平面顯示技術概論

前瞻3D顯示技術

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大綱

- 歷史回顧
- 立體視覺原理
- 世界主要技術簡介
- 3D顯示技術應用領域
- 3D Display Researches in ITRI/OES

顯示器趨勢


人有雙眼
視差
人眼有10⁹個視
覺細胞
人眼有色彩感測
細胞
3D
Natural
Vision
HDTV
Color
Audio has been "3D"ed

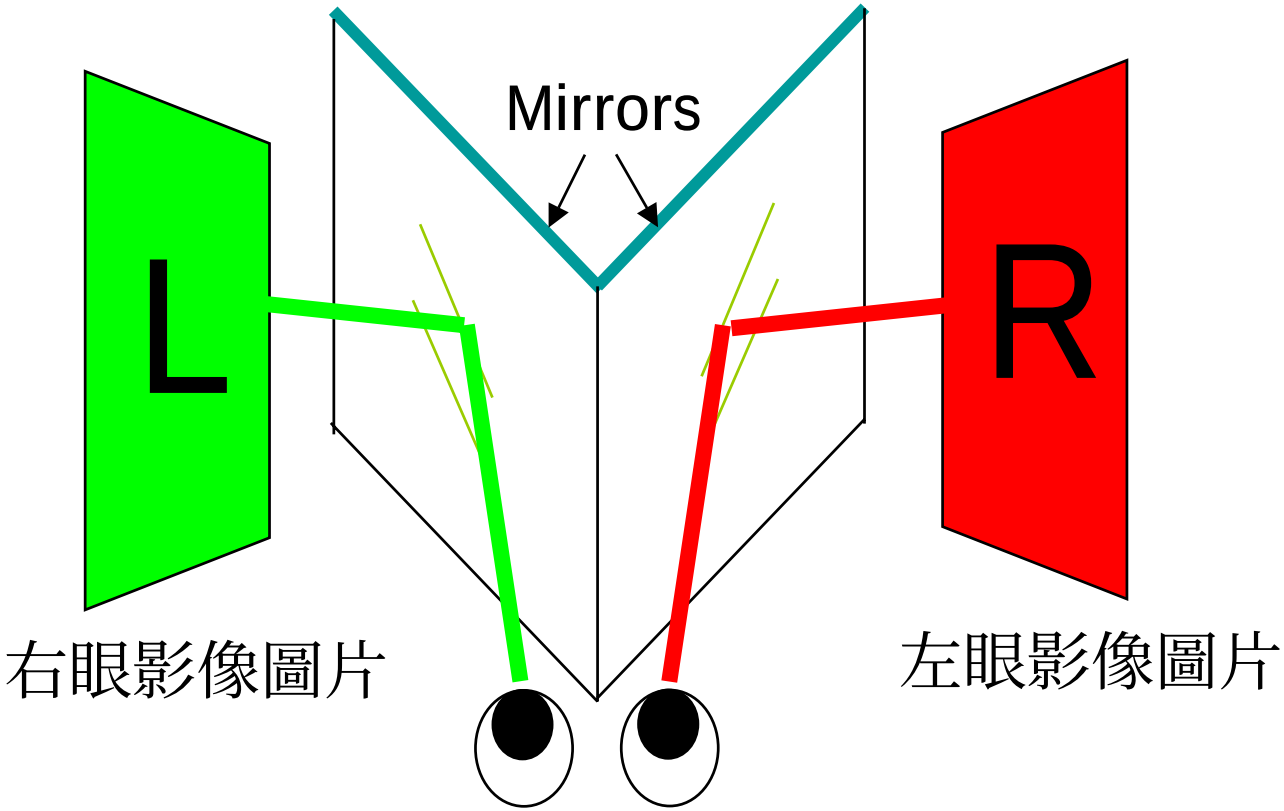
歷史回顧--日本電視發展沿革

1953	黑白電視放送開始(B/W TV broadcasting started)	
1960	彩色電視放送開始(color TV broadcasting started)	映像彩色化
1982	立體音響電視放送(stereo audio broadcasting started)	音響立體化
1986	29 inch 大畫面 (large screen)	畫面擴大化
1989	衛星放送開始(satellite TV broadcasting started)	高畫質、高音質化
1989	Hi-Vision 實驗放送開始(Hi-Vision experimental broadcasting started)	畫質高密度化
1989	LCD 投影系統販賣開始(LCD projection system started to sell)	超大型畫面化
1991	超廣角電視販賣開始(super wide view-angle TV started to sell)	畫面廣角化
1994	立體視電視販賣開始(stereo TV started to sell)	畫面立體化
2001	NHK 發表網路立體影像傳輸技術 (NHK announced the stereo images transmission technology)	

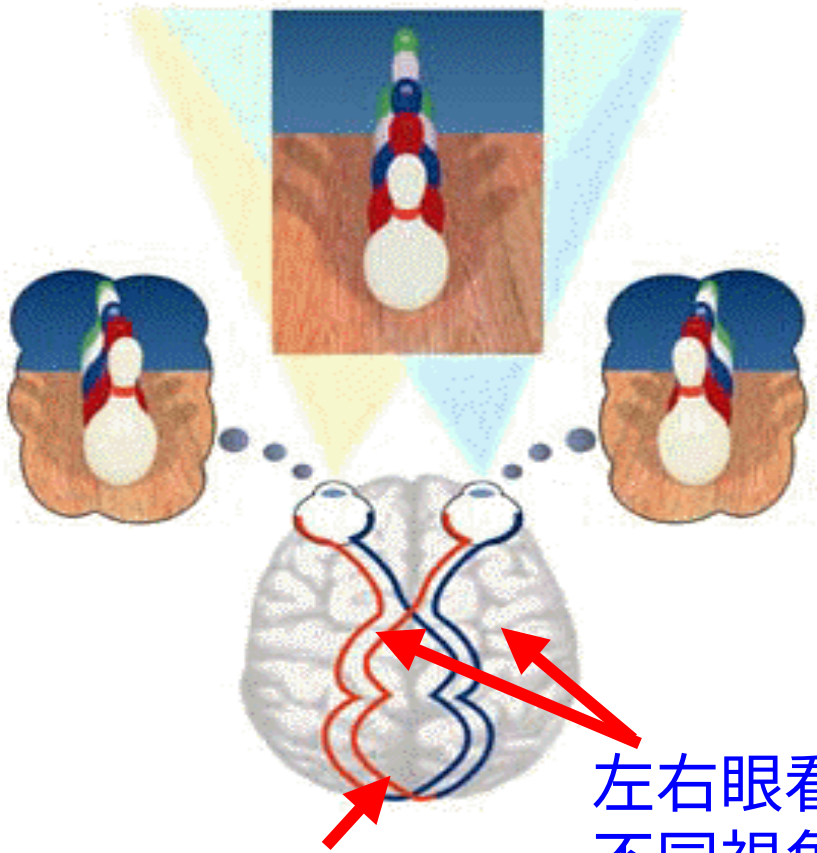
3D 顯示器的發展

- 1830s —Mirror Stereoscope Viewer, by Wheatstone
- 1850s —紅藍眼鏡立體影片,by D’Almeida
- 1920s —Shutter式立體影片,by Hammond
- 1936 —MGM推出紅藍眼鏡商業電影
- 1939 —偏極眼鏡立體影片, by Chrystler Co.
- 1990s —裸眼式立體顯示器萌芽
- 2003 —日本Sharp推出3D量產商品

Wheatstone's Mirror Stereoscope Viewer(1835)



3D 視覺機制



左右眼看到不同視角影像

大腦融合成具深度資訊的3D影像

3D 顯示需求

左眼看到左眼影像
右眼看到右眼影像

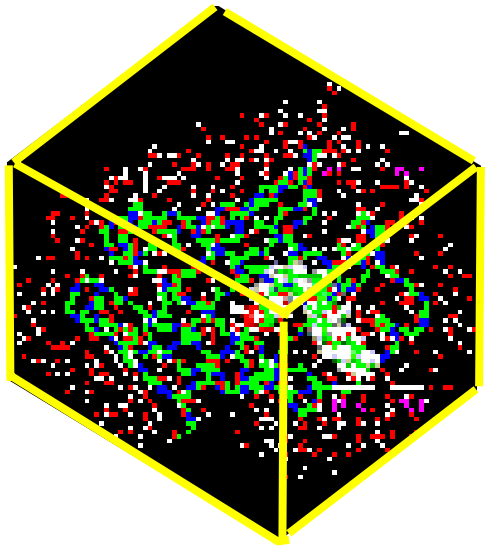
立體視覺實驗

- 將您的鼻尖對準下圖的眼睛圖案。
- 調整眼睛焦距使眼睛圖案清晰顯示。
- 在您的鼻子前面約 25 公分處豎起大拇指。
- 繼續將眼睛聚焦在眼睛圖案上。如果您的立體視覺沒有問題，you will see two thumbs framing one eye.
- 其次，將您的眼睛改聚焦在大拇指上。You should see two eyes framing one thumb.

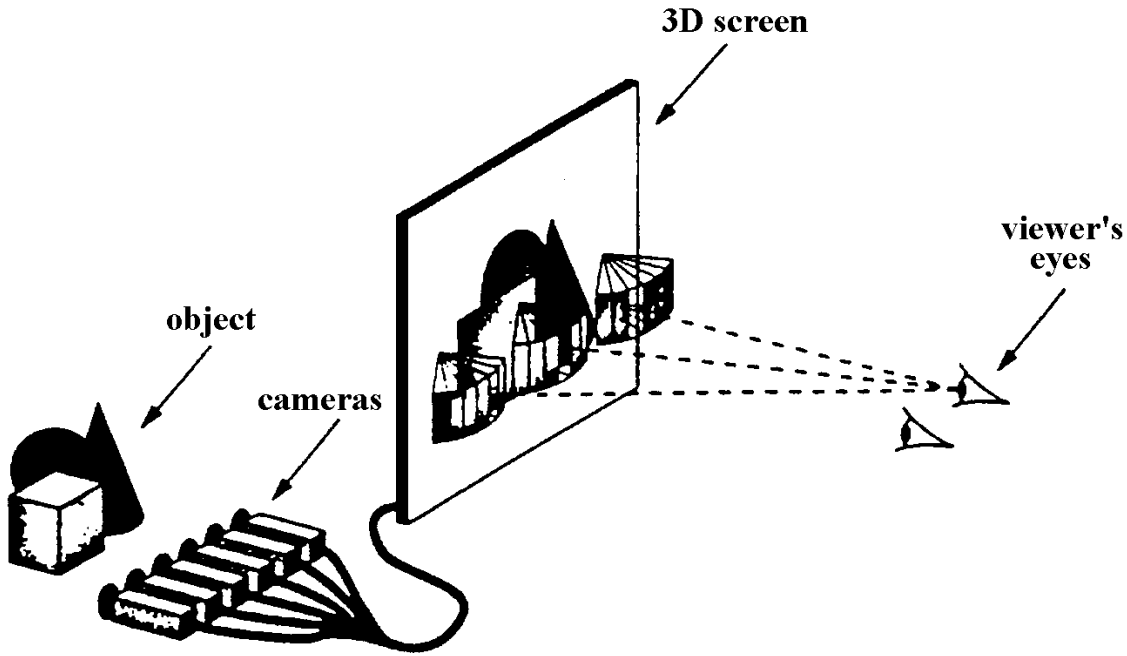
至少有 12% 的人在立體視覺方面有某種程度的問題。約少於 5% 的人有嚴重的視覺障礙，致使其立體感知極為困難或完全不可能。

