Virtual Reality

Course ID: CSIE 7633

Lecturer: Ming Ouhyoung, Professor

(歐陽明)

課名: 虛擬實境

Textbook: Understanding Virtual Reality, by William R. Sherman, Alan B. Craig,

Morgan Kauffmann Inc., (2004-), distributed by 新月, 東華 書局

Course syllabus

- Part I: Virtual Reality
  1. Look real, sound real, feel real, smell real, react realistically and in real-time
  2. 3D Sound, directional sound
  3. Environment Walkthrough, Distributed Interactive Simulation (DIS)
  4. Tracking devices: space tracker, tracking algorithms
  5. Immersive display: Head Mounted Display, BOOM, Stereo shutter glasses
  6. Force Feedback Devices (Joystick, PHANToM etc.)
  7. Trajectory prediction algorithms

Part II, III

- Part II: Display and Visualization
  1. Modeling (Solid modeling, build large models, physically based modeling, motion dynamics)
  2. Global illumination algorithms(radiosity, volume rendering, scientific sualization)
  3. Texture mapping and advanced animation
  4. Graphics packages : OpenGL (X window, Win), DirectX(WinXP, 7, 8)

  Part III: Hardware and accelerators
  1. High performance graphics architectures (Pixel-Planes, Pixel Machine, SGI reality engine, PC Graphics (nVidia, ATI), Accelerator Chips & Cards)

Table of contents (course slides)

Virtual Reality(虛擬實境)

In Chinese

虛擬實境的基本原理在於利用電腦產生並控制一個虛擬的世界，在此虛擬世界中，可以感受到如同處於一個真實的環境。

Textbook Definition

a medium composed of interactive computer simulations that sense the participant's position and actions and replace or augment the feedback to one or more senses, giving the feeling of being mentally immersed or present in the simulation (a virtual world).

The Ultimate Display

The ultimate display would be a room within which the computer can control the existence of matter. Such a display could literally be the Wonderland into which Alice walked.   - Ivan E. Sutherland [1965] Father of CG and VR

Cyberspace

a location that exists only in the minds of the participants, often as a result of technology that enables geographically distant people to interactively communicate.

Augmented Reality

a type of virtual reality in which synthetic stimuli are registered with and superimposed on real-world objects; often used to make information otherwise imperceptible to human senses perceptible.

Terminologies Used

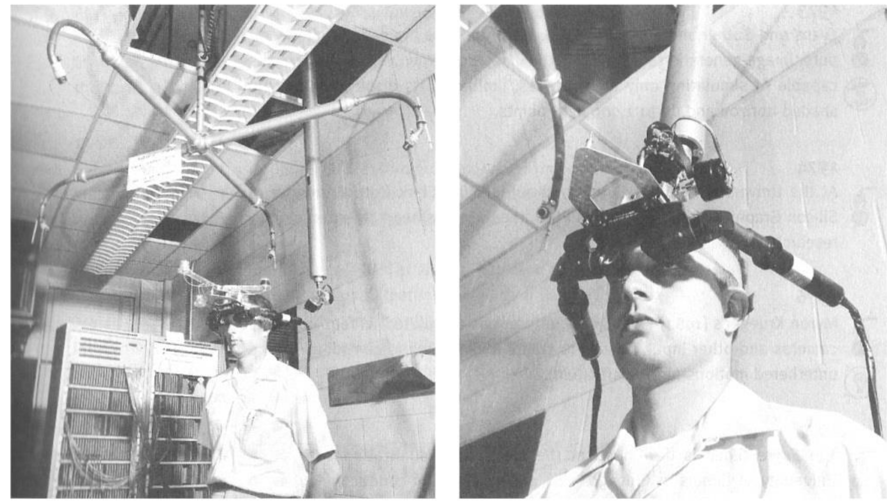
- Virtual Environment
- Micro Worlds
- Virtual Worlds
- Telepresence
- Virtual Reality

CHARACTERISTICS	Where?			Who?		Physical immersion?		Mental immersion?		Computer required?		Interactive?	
MEDIA	Real world here	Real world there	Virtual world	Me	We	Yes	No	Yes	No	Yes	No	Yes	No
Virtual reality *			X	X	X	X		?		X		X	
Augmented reality	X			X	X	X				X		X	
Telepresence		X		X		X					X	X	
Teleoperation		X		X			X				X	X	
Telephone *			X		X		X	X			X	X	
Novel			X	X			X	X			X	X	
Interactive fiction			X	X			X	X		X		X	
Online chat *			X		X		X	X		X		X	
Live TV documentary		X		X	X		X	X			X		X
TV situation comedy			X	X	X		X	X			X		X
Cyberspace			*		*			*				*	

V.R. Conditions to Meet

I. Sutherland[1965]

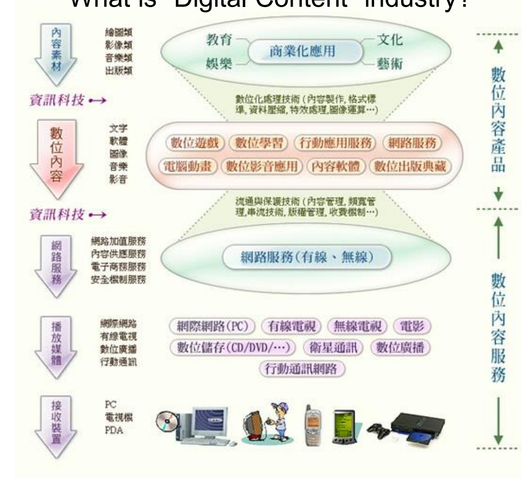
- Looks real
- Moves realistically
- Feels real
- Sounds/Smells real
- Real-time Response



Sample virtual worlds include a stick representation of a cyclohexane molecule

FIGURE 1-17 Ivan Sutherland created a viable head-mounted

What is "Digital Content" industry?



DEMO video to know the devices in VR

- Virtual Drum (stereo glasses/trackers)
- Joystick (Force Feedback Display)
- Dressing Mirror/mirror_system_video
- Robotic Surgery (Davinci Surgery System)
- The Centrifuge Brain Project (Virtual Roller Coaster)
- VIDEO_Face_Shift (facial expression)
- Tantofish_HeadMotionTracking (Kinect)
- 06 Panorama/Cardboard VR HMD (360 degrees display)
- 07 Building Walkthrough (HMD + Treadmill)

More Demo

- Augumented_Reality_cars (autostereoscopic display)
- 3D_DDR (3D Dance Dance Revolution, 2006, gesture recognition)
- Mocap_skating (motion capture with cameras and markers)
- 2014_2015_CHI (Robin etc. under 2015_CHI directory)

DigitEye (Fish Eye app), Mike_TouchSense (Users' Finger Pads), Mute Robot (Kinect Apps)

- Birdly Project (Flying Eagles, under 2014_Flying_Eagle_SIGGRAPH_EMERGING_TECH directory)
- Flight_simulator (360 degrees flight simulator by US air force)

Expected capabilities from taking this course

- Know VR (and Augmented Reality)
- Know human factors in VR
- Understand the basic instruments/devices in VR
- Implementing a graphics simulation (short story for one minute)
- Implementing a VR system

VR and recent developments
Wearable devices:
Google glasses
Oculus HMD (Appendix 1)
Google Cardboard
VR HMD (Appendix 2)

Ming Ouhyoung

Google Glass: Specification

- The core of Google Glass is its tiny prism display which sits not in your eyeline, but a little above it. You can see what is on the display by glancing up. The glasses also have an embedded camera, microphone, GPS and, reportedly, use bone induction to give you sound.

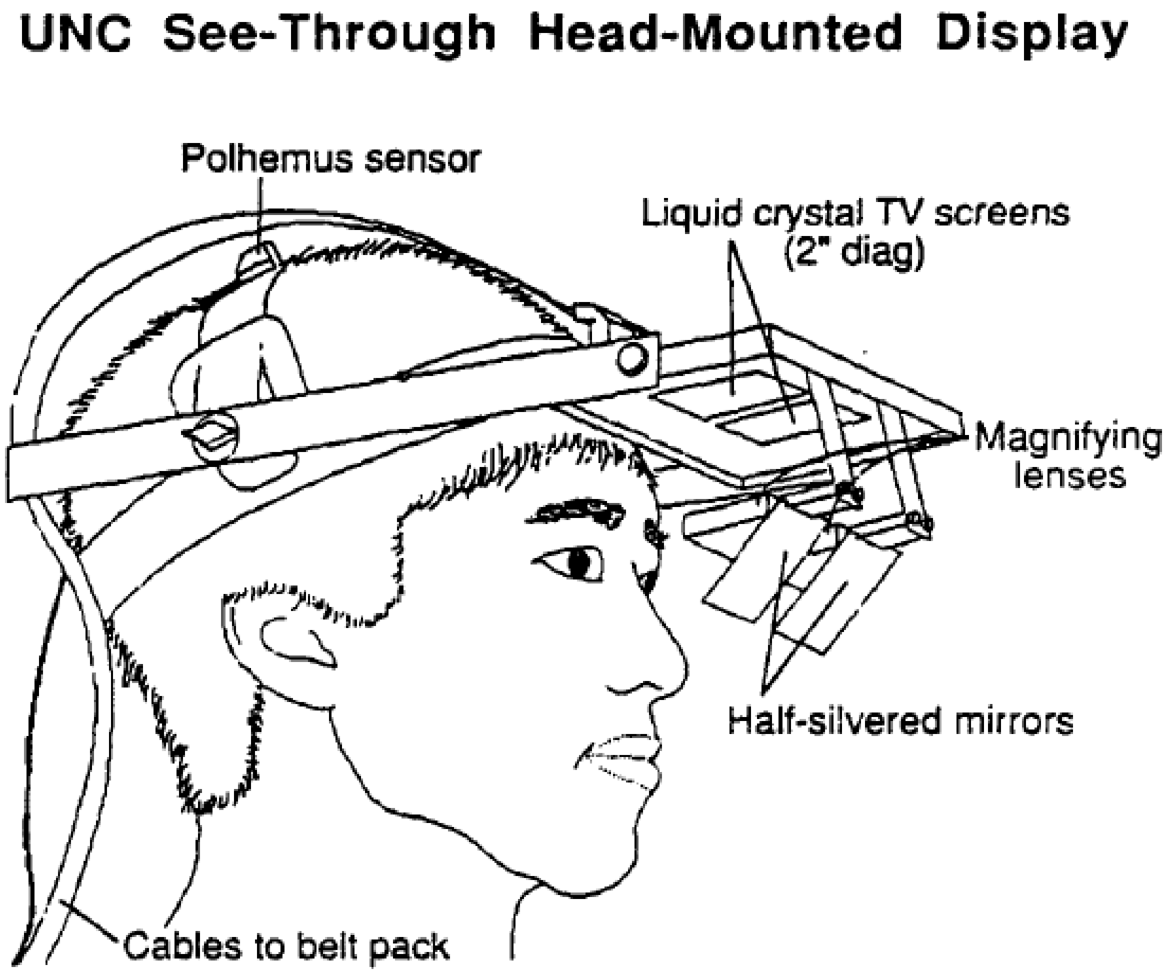
- the glasses are expected "to cost around the price of current smartphones." So that's around $750/£500, then, possibly with the help of a hefty Google subsidy.

Google Glass 2013

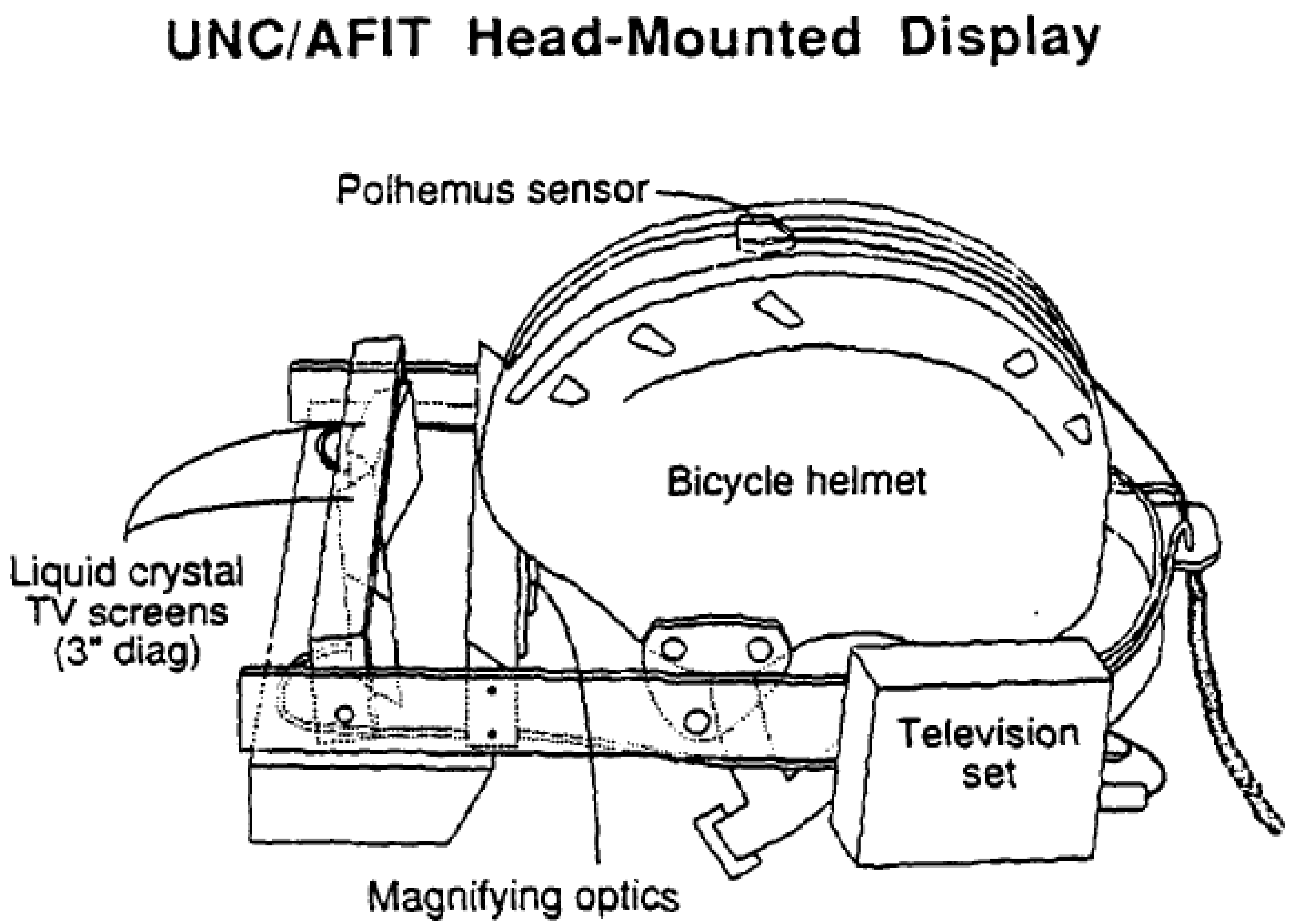
Does Project Glass represent the next big step in mobile communications?

Google Glass

UNC See-through Head-mounted display (1989)



UNC-US AF
Head-mounted display (1989)



Sony HMD

Canon Mixed Reality HMD

Meta Glasses: Meta Inc. and Epson Inc.

- https://www.spaceglasses.com/

- Head up display: used in pilots of fighter planes.
- No need of stereo display.
- In car business: embed front panel display.
- Must have vs Nice to have

Why important

- Popularity of smart phones
- Constant information display by Internet explorers, Chrome, Safari, etc.
- Not allowed to use smart phones during driving for the driver.
- However, important short messages are necessary, including Yes/No quick answers.
- Stereoscopic display is not a must, but nice to have [* ?]

New VR/AR glasses design

- See through features
- Light weight,
- Independent of eye sight values (near sight, far sight for elders), so that original eyeglasses can be used.
- Appears to be at least 40 cm ahead.
- Simple gesture recognition, Yes/No selection, slider up/down, left/right.

3D/Stereo Display

Sources from ITRI (工研院, 前瞻顯示計畫)

2D Multiplexed 3D Display (Autostereoscopic Display)

- Projection
- Parallax-Barrier
- Lenticular lens
- Sub-pixel color filter
- Viewer-tracking
- Time multiplexed

Types of 3D/Stereo Displays for 3D TV and Animation

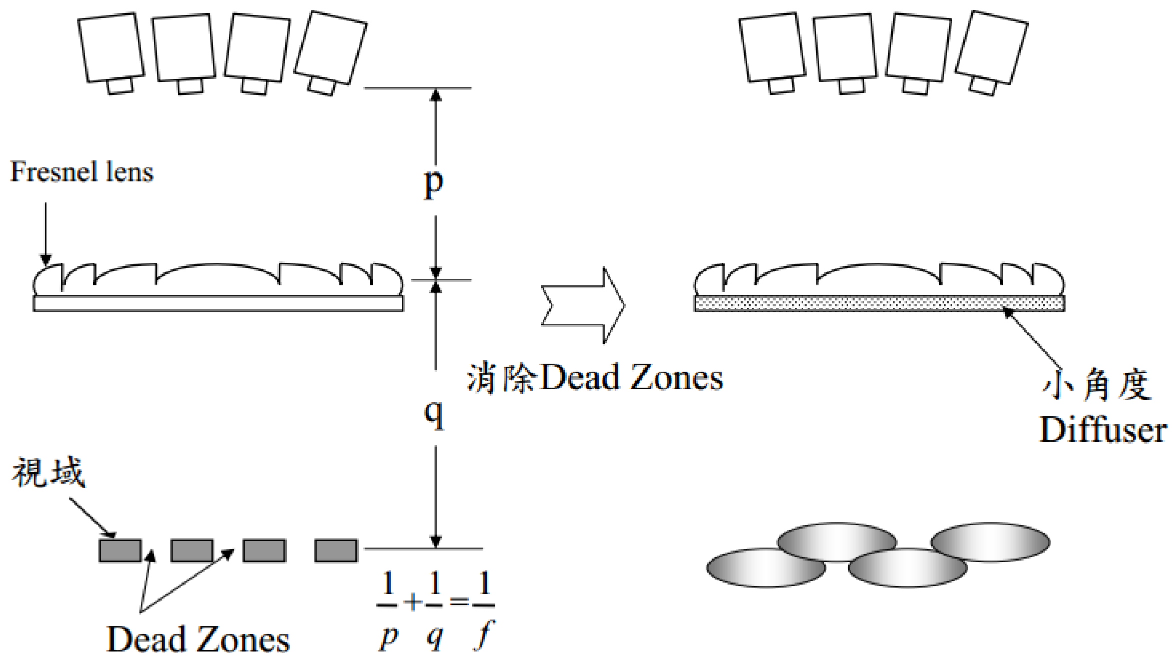
Left and right eye: about 6 degrees difference in viewing an object, if placed ahead of our head 60 cm away.

（Human Interpupillary Distance: 55 ~ 71 mm, assuming average 6mm interpupillary distance, then the viewing angle is about 5.72 degrees a circle of radius 60 cm, 6mm means 5.72 degrees)

◇ stereoscopic(眼鏡式技術)
◇ polarizing glasses(偏光眼鏡)
◇ shutter glasses（快門眼鏡）
◇ autostereogram （裸視3d技術）
◇ parrallax barrier（光柵式）
◇ lenticular lens（柱狀透鏡式）

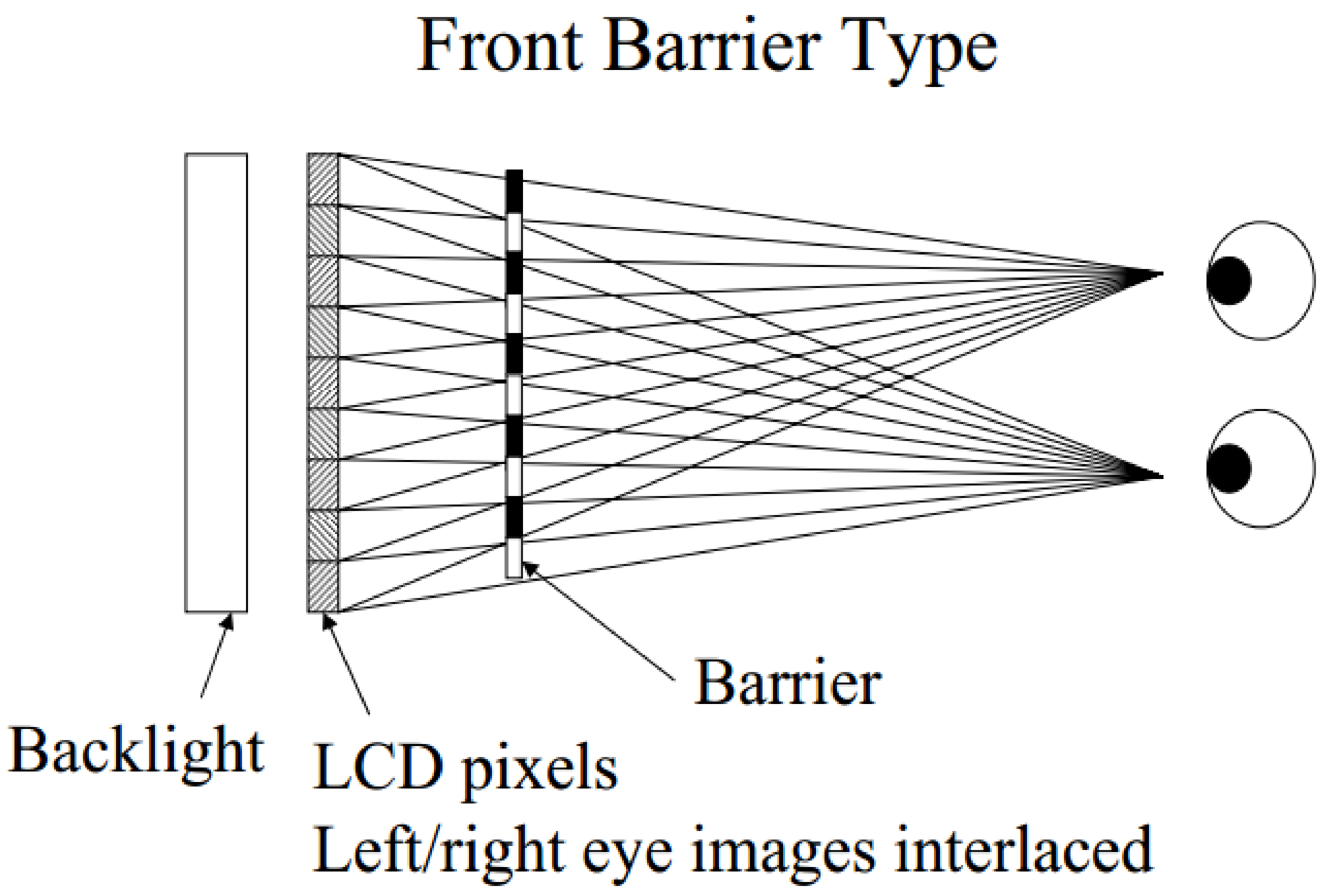
3D Display: Multi-Projectors

投影式多視域3D Display



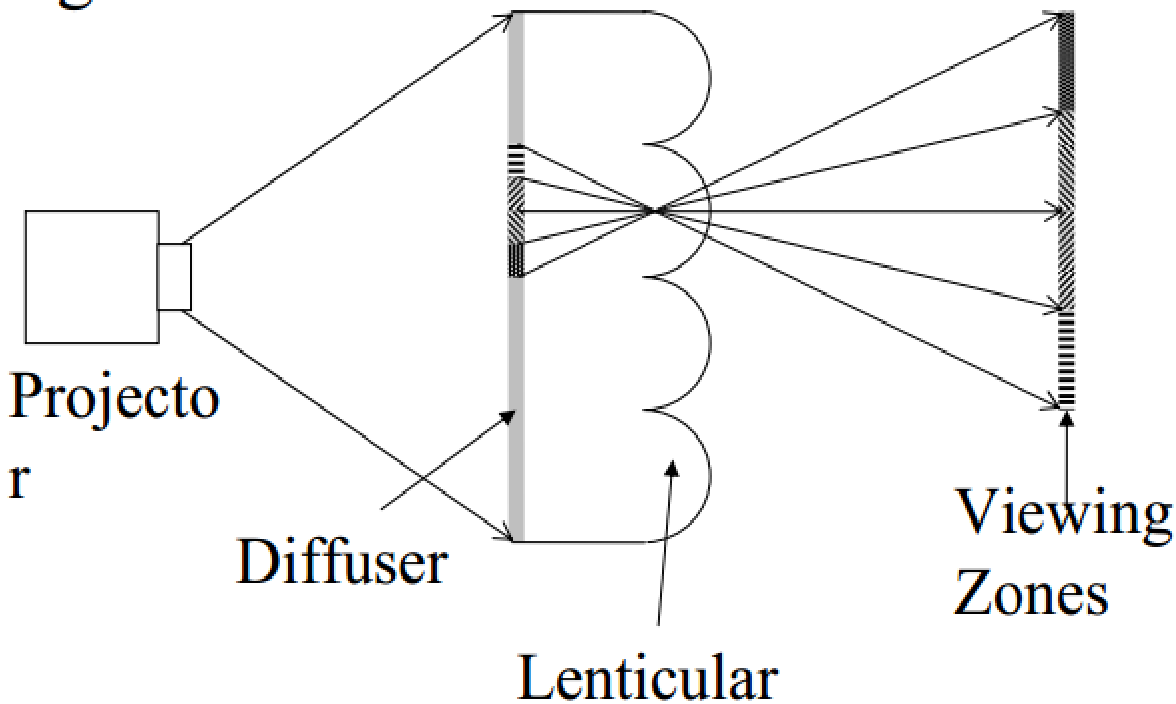
$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

Parallax Barrier 3D Display



Lenticular 3D Display—投影式

- **Sanyo**
  - Single Lenticular



Virtual Reality

1994 prediction: Research Directions and Future Trend

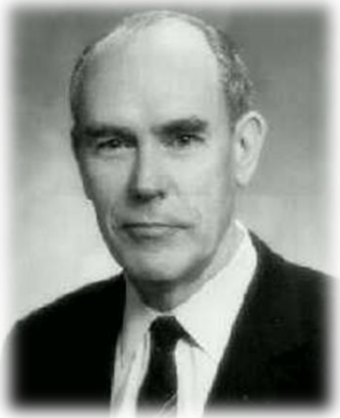
Few Technologies in recent years have evoked such fiery discussions in the technical community, and fewer still have sparked such passionate involvement of the humanities and the cultural sector. --- Carl Machover.

VR: The quality of the experience is crucial. To stimulate creativity and productivity, the virtual experience must be credible. The "reality" must both react to the human participants in physically and perceptually appropriate ways, and confirm to their personal cognitive representations of the micro world in which they are engrossed. --- Carl Machover CG&A 1994.

Ivan Sutherland at the console of the TX-2- Sketchpad Project, MIT, 1963 In 1963, his Ph.D. thesis, "Sketchpad: A Man-machine Graphical Communications System," used the lightpen to create engineering drawings directly on the CRT.

Basic Equipment
(video demo)

- visual display
  - helmet-mounted display
  - see-through helmet
  - mounted display
  - liquid-shutter glasses
- acoustic display
  - 3D sound
- haptic display
  - force-feedback joystick or arm
  - force feedback data-glove
- 6D Sensors: 6D tracker & data-glove
- Mechanical sensors: robot arm
- Motion sensor: camera

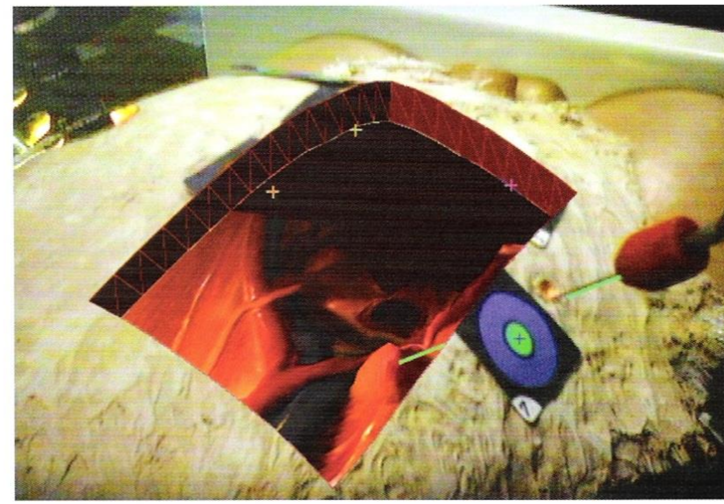


Ivan Sutherland,
Born: 1938, Hastings, Nebraska
Profession: Engineer, Entrepreneur, Capitalist, Professor
Position: V.P. and Fellow, Sun Microsystems, Inc.
Education: Ph.D. Massachusetts Institute of Technology
M.S. EE California Institute of Technology
B.S. EE Carnegie Institute of Technology (now Carnegie Mellon University)
Patents & Publications: See list
Honors & Professional Societies (partial list):
Smithsonian Computer World Award, 1996
AM Turing Award, Association for Computing Machinery, 1988
First Zworykin Award, National Academy of Engineering, 1972
Member, National Academy of Sciences, since 1978
Member, National Academy of Engineering, since 1973
Member, Institute of Electrical and Electronic Engineers (IEEE)
Fellow, Association for Computing Machinery
Latest Accomplishment: Became a historical relic in the Smithsonian
Proudest Accomplishment: Four Grandchildren

Scientific Visualization

PLATE 5 *In the Mandala application, a virtual reality experience with a second person point of view, the participant watches their actions on a screen as their image interacts with the virtual drums.*

PLATE 6 *Fiducial markers, such as the blue and green target seen here, provide a landmark for optical tracking systems. In this augmented reality application, a virtual representation of the patient's internal organs is displayed in registration with their body.*



- Evolution
  - 2D display
  - 3D display
  - stereoscopic display
- stereoscopic display with haptic display
- Visualization of planetary surfaces(NASA)
- Virtual wind tunnel (NASA NAS project)
- Molecular synthesis (UNC, GMD, U.York)

Medical applications

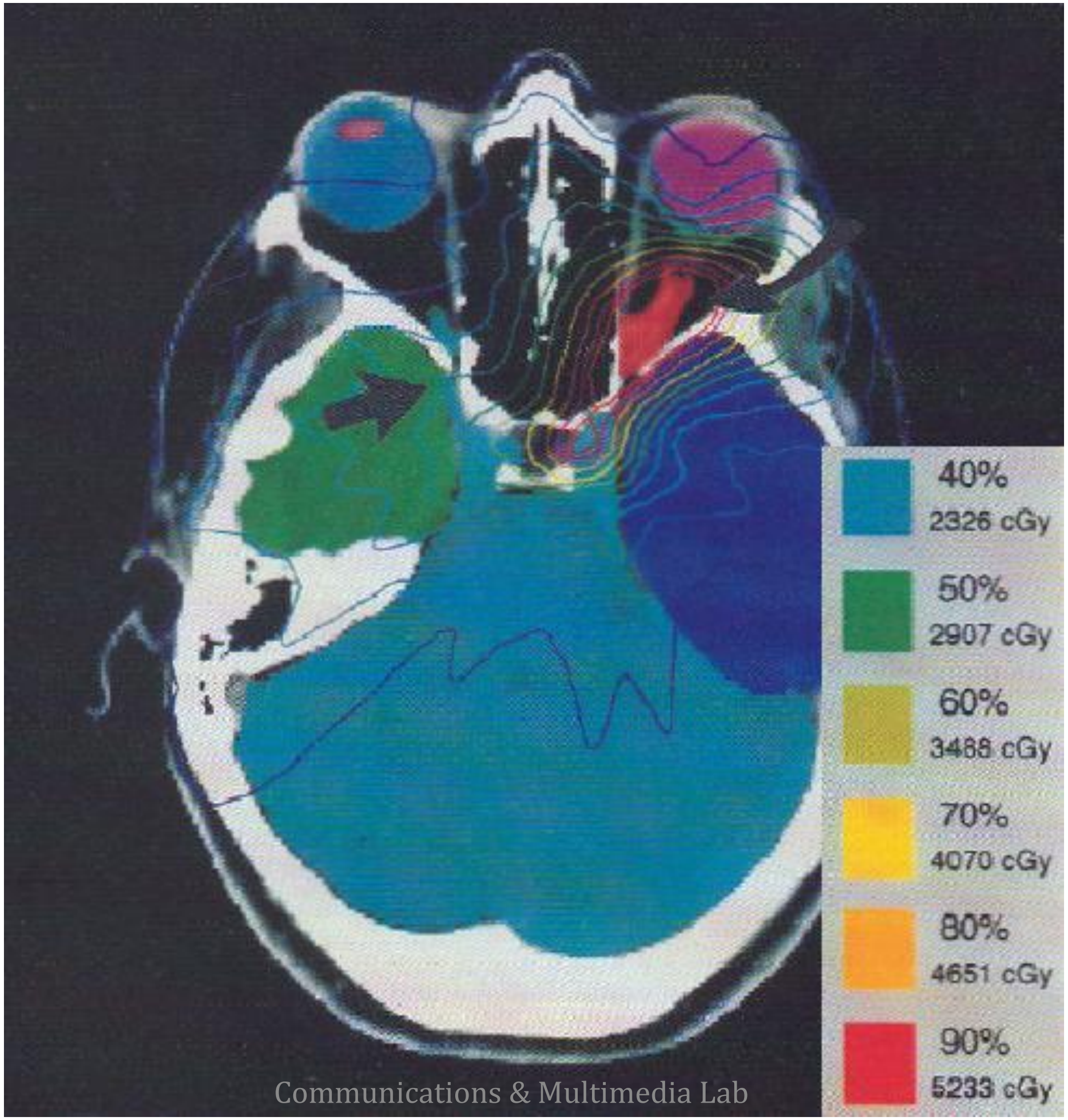
- Virtual stereotactic surgery
  - from CTs
  - from MRIs
  - Davinci surgery (Demo)
- Ultrasonic imaging: A virtual environment perspective
- Pathological tremor investigation
- Radiation treatment planning

radiation treatment planning

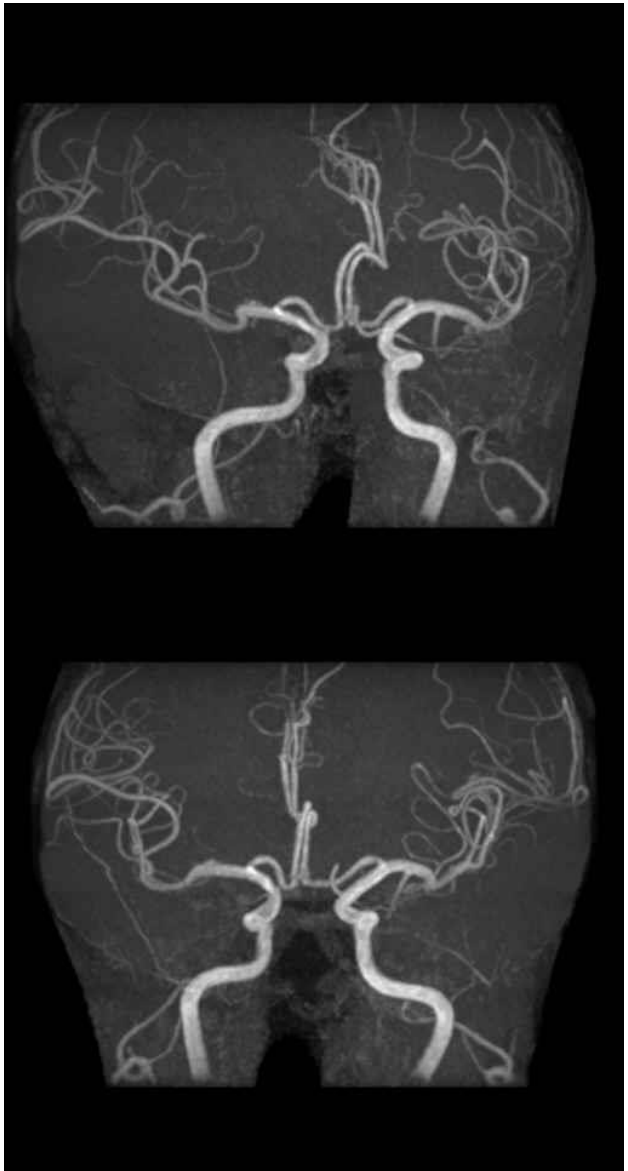
- In radiotherapy, **radiation treatment planning** is the process in which a team consisting of radiation oncologists, radiation therapist, medical physicists and medical dosimetristsplan the appropriate external beam radiotherapy or internal brachytherapy treatment technique for a patient with cancer.

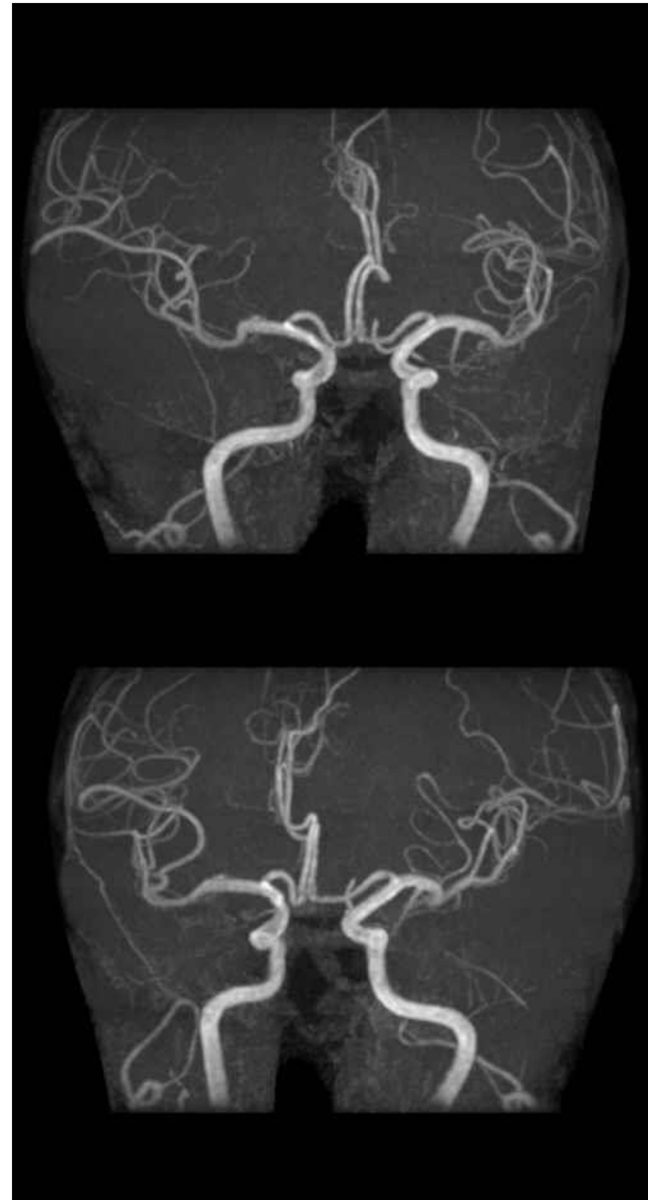
- Forward planning is a technique used in external-beam radiotherapy to produce a treatment plan. In forward planning, a treatment Medical physicist places beams into a radiotherapy treatment planning system which can deliver sufficient radiation to a tumour while both sparing critical organs and minimising the dose to healthy tissue.

radiation treatment planning



Ming’s brain vessels, MRI, for tumor scan





Virtual Cockpits

- Virtual Coupled Airborne System Simulator (USAF)
- Virtual Environment configurable training aid(Brough, British Aerospace)
- Real and virtual environment configurable training aid(Brough)
  - mix a virtual world with a real world.
  - concept: mount a color TV camera onto a HMD and couple the result into HMD via a chroma processing system.

