualization, modeling,