3D Display System的工作原理

體積式



螢幕式



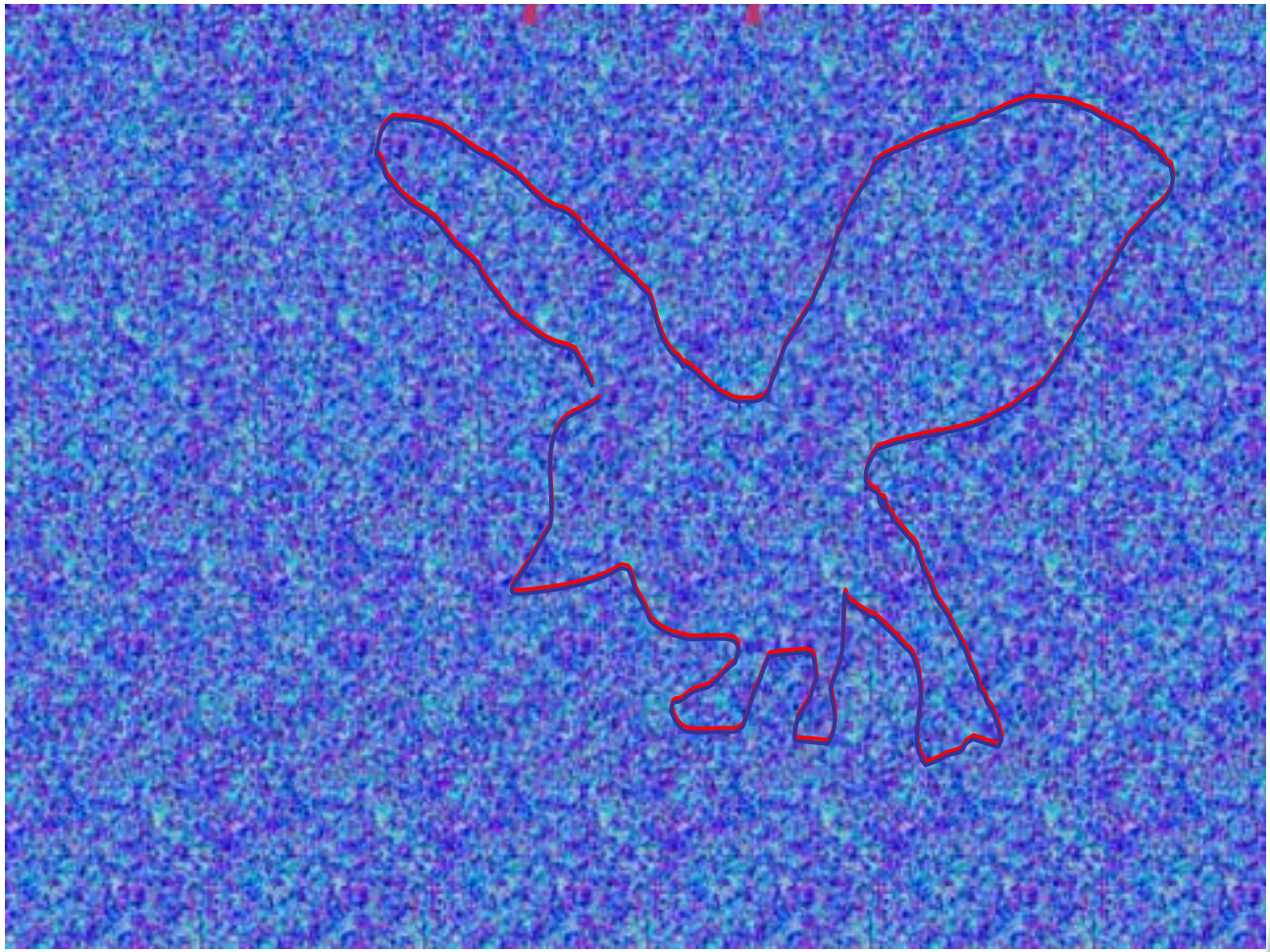
- 世界主要技術簡介

國際現況

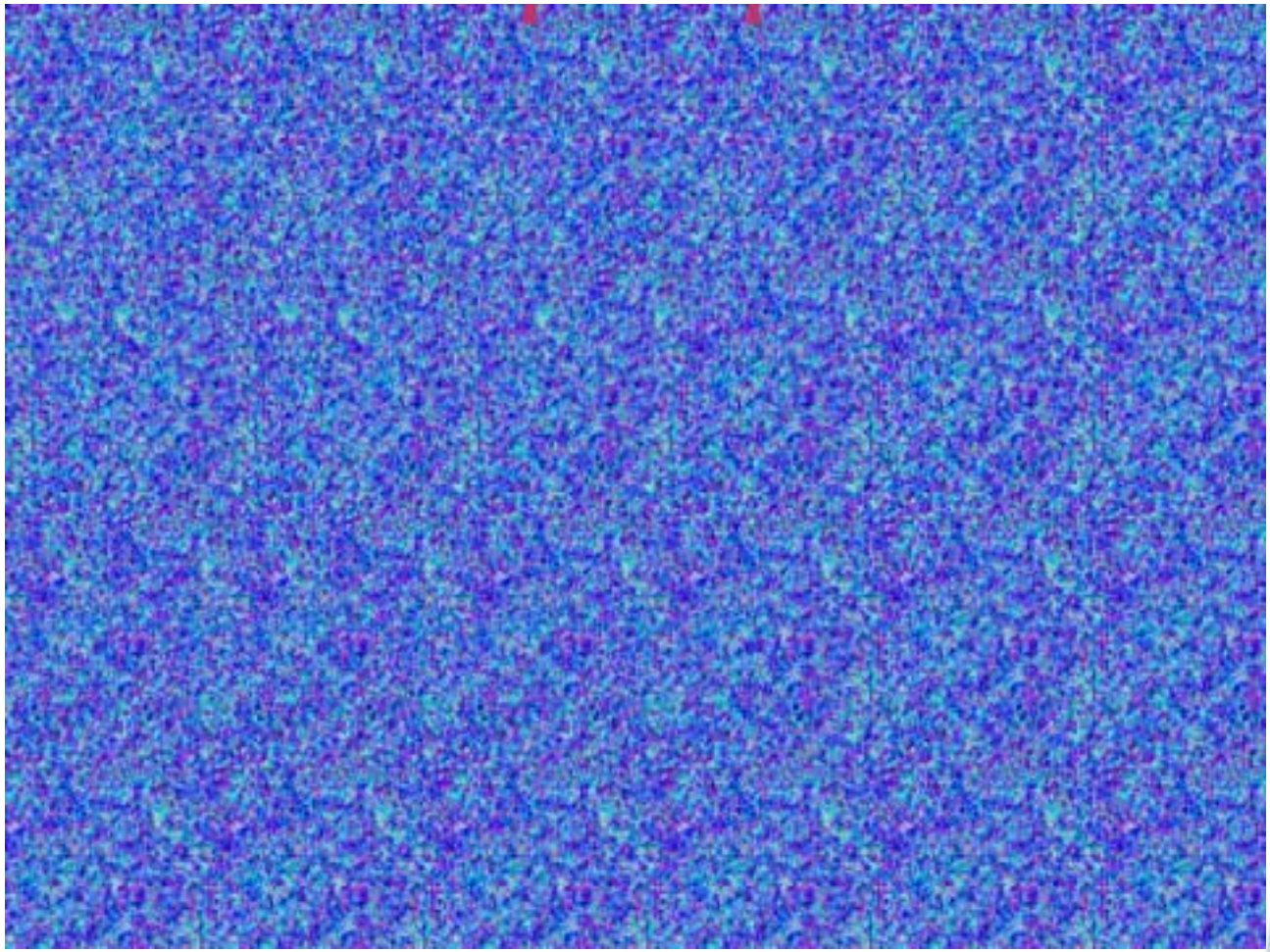
- Sharp 已推出 3D 手機、3D Notebook PC、3D LCD monitor，並應用相關技術於雙影像 LCD-TV。
- Philips、Toshiba、Samsung、NTT、Hitachi、 Mitsubishi 、 Sony 、 Sanyo、StereoGraphic、DTI…等多家公司推出 Prototype。
- 日本有 先後有HODIC 、TAO、3D Consortium、及 3D Business Promotion Consortium 等組織大力推展，其中 3D Consortium 於 2003 年成立，已有超過一百七十個以上會員，大多是國際知名企業，台灣有工研院及電子電機工會入會。
- 歐洲2002年成立ATTEST(**A**dvanced **T**hree-dimensional **Te**levision **S**ystem **T**echnologies)聯盟，由Philips主導，以Human Factor為中心，從事硬體系統、軟體內容、影像編碼、傳播系統等的先期研究，後續又成立 3D TV 計劃 (2004-2008)，涵蓋 6 個國家，十餘公司與研究單位
- 目前主要技術瓶頸在於解析度與觀看自由度無法兼顧。

現在幾種常見的立體顯示方法(靜態圖片)

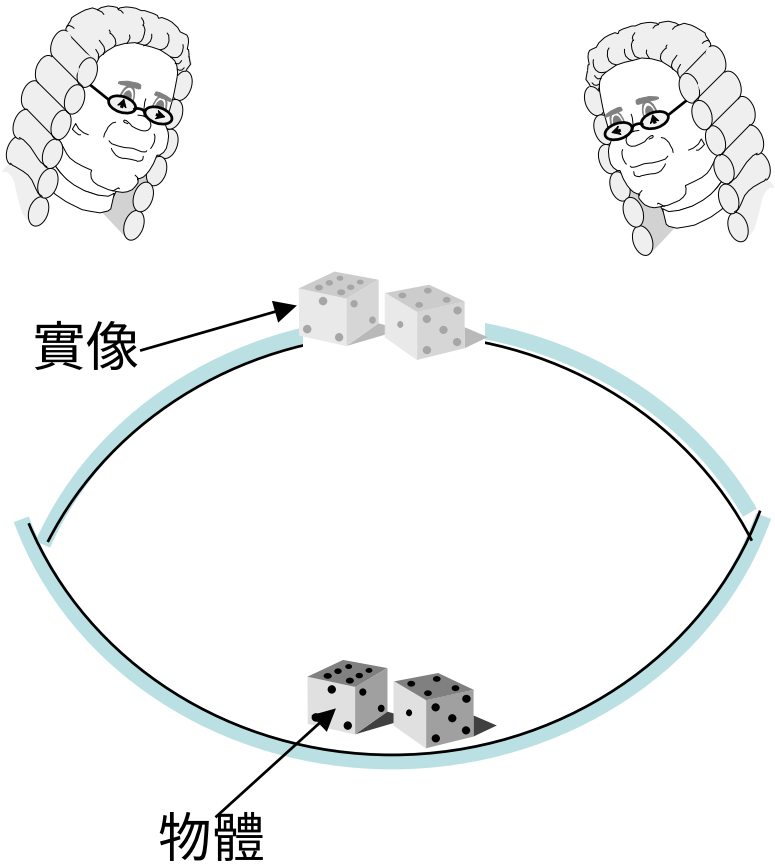
SIRDS - a Bird



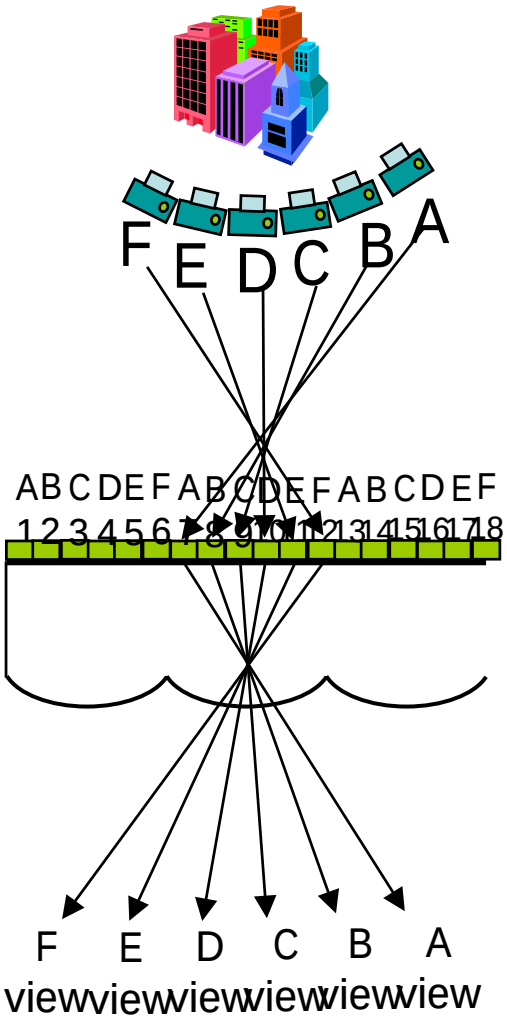
SIRDS - a Bird

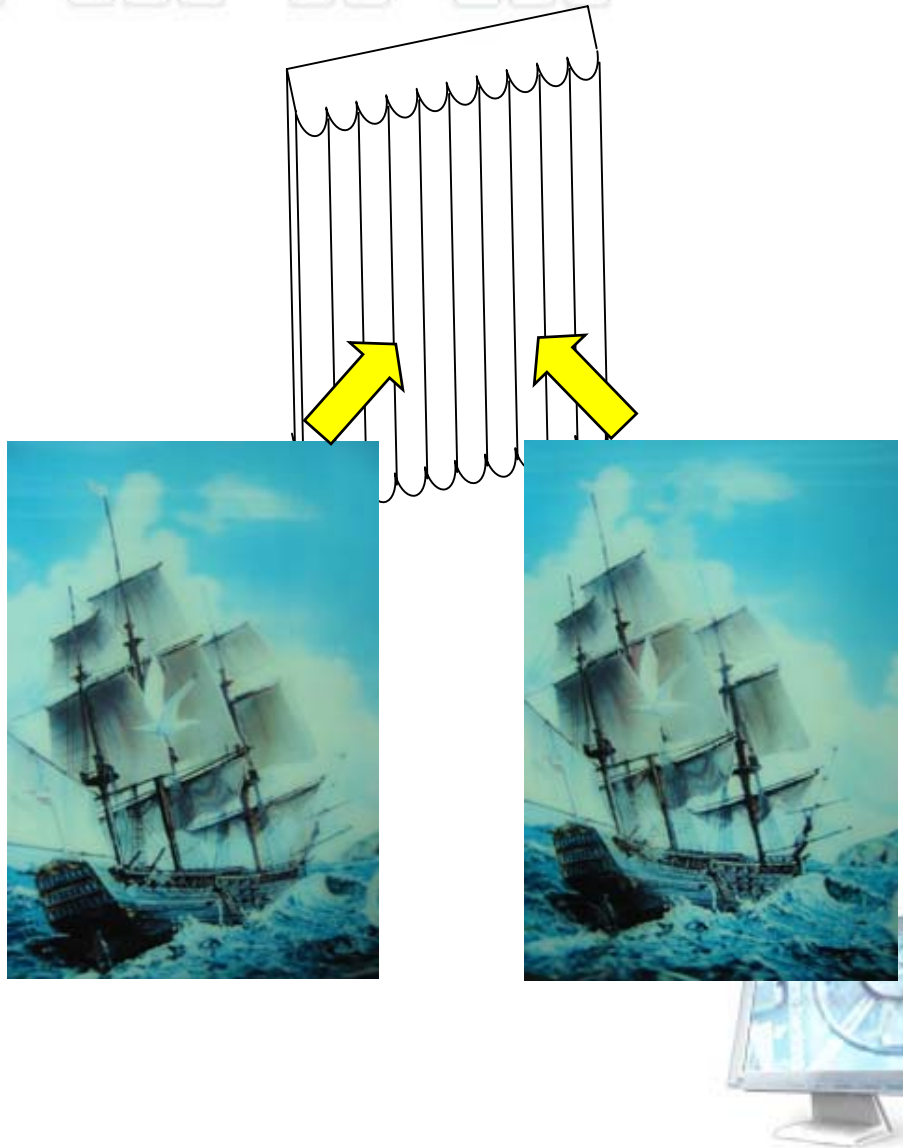


實體立體投影系統



Lenticular 立體圖片





全 像 片

3D影像顯示技術一覽

3D影像顯示技術

戴眼鏡式

- 快門眼鏡(Shutter glasses)
- 偏光眼鏡(Polarization glasses)
- 紅綠眼鏡(Anaglyph)
- 明暗眼鏡(Pulfrich effect)
- 頭盔式顯示器(HMD)

裸眼式

- 全像式(Holographic)
- 體積式(Volumetric)
- 2D多工式(2D Multiplexed)

(自動立體顯示Autostereoscopic Display)

- 2 views
- multiple views

各種立體眼鏡

- **Anaglyph 3D Glasses** 
  - 紅綠或紅藍眼鏡 for interpreting anaglyphic art. Used for viewing 3D comics, 網際網路之3D網站、立體電影或電視節目、立體電玩、以及立體照片。
- **Polarized 3D Glasses** 
  - 包含線偏極或圓偏極之 3D 眼鏡，主要用於立體雷射秀、立體動感電影院及 3D 電影。
- **Shutter 3D Glasses** 
  - 包含有線或無線液晶偏極 3D 眼鏡、同步訊號發射器等，主要用於立體雷射秀、3D虛擬實境、立體電視節目。
- **Pulfrich 3D Glasses** 
  - 由一片深色鏡片及一片透明鏡片組成，用於立體電視節目、錄影帶及多媒體電腦影片。
- **HMD**
  - 頭盔式顯示器，使用微型顯示面板(micro-display)，用於立體電子遊戲、3D虛擬實境。

Electronic Holography

全像3D Display原理

Real object

-infinite number of view

wavefront

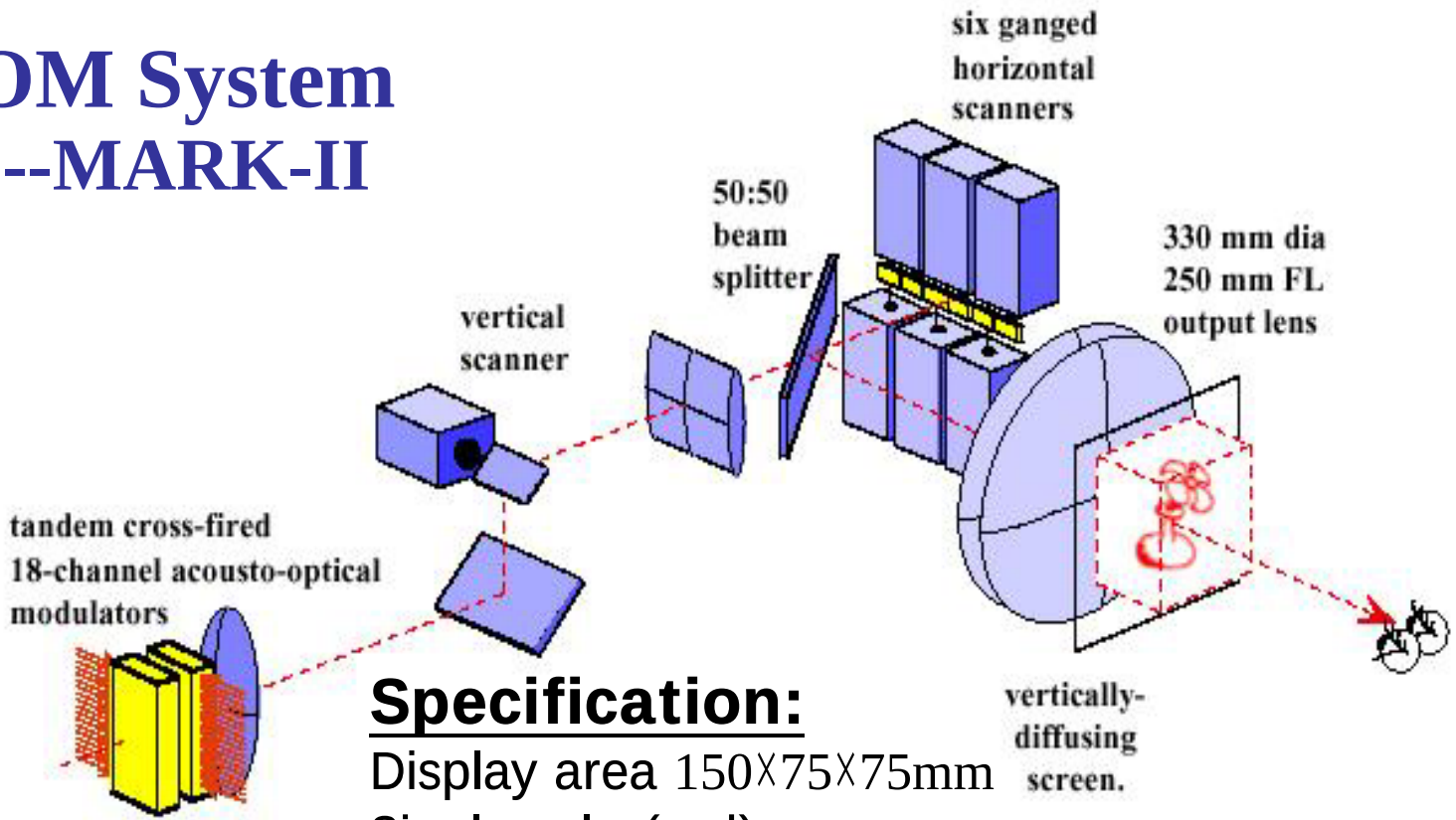
Holographic display

-finite number of view

利用Grating調制出光,
產生所需wavefront

Holo-Video of MIT/Media Lab

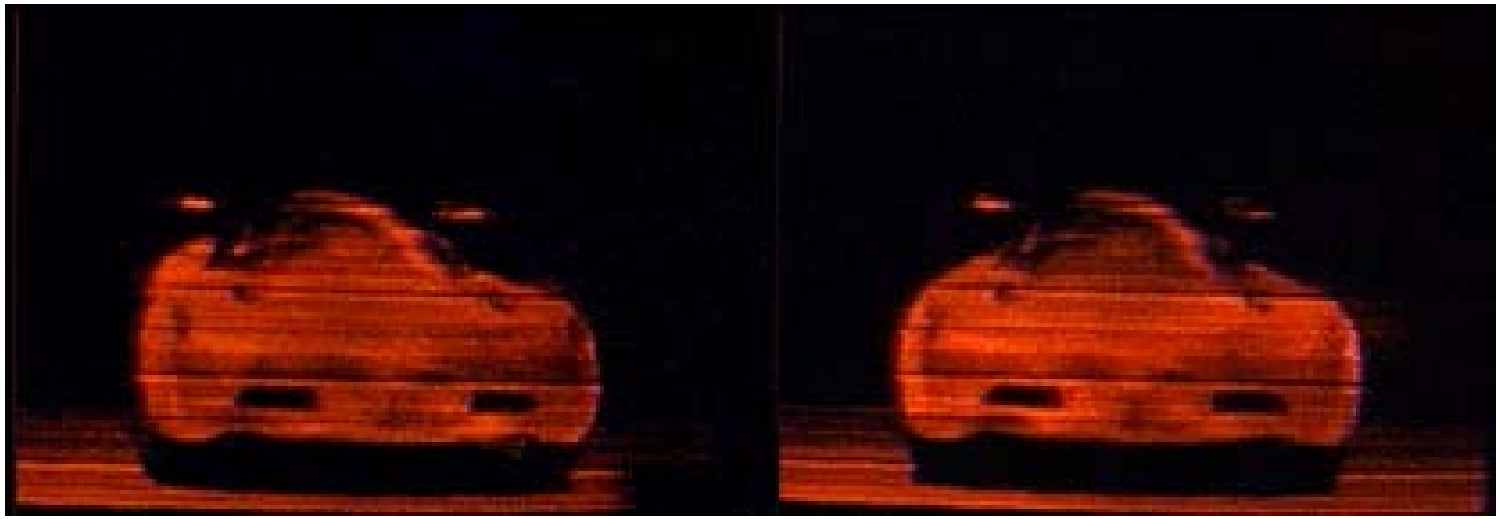
AOM System --MARK-II



Specification:

Display area 150X75X75mm
Single color(red)
field of view 30°
frame rate 2.5 Hz

Holo-video Images



•The above images are a stereo pair taken near the far left of the display. The image is of a Honda EPX concept vehicle from a database supplied by Honda Research and Development Co.