The Stewart Motion Platform, Consists of a fixed base and a moving platform connected by six extensible actuators.

Provide sensation of motion by tracking desired trajectory. Currently in Professor L C Fu's lab.

Telepresence

- control a robot by remote control, especially in hazardous environments
- Virtual environment remote driving experiment(ARRL)
- Man in virtual space (ESA)
- Astronaut simulation (TNO-FEL, NASA)
- Conduction robots (Fujita)
  - control in Japan, action in America
  - problem: long-distance communication's delay

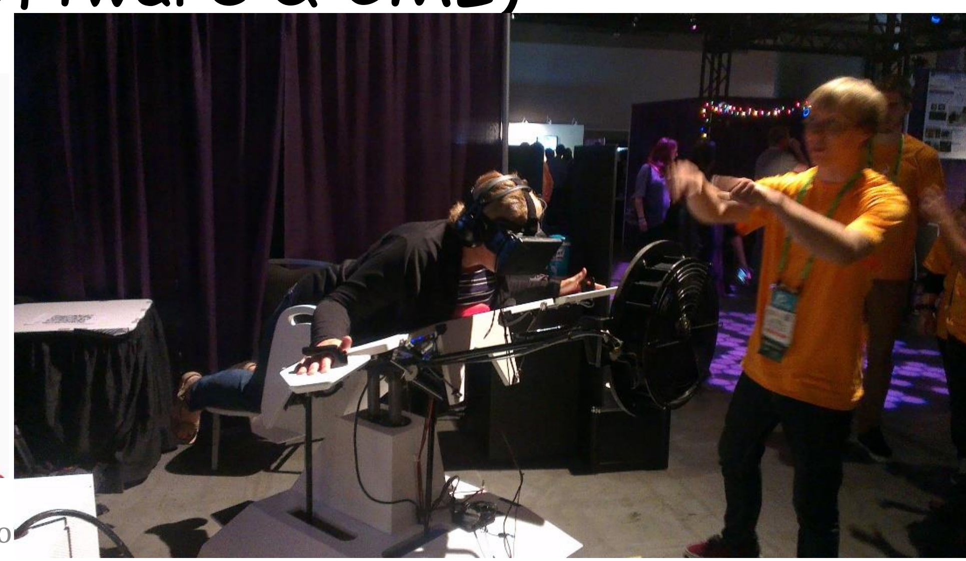
CAD/CAM

- Rover 400 car interior design(Brough)
- 3D CAD shape model(NEC)
- Operations with virtual aircraft(Boeing VSX)
- Positioning clothing in 3D(Switzerland)
- Hair style design(NTU CML)
- Software analysis(Tepco)
- Maintenance systems(Brough)

Entertainment

- Star Wars, Lucasfilm (USA)
- Sega, Nintendo (Japan)
- W Industries (UK)
- Evans & Sutherland (USA)
- Virtual DOOM (id Software & CML)

2014



Virtual Reality

1994 prediction: Research Directions and Future Trend

Related areas of technology:

multimedia, HDTV, information superhighway, 3D graphics, video games, arcade, theme parks.

America's entertainment economy

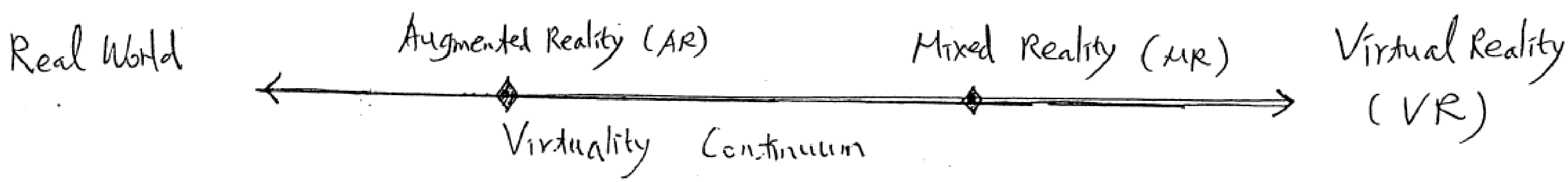
(Business Week, March 14, 1994)

As consumers spend big bucks on fun, companies are plowing billions into theme parks, casinos, sports, and interactive TV.

The result: Entertainment is reshaping the U.S. economy.

Virtual Reality

Research Directions and Future Trend

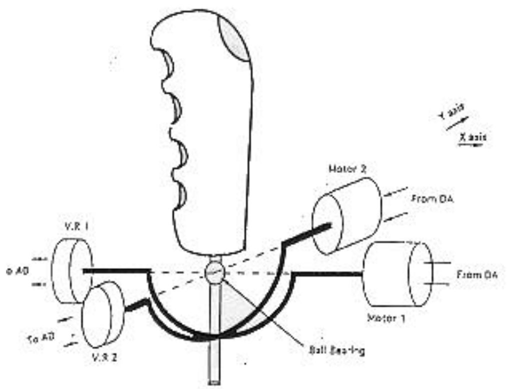


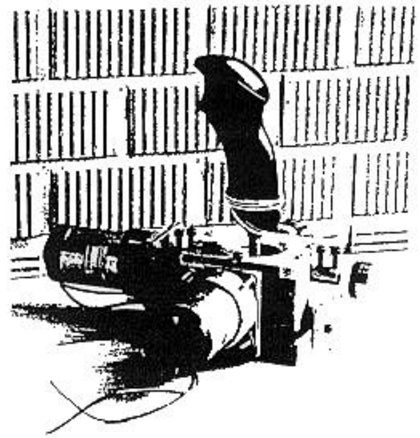
A prediction made in 1994,

Future trends:

- The applications market will dominate the technology and research directions. Contents Industry : World No.1 Revenue (2001)
- Low cost high performance graphics engine, even reaching 1 million Gouround or Phong shaded polygons per second.
- High precision body suit/sensors, 6D trackers, 3D mouse, data glove.
- Low cost force feedback joystick, tactile glove. Authoring tools for VR packages.
- Light weight HMD, eyeglasses, stereo LCD.

Force Feedback Joystick (1995), patented in Taiwan





Molecular visualization

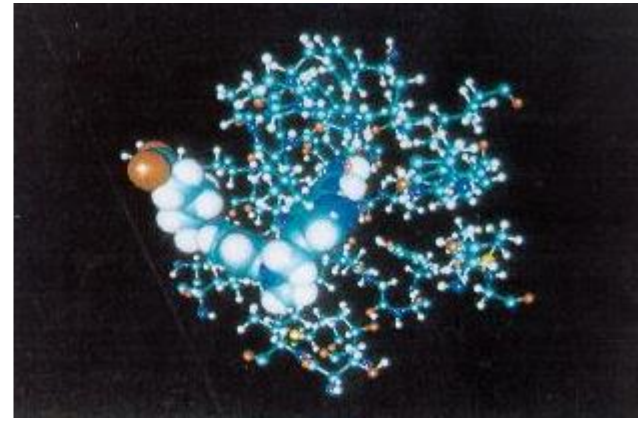
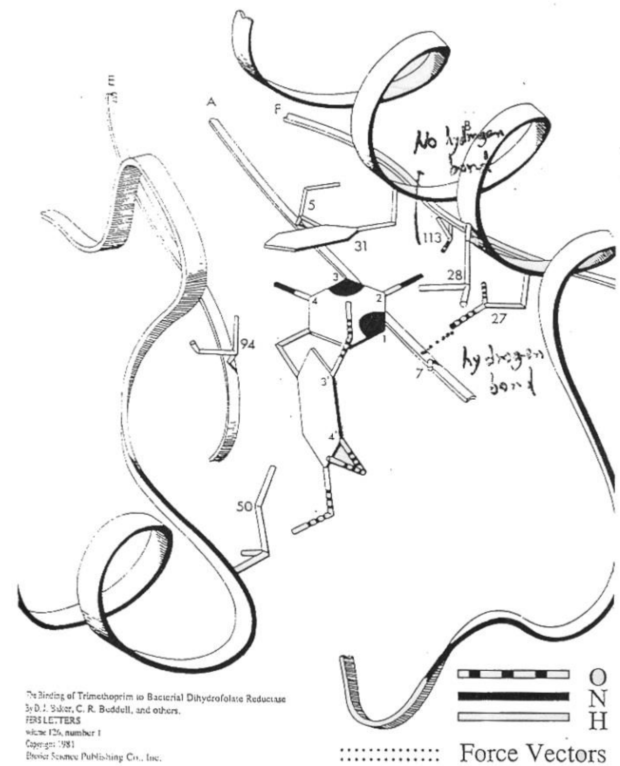


Figure 4. The Binding Site For TMP in E. Coli DHFR



Virtual Drum

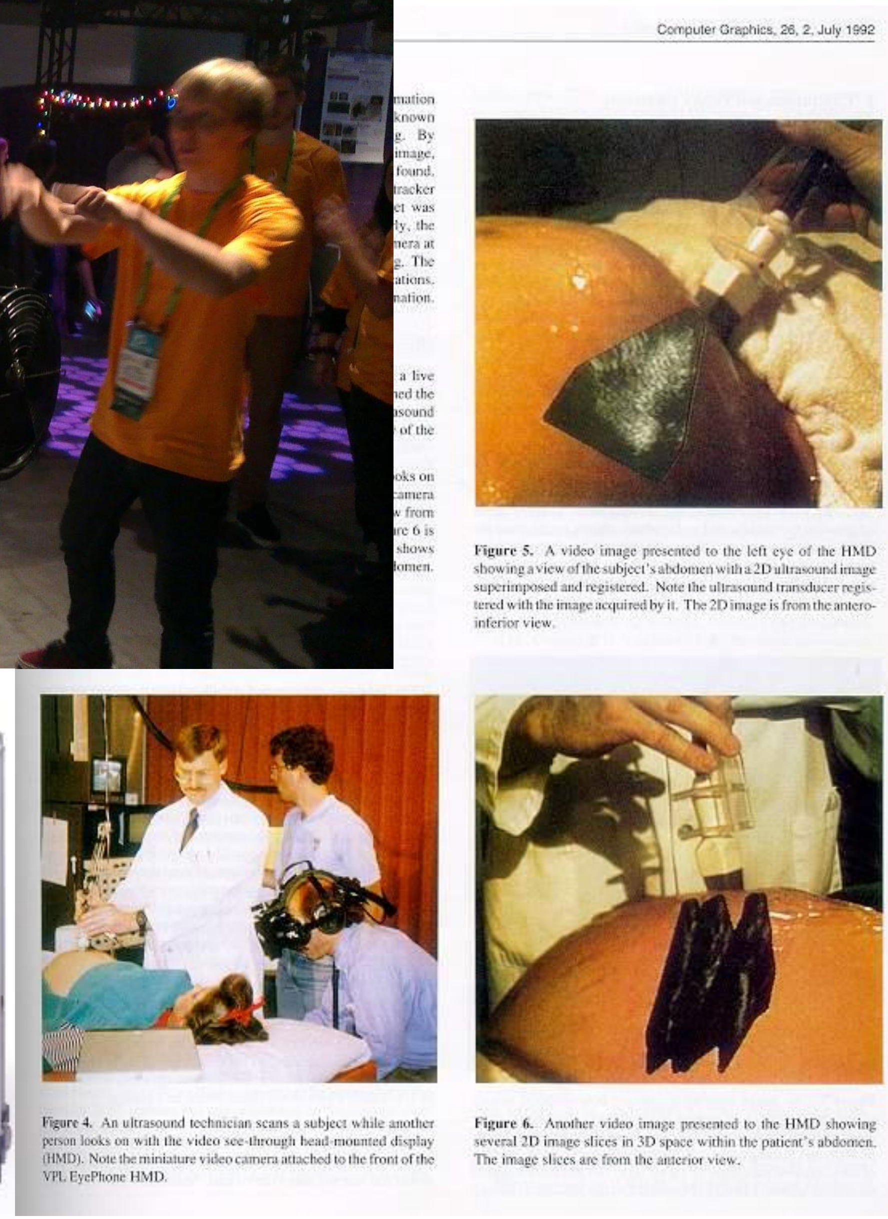

Computer Graphics, 26, 2, July 1992

Figure 5. A video image presented to the left eye of the HMD showing a view of the subject's abdomen with a 2D ultrasound image superimposed and registered. Note the ultrasound transducer registered with the image acquired by it. The 2D image is from the antero-inferior view.

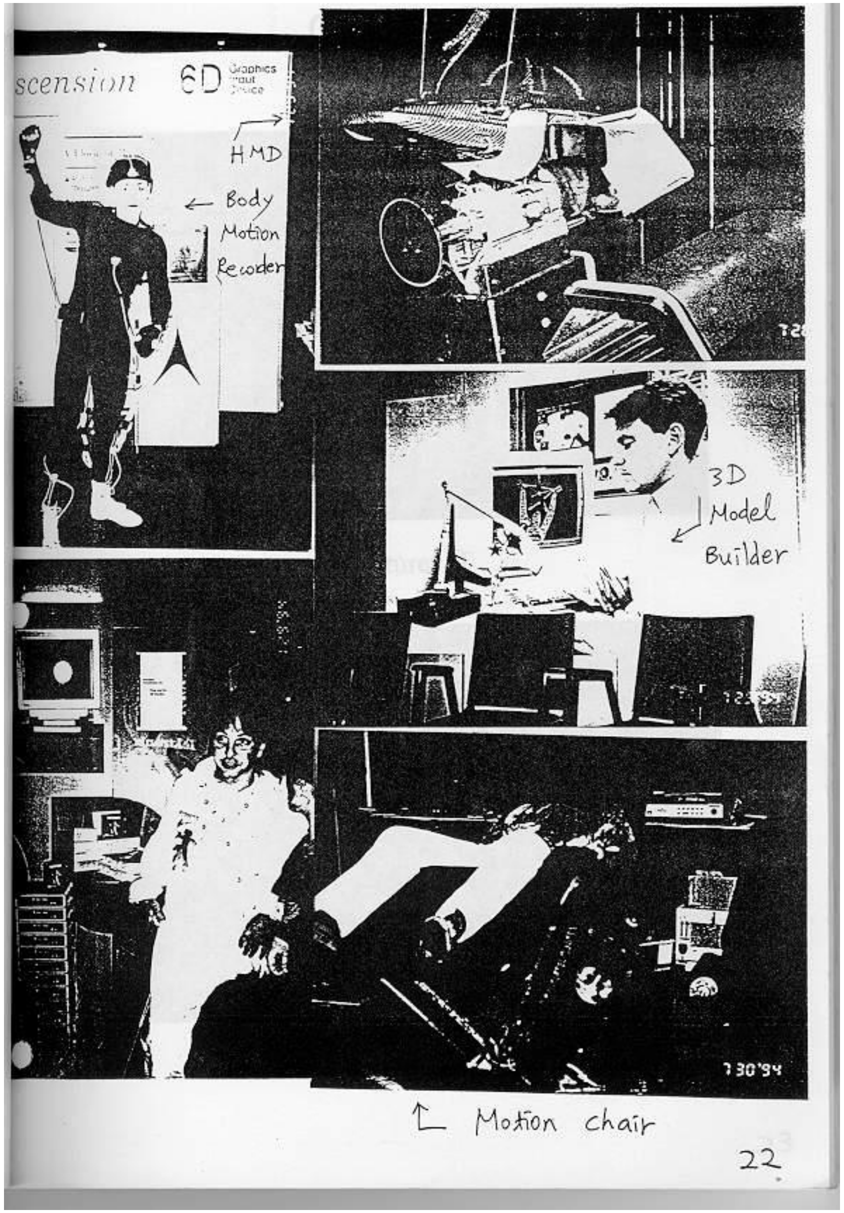
Figure 4. An ultrasound technician scans a subject while another person looks on with the video see-through head-mounted display (HMD). Note the miniature video camera attached to the front of the VPL EyePhone HMD.

Figure 6. Another video image presented to the HMD showing several 2D image slices in 3D space within the patient's abdomen. The image slices are from the anterior view.

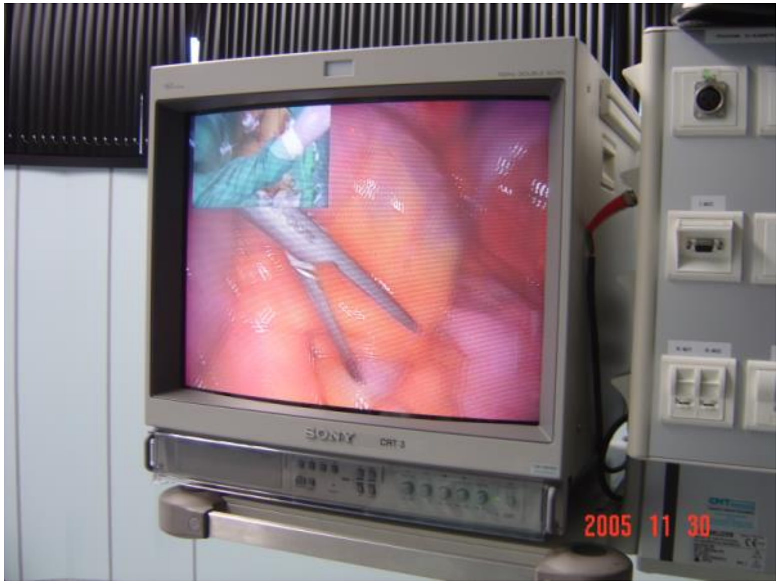
Disney Future World entertainment: VR (since 1994)

- **Disney Vision Adventure: In Virtual Reality**, a show that took place in Innoventions about how Disney movies are made using CGI technology featuring Iago from *Aladdin*.

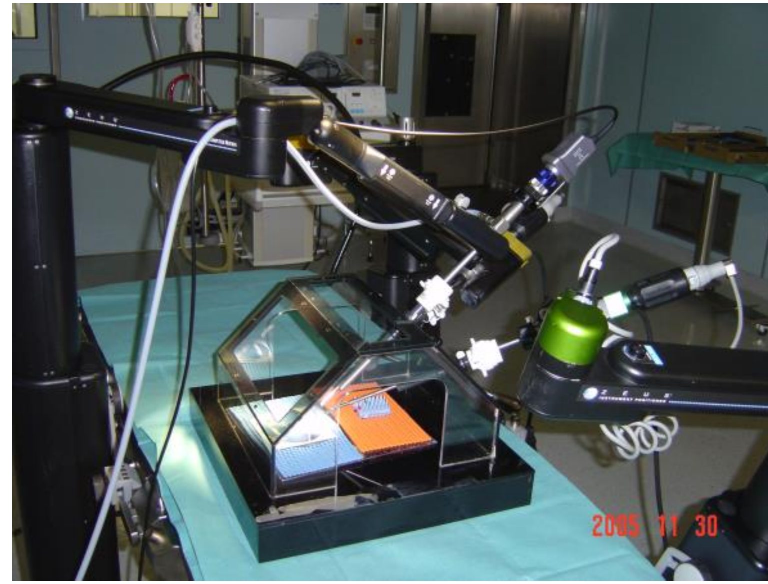
In Epcot Center, Disney Worlds, Florida, USA, 1996



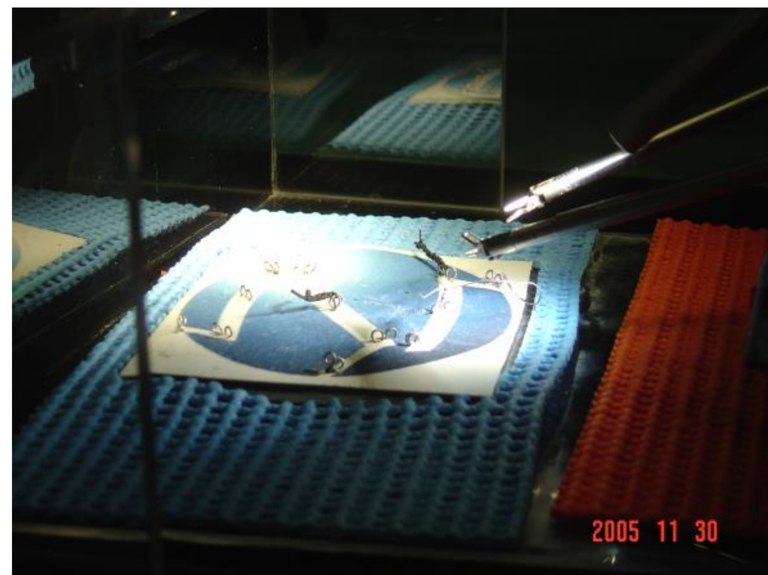
In Pasteur Research Center, Strasbourg, France, 2005



Laparoscope(內視鏡顯微手術)
Large number of medical doctors were trained in this way in France



Remote Robot Surgery



Sewing simulation: tie knots

Data glove (1995)

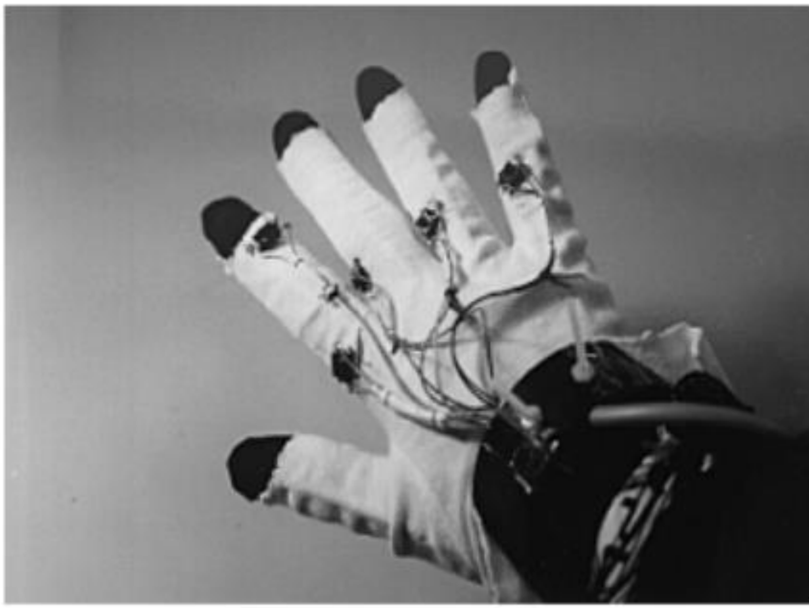
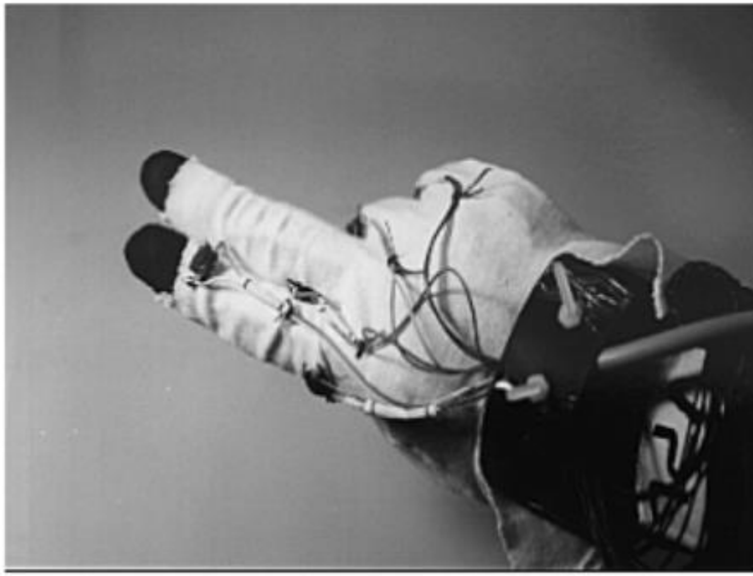


Photo 1. *Sensing Glove with five tact switches.*

Photo 2. *Gesture "M" with switch c pressed.*



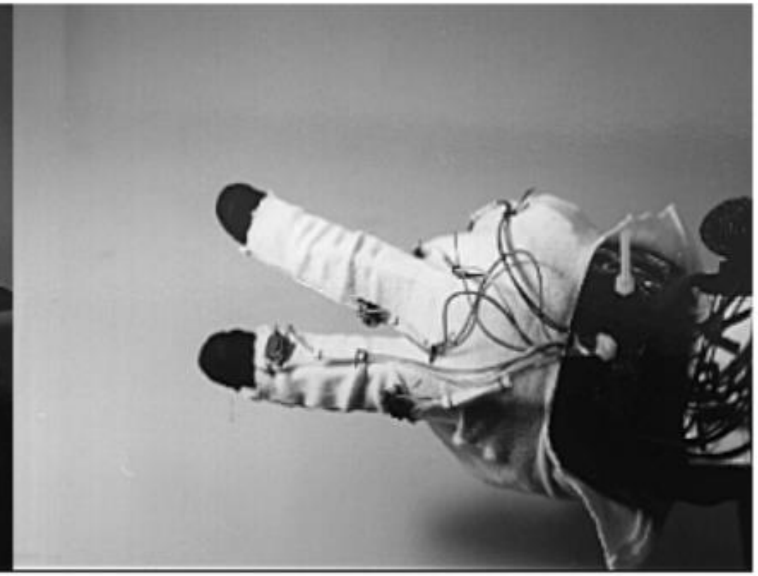


Photo 5. *Gesture "U" with switch a pressed.*

Photo 6. *Gesture "V".*

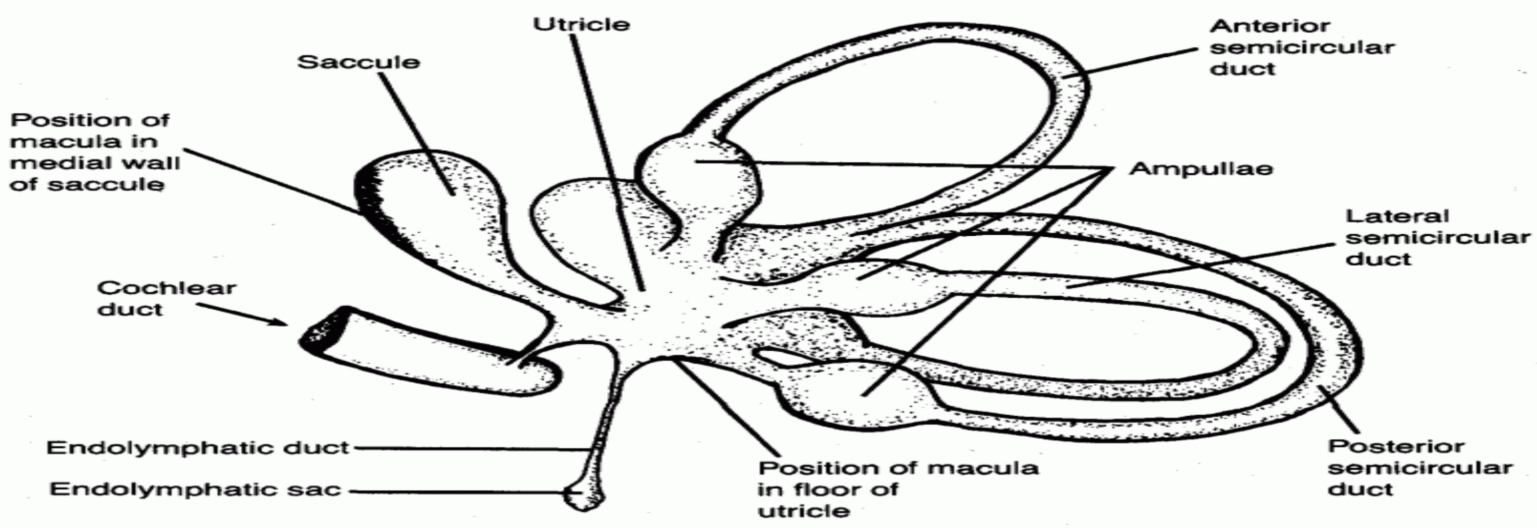
Human Factors

- Visual acuity: eye's ability to distinguish two points of light is limited to 1.5 – 2.0 mm at a distance of 10 meters. (or 2 microns on the retina)
- Sound: at 0 degree Celsius, travels at 331 meters per second
- Hearing range for a young healthy person, 20Hz to 20KHz
- Tactile: (receptors, Pacinian corpuscles) respond to frequencies 30-700Hz

  PS: 感覺神經末梢一種層狀囊包

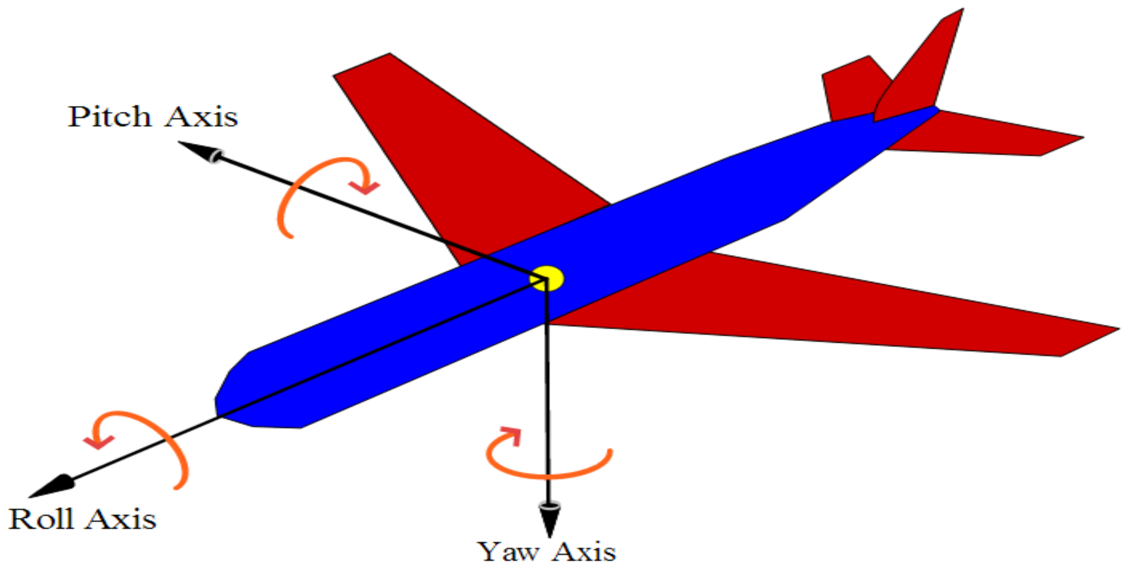
Human factors part 2

- Sensing equilibrium and head rotation: (human ears) the semicircular ducts (半規管) are sensitive enough to detect angular acceleration of 1 degree per second squared.



The vestibular labyrinth

- The semicircular ducts provide sensory input for experiences of rotary movements. They are oriented along the pitch, roll, and yaw axes.



Short questions

- (a) Is a typical RPG (role playing game) game considered VR technology? Why and why not?
- (b) What is motion parallax? How to estimate the thickness of a brick if front of us, if we have only one good eye and the other eye is blind?
- (c) Please describe three cases where it is easy to cause “motion sickness”, why?
-

Motion sickness

- In boat rides
- Driving in mountain roads
- Inconsistent sensing of eyes and ears (semi-circular ducts), and one is fixed while the other one is moving.

Virtual Reality TERM PROJECT LISTING

Pure VR/AR oriented:

1. A 3D sound Synthesizer + HMD
2. An optical tracker (church's algorithm) + HMD
3. Virtual objects (molecules, etc.) manipulation with HMD
4. A force feedback application
5. Virtual design using Cardboard HMD (house construction, interior design, lighting simulation etc.)

6. Choose your own projects: Human Computer Interfaces, Installation Arts, Games, etc.

VR Term Project (II): graphics oriented:

1. Rendering/Animation of articulated figures in HMD
2. Rigid body animation (Newton's laws)
3. Ray tracing or Radiosity method for a room / many objects with different materials
4. Volume rendering for a set of tomography slides (Data set from National Taiwan University Memorial Hospital etc.)
5. Sketch system for animation (Teddy system)
6. Oil painting and water color effects for images
7. 3D morphing and animation with skeleton mapping

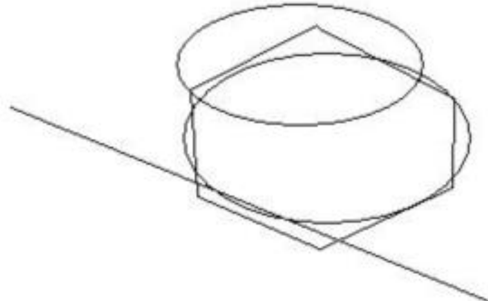
VR Term Project (III)

8. Motion retargeting (motion of cats likes that of a human)
9. Hardware GPU/GPGPU acceleration research and applications
10. Beautifying Images (Color harmonization, face beautification)
11. Water Rendering, mud simulation

Research topics

Virtual world
immersion
sensory feedback
interactivity

collision detection

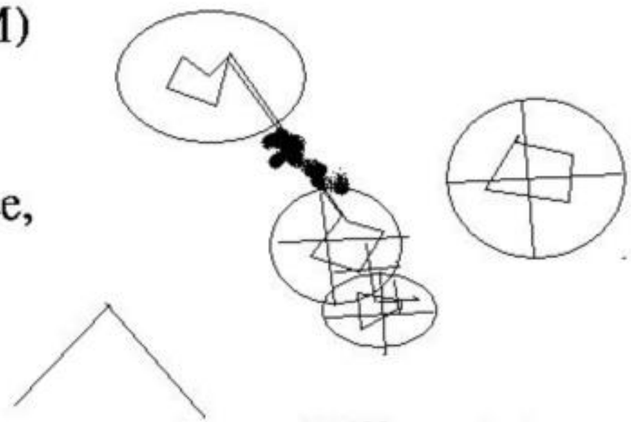


static, dynamic: N objects (K polygons), M polygons (human)

O(K*M * N) ==> O(K*M)

bounding box/sphere,

Binary space partitioning tree,
Octree, K-D Tree:
Log(M)*N



level of details
Latency compensation
image-based VR

Grey system theory, Differential equations/ laws of motion. (Kalmann Filter)

Just Noticeable Difference

To estimate the Details Visibility Change between two images of signifcantly different dynamic range, knowledge of the hypothetical HVS response to given physical contrasts under given adaptation conditions is required. A reasonable prediction for a full range of contrast values is given by the following transducer function that is derived and approximated by Mantiuk et al. [MMS06]:

$T(G)$ = 54:09288 G0:41850; (6)

with the following properties:

$T(0) = 0$ and $T(Gthreshold) = 1$;(7)

The transducer function estimates the HVS response to physical contrast in Just Noticeable Difference (JND) units. Thus for a given contrast threshold, *Gthreshold* , a transducer value equals 1 JND. It is important to note that this measure holds for suprathreshold measurements, since it not only estimates the detection, but also the magnitude of change.

Just Noticeable Difference

The approximation given by Equation (6) has been derived with the assumption of 1% contrast detection threshold, i.e. *Gthreshold* =log10(1:01). Although such an assumption is often made in image processing for LDR, the detection threshold depends on an adapting luminance level and is described by the Threshold Versus Intensity (TVI) function [CIE81].

VR Game in an Arcade

1.Visual Fighter,	SEGA,	3D graphics
2.Rad Mobile,	SEGA,	2D graphics, seat feedback
3.Visual Racing,	SEGA,	3D graphics, wheel feedback
4.Helicopter,	NAMCO,	3D graphics, driver seat back impact
5.Motorcycle,	SEGA,	2D graphics, Driver body tilting control
6.Train,	SEGA,	3D graphics, marching acceleration/ deacceleration
7.mining car,	SEGA,	2D graphics, vibration of seat
8.V.R.Galaxy,	SEGA,	Surrounding wall 3D graphics, seat tilting
9.Roller ciaster,	SEGA,	Sphere with 3D graphics windows, body roll & spin

SEGA SATURN by SEGA

SEGA Saturn was shipping in Nov. , 1994. It is the next generation of SEGA TV-game machine
Its existence acclaims the new age of 3DCG, and brought this age into your house !

Let's see what it is :

- CPU :
  Sega Saturn uses a pair of SH2 , a kind of 32-bit RISC processor by Hitachi, for computing and video output, and one M68000 for audio output. The total computing ability is about 56 MIPS.
- RAM :
  Sega Saturn uses 2MB as main RAM, 1.5 MB as V-RAM, 512 KB as Audio Output and another 512 MB as CD-ROM buffer. Total RAM used is 4 MB!
- 3DCG :
  Sega Saturn has build-in hardware supporting 3DCG, of course. It is able to display (compute) about 200,000 polygons, including flat-shading, gouraud-shading, and texture-mapping. It uses Z-sort to solve the problem of Z value, and about 3 light sources.
- 2DCG :
  Sega Saturn also supports 2D image processing. It can display 1 layer of sprite in front of 5 layers of BG, including scaling, stretching, and rotating (by 3 axis). In addition, SS could support animation of its own format (about 2/3 screen sized).
- CD-ROM :
  Double-speed CD-ROM driver. Of course it can be used to display normal CD(usually used as BGM), Photo CD, CD-G, and video CD(MPEG1,optional).