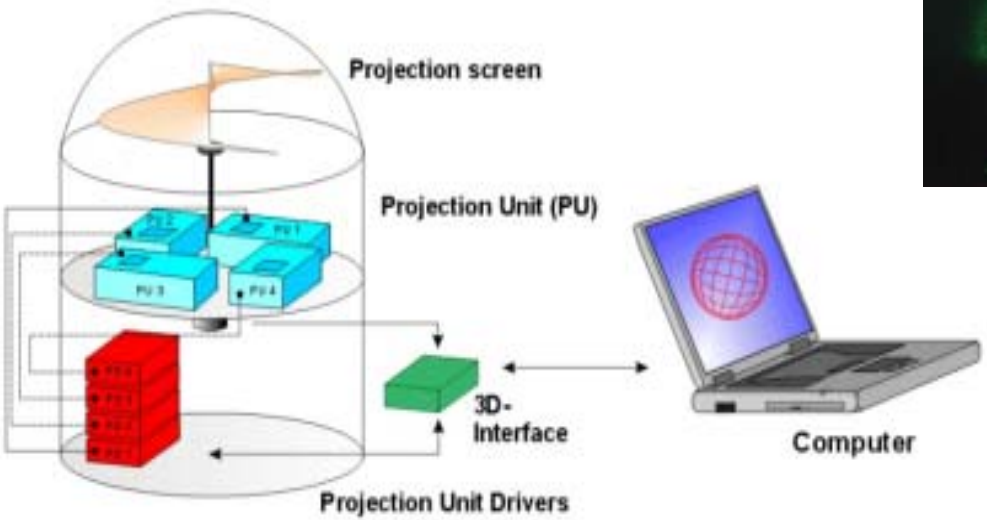
Holo-Video 的頻寬問題

- Sampling rate = $2fg = 2\sin\theta/\lambda$
  - θ ：diffractive angle (angle of view-zone)
  - λ ：wavelength
- 一個長h寬w的image,每一Frame 取樣總數為
  - $4hw\sin^2\theta/\lambda^2$
- 10“X10“ image ,30^o視角,24bits color,60 Hz
  - date rate $=60X24X4X254X254X\sin^2 30^o/(0.0005)^2$
  - ~ $370X10^{12}$ bits/sec = 370 THz

Volumetric Display

Volumetric 3D Display-I

Flex's Spiral Surface System

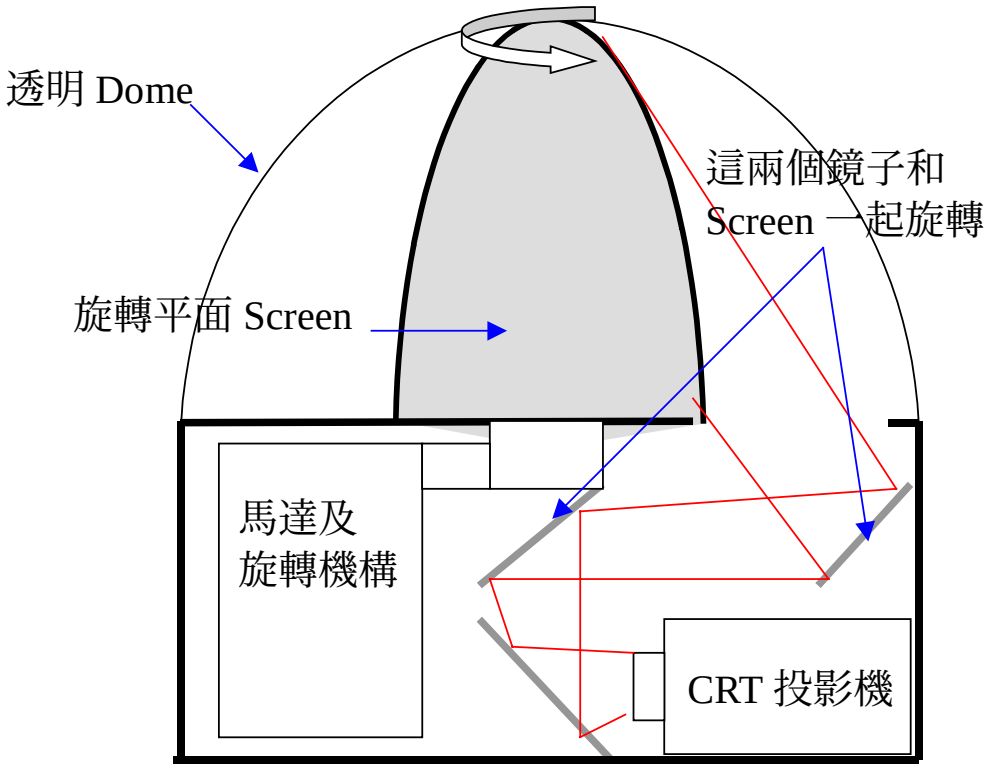


Volumetric 3D Display-II

Rotating Projection Screen

Actuality System--DLP Projector

SDI Corporate R&D Center--CRT Projector



DepthCube of Light Space Technology

Multi-planar Optical Element--20-layer PDLC

Image size : 15.7” x 11.8” x 4”
Color : 32,768
Number of layers : 20
Refresh rate : 20 Hz
Resolution : 1024 x 768 x 608
Size : 25” x 22” x 29.8”

2D Multiplexed 3D Display (Autostereoscopic Display)

-Projection

-Parallax-Barrier

-Lenticular lens

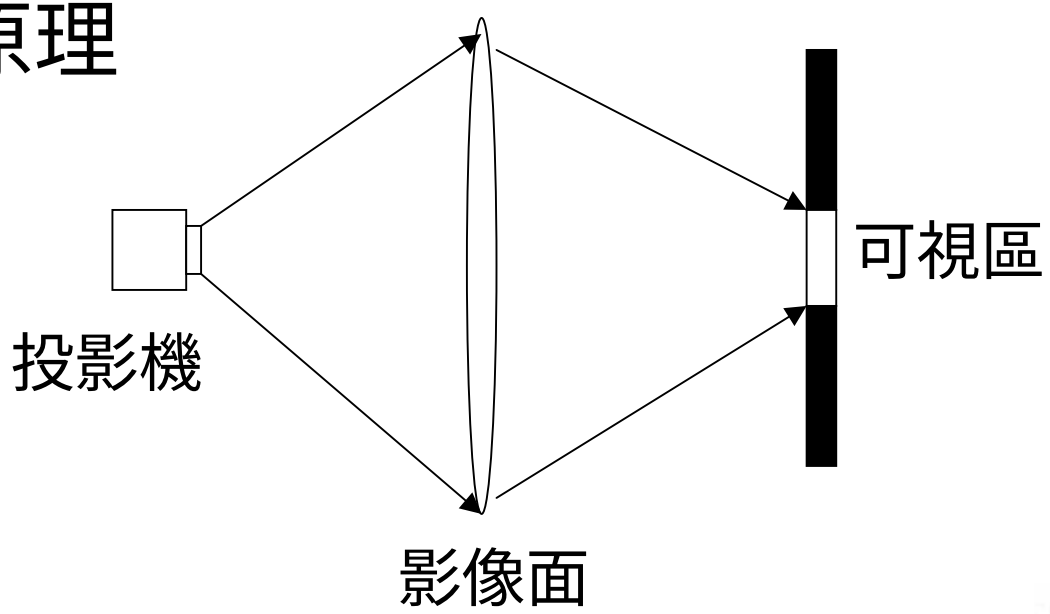
-Sub-pixel color filter

-Viewer-tracking

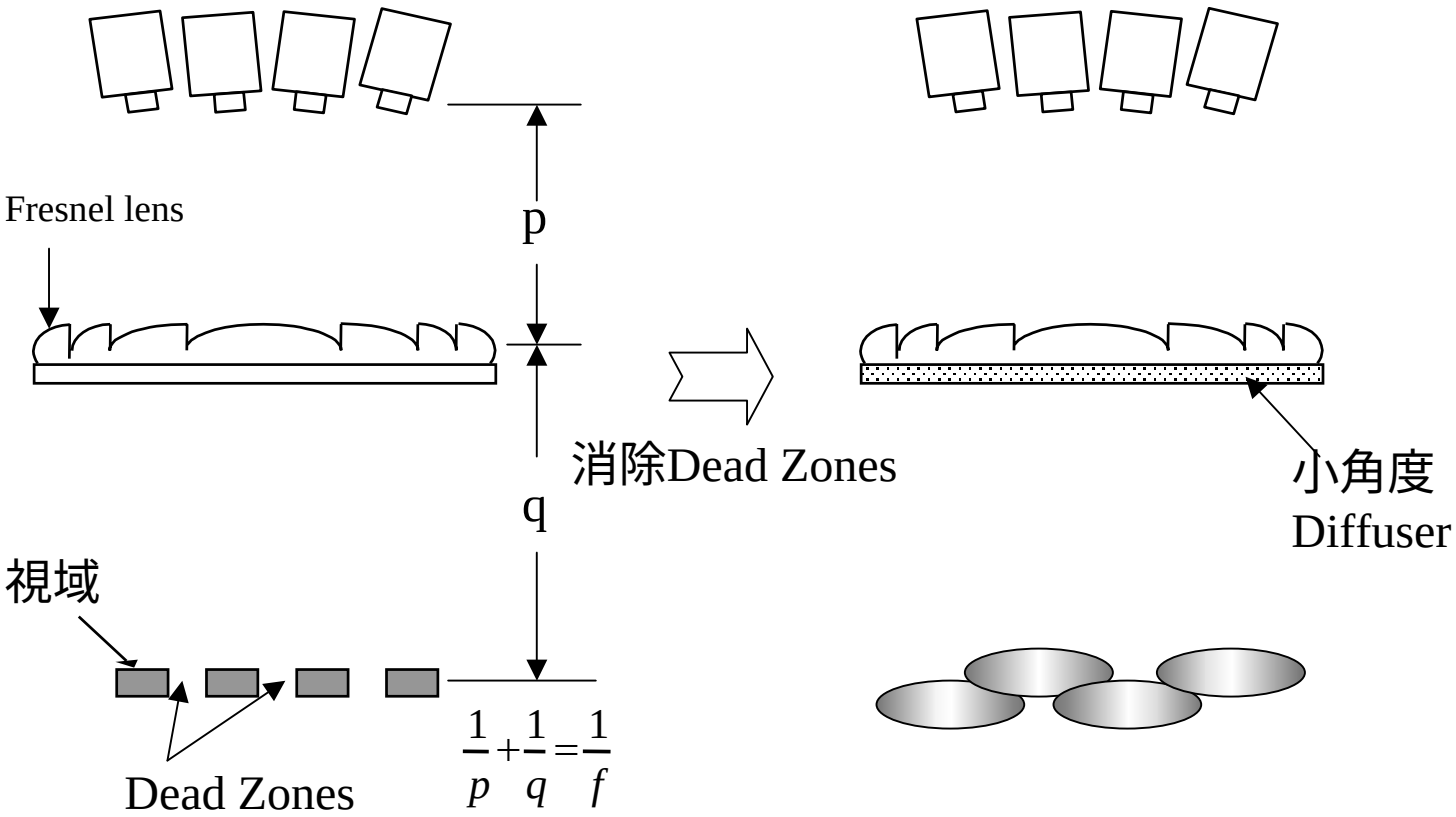
-Time multiplexed

基本投影式3D Display

- 代表性研究單位：日本的Hitachi；美國的Hines Lab Inc.；歐洲的Heinrich Hertz Inst. 和Stuttgart University；澳洲的Dynamic Digital Depth Inc
- 應用原理

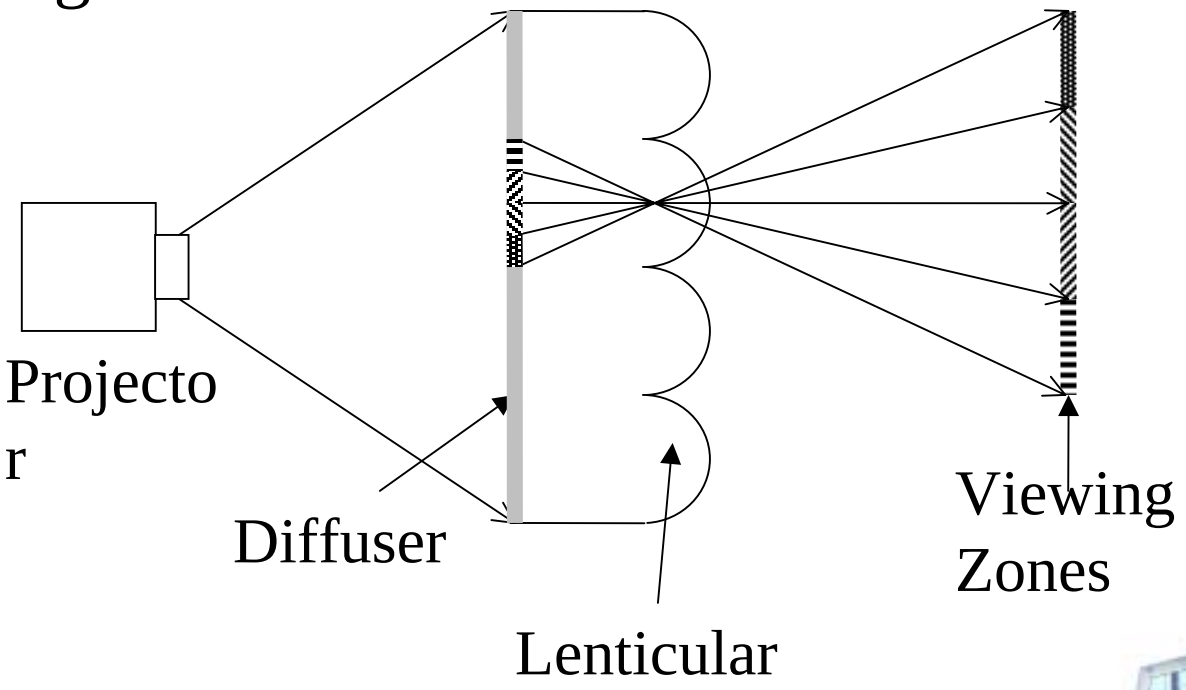


投影式多視域3D Display



Lenticular 3D Display—投影式

- **Sanyo**
  - Single Lenticular



40” Lenticular 3D Display

50” Lenticular 3D display
~ 4 views ~

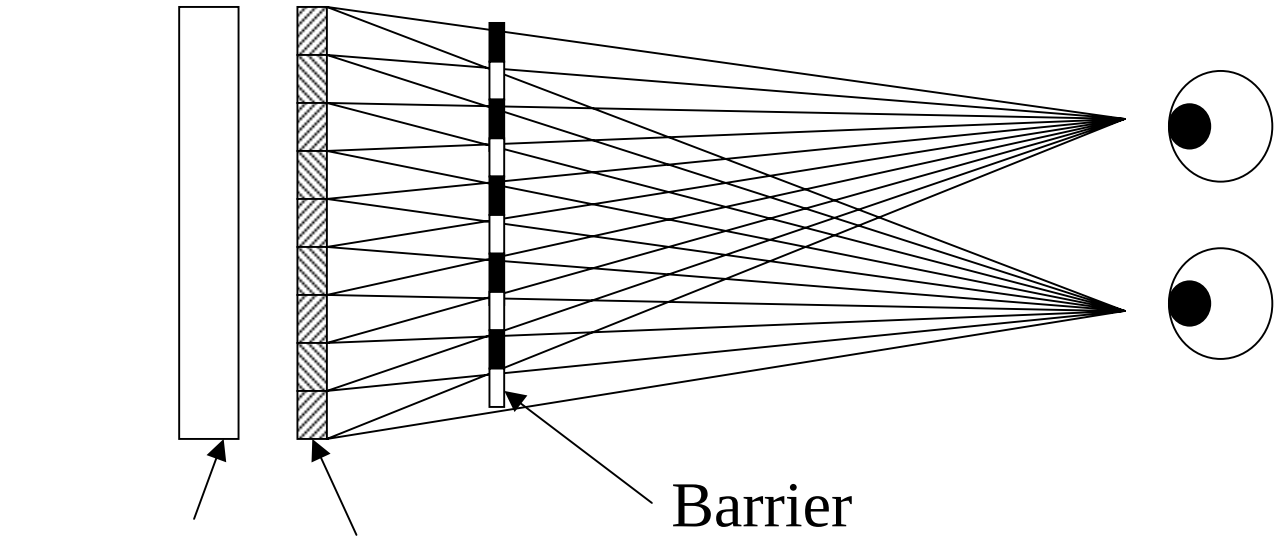
70” Lenticular 3D Display

Double Lenticular Hi-Vision 110” 3D Display

ハイビジョン立体ミニシアター

Parallax Barrier 3D Display

Front Barrier Type



Left/right eye images interlaced

Parallax-Barrier 3D Display of Sanyo

15” XGA

16” SXGA

3D 手機 - Sharp

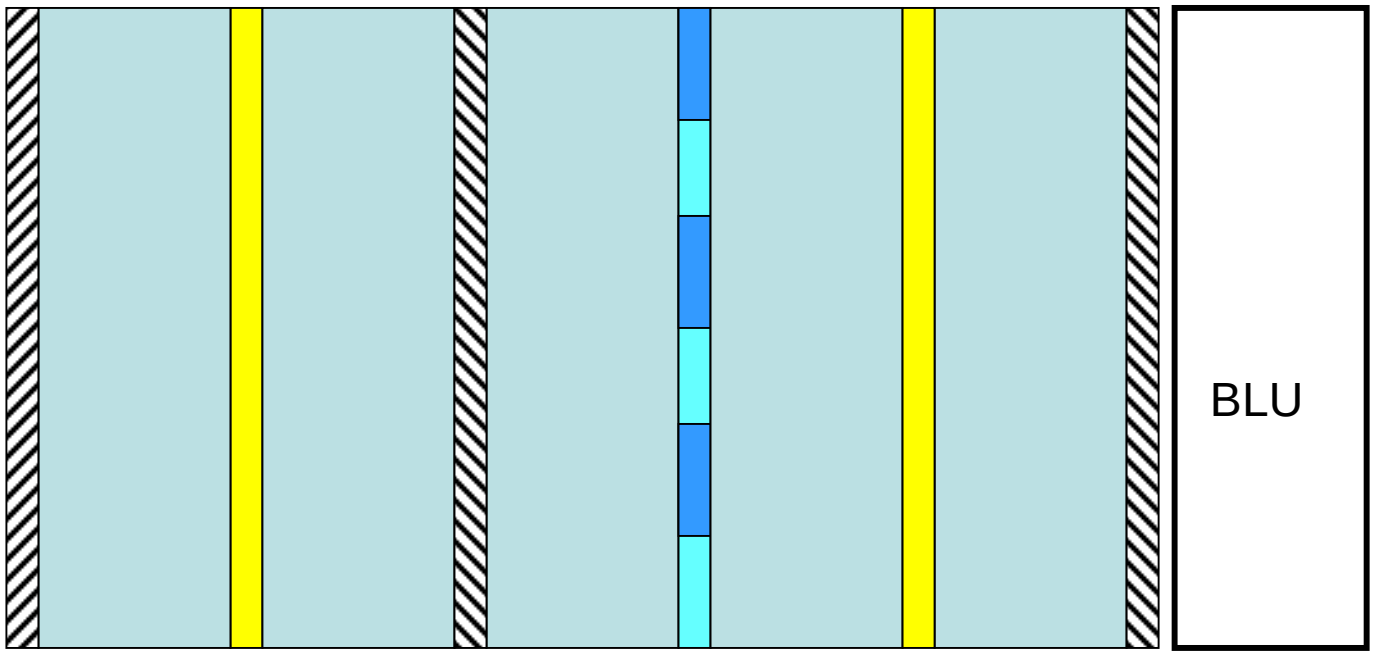
Sharp / NTT DoCoMo SH251is

- 2D/3D顯示切換
- 176 x 220, 2.2吋 65536色LCD
- 單鏡頭拍攝
- 31萬畫素CCD
- 軟體2D to 3D影像轉換
- 110 g

Sharp / NTT DoCoMo SH505i

- 2D/3D顯示切換
- 240 x 320(QVGA), 2.4吋 65536色LCD
- 100萬畫素CCD
- 單鏡頭拍攝
- 軟體2D to 3D影像轉換功能增強
- 125 g