Sony PLAYSTATION Specifications

Emotion Engine'128bit CPU'

運行速度	300MHz
快取記憶體	指令 16Kbyte / 資料 8Kbyte + 16Kbyte (SP)
主記憶體	Direct RDRAM
記憶體容量	32MByte
Memory Bus Bandwidth	每秒3.2GByte
副處理器	FPU(浮點數乘加算器 x 1, 浮點數減算器 x 1)
向量處理器	VU0 + VU1 (浮點數乘加算器 x 9, 浮點數減算器 x 3)
三次元CG座標演算性能	每秒6600萬多邊形
浮點數演算性能	每秒6.2GFLOPS
壓縮畫像解碼器	MPEG-2
消耗電力	15W

儲存媒介

CD-ROM

DVD-ROM

Graphics Synthesizer

運行速度	150MHz
DRAM Bus Bandwidth	每秒48GByte
DRAM Bus Size	2560bit
畫像構成	RGB:Alpha:Z(24:8:32)
最高描繪性能	每秒7500萬多邊形
圖像處理機能	貼圖/衝撞測繪,煙霧效果,a混合,雙線性/三線性濾波器
	密封地圖,抗變形裝置,複合傳送,透視圖

音聲處理 (SPU2+CPU)

同時發聲數	ADPCM: 48ch (SPU2) + 軟體音源數
取樣頻率	44.1/48KHz

I/O Processor

CPU核心	PlayStation CPU
運行速度	33.8/37.5MHz
Sub-Bus	32bit
輸出入協定	IEEE1394, USB
通訊埠	PCMCIA格式PC卡對應

SEGA SATURN 主機性能介紹

CPU 中央處理晶片	SH-2 (32bit RISC) 2 棵,和 SH-1 用來管理 CD-ROM(共 3 顆 32 bit 的 CPU)
CD － ROM 光碟機	二點五倍速光碟機
軟體讀取方式	CD 或卡匣
影像處理 LSI	VDP1 (3D 影像處理) & VDP2(背景處理)
影像功能	擴大,縮小,旋轉,變形機能 最多五面畫面(可各別擴大,縮小)
聲音處理 LSI	SCSP (128 階 DSP, 32 聲道) MC68EOO -3D特殊音效用)
記憶體 Memory	共 36 Mega bits 的 RAM 和 256K 的快取 Memory
特殊功能	最高1677萬色,放大,縮小,視窗,變形 ,TEXTURE MAPPING 處理 , FM 音源 44,1KHZ 取樣, PCM 32 音源, 32 聲道, 80 萬多邊形處理
售價	約新台幣 4500 元
以發行軟體數目	將近 1500 種

Recent development in game consoles (2006-2014)

- Nintendo,
- Sony
- Microfoft

Nintendo 64 Specs

實體體積:

- 10.25" x 7.5" x 2.57"
- 2.42 lbs

Custom CPU:

- Custom 64-bit MIPS R4300i-class RISC CPU (93.75 MHz)
  - 64-bit data path, registers, buffer
  - 5-stage pipeline
- CPU Benchmarks
  - 125 Dhrystone MIPS (93 million operations/sec)
  - 60 SPECint92
  - 45 SPECfp92

Co-Processor:

- Custom 64-bit MIPS RISC "Reality Immersion" RCP (62.5 MHz)
  Built-in Audio/Video Vector Processor (RSP)
- RCP Benchmarks
  - Over half a billion (500,000,000) vector operations/sec
    - 10 times more than some Pentium engines
  - Built-in Pixel Drawing Processor (RDP) takes care of:
    - Advanced Texture-Mapping
      - Detail Texturing
      - Tri-linear Mip Map Interpolation
      - Perspective Correction
      - Environment Mapping
      - Depth Buffering
    - Color Combiner
    - Anti-Aliasing and Blending
    - Rasterizing
    - Z-Buffering
    - Automatic LOD Management
    - Vertex positioning and transformations
    - Depth, color and texture clipping
    - Transparency (256 levels max)
    - Gouraud Shading

Processor/Co-Processor Engine:

- Contains Over 4 Million Transistors Total
- Manufactured by NECBased on .35 Micron Process

Memory:

- 4 Megabytes (36 megabits) total RAM
- Rambus DRAM subsystem
  - Transfers up to 562.5 MBytes/sec
- Custom 9-bit Rambus Bus (to the DRAM)
  - Runs at 500 MHz max
- Internal data bus to the RCP is 128-bit

聲音:

- Stereo 16-bit
- ADPCM Compression
- 100 PCM channels possible
  - Each PCM channel takes 1% of the CPU time
    - Average 16-24 channels
- Wavetable Synthesis
- Sampled at 48 KHz max
- Internal Special Effects
  - Voice (w/ Pitch Shifting)
  - Gain and Pan
  - Reverb and Chorus
- External (software) Effects Supported

影像:

- Video Output
  - RF、Stereo A/V、S-Video、HDTV
- Video and Resolution:
  - 256 x 224 to 640 x 480
    - Limited by TV Standards
    - Flicker Free Interlace Mode
  - 21-bit color output
  - 32-bit RGBA Pixel Color Frame Buffer

Controller Ports:

- Four Controller Ports
- Three-prong Feed

Controllers:

- Digital joypad at left
- Analog stick in middle
- Six buttons on the right
  - 'B' and 'A' buttons
  - Four "C Group" buttons
  - 'L' and 'R' buttons on top
  - One "Z Trigger" button on the bottom
- Memory card port on back
  - Initial controller paks start out at 256k
  - Paks (up to 2 MB) will be available
  - Supports other 'paks' such as a "Jolt Pak"

擴充槽:

- Cartridge Slot
- Controller Ports
- Extension Port (bottom)
- Memory Expansion option (top front)

N64 Console Games:

- Games begin at 32-128 Megabits
- Uses JPEG image format for pre-rendered images
- Produces polygon graphics on the fly
- On-board hardware decompression; software optional
- 256 Megabit carts max; (four 64 meg ROMs)Downward Compatible

Nintendo Wii Specs

- **System specs**
  Central Processing Unit (CPU) *IBM Broadway 729MHz*
  Graphics Processing Unit (GPU) *ATI Hollywood 243MHz*
  Supported Resolution Up to 480p
  System Memory *88MB*
  Internet Connectivity *WiFi 802.11 b/g*
- **Media**
  Internal Storage *512MB Flash Memory*
  Optical Drive *12cm Wii Disc & 8cm GameCube Disc. Discs will self-load into the bay.*
  12cm Disc Capacity *4.7Gb (or 8.5Gb Dual Layer)*
  Memory Expansion *1 x SD Memory*
- **Backward Compatibility**
  Downloadable Games *NES, SNES, N64, Genesis, Neo-Geo, TurboGrafix16 (and CD)*
  Disc Compatibility *GameCube*
- **Connectivity**
  Wii Controller Ports *4 x Wireless*
  GameCube Controller Ports *4 Ports*
  GameCube Memory Expansion *2 Ports*
  USB 2.0 *2 Ports*
  Internet Wireless *IEEE802.11b/g or a USB LAN adaptor. WiiConnect 24 persistant connection, even when powered off.*
  Output ports *AV Multi-output port, allowing Composite, S-Video and Component.*
- **Controller**
  Connection method *Bluetooth (wireless)*
  Wiimote Buttons *3 axis motion sensor, + Direction pad, A, B, Minus, Home, Power button, 1 and 2*
  Nunchuck Buttons *3 axis motion sensor, Analog stick, C and Z*
  Force feedback (rumble) *Yes*
  Other features *Wiimote has a speaker and an expansion port*

Nintendo Wii

- **First six weeks of sales volume in Japan (2006/11-2007):**
  - PS3: 310K, Xbox360: 110K,Wii: 1130K
- Why is it successful?
  1) Human Computer Interface breakthrough VS. Graphics rendering power
  2) Make the player pie bigger: including the traditional non-game players: such as grandparents and grandchildren, not just youth groups.
  3) Traditional game players are usually lonely in one room, with networking connected to outside world only, while the Wii includes everyone in one game in one room (a social medium).
  4) Single-handed remote control, much less buttons and control.
  5) Good to "PLAY" vs. Good to "LOOK“
  6) 3D orientation and location control, added force feedback: vibration and sound,
- My own experience: DEMO
- SIGGRAPH2006_EmergingTech: 3D_DDR
- VR: The quality of the experience is crucial. To stimulate creativity and productivity, the virtual experience must be credible. The "reality" must bothreact to the human participants in physically and perceptually appropriate ways, and confirm to their personal cognitive representations of themicroworld inwhich they are engrossed.---CarlMachoverCG&A 1994.

Nintendo Wii

Wii Market performance 2007

- **(3) Market share: (2007/2)**
- **First six weeks of sales volume in Japan:**
- **PS3: 310K, Xbox360: 110K, Wii: 1130K**
- **(4) Supports: N64, Game Cube, Wi-Fi wireless network with browser, 512 M RAM, SD reader etc.**
-
- As a comparison to the prediction in 2005:
- Market Now: (BusinessWeek 2005, February 28) Games: US24.5 billions revenue in 2004, larger than the movie box-office business Game software sales: 7.3 billion, (1) EA (Electronic Art): $3 billion, and top five game developers accounted for 56% of the revenue. Likely winners: SONY, EA (Consoles, games, movies, only Sony has it all) At risk: Ninendo, Activision (second largest independent game developer), Walt Disney 2004: game consoles: Sony (56.4%), Microsoft (24.9%), Nitendo(18.7%) 39% of video gamers are women.

Nintendo: Wii remote

Why is it successful?

(1) Human Computer Interface breakthrough VS. Graphics rendering power

(2) Make the player pie bigger: including the traditional non-game players: such as grandparents and grandchildren, not just youth groups.

(3) Traditional game players are usually lonely in one room, with networking connected to outside world only, while the Wii includes everyone in one game in one room (a social medium).

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VR: The quality of the experience is crucial. To stimulate creativity and productivity, the virtual experience must be credible. The "reality" must both react to the human participants in physically and perceptually appropriate ways, and confirm to their personal cognitive representations of the microworld in which they are engrossed. --- Carl Machover CG&A 1994.

Trend: Virtual Reality in 1994 and 2005

Research Directions and Future Trend

- Market Now: (BusinessWeek 2005, February 28)
  - Games: US24.5 billions revenue in 2004, larger than the movie box-office business
  - Game software sales: 7.3 billion,
    - EA (Electronic Art): $3 billion, and top five game developers accounted for 56% of the revenue.
  - Likely winners: SONY, EA (Consoles, games, movies, only Sony has it all)
  - At risk: Nintendo, Activision (second largest independent game developer), Walt Disney
  - 2004: game consoles: Sony (56.4%), Microsoft (24.9%), Nitendo(18.7%) 39% of video gamers are women.
- Compared to past predictions:$250 million worth of VR products and services will be shipped in 1994.
- One billion dollars by 1997 (IEEECG&A, p15, Vol 14, No 1, Jan 1994)
  - S.E.Tice, President of S.E.Tice Consulting, Inc.
  - Carl Machover, President of Machover Associates.
- VR is growing at annual rates on the order of 60% (twice the growth rate graphics experienced 25 years ago)

- Three company's revenue and profits in 1994:
  - Nintendo has $3.2B in sales, approximately $850M net(1/4)
  - Sun Microsystems has $2.47B in sales, approximately $110M net(1/24).
  - Intel has $3.92B in sales, approximately $650M net 1/6).

Virtual Reality

(1994 prediction) Research Directions and Future Trend

Entertainment

SEGA. David Rosen started SEGA in 1954 in Japan.(4 billion 1993; 2.2 billion 1992; 1.2 billion 1991)

SEGA will exploit the efficiency of electronics over iron and steel to creat a new entertainment form: virtual-reality theme parks. Parks packed with VR will occupy perhaps 3% of the land area of Florida's Disney World, so they can be put in densely populated areas.

Nintendo(任天堂) Market share in Japan 78%, in US 51%, in Europe 41%

Revenue distribution:(SEGA)

1/6 for ARCADES

1/6 for Home-use software

1/3 for Home-use game machines

VR related games are already approaching 1/2 of ARCADES.

Virtual Reality

(1994) Research Directions and Future Trend

3D graphics & VR games worth 2/3 of 8 billion dollars business => (Nintendo + SEGA)

Data from Business Week. Feb 21, p38-44

Nintendo & SEGA plus others expect to make 40 million video-game machines over the next five years

Buyers:	ChipMaker:
Nintendo (project Reality game machine, due 1995)	Silicon Graphics
SEGA(Saturn game machine, due 1994)	Hitachi
Nintendo	V800 low-power consumption chip

New player: Microsoft
Xbox, Xbox 360, Xbox one

- Strategy: no profit or negative profit for hardware (game console), but profitable from software game titles.

  Two billion US$ loss during the first three years.
- No other OEM/ODM big countries such as

  Taiwan and South Korea can enter this market in the future.

Microsoft's 2013 Q2(October to December Quarter): record $24.52 billion revenue and 3.9 million Xbox One sales

- For both Microsoft and Sony, their latest-generation video game console hardware is unprofitable at the time of release, requiring the companies to subsidize it initially. However, these companies easily can largely compensate for their losses though sales of highly lucrative game titles,

Huge loss between 2001 to 2005

- **2001: Microsoft could lose as much as $2 billion on Xbox--potentially selling the game console at a loss for three years or more--before breaking even in fiscal 2005, according to a Merrill Lynch report released Tuesday.**
- The expected losses represent a standard practice in the video game industry of relying on income from software sales and licensing to subsidize hardware costs. The practice helped drive Sega out of the hardware business earlier this year because the company could no longer come up with money to cover losses associated with production of its Dreamcast console.

Microsoft Xbox 360

Microsoft Xbox 360 Specs

Custom IBM PowerPC-based CPU	•3 symmetrical cores running at 3.2 GHz each •2 hardware threads per core; 6 hardware threads total •1 VMX-128 vector unit per core; 3 total •128 VMX-128 registers per hardware thread •1 MB L2 cache
CPU Game Math Performance	•9 billion dot product operations per second
Custom ATI Graphics Processor	•500 MHz •10 MB embedded DRAM •48-way parallel floating-point dynamically-scheduled shader pipelines •Unified shader architecture
Polygon Performance	•500 million triangles per second
Pixel Fill Rate	•16 gigasamples per second fillrate using 4X MSAA
Shader Performance	•48 billion shader operations per second
Memory	•512 MB GDDR3 RAM •700 MHz DDR •Unified memory architecture
Memory Bandwidth	•22.4 GB/s memory interface bus bandwidth •256 GB/s memory bandwidth to EDRAM •21.6 GB/s front-side bus
Overall System Floating-Point Performance	•1 TFLOP
Storage	•Detachable and upgradeable 20 GB hard drive •12X dual-layer DVD-ROM •Memory unit support starting at 64 MB

I/O	•Support for up to 4 wireless game controllers •3 USB 2.0 ports •2 memory unit slots
Optimized for Online	•Instant, out-of-the-box access to Xbox Live features, including Xbox Live Marketplace for downloadable content, Gamer Profile for digital identity and voice chat to talk to friends while playing games, watching movies or listening to music •Built in Ethernet Port •Wi-Fi Ready: 802.11 A, B and G •Video Camera Ready
Digital Media Support	•Support for DVD-Video, DVD-ROM, DVD-R/RW, DVD+R/RW, CD-DA, CD-ROM, CD-R, CD-RW, WMA CD, MP3 CD, JPEG Photo CD •Stream media from portable music devices, digital cameras, Windows XP PCs •Rip music to Xbox 360 hard drive •Custom playlists in every game •Windows Media Center Extender built in •Interactive, full screen 3D visualizers
HD Game Support	•All games supported at 16:9, 720p and 1080i, anti-aliasing •Standard definition and high definition video output supported
Audio	•Multichannel surround sound output •Supports 48 KHz 16-bit audio •320 independent decompression channels •32-bit audio processing •Over 256 audio channels
System Orientation	•Stands vertically or horizontally
Customizable Face Plates	•Interchangeable to personalize the console

Microsoft Xbox Kinect

Kinect is a motion sensing input device by Microsoft for the Xbox 360 video game console and Windows PCs. Based around a webcam-style add-on peripheral for the Xbox 360 console, it enables users to control and interact with the Xbox 360 without the need to touch a game controller, through a natural user interface using gestures and spoken commands. The project is aimed at broadening the Xbox 360's audience beyond its typical gamer base. Kinect competes with the Wii Remote Plus and PlayStation Move with PlayStation Eye motion controllers for the Wii and PlayStation 3 home consoles, respectively. A version for Windows was released on February 1, 2012.

Microsoft released a non-commercial Kinect software development kit for Windows 7 on June 16, 2011, with a commercial version following at a later date. This SDK will allow .NET developers to write Kinecting apps in C++/CLI, C#, or Visual Basic .NET.

Microsoft Xbox Kinect Specs

Sensor

Colour and depth-sensing lenses
Voice microphone array
Tilt motor for sensor adjustment
Fully compatible with existing Xbox 360 consoles

Field of View

Horizontal field of view: 57 degrees
Vertical field of view: 43 degrees
Physical tilt range: ± 27 degrees
Depth sensor range: 1.2m - 3.5m

Data Streams

320×240 16-bit depth @ 30 frames/sec
640×480 32-bit colour@ 30 frames/sec
16-bit audio @ 16 kHz

Skeletal Tracking System

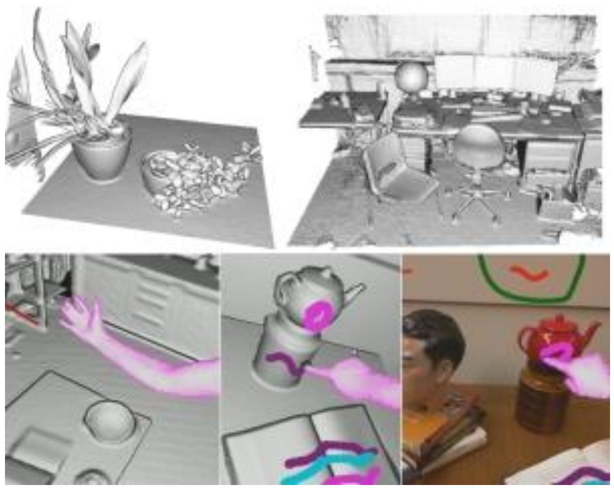
Tracks up to 6 people, including 2 active players
Tracks 20 joints per active player
Ability to map active players to Live Avatars

Audio System

Live party chat and in-game voice chat (requires Xbox Live Gold Membership)
Echo cancellation system enhances voice input
Speech recognition in multiple

Microsoft Xbox Kinect

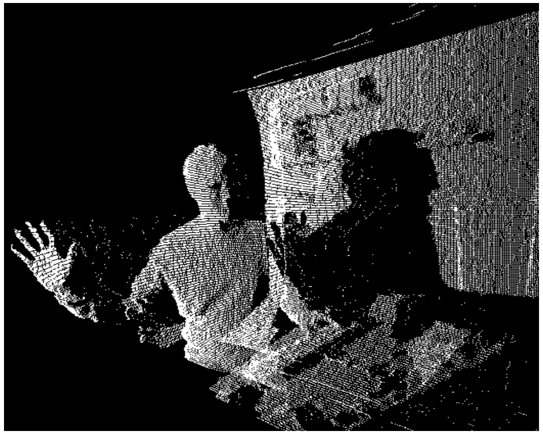
Widely used in researches:

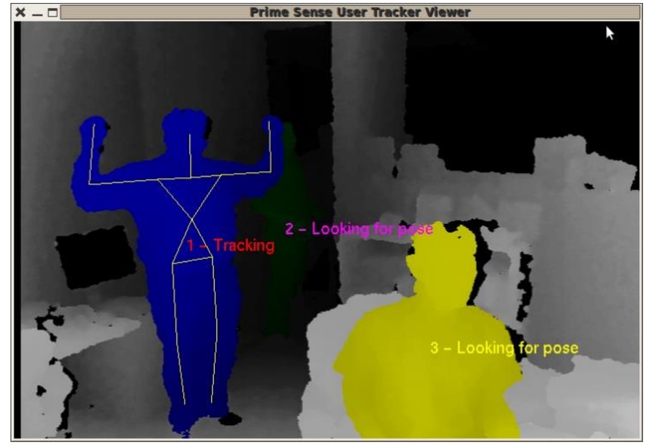


Shahram Izadi, David Kim, Otmar Hilliges, David Molyneaux, Richard Newcombe, Pushmeet Kohli, Jamie Shotton, Steve Hodges, Dustin Freeman, Andrew Davison, and Andrew Fitzgibbon, KinectFusion: Real-time 3D Reconstruction and Interaction Using a Moving Depth Camera, ACM Symposium on User Interface Software and Technology, October 2011

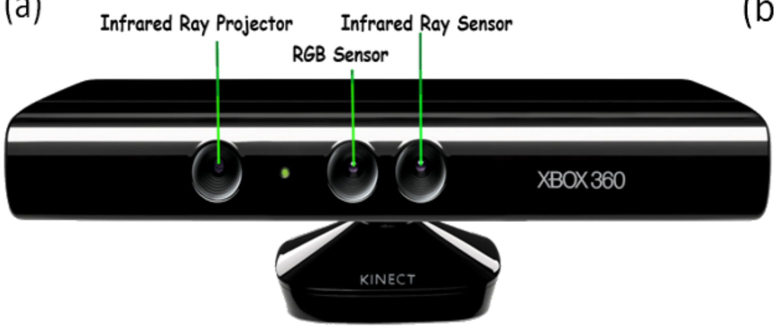
REALTIME PERFORMANCE-BASED FACIAL ANIMATION
Thibaut Weise, Sofien Bouaziz, Hao Li, Mark Pauly
ACM Transactions on Graphics, Proceedings of the 38th ACM SIGGRAPH Conference and Exhibition 2011, 08/2011 -SIGGRAPH 2011[paper] [video] [fast forward] [bibtex]

Microsoft Xbox Kinect

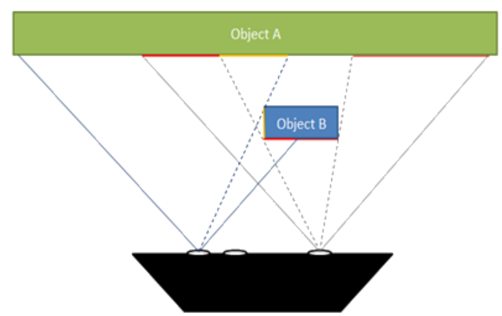




(a)



(b)



(c)

Sony PlayStation 3,4

- Sony has to sell its PC/NB and TV division in 2013/2014

Sony PlayStation 3

PlayStation 3 slim (PS3 CECH-2000 model) is the revamped version of Sony's seventh generation video game console - PS3, which was launched by Sony Computer Entertainment in 2009. Other than the new sleek design, these PS3 slim console also boasts of potent mix of new (such as the removable hard drive) and old features (such as online gaming, a high-definition optical disc format and Blu-ray Disc technology), which make gaming easier and interesting.

While the first two consoles of these series were armed with 120GB and 250GB HDD, they were eventually discontinued to make way for the two existing models - the 160GB slim and the 320GB slim in 2010. (The 320GB PS3 slim though, is only available as a part of the PS3 bundle.) As with their predecessors, both models come with a Blu-ray drive which can be used for multimedia purposes as well. Some of the most popular PS3 games include Medal of Honor - Frontline, Far Cry 2, Demon's Souls, MAG, inFamous, Resident Evil, Kill Zone 2, etc. At the same time, the addition of PlayStation Move which facilitates motion gaming has also added to the popularity of PS3 slim console.

Sony PlayStation 3 Specs

CPU: Cell Processor
PowerPC-base Core @3.2GHz
1 VMX vector unit per core
512KB L2 cache
7 x SPE @3.2GHz
7 x 128b 128 SIMD GPRs
7 x 256KB SRAM for SPE
* 1 of 8 SPEs reserved for redundancy total floating point performance: 218 GFLOPS
GPU:RSX @550MHz
1.8 TFLOPS floating point performance
Full HD (up to 1080p) x 2 channels
Multi-way programmable parallel floating point shader pipelines
Sound: Dolby 5.1ch, DTS, LPCM, etc. (Cell-base processing)
Memory:
256MB XDR Main RAM @3.2GHz
256MB GDDR3 VRAM @700MHz
System Bandwidth:
Main RAM: 25.6GB/s
VRAM: 22.4GB/s
RSX: 20GB/s (write) + 15GB/s (read)
SB: 2.5GB/s (write) + 2.5GB/s (read)
System Floating Point Performance:2 TFLOPS
Storage:
HDD
Detachable 2.5" HDD slot x 1
I/O:
USB: Front x 4, Rear x 2 (USB2.0)
Memory Stick:standard/Duo, PRO x 1
SD:standard/mini x 1
CompactFlash:(Type I, II) x 1
Communication: Ethernet (10BASE-T, 100BASE-TX, 1000BASE-T) x3 (input x 1 + output x 2)
Wi-Fi:IEEE 802.11 b/g
Bluetooth: Bluetooth 2.0 (EDR)
Controller:
Bluetooth (up to 7)
USB2.0 (wired)
Wi-Fi (PSP®)
Network (over IP)
AV Output:
Screen size:480i, 480p, 720p, 1080i, 1080p
HDMI:HDMI out x 2
Analog:AV MULTI OUT x 1
Digital audio:DIGITAL OUT (OPTICAL) x 1
CD Disc media (read only):
PlayStation CD-ROM
PlayStation 2 CD-ROM
CD-DA (ROM), CD-R, CD-RW
SACD Hybrid (CD layer), SACD HD
DualDisc (audio side), DualDisc (DVD side)
DVD Disc media (read only):
PlayStation 2 DVD-ROM
PLAYSTATION 3 DVD-ROM
DVD-Video: DVD-ROM, DVD-R, DVD-RW, DVD+R, DVD+RW
Blu-ray Disc media (read only):
PLAYSTATION 3 BD-ROM
BD-Video: BD-ROM, BD-R, BD-RE

Sony Playstation 4

- The PlayStation 4 uses a processor developed by AMD in cooperation with Sony.
- The CPU consists of two quad-core Jaguar modules totaling 8 x86-64 cores.
- The GPU consists of 18 compute units to produce a theoretical peak performance of 1.84 TFLOPS.
- The system's GDDR5 module contains 8 GB of GDDR5 memory, 16 times the amount of RAM found in the PS3 and is expected to give the console considerable longevity.

Sony PlayStation Move

The PlayStation Move combines a video camera with a physical controller packed with motion-sensing electronics, making it the technological cross between Kinect and the Nintendo Wii. The Move Motion Controller, or "wand," combines a gyroscope, accelerometer, and magnetic sensor (a sort of digital "compass" that uses the Earth's magnetic field to determine the controller's orientation) to track the controller in three dimensions, while the glowing ball at the end gives the PlayStation Eye camera a visual reference for handling aiming, cursor movement, and other motion. Like Kinect, PlayStation Move requires room to function; Sony recommends 5 to 9 feet between the player and the PlayStation Eye, but you can play anywhere from 2 to 10 feet of the camera.

Sony PlayStation Move Specs

- **PlayStation Move Specifications and Details**
- **Features**
  "The latency for the Playstation Move is under one frame" - Scott Rohde, vice president of product development, SCEA.
- **PlayStation®Move motion controller**
  Three-axis gyroscope
  Three-axis accelerometer
  Terrestrial megnetic field sensor
  Colour-changing sphere for Playstation Eye tracking
  Bluetooth® technology
  Vibration feedback
- **PlayStation®Move sub-controller**
  Built-in lithium-ion rechargeable battery
  Bluetooth® technology
  2 DUALSHOCK® or SIXAXIS® Wireless Controller replacement capability.
- **PlayStation® Eye**
  Built-in four-capsule microphone array
  Echo cancellation
  Background noise suppression
- **Price**
  "Under $100" (£47)

Comparism -The System

For the Wii, all the motion-control magic is in the remote. An accelerometer tracks movement, while an IR sensor monitors the positioning of lights emitted by the sensor bar. Its motion-sensing abilities weren't so great at first; initially, your movements with the Wiimote were reflected only approximately in games with gestures and broad motions. The addition of Wii MotionPlus, an accessory that gives the Wiimote a gyroscope sensor to complement the accelerometer, improves the motion detection greatly. Nintendo recently began to sell the Wii Remote Plus, a Wiimote with built-in MotionPlus sensors, removing the need for a separate accessory. The Wii's biggest weakness (wiikness?) is its graphics; unlike the PlayStation 3 and Xbox 360, the Wii doesn't display high-definition content.

Thanks to a sophisticated depth-sensing camera (actually a single color camera for image recognition, and two monochrome cameras placed a few inches apart to determine where you are in a three-dimensional space), Kinect can track your movements without a physical controller. All of the heavy lifting is handled by the Kinect sensor and the console, and you can navigate menus and play games without laying a finger on a piece of plastic. A microphone array adds voice recognition to the mix, letting users control the system using voice commands or hand-waves. Because the system is camera-only, it needs a lot of space; Microsoft recommends 6 to 8 feet between the Kinect sensor and the user.

The PlayStation Move combines a video camera with a physical controller packed with motion-sensing electronics, making it the technological cross between Kinect and the Nintendo Wii. The Move Motion Controller, or "wand," combines a gyroscope, accelerometer, and magnetic sensor (a sort of digital "compass" that uses the Earth's magnetic field to determine the controller's orientation) to track the controller in three dimensions, while the glowing ball at the end gives the PlayStation Eye camera a visual reference for handling aiming, cursor movement, and other motion. Like Kinect, PlayStation Move requires room to function; Sony recommends 5 to 9 feet between the player and the Playstation Eye, but you can play anywhere from 2 to 10 feet of the camera.

Comparism -The Deal

Unlike Kinect and PlayStation Move, the Wii's motion control system is integral to the console itself. If you have the console, you already have the motion control. Starting from scratch, the Wii is easily the least expensive of the three set-ups, costing just $199 for everything you need. The default Wii bundle includes the system, a Wii remote, a Wii nunchuck, the Wii MotionPlus accessory, and copies of Wii Sports and Wii Sports Resort. Nintendo also offers a limited edition bundle for the same price, celebrating the 25th anniversary of Super Mario Bros. with a red Wii, a red Wiimote with integrated MotionPlus, and copies of Wii Sports and New Super Mario Bros. Wii. If you already have the system, you can pick up additional Wiimotes with integrated MotionPlus for $40 each, and Nunchuck accessories for $20 each.

Kinect itself costs $150, and includes a copy of the game, Kinect Adventures. If you don't have anXbox 360, you can pick up a Kinect bundle, including a 4GB Xbox 360, for $299. It's $50 less than Kinect and the 4GB Xbox 360, but if you want storage space, you might want to spring for Kinect and the 250GB Xbox 360 for $449. Either way, you only need Kinect itself for motion-controlled multiplayer games; unlike PlayStation Move and the Nintendo Wii, Kinect doesn't require additional controllers for additional players.

If you already have a Playstation 3, the Playstation Move Sports Champions Bundle gives you the PlayStation Eye, a Move Motion Controller, and a copy of Sports Champions for $99. If you want to go all-in with a new console, the $399PlayStation 3with PS Move bundle includes everything in the Sports Champions Bundle, plus a 320GB PS3 system. Piecemeal, the PlayStation Eye costs $40, each Move Motion Controller is $50, and each optional Navigation Controller runs $30. For multiplayer games, you'll need at least one extra Move Motion Controller on top of the one included in the bundle.

Comparism -The Games

While Kinect and PlayStation Move are both very new, the Wii has been around since 2006, and it has developed a very large library in that time. Some of the more notable games that take advantage of the Wii's motion-sensing abilities include Mario Kart Wii, Rayman Raving Rabbids, Boom Blox, Red Steel 2, and many others.

Including titles like sports mini-game compilation MotionSports, dance game Dance Central, and painfully cute virtual pet game Kinectimals.

Besides the bundled Sports Champions, a Wii Sports-like mini-game compilation, several Move-exclusive games are currently available, including virtual pet game EyePet and quirky pseudo-skating game Kung-Fu Rider. Besides Move-specific games, several currently available and upcoming PS3 titles support Move control schemes, including Resident Evil 5, Heavy Rain, and LittleBigPlanet 2.

Comparism -pros and cons

The pros:
Inexpensive. Huge game library.

The cons:
The least accurate motion sensing of the three systems. Not high-def.

The bottom line: The Wii's been around the longest, and while both Kinect and PlayStation Move are more technically impressive with their advanced motion sensing and graphics, the Wii has the biggest library of motion-sensing games.

The pros:
Totally hands-free. One Kinect accommodates multiple players. Voice control is very cool and works well.

The cons:
Requires a lot of space. Slightly more lag whan than Playstation Move.

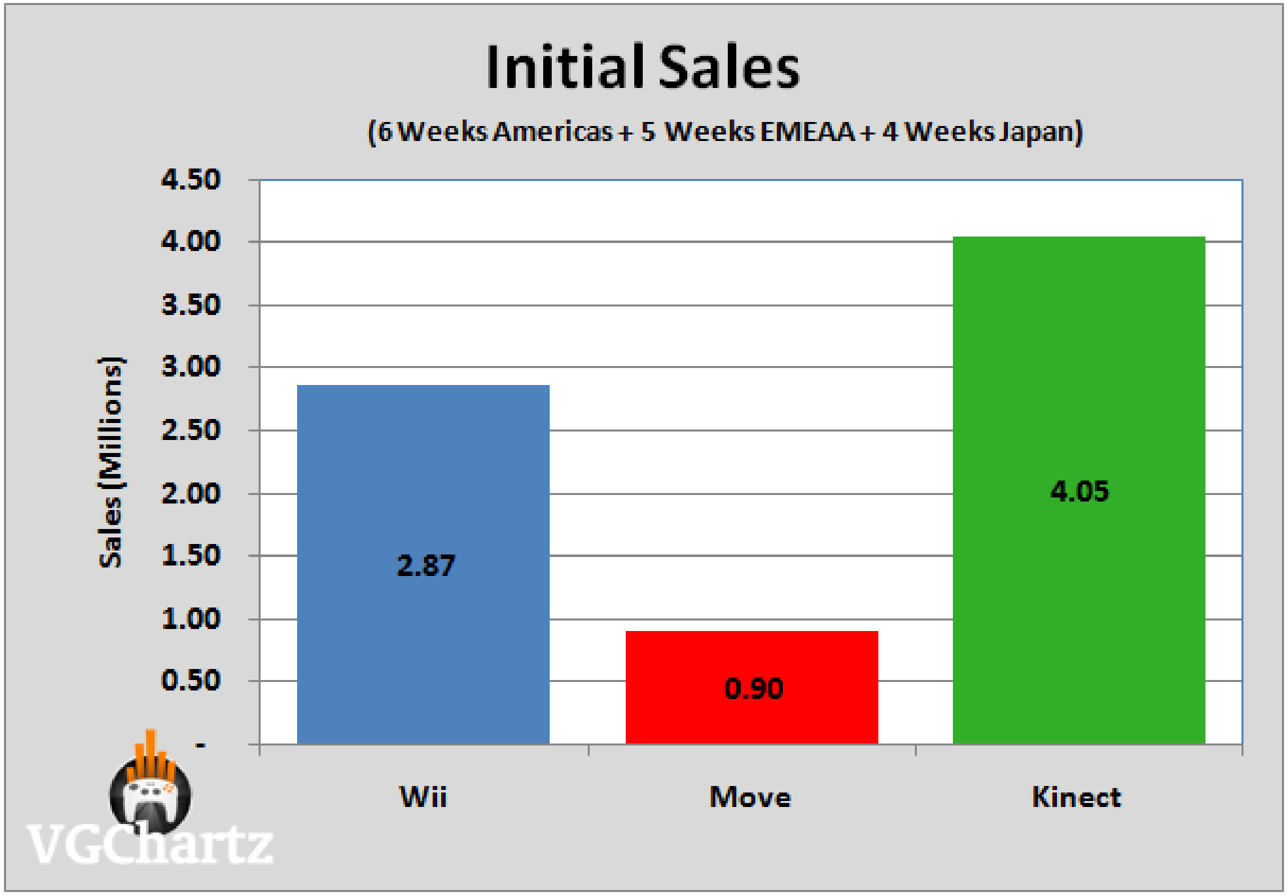
The bottom line: If you have the room for it, Kinect offers both multiplayer motion gaming and voice-controlled menu navigation right out of the box. If your Xbox 360 is wedged into the corner of a cramped studio apartment, though, you'll probably have some problems playing.

The pros:
Least expensive entry bundle. Very accurate motion tracking.

The cons:
Requires a wand, sometimes two, depending on the game, for each player.

The bottom line:
Sony's motion gaming system isn't quite as accessible as Kinect, where players can just jump in and out of games without any calibration, but it tracks motion better than the Wii, and supports a broader range of games.

Comparisn (2007-2010) -Initial Sales



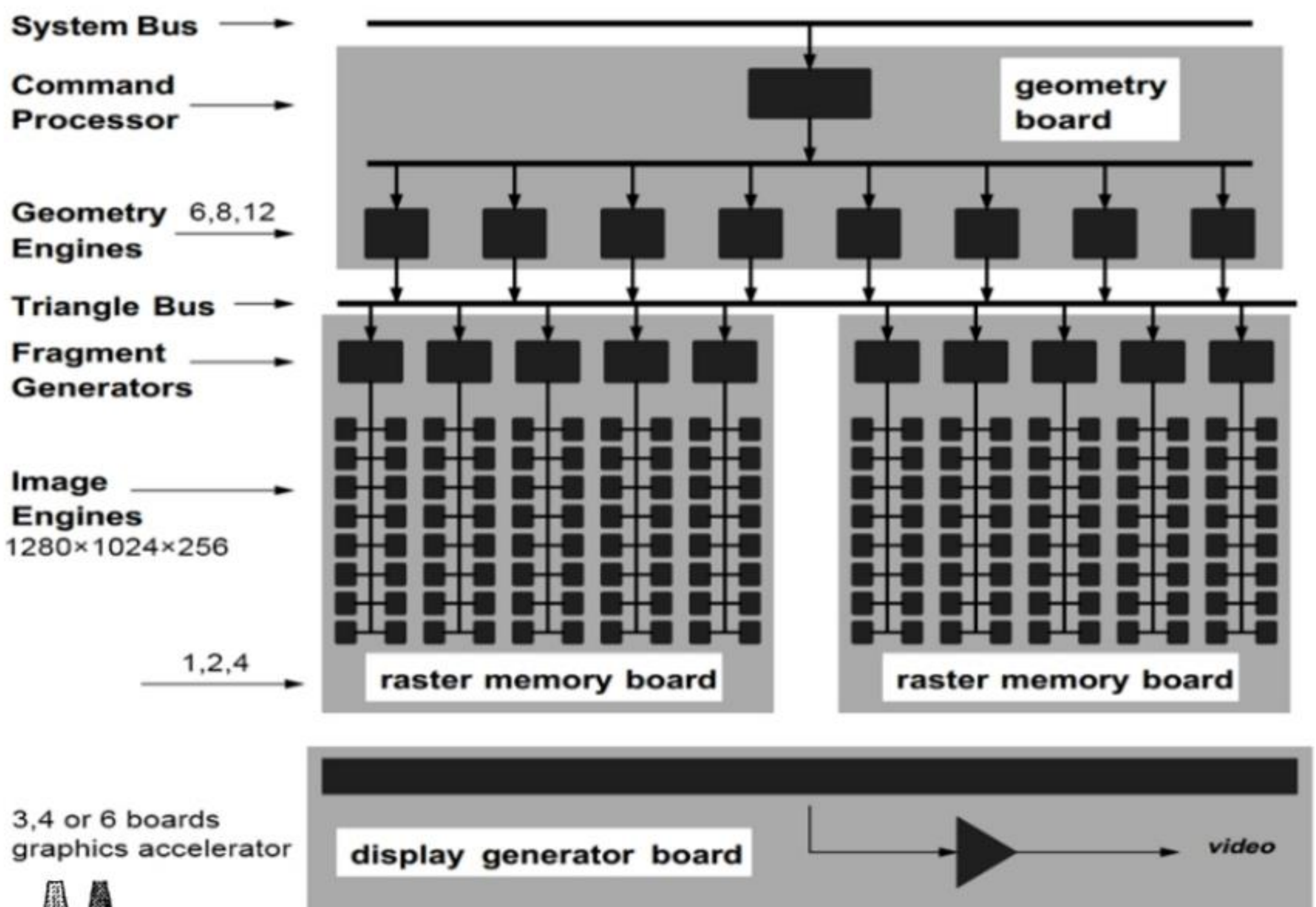
Conclusion of game controllers

- Innovative HCI determines initial sales

GPU/Graphics Hardware

- Moor’s Law
- GPGPU
- Easy for VR development: Real-time response

RealityEngine



A Triangle

CP
Position
Color
Normal
Texture Coord.

→ 1 →

GE
slope regarding
red, green, blue,
alpha,depth
texture

→ BC →

FG
color,depth,
texture coord.
subsample mask

→

IE
refresh
frame
buffer

- The stream of rendering commands merges only at Triangle Bus
- Each triangle is processed by almost all the processors
- Moderate FIFO memories are included

6

Illumination model

1) Ambient light (漫射)

$$I = I_a \times k_a \times Obj(r,g,b)$$

I_a : intensity of ambient light

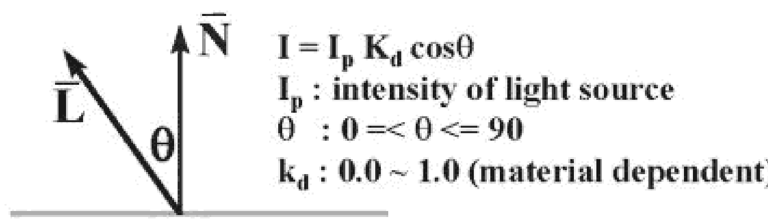
k_a : 0.0 ~ 1.0

$Obj(r,g,b)$: object color

2) Diffuse reflection (散射)

$$I = I_p(r,g,b) \times K_d \times Obj(r,g,b) \times \cos\theta$$

$I_p(r,g,b)$: light color



3) Light source attenuation

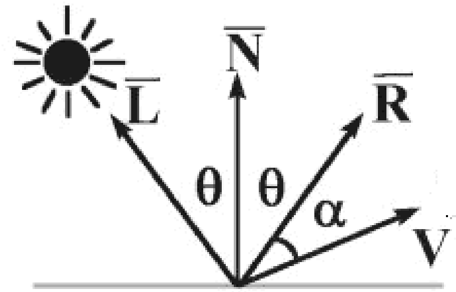
$$I = I_a k_a + f_{att} I_p K_d (\vec{N} \cdot \vec{L}) \qquad f_{att} = \frac{1}{d_L^2}$$

Illumination model

4) Specular reflection (似鏡面反射)

$I = K_s \times I_p(r,g,b)\cos^n a$

K_s : specular - reflection coefficient

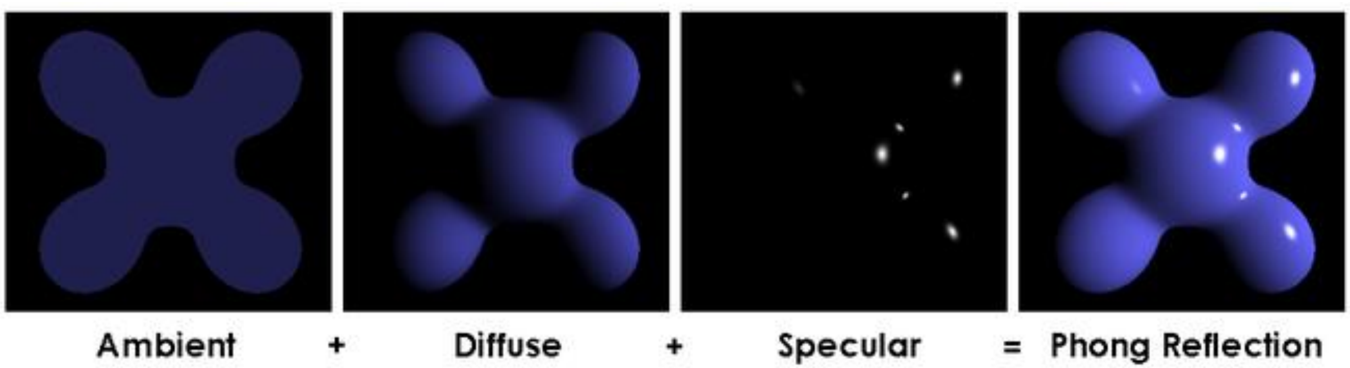


W(θ)=k_s specular-reflection coefficient

λ : wave length

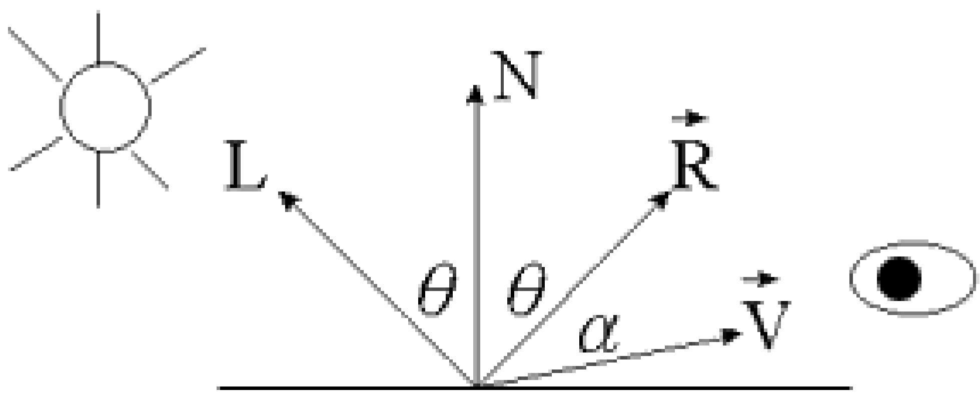
Phong illumination model

$$I_\lambda = I_{a\lambda}K_aO_{d\lambda} + f_{att}I_{p\lambda}[k_dO_{d\lambda}\cos\theta + w(\theta)\cos{}^n\alpha]$$



Faster specular reflection calculation: Halfway vector approximation

- halfway vector



$$\vec{H} = \frac{\vec{L}+\vec{V}}{|\vec{L}+\vec{V}|}$$

Polygon shading : linear interpolation

a. flat shading :

constant surface shading.

b. Gouraud shading:

color interpolation shading.

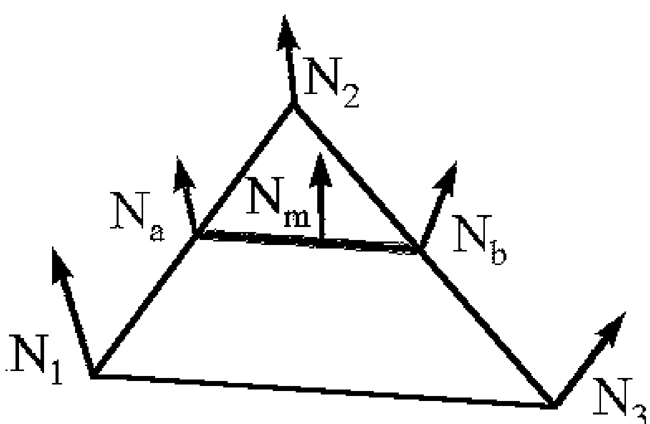
c. Phong shading:

vertex normal interpolation shading

Phong Shading

- Use a big triangle, light shot in the center, as an example!
- The function is really an approximation to Gaussian distribution

macroscopic



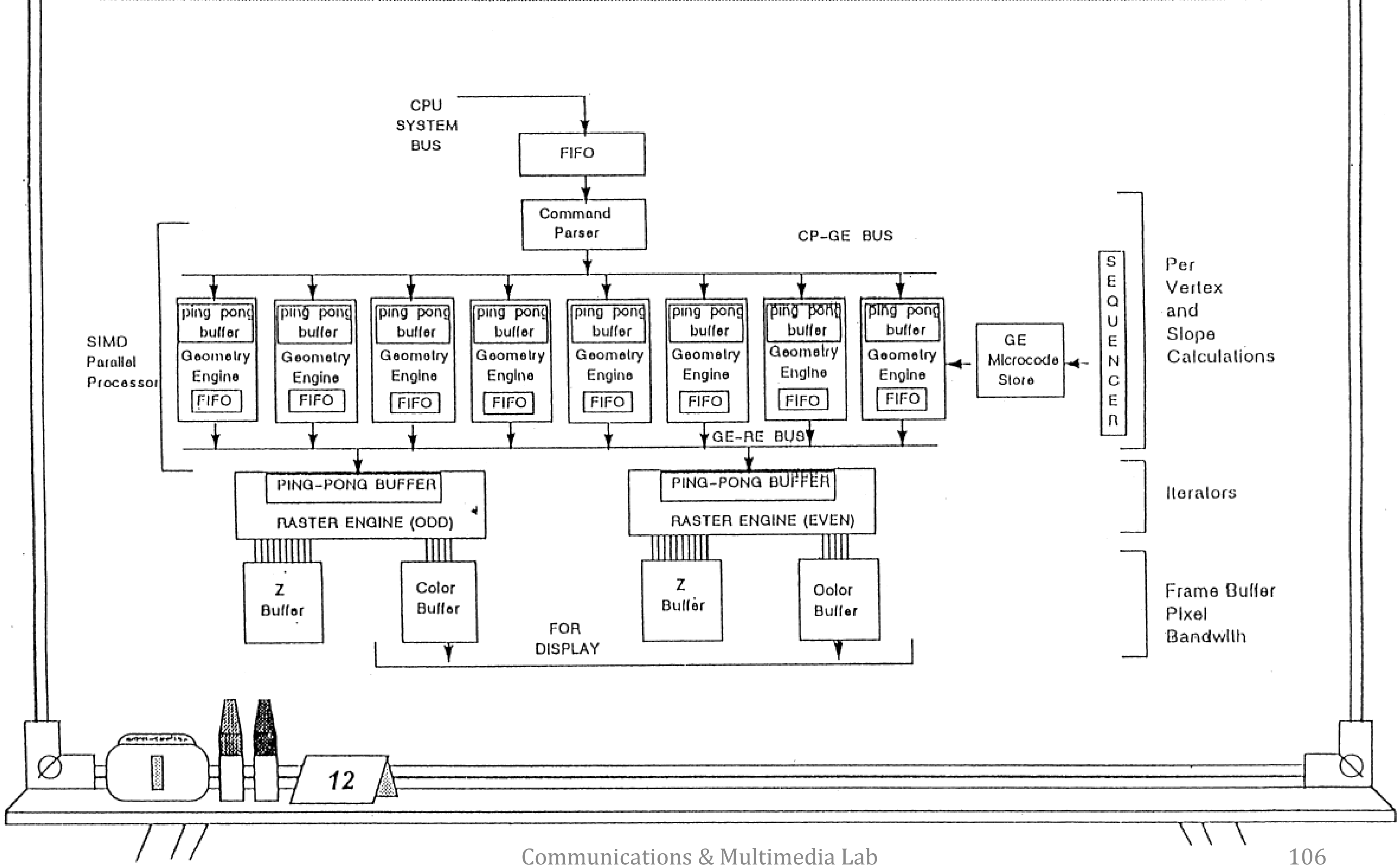
- The distribution of microfacets is Gaussian. [Torrance, 1967] (Beckmann distribution func.)
- Given normal direction N_a and N_b, N_m = ?
  - interpolation in world or screen coordinate?
  - in practice

Geometry Engine & Triangle Bus

- Geometry Engines
  - Intel i860XP, 50MHz, 100 Mflops
  - 2 Mbytes of combined code/data DRAM, 1 ASIC
  - Code programming
    - » Code is first developed in C, cross compiled for i860XP
    - » Code that is executed frequently is then re-coded in i860XP assembly code.
  - Treat each parameter as a plane equation, compute signed slope in the positive X and Y screen directions
  - Decompose all polygon to triangles
- Triangle Bus
  - Handle over 1 million triangles
  - Broadcast rasterization data, point, line segment, texture images

8

Indigo²


CPU
SYSTEM
BUS
FIFO
Command
Parser
CP-GE BUS
SIMD
Parallel
Processor
ping pong
buffer
Geometry
Engine
FIFO
GE
Microcode
Store
SEQUENCER
Per
Vertex
and
Slope
Calculations
GE-RE BUS
PING-PONG BUFFER
RASTER ENGINE (ODD)
RASTER ENGINE (EVEN)
Iterators
Z
Buffer
Color
Buffer
FOR
DISPLAY
Frame Buffer
Pixel
Bandwith
12

Geometry Engine

- Per vertex and the slope calculation
- Architecture
  - ※ Microcoded SIMD processor
  - One multiplier and one adder
  - high data bandwidth and multiple threads of execution
  - Six busses, four port regisiter file, two special data stores
  - Flexible independent addressing and control of data movement are accomplished through very wide instruction word
- Parallel Consideration
  - Goal: linear performance increase and lowest possible impact over and above a uniprocessor solution
  - Approach: Pipeline, MIMD, SIMD

Command Parser

- Detect boundaries between primitive, initiate GE execution
- Operation
  - Round robin scheme of distribution
  - Tell GE sequencer which GEs are loaded
  - Passes the address to begin execution, and then issues
  - Interlock mechanism
- GE sequencer
  - Branching is controlled within separate fields of VWIW
  - Stall control of GEs independently
    - » those GEs not loaded
    - » implementing conditional subroutine calls across SIMD

Pixel-Planes

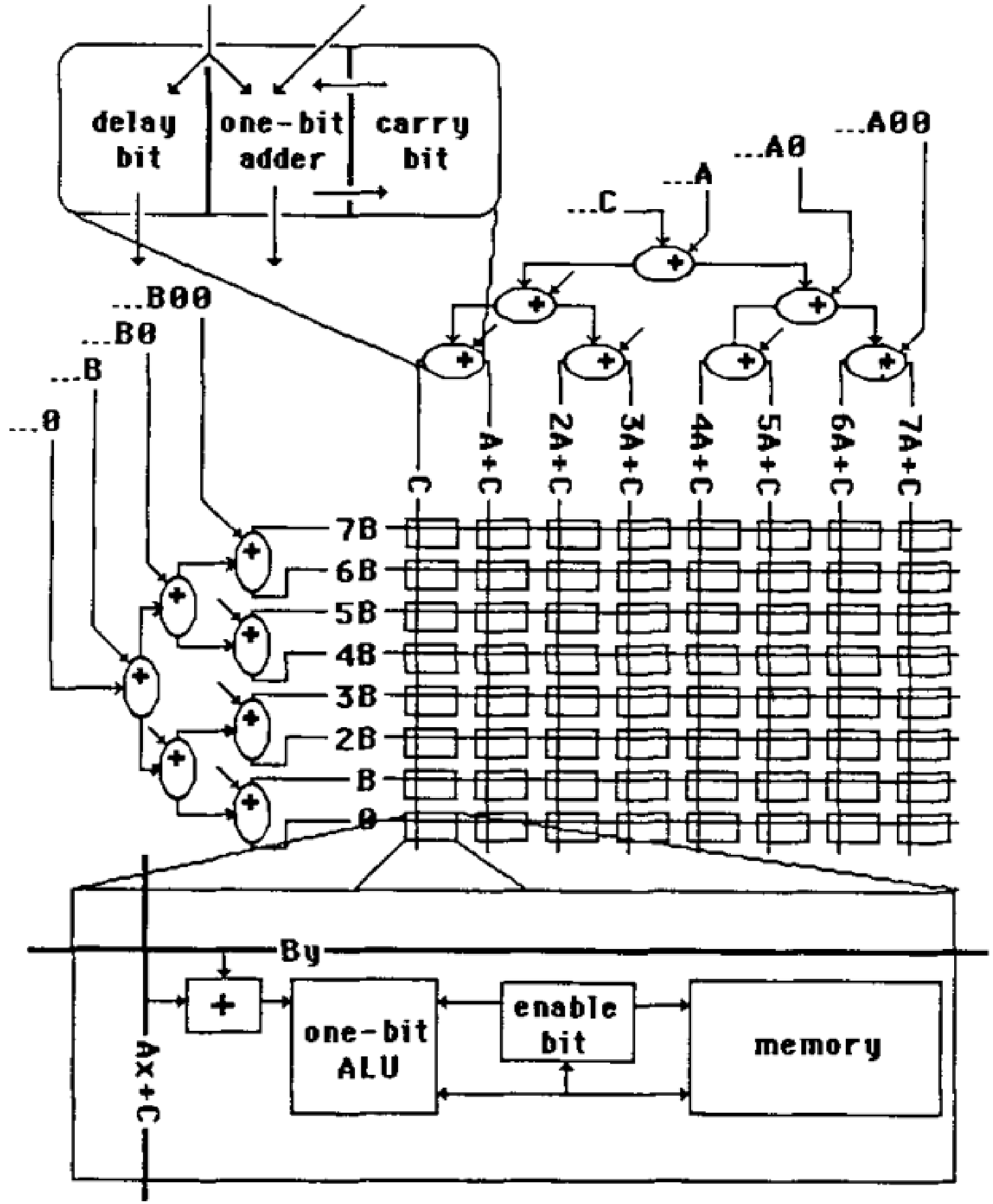
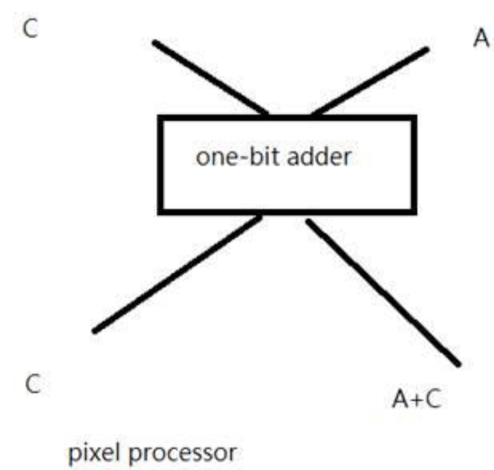
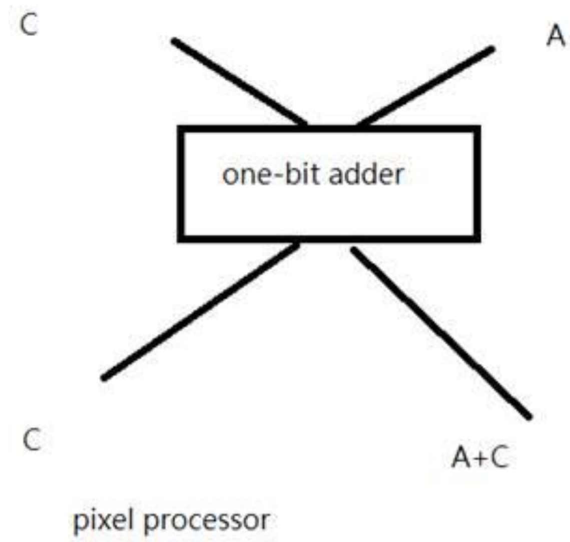


Fig. 1: Conceptual design of an 8×8 Pixel-Planes chip.



Bit operation



Binary representation:

for easy hardware architecture/realization

Right most significant bit, and shift left at each clock!

Eg.:
011 equals 6 in Decimal
01100 equals 6
0101 equals 10
01111000 equals 30 in Decimal
(all zeros at the right ends: redundant, for pipeline operations)

Exam examples

- For a triangle defined by vertices (5, 9) (3,2) and (10,3), please write a parallel procedure using fast_calculate() to draw all the pixels (x1, y1) inside this triangle.

- There is a functon fast_calculate (A,B,C, x, y) which can be evaluated in parallel, where fast_calculate() can calculate A*x + B*y +C for each pixel position (x, y) in PixelPlanes.

Scan Conversion (a triangle)

2.1.1 Scan Conversion. The object of this step is to determine those pixels which lie inside a convex polygon. Initially, all Enable registers are set to 1. Each edge of the polygon is defined by two vertices, $v_1 = (x_1, y_1)$ and $v_2 = (x_2, y_2)$, which are ordered so that the polygon lies on the left of the directed edge $v_1 v_2$. Then the equation of the edge is $Ax + By + C = 0$, where $A = y_1 - y_2$, $B = x_2 - x_1$, and $C = x_1 y_2 - x_2 y_1$. Furthermore, $f(x, y) = Ax + By + C$ is positive if and only if (x, y) lies on the same side of the edge as the polygon. The translator computes A, B, and C, and these coefficients are then broadcast to Pixel-planes. A negative $f(x, y)$ causes the Enable register for (x, y) to be set to 0; otherwise the Enable register is unchanged. A pixel is inside the polygon if and only if its Enable register remains 1 after all edges have been broadcast.

Gouraud Shading

– For a triangle defined by vertices (0, 0), (2, 4) and (6,2) with their colors on blue channel are 10, 50, 20, respectively. Please provide the precise A,B,C values such that the result of the formula $Ax+By+C$ indicates the value of the pixel(x,y) on the blue channel using Gouraud shading(smooth shading, or called color interpolation shading).

– Please calculate the values of the pixels (1, 1) and (3, 2) by adopting your formula above.

Gouraud Shading

For example, suppose the polygon has 3 vertices (x_1, y_1), (x_2, y_2), and (x_3, y_3) with red components R_1, R_2, R_3. Geometrically, one can visualize linear interpolation of the red component at (x, y) as selecting the third component of the point (x, y, R) that lies on the plane passing through (x_1, y_1, R_1), (x_2, y_2, R_2), and (x_3, y_3, R_3) in xyR-space. The translator computes the equation of this plane as follows:

Step 1: The vector equation

$$(x, y) = s(x_2 - x_1, y_2 - y_1) + t(x_3 - x_1, y_3 - y_1) + (x_1, y_1) \quad (6)$$

Shading 2

is solved for s and t which are written in the form:

$$
\begin{aligned}
s &= A_1 x + B_1 y + C_1 \\
t &= A_2 x + B_2 y + C_2
\end{aligned}
\qquad (7)
$$

Step 2: The plane equation is written in the form $R = Ax + By + C$, where

$$
\begin{aligned}
A &= A_1(R_2 - R_1) + A_2(R_3 - R_1) \\
B &= B_1(R_2 - R_1) + B_2(R_3 - R_1) \\
C &= C_1(R_2 - R_1) + C_2(R_3 - R_1) + R_1
\end{aligned}
\qquad (8)
$$

Visibility testing

- For 3D triangle vertices A(5, 9, 0), B(3, 2, 0) and C(10,3, 0), how to use Z-buffer algorithm in Pixel Planes for visibility testing? Hint: Z-buffer algorithm:
- Initialize frame_buffer [1000, 1000] to be all very big numbers (far from view point).
- For a pixel (x,y) located inside a triangle,
- If it is closer (its Z value) to the view point (human eye), then paint this pixel with its color. At the same time, set frame_buffer (x,y) = Z value.
- Otherwise, don't paint this pixel.

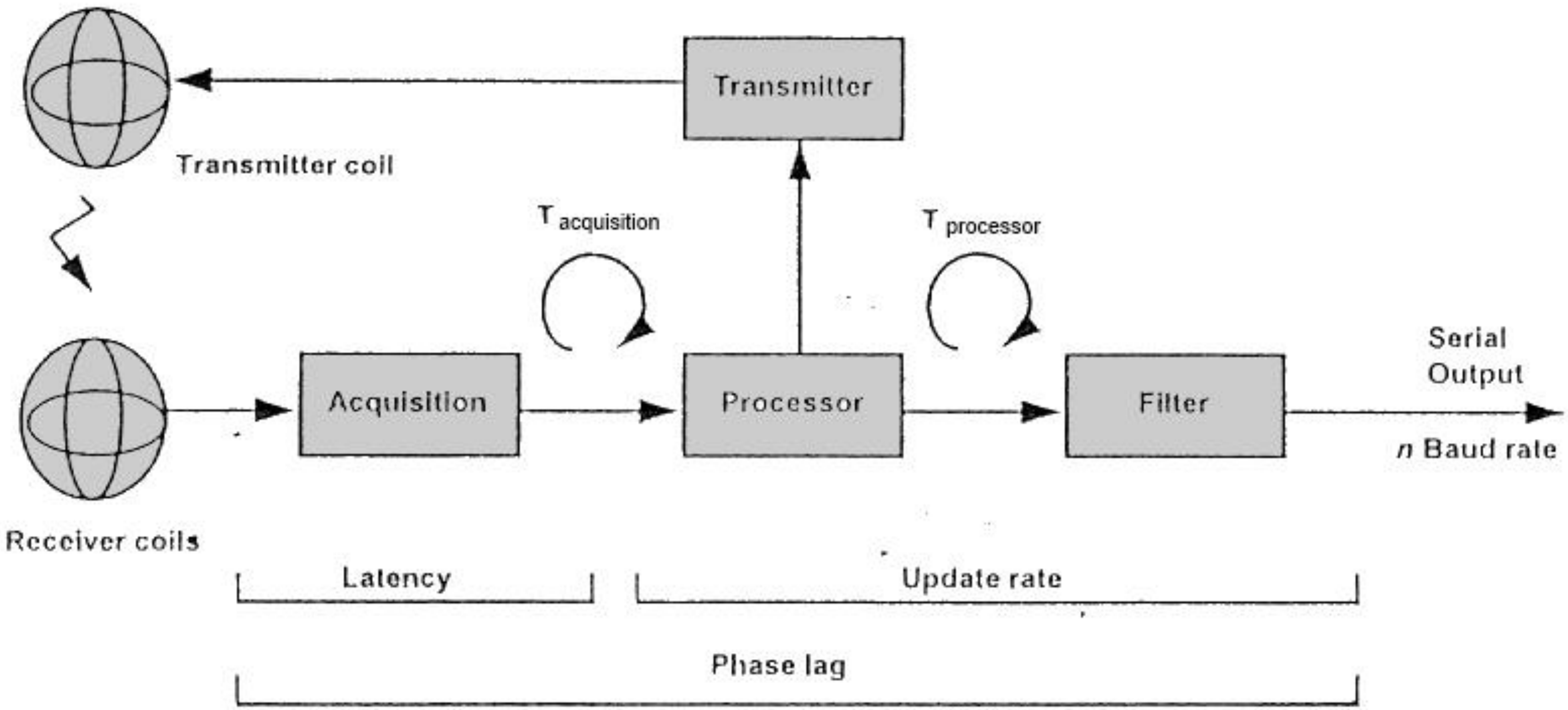
Space Tracing System

- **Magnetic tracking system**
  - Widely used
  - Inexpensive and readily available
  - Limited range of operation
- **Acoustic tracking system**
  - Good accuracy, responsiveness and registration
  - Time-of-flight
    - Suffer from acoustic noise
  - Phase coherent
    - Higher data rate => better performance
    - Suffer from cumulative error
- **Mechanical tracking system**
  - Good accuracy, responsiveness and registration
  - Easy to integrate force feedback
  - Limited range of operation
  - Do not allow multiple users to work in the same working space
- **Optical tracking system**
  - Fixed transducer, pattern recognition
  - Trade off between accuracy and range of operation


SensAble

Space Tracking System

☞ A generic architecture



Critical Parameter in Tracker

- **Static accuracy**
  - the ability of a tracker to determine the coordinates of a position in space
- **Dynamic accuracy**
  - Relates to the system accuracy as the tracker's sensor is moved
- **Latency**
  - Is the time lag between when the acquisition portion of the system can acquire new data and the time when the image is updated.

Display Jitter

- **Jitter**
  - Can be observed as burring of an image (two or more images may be seen)
  - reduces the perceived resolution
  - has a long delay or persistence time can be extremely detrimental
  - may strongly contribute to simulation sickness

Reduce the Latency

	Without Prediction	Prediction with slow motion	Prediction with fast motion
Umbrella (6tri)	166 ms	< 50 ms	100 ms
Teapot (604tri)	248 ms	133 ms	180 ms

The latency with and without latency using an SGI Indigo XS24Z R4000 plus a 6D tracker (Ascension, “flock-of-birds”)

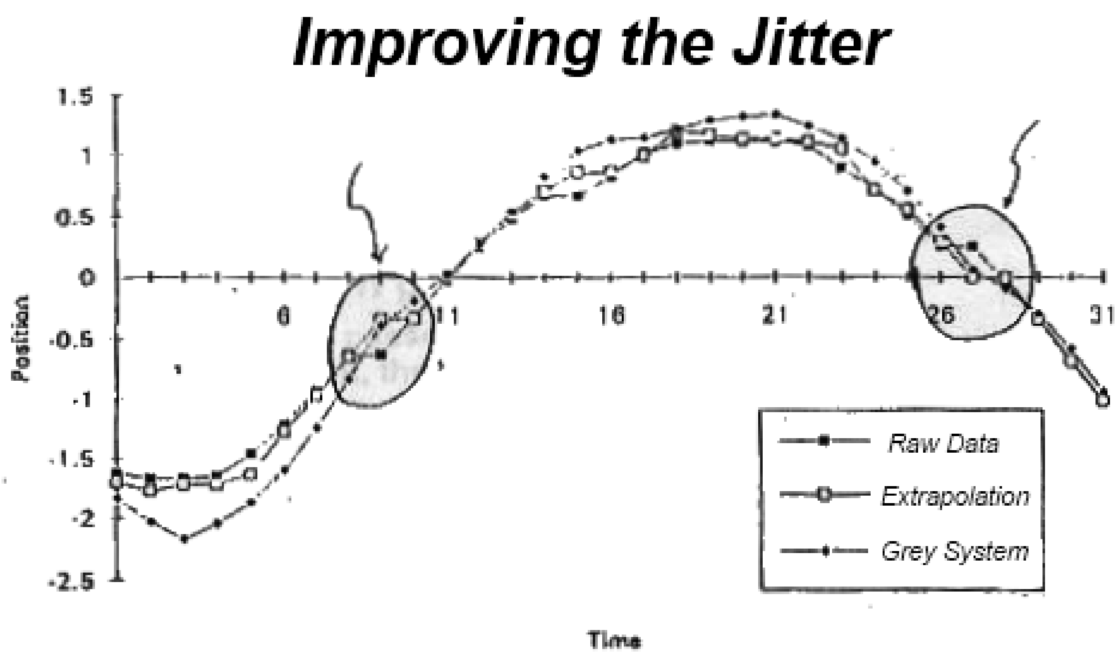


Figure 2 shows the measured data and predicted data using (a) two-point (line) extrapolation and (b) 6-point Grey System Model (GM) prediction. The X-axis means number of sampling Intervals (frame update time). And Y-axis means one element (position x) of tracker location.

3D SOUND SERVEY

- To strive, to seek, to find, and not to yield

  – Tennyson
- That the powerful play goes on and you might contribute a verse

  – Walt Whitman

4 cues relative to distance

- First power law for stimulus pressure
- Selective attenuation of high frequency due to absorption by the atmosphere
  - 0.1 dB per meter(only high frequency)
- proportion of direct to reverberant sound
- absolute motion parallax
  - as an observer passes by a source with unchanging head orientation, the azimuth of the source change
  - see fig. 2.
- result
  - 2/15 intracranial (頭蓋)
  - 13/14 external

Simulation Near Eardrum(1989)

Ref: "Headphone simulation of free-field listening. I: Stimulus synthesis",
Frederic L. Wightman, Doris J. Kistler, pp. 858-865, J. Accoust. Soc. Am., 85(2), February 1989.

Goal: Given x1(t), produce x2(t) s.t. y2(t) equals to y1(t)

- x1(t): electrical signal from a loudspeaker·
- x2(t): electrical signal from a earphone·
- y1(t): resultant electrical signal at eardrum from x1(
- y2(t): resultant electrical signal at eardrum from x2(

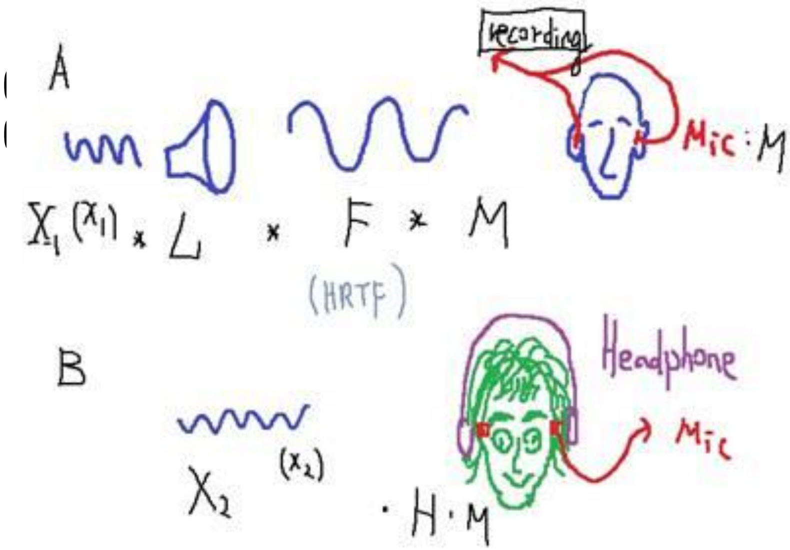
→ Fourier Transform : Y1 = X1 L F M

-L: Loudspeaker transfer function
-F: the free-field-to-eardrum transfer function
(Head Related Transfer Function, HRTF)
-M: microphone transfer function
-H: headphone-to-eardrum transfer function

Y2 = X2 H M

Let Y1 = Y2 → X1LFM = X2HM → X2 = X1 L F/H

Desired filter transfer function T = L F/H.



measurements were made at all elevations except +72 and + 90 deg, and at all azimuths around the circle in 15-deg steps.Thus transfer functions were measured from both ears at 144 source positions.10 subjects were measured.

Active Localization of Visual Sound(1990)

- Goal:
  - to achieve effective localization of virtual sounds that would enable an observer to walk quickly and effortlessly to the position of a simulated sound.
  - see fig.1
- Approximation
- head sha $\square\delta t = 257(\theta + \sin\theta)\mu s$
  - crossover frequency 1.8kHz
  - sinusoidally s.t. Left is attenuated 16dB to Right at 90 deg
- Pinnae shadow
  - azimuth = 0, minimum
  - azimuth = 180, maximum 3dB

Sources

- On the Difference Between Localization and Lateralization(1972)
  - G. Plenge(West Germany)

- Headphone Simulation of Free-field Listening
  I : Stimulus Synthesis(1989)

- Headphone Simulation of Free-field Listening
  II: Psychophysical Validation(1989)
  - Frederic L. Wightman and Doris J. Kistier J. Acoustical society of America 85, p858-67

- Active Localization of Virtual Sounds(1990)
  - Jack M. Loomis, Chick Hebert, Joseph G. Cicinelli

- Localization Using Nonindividualized Head-Related Transfer Function(1993)
  - Elizabeth M Wenzel, Marianne Arruda, Doris Kistler, Federic L. Wightman SIGCHI'89, Presence 1(1), 80-107

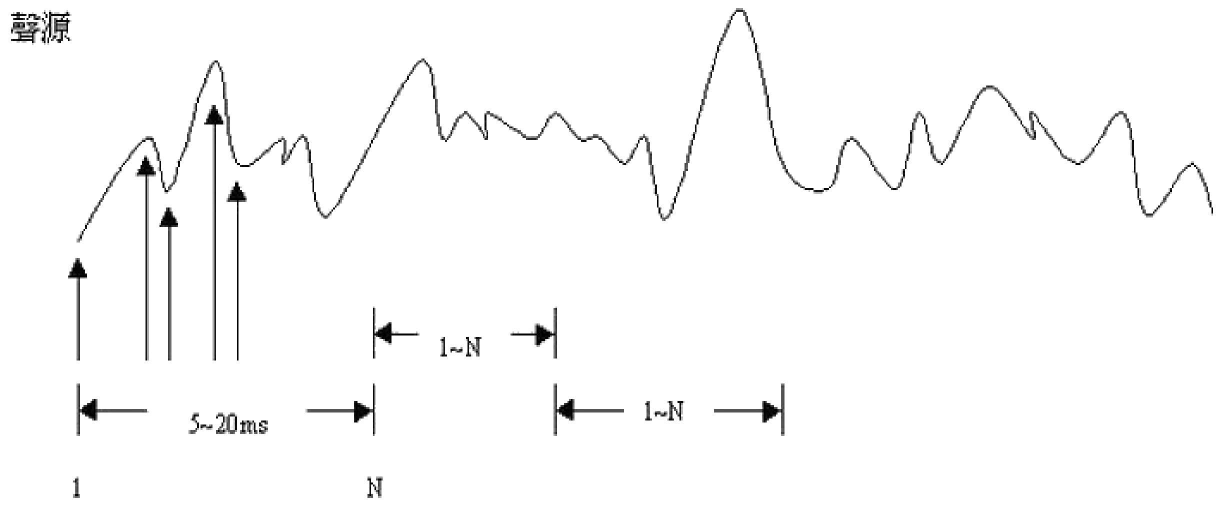
Simulation History

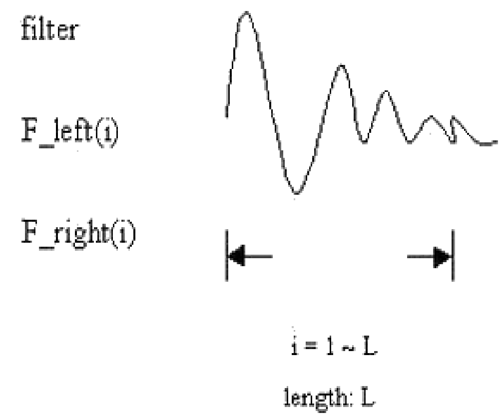
- Evolution
  - Dummy Head -> Pinnae -> Canal -> eardrum
- 1972(Dummy Head Record)
  - Conclusion:
    whether lateralization or localization does not depend upon whether the sound is conveyed by earphone or not
- Interaural Intensity Difference(IID)
- Interaural Time of Arrival Difference(ITD)

Nonindividual HRTF(1993)

- Goal:
  - use a good localizer's HRTF as a universal HRTF
  - need not to customize HRTF for every individual
- Result:
  - an increase in rate of front-back confusion
  - slightly degraded for good localizer using HRTF from another good localizer
  - large errors made for good localizer using HRTF from a poor localizer
  - poor anyway for a poor localizer
- Solving: Y1 = Y2
  - X2 = X1LF/H
  - define T = LF/H
- Goal:
  - measure T for every subject in 144 source positions
  - given x1(t), then X2 = X1T, and x2(t) is available
- Experiments:
  - measure Y1, X1, Y2, X2(can be measured)
  - LFM = Y1/X1, and HM = Y2/X2
  - T = LFM/(HM) = LF/H
  - Transfer function were measured from both ears at 144 source positions
  - elevation -36, -18, 0, 18, 36, 54 degrees(6 divisions)
  - azimuth - 15 degree each step(24 divisions) so 6 * 24 = 144
  - See Fig. 1, 2, 3, 4 and 6.
- Comments：
  - L: loudspeaker transfer function
  - F: free-field-to-eardrum transfer function
  - H: headphone-to-eardrum transfer function
  - X1(t): loudspeaker signal
  - X2(t): headphone signal
  - Y1(t): headphone results from X1(t)
  - Y2(t): eardrum received from X2(t)

input(n), n = 1 ~ N





本源經過濾波器的作用: convolution input(n) F-left 相當於將 filter F-left 左右反轉，然後與聲源相乘。

convolution(Product if Crystal River Engineering)

(with measured pinnae impluse response)

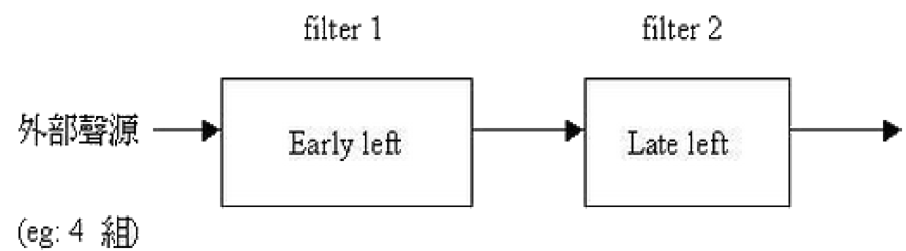
$$\text{Output\_left}(n) = \sum_{i=1}^{L} [\mathit{left}(i,n) * \mathit{input}(n-i)]$$