Sharp 2D/3D switch原理



3D Notebook - Sharp & NEC

Sharp 3D notebook

ノートパソコン“Mebius”
<PC-RD3D>
※画面はハメコミ合成です。

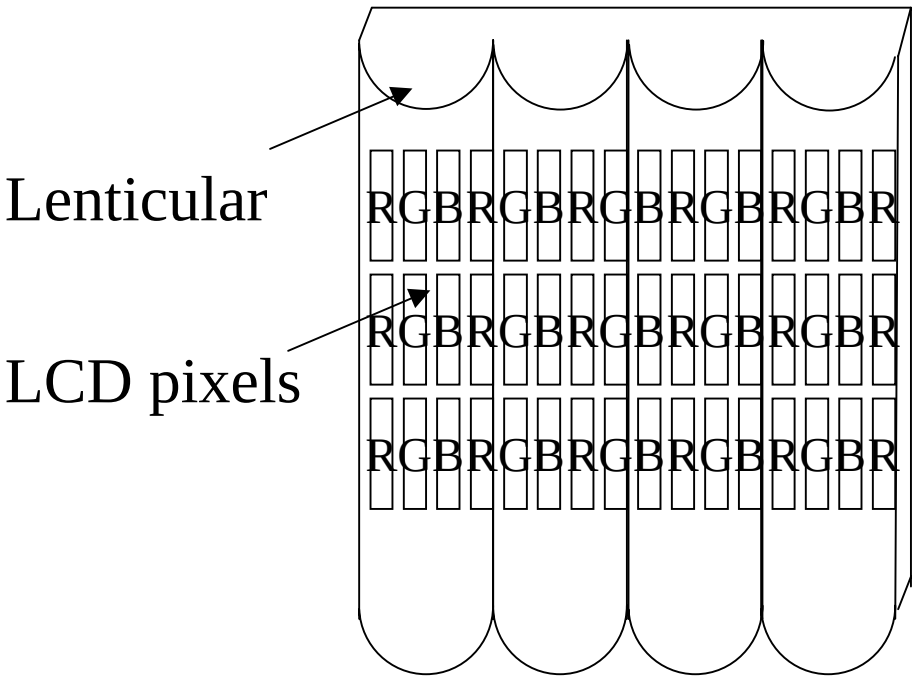
Switchable Parallax Barrier技術

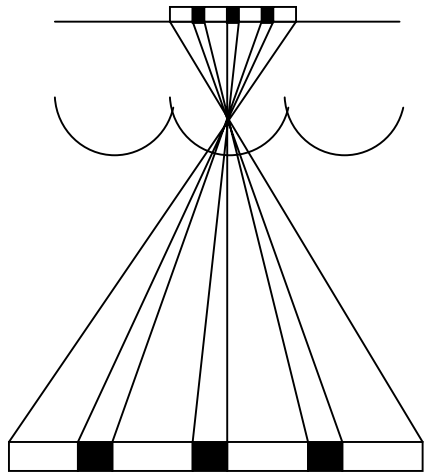
NEC 3D notebook

3D Monitor - Sharp

Sanyo Epson的Stepped Barrier技術

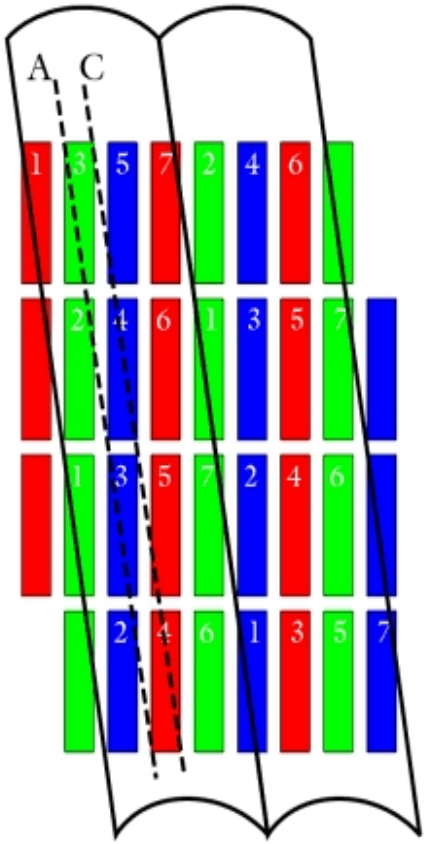
Lenticular 3D LCD



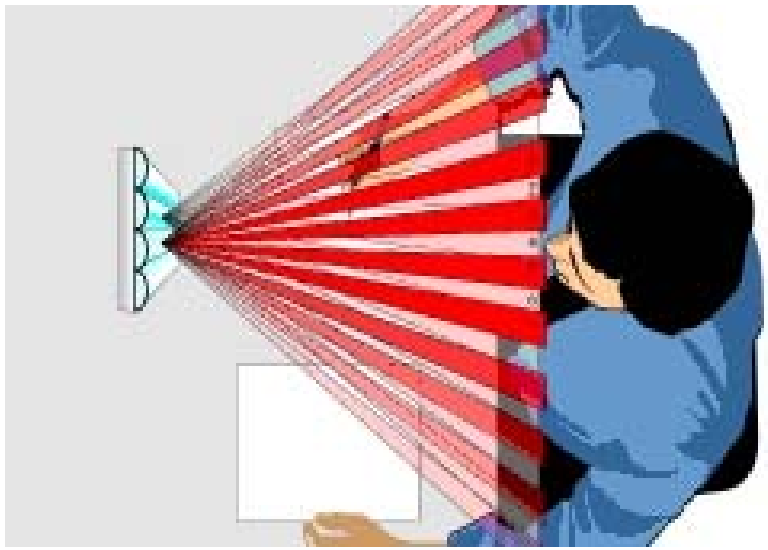


Black Matrix of LCD will cause dead view-zone

Slanted Lenticular 3D LCD of Philips



- 避免犧牲同一方向解析度
- 解決Dead-zone問題



Slanted Lenticular 3D Display of StereoGraphics

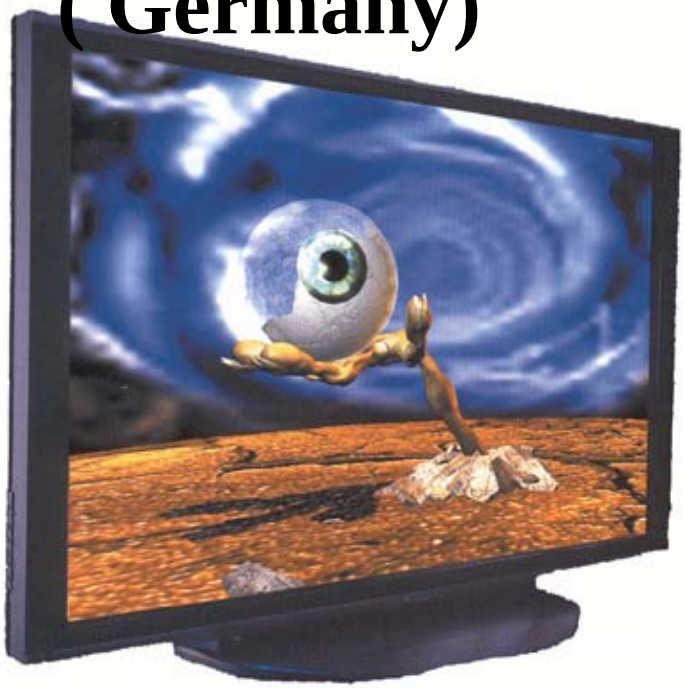
22.2“ 3840 x 2400

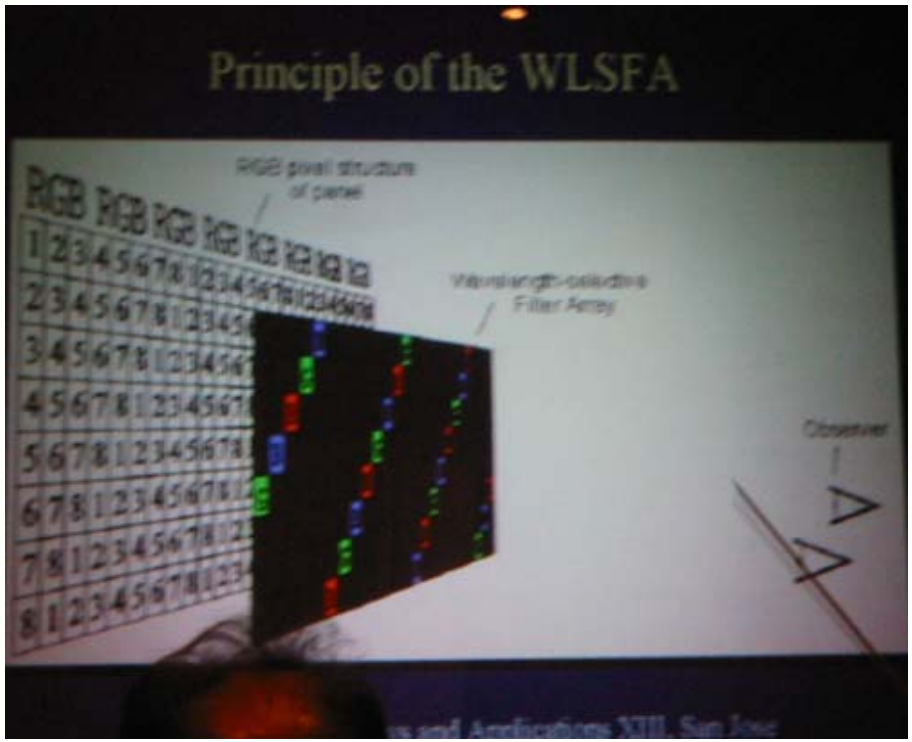
40“ 1280 x 768

* 東京農工大學Takaki教授已完成72 views 的prototype

WaveLength-Selective-Filter-Array 3D Display

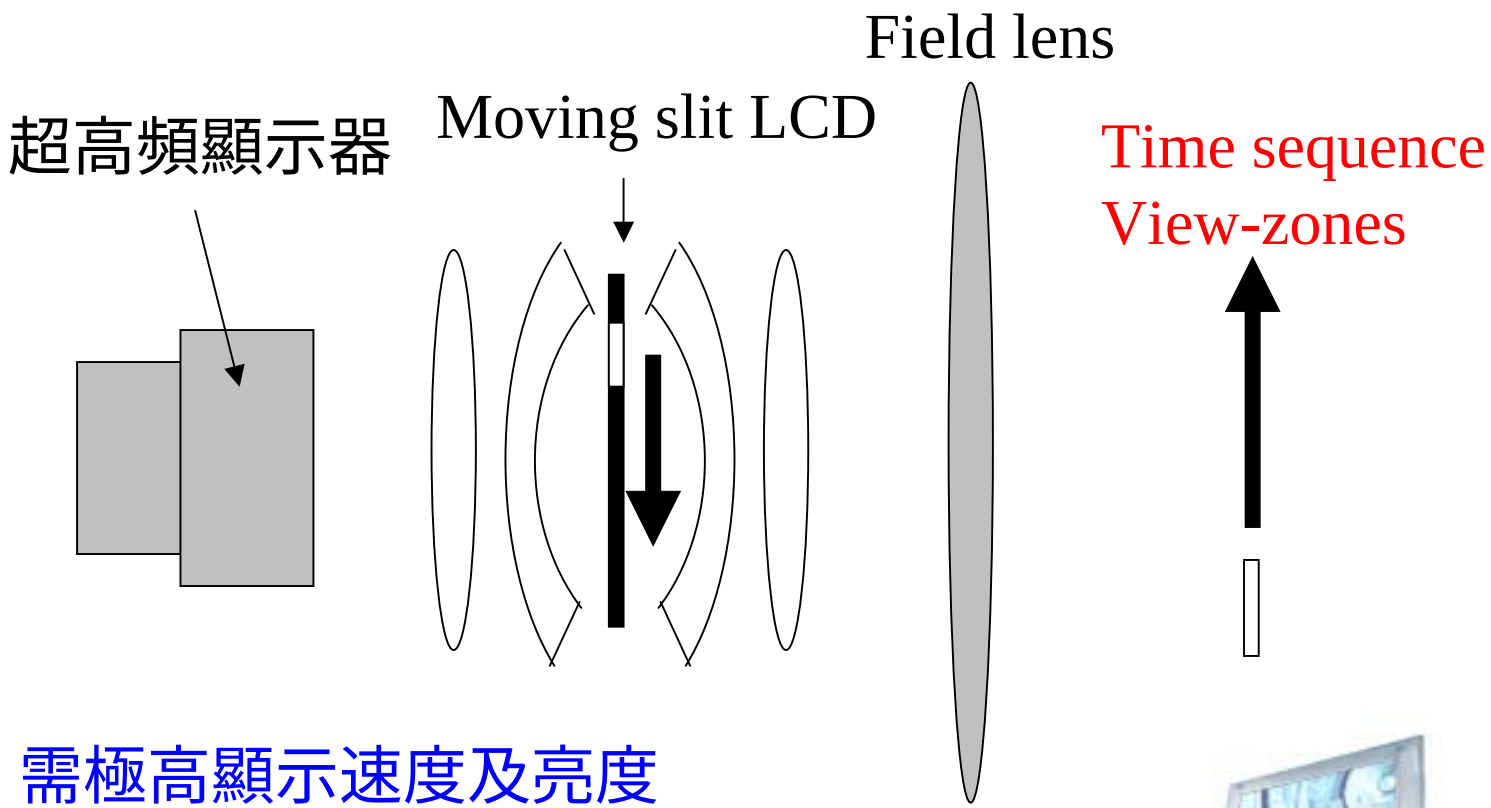
- **4D Vision (Germany)**





英國劍橋大學的3D Display

時間多工立體顯示器



* 需極高顯示速度及亮度之顯示面板的開發

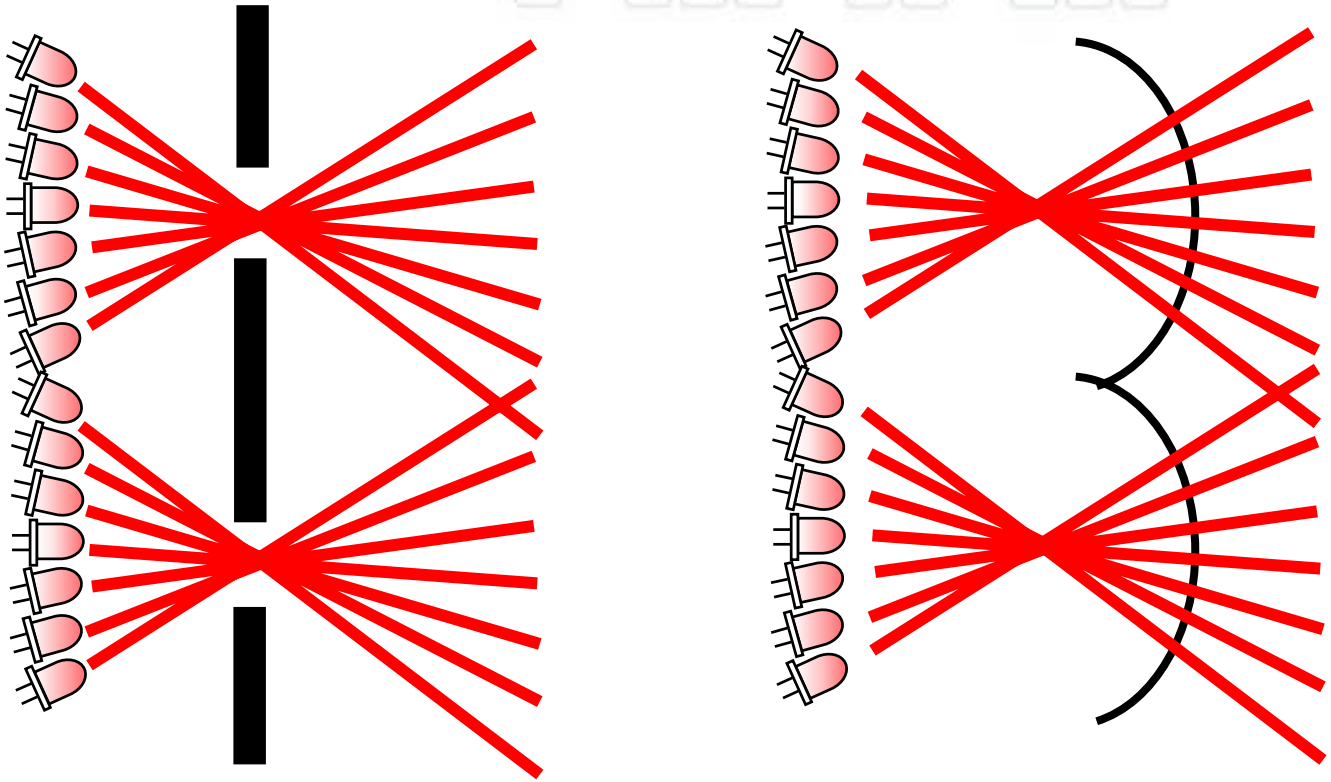
英國劍橋大學的3D Display

Specifications:
50” screen
15 color VGA
views for 2 viewers
12^0 field of view
each.

Application:
3D gaming machine

其他Autostereoscopic Display

Nichia的超大型LED 3D Display

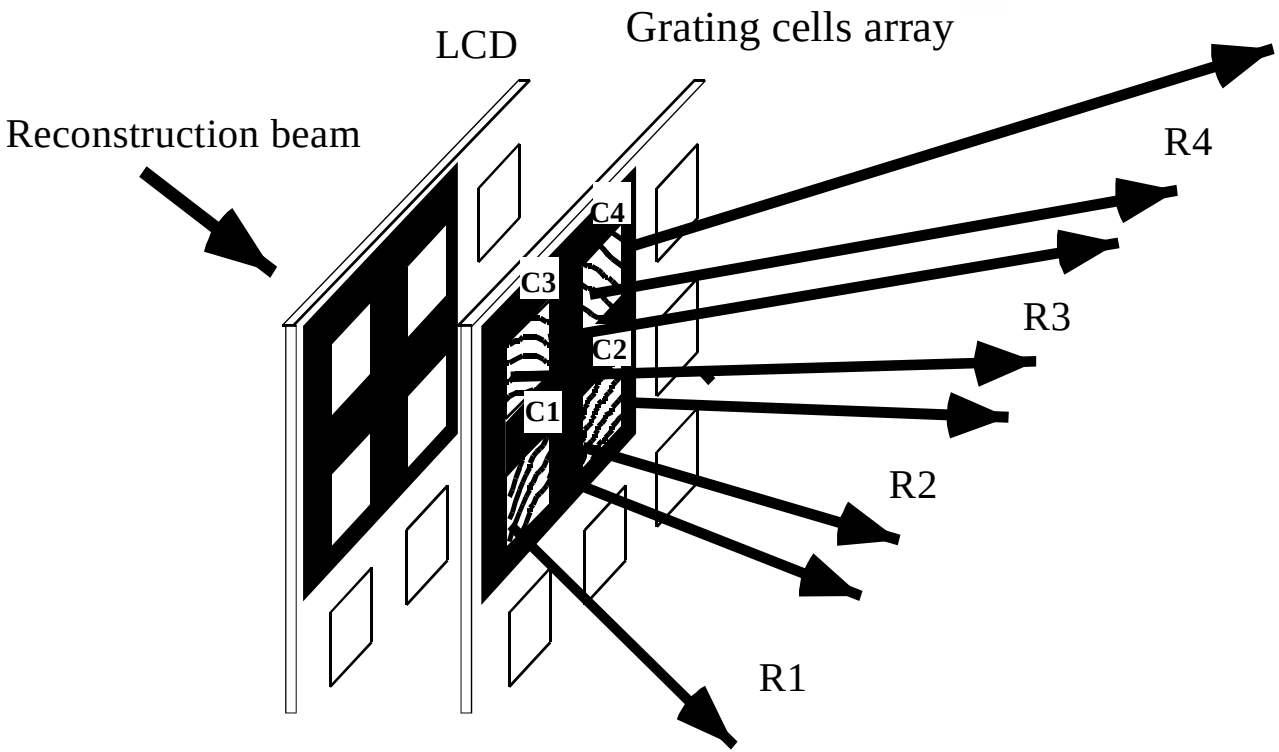


8mm LED pitch for 20m viewing--2m thick

use of double lenticular to reduce the thickness

☞ new thickness is 50 cm

Partial-Pixel-Grating 3D Display of Toppan



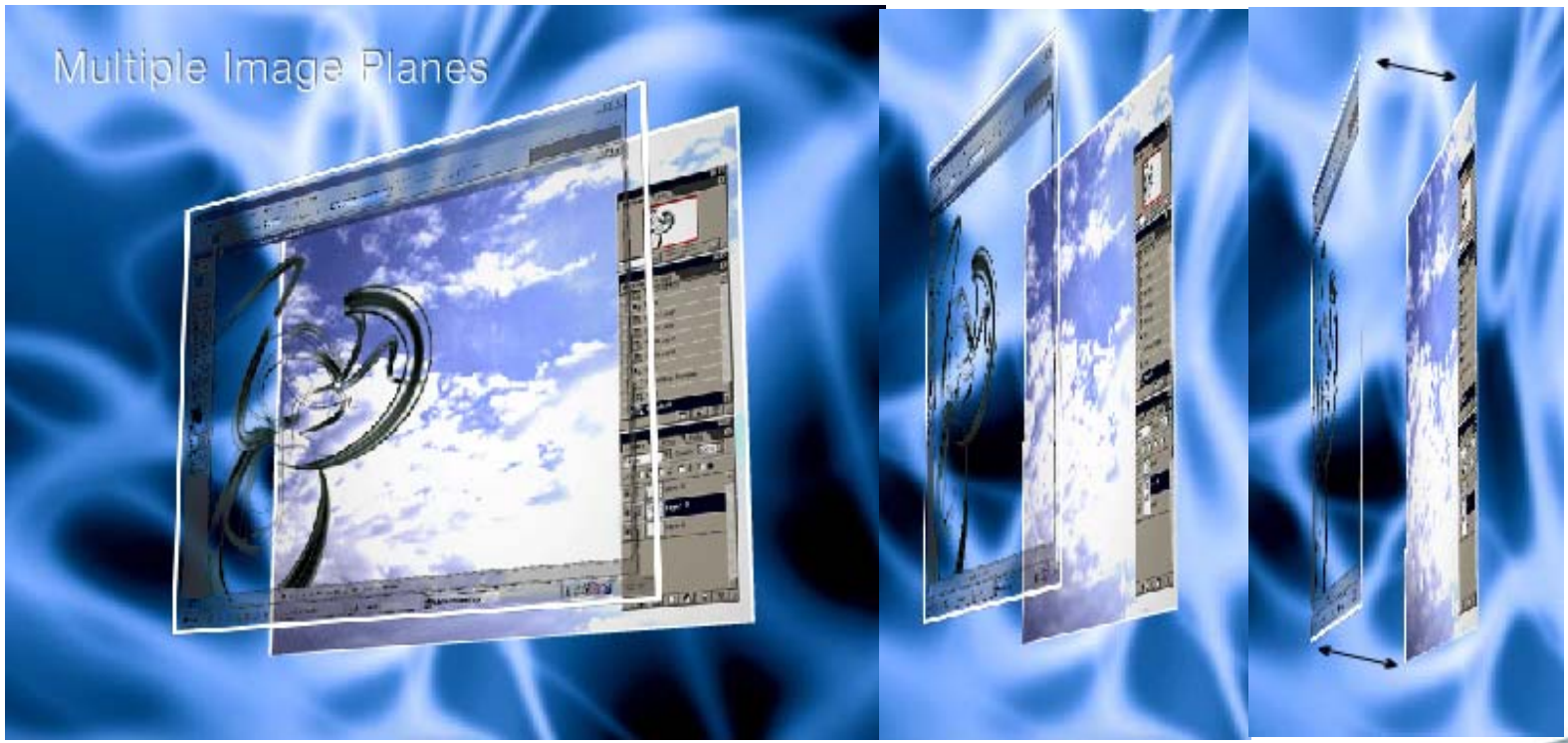
LCD and Grating Cells Array

Multi-layer LCD display of DVI

DVI: Deep Video Imaging
(ActualDepth™)

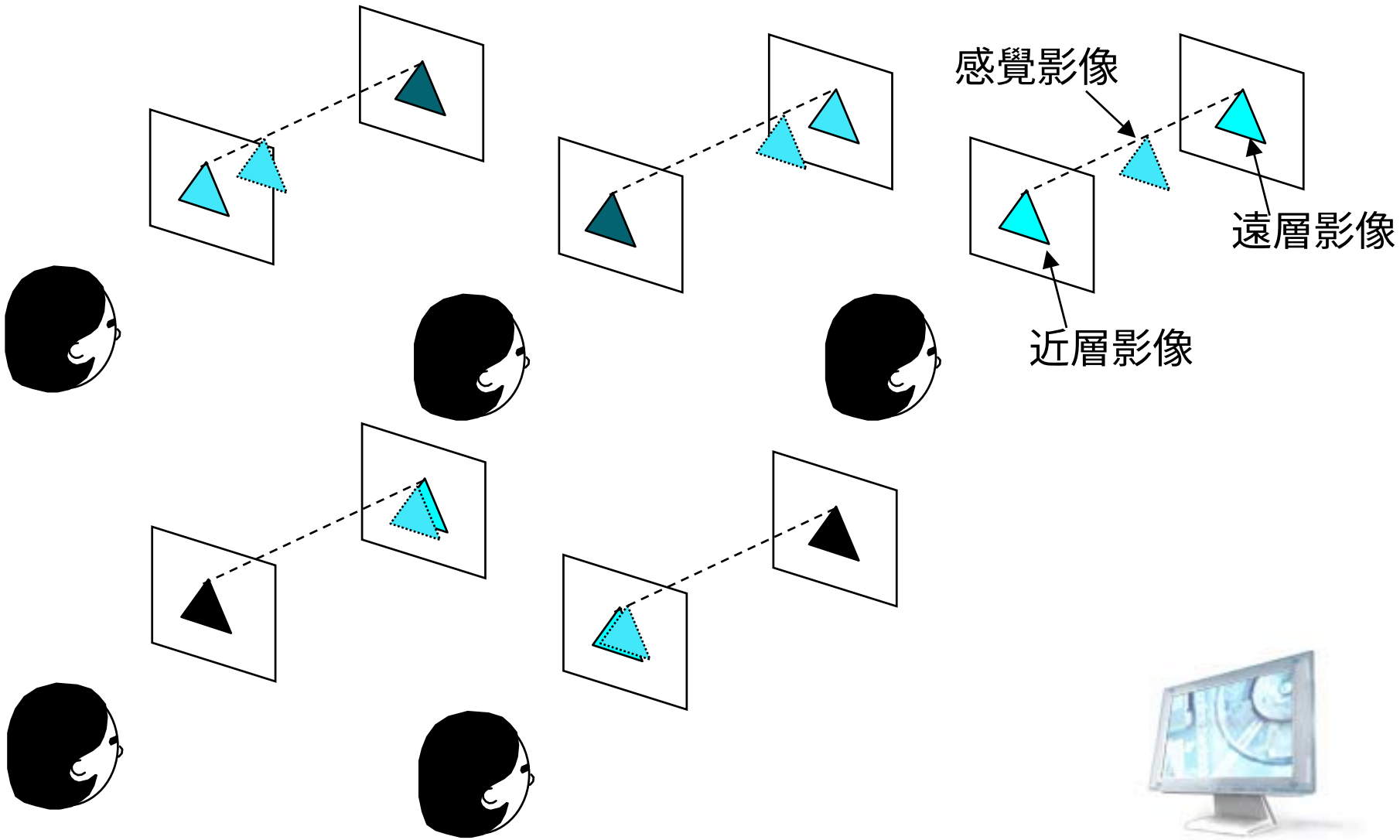
- 利用多層LCD 前後排列，分別顯示前景與後景，形成前後深度感。
- 以前後景的明暗差，配合景物相對關係的巧妙安排，避免重影現像，但角度大時仍難免。
- 前景實體部份顏色要深，其他部份要全白(透明) 。
- 各層LCD之間相臨的偏光膜必須為同向。
- 層數增加，亮度嚴重下降。