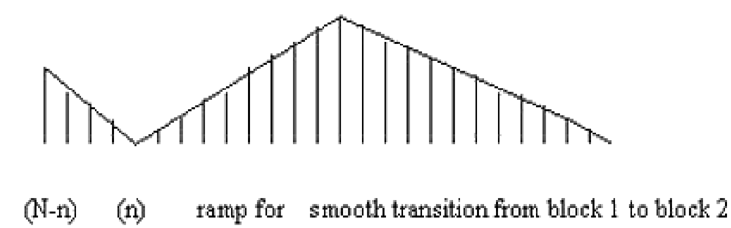
Where L: number of coef's in the measured responses(filter length)

n: N the number of input samples in n block(5~20 ms of sound)

$$\text{left}(i, n) = (N-n)\frac{\mathit{Earlyleft}(i)}{N} + n\frac{\mathit{Lateleft}(i)}{N}$$

n = sample index





$e^{it} = \cos(t) + i \sin(t)$

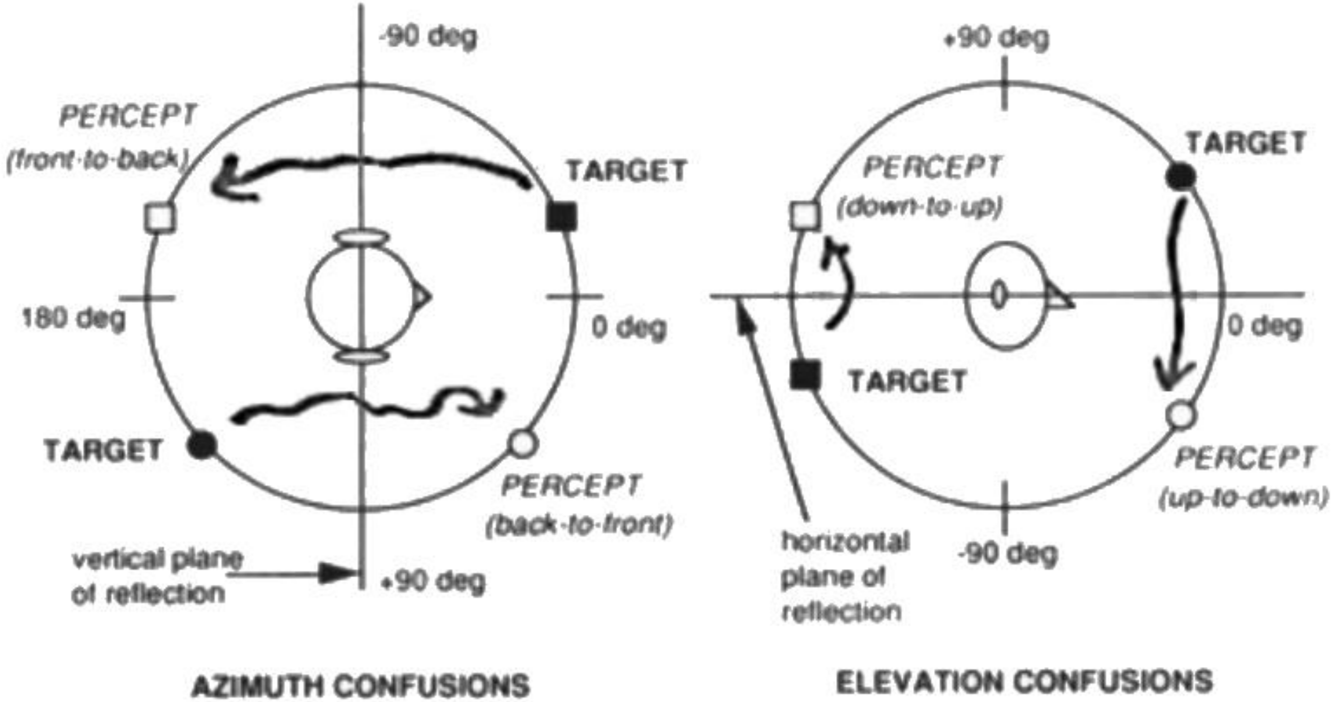
Theory:

- **Continuous**
  - For a continuous function of one variable f(t), the Fourier Transform F(f) will be defined as:
    - $F(f) = \int_{-\infty}^{\infty} f(t) e^{-2j\pi f t} dt$
  - and the inverse transform as:
    - $f(t) = \int_{-\infty}^{\infty} F(f) e^{2j\pi f t} df$
  - where j is the square root of -1 and e denotes the natural exponent
    - $e^{j\emptyset} = \cos(\emptyset) + \sin(\emptyset)$

- **Discrete**
  - Consider a complex series x(k) with N samples of the form
    - $x_0, x_1, x_2, x_3, \ldots x_k, \ldots x_{N-1}$
  - where x is a complex number
    - $x_i = x_{real} + j x_{image}$
  - Further, assume that that the series outside the range 0, N-1 is extended N-periodic, that is, $x_k = x_{k+N}$ for all k. The FT of this series will be denoted X(k), it will also have N samples. The forward transform will be defined as
    - $X(n) = \frac{1}{N} \sum_{k=0}^{N-1} x(k)\, e^{-jk2\pi n/N}, for\ n = 0 \ldots N-1$
  - The inverse transform will be defined as
    - $x(n) = \sum_{k=0}^{N-1} X(k)\, e^{jk2\pi n/N}, for\ n = 0 \ldots N-1$

Convolution

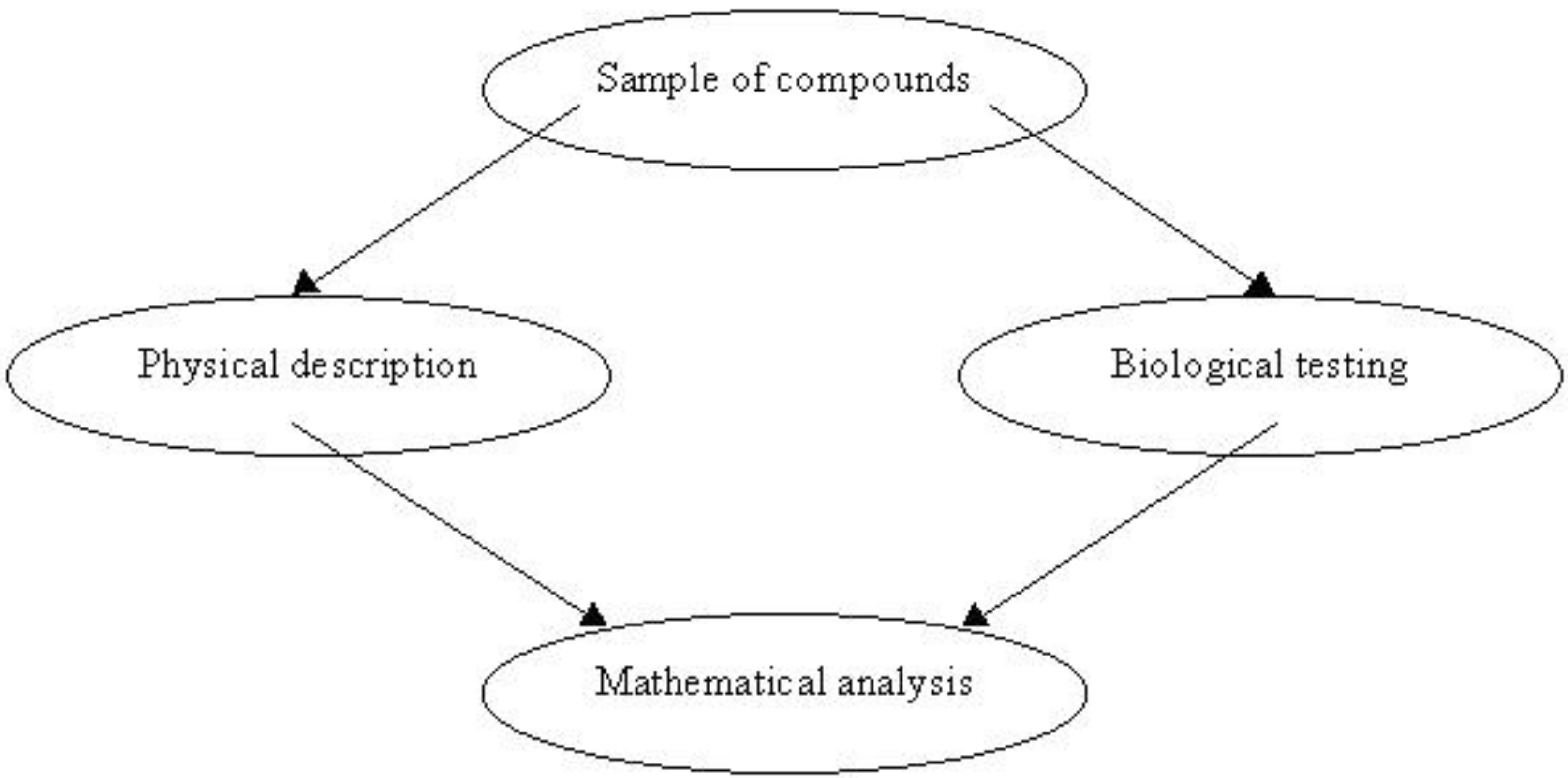
- Convolution in time domain equals multiplication in frequency domain.
- The behavior of a linear, time-invariant discrete-time system with input signal *x[n]* and output signal *y[n]* is described by the *convolution sum*
  - $y[n] = \sum_{k=-\infty}^{\infty} h[k]x[n-k]$
- The signal *h[n]*, assumed known, is the response of the system to a unit-pulse input.
- For longer sequences, convolution may pose a problem of processing time; it is often preferred to perform the operation in the frequency domain: if *X*, *Y* and *Z* are the Fourier transforms of *x*, *y* and *z*, respectively, then:
  - $Z=XY$
- Normally one uses a fast Fourier transform (FFT), so that the transformation becomes
  - $x \otimes y = FFT^{-1}(FFT(x)FFT(y))$
- For the FFT, sequences *x* and *y* are padded with zeros to a length of a power of 2 of at least $M + N - 1$ samples.
- DEMO: http://www.srslabs.com/Demonstrations.asp



例如：車內後座喇叭，前座沒有（Standard Installation）

FIG. 1. Illustration of the types of confusion errors observed for location judgments in the study. Confusions of perceived azimuth, with respect to the target azimuth, are shown on the left (i.e., front-to-back confusions: Perception of a forward target in the rear hemisphere; back-to-front confusions: Perception of a rear target in the forward hemisphere). Analogously, confusions of perceived elevation are illustrated on the right (i.e., up-to-down or down-to-up confusions). Reprinted with permission from ACM Press (Wenzel *et al.*, 1991).

Molecular binding problem (1)



Binding relationship

DHFR：Dihydrofolate reductase enzyme(酵素)

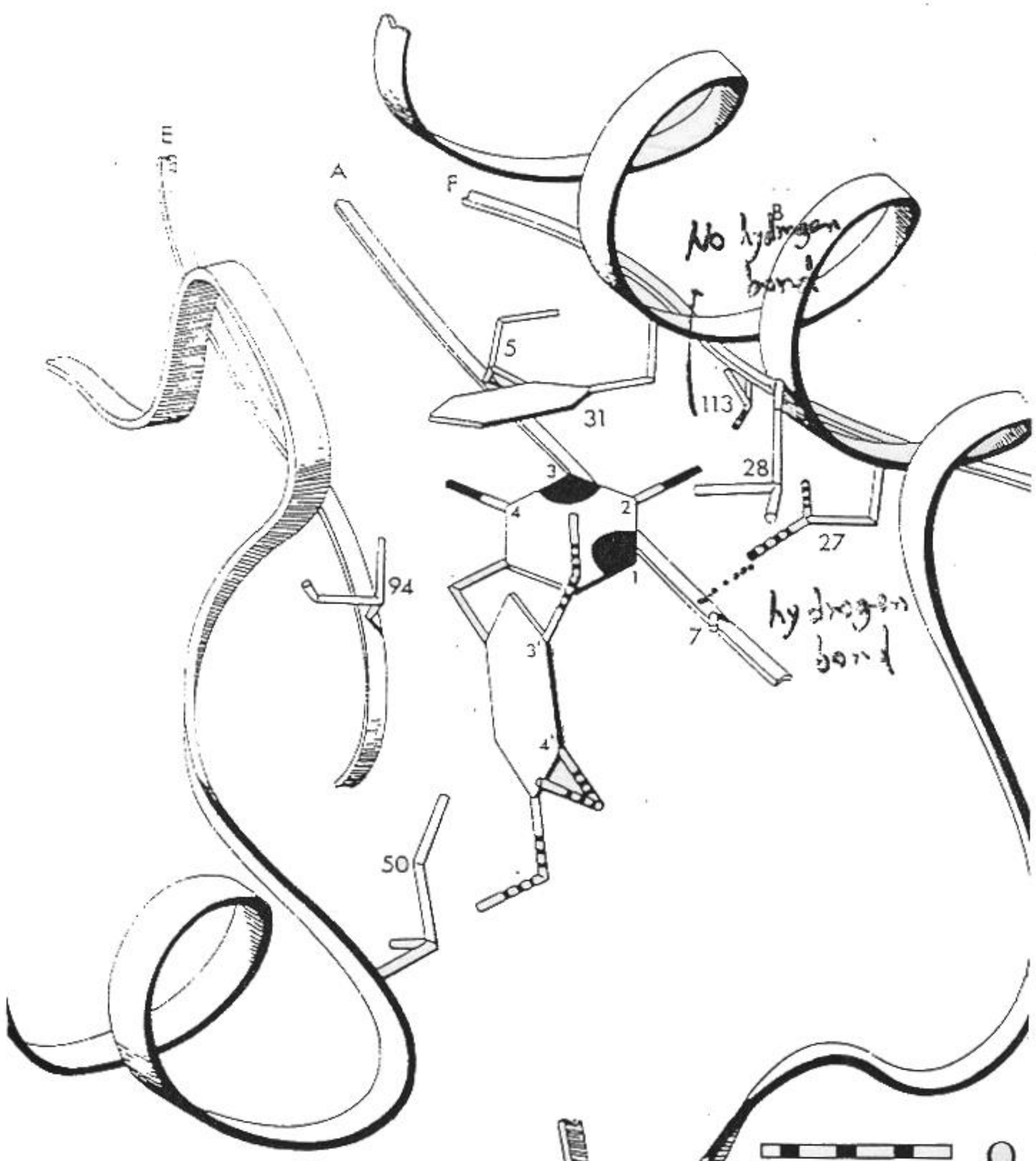
Trimethoprim (an anti-bacterial drug) and methotrexate (MTX, an anti-cancer drug) binds to DHFR much easier than folate.
Therefore, analogues of trimethoprim and methotrexate becomes good candidates for binding tests.

科普導讀：天下文化所出版《基因聖戰》
（Jerry Bishop 著，楊玉齡 譯），1994, 10

Where to obtain the molecules?
from Brook heaven Protein Databank(US. $70, one CD)

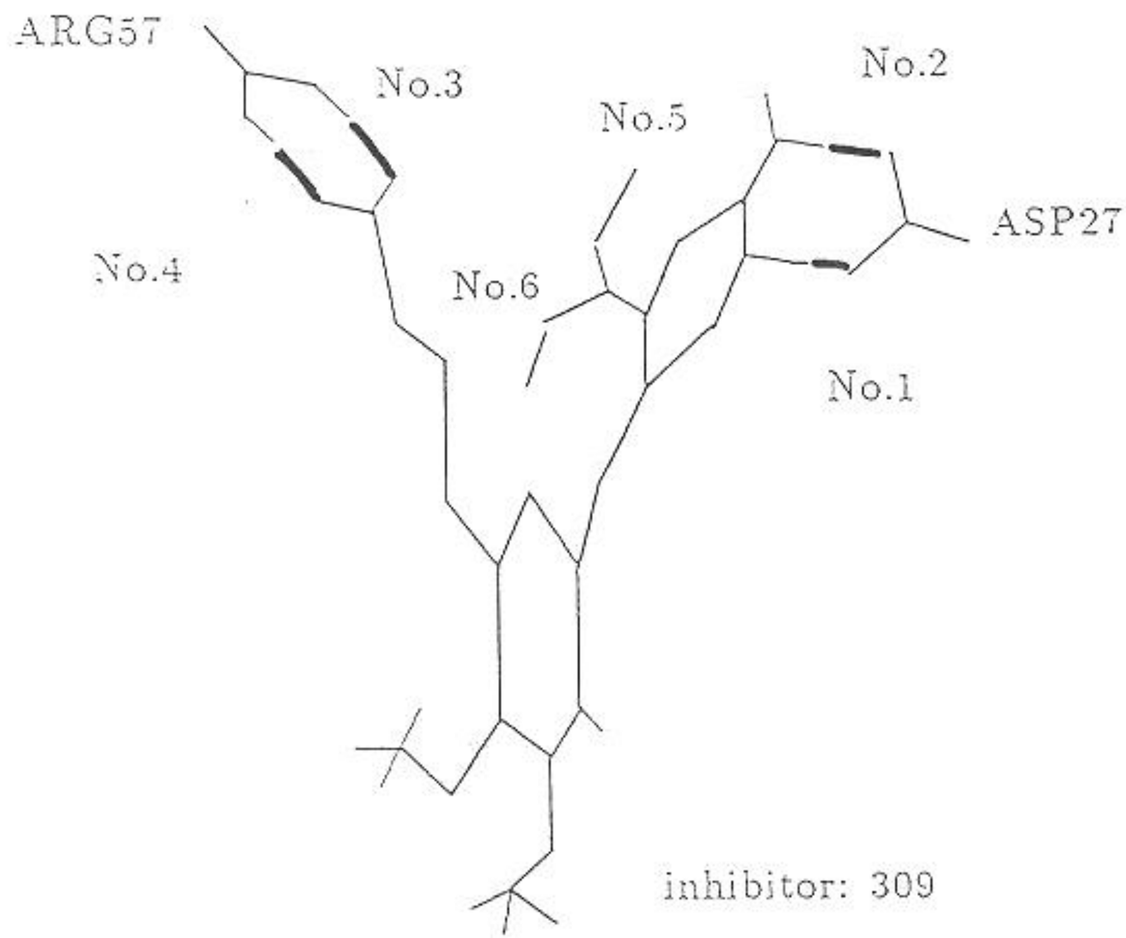
available from ftp.csie.ntu.edu.tw(台大資訊系),
including X-ray, CT, MRI, Ultrasound data.

Figure 4. The Binding Site For TMP in E. Coli DHFR



The Binding of Trimethoprim to Bacterial Dihydrofolate Reductase
By D. J. Baker, C. R. Beddell, and others.
FEBS LETTERS
volume 126, number 1

Figure 9: Inhibitor 309 bound to DHFR in crystal conformation



Two ways to solve the molecular binding problem

1) Man-in-the-loop design (Human Computer Interface)

2) Algorithms (searching & global optimization)

   if 5 degrees in rotation, 0.2 angstrom in translation

   search range = 10 angstrom(Å), a drug molecule with 6 single bands,

   →cardinality of search space $50^3 \times 72^9 = 6.5 \times 10^{21}$

   Energy calculation on SUN SparcStation 10 ≅ 0.1ms (fast method)

   Brute force search will take 200 years

Molecular binding problem (2)

- Problem definition
  - Given 2 molecules
  - Energy minimization problem
- Quantitative analysis
  - Electrostatic force
  - van der Waals force

Computational Complexity

- Quantum mechanics
  - O(n^4) where n = number of orbitals
  - Eg. In Gaussian 82, 38 Cray hours for dimethyl phosphate, which contains less than 50 atoms
- Molecular mechanics
  - O(M*N) where M is the number of atoms in protein, N is the number of atoms in a drug molecule
  - Grid tabulation O(n)
- Molecular Dynamics
  - Molecular mechanics solution as a function of time

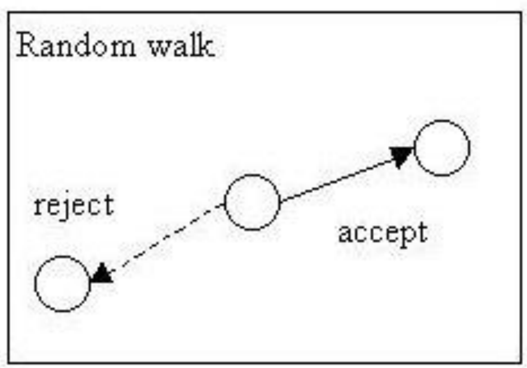
Annealing genetic algorithm (1)

- Objective
  - Automatic and efficient

- Solution
  - Simulated annealing + Genetic algorithm

Annealing genetic algorithm (2)

- Simulated annealing(SA)
  - *S..Kirkpatrick, Science, Vol 220, No 4598, pp671-680, 1983*
  - Guided random search

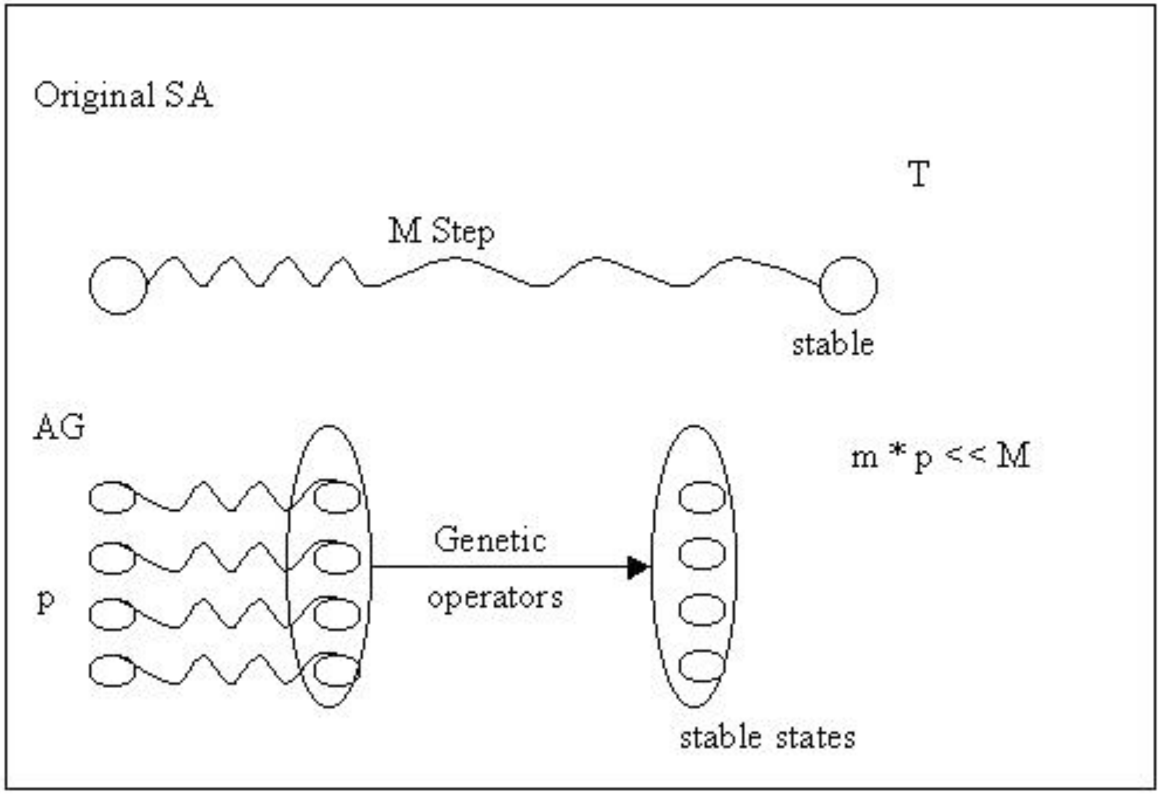


$$Prob = exp\left(-\frac{\Delta C}{T}\right)$$

ΔC : cost difference
T : temperature

Algorithm: after perturbation, the cost difference is ΔC,
Get random number [0, 1]
if (random number < prob)accept;
else try another perturbation

Annealing genetic algorithm (4)

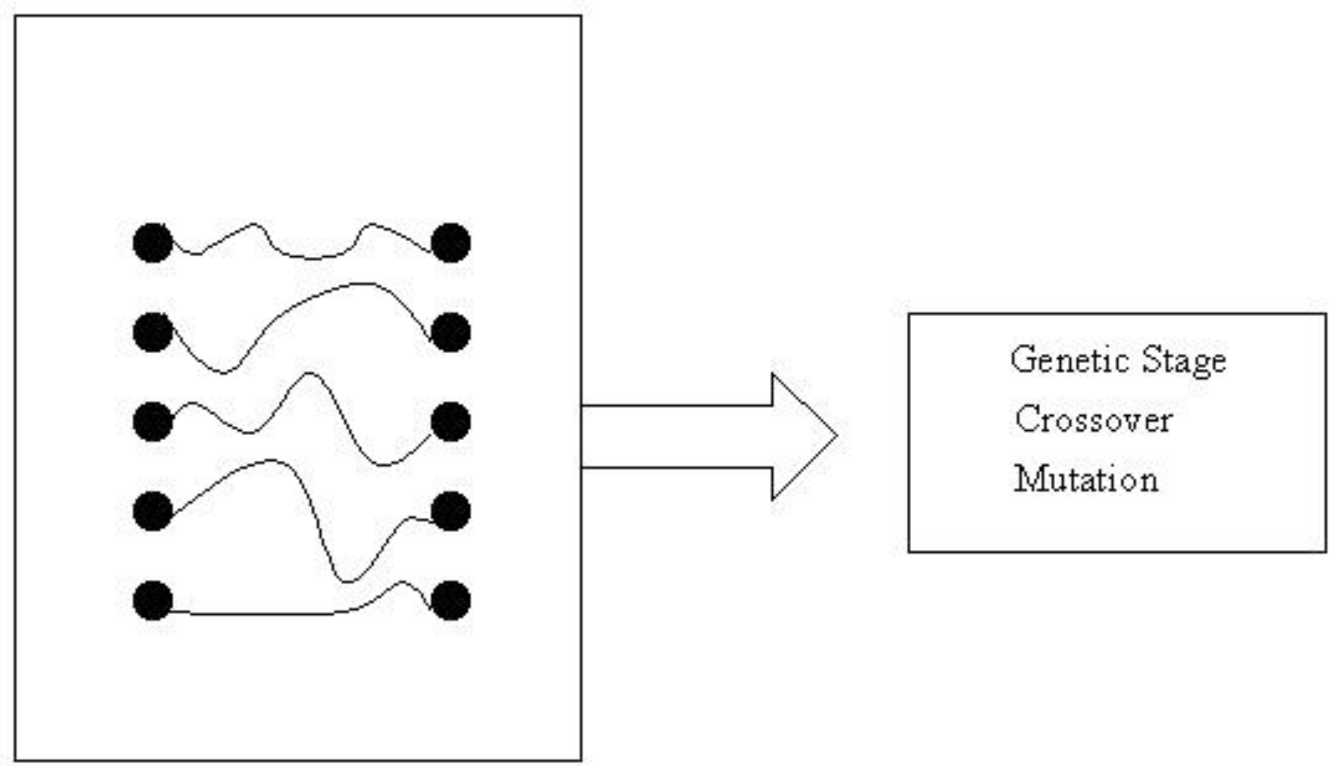


1) F.T. Lin, C.Y. Kao, C.C. Hsu, "Applying the Genetic Approach to Simulated Annealing in Solring Some NP-Hard Problems", IEEE tr. System, Man, Cybernetics, Nov 1993.

2) L.H. Wang, C.Y. Kao, M. Ouhyoung, W.C. Chen, Proc. Tools with AI(TAI' 94), Nov 1994.

Annealing genetic algorithm (5)

- **Concept**
  - Population-based SA
  - Boltzmann type selection operator



Result (2)

- Parameter setting
  - population size = 50
- Precision of Search Space
  - 0.2 angstrom in translation
  - 5 degrees in rotation

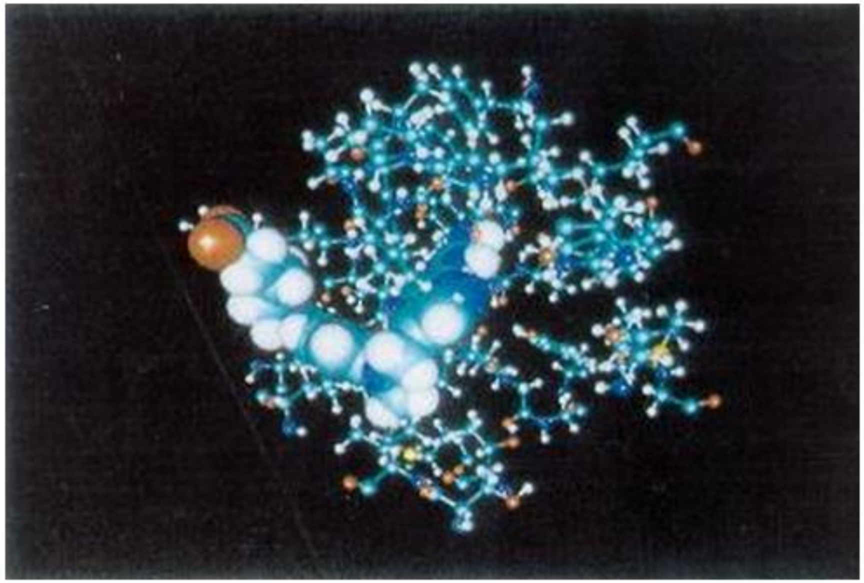


figure 3.5 : The binding structure of Inhibitor 91 with DHFR

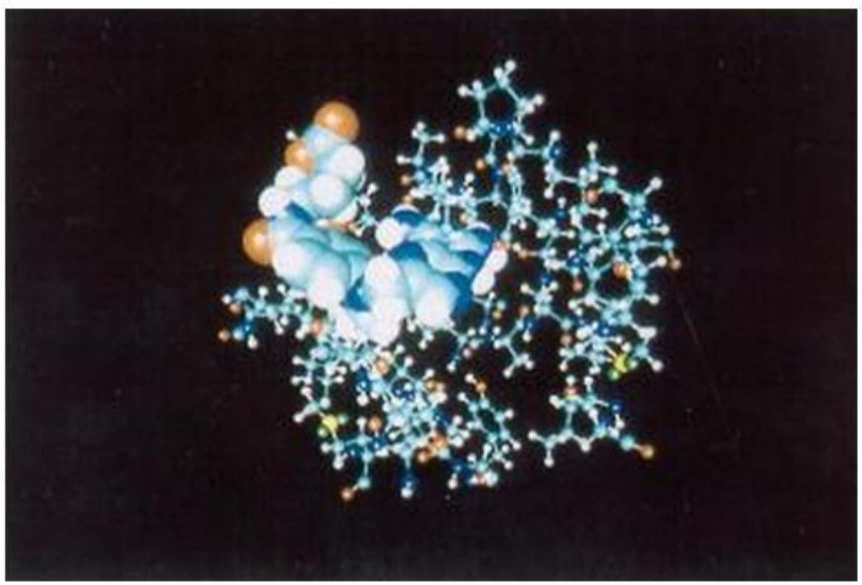
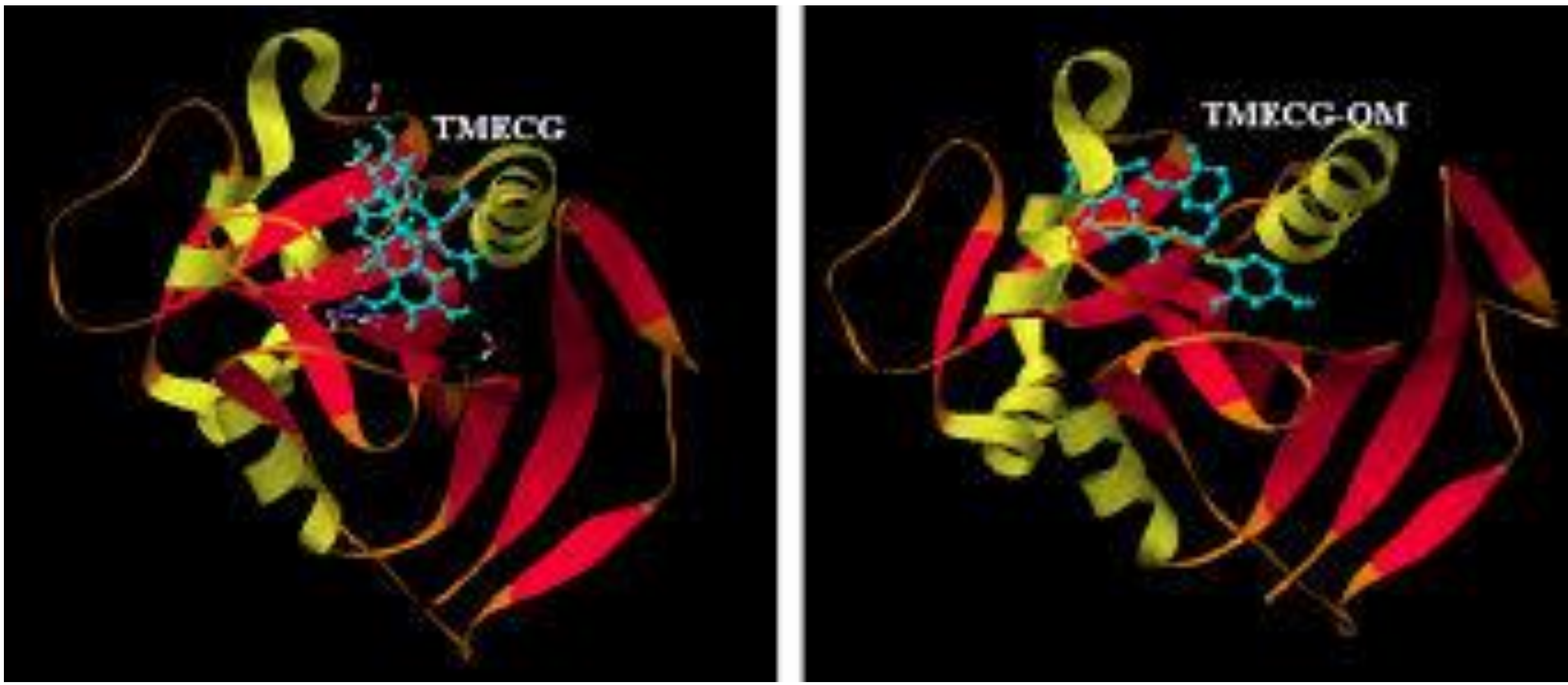


figure 3.5 : The binding structure of Inhibitor 309 with DHFR

Protein DHFR (dihydrofolate reductase) with inhibitors

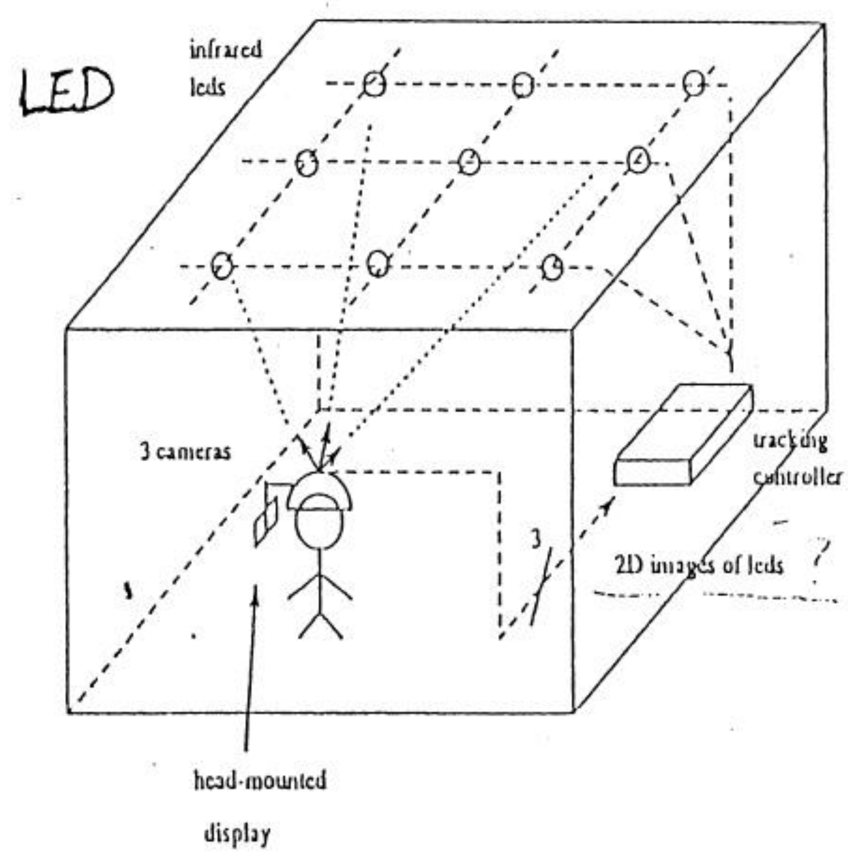


Conclusion

- AG is stable and powerful
- Algorithm-only approach can obtain reasonable solutions
- Based on AG, drug design tool can be developed

Optical Trackers
Environment setup

- Outside-in vs Inside-out optical trackers
- Environment



Algorithms: Inferring 3D position

- Inferring 3D position from 2D image

$(X_1, Y_1, Z_1, 1)$: point A in 3D, $(x_1, y_1, 1)$: point a in 2D

$\Rightarrow [X_1, Y_1, Z_1, 1]\, M_{4x3} = [x_1, y_1, 1]$, solve M_{4x3}

- 12 unknowns in M, each 3D point provides 2 independent constrains => 6 points

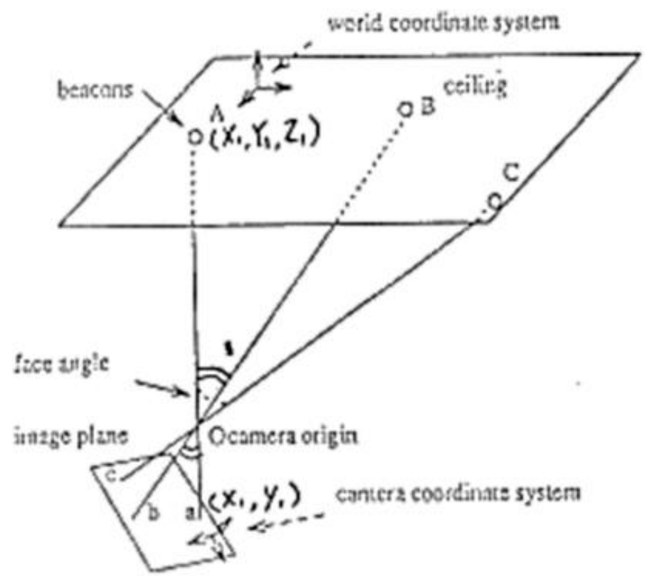


Figure 2: Church's algorithm

Algorithms: Inferring 3D position

Church(1945) method: modified by iterative converging.