Multi-layer LCD display of DVI

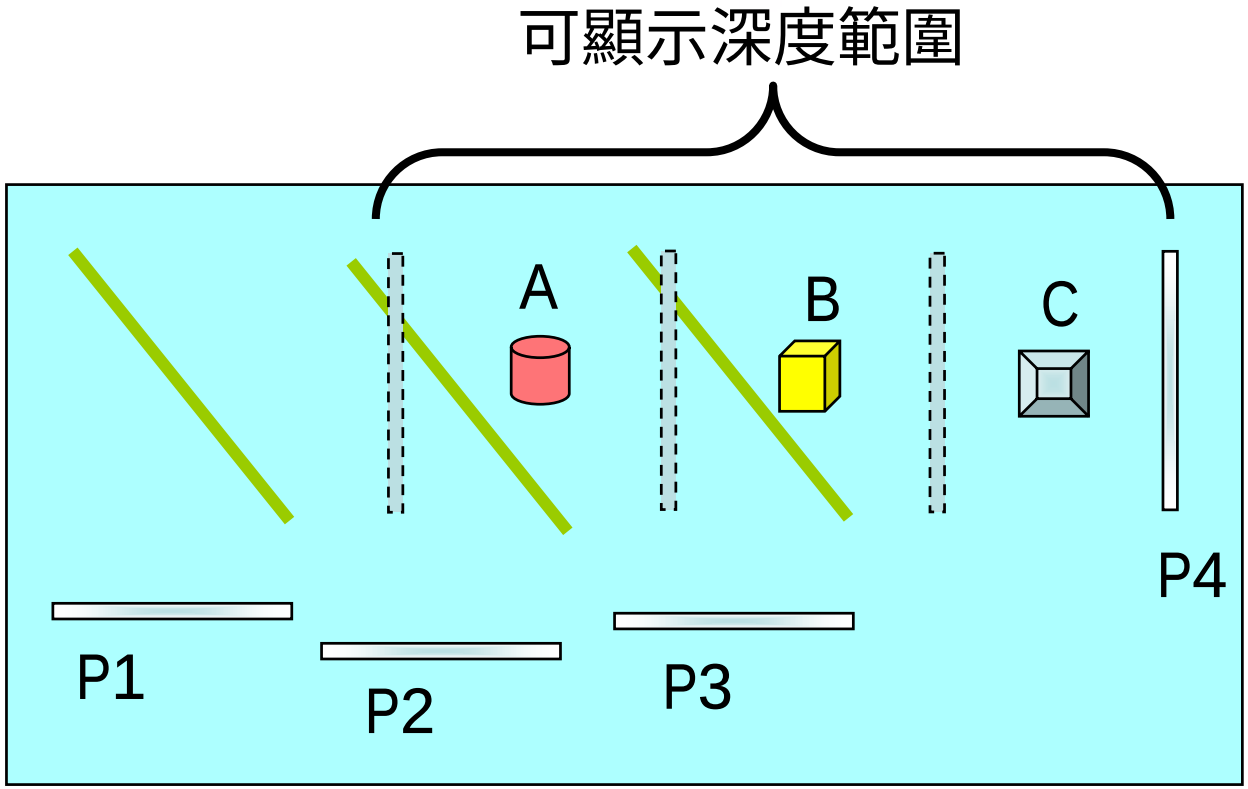


Brightness-Modulated-Depth System of NTT

Principle

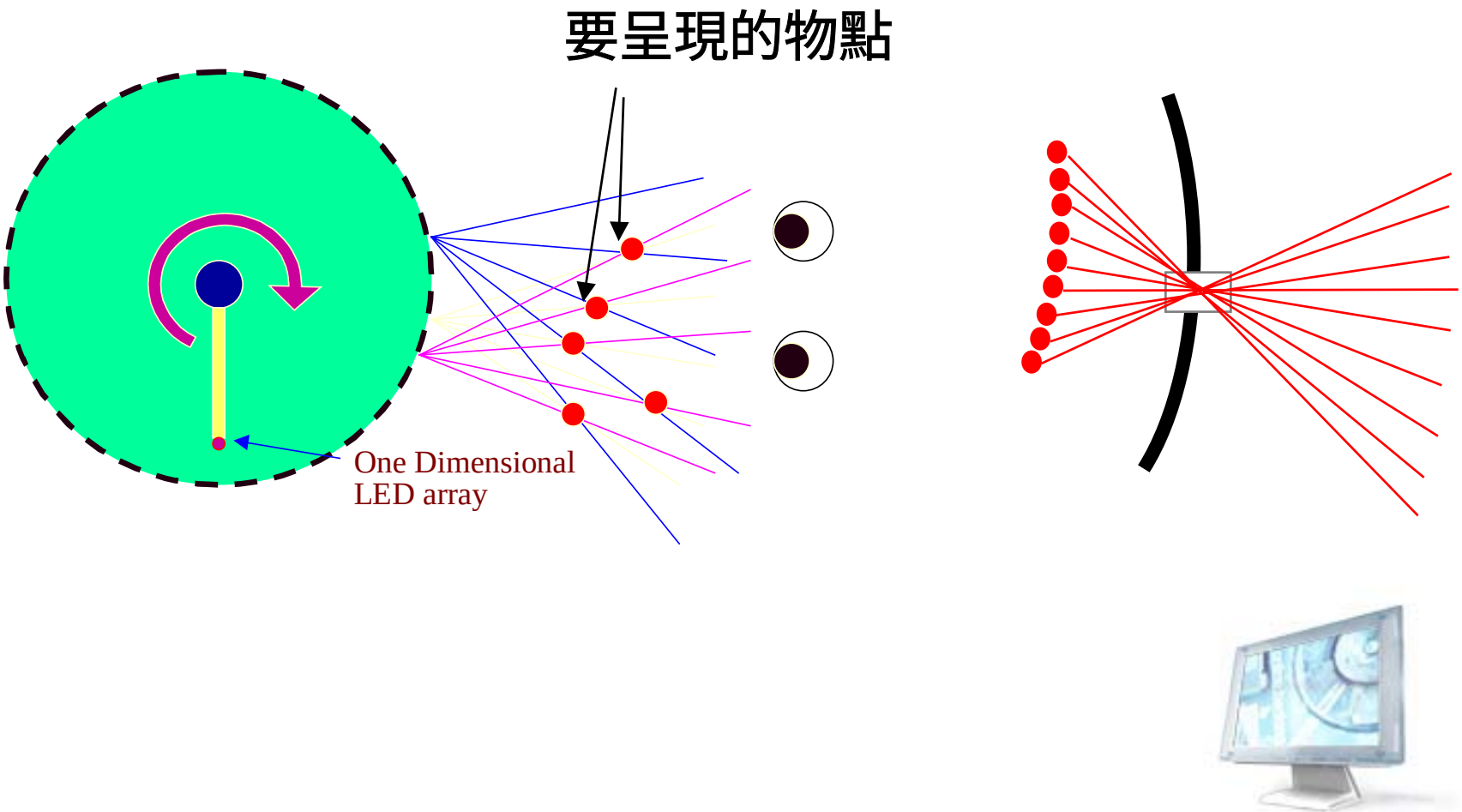


Brightness-Modulated-Depth System of NTT

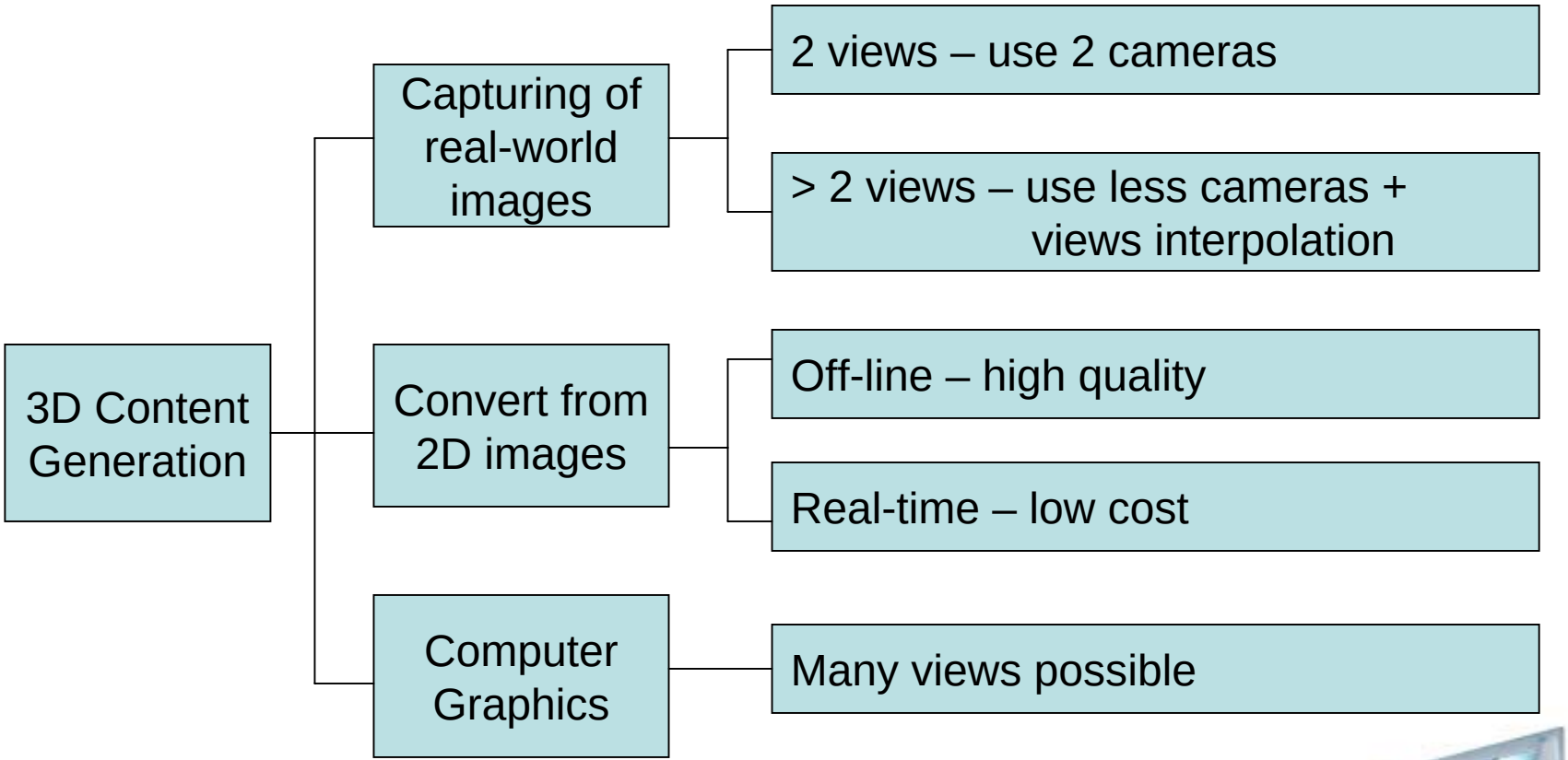


☞物體A以P1和P2顯示
物體B以P2和P3顯示
物體C以P3和P4顯示

TAO的360º圓柱系統

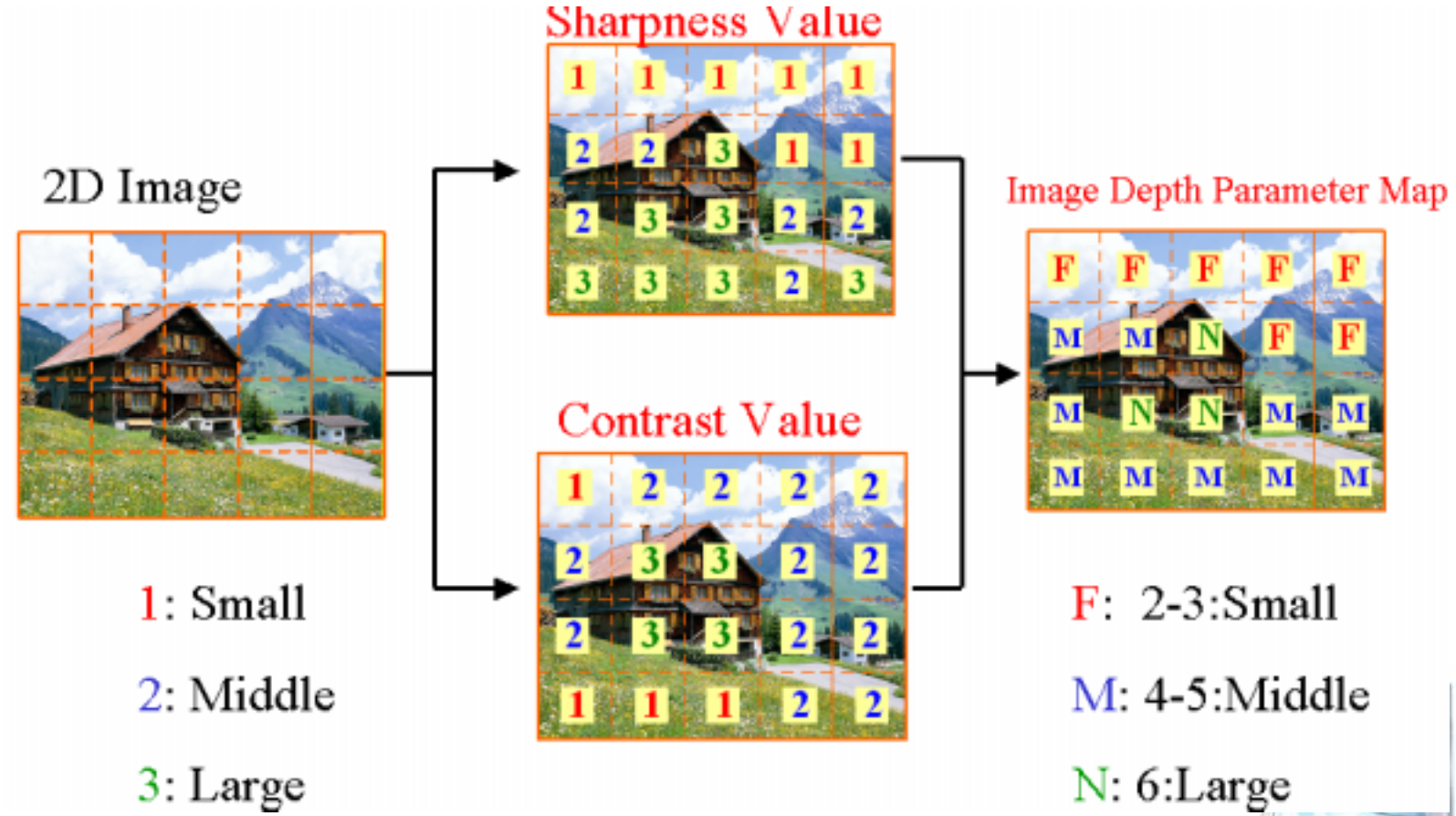


3D Content


3D Content Generation
Capturing of real-world images
2 views – use 2 cameras
> 2 views – use less cameras + views interpolation
Convert from 2D images
Off-line – high quality
Real-time – low cost
Computer Graphics
Many views possible

2D/3D Conversion

利用單眼深度線索(如：模糊、對比、遮蔽、陰影、大小...)，利用軟體將2D影像轉成3D的技術



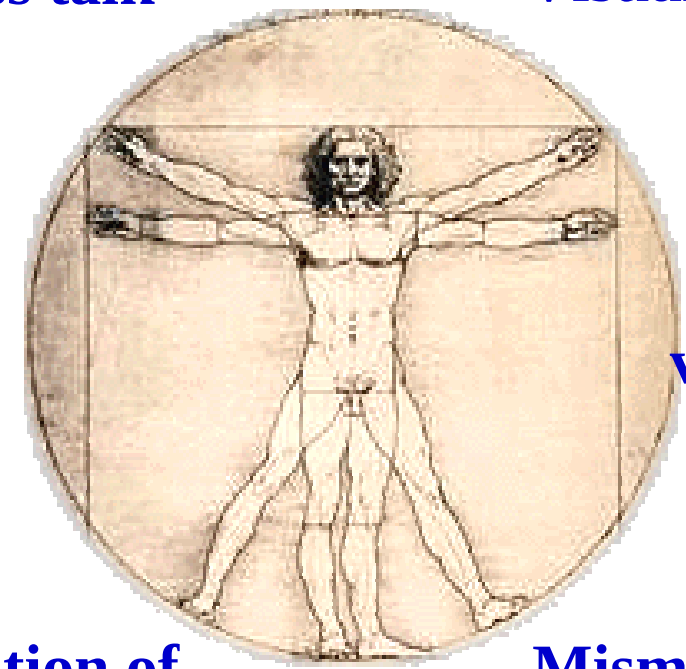
Home 3D Theater Solution of Mercury

3D STB + PC monitor

Human Factors of 3D Vision

Cross talk

Visual fatigue



Just-enough disparity

Requirement of view-zone number

Integration of stereo cue and 2D depth cues

Mismatch of Accommodation and Convergence

超多視域顯示技術
（Super Multi-View-SMV）

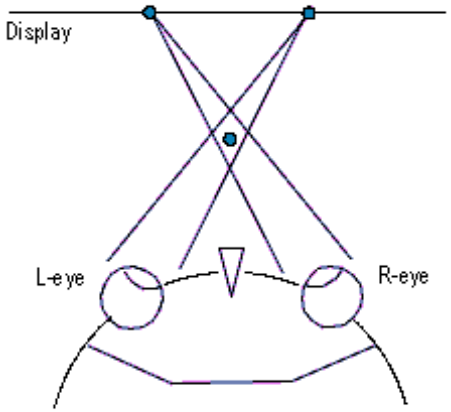


Fig.1 Optical configuration of the conventional stereogram.

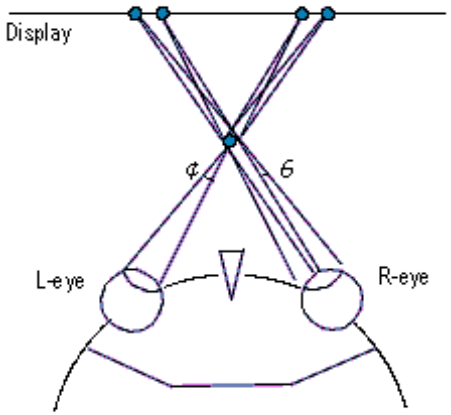
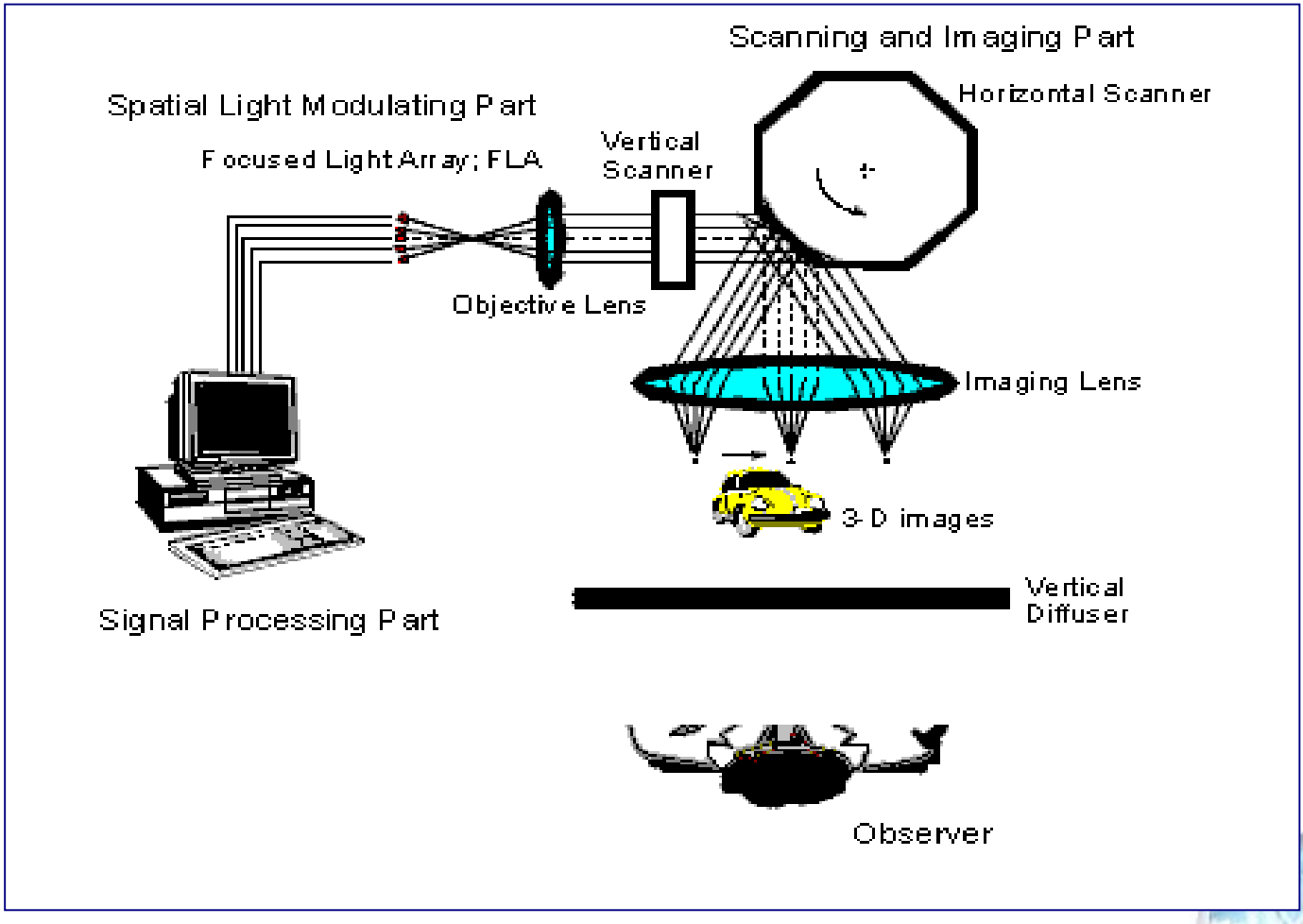
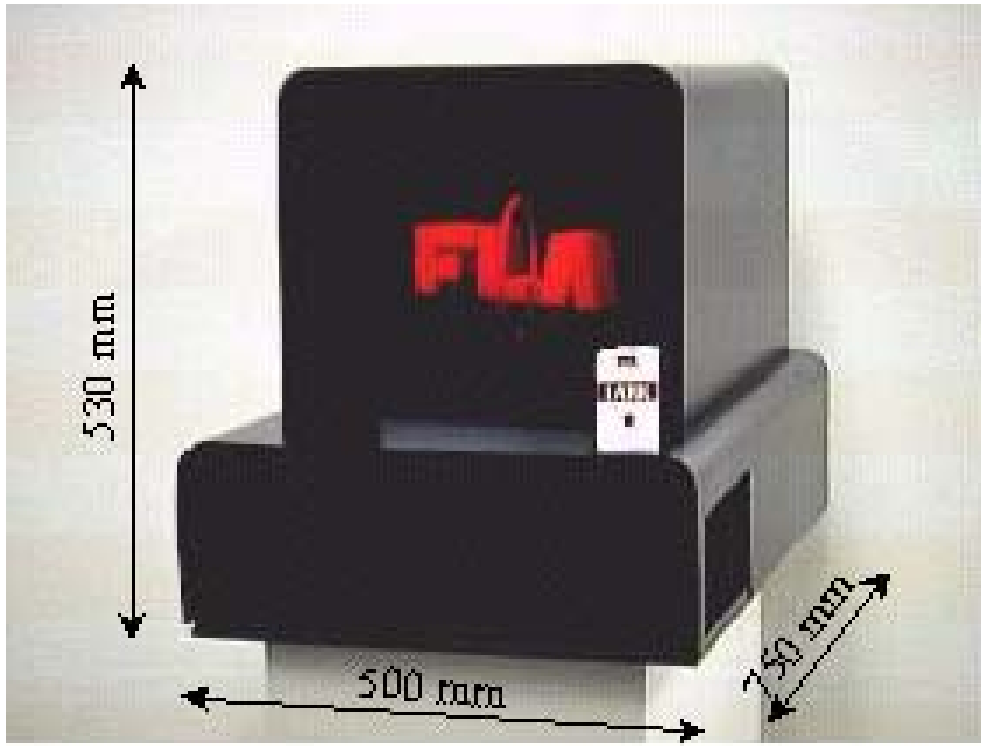


Fig. 2 Optical configuration of the super-multi-view stereogram.

Focused Light Array 3D Display



SMV 原型機

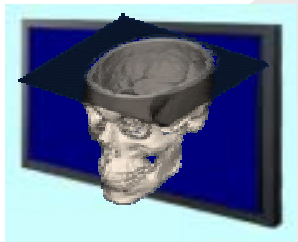


An Experimental Display with 45-View Images

3D顯示技術應用領域

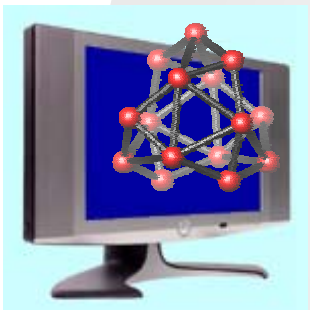
Scenario

3D Home information center

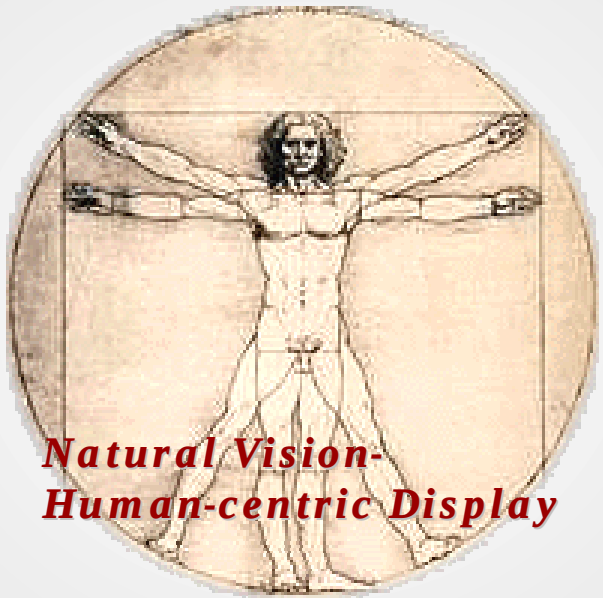


3D Medical Imaging

擬真遠距居家照護



3D Education



3D Entertainment

3D Simulator

3D advertisement

Desktop 3D : Application
~ 3D Information KIOSK ~

Evaluation of vision factors by viewing 3D

Application : Home TV

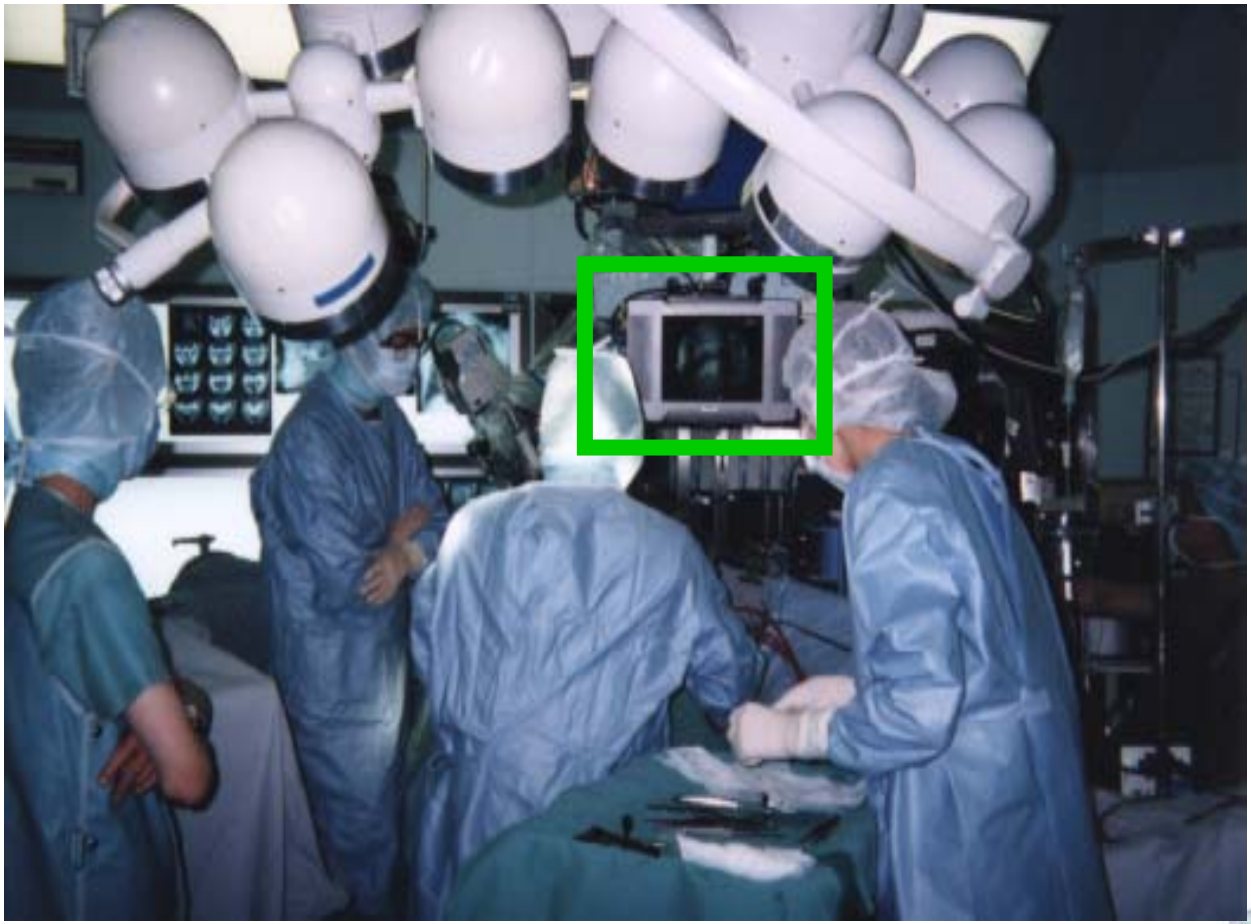
Application：Entertainment
~ Pachinko ~

Application : Entertainment
~ Sports Simulation ~

Application : Entertainment
~ Fortune Teller Game ~

Application : Medical

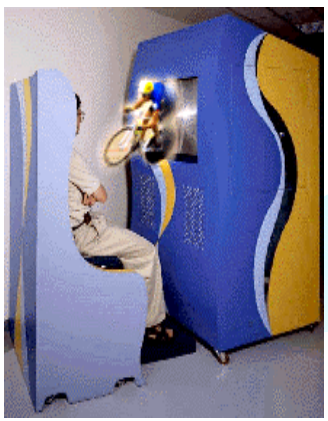
Application : Medical



Application：Medical

Researches in ITRI/OES

光電所立體顯示技術研發歷程



投影式立體顯示系統

雙液晶面板系統

微位相差追跡式系統

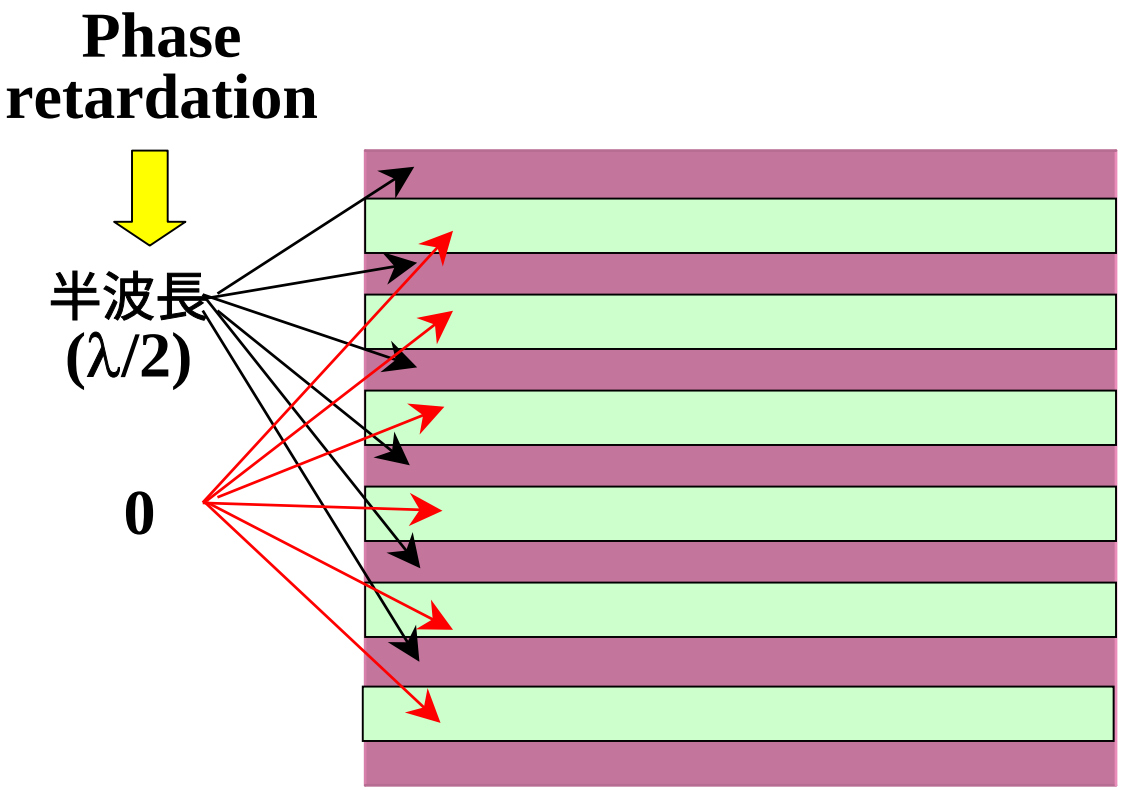
薄型微位相差追跡式系統

Microretarded large 3D screen

Microretarder 技術

FY87 →

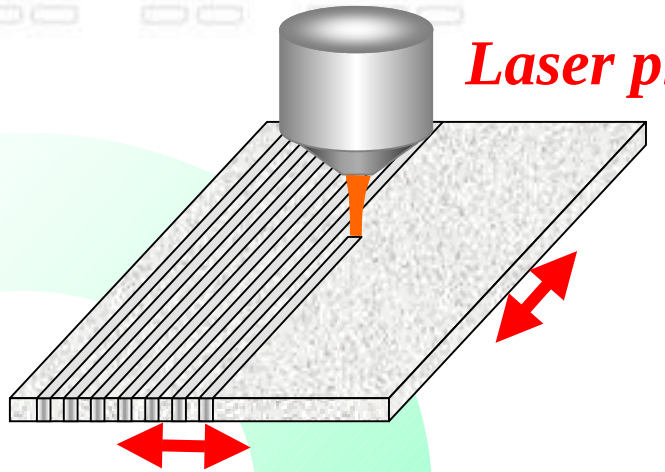
What is Microretarder ?