3 points, iterative method

$\angle AOB = \angle aOb$, guess point O's 3D position

in camera coordinate: $O(0, 0)$, $a(x_1, y_1)$, $b(x_2, y_2)$

in world coordinate: $O(X, Y, Z)$, $A(X_1, Y_1, Z_1)$, $B(X_2, Y_2, Z_2)$

compute $\angle aOb = \cos^{-1}(Oa \bullet Ob \,/\, |Oa||Ob|)$

same as $\angle AOB = \cos^{-1}(OA \bullet OB \,/\, |OA||OB|)$

if $(\angle aOb - \varepsilon) < \angle AOB < (\angle aOb + \varepsilon)$, add an adjustment:

$diff = | \angle aOb - \angle AOB |$

$(\Delta X, \Delta Y, \Delta Z) = (\partial diff / \partial X, \partial diff / \partial Y, \partial diff / \partial Z)$

$\Rightarrow O(X', Y', Z') = O(X + \Delta X, Y + \Delta Y, Z + \Delta Z)$

Algorithms: System errors

- Sources of errors:
  - limited resolution and nonlinear characteristics of the photodiode

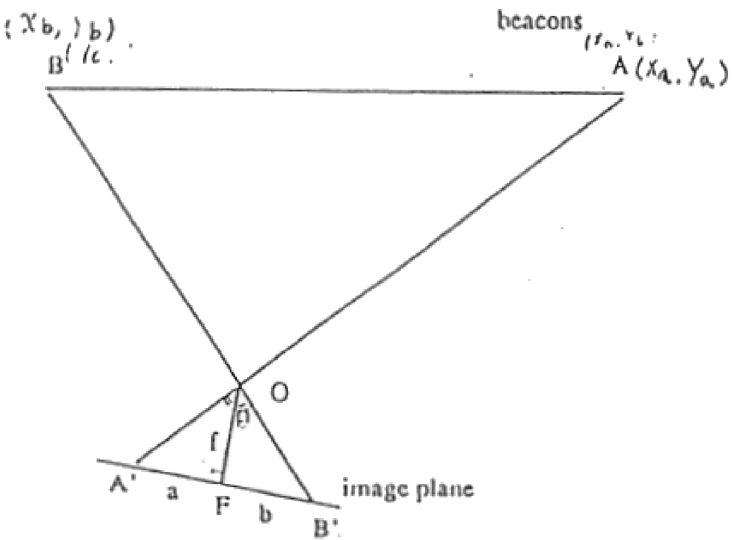


Figure 3: Error in the image plane

<u>ERROR in camera coordinate:</u>

$\theta = \angle A'OB' = \angle A'OF + \angle FOB' = \tan^{-1}(a/f) + \tan^{-1}(b/f)$

$\varepsilon_\theta = (\partial\theta / \partial a)^* \varepsilon_a + (\partial\theta / \partial b)^* \varepsilon_b + (\partial\theta / \partial f)^* \varepsilon_f$

$= (1/(a^2+f^2) + 1/(b^2+f^2)) * fD/2r$

D: width of photodiode, r: resolution of photodiode

<u>ERROR in world coordinate:</u>

$\angle AOB = \cos^{-1}(OA \bullet OB / |OA||OB|)$

$\varepsilon_\theta = ((x_a+y_a)/|OA|^2 + (x_b+y_b)/|OB|^2) * \varepsilon_p$

ε_p : maximum error in the position of beacons

Algorithms: System errors

- Result
  - In camera coordinate
    - long focal length
    - large separation between image points
    - high resolution of photodiode
- In world coordinate
  - large separation between beacons

Algorithms: Multiple views

- Church method fails since O_bO_a unknown
- Generalize Church method

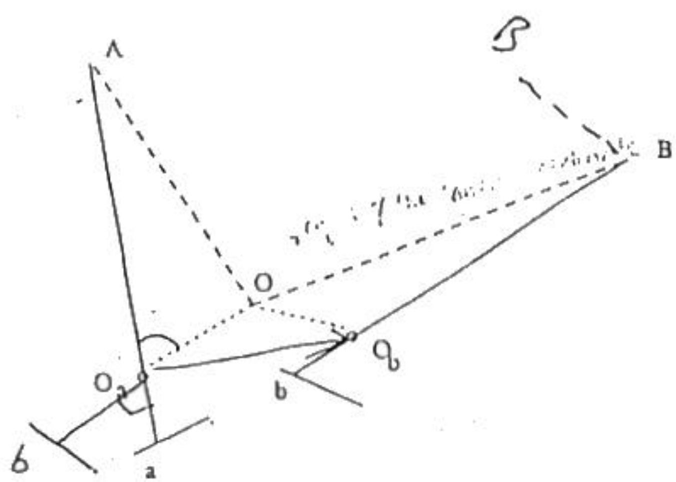


Figure 4: Multiple cameras with separated nodal points

<u>$\angle AOB$ in world coordinate:</u>

$\angle AOB = \cos^{-1}(OA \bullet OB / |OA||OB|)$

<u>$\angle AOB$ in camera coordinate:</u>

$\angle OO_aa = \cos^{-1}(O_aa \bullet O_aO / |O_aa||O_aO|)$

same as $\angle OO_bb$

using law of cosines,

$|OA|^2 = |O_aO|^2 + |O_aA|^2 - 2|O_aA||\Theta_aO|\cos(\angle AO_aO)$

$O_aA = - O_aa\,|O_aA|/|O_aa|$, $OA = OO_a + O_aA$

same as OB

$\angle AOB = \cos^{-1}(OA \bullet OB / |OA||OB|)$

Apply Church's method

Performance Evaluation

- Update rate

machine	speed (updates/sec)
Sun 3/50	< 1
Sun 3/60	7
Sun 4	82
Vax-II	25
Vax-3200	69
DECstation-3100	215

- Accuracy
  - 0.1° rotational and 2mm translational movements

Position Coverage The instrument will provide the specified accuracy when receivers are located within 30"(76cm.) of the transmitter. Operation with separations up to 120"(305cm.) is possible with reduced accuracy.

Negative Coverage: The receivers are all-attitude.

Static Accuracy 0.03"(0.08cm) RMS fro the X, Y, or Z receiver position, and 0.15° RMS for receiver orientation.

Resolution 0.0002 inches/inch of range(0.0005 cms/cm of range), and .025 deg.

Latency 4.0 milliseconds from center of receiver measurement period to beginning of transfer from output port.

Output Software selectable including extended precision. Cartesian coordinates of position and Euler orientation angles are standard. Direction cosines and quaternions are selectable. English or metric units are also selectable.

Update Rate

One receiver:	120 updates/second/receiver
Two receivers:	60 updates/second/receiver
Three receivers:	40 updates/second/receiver
Four receivers:	30 updates/second/receiver

Carrier Frequency The FASTRAK may be configured with any one of four discrete carrier frequencies to allow simultaneous operation of up to four instruments in close proximity. Carrier frequencies are selected via color coded Frequency Select Modules (FSM). These frequencies are:

Reference #	Frequency	Color Code
1	8013Hz	Black
2	10016Hz	Red
3	12019Hz(Standard)	Yellow
4	14022Hz	Blue

The color dot can be found on the FSM, on the end closest to the connector.

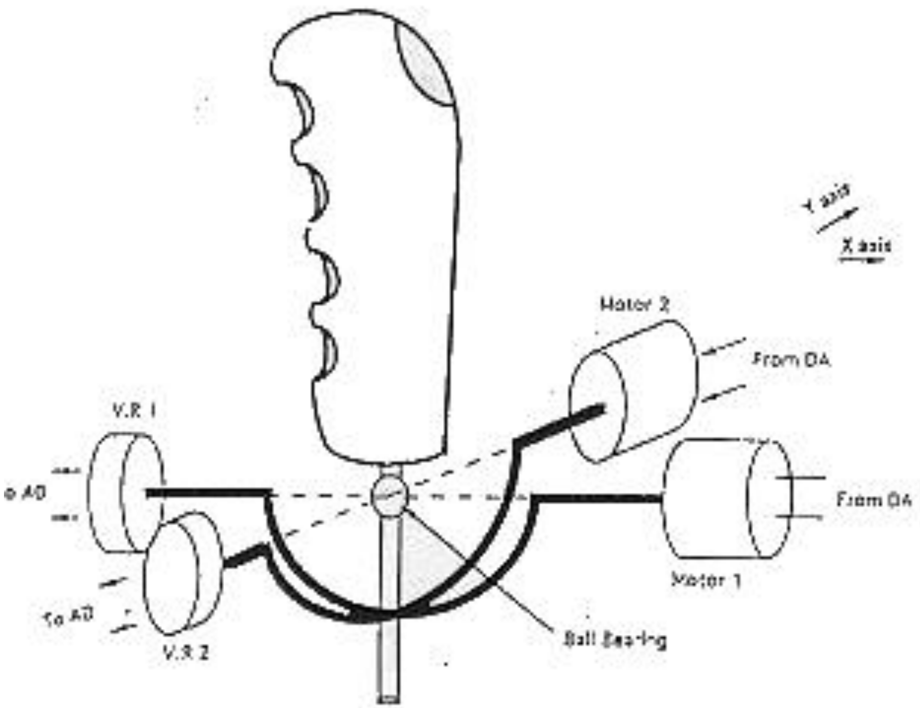
Interfaces IEEE-488 parallel port at 100k Bytes/second maximum, and RS-232C serial port with software selectable baud rates of 300, 1200, 2400, 4800, 9600, 19200, 38400, 58600 and 115200; ASCII or Binary format. The factory standard for RS-232C is 9600 baud. An RS-422 port is available as an optional serial port in lieu of the RS-232 at the same baud rates.

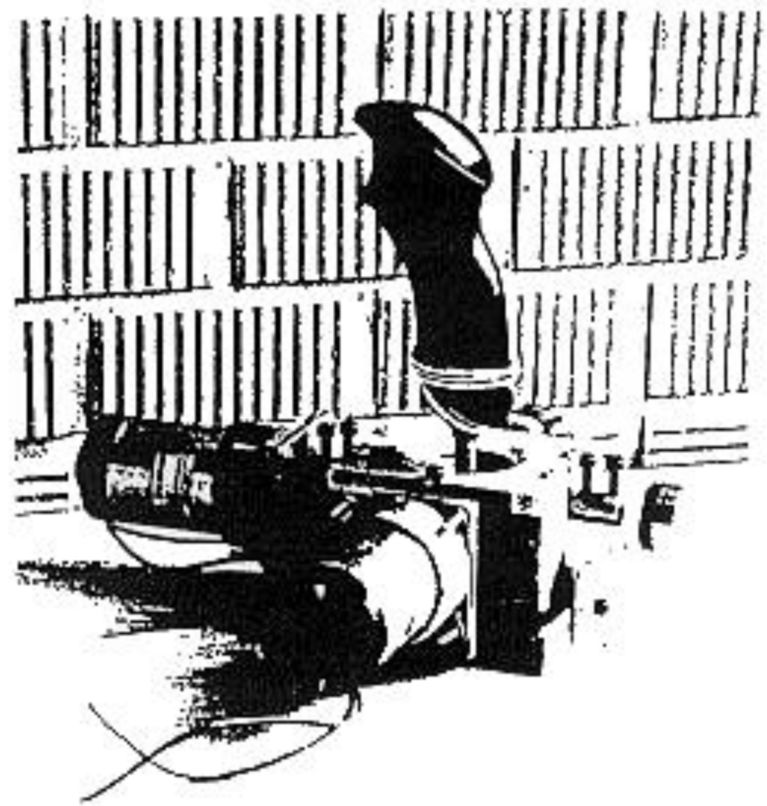
The Development of a Force Feedback Joystick
and
Its Use in the Virtual Environment

Overview

- Motivation
- Implementation
- How to simulate behaviors of objects
  - theory and experiments
- VR prototype(Virtual Reality)
- Conclusion and future work

Mechanical Structure



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158

Force feedback 2 Joystick

- the Force Feedback Pro was replaced with a Precision 2 derivative, the Force Feedback 2. Since the release of the Force Feedback 2, the stick has garnered a reputation of reliability and resiliency, many Force Feedback 2 sticks are still in use currently. On eBay Sidewinder Force Feedback 2 joysticks regularly sell for more than the original MSRP of $109.


Microsoft

Patents

- 歐陽明, 蔡武男, "觸覺回饋裝置", 中華民國發明第079611號, 85/07/11-104/6/11
  “Tactile feedback device”, Taiwan patent 079611, 1996/7/11-
- Ming-Chang Tsai, Touching Feedback Device, US patent number: 5589854, 1996/12/31-

Force Feedback Wheel

- ***FREX Force Feedback Wheel SimWHEEL***

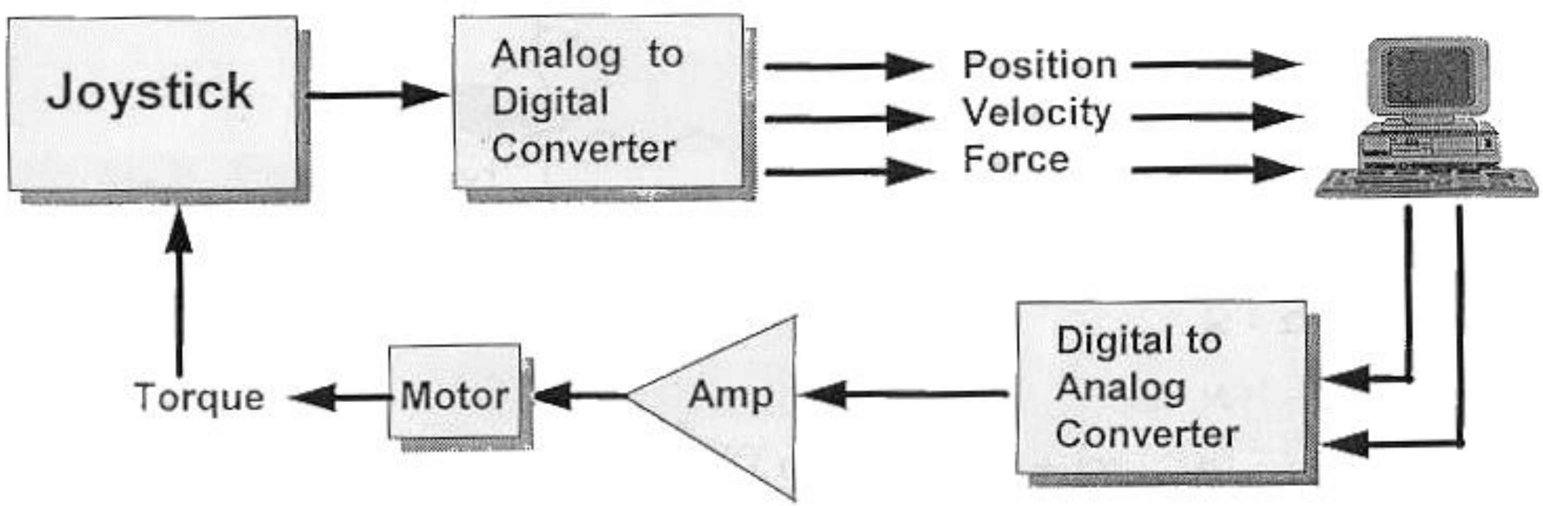
Why implementing a force feedback joystick

- Correctly and efficiently manipulate 3D objects on a 2D screen
- Virtual environment
  - visual, audio, and haptic information
- Enhance the illusion of virtual environment
- Commercially available (Microsoft, etc.)

A simple flight simulator

- X-wing like game

Flow Control



Newton's Three Laws of Motion

- 1.

Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.

- 2. The relationship between an object's mass *m*, its acceleration a, and the applied force *F* is *F = ma*. Acceleration and force are vectors (as indicated by their symbols being displayed in slant bold font); in this law the direction of the force vector is the same as the direction of the acceleration vector.

- 3.

III. For every action there is an equal and opposite reaction.

Generating forces

- Spring Force = k * (position- position_0)
- Damper Force = b * velocity
- Mass   Force = m*acceleration

- In general: force model is

Force = k* x + b*v + m*a ,

where x = position, v = velocity, a = acceleration

Note: b: viscosity (黏滯力系數)

How about in a sand paper?

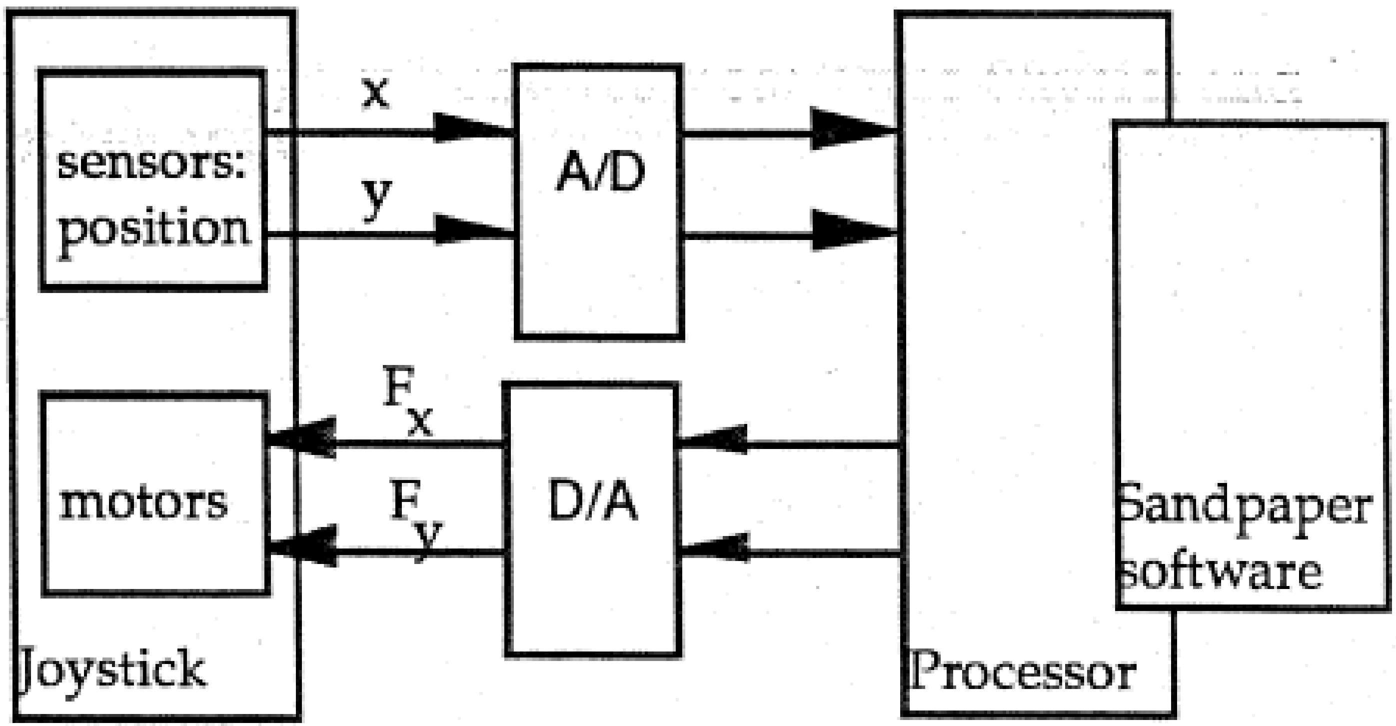


Figure 4 Block Diagram of Hardware System

Sand paper simulation

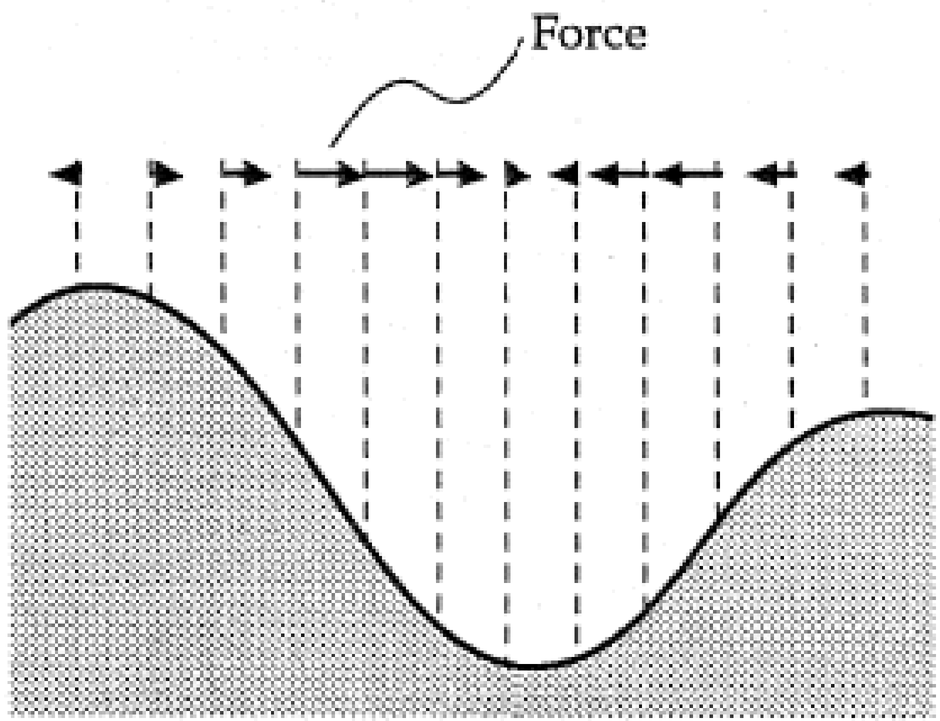
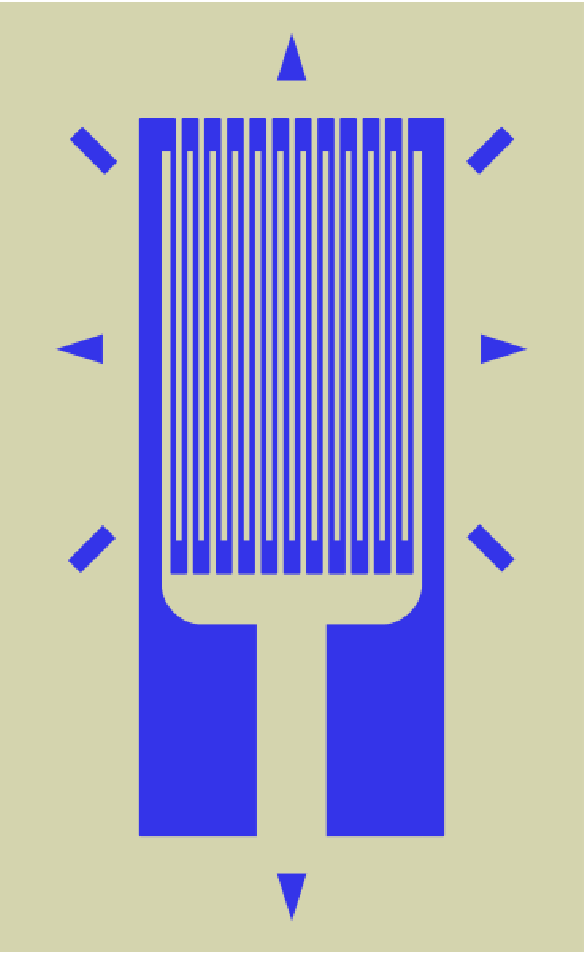


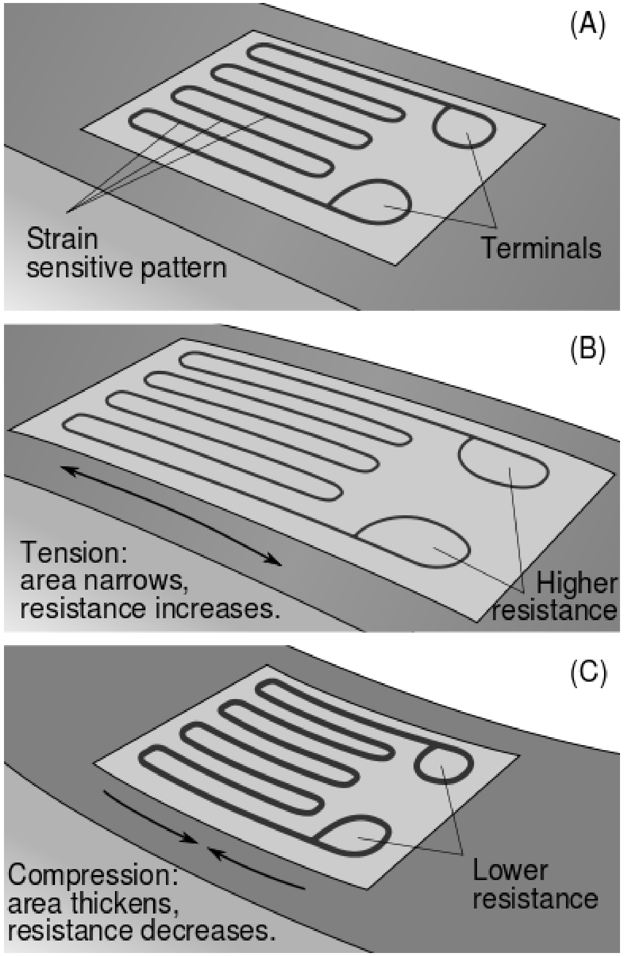
Figure 2 Gradient Technique: enlarged cross section of surface depth map

How to measure force (torque)? strain gauge



- A **strain gauge** (also **strain gage**) is a device used to measure the strain of an object. Invented by Edward E. Simmons and Arthur C. Ruge in 1938, the most common type of strain gauge consists of an insulating flexible backing which supports a metallic foil pattern.

Principles of strain gauge



A force feedback Joystick model

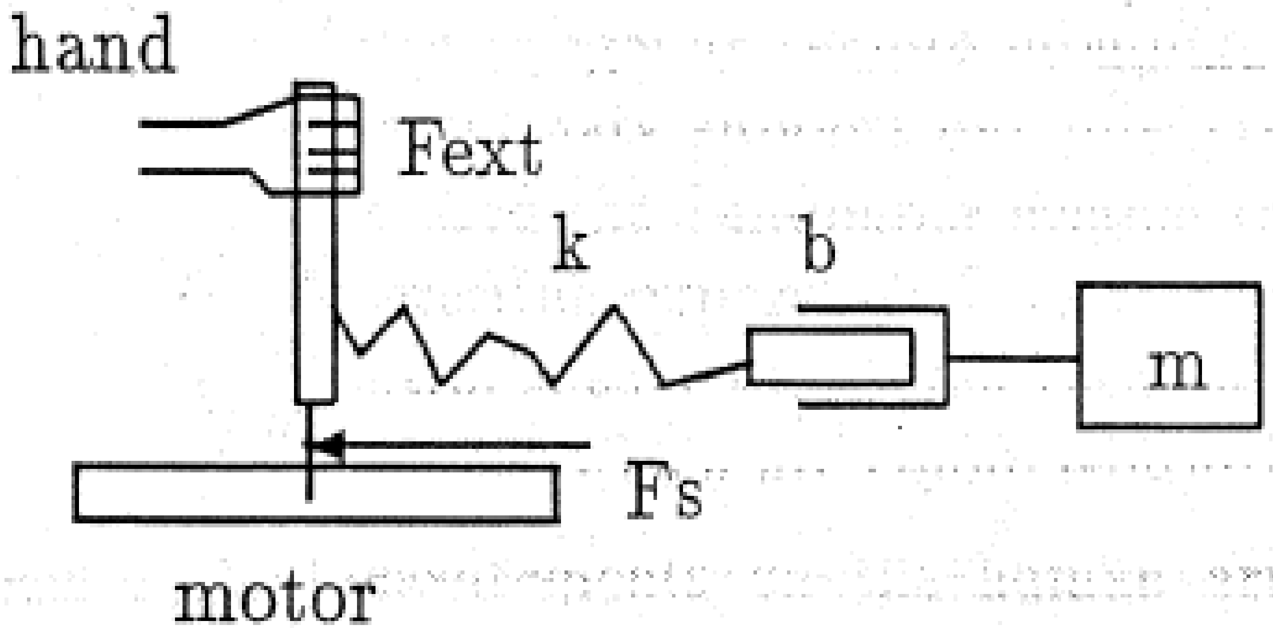


Figure 5: A joystick system

$$ma + bv + kx = F_s - F_{ext} \qquad (1)$$

Force model continued (1)

$$ma + bv + kx = F_s - F_{ext} \quad (1)$$

Suppose the target virtual spring-mass system has mass M, stiffness K, and viscosity B, then the force measured at the sensor is

$$-F_{ext} = Ma + Bv + K(x - x_0) \quad (2)$$

where x_0 is the rest position. From 1, the force required at motor is

$$F_s = ma + kx + bv + F_{ext} \quad (3)$$

from 2, let $1/M = W$

$$a = W[K(x_0 - x) - Bv - F_{ext}] \quad (4)$$

Force model: final

$$F_s = ma + kx + bv + F_{ext} \quad (3)$$

from 2, let $1/M = W$

$$a = W[K(x_0 - x) - Bv - F_{ext}] \quad (4)$$

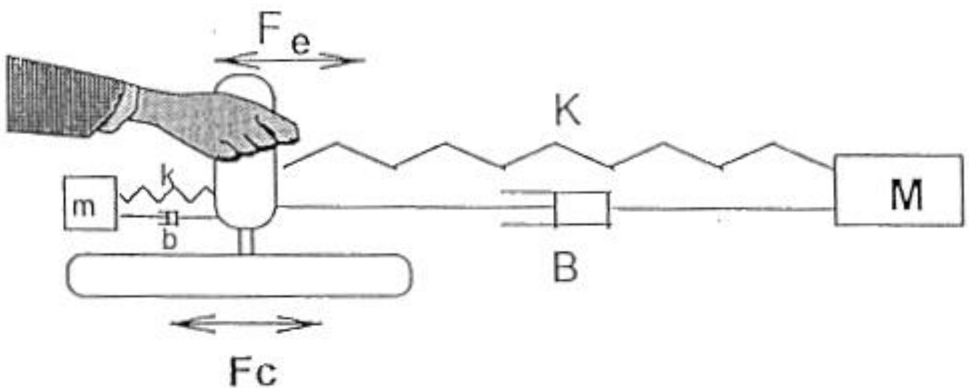
substituting 4 into 3

$$F_s = mW[K(x_0 - x) - Bv] + kx + bv + F_{ext}(1 - mW) \quad (5)$$

Equation 5 says that if the position x, velocity v, and the force from sensor F_{ext} can be measured, the system can simulate any object by controlling motor forces only.

How to simulate the behavior of objects --- Theory

- Impedance Control Theory



B: viscosity

K: stiffness

M: mass

$$Fc = (1-\frac{m}{M})Fe - \frac{m}{M}[Bv + K(x-x_0)] + bv + kx$$

Fc: force by the motor

Fe: force to the user

Simulate a simple spring, stiffness K, mass m, and no viscosity

- Let Fs = K (X0 – X),

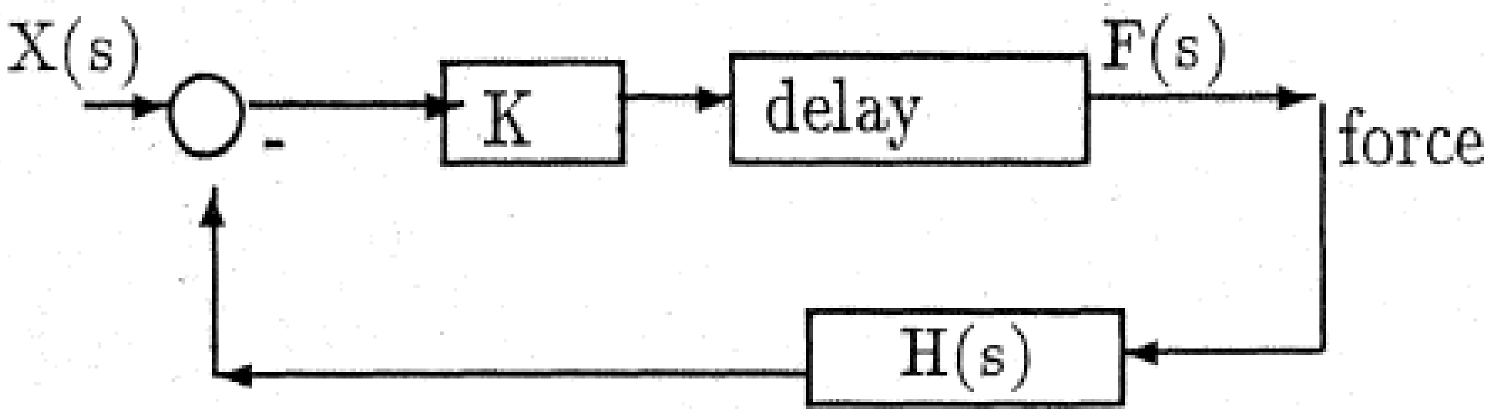
-Fext = - K (X0 – X) – ma –bv)

= ma + bv + K (X-X0)

So the real feeling is like holding a spring with stiffness K, mass m, and viscosity b

(not the same, but similar forces are generated).

An Analog system with delay T



where K = spring constant,

$H(s) = 1/(Ms^2 + Bs)$, M: mass, B:viscosity,

delay = e^{sT},T: sampling period

Figure 6: An analog system with delay T

Transfer function between output force and input position

The transfer function between output force and input position becomes

$$
\begin{aligned}
F(s)/X(s) &= Ke^{-sT}/[1 + KH(s)e^{-sT}] \\
&= (Ms^2 + Bs)Ke^{-sT}/[K + (M + \\
&\quad 1/2KT^2)s^2 + (B - KT)s]
\end{aligned}
$$

Control theory analysis: unstable condition appears when ….

The system becomes unstable, when

$KT - B > 0$, where K = stiffness of the system, B is viscosity, and T is the delay

actually $T > 2 * B/K$ can be unstable for the system!

When the human hand in holding a joy stick,

$K = Hh + k$, $M = Mh + m$, $B = Bh + b$,

where Hh, Mh, and Bh are human parameters.

A magic joystick here!

- Hold it horizontally (sideways), it is unstable; the more force you apply, the more unstable is your hand.

But, hold it vertically (back and forth motion), the system is VERY stable!

How come?? A programmable joystick, where total viscosity is "orientation dependent".

Human arm viscosity is (vertically) 10

while horizontally, 3

But the joystick has a constant viscosity of 3.5 (assuming in both ways)

viscosity in horizontal movement	viscosity in vertical movement	viscosity in X-axis	viscosity in Y-axis	stiffness of arm	sampling period
3	10	3.496	3.86	400	13.6

viscosity : Newton-sec/m, stiffness : Newton/m, sampling period : msec

a magic that fooled everyone!

Condition 1 : stable in vertical moving, unstable in horizontal collision with a wall

	Left wall Stiffness=688 Newton-sec/m	Upper wall Stiffness=688 Newton-sec/m
Maximal sampling period	2*(3.496+3)/(688+400)=11.94 ms	2*(3.86+10)/(688+400)=25.4 ms

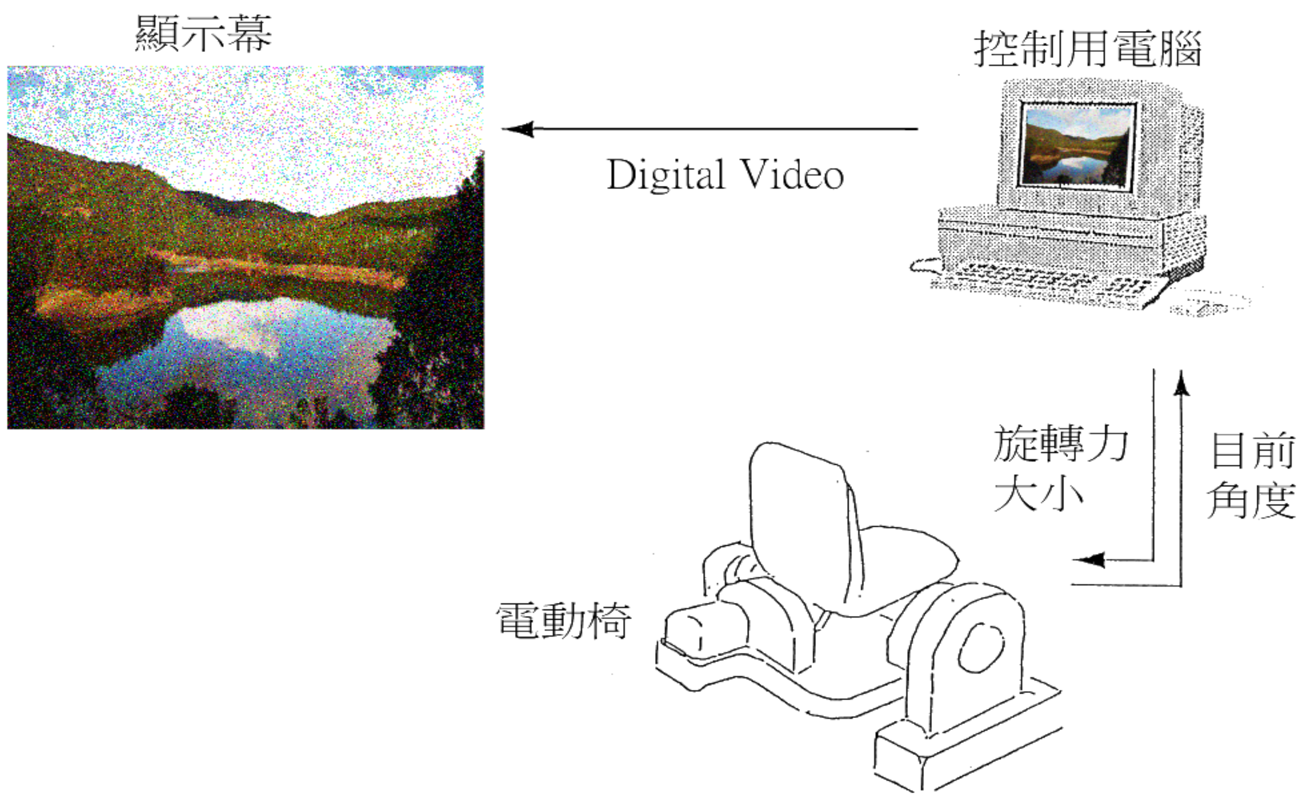
Condition 2 : stable in both vertical and horizontal moving, sampling period at 10ms

	Left wall Stiffness=688 Newton-sec/m	Upper wall Stiffness=688 Newton-sec/m
Maximal sampling period	2*(3.496+3)/(344+400)=17.46 ms	2*(3.86+10)/(688+400)=25.4 ms

Self-Design in the past

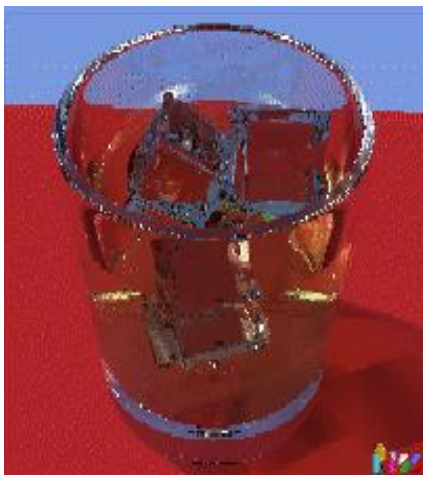
- 1. Electric Motion Chair for fly-through
- 2. Fly over the Taipin Mountain

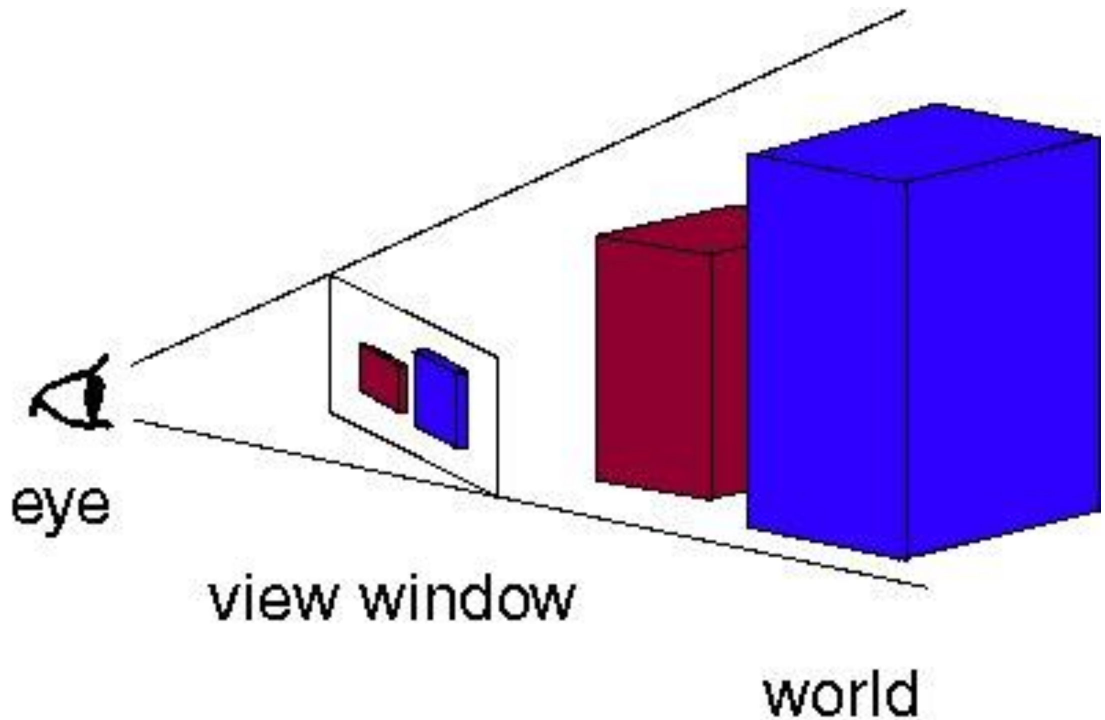
System Architecture: motion chair + controllable display



Ray tracing: Turner Whitted

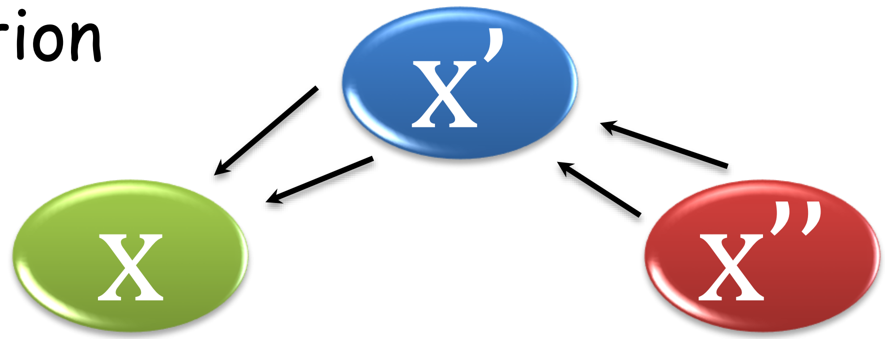
- Key to success, from light to eye or from eye to screen?