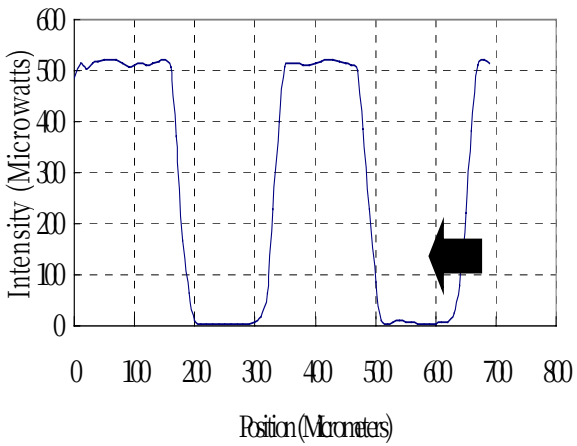


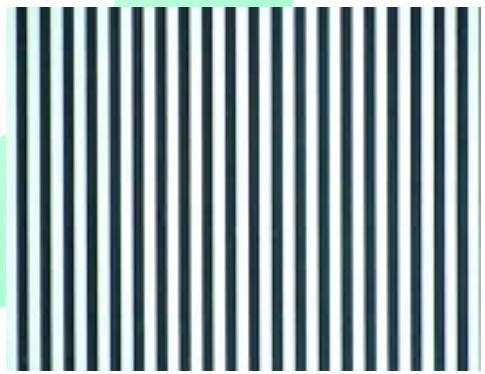
Microretarder製程

Fabrication system

Laser process



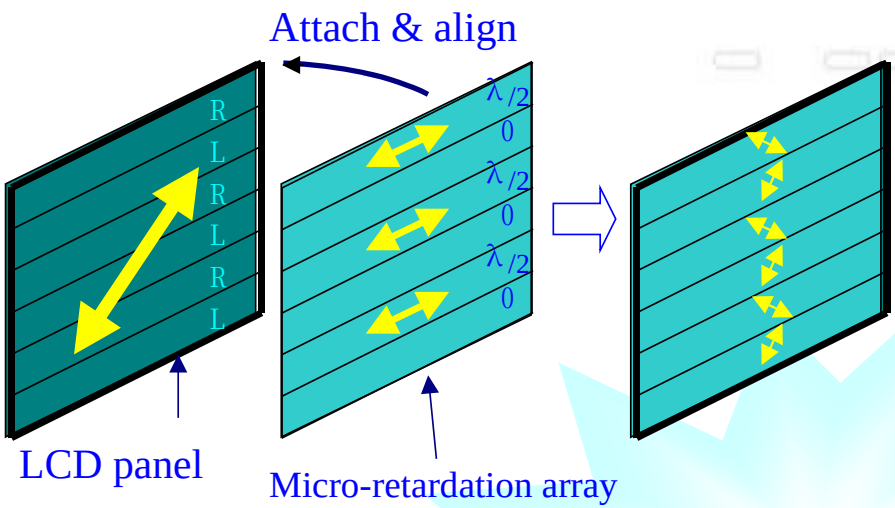




Retardation Measurement

成品放大(上下加偏光板)

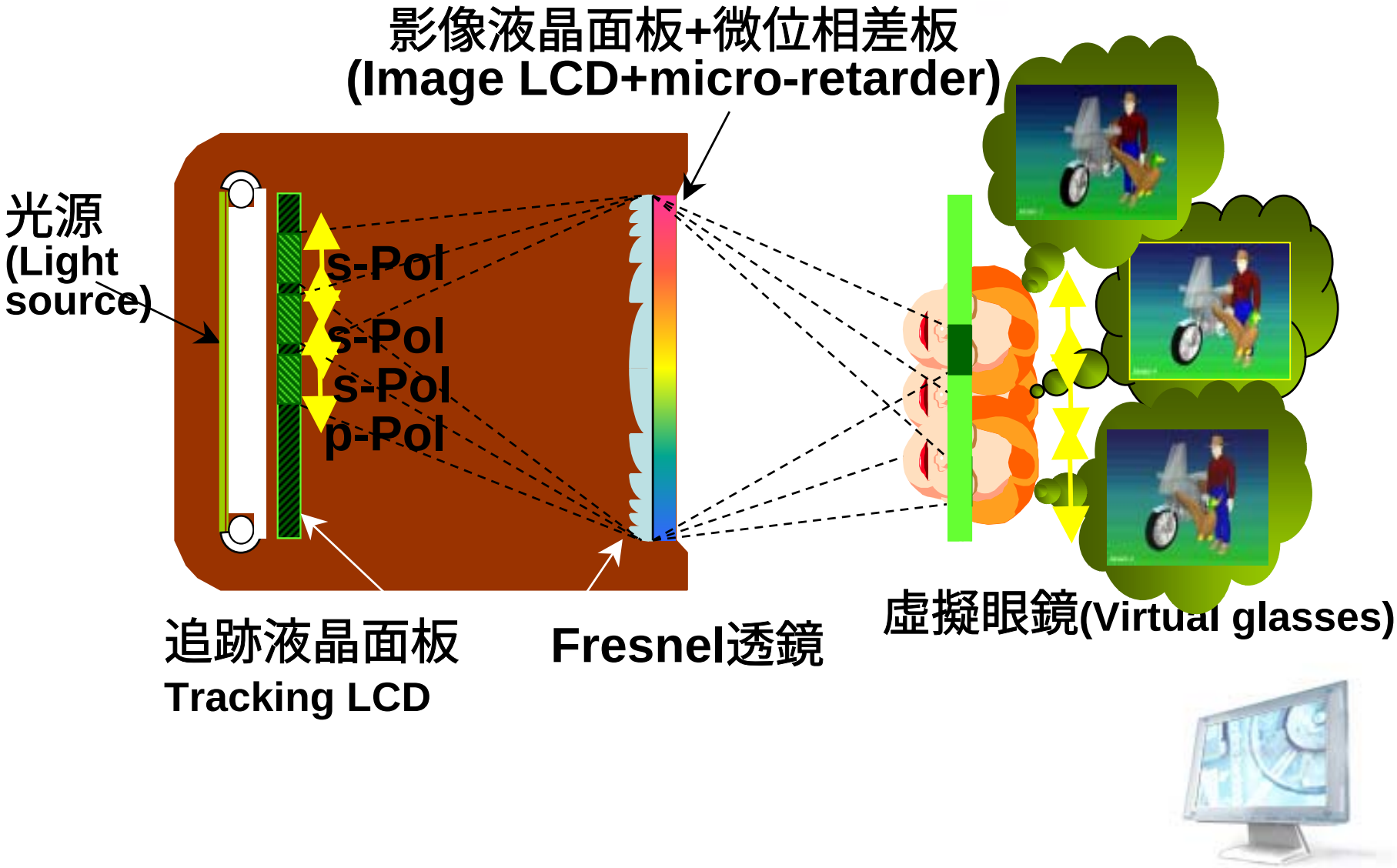
2D/3D相容LC-TV/Monitor



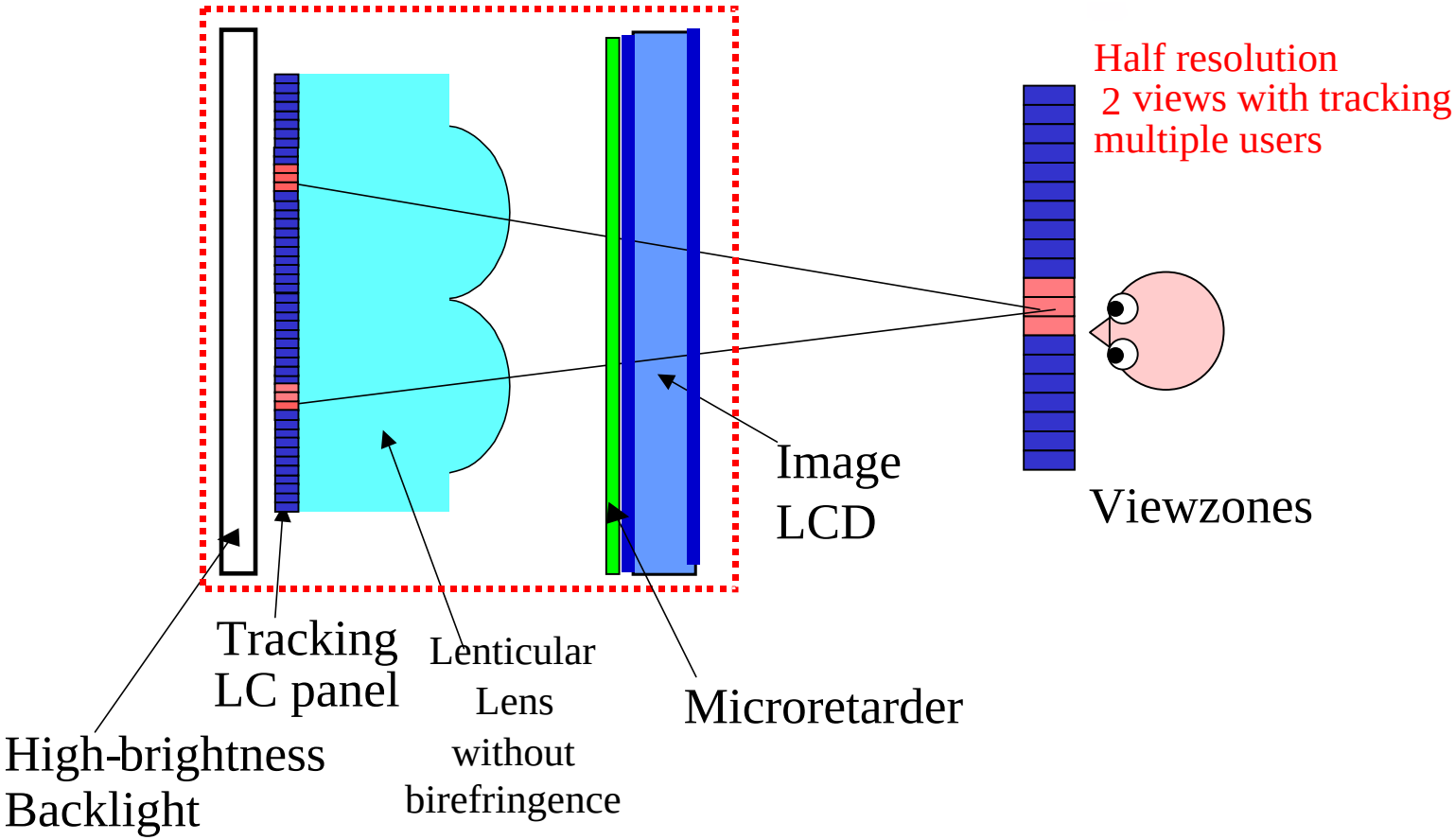
在家用電視也能享受3D虛擬實境
--2D/3D LC TV

最簡單、低成本使LCD
兼具2D/3D功能的方法

微位相差追跡式立體顯示器

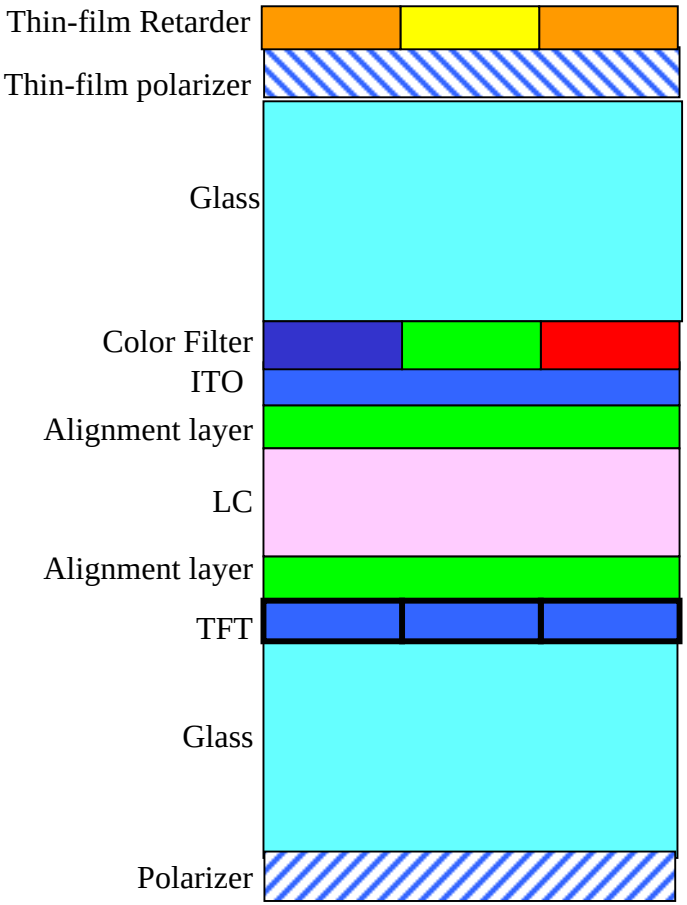


追跡式立體FPD

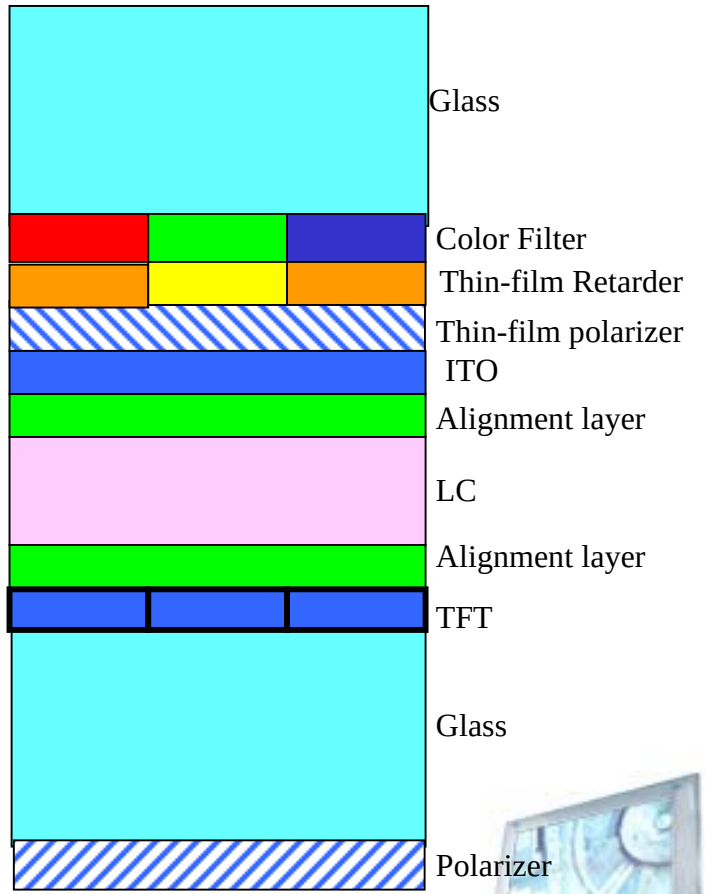

Half resolution
2 views with tracking
multiple users
Image
LCD
Viewzones
Tracking
LC panel
Lenticular
Lens
without
birefringence
Microretarder
High-brightness
Backlight

In-cell 3D LCD

Out-cell configuration



In-cell configuration



未來趨勢

- 全像技術頻寬需求太高
- Volumetric技術之顯示特性不適用於TV
- 2D Multiplexed技術需解決兼顧觀看位置自由度、解析度之問題
  - --極高解析度之顯示面板(目前最高3840 x 2400)
  - --Multiple Images Integration(use fiber/waveguide ?)
  - --Viewer tracking
- TV牽涉層面廣泛, 非顯示系統可以單獨成功
  - --即使硬體問體解決，還有content及傳輸問題

➡ Only niche market could be the killer application

Strategy analysis

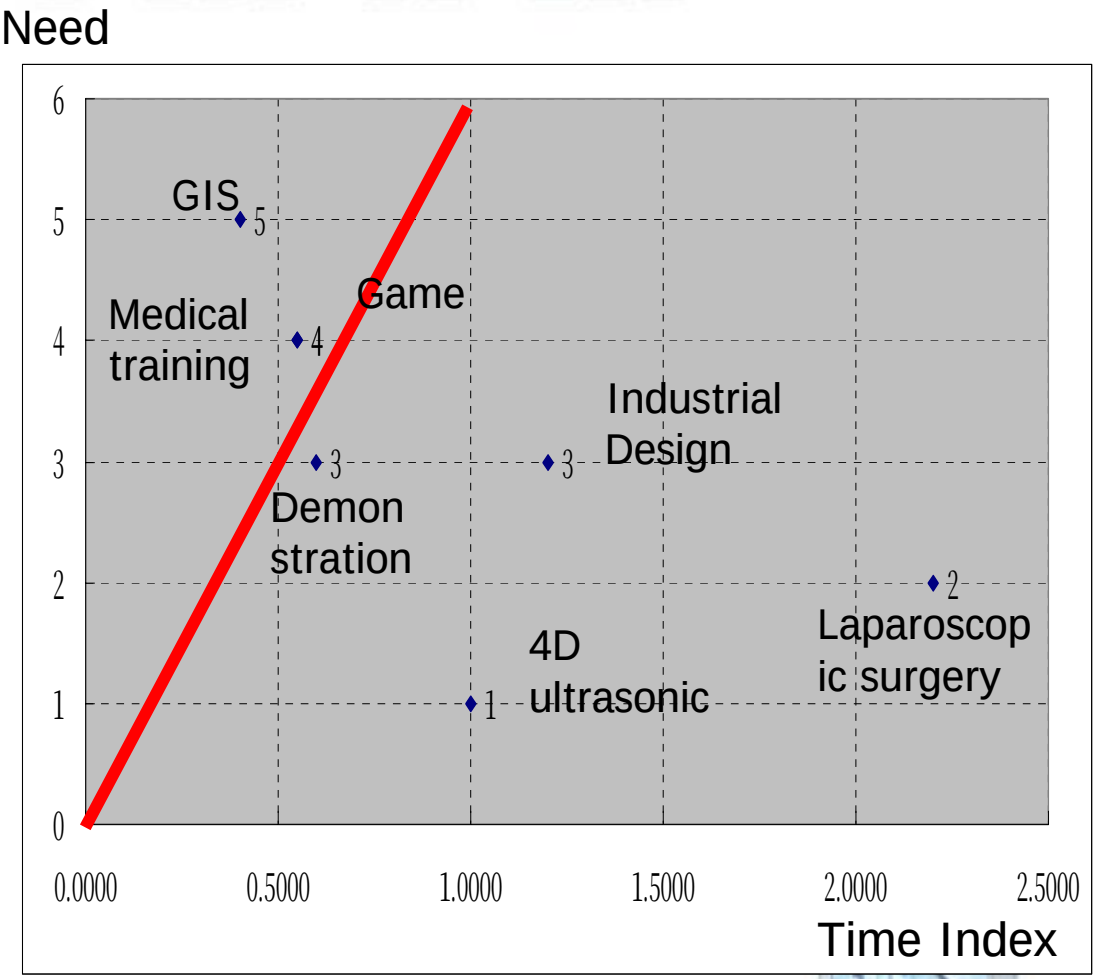
可能之產品方向
Demonstration、Game、

分組評估各產品之
competitor及其Price

訂定目標產品具競爭力之規格及strategy price

評估達成該產品規格及價格目標之技術難度(technical barrier評分)

各產品之需求調查與評分



The End, Thanks