The Rendering Equation [Kajiya 86]

global illumination idea:

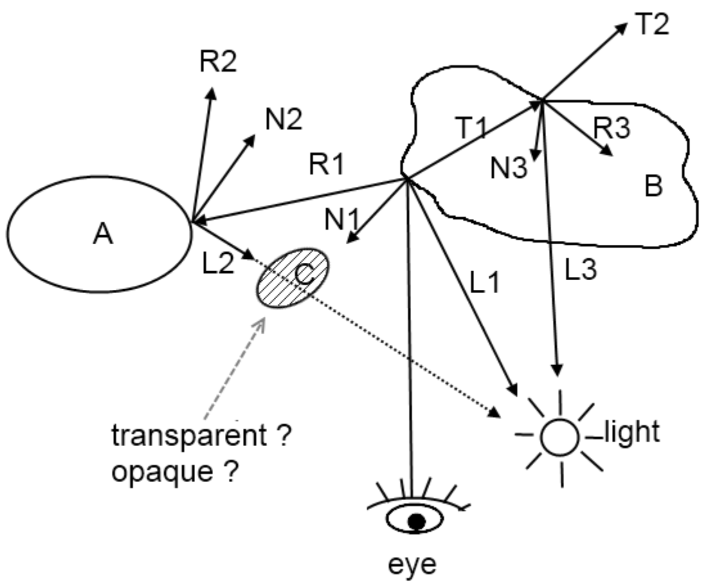


$$I(x,x') = g(x,x')\left[e(x,x') + \int_S \rho(x,x',x'')I(x',x'')dx''\right]$$

where

I(x,x'):	intensity passing from x' to x
e(x,x'):	emitted light intensity from x' to x
p(x,x',x"):	intensity of light reflected from x" to x from the surface at x'
g(x,x'):	$\begin{cases} 0 \text{ if X' is invisible from x} \\ {}^{1}/_{r^2} \text{ if visible} \end{cases}$

A simple recursive ray tracing



Li: Shadow Ray

Ri: Reflected Ray

Ni: Normal

Ti: Transmitted Ray

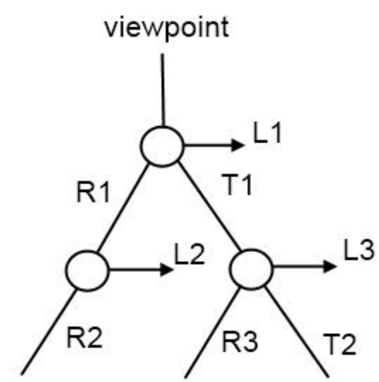
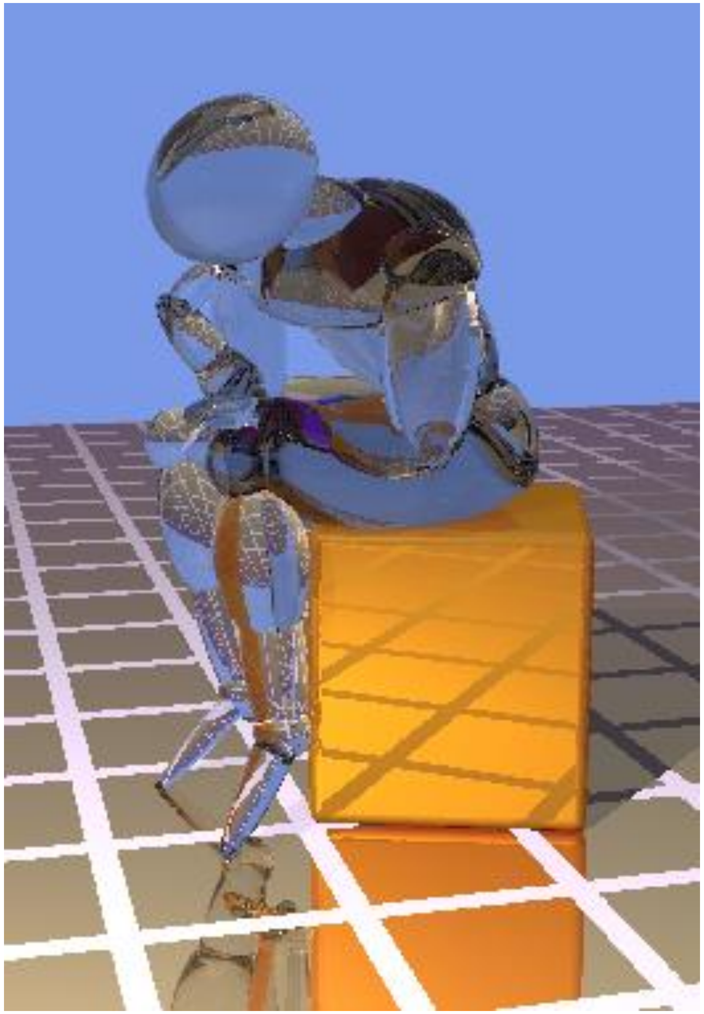
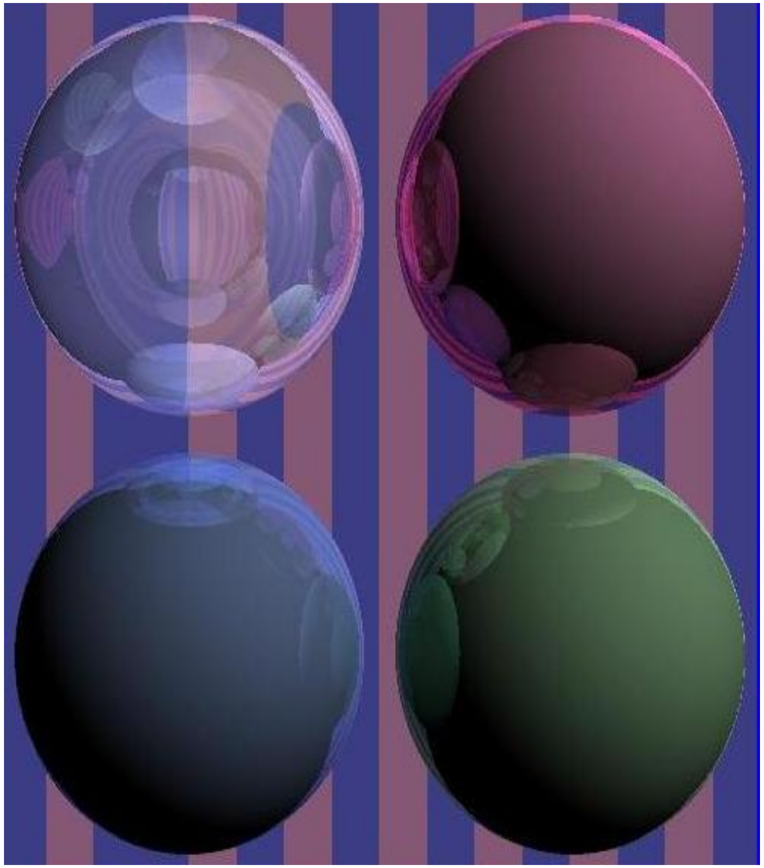


Fig 16.55 A ray tree

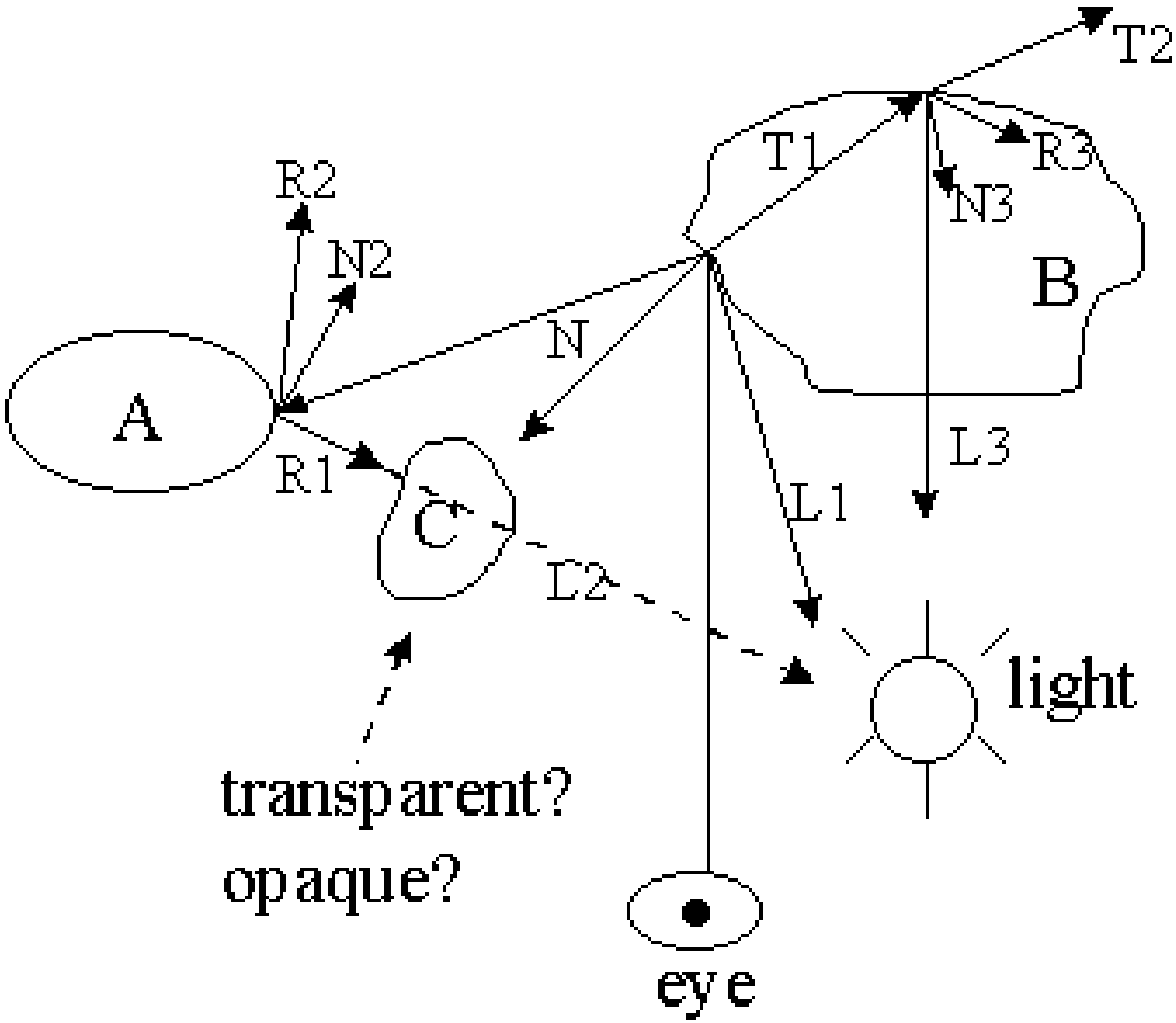
Whether

1) L1 = R1 + T1 ? or
2) f(L1) = f(R1) + f(T1) ? or
3) Color = f(L1,R1,T1) ?





Ray tracing(1)



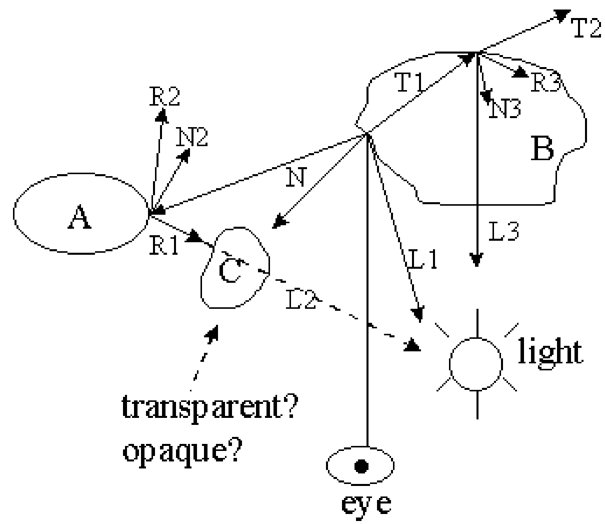
Simple recursive ray tracing

L_i: shadow ray

R_i: reflected ray

N_i: normal

T_i: transmitted ray



whether

1. $L_1=R_1+T_1$? or
2. $f^1(L_1)=f(R_1)+f(T_1)$? or
3. Color=$f(L_1,R_1,T_1$

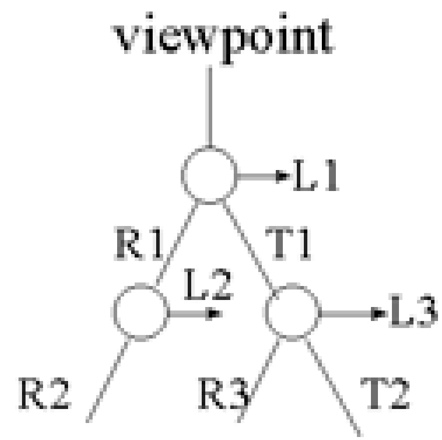
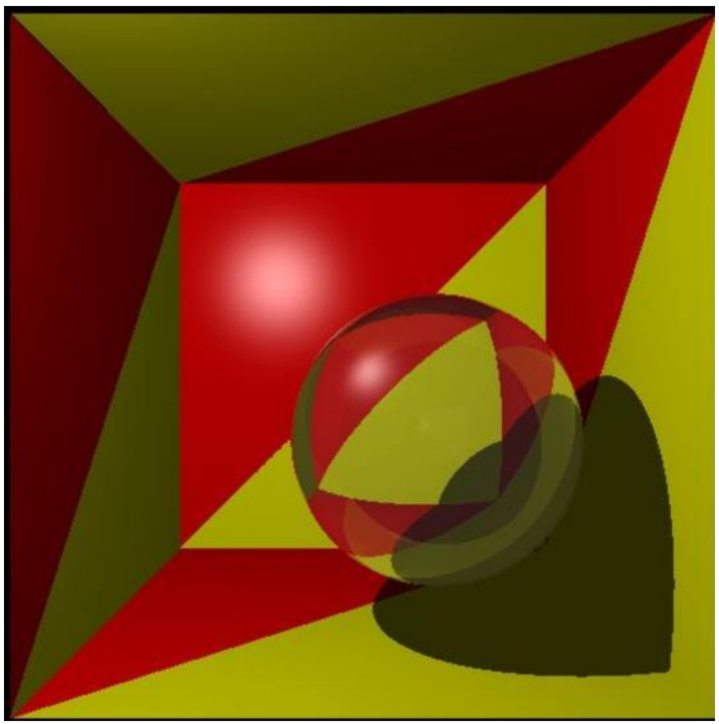
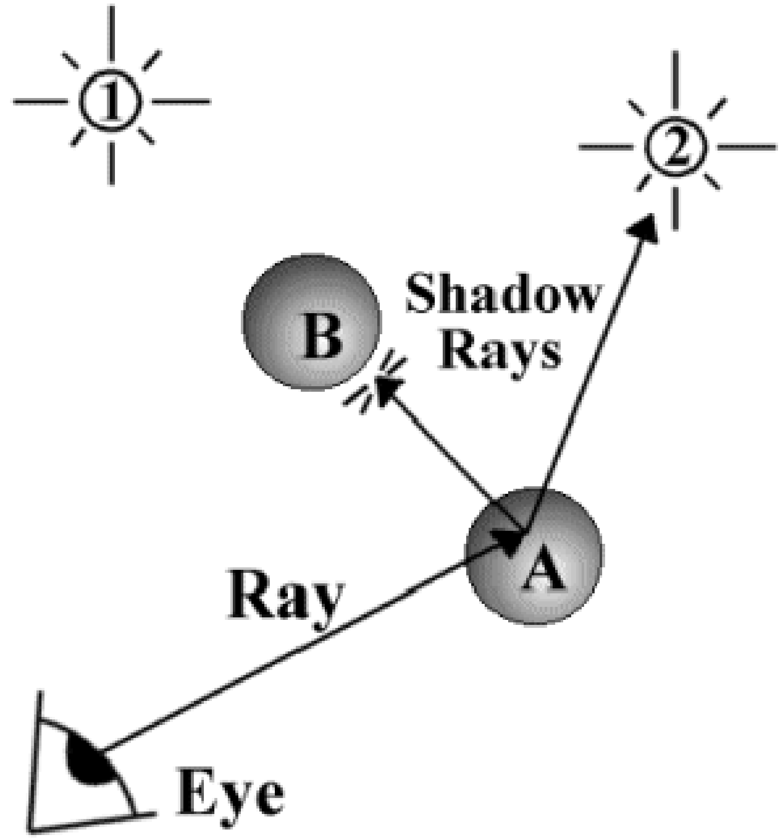


fig 16.55 Aray tree

Shadow in ray tracing

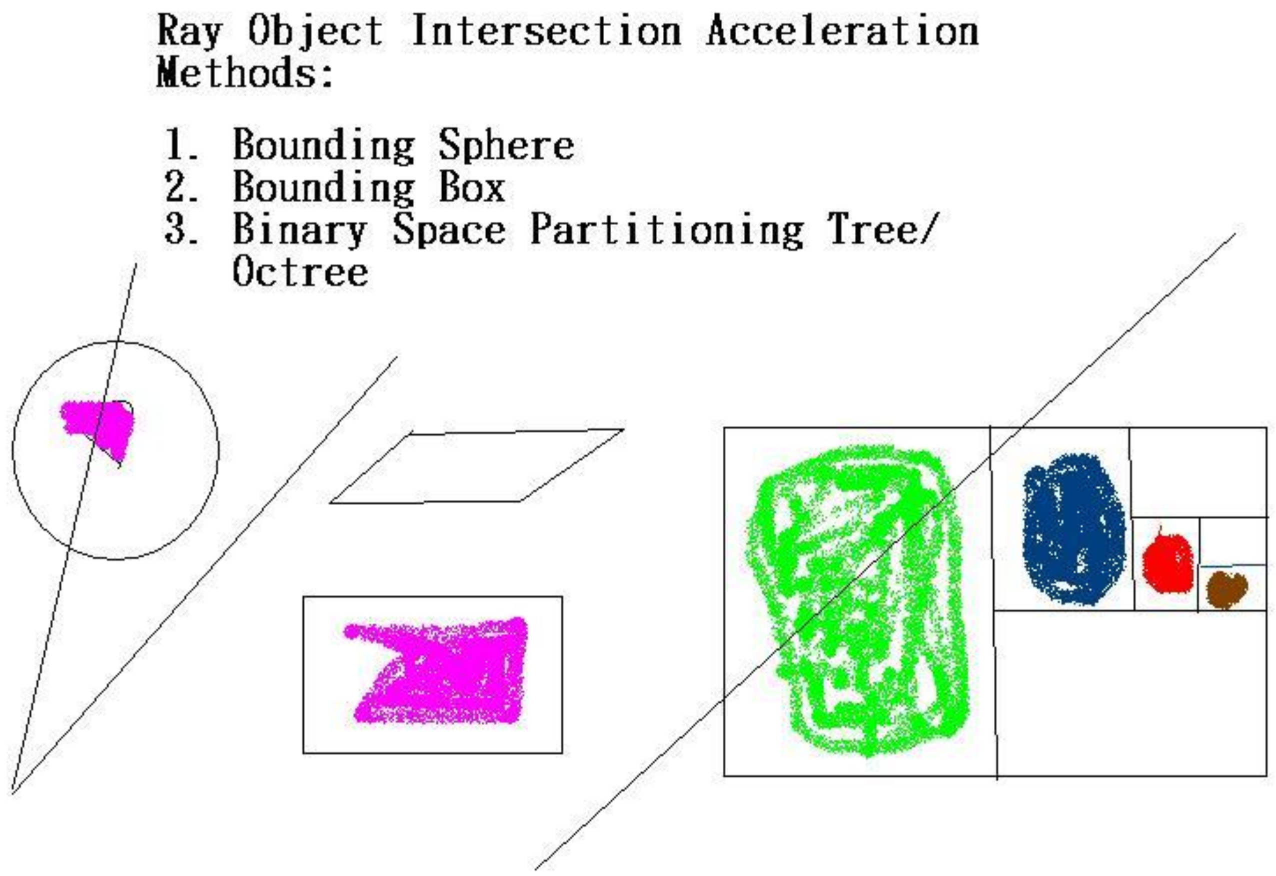




Ray Tracing Algorithm

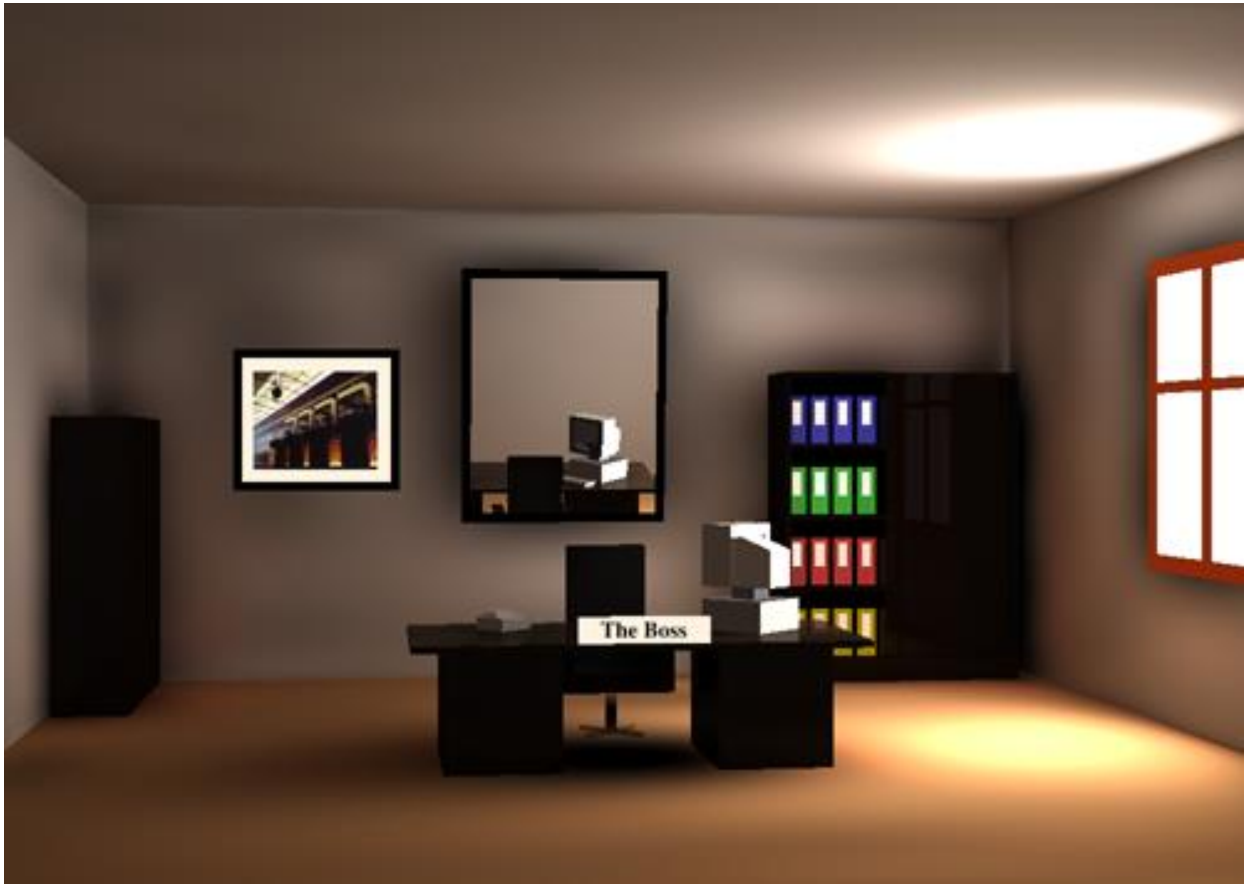
```
Trace(ray)
    For each object in scene
        Intersect(ray, object)

    If no intersections
        return BackgroundColor

    For each light
        For each object in scene
            Intersect(ShadowRay, object)
            Accumulate local illumination
            Trace(ReflectionRay)
            Trace(TransmissionRay)
            Accumulate global illumination
```

Ray-object intersection acceleration



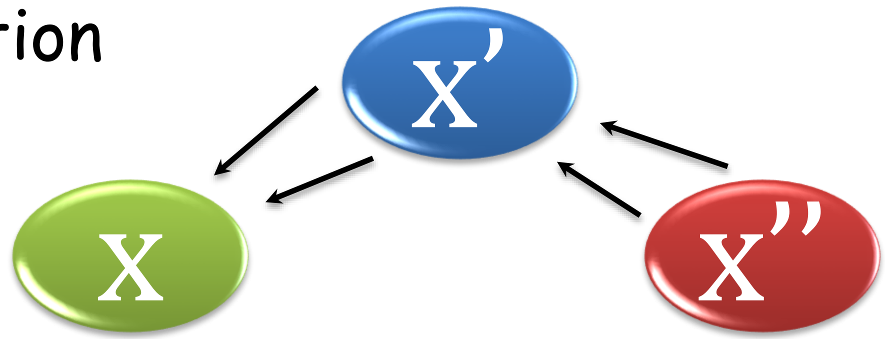
What is still missing in ray-traced images?

- Diffuse to diffuse reflection?



The Rendering Equation [Kajiya 86]

global illumination idea:



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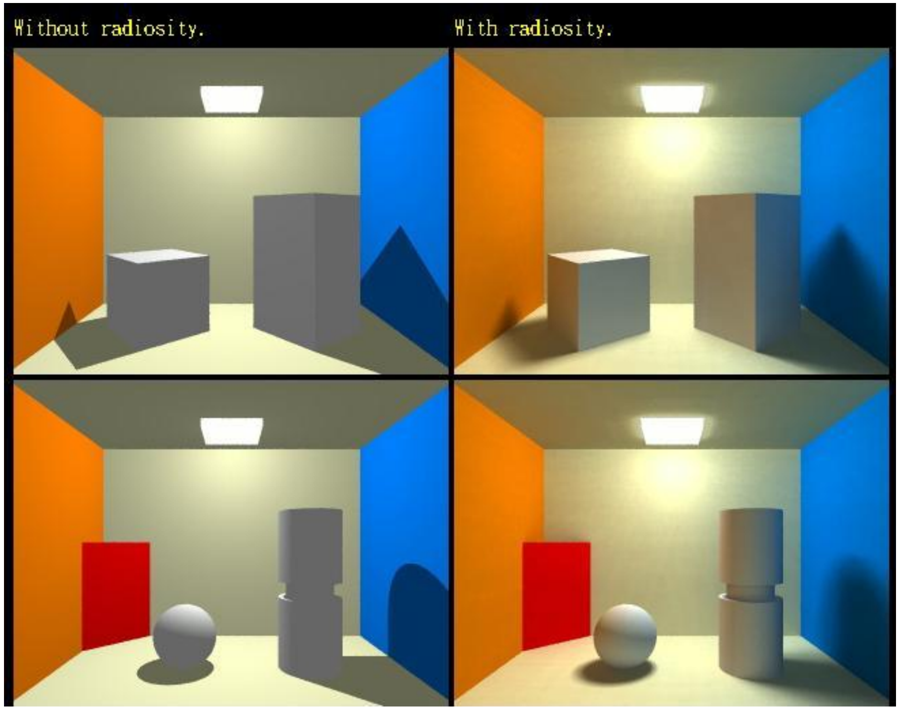
where

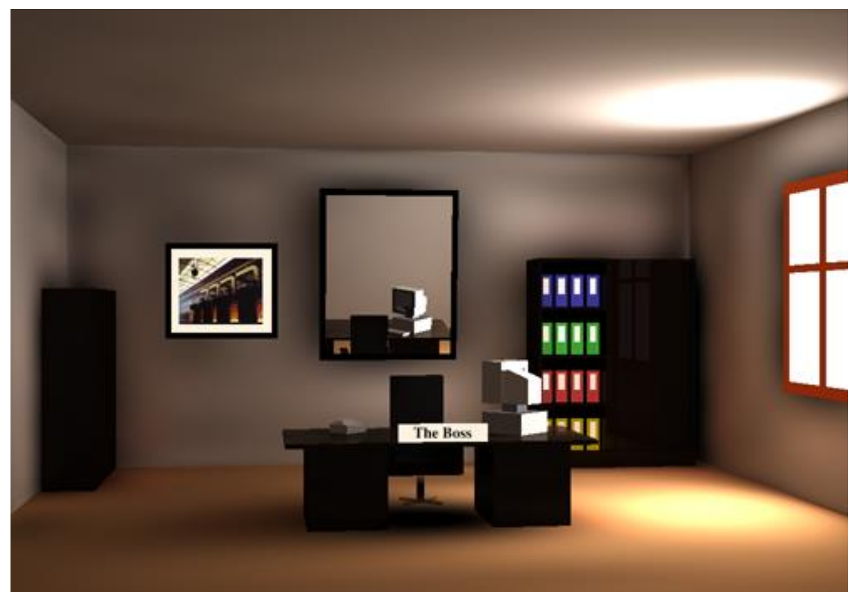
- I(x,x'): intensity passing from x' to x
- e(x,x'): emitted light intensity from x' to x
- p(x,x',x"): intensity of light reflected from x" to x from the surface at x'
- g(x,x'): $\begin{cases} 0 \text{ if X' is invisible from x} \\ {}^{1}/_{r^2} \text{ if visible} \end{cases}$

Radiosity (熱輻射法)

Donald Greenberg and Tomoyuki Nishita

Radiosity: Cornell Box, the first that passed Turing test.




The Boss

Radiosity Methods

1) Equation

$$B_i = E_i + \rho_i \sum_{j=1}^{n} B_j F_{j,i} \frac{A_j}{A_i} \quad or \quad B_i A_i = E_i A_i + \rho_i \sum_{j=1}^{n} B_j F_{j,i} A_j$$

(Energy Balance)

where

B_i , B_j: the radiosity of patches i and j

E_i: the rate at which light is emitted from patch i

P_i: patch i's reflectivity

F_{ji}: formfactor (configuration factor) , which specifies the fraction of energy leaving the patch j that arrives at patch i

A_i, A_j : areas of patch i and j

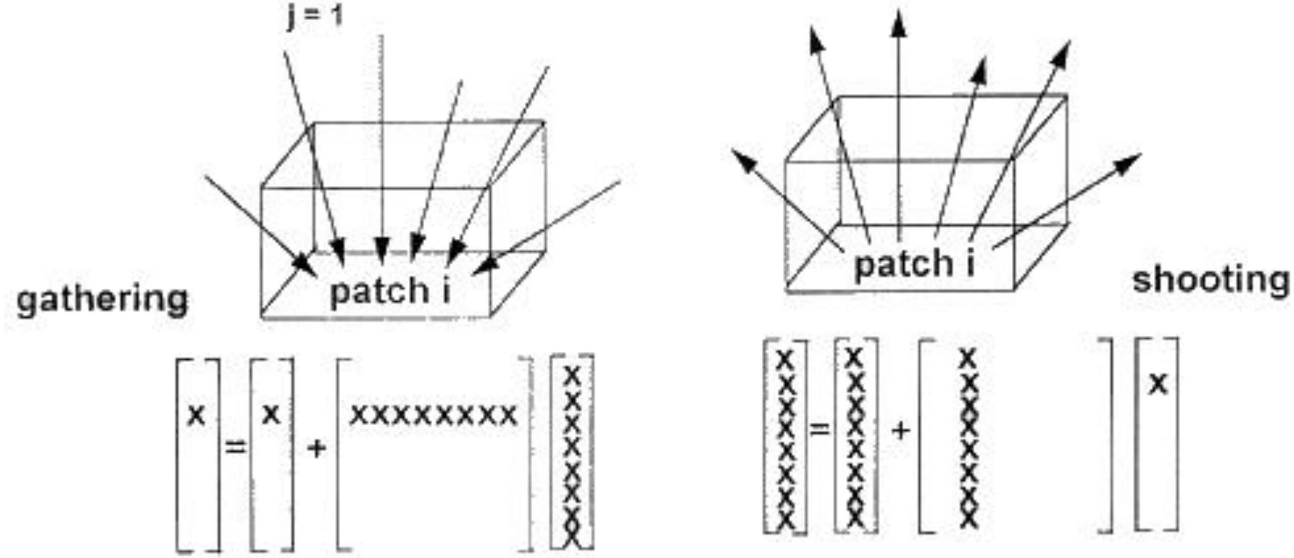
2) $\mathrm{A_i F_{i,j} = A_j F_{j,i}}$

3) Simplified equation from (1) $B_i = E_i + P_i \sum_{j=1}^{n} B_j F_{i,j}$

2.1 Gathering vs. shooting

Reconsider the equation

$$B_i = E_i + \rho_i \sum_{j=1}^{n} B_j F_{ij}$$, we can find B_i due to $B_j = \rho_i B_j F_{ij}$

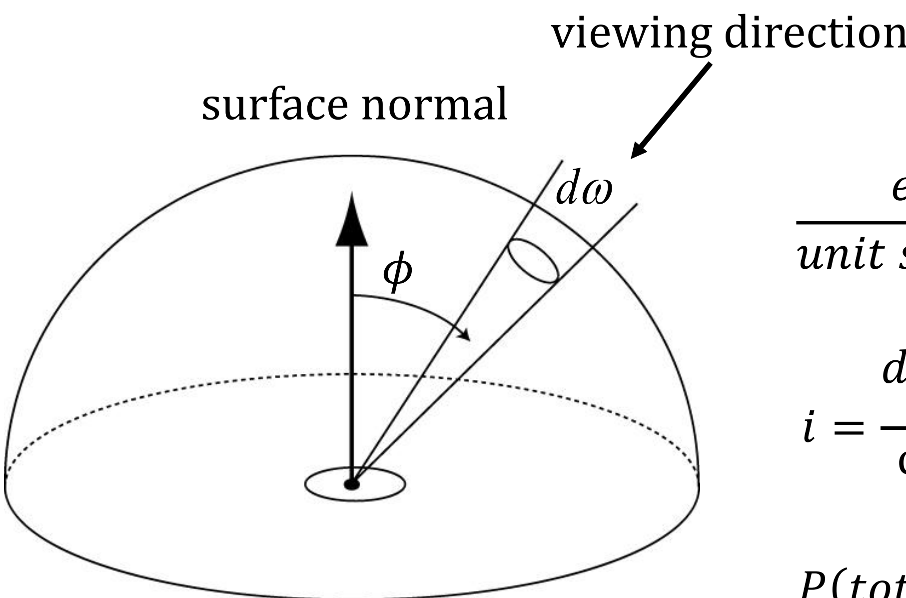


$$B_i = E_i + \sum_{j=1}^{n} (\rho_i F_{ij}) B_j$$

for all j :

$$B_j = B_j + \Delta B_i(\rho_j F_{ji})$$

1.2 Form-factor



$$\frac{energy}{unit\ solid\ angle} = \frac{dP}{d\omega} = k\cos\phi \ldots (1)$$

$$i = \frac{dP/d\omega}{\cos\phi} = \frac{k\cos\phi}{\cos\phi} = k \ldots (2)$$

$$P(total\ energy) = \int_{2\pi} dP = \int_{2\pi} i\cos\phi\, d\omega \ldots (3)$$

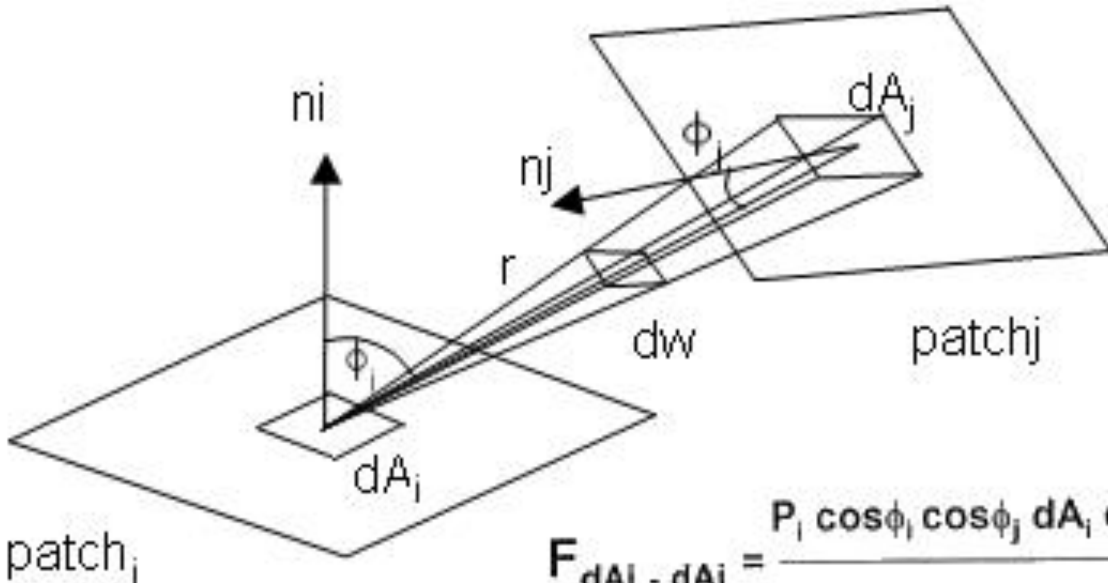
Where,

i = intensity in a viewing direction ($^{watt}/_{meter^2 \cdot unit\ solid\ angle}$)

dP = the energy in the direction within a solid angle ($^{watt}/_{meter^2}$)

ϕ = polar angle measured from the surface normal to the viewing direction

$d\omega$ = differential solid angle



$$F_{dAi-dAj} = \frac{P_i \cos\phi_i \cos\phi_j \, dA_i \, dA_j / \pi r^2}{P_i \, dA_i}$$

$$= \frac{\cos\phi_i \cos\phi_j \, dA_j}{\pi r^2}$$

$$d\omega = \frac{\cos\phi_j \, dA_j}{r^2}$$

then , by (1), (2)

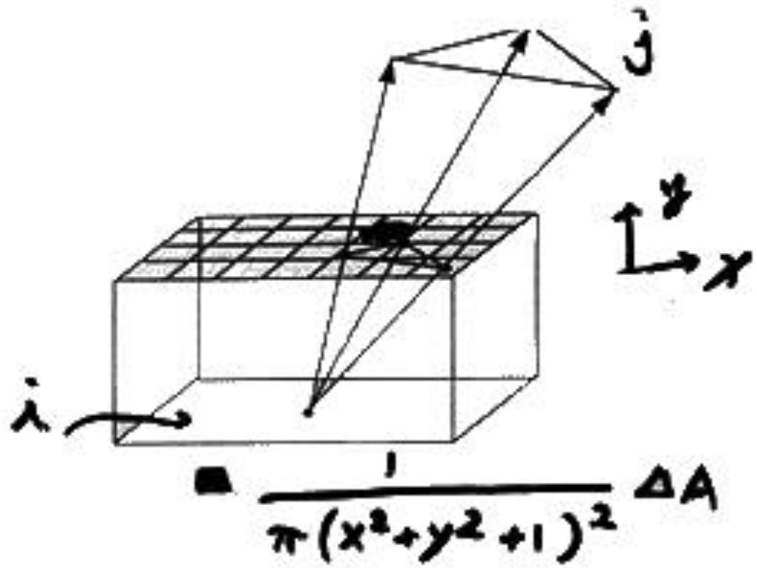
$$F_{dAi-Aj} = \int_{A_j} \frac{\cos\phi_i \cos\phi_j \, dA_j}{\pi r^2}$$

$$dP_i dA_i = i_i \cos\phi_i \, d\omega \, dA_i$$

$$= \frac{P_i \cos\phi_i \cos\phi_j \, dA_i \, dA_j}{\pi r^2}$$

$$F_{Ai-Aj} = F_{ij} = \frac{1}{A_i} \int_{A_i} \int_{A_j} \frac{\cos\phi_i \cos\phi_j dA_i \, dA_j}{\pi r^2} \quad \text{--- (4)}$$

2.3 Hemi-cube method



for each face do:

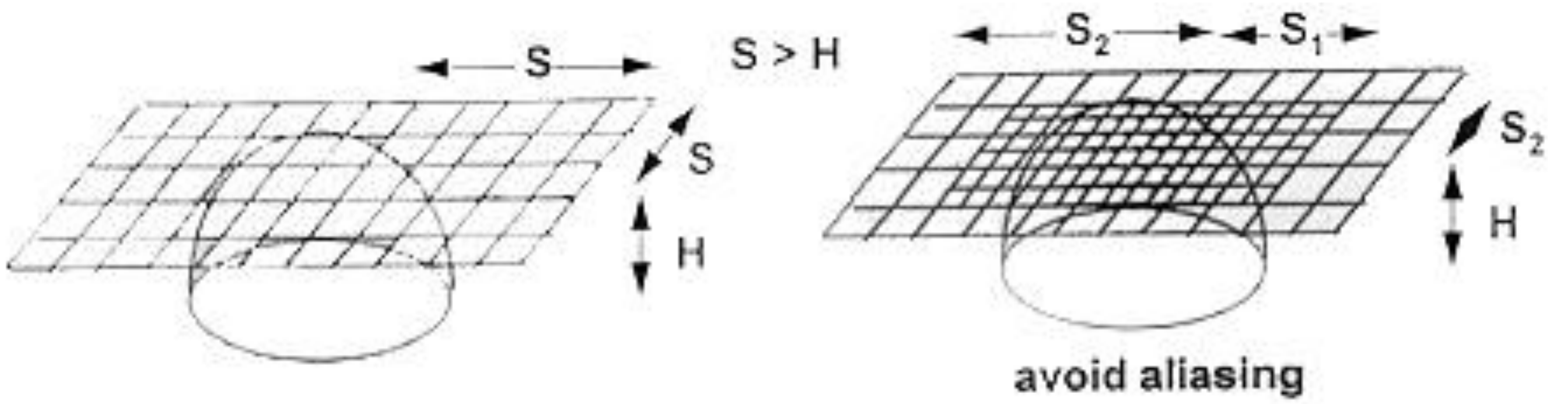
a. Transformation
b. Clipping
c. Scan conversion
d. Depth-buffering

2.4 Solving in sorted order

During each iteration, always find the patch which has maximal unshot energy.

Those concepts cause a progressive refinement algorithm.

3.1 Single plane algorithm:



3.2 modified hemi-cube algorithm:

When the lost energy (caused by single plane algorithm) accumulated exceeds its delta radiosity, it shots through the four sides beneath the plane. In effect, the lost energy becomes "delayed" energy.

rearranging terms

$$B_i - \mathrm{P}_i \sum_{j=1}^{n} B_j F_{i-j} = E_i$$

a set of simultaneous equations

$$\begin{bmatrix} 1-\rho_1 F_{1\text{-}1} & -\rho_1 F_{1\text{-}2} & \cdots & -\rho_1 F_{1\text{-}n} \\ -\rho_2 F_{2\text{-}1} & 1-\rho_2 F_{2\text{-}2} & \cdots & -\rho_2 F_{2\text{-}n} \\ \vdots & \vdots & & \vdots \\ -\rho_n F_{n\text{-}1} & -\rho_n F_{n\text{-}2} & \cdots & 1-\rho_n F_{n\text{-}n} \end{bmatrix} \begin{bmatrix} B_1 \\ B_2 \\ \vdots \\ B_n \end{bmatrix} = \begin{bmatrix} E_1 \\ E_2 \\ \vdots \\ E_n \end{bmatrix}$$

key: progressive Refinement [M. Cohen]

2.2 Shooting algorithm (iteration)

for each iteration, for each patch i

for each patch j:

calculate the formfactors Fij using hemi-cube at patch I

$\Delta Rad = \rho_j \Delta B_i F_{ij} A_i / A_j$

$\Delta B_j = \Delta B_j + \Delta Rad$ /*update change since last time patch j shot light */

$B_j = B_j + \Delta Rad$ /* update total radiosity of patch j */

$\Delta B_i = 0$ /* reset unshot radiosity for patch i to zero */

initialization:

for all patch i:

if patch i is a light source, then $B_i = \Delta B_i = E_i$, else $B_i = \Delta B_i = 0$

Result 1: Steel Mill with millions of polygons: Progressive refinement of radiosity

VR Chap 8 (1)

歐陽明　　教授
Ming Ouhyoung

Outline:

- Will VR Meet Your goals ?
- Is VR the Appropriate Medium ?
- What Makes an Application a Good Candidiate for VR?
- Creating a VR Application.
- Adapting from other Media.

Will VR Meet Your goals ?

- Safety
- Marketing
- Cost savings
- Profit

- Conveying ideas as artistic expression
- Improved ability to examine and explore 3D data
- Entertainment or escapism
- Improved quality of life

Is VR the Appropriate Medium?

- Moby Dick(or The Whale)

Citizen Kane

Directed by
Orson Welles

What Makes an Application a Good Candidiate for VR?

- A key component of VR : real time interface.
- VR relies on a 3-D environment, tasks that are inherently 1-D or 2-D are not likely take advantage of VR.
- The imprecision and lag in current tracking methods, as well as relatively slow computation, makes tasks that require a very close registration with the real world a difficult targets.

- Most VR devices are oriented toward visual and audio display. Because of this, there has been less work done applications for which haptic display.

- There are many problems for which the same benefits and problem solving capabilities of simulation can be extended to the medium of VR.

  - Problems that cannot be tackled in the physical world.
  - Problems that cannot be studied safely.
  - Problems that cannot be experimented with due to cost constraints.
  - Problems in “What if?” studies.

Creating a VR Application

- How ?
- Familiarize yourself with the medium of VR to the greatest extent feasible .
- VR experiences .
- VR hardware devices .
- You may derive your VR experience from three sources (1)another medium , (2) an existing VR application , (3) scratch .

Adapting from Other Media

- It often does not work to indiscriminately transfer content from old medium to VR:

  In transferring a book to a movie, a screenwriter adapts the narrative from the textual to the visual.
- VR is an inherently an interactive medium; therefore, the simple transference of content from sequential media makes little sense.

Virtual Reality Oral Present - Chapter 8 Part II

Ming Ouhyoung

Creating a VR Application

- Adapting from other Media
- Adapting from an Existing VR Experience
- Creating a New VR Experience

Adapting from an Existing VR Experience

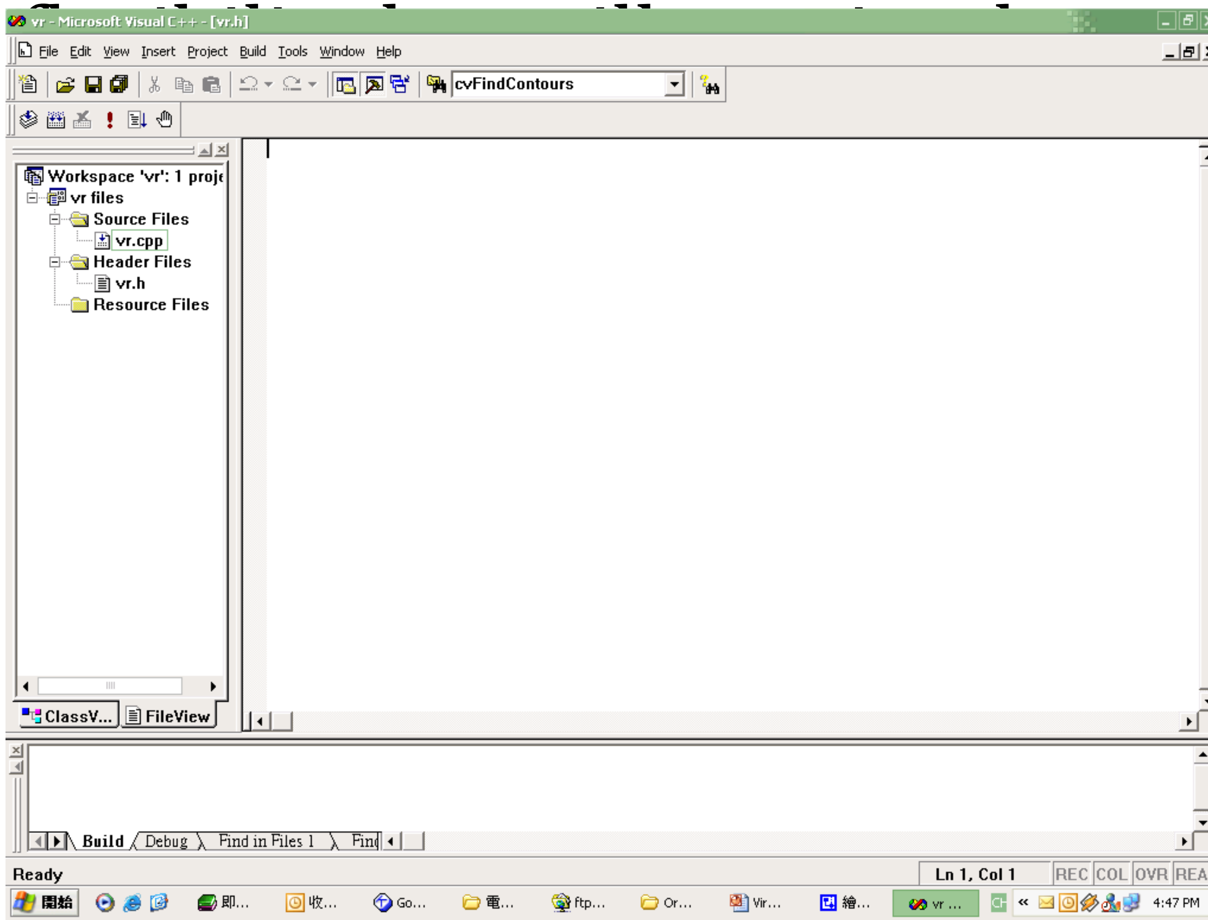
- Converting an existing VR application into one suitable for your needs

- Crumbs visualization application
  - Crumbs is a visualizing, exploring, and measuring features within volumetric data sets. (Appendix B)

Website : http://www.ncsa.uiuc.edu/VR/cavernus/CRUMBS/Crumbs.html

Creating a New VR Experience

- Creating an experience from scratch allows the most … st effort.

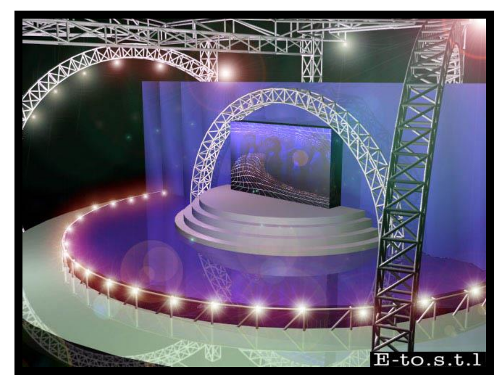


The Experience Creation Process

- There are courses of action by which one can reduce the amount of wasted effort.
- Many successful VR experiences and other computer applications have relied on user tests to hone the content and the interface.

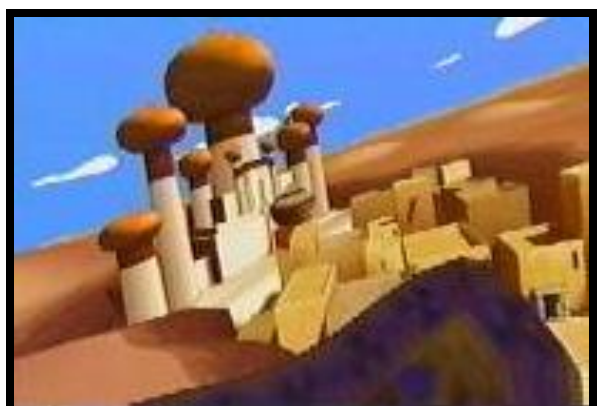
The Experience Creation Process

- Form your VR team - What people do you need?
  - Programmers
  - Content Experts
  - Set Designers
  - Prop Creators
    (theatrical property, the stage)
  - Sound Effect Experts
  - Hardware Engineers



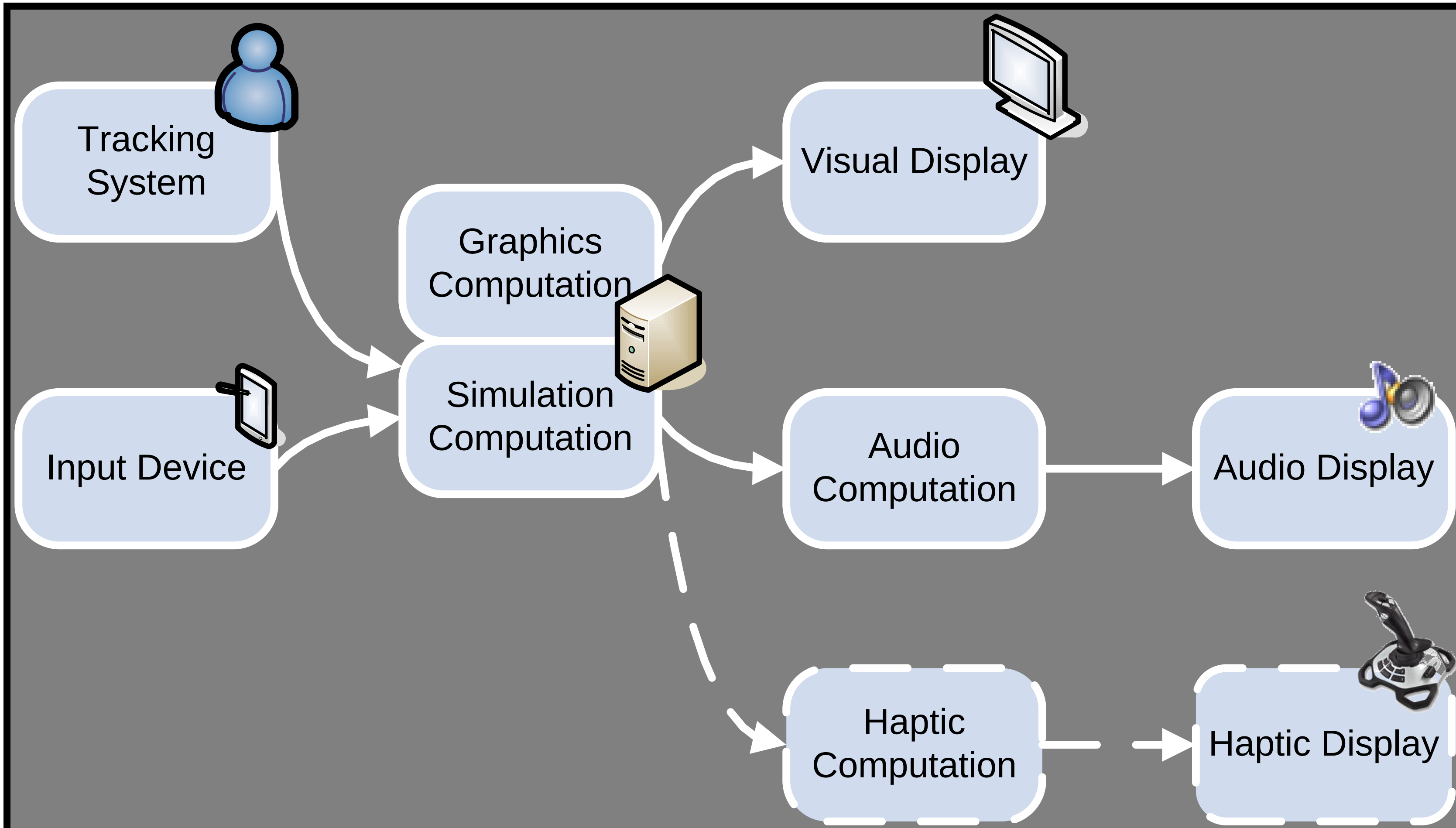
The Experience Creation Process

- It's generally wise to use a software system!!
  - More flexible
- Disney Aladdin VR experience
  - …evelopment language of Disney team



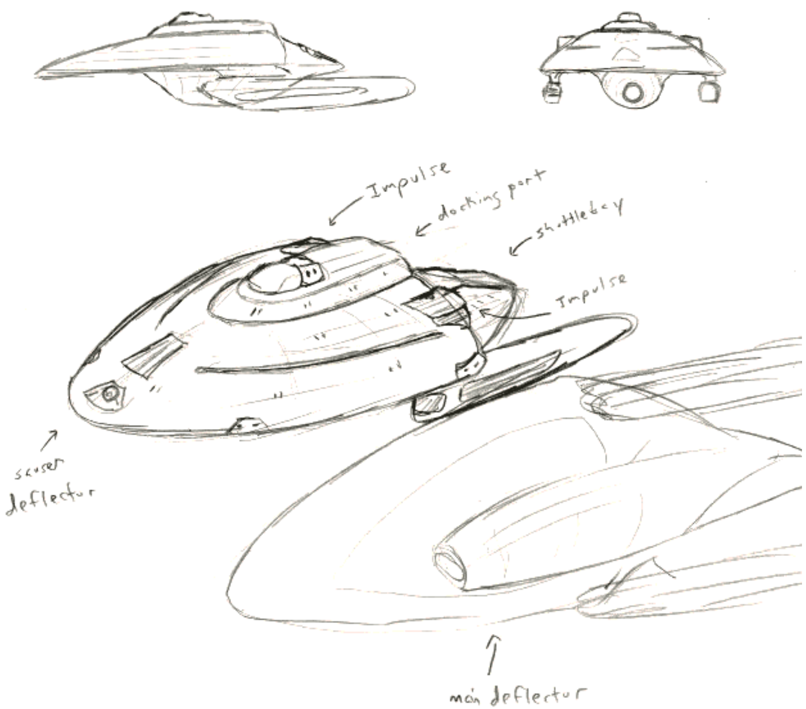
The Experience Creation Process

- A Typical VR system



Designing a VR Experience

- It's wise to approach the creation of a VR experience with good design practices.



Design Deliberately

- Customer Highest !!
  – Design to make things easier for the user, not the programmer.
- Looking from the top down
  – Design a VR experience should be constructed looking from the global view toward the goal.
- Don’t Just keep a particular feature. If the feature doesn’t live up for the user’s experience, then it isn’t worth keeping.
- Don’t forget the special features in VR
  – Virtual Reality has more options than day to day reality.

Design with the System in Mind

- Use an existing system, or make from scratch ?
- If your project will continued for a considerable amount of time,
  - You can take advantage of the fact that technology is getting improved.
- If your project will involve large hardware
  - You may convince your hardware manufacturer to let you test out the next generation of their product.

Design with the Venue in Mind

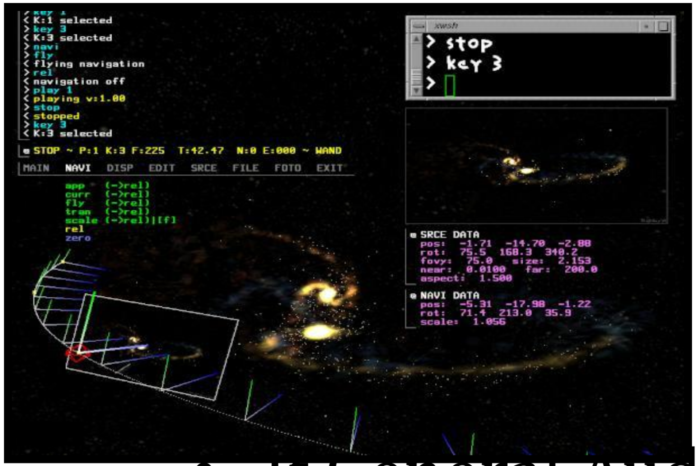
- If a venue with limited space
  - Likely require a HBD (head –based) or HMD (head-mounted display)
- If the venue is theater-style
  - High-resolution projection-based display

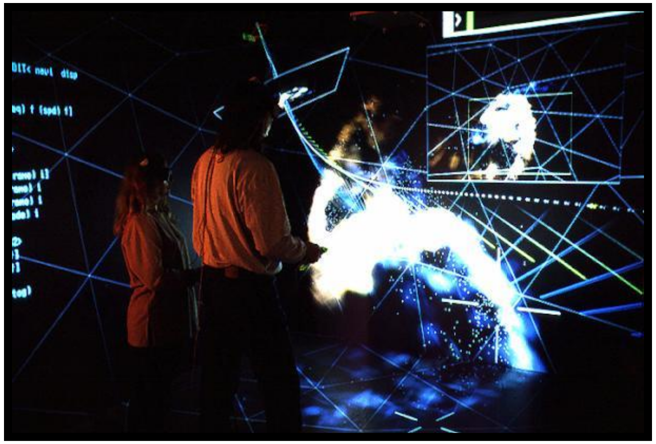
large that participa

e HBD or hand-based

Design with the Audience in Mind

- Know your audience is the most important tenet a designer should remember.
- NCSA's Virtual Director application is a VR tool using widely for computer animation





- If General Audience
  - Avoid language-based messages
  - Choose internationally recognizable sounds and symbols

Design with the Audience in Mind

- AGE : If user is child
  – Head-based displays and shutter glasses may slip off
- EXPERIENCE :
  – Children - Easy
  – Adults – Car-like steering interface
  – Videogame players – Complicated handler
- CULTURE :
  – Virtual VR arcade system was being deployed in the Middle East, they discovered that most men wore a headdress, they could not don the standard HMD

Experience Design:
Applying VR to a Problem (III)

Ming Ouyoung

Outline

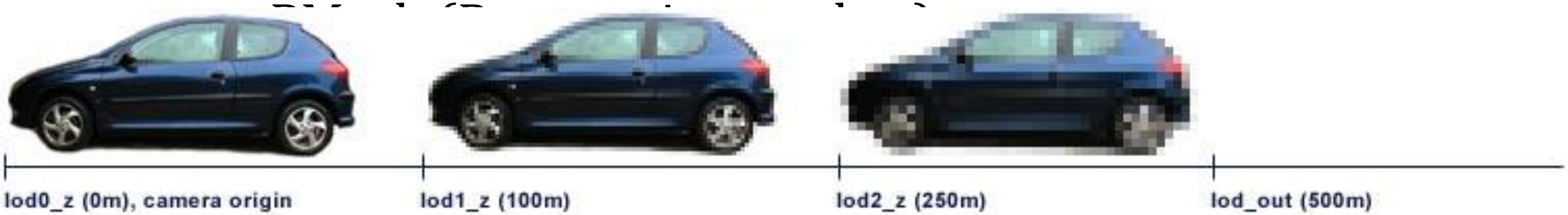
- Consider Design Tradeoffs
- Design the User Objective
- Design the End of the Experience
- Document, Deploy, and Evaluate the Experience
- The Future of VR Design

Consider Design Tradeoffs

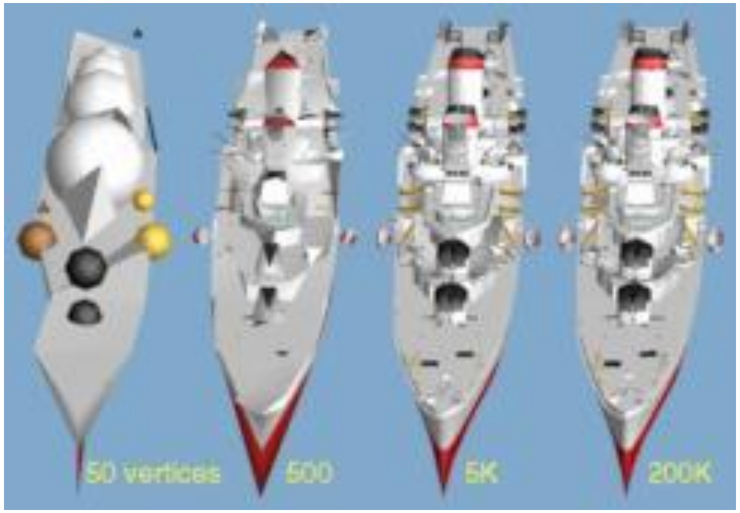
- Between ***world complexity*** and ***expense required for high computer performance***.
  - World complexity affects *how the designers choose* to represent the world.
  - Ex. A representation using *highly complex rendering techniques* may be totally inappropriate for a system *with less graphical rendering power*.

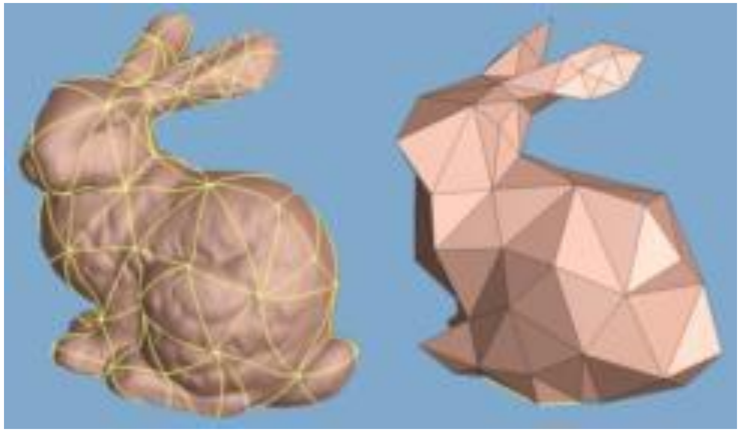
Consider Design Tradeoffs

- Between the ***complexity of interaction*** in the world and the ***narrative***.
  - <u>*Limiting*</u> the path of travel
  - Only concern with the world near the user's path.
    - LOD (Level of Details)



Consider Design Tradeoffs





Hugues Hoppe
http://research.microsoft.com/~hoppe/

Consider Design Tradeoffs

- Allow the user *full freedom to move* but keep them *within certain regions*, through ***constraints*** other than limiting path.
  - Flight simulation: designers can keep you in a certain space by ensuring that *if you go outside of that space you will be shot down*.
  - Aladdin's Magic Carpet Ride: by creating regions of the world where the user doesn't go because they're *uninteresting or impassable*.

Consider Design Tradeoffs

Aladdin's Magic Carpet Ride

Original imagery was antialiased 640x480 at 60HZ.
These images are from a very lossy quicktime video.

http://www.realityprime.com/disney.htm
http://vr-atlantis.com/lbe_guide/lbe_pictures.html

Consider Design Tradeoffs

- Controlling the narrative, directing the user's experience
  - Constraining travel
  - Apply more creation and rendering resources, that are *particularly interesting* to participants, *in detail*.

Consider Design Tradeoffs

- The most effective presentation is not always the most complex.
- Kathryn Best: “The answer is not to simplify everything, but to emphasize certain features and let the brain fill in the rest.”

Design the User Objective

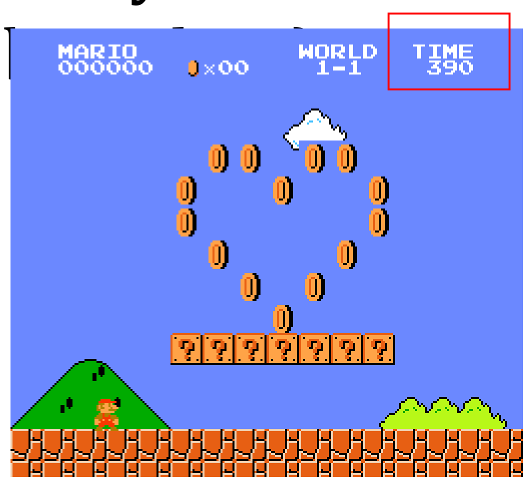
- Type and amount of user interface depends on the objective.
- For applications in which the user must be able to manipulate objects, the interface becomes more complicated.
- The more complicated the interactions and the interface, the more user testing must be done – another tradeoff.

Design the End of the Experience

- *Open ended*: user in the virtual world for an indefinite amount of time.
- *Concrete ended*: definite close.
- Neither open ended nor fixed experiences require a participant to be immersed uninterrupted for the entire duration.
- Many VR applications allow the participant to return later and pick up where they left off.

Design the End of the Experience

- Three ways a quintessential(classical) non-perpetual experience may end:
  - Time expiration (ex. 5 minutes are up)
  - Terminal event (final ball drops)
  - Early user termination (user leaves from



Design the End of the Experience

- The first two publicly exhibited *Alladdin* experiences lasted 5 minutes:
  - tried to accomplish a *specific goal* to *win* the game.
  - extra time was not given to allow the participant a chance to just explore the world.
- Ford Galaxy VR experience
  - Fixed-length narrative with a complete story (begin, middle, and end).

Design the End of the Experience

- Open ended experiences
  - Formal ending: strong narrative, lengthy, eventually do come to a conclusion.
    - Novel, text adventure (interactive fiction), role-playing games.
  - Legend Quest game
    - Open ended
    - Saving and restoring the state of experience.

Design the End of the Experience

- **Denouement (ending)**
  - For story or story-oriented experiences, ends are bound up. It is up to content creator.
  - For exploratory application, it is up to the participant to figure out.

Document, Deploy, and Evaluate the Experience

- During development, some *documentation* will likely be available as the VR experience is *readied for deployment*.
- Monitor the user's proficiency
  - Provide subtle hints
  - Nudge users along in the right direction

Document, Deploy, and Evaluate the Experience

- The installation effort and amount of personnel training depend heavily on:
  - the type of environment
  - whether it is an existing VR facility.
- Any system deployed offsite in a public venue should have easily interchangeable spare units for the most fragile and vulnerable components.

Document, Deploy, and Evaluate the Experience

- What is a good measure of success?
  - Was the goal attained? -> hard to measure.
  - More concrete measuring stick, such as profit made or money saved, time saved, or increased test scores.
  - Whether people did gain new understanding of a concept.
  - Mentally immersed
  - Performing better on the job because of the experience.

The Future of VR Design

- We are still in the embryonic (萌芽期) stage of the medium.
- VR continues to develop and shows promise as a medium capable of impacting the way we communicate, think, do business, and learn.

The Future of VR Design

- Developments
  - Grow acceptance and familiarity of VR
  - Have a basic knowledge of what to do in a new VR application.
  - The technologies that VR is built on will continue to improve.
  - Facilitating a collaborative VR work environment.

The Future of VR Design

- Move from specialized, custom-built application toward mass distribution.
- Predesigned VR applications for scientific visualization and architectural walkthroughs.
- VR tools to help design VR experiences.
- Computers may come “VR ready.”
- People will be interested in exploring the possible benefits of applying VR to their endeavors.
- VR will be used in many new arenas.

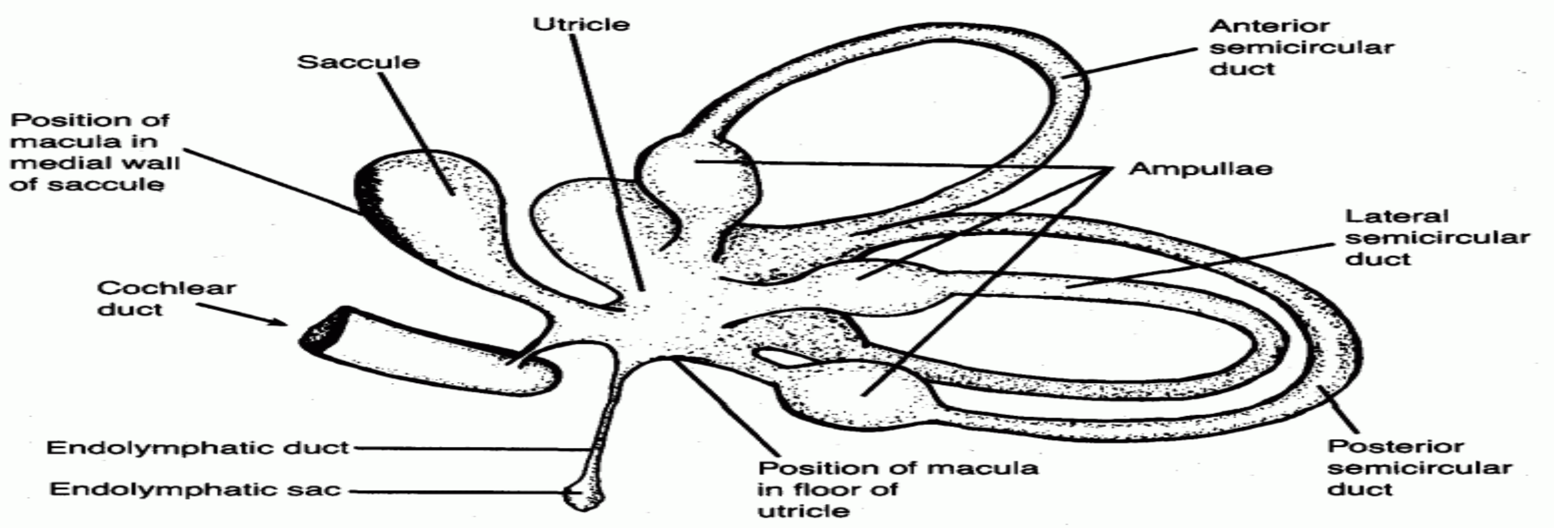
Human Factors

- Visual acuity: eye's ability to distinguish two points of light is limited to 1.5 – 2.0 mm at a distance of 10 meters. (or 2 microns on the retina)
- Sound: at 0 degree Celsius, travels at 331 meters per second
- Hearing range for a young healthy person, 20Hz to 20KHz
- Tactile: (receptors, Pacinian corpuscles) respond to frequencies 30-700Hz

  PS: 感覺神經末梢一種層狀囊包

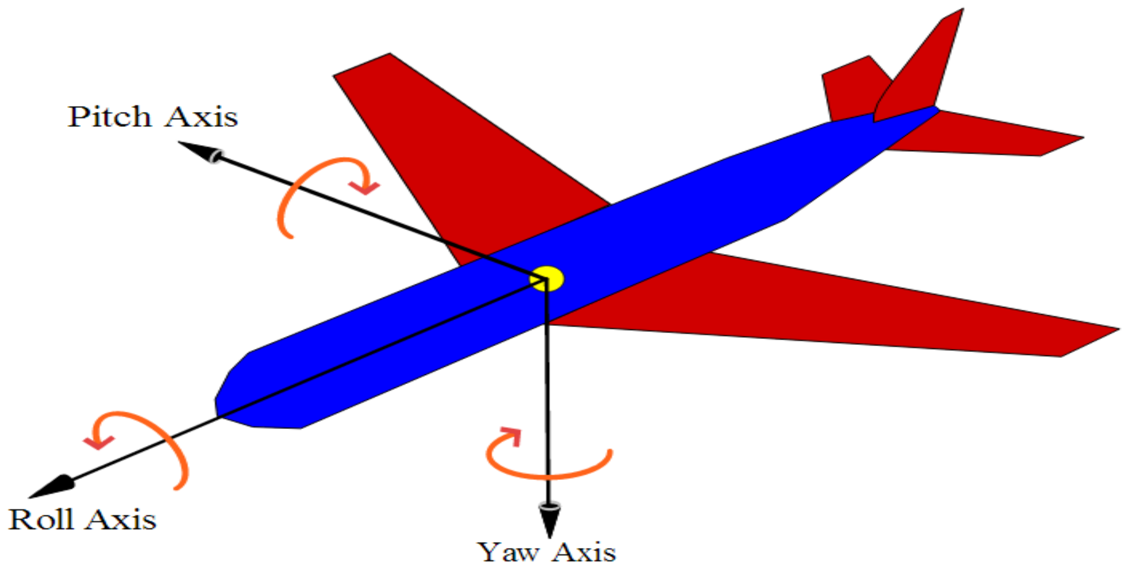
Human factors part 2

- Sensing equilibrium and head rotation: (human ears) the semicircular ducts (半規管) are sensitive enough to detect angular acceleration of 1 degree per second squared.



The vestibular labyrinth

- The semicircular ducts provide sensory input for experiences of rotary movements. They are oriented along the pitch, roll, and yaw axes.



Short questions

- (a) Is a typical RPG (role playing game) game considered VR technology? Why and why not?
- (b) What is motion parallax? How to estimate the thickness of a brick if front of us, if we have only one good eye and the other eye is blind?
- (c) Please describe three cases where it is easy to cause "motion sickness", why?
-

Motion sickness

- In boat rides
- Driving in mountain roads
- Inconsistent sensing of eyes and ears (semi-circular ducts), and one is fixed while the other one is moving.

Virtual Reality TERM PROJECT LISTING

Pure VR oriented:

1. A 3D sound Synthesizer
2. An optical tracker (church's algorithm)
3. Virtual objects (molecules, etc.) manipulation
4. A force feedback application
5. Virtual design (house construction, interior design, lighting simulation etc.)
6. Choose your own projects: Human Computer Interfaces, Installation Arts, Games, etc.

VR Term Project (II): graphics oriented:

1. Animation of articulated figures (linked)
2. Rigid body animation (Newton's laws)
3. Ray tracing or Radiosity method for a room / many objects with different materials
4. *Volume rendering for a set of tomography slides (Data set from National Taiwan University Memorial Hospital etc.)
5. Sketch system for animation (Teddy system)
6. Oil painting and water color effects for images
7. 3D morphing and animation with skeleton mapping

VR Term Project (III)

8. Motion retargeting (motion of cats likes that of a human)
9. Hardware GPU/GPGPU acceleration research and applications
10. Beautifying Images (Color harmonization, face beautification)
11. Water Rendering, mud simulation

Final project schedules

- 1. Final project demo: June 16
  Final report (7 – 15 pages, report format)
  Deadline: June 17 5:00pm

- 2. Oral presentation (paper): 5 minutes/per person
  scored by all participating students!
  Date 1: June 26,
  Date 2: June